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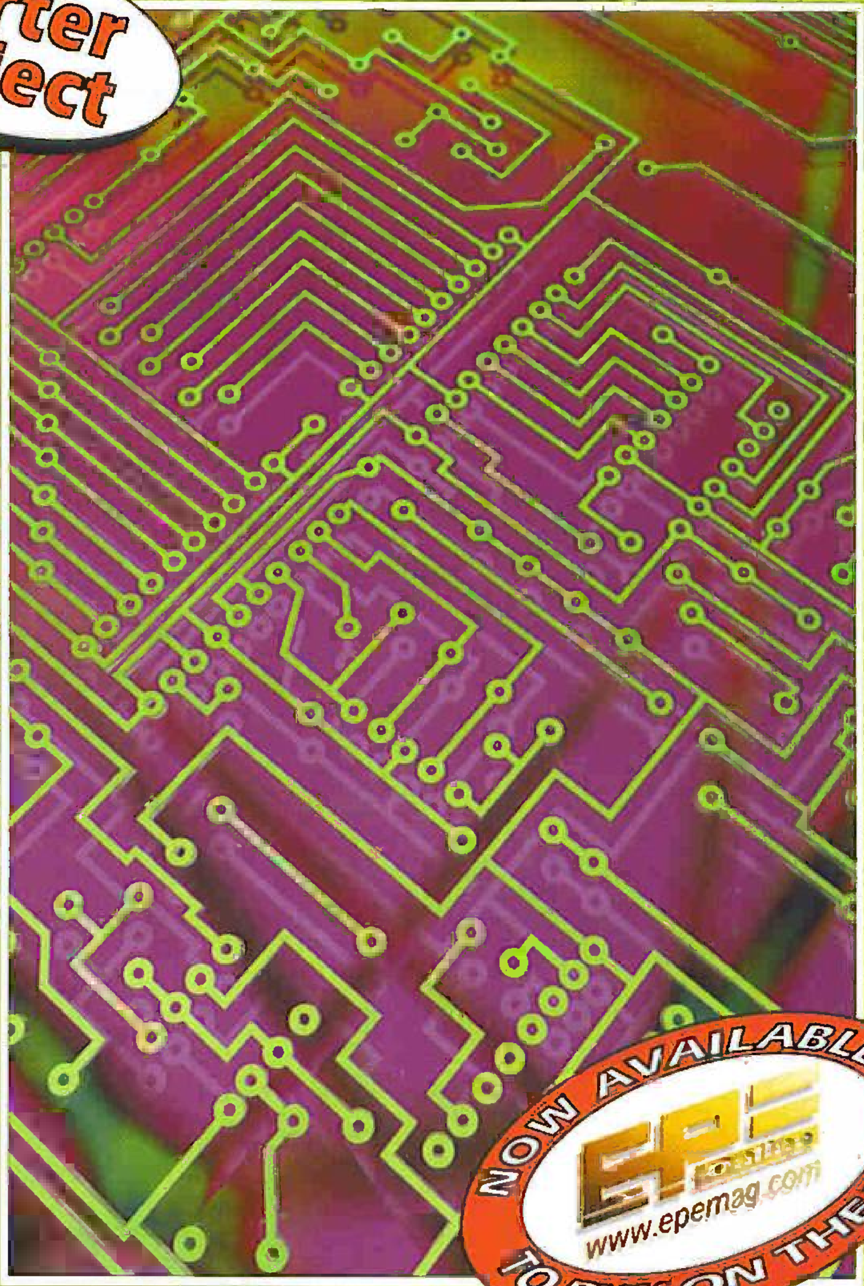

LOOP AERIAL SW RECEIVER

Easy to build and use.
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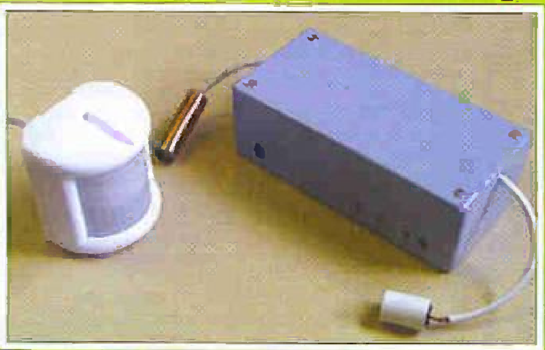

CHILD GUARD

Helps protect from heat sources

8 CHANNEL DATA LOGGER - 2

Uses the new PIC 16F877

FROM PIPELINES TO PYLONS - 2

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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 torroidal 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. 170x250x220mm, 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 SS81. 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 SS60 The 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 SS81 Power supplies £5 ref SS60

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, buitin automatice reset overload protector, keyed shaft (40x16mm)Made by Leeson £99 each ref LEE1

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

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS Could be adapted for laser listener, long range communications etc Double beam units designed to fit on the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for alignment. 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 electronics 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 £8 Useful 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 rate PCB measures just 70x55mm 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 connectors. £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 Neodymium 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, XK and KA bands, speed cameras, and all known speed detection systems. 360 degree coverage, front&rear waveguides. 1.1"x2.7"x4.6" fits on visor or dash £149

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

LAPTOP LCD SCREENS 240x175mm, £12 ref SS51

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

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

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

Online web catalogue bull-electrical.com

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

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

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

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

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

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

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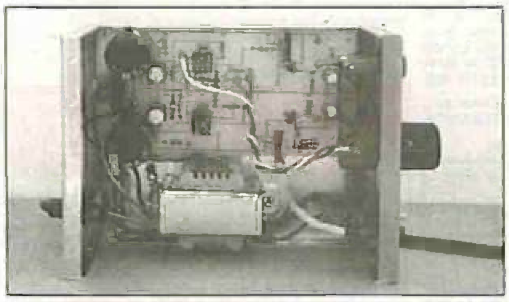
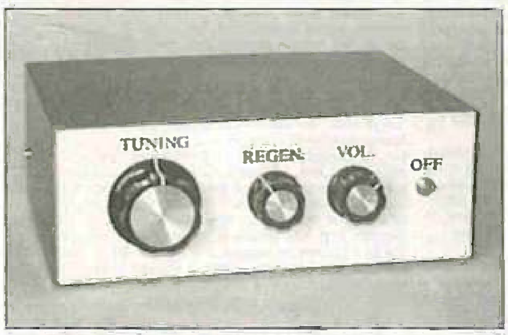
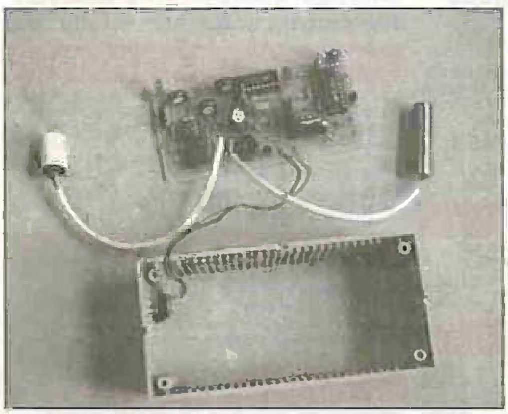
The No. 1 Magazine for Electronics Technology and Computer Projects







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Our October '99 issue will be published on Friday, 3 September 1999. See page 627 for details.

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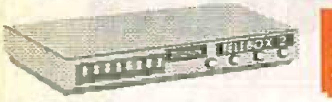
Converts your colour monitor into a QUALITY COLOUR TV!!



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 Prodrive 42mb SCSI I/F, New RFE	£49.00
5¼" MINISCRIBE 3425 20mb MFM I/F (or equiv.) RFE	£49.95
5¼" SEAGATE ST-238R 30 mb RLL I/F Refurb	£69.95
5¼" CDC 94205-51 40mb HH MFM I/F RFE tested	£69.95
5¼" HP 97548 850 Mb SCSI RFE tested	£99.00
5¼" HP C3010 2 Gbyte SCSI *differential* RFE tested	£195.00
8" NEC D2246 85 Mb SMD interface. *New*	£199.00
8" FUJITSU M2322K 160Mb SMD I/F RFE tested	£195.00
8" FUJITSU M2392K 2 Gb SMD I/F RFE tested	£345.00

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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 available - CALL

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

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

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

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

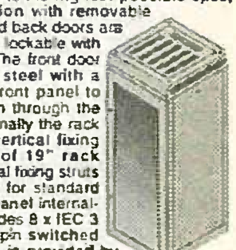
Superb quality 6 foot 40U
Virtually New, Ultra Smart
Less than Half Price!

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 casters 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 !!

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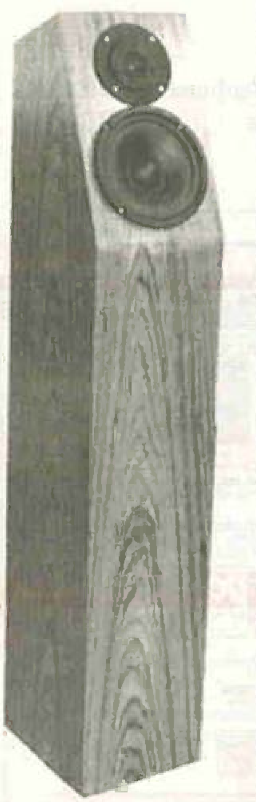
PIC16F87x MINI TUTORIAL

As we explained in the 8-Channel Analogue Data Logger of Aug/Sept '99, the PIC16F87x family of microcontrollers 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.

In this Mini Tutorial we take a closer look at how the PIC16F87x family can be programmed to implement the type of functions offered by the Data Logger. Knowledge of how and why these routines are written will greatly assist you in writing similar functions for other applications. The discussions have the emphasis placed on the PIC16F877 device, but in principle they equally apply to the PIC16F873, '874 and '876 devices as well.

Some of the author's investigations were clouded by ambiguities in the PIC16F87x data sheet and took considerable experimental research to understand how to implement some functions. By reading this article, you could be saved much time and heart-ache when attempting to use the functions in your own designs.

THE QWL LOUDSPEAKER



The design and construction of a Quarter Wave Loaded loudspeaker system.

This article was written originally in 1988 for ETI, and a modified version is presented describing the incorporation of improved drivers and a matching crossover. It is hoped that the design will appeal to existing owners of the QWL in terms of an upgrade, as well as to new constructors looking for a wide frequency range loudspeaker occupying a reasonable floor space.

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

These loudspeakers are relatively cheap for the performance obtained (as a useful rule of thumb they compare very favourably with commercial designs costing in the order of three times the cost of the speaker units and crossovers in this design) and are fairly simple to build. They occupy very little floor space, are easily moved to a desired position for serious listening, and are of the right height to preclude the need for stands. The overall design has been carefully selected on the basis of a combination of good measured frequency response, stereo imaging, sound quality and efficiency.

MAINS CABLE DETECTOR

Probably most do-it-yourself enthusiasts are aware of the dangers of drilling into the walls of practically any building, and use some form of pipe/cable detector to check that it is safe prior to doing any work of this type. Such precautions should ensure that there are no nasty surprises, but some types of cable can be difficult to detect. Most pipe and cable locators are actually metal locators that are optimised for this application. They are quite good at finding things like nails in doors and plasterwork, locating metal pipes, and finding cables in metal conduits. They tend to be less effective at finding electric cables that are in plastic conduits. The problem seems to be that there is simply not that much metal in an electric cable, especially a lighting type that is only designed to carry modest currents. This makes such cables difficult to detect unless they are close to the surface of a wall.

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

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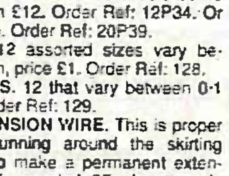

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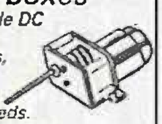

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As featured in March '97 issue.

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

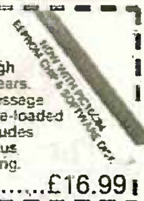
KIT 866.... Full kit including four electrodes £32.90

1000V & 500V INSULATION TESTER

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

KIT 848.................£32.95

SPACEWRITER



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

KIT 849.....................£16.99

12V EPROM ERASER

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

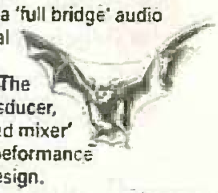
KIT 790..........................£28.51

SUPER BAT DETECTOR

NEW!

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

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



KIT 861.....................£24.99
ALSO AVAILABLE Built & Tested £39.99

E.E. TREASURE HUNTER P.I. METAL DETECTOR MKI

Magenta's highly developed & acclaimed design. Quartz crystal controlled circuit. MOSFET coil drive. D.C. coupled amplification. Full kit includes PCB, handle, case & search coil.

- KIT INC. HEADPHONES
- EFFICIENT CMOS DESIGN
- POWERFUL COIL DRIVE
- DETECTS FERROUS AND NON-FERROUS METAL – GOLD, SILVER, COPPER ETC.
- 190mm SEARCH COIL
- NO 'GROUND EFFECT'

KIT 815.........................£45.95

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

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

Kit No. 845................£64.95

EPE PROJECT PICs

NOW £5.90

Programmed PICs for all* EPE Projects
Now one price
£5.90 each
(*some projects are copyright)

ULTRASONIC PEsT SCARER

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

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

KIT 812...£14.81

0999

ELECTRONIC COMPONENTS

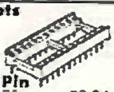
See Next / Last Months Ad. for COMPONENT ACCESSORIES

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

All Major Credit cards Accepted

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

DIL Sockets



Stamped Pin
6 Pin DIL 0.3" £0.06
8 Pin DIL 0.3" £0.06
14 Pin DIL 0.3" £0.11
16 Pin DIL 0.3" £0.11
18 Pin DIL 0.3" £0.12
20 Pin DIL 0.3" £0.12
24 Pin DIL 0.6" £0.13
28 Pin DIL 0.6" £0.13
40 Pin DIL 0.6" £0.19

Turned Pin
8 Pin DIL 0.3" £0.11
14 Pin DIL 0.3" £0.20
16 Pin DIL 0.3" £0.23
18 Pin DIL 0.3" £0.25
20 Pin DIL 0.3" £0.28
24 Pin DIL 0.6" £0.35
28 Pin DIL 0.6" £0.41
40 Pin DIL 0.6" £0.64

0.1" Pin Header Strip
1 x 36 Way Straight £0.38
2 x 36 Way Straight £0.56
1 x 36 Way 90° £0.54
2 x 36 Way 90° £0.80
Available in 2,3,4,5 & 10 ways. Also female PCB sockets & jumper links.
20 Way Socket Strip £0.48

Transistor Sockets
TO18-4 Base Socket £0.24
TO5 Base Socket £0.24

IDC Cable Sockets

10 Way Socket £0.25
14 Way Socket £0.35
16 Way Socket £0.37
20 Way Socket £0.37
26 Way Socket £0.38
34 Way Socket £0.39
40 Way Socket £0.55
50 Way Socket £0.80

PCB Box Headers

10 Way Straight £0.27
14 Way Straight £0.36
16 Way Straight £0.36
20 Way Straight £0.32
26 Way Straight £0.57
34 Way Straight £0.57
40 Way Straight £0.63
50 Way Straight £0.96
10 Way 90° £0.33
16 Way 90° £0.42
20 Way 90° £0.53
26 Way 90° £0.70
34 Way 90° £0.81
40 Way 90° £0.83
50 Way 90° £0.95

PCB Latch Headers

10 Way Straight £0.50
16 Way Straight £0.70
20 Way Straight £0.78
26 Way Straight £0.81
34 Way Straight £0.86
40 Way Straight £1.56
50 Way Straight £1.29
10 Way 90° £0.58
16 Way 90° £0.78
20 Way 90° £0.82
26 Way 90° £1.06
34 Way 90° £1.14
40 Way 90° £1.26
50 Way 90° £1.74

DIL Headers

14 Way DIL £0.54
16 Way DIL £0.59
24 Way DIL £0.90
40 Way DIL £1.02

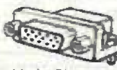
Transistion Headers
10 Way Transistion £0.49
14 Way Transistion £0.47
16 Way Transistion £0.47
20 Way Transistion £0.54
26 Way Transistion £0.62
34 Way Transistion £0.67
40 Way Transistion £0.90
50 Way Transistion £1.02

D Type Connectors

Solder Bucket
9 Way Male Plug £0.26
9 Way Female Socket £0.27
15 Way Male Plug £0.36
15 Way Female Socket £0.39
15 Way H.D. Plug £0.47
15 Way H.D. Socket £0.78
23 Way Male Plug £0.49
23 Way Female Socket £0.49
25 Way Male Plug £0.36
25 Way Female Skt £0.39

IDC Ribbon Mounting
9 Way Male Plug £1.08
9 Way Female Socket £1.08
25 Way Male Plug £1.18
25 Way Female Socket £1.13

Right Angled PCB



9 Way Male Plug £0.37
9 Way Female Socket £0.35
15 Way H.D. Socket £0.77
25 Way Male Plug £0.53
25 Way Female Socket £0.51

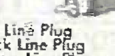
Plastic D Covers
9 Way Cover - Grey £0.30
9 Way Cover - Black £0.30
15 Way Cover - Grey £0.33
23 Way Cover - Grey £0.36
23 Way Cover - Black £0.36
25 Way Cover - Grey £0.34
25 Way Cover - Black £0.37
9 to 9 Cover / Case £0.96
25 to 25 Cover / Case £0.84
9 to 25 Cover / Case £0.96

Audio Connectors

2.5mm Jack Plug £0.21
2.5mm Line Socket £0.16
2.5mm Chassis Socket £0.20
3.5mm Mono Plug £0.24
3.5mm Mono Line Skt £0.30
3.5mm Mono Chassis £0.14
3.5mm Stereo Plug £0.36
3.5mm Stereo Line Skt £0.37
3.5mm Stereo Chassis £0.34
¼" Mono Plug £0.34
¼" Mono Line Socket £0.35
¼" Mono Chassis Sk £0.35
¼" Stereo Plug £0.40
¼" Stereo Line Socket £0.38
¼" Stereo Chassis Skt £0.40
NEUTRIK Speakon Plug £2.81

DIN Series
2 Pin Line Plug £0.19
2 Pin Chassis Socket £0.15
3 Pin Line Plug £0.27
3 Pin Chassis Socket £0.28
4 Pin Line Plug £0.24
4 Pin Chassis Socket £0.26
5 Pin Line Plug 180° £0.30
5 Pin Chassis Skt 180° £0.33
5 Pin Line Plug 240° £0.24
5 Pin Chassis Skt 240° £0.32
5 Pin Line Plug 360° £0.24
5 Pin Chassis Skt 360° £0.32
6 Pin Line Plug £0.34
6 Pin Chassis Socket £0.35
7 Pin Line Plug £0.35
7 Pin Chassis Socket £0.37
8 Pin Line Plug £0.44
8 Pin Chassis Socket £0.36

Phono Series

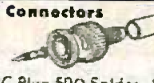


Red Line Plug £0.20
Black Line Plug £0.20
Yellow Line Plug £0.20
White Line Plug £0.20
Red Line Socket £0.20
Black Line Socket £0.20
Yellow Line Socket £0.20
White Line Socket £0.20
Red Chassis Socket £0.20
Black Chassis Socket £0.20
Gold Plated Plug Red £0.66
Gold Plated Plug Black £0.66

XLR Series - metal

3 Pin Line Plug £1.46
3 Pin Line Socket £1.71
3 Pin Chassis Plug £1.50
3 Pin Chassis Socket £1.49
Neutrik Line Plug £1.68
Neutrik Line Socket £1.99
Neutrik Chassis Plug £2.13
Neutrik Chassis Socket £2.32

RF Connectors



BNC Plug 50Ω Solder £0.99
BNC Plug 50Ω Crimp £0.68
BNC Plug 75Ω Solder £0.95
BNC Plug 75Ω Crimp £0.68
BNC Chassis Socket £0.81
F Plug - Twist £0.24
F Plug - Crimp £0.26
TNC Plug 50Ω Solder £1.24
TNC Plug 50Ω Crimp £0.85
TNC Plug 75Ω Solder £1.40
TNC Plug 75Ω Crimp £1.16
UHF Plug 5mm Cable £0.63
UHF Plug 11mm Cable £0.75
UHF Chassis Skt- Sqr £0.50
UHF Chassis Skt- Rnd £0.73
Extensive range of RF connectors in stock, inc.FME, SMA, Mini UHF & N Type.

Terminals

Colours Red, Black, Green, Blue, White or Yellow
2mm Solder Plugs £0.18
2mm Chassis Sockets £0.26
4mm Solder Plugs £0.35
4mm Stackable Plugs £0.40
4mm Chassis Sockets £0.25
4mm Binding Posts £0.54
33mm Crocodile Clips £0.13

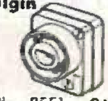
Power Connectors DC Low Voltage

DC Plug 0.7ID 2.35OD £0.47
DC Plug 1.3ID 3.4OD £0.32
DC Plug 1.7ID 4.0OD £0.47
DC Plug 1.7ID 4.75OD £0.47
DC Plug 2.1ID 5.0OD £0.25
DC Plug 2.5ID 5.0OD £0.24
DC Plug 3.1ID 6.3OD £0.46
DC Line Socket 2.1mm £0.57
DC Line Socket 2.5mm £0.56
DC Chassis Skt 2.1mm £0.40
DC Chassis Skt 2.5mm £0.41

IEC Mains 6A 250Vac

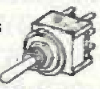
3 Pin IEC Line Socket £1.08
3 Pin IEC Line Plug £1.78
3 Pin Chassis Socket £0.55
3 Pin Chassis Plug £0.72

8 Way Bulgin



8 Pin Line Plug P551 £4.08
8 Pin Chassis Skt P552 £1.39

Toggle Switches



Sub-Miniature
3A 125V 1A 250V
5mm Ø Mounting Hole
SPST 5 x 10mm £0.58
SPDT 5 x 10mm £0.60
SPDT C/Off 5 x 10mm £0.81
DPDT 9.2 x 10mm £0.66

Miniature
6A 125V 3A 250V
6.2mm Ø Mounting Hole
SPST 8 x 13mm £0.65
SPDT 8 x 13mm £0.60
SPDT c/off 8 x 13mm £0.60
SPDT c/o Biased 2 way £0.97
SPDT c/o Biased 1 way £1.04
DPDT 12 x 13mm £0.72
DPDT c/off 12 x 13mm £0.80
DPDT c/o Biased 2 way £1.28
DPDT c/o Biased 1 way £1.28

Standard
10A 250V Push on terminals
12mm Ø Mounting Hole
SPST 18 x 30mm £1.28
SPDT 18 x 30mm £1.31
SPDT c/off 18 x 30mm £1.43
DPDT 21 x 30mm £1.65
DPDT c/off 21 x 30mm £1.68

Slide Switches

Miniature
300mA 125V
7 x 15mm Mounting Hole
DPDT 7 x 23mm £0.20

Standard
1A 125V
5.5 x 12mm Mounting Hole
DPDT 12 x 35mm £0.25
DPDT c/o 12 x 35mm £0.27

Rotary Switches

150mA 250V
Make before Break 22mm Ø
9.8mm Ø Mounting Hole
1 Pole 12 Way £0.84
2 Pole 6 Way £0.84
3 Pole 4 Way £0.84
4 Pole 3 Way £0.84

Push Switches

Miniature Round
250mA 125V 28 x 10mm
7mm Ø Mounting Hole
Non Latching Push to Make
Black PTM £0.23
Red PTM £0.23
Yellow PTM £0.23
Green PTM £0.23
Blue PTM £0.23
White PTM £0.23
Non Latching Push to Break
Black PTB £0.24

Standard Square

1A 250V
39 x 15MM
12mm Ø Mounting Hole
Non Latching Push to Make
Black PTM £0.60
Red PTM £0.60
Blue PTM £0.60
White PTM £0.60
Latching -push On push Off
Black £0.65
Red £0.65
Blue £0.65
White £0.65

Rocker Switches
Miniature
6A 250V Solder Tags
SPST 21 x 14 x 16mm £0.69
DPDT 21 x 24 x 22mm £0.96
SPST - Red Neon £1.02
SPST - Green Neon £1.02
SPST - Amber Neon £1.02

Standard
15A 250V Push on Tags
SPST 30 x 11 x 22mm £0.58
DPDT 30 x 25 x 22mm £1.12

Illuminated
15A 250V Push on Tags
SPST 30x14mm Red £0.84
DPST 30x25mm Red £1.40
DPST 30x25mm Amber £1.40
DPST 30x25mm Green £1.40

Relays
PCB Mounting
1A 24Vdc DPDT 5V £1.38
1A 24Vdc DPDT 12V £2.00
3A 110V SPDT 6V £0.58
3A 110V SPDT 12V £0.58
5A 110V SPDT 6V £0.72
5A 110V SPDT 12V £0.72
5A 110V DPDT 6V £0.93
5A 110V DPDT 12V £0.93
5A 240V DPDT 6V £1.76
5A 240V DPDT 12V £1.76
10A 240V SPDT 6V £1.25
10A 240V SPDT 12V £1.44
10A 240V SPDT 24V £1.44

Computer Accessories Adaptors

9M Gender Changer £2.18
9F Gender Changer £2.29
25M Gender Changer £2.60
25F Gender Changer £2.80
9 Male - 25 Female £1.90
9 Female - 25 Male £1.90
9M - 6 Mini Din Male £2.40
9F - 6 Mini Din Female £2.40
5M Din - 6F Mini Din £2.08
5F Din - 6M Mini Din £2.08

Testers / Patch Boxes
Mini Tester 7 LEDs £4.72
Check Tester 18 LEDs £6.32
Enhanced + Switches £15.25
25D Jumper Box M-F £2.90
25D Patch Box M-F £7.32
Anti-Static Wrist Strap £4.76
RS232 Surge Protector £5.43
Mains Surge Protector £11.99
4 Gang Surge Block £15.50

Leads & Cables

1.5m Printer Lead £3.40
5m Printer Lead £9.38
10m Printer Lead £8.75
Serial Printer 25M-9F £4.50
Serial Printer 25M-25F £4.45

Null Modem Leads
9 Female - 9 Female £3.16
25 Female- 25 Female £4.63
9 Female - 25 Female £3.18
9&25F to 9&25F £5.52

Modem Leads
25Male to 9Female £4.08
25Male to 25Female £4.75

PC Link Leads
Interlink 25M to 25M £4.38

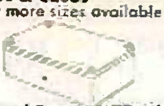
Patch Lead
25Male to 25Male £4.50
36Male to 36Male £2.60

Internal Leads
Floppy Cable A/B £3.00
Hard Disk 2xIDE £1.65
Power 3½-2 x 3½ £1.88
Power 5¼-2 x 5¼ £1.59
Power 5¼-2 x 3½ £2.24
Power 5¼-3½,5¼ £2.24

Networking
BNC T Piece FMF £1.71
BNC T Piece FFF £2.40
BNC Coupler F £0.95
BNC Coupler M £1.65
BNC Ratchet Crimper £17.44
50Ω BNC Terminator £1.24
Thinnet Cable per m £0.39

Boxes & Cases

Many more sizes available



General Purpose Plastic
75 x 56 x 25mm £0.99
75 x 51 x 22mm £0.99
111 x 57 x 22mm £1.12
79 x 61 x 40mm £1.70
100 x 76 x 41mm £1.79
118 x 98 x 45mm £2.08
150 x 100 x 60mm £2.77
150 x 80 x 50mm £2.72

Diecast Aluminium
50 x 50 x 31mm £2.67
100 x 50 x 25mm £2.98
112 x 62 x 31mm £3.55
120 x 65 x 40mm £4.05
150 x 80 x 50mm £5.36
121 x 95 x 61mm £5.99

Two Piece Aluminium
133 x 70 x 37mm £2.08
102 x 102 x 37mm £1.94
102 x 70 x 37mm £1.81
102 x 63 x 50mm £1.98
76 x 51 x 25mm £1.34
152 x 102 x 50mm £2.99
178 x 127 x 63mm £3.62
203 x 152 x 76mm £4.64
102 x 102 x 63mm £2.15
133 x 102 x 63mm £2.57
152 x 102 x 76mm £3.23

Steel/Aluminium
Plastic coated steel top, Aluminium base
152 x 114 x 44mm £4.19
203 x 127 x 51mm £5.04
229 x 127 x 63mm £5.80
114 x 63 x 57mm £3.04

Wire & Cable
Ribbon Cable
Price per 300mm (1ft)
10 Way Grey Ribbon £0.11
16 Way Grey Ribbon £0.17
20 Way Grey Ribbon £0.24
26 Way Grey Ribbon £0.28
34 Way Grey Ribbon £0.38
40 Way Grey Ribbon £0.48
50 Way Grey Ribbon £0.53
60 Way Grey Ribbon £0.64

Enamelled Copper Wire
Per 50g (2oz) Reel
500g reels available
14 SWG Enamelled £0.97
16 SWG Enamelled £0.97
18 SWG Enamelled £0.97
20 SWG Enamelled £0.97
22 SWG Enamelled £1.01
24 SWG Enamelled £1.12
26 SWG Enamelled £1.14
28 SWG Enamelled £1.22
30 SWG Enamelled £1.24
32 SWG Enamelled £1.25
34 SWG Enamelled £1.27
36 SWG Enamelled £1.29
38 SWG Enamelled £1.55
40 SWG Enamelled £1.84

Tinned Copper Wire
Per 50g (2oz) Reel
500g reels available
14 SWG Tinned £0.97
16 SWG Tinned £0.97
18 SWG Tinned £0.97
20 SWG Tinned £1.01
22 SWG Tinned £1.01
24 SWG Tinned £1.03
26 SWG Tinned £1.03
24 SWG Tinned £1.03

Equipment Wire

Colours Black, Brown, Red, Orange, Yellow, Green, Blue, Purple, Grey & White
Per 100m Reel Solid
1/0.6mm £2.72
Stranded 7/0.2mm £2.53

Opto Electronics
LEDS
3mm Red Led £0.08
3mm Green Led £0.09
3mm Yelow Led £0.10
3mm Orange Led £0.10
5mm Red Led £0.08
5mm Green Led £0.08
5mm Yelow Led £0.08
5mm Orange Led £0.10
5mm Red Flashing £0.44
5mm Green Flashing £0.50
5mm Yellow Flashing £0.54
5mm Bi-Colour Led £0.33
5mm Tri-Colour Led £0.28

7 Segment Displays
0.56" Red C.Cathode £0.78
0.51" Red C.Anode £0.78
0.3" Red C.Cathode £0.78
0.3" Red C.Anode £0.78

Infra Red Devices
5mm IR Emitter £0.23
5mm IR Emitter £0.39
5mm Photo-Transistor £0.26
5mm Photo-Transistor £0.64
Photo Diode £0.75
4N25 Opto-Coupler £0.38
4N26 Opto-Coupler £0.36
4N32 Opto-Coupler £0.45
6N135 Opto-Coupler £1.30
6N136 Opto-Coupler £0.85
6N137 Opto-Coupler £0.90
6N138 Opto-Coupler £1.30
6N139 Opto-Coupler £0.90
CNY17-1 O-Coupler £0.47
CNY17-2 O-Coupler £0.38
CNY17-3 O-Coupler £0.47
IS-74 Opto-Coupler £0.45
ISD-74 Opto-Coupler £0.96
ISQ-74 Opto-Coupler £1.52
MOC3020 Opto-Triac £0.68
MOC3041 Opto-Triac £0.96
ORP12 LDR £0.89

Solar Cells
0.45V Screw Terminals
100mA 26 x 46mm £0.85
200mA 35 x 56mm £1.19
400mA 45 x 75mm £1.70
800mA 66 x 95mm £2.96
1000mA 76 x 95mm £3.52

Crystals
DT-38 Small Can
32.768KHz £0.42

HC-49/U Case
1.8432MHZ £1.49
2.0MHZ £1.49
2.4576MHz £1.24
3.2768MHz £0.96
3.579545MHz £0.81
3.6864MHz £0.81
4.0MHz £0.81
4.194304MHz £0.81
4.433619MHz £0.81
4.9152MHz £0.81
6.0MHz £0.81
6.144MHz £0.81
7.3728MHz £0.81
8.0MHz £0.81
8.867238MHz £0.81
10.0MHz £0.66
11.0MHz £0.81
11.0592MHz £0.81
12.0MHz £0.83
14.7456MHz £0.83
16.0MHz £0.83
20.0MHz £0.90

EVERDAY PRACTICAL ELECTRONICS PROJECTS
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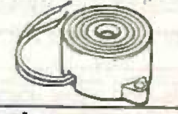
Pulsed Peizo Sounder
High output peizo sounder with flying leads, built in driver & pulsed circuit.
3-20Vdc, 18mA,
85dB (Min 9Vdc), 42mmØ.



£0.85 ea
£0.79 (25+)
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FUDGE

The mains supply in the UK, as everyone now knows (don't they?), is 230V a.c., changed some years ago to fall into line with the rest of Europe. Why? Who knows! However, if you measure it you will find that it is actually 240V plus or minus a few per cent, carefully controlled by the generating companies.

Most of the time it does not worry us editorially, we quote 230V because someone in authority somewhere says that is the standard; we know it's actually 240V but when you are part of Europe you get to a point where you let these things wash over you. This month, however, we have had to make it clear that 230V and 240V are actually the same thing!

In Alan Winstanley's excellent *Pipelines To Pylons* feature, Alan explains how the mains is derived and how we get to 240V (oops, sorry, 230V) from the 400kV that is originally transmitted. Of course, if we call the mains voltage 230V none of the explanations in Alan's article make any sense. So, please forgive us Mr. EU, we have had to tell the truth this month and let readers know that 230V is just a fudge – what we in the UK actually get is a very good, highly reliable, 240V a.c. 50Hz mains supply. But, of course, in future we will do as we are told and call it 230V, unless of course at some other time in the future we have to tell the truth to make the maths work.

Perhaps someone somewhere can give us a reason why we need to standardise with the rest of Europe and call 240V 230V. It's not as if we have actually changed anything except what we call it. We still exchange power with France across the English Channel and appliances still work happily in any country in Europe. And, as Alan said to us in an E-mail "either value is still enough to give you a frizzy hairdo" (or much worse).

DANGER

On a more serious note, Alan's article covers all the points readers have been querying over the past months about earthing of the supply, etc. Although I know the basics of supply from my training back in the distant past, the article has clarified a number of points for me and made me realise how complex power generation now is.

It also underlines some of the dangers, particularly of high voltage installations and I must admit that I did not realise how far power could jump at these voltages. Such installations are fenced off for good reason – the message is to stay well away. Don't ever think that you will be safe simply because you won't touch anything; at the high voltages concerned you don't need to touch anything to be killed.

Mike Kenward

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Starter Project

LOOP AERIAL SW RECEIVER

ROBERT PENFOLD

You don't have to surf-the-net to capture the world. Just build this low-budget receiver and be amazed!

THERE have been electronic projects for just about everything imaginable published in recent years, but a simple shortwave (SW) receiver is still one of the most interesting electronic devices that you can build.

Commercial shortwave sets are now highly sophisticated pieces of electronics, and it is probably not feasible for the home constructor to compete with these. However, at the other end of the scale it is possible to produce simple and inexpensive receivers that are fun to build and will pick up numerous stations from around the world.

IN RANGE

The design featured here is intended for broadcast band reception at frequencies from about 4·5MHz to 14MHz. This provides coverage of the popular 49, 41, 31, 25, and 22 metre bands. It does not require an elaborate aerial or an earth connection, and the aerial is a form of loop antenna.

The term "loop" is perhaps not entirely appropriate in this case, because the aerial is actually about 2·5m of 300 ohm impedance ribbon feeder. This form of loop antenna has the advantage of being easy to accommodate, and it seems to provide quite strong output signals.

The loop is, in fact, about two or three metres on one dimension and only about 10mm on the other, rather than a circle of around two metres in diameter, but this does not seem to have a drastic effect on performance. The output of the set is adequate to drive either a crystal earphone or a pair of medium impedance headphones.

This is a very simple design using just three transistors. There are no unusual coils to wind or buy because the loop aerial also acts as the tuning coil, so it is very easy to build.

TUNED CIRCUIT

The block diagram of Fig.1 shows the simple arrangement used in this SW Receiver. Conventionally, the aerial is a long piece of wire which has one end connected to the receiver and the other end left unconnected. The aerial provides signals over a wide range of frequencies and a filter must remove all except those signals that are close to the required reception frequency.

A sophisticated receiver has complex circuits to provide this filtering, but a simple receiver such as the one featured here has to rely on one simple filter. This is invariably a parallel tuned circuit, which is merely a capacitor connected in parallel with an inductor.

This very simple form of receiver has two main shortcomings, which are a lack of sensitivity and inadequate selectivity. A receiver's selectivity is its ability (or lack of it) to pick out just one transmission from several stations on similar frequencies. Without some help a single tuned circuit does not provide adequate selectivity.

POSITIVE FEEDBACK

This help is in the form of positive feedback from the output of the amplifier to the tuned circuit at the input. As one would expect, this recycling of some of the signal provides an effective boost in gain, and improved sensitivity.

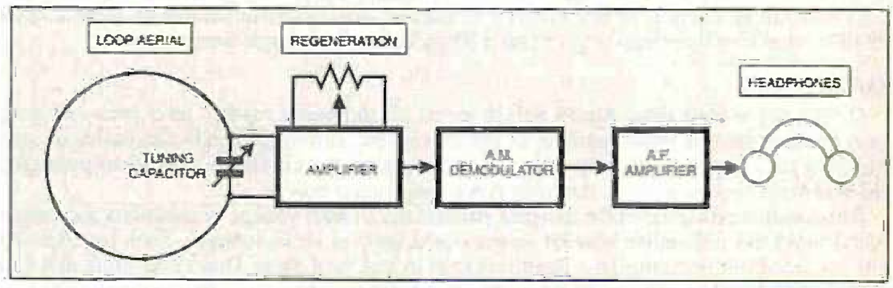


Fig.1. Block diagram for the simple Loop Aerial SW Receiver.

At a certain frequency, called the "resonant frequency", this type of circuit has infinite impedance. Away from the resonant frequency the impedance falls away rapidly to a low level. In effect, signals at or close to the resonant frequency are allowed to pass through to the subsequent stage while signals at other frequencies are short-circuited to earth.

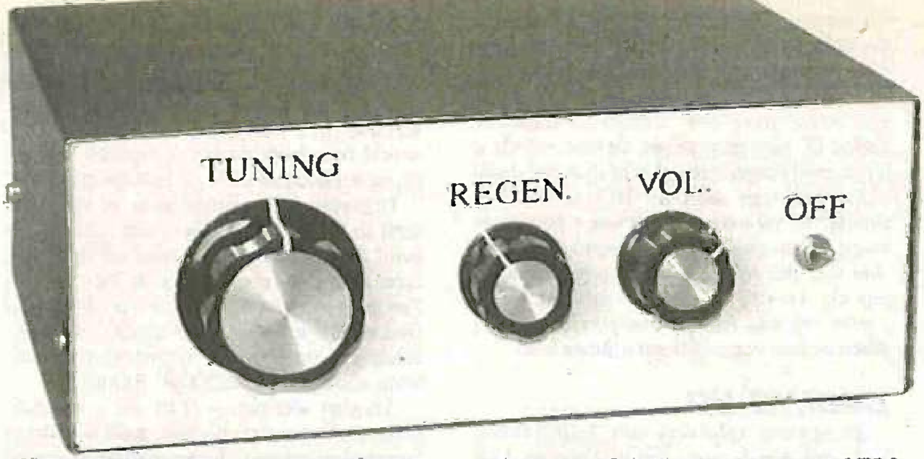
In this design the aerial and the inductor in the tuned circuit are one and the same. The aerial is a large single-turn inductor, and the size of the aerial determines its inductance. The capacitor in the tuned circuit is a variable type, and this permits the reception frequency to be varied over a wide frequency range. The aerial only operates efficiently at its resonant frequency and at nearby frequencies, and this gives much the same result as using a separate long-wire aerial and tuned circuit.

The output from the aerial feeds a two-stage amplifier that has a buffer stage to provide a high input impedance. This is essential, as loading on the tuned circuit would otherwise reduce its efficiency to the point where it would not give adequate bandpass filtering. The second stage of the amplifier provides a substantial amount of voltage amplification.

Less obviously, it also provides a great improvement in selectivity. This is due to the fact that there is more feedback at the centre of the passband than there is away from resonance where the receiver operates less efficiently. This feedback, or "regeneration" as it is normally called in this context, therefore provides a much higher boost in sensitivity at the centre of the passband, narrowing the passband in the process.

There is a definite limit to the amount of feedback that can be used, and exceeding this limit results in the circuit breaking into oscillation. Optimum results are obtained with the regeneration control set just below the point at which oscillation occurs.

The output from the amplifier is fed to a conventional a.m. demodulator that recovers the audio signal from the received r.f. (radio frequency) carrier wave. Even on strong signals the output level from the demodulator will be quite low, and an audio amplifier is therefore used to boost this signal to a more usable level. Good volume is obtained from a crystal earphone or medium impedance headphones.



COMPONENTS

Resistors

R1	1k	See SHOP TALK page
R2	560Ω	
R3	470k	
R4	5k6	
R5	1M	
R6	2k2	

All 0·25W 5% carbon film

Potentiometers

VR1	1k rotary carbon, lin
VR2	4k7 rotary carbon, log

Capacitors

C1, C3	1n Mylar (2 off)
C2, C4	10n ceramic (2 off)
C5	1μ radial elect. 50V
C6, C7	100μ radial elect. 10V (2 off)
VC1	365p variable (see Shoptalk)
Cx	twisted lead, see text

Semiconductors

D1	OA91 germanium signal diode
TR1	BF244A *n*-channel j.f.e.t.
TR2	BC559 *pnp* silicon transistor
TR3	BC549 *npn* silicon transistor

Miscellaneous

S1	s.p.s.t. min toggle switch
B1	9V (PP3) battery, see text
SK1, SK2	2mm or 4mm socket (2 off)
SK3	3·5mm jack socket (see text)
PL1, PL2	2mm or 4mm plug, to match sockets SK1, SK2 (2 off)
L1	300 ohm ribbon feeder (approx 2·5m) for aerial loop (see text)

Metal instrument case, see text; 0·1 inch pitch stripboard, size 31 holes x 20 copper strips; control knob (3 off); crystal earphone or headphones (see text); battery connector; wire; solder pins; solder, etc.

Approx. Cost Guidance Only £11 excl. batt. & variable cap

CIRCUIT OPERATION

The complete circuit diagram for the Loop Aerial SW Receiver is shown in Fig.2. L1 is the loop aerial itself, and VC1 is the tuning capacitor. TR1 is a junction gate field effect transistor (j.f.e.t.) which is used here in the common source mode. Unlike an ordinary bipolar transistor, a j.f.e.t. requires a reverse bias in order to provide linear amplification.

Resistor R2 results in the source(s) of TR1 being taken to about 0·5 volts or so positive, while aerial coil L1 biases the gate (g) input to the 0V rail and provides the small reverse bias. Bypass capacitor C2 removes the negative feedback that would otherwise be introduced by R2.

Transistor TR1 provides a certain amount of voltage gain, but its main purpose is to provide a high load impedance for the tuned circuit. A high input impedance is a natural characteristic of a j.f.e.t. and other field effect devices.

GAIN

Most of the voltage gain is provided by *pnp* transistor TR2, which operates as a simple common emitter amplifier. Regeneration control VR1 enables a controlled amount of feedback to be provided over the entire amplifier via capacitor Cx. The value of Cx is extremely low, and it is not actually a "proper" capacitor. It is simply two short pieces of insulated wire twisted together.

Capacitor C3 couples the output of TR2 to a conventional diode demodulator, which has D1 and C4 to respectively provide the rectification and the smoothing. The amplitude of the carrier wave is proportional to the audio signal voltage.

On the face of it, simply using some low-pass filtering will give an output signal that is equal to the average signal level, and therefore provides the required audio output signal. In practice this would not happen because the carrier wave is an a.c. signal, and the positive half cycles balance the negative half cycles to give an average output voltage of zero. Removing one set of half cycles eliminates this balancing, and gives the required demodulation.

Potentiometer VR2 is the "load resistor" for the demodulator and is also the volume control. From here the signal is coupled, via C5, to a common emitter amplifier based on transistor TR3. The output power available from TR3 is not very great, but it is sufficient to drive a crystal earphone. It will also drive medium impedance headphones if the phones are connected in series. Other types of headphone and earphone are unlikely to provide acceptable results.

The current consumption of the circuit is around 12mA or so. A good quality PP3 size battery is adequate to power the set, but if it is likely to receive a great deal of use it would be more economic to use six AA-size cells in a holder.

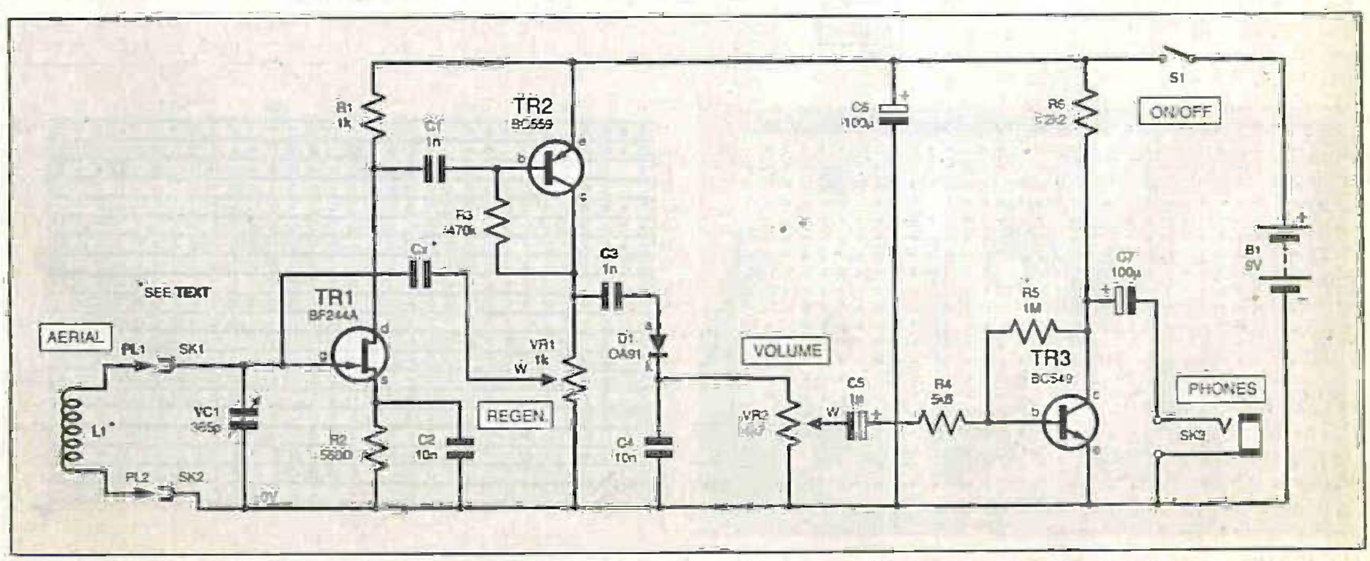


Fig.2. Complete circuit diagram for the Loop Aerial SW Receiver. The loop aerial is a single "loop" of about 2·5m of 300 ohm feeder cable and full details can be found in Fig.3

CONSTRUCTION

This simple receiver circuit is built up on stripboard and the component layout and wiring, together with the underside view showing breaks in the copper tracks, are shown in Fig.4. The board measures 31 holes by 20 copper strips, but it is not sold in this size.

Commence construction by cutting a larger piece of board to size using a hacksaw, cutting along the rows of holes. This produces some rough edges but they are easily filed to a neat finish.

Next the two 3mm diameter mounting holes are drilled in the board and the three breaks in the copper strips are made. A special tool for cutting copper strips is available, but a handheld twist drill of about 5mm in diameter does the job quite well. Whatever tool you use, make sure that the strips are broken across their full width.

The board is now ready for the components to be fitted. Fit the resistors and capacitors first, making sure that the three electrolytic capacitors have the correct orientation. Use single-sided solder pins at the points where connections to the sockets, controls, and battery clip will be made.

Finally, fit the semiconductors, making sure they have the correct orientation. Diode D1 is a germanium device, which is more easily damaged by heat than the usual silicon devices such as TR1 to TR3. It should not be necessary to use a heatshunt when connecting this component, but make sure that the soldered joints are completed quickly. Having connected one lead, allow a few seconds for the component to cool down before connecting the other lead.

CASING-UP

Shortwave receivers are traditionally built into metal cases, but this design does not rely on the case to carry any connections and it can be housed in a plastic case if preferred. It is important to keep the wiring reasonably short, and it is probably best not to depart too far from the general layout used for the prototype (see photographs).

VARIABLES

It is advisable to use a large control knob on tuning control VC1 because this makes accurate tuning easier, but it will necessitate the use of a fairly tall case. Ideally, VC1 would be a high quality air-spaced variable capacitor such as a 365pF Jackson type "O".

Unfortunately, components of this type tend to be very expensive, and some of the solid dielectric types (as used on the prototype) are not much better in this respect. Probably the best low-cost option, if you can find one, is to use a good quality "surplus" air-spaced component. Any maximum value from about 250pF to 500pF will do.

Another alternative is to use a low cost solid-dielectric component, such as used in "transistor radios". These usually have two "a.m." sections, which are used in parallel (i.e. wire the two non-earth terminals together). Any low value "f.m." sections can be wired in parallel with the "a.m." sections or just left unused.

Some variable capacitors require the usual 10mm diameter mounting hole, but

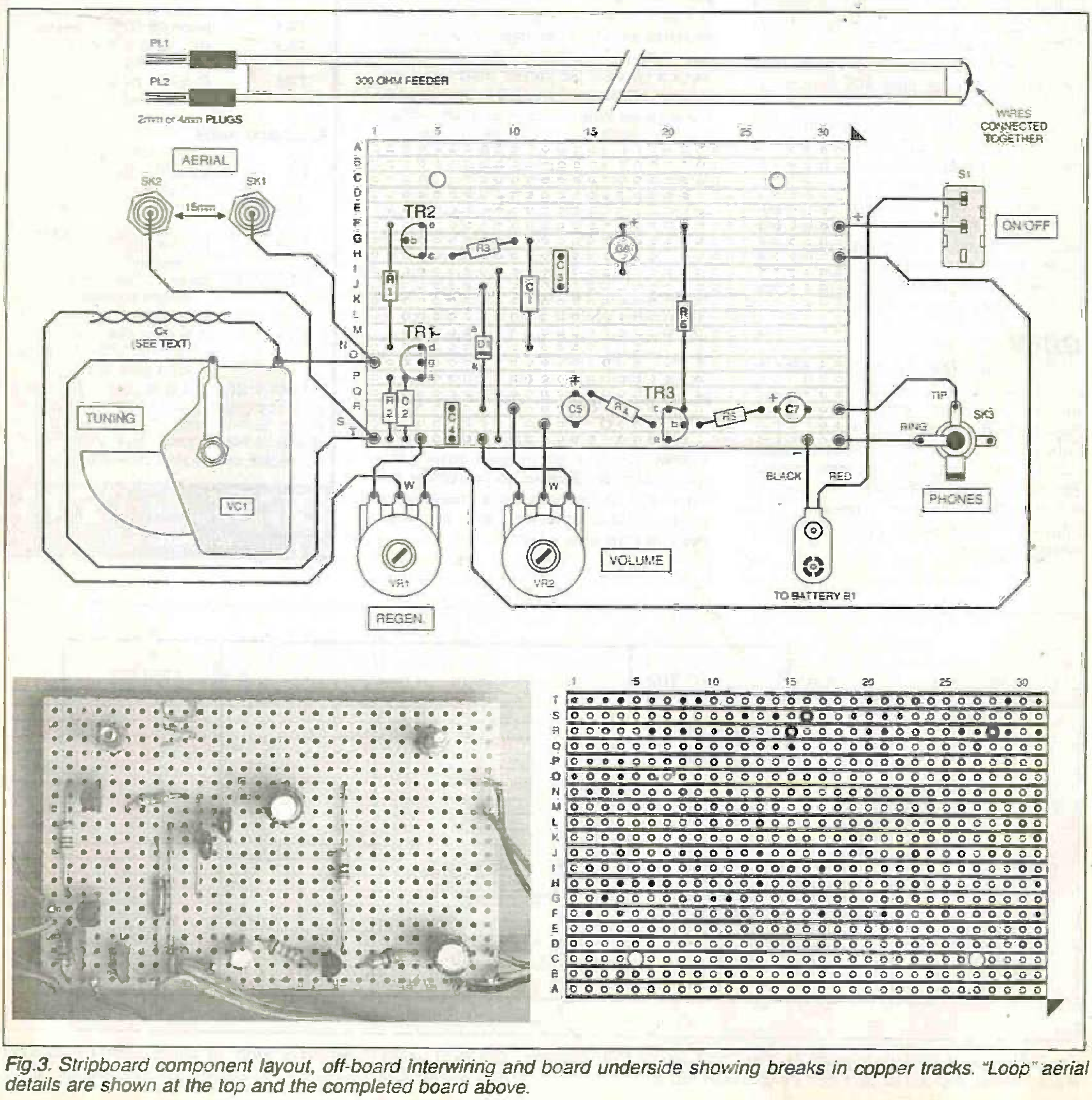


Fig.3. Stripboard component layout, off-board interwiring and board underside showing breaks in copper tracks. "Loop" aerial details are shown at the top and the completed board above.

most are fixed to the front panel using two or three short screws that fit into threaded holes in their front plates. With this second type it is often easier to glue them in place using a good quality adhesive such as an epoxy type. If longer fixing screws are used, make sure they do not penetrate so far into the front plate that they damage or foul the vanes.

SOCKETS

Sockets SK1 and SK2 are mounted on the rear panel of the case, and they must be quite close together (a gap of 15mm is about right). If the set will be used with a crystal earphone SK3 must be a 3·5mm jack socket, which matches the plugs normally fitted to this type of earphone. The switch contact fitted to open style sockets of this type is not required in this case, and one tag is therefore left unused.

A 3·5mm stereo socket is required for medium impedance headphones of the type sold as replacements for use with "Walkman" style units. These sockets are available in several styles, and the retailer's literature should include connection information. The 'phones are used in series, which means that the common earth tag is left unconnected and the board is wired to the other two tags.

The circuit board is mounted on the base panel of the case using metric M2·5 screws. Include spacers about 6mm long between the board and the case.

The wiring is perfectly straightforward, see Fig.3, apart from capacitor Cx. Ideally this would be made from two pieces of single-strand insulated wire, but ordinary multi-core connecting wire will do. Simply twist the ends of the wires together so that they are entwined over a length of about 50mm. If you use multi-core wire it is advisable to wrap some tape around the wires to ensure that everything stays in place.

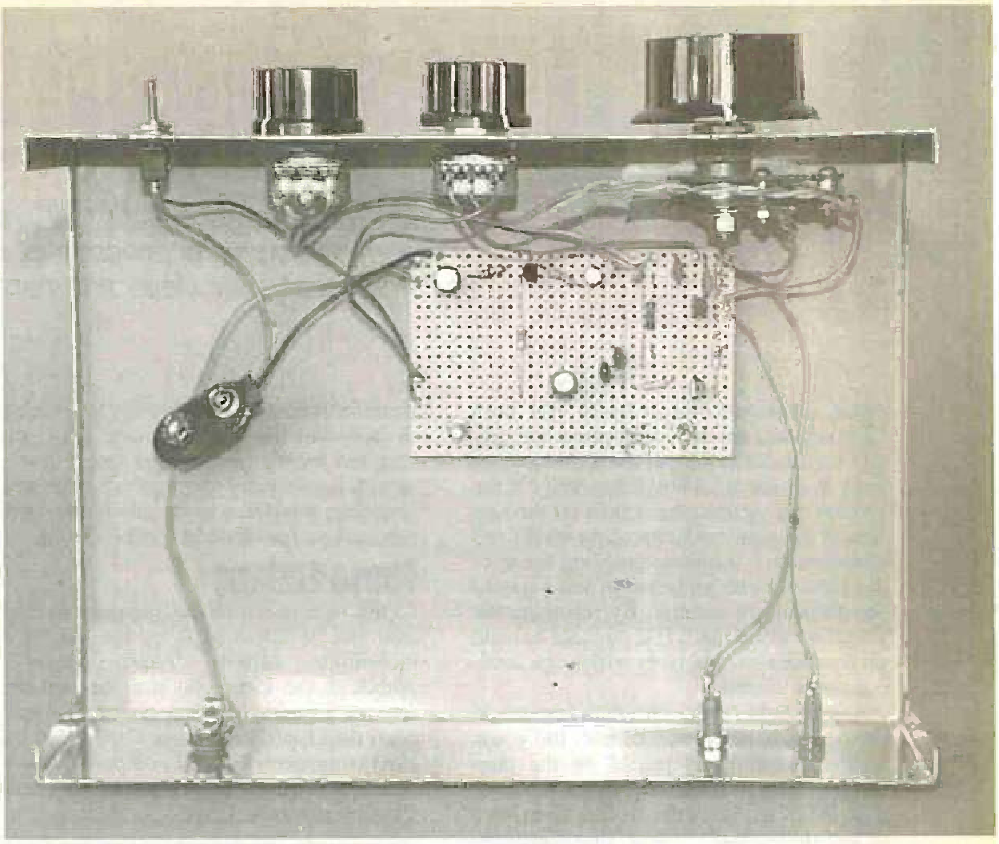
AERIAL

Details of the aerial are also provided in Fig.3. A 2·5 metre length of 300 ohm ribbon feeder provides the approximate frequency coverage specified previously. Alternatively, you can use two aerials of different lengths to give the receiver two bands, and broaden its frequency coverage.

Band changing is then achieved by unplugging one aerial and connecting the other instead. This is a rather crude way of doing things, but is essentially the same as the plug-in coil method that has traditionally been used for simple shortwave receivers.

Realistically, the receiver is unlikely to perform well at very high frequencies, and there are relatively few a.m. broadcast stations to be found on the low frequency bands. One aerial about 1·5 metres long and one about 3·5 metres in length will provide coverage of the broadcast bands from 60 metres to 13 metres. Using 300 ohm ribbon feeder is not particularly expensive, so you might like to experiment with aerials of various lengths to see what, if anything, can be received at higher and lower frequencies.

It is very easy to make the aerial. Start by removing about 25mm of the plastic "ribbon" at each end of the cable using a sharp modelling knife, taking due care not to cut either yourself of the wires in the cable.



Suggested component layout and wiring inside the prototype metal case. The aerial and headphone sockets are mounted on the rear panel. Space must be allowed for a 6-cell AA-size battery pack if the receiver is to be used regularly.

Using ordinary wire strippers remove a few millimetres of insulation from each end of both wires, and "tin" the exposed ends with solder. At one end of the cable solder the two wires together to close the loop. At the other end of the cable fit two 2mm or 4mm plugs to match the type of socket used for SK1 and SK2.

IN USE

After a final check of the wiring it is time to connecting everything together and test the receiver. The aerial will not work well if it is left in a crumpled heap, but on the other hand it does not have to be kept perfectly straight. The prototype worked well with the aerial at about 30 degrees to the horizontal with the far end fixed to a cupboard with a piece of Bostik Blu-Tack.

With Regeneration control VR1 fully backed-off in a counter clockwise direction and Volume control VR2 well advanced it will probably be possible to receive a few stations, but not very well. Accurate adjustment of the Regeneration control is crucial if good results are to be obtained. Advancing this control should give much improved results with better sensitivity and selectivity.

However, as explained previously, advancing the Regeneration control too far results in the set breaking into oscillation. This will be heard as increased noise in the headphones, and a tone of varying pitch as the set is tuned across a station.

Optimum results are obtained with the Regeneration control backed off just far enough to bring the set out of oscillation. Any large changes in the setting of tuning control VC1 will probably require some readjustment of the Regeneration control in order to maintain good results.

RECEPTION

The main shortwave broadcast bands will provide a range of interesting stations at practically any time of the day. Bear in mind though, that reception is at the mercy of the upper atmosphere, and is affected by factors such as the weather, sunspot activity, and the time of year. At times reception may be exceptionally good, while at other times the bands might provide few signals at all.

Normally, in the UK, it will be possible to receive stations from all over Europe, plus perhaps a few stations in North Africa, the Middle East, etc. When conditions are favourable it is possible to receive stations from much further afield.

You do not have to be a linguist to follow some of the programmes, as many countries put out programmes in English. For example, one of the first transmissions heard when testing the prototype was an English language broadcast from Turkey. □

New Technology Update

Ian Poole investigates the problems facing the photolithography process of producing today's i.c.s and finds that new ideas and techniques need to be explored.

THE semiconductor industry has been predicting the demise of photolithography for almost as long as the technique has been in existence. Photolithography is the process that defines the details on the surface of the semiconductor using masks and photoresistive solutions enabling areas of the surface to be protected or left exposed for diffusion or etching. By repeating the processes many times it is possible to build up the different structures within the semiconductor circuit.

As the sizes of the different features in the i.c.s have been reduced over the years, so the requirements placed on the photolithography process have increased. Over a period of ten years the feature sizes have fallen dramatically. Now manufacturers have to support sub-micron sizes for all their new products. Sizes of 0·1 microns are being talked about for production although the procedures for achieving this are not easily available at the moment.

Not only does this push the manufacturing tolerances right to the limit, but it also means that the photolithographic process requires further development. To achieve this the process needs to be optimised to enable it to cope with the minute sizes that are required, and a greater problem is that the sizes are now below the wavelength of light itself and this places a physical limit on the ultimate performance of the technique.

Problems Unmasked

Despite these problems the sizes have continued to shrink. New methods of overcoming problems have now been found although a few years ago they appeared to be insurmountable. This has enabled today's i.c.s to become a reality. Further developments are now required if the sizes are to fall even further.

Whilst photolithography is a technology that has been used for very many years, it is one that is likely to remain for some time yet. With the huge investments required to enable new technologies to be introduced, and the enormously competitive nature of the industry, it is essential that manufacturers quickly see a return for their money.

This has given the impression that companies may appear to be very conservative when it comes to revolutionary new technologies that require completely new lines to be installed. As a result methods of significantly improving techniques based on lithography have continued to surface.

As feature sizes started to shrink towards the limits of conventional light, ultra-violet with its shorter wavelengths was used. This approach is now used in the production of many of the i.c.s being manufactured today. However, to be able to achieve the feature sizes that are required for the new designs being developed it is necessary to progress further and introduce new ideas to be able to meet the required performance in manufacturing.

Phase Shifting

One way in which the required definition can be obtained is by the use of a technique called "phase-shifting". Although the technique has been known for many years it is only now that it has been developed to a stage that it can be used commercially by a company named Numerical Technologies based in Santa Clara, California, USA.

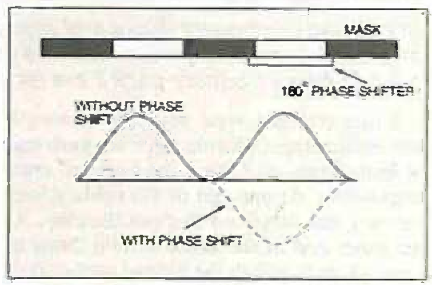


Fig.1. Phase shifting technique.

The new patented approach basically uses a software package to generate masks to phase-modulate the light in a two pass process. As shown in Fig. 1, phase shifting selectively modulates the phase of light as it passes through the photomask. The high-quality image produced by this process greatly improves resolution and depth of focus so that the tiny features in designs can "print" accurately on a wafer.

One of the advantages of the new system is that it is compatible with existing industry standards. The software package takes inputs from industry standard i.c. layout files and then automatically configures them for phase-shifting photomasks. The phase-shifting masks will print polygate lengths as small as 0·09 microns, about half the length in today's leading-edge i.c.s, using the standard 248nm wavelength light.

The new system is being well received in the market. Early this year Motorola indicated they are to deploy the system in their production to enable them to manufacture PowerPC processors with increased speed for communication applications. This was undertaken as a joint venture between NumeriTech and Motorola and will allow them to shrink the gate lengths to 0·10 micron with the existing manufacturing processes.

Optical Correction

In addition to using a phase-shifting mask it is possible to further enhance the images by using a process named optical proximity correction (OPC). The process, it is claimed, resolves the distortion that results from a variety of factors including optical proximity as well as diffusion and the effects associated with etching and the resist itself.

It is found that as the shapes progress from the original design through the reduction to the final mask and then into the manufacture of the silicon, they become less well defined. This is witnessed by effects such as the rounding of corners or the shortening of lines.

There are a variety of techniques that are used to achieve improvements. The outside corners can be enhanced by the addition of small squares. The inside corners can be trimmed so that excessive rounding or line shortening is reduced or prevented.

The corrections also make the final wafer image match the designer's layout more closely, preventing short and open circuits. It also means that the final chip more accurately matches the original simulations.

Alternatives

As might be expected phase-shifting and optical correction are not the only techniques that are being developed. Other techniques have their place as well.

One, known as electron beam lithography, uses the same basic techniques as photolithography, but instead of using light to expose the photo-resist, it utilises an electron beam. Naturally a different photoresist must be used – one that is sensitive to an electron beam.

As these beams have a much shorter wavelength it is possible to achieve higher degrees of definition. The system effectively writes directly onto the wafer, and the performance is highly dependent upon the beam forming optics.

One of the main drawbacks of this system is that because it uses an electron beam, rather than light, this process must take place in an evacuated chamber. This makes throughput much lower and this is a critical aspect of any semiconductor manufacturing process these days.

Whatever techniques are used, it can be seen that there are still plenty of options to reduce the feature sizes within integrated circuits still further. However, a point will eventually come when it is not possible to use photolithographical methods. Even now research is being invested in possible methods of overcoming these problems, and it will be interesting to see what arises in the coming years.

News . . .

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

PHONE-LESS INTERACTIVE TV

Irish viewers will soon be able to participate in TV programs while at home, and without a phone-link. Barry Fox reports.

SOUTHERN Ireland will pioneer the use of a new digital TV system that lets viewers interact with the broadcaster, without needing a phone, cellphone or cable connection. The service will be launched next year by Digico, a private company now being spun off from state broadcaster RTE, Radio Telefis Eireann. Digico will offer teleshopping and let millions of viewers vote on quiz questions or political issues without overloading the country's phone system.

Digico will compete head on with Ireland's Cablelink cable system, bought recently by NTL, and with Rupert Murdoch's Sky satellite service which already transmits digital services into Eire but needs a phone line for interaction.

WINDS in the Rigging

RTE is developing the technology, called WINDS or Wireless Interactive Network for Digital Services, with EU funds. Digital terrestrial TV signals are broadcast in the usual way, using Europe's Digital Video Broadcasting standard. But the home receiver also works as a low power transmitter, sending data signals back to Digico's masts from an existing UHF rooftop or set-top aerial.

The Irish government has allocated 1MHz slices of the UHF spectrum to carry the return path signals. Each slice is split into 1000 very narrow channels and the receiver can hop between channels until it finds one in its area that is clear.

WINDS borrows from GSM digital cellphone technology to keep transmission powers at a minimum, and so let the system re-use the same frequencies in closely neighbouring areas. The receiver transmits and receives test signals, and automatically optimises its transmission strength. Urban areas will have more 1MHz slices and use relay stations to let the receivers transmit at very low power, in very small cell zones.

Wide Range Coverage

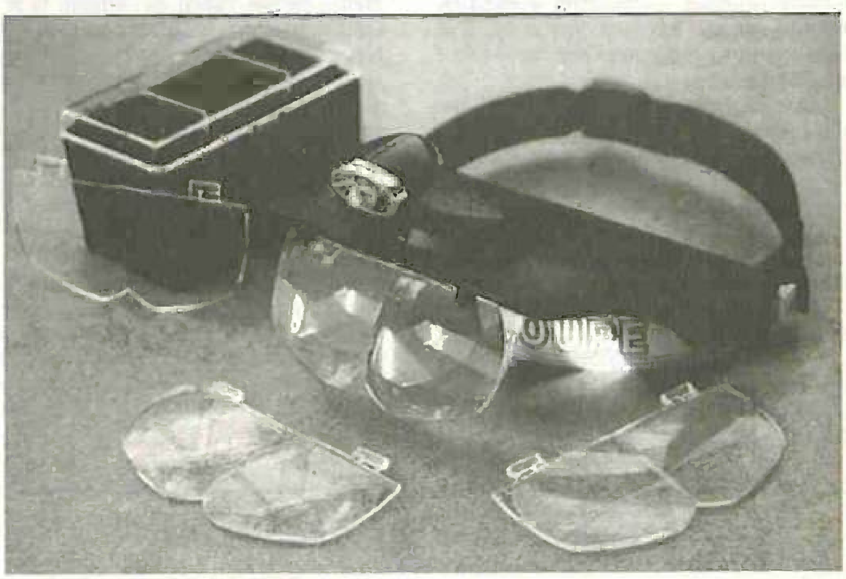
Because Ireland has spare UHF frequencies and is a long way from other countries' transmitters, 30 masts will be able to transmit digital TV programmes at high power and reach 98 per cent of homes. Up to 20,000 receivers can transmit back to one broadcast mast at the same time.

The return path bit rate changes depending on what data has to be transmitted, and the data is packaged like a TC/IP Internet signal to make it error-resistant. Recent tests with CCETT, the Centre Commun d'Etudes de Telediffusion et Telecommunications, at Rennes in France, have shown that a home receiver can return a data signal 30 kilometres with transmission powers of well under the one watt licensed by the Irish government.

Although Digico will only have airspace for six broadcast channels, carrying less than 40 programmes, the company plans to launch in September 2000 with a receiver that houses a 25 gigabyte hard disk. This will let the viewer store up to 10 movies for later viewing.

Says Peter Branagan, Director of Digital Planning at RTE, "Interactivity is the new paradigm. WINDS can provide a wireless return path that is free to use and adds less than 30 Euros to the cost of the receiver. And viewers will be able to interact even when their teenagers are on the phone"

HEADBAND MAGNIFIER



APART from a good selection of test equipment and a wealth of enthusiasm, the intrepid electronics enthusiast needs one other vital workshop aid, good eyesight. Sadly, good vision is not necessarily an attribute always readily available and the miniature size of so many of today's components can make a fair number of enthusiasts feel inadequately equipped! Where funds permit, some enthusiasts faced with this problem emulate professional workshop engineers and have a large bench-mounted angle-poise magnifier complete with its own light source. Such things are not cheap, however.

Readers who would like to inexpensively improve their ability to view fine detail might care to consider Sheshto's new versatile Headband Magnifier Kit. It really is an astonishingly simple yet ingenious approach to the problem. It comprises an adjustable headband, four interchangeable pairs of lenses, and a spotlight!

Shesto say that it provides the complete answer for achieving the best results when doing close-up work and offers the ideal way to work on any craft, hobby or DIY project, leaving your hands free to get on with the job. We salute our irons to that belief!

The four precision-ground optical lenses are designed to cover all focal lengths needed from semi-close-up to very close-up and are easily changed over with the simple clip-in slots on the headband. The lenses can be pushed up out of the line of vision when not required. The magnifications and working distances are: 1·2× 520-620mm (20-24in), 1·8× 230-320mm (9-12in), 2·5× (150-25mm (5-10in), 3·5× 80-120mm (3-5in).

As can be seen in the photo, the battery operated adjustable spotlight is very neatly incorporated on the top of the headband. It can be switched on for those extra delicate close-up jobs. Those of us whose eyesight is no longer 20-20 will know that just increasing the illumination on a subject can on its own help the eyes to focus better.

The price of £34.95 plus £3.00 p&p is a very small outlay for something that could well enhance your ability to take a closer view of the world, and especially your hobby.

Shesto state that for 90 years they have specialised in tools, supplies and equipment for technicians and craftsmen. They say that their Essential Tool and Reference Guide is packed with useful information and features over 2000 hard to find tools and references; its price £5.

For more information, contact Shesto Ltd., Dept EPE, Unit 2, Sapcote Trading Centre, 374 High Road, Willesden, London NW10 2DH. Tel: 0181 451 6188. Fax: 0181 451 5450. (No web site or E-mail quoted.)

HEAR, HEAR!

Barry Fox, with ear to the ground, hears whispers about a new amplifying system.

TECHNOLOGY is now available to help judges hear people who are nervous in court, and let the world hear MPs who mumble in Parliament. After developing a system to help audiences hear what was going on in a local children's theatre, Philips of the Netherlands is using its Profecta Acoustic Feedback Suppressor to let a public address system sound four times louder than is usually possible without "howlround" feedback.

Audio systems howl because the microphones pick up stray sound from the loudspeakers, and feed it to the amplifier and back to the loudspeakers. So the sound goes round in circles, getting louder all the time and finally resonating like an organ pipe at whatever frequency the system is most efficient at reproducing.

Early feedback suppressors worked by filtering out the resonant frequency. This kills the howl but makes the reproduced sound very unnatural.

More modern systems de-correlate the input and output sound by shifting the frequency of all the sound from the speakers by around 5Hz. So the microphones do not reinforce the same frequencies in a vicious circle. This limits feedback but adds a myriad of faint echoes to the sound, all with slightly different pitch, like an acoustic hall of mirrors. So a single voice starts to sound like a choir.

If a de-correlation system adds more than 3dB gain over the level at which feedback would normally start, the echo effect becomes offensive and makes speech unintelligible. As the human ear needs an increase of 10dB to register a subjective doubling of loudness, a 3dB improvement is hardly noticeable.

Philips Communication and Security Systems division has now programmed digital signal processing chips to shift the frequency of the sound while predicting what the added echoes will be like. Profecta AFS then generates signals which exactly match the predicted echoes in pitch and level, and subtracts them from the microphone input. So the shifted sounds coming from the speakers never reach the amplifier.

This lets the amplifier add around 20dB more gain than would normally cause feedback howl, and without a choir effect.

Philips first tried Profecta AFS at a children's theatre called de Schalm near its laboratory at Eindhoven in the Netherlands. The theatre had to sling the stage microphones high to stop the children hitting their heads when they skipped and jumped around the stage. The high microphones were then unable to pick up the performers' voices without feedback. Since AFS was installed the audience has for the first time been able to hear what is being said and sung.

Philips then packaged AFS in a rack mount for sale to PA firms, at around £2500. Units have already been installed in the Dutch and Spanish Parliaments, and were recently demonstrated to the UK's Houses of Parliament and Royal Courts of Justice.

DIGITAL TV COLLEGE

WE were extremely interested to learn that the College of North West London has started courses on servicing digital TV equipment. Their press release comments that bridging the gap between old and new technology is the challenge that faces all training establishments. Whilst digital TV was launched last year to a mixed reaction, it is now taking off in a big way and the College says that it is streets ahead of the field in offering the latest state-of-the-art servicing facilities.

The College has invested £20,000 on installing 20 digital TV workstations, fully equipped with digital storage oscilloscopes, spectrum analysers and logic probes, to allow students to test and fault-find using digital TV receivers, both satellite and terrestrial. It has a selection of digital set-top decoders from various major manufacturers, including Philips, Nokia and Pace, and trains students to service all of them.

It is still the only FE college in the UK to provide digital TV training courses, because the technology is so new. This means that it attracts lecturers and engineers from employers all over Britain, including the BBC, IBM, the Comet chain and other FE colleges.

Deputy Head of Department John Raynard says that "Our intention is to bridge the gap between analogue/digital technology and microprocessor-based systems. We offer one-day courses for the servicing industry, either on college premises or on site. They can be either off-the-shelf or customised for service engineers who need a specific updating or upgrading programme."

The College offers three current one-day courses, held approximately once a month, leading to college certificates, which are: Digital TV Broadcasting and Reception, Servicing Digital TV Decoders, Microprocessors for TV Service Engineers.

Additionally, the College has received accreditation to offer the City & Guilds course on Digital TV at Level 3 of the Electronic Servicing 2254 from September '99. The College will set the exams, but students who pass will get a C&G certificate – the first college-devised unit of this type in the UK.

For further information contact Kay Shelley, College of North West London, Dudden Hill Lane, London NW10 2XD. Tel: 0181 208 5196. Fax: 0181 208 5151. Web: www.cnwl.ac.uk. (Say that *EPE* has told you about the College.)

GREENWELD RE-LIVES!

IT'S always heart-warming to be able to report good news about a situation that had previously seemed depressing. In our July issue we reported that Greenweld Electronics had ceased trading, but that a purchaser for the business was being sought. We are delighted to report that a purchaser has indeed been found and that the name Greenweld will soon reappear.

The name and assets of this renowned electrical and mechanical surplus company have just been bought by a new company run by two brothers with a science background.

By the time you read this, the company will have started operations from their new base in Essex and a catalogue will be mailed out at the beginning of September to all those on the database. The new company will continue to supply the same range of goods which it hopes to supplement with additional items of a general scientific and technical nature.

We have received this information just as we go to press with this issue and do not yet know details of what is happening with the previous Greenweld site at Southampton, nor do we know details of the new location in Essex. We hope to publish information on both matters in the next issue. Hopefully we shall also be able to tell you a bit more about the company which has resurrected Greenweld.

All too often over the years we have seen the demise of enterprising electronics businesses. It is really good to know that Greenweld has been saved and wish the venture every success..

Until we can provide more details, you can contact Greenweld as follows: E-mail: greenweld@aol.com. Fax: 01992 613020. Web: www.greenweld.co.uk. (Phones had not been installed at the time of writing.)

Hi-Fi Show '99

THE Hi-Fi Show, Europe's biggest hi-fi and home entertainment exhibition, will be staged at the newly refurbished Novotel Hotel, Hammersmith, London on 23-26 September '99. This huge show has outgrown its previous venue and the city-centre move will provide further expansion with more rooms, exhibitors and products to be launched.

The Hi-Fi Show '99 will be a pivotal event in the history of home entertainment. As the final show of the Millennium, it will be a celebration of familiar and traditional technologies and a reception for the formats that will shape our listening and viewing pleasure in the future. Over 200 of the world's leading hi-fi companies will demonstrate and launch their latest equipment.

Exclusively at the show, the BBC will provide hands-on demonstrations of the new Digital Radio Broadcast (DAB). This will take over from FM, giving improved quality and reception.

Tickets for the Hi-Fi Show '99 are available from the ticket hot-line 0181 774 0790. Adult admission is £4 in advance, £5 on the day. Under 14's go free. The show is open 10am to 6pm.

NET MUSIC PROTECTION

Barry Fox reports on the initiative for tighter copyright protection for Net-sourced music and games.

THE music and electronic industries' Secure Digital Music Initiative has now agreed the framework for copyright control on portable players that can download music from the Internet (see SDMI's website www.sdmi.org). Leonardo Chiariglione, the SDMI's Executive Director, is not bothered that some companies, including Thomson and subsidiary RCA, have jumped the gun by launching proprietary systems.

"They are all downstairs helping to write the standard" he said during a 3-day meeting of 200 representatives from 150 member companies in London. "Sometimes different people inside the same company have different strategies. Niche products will not succeed because consumers need the assurance that they are not tied to a proprietary source of music. People must be able to get what they want from anywhere that has it".

The SDMI was formed last December when the music industry failed to block the sale of Diamond Multimedia's Rio solid state portable. Chiariglione, who heads the TV Technologies division at Telecom Italia, has for the past 11 years chaired the committees which set the MPEG digital video compression standards.

SDMI builds on technology used in the MPEG-2 standard for digital video disc and TV, and MPEG-4 for video on the Internet. The bitstream carries keys which can be used, with extra keys in the player, to unlock encrypted content. When an SDMI-compliant PC downloads music from the Internet, or copies it from a CD, it will encrypt the music so that it can only be used in one portable player which is electronically locked to the PC.

By 31 March 2000 the SDMI will extend this protection framework to cover the entire delivery chain, whether the Internet or broadcast airwaves.

Says Chiariglione "SDMI will then protect movies, games and TV. It's a fundamental step which lets the seller and buyer agree on a contract. This opens the way for an infinite number of new business models".

RAE COURSE

THE Hilderstone Radio Amateurs' Examination Course commences on 23 Sept '99 in the Sandwich area of East Kent (exact location not yet advised). Tutor Ken Smith G3JIX advises that this is the usual course for the Amateur Radio Licence Exam, but also much of the content covers a very good grounding for general electronics interests (including some of the history as well).

This course has been run at intervals for many years, with eminent success. Ken says that we have exciting times ahead for Amateur Radio and that "wireless" methods are growing amazingly throughout the professional and commercial world. Furthermore, Amateur Radio continues to be central to a stimulating, fun-based and entertaining introduction to modern technolgy.

"It is", says Ken, "one of those pastimes that increases your circle of friendships greatly – and on a world-wide basis. All interested people, whatever their age etc., are most welcome to explore with us this remarkable technology with a very human face; and the Exam does not have to be sat, of course!"

For more information contact Ken Smith via G3JIX, or tel: 01304 813175, or via ken.smith@saqnet.co.uk.

LOW ENERGY FOOD

NO, we are not about to advocate yet another slimming diet, but to compliment Sainsbury's for the energy saving concepts being embodied into their new store at the Millennium site in London.

The refrigeration system, for example, will be partly cooled by the lower lying ground water that remains at a constant 10°C throughout the year. The heat output by this system will be used to heat the store. Earth banks around the building will help insulate against temperature changes, while the reinforced concrete walls act as a giant storage heater, absorbing heat in the day and releasing it at night. Wind turbines and solar cells generate power which is stored in batteries and used to light the building at night. There will also be free recharge points for customers' electrically powered cars. It all seems very forward looking.

The store will open in September.

CIRKIT JOINS DELTRON

IF you use coils in your electronics designs, the chances are that Cirkit Distribution will be one of the companies who come to mind when you are thinking about which supplier to use. You will probably use Cirkit for other electronic components as well. It will, therefore, be of interest to you to know that Circuit Distribution has been acquired by Deltron Electronics.

Cirkit has been trading since 1984 and has been part of the Bulgin Group since its creation. Deltron is a growing public company primarily focussed on distribution activities in the UK and abroad. The business of Cirkit will operate as part of the Roxburgh Electronics subsidiary of Deltron.

FASTER PHONE LINES

BETWEEN now and next spring, BT will be installing equipment that will transform ordinary phone lines into digital channels which operate up to ten times faster. Initially, 400 exchanges around the UK, covering nearly six million households and businesses, will be upgraded.

The ADSL (Asymmetric Digital Subscriber Line) technology can boost existing local copper networks by using sophisticated electronics at the exchange and in customers' premises, without digging up streets and pavements.

ADSL works by transmitting and receiving digital signals across the copper pair of wires connecting each customer to the exchange. It operates on a frequency band higher than that used by the voice line operating in the same copper pair, so that the two services do not interfere with each other.

At the customer's end the equipment consists of two principal items. A filter, or "splitter", provides separate physical sockets for the digital service and the voice service. A normal telephone plugs into the phone socket on the splitter. An ADSL modem plugs into the digital port on the splitter and is then plugged into appropriate digital consumer equipment, e.g. a PC or digital TV.

LISTEN TO THE ECLIPSE

By Barry Fox

The Rutherford Appleton Laboratory at Chilton in Oxfordshire has a plan to let people research the solar eclipse on August 11, without travelling to Cornwall, France, Germany or Romania. All they need is a simple Medium Wave radio to log the reception of distant stations.

Radio waves usually travel in straight lines, and cannot reach past the horizon. They also reflect off the upper (E and F) layers of the ionosphere, some 300km up, to "skip" long distances. But during the day, the lower (D) level of the ionosphere, at around 100km, absorbs radio waves. So distant radio stations can be heard at night but not in the day.

RAL wants to use this effect to track what happens to the ionosphere when the eclipse effectively turns off the sun's ionising radiation and the lower level decays after a few seconds.

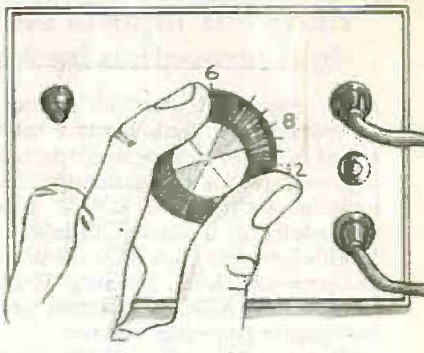
The last time the UK saw a total eclipse was in 1927, when radios were a luxury and ionospheric science was a novelty. Now virtually everyone has an MW radio and a tape deck to record reception.

RAL has checked all suitable frequencies and found two MW stations, *Radio La Coruna* in Spain on 639kHz and *Radio Marseilles* on 675kHz, which are ideal for the test. Both can normally be heard only at night in the UK. If they can be heard on the morning of the eclipse it signifies a dramatic change in the lower level of the ionosphere which is letting waves through for reflection instead of absorbing them.

Anyone interested should tune to the station on a night before the eclipse, leave the radio set to that frequency and tell RAL their post code and what they heard or did not hear during the eclipse. RAL will then log the effect over the whole country.

Further details are available from RAL's web site at www.wdc.rl.ac.uk.

VARIABLE DUAL POWER SUPPLY



TONY SERCOMBE

Fully variable from ±3V to ±15V, this 500mA workshop tool is short-circuit proof, and highly useful!

SOME time ago the author urgently needed a split level power supply and for quickness copied a previously published circuit. It worked well, with one exception, that it had no protection against accidental short circuits.

In the author's case, these could happen with the negative output, mainly due to the fact that on most of his printed circuit boards the negative and earth lines were in close proximity. The slightest contact between the two would cause instant destruction of the negative feed transistor. So, on the last occasion this occurred, it was decided to revisit the circuit, and the design described here is the result of that investigation.

CIRCUIT DESCRIPTION

As can be seen from the circuit diagram in Fig.1, a centre-tapped transformer (T1) is used so that both positive and negative voltages may be obtained from the bridge rectifier (REC1). Capacitors C1 and C2 smooth the rectified voltage. Resistors R1 and R2 provide a discharge path when the power supply is switched off.

Two LM301 op.amps are used as the controlling elements, the negative controller (IC2) being slaved from the positive controller (IC1), the latter acting as the master in conjunction with potentiometer VR1, which sets the output voltages.

A reference supply voltage for the op.amps is obtained from Zener diodes D1 and D2, which set it at ±18V. Variable d.c. feedback is applied to pin 2 of IC1 via VR1. Thus, as the feedback is increased the output drops, and when decreased it rises. IC2 is controlled by the output of IC1 and thus adjusts the negative line accordingly.

The outputs of each of the op.amps feed the bases of Darlington transistors TR1 and TR3, via resistors R12 and R9 respectively. The outputs from the transistors are then fed via low value (1Ω) resistors to the power output sockets. Capacitors C7 to C10 help to smooth any high-frequency spikes or noise at the output sockets. Resistors R15 and R16 provide a discharge path when the unit is switched off.

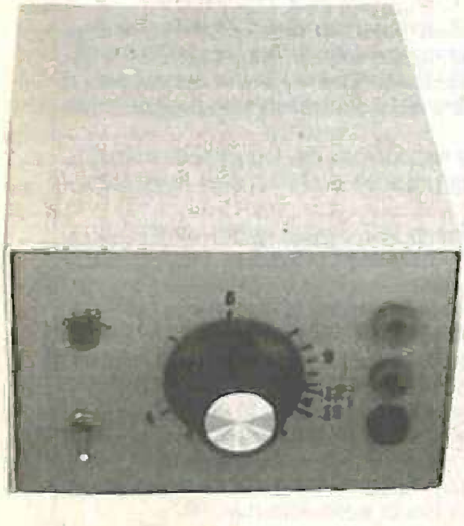
CURRENT LIMITING

The purpose of transistors TR2 and TR4 is to limit the current that can be drawn should an excessive load be presented to the unit's outputs. As more current is drawn, an increasing voltage drop occurs across resistors R13 and R14, so driving the base of TR2 more positive than its emitter, and the base of TR4 more negative.

These transistors now start to turn on, so shunting the bases of TR1 and TR3, having the effect of turning them off in extreme cases. The current drawn by TR2 and TR4 is restricted to a safe maximum limit by resistors R12 and R10 in series with the outputs of the op.amps. The resistors also serve to prevent the op.amp outputs being sunk almost to ground in the event of a complete short circuit.

The power supply will stand a total short circuit at its outputs, with no damage being caused to them, or to the transformer or rectifier.

It should be noted that resistors R10 and R11 across the output and feedback connections of the op.amps should be matched to at least one per cent to maintain sensible tracking between the two outputs. It may well be worth measuring several samples with a multimeter to get identically matching values.



A wirewound potentiometer is recommended for VR1 since the resolution is likely to be better in this application.

CONSTRUCTION

Since this unit is mains powered, great care should be exercised in its construction. If in any doubt about constructing it, consult a qualified electrician. Mains voltages can be lethal if abused.

Details of the printed circuit board component positions and track layout are shown in Fig.2. This board is available from the *EPE PCB Service*, code 242.

It is a wise precaution to use sockets for the op.amps as they would otherwise be very difficult to remove without damaging the p.c.b., should this become necessary.

Although not used in the prototype, a 0V to 20V moving coil meter could be wired across the outputs, with a changeover switch to select which output is monitored. However, these are quite expensive and the prototype used a calibrated scale drawn around the knob for potentiometer VR1. If done with care, this method can have a very neat appearance, and is probably accurate enough for most purposes. Otherwise, the output may be monitored with a multimeter.

A metal case should be used to house the power supply, and this should be connected to the mains supply earth via the power cable. The mains fuse can be of the cartridge type mounted on the back panel. A cable clamp must be used for the mains input cable.

For the prototype, 4mm single sockets were used as the d.c. power output connectors. Other types of socket may be used to suit individual requirements.

TESTING

Once the p.c.b. has been assembled, fully check for any mistakes, and for the good quality of the soldering. On the prototype, the mains transformer was pop-riveted close to the edge of the long side of the case, and the p.c.b. was secured to the base with self-adhesive p.c.b. supports. However, it is best not to fully fix the p.c.b. until testing is complete.

A piece of insulating plastic sheet should be cut to just under the size of the p.c.b. and placed between it and the case floor. These sheets are readily obtainable from model shops.

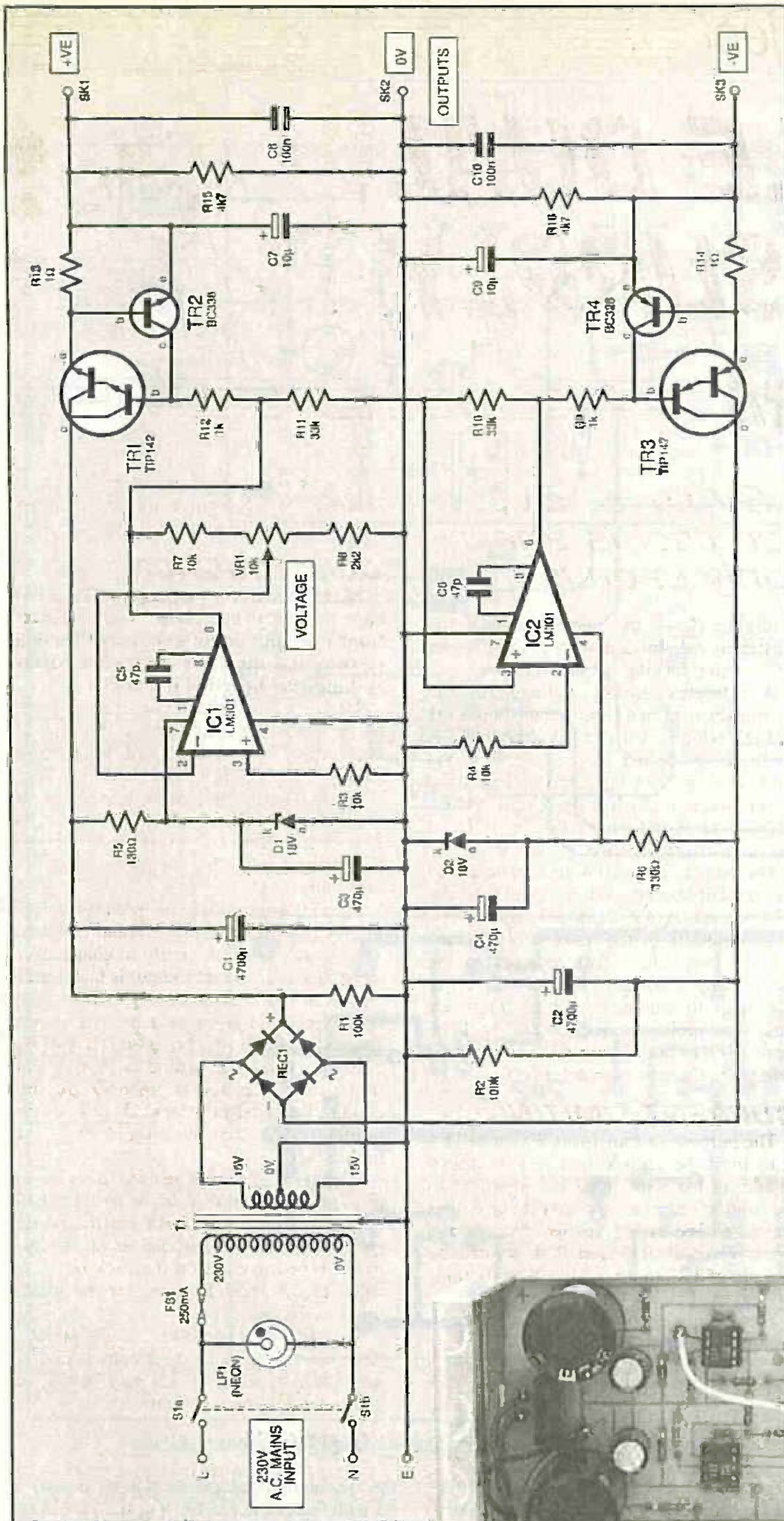


Fig.1. Complete circuit diagram for the Variable Dual Power Supply.

COMPONENTS

Resistors

R1, R2	100k (2 off)
R3, R4, R7	10k (3 off)
R5, R6	130Ω (2 off)
R8	2k2
R9, R12	1k (2 off)
R10, R11	33k 1% (see text) (2 off)
R13, R14	1Ω 0·6W (2 off)
R15, R16	4k7 (2 off)

All 0.25W 5% carbon film unless stated.

See **SHOP TALK** page

Potentiometer

VR1	10k wirewound

Capacitors

C1, C2	4700μ radial elect. 35V (2 off)
C3, C4	470μ radial elect. 25V (2 off)
C5, C6	47p ceramic (2 off)
C7, C9	10μ radial elect. 25V (2 off)
C8, C10	100n ceramic (2 off)

Semiconductors

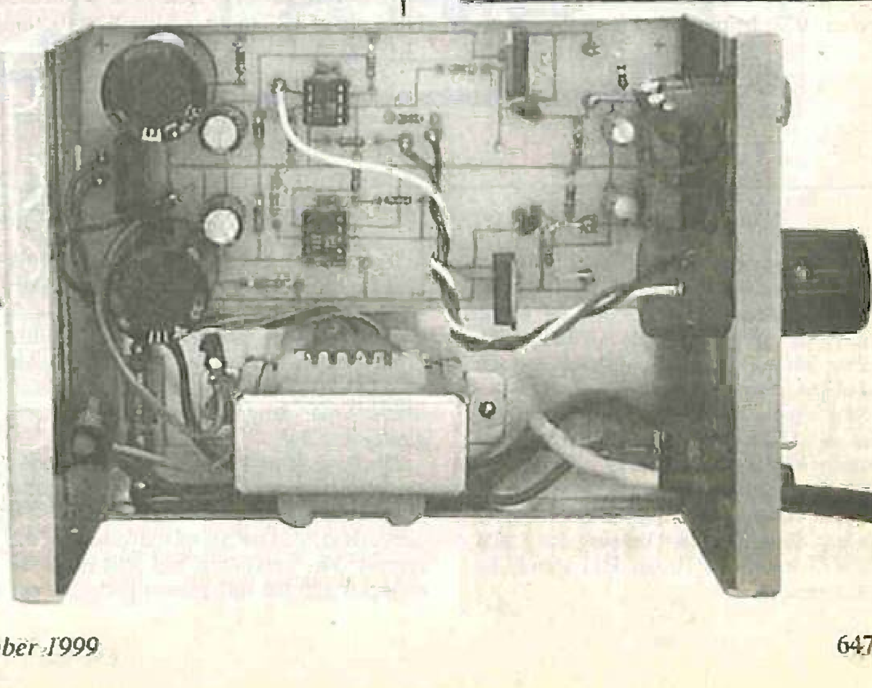
TR1	TIP142 *npn* Darlington transistor
TR2	BC338 *npn* transistor
TR3	TIP147 *pnp* Darlington transistor
TR4	BC328 *pnp* transistor
IC1, IC2	LM301 op.amp (2 off)

Miscellaneous

FS1	250mA fuse, anti-surge, 20mm
LP1	mains rated neon lamp, panel mounting
REC1	bridge rectifier, 50V 1A (in-line pins)
S1	s.p.s.t. mains rated toggle switch
SK1 to SK3	4mm single socket (see text) (3 off)
T1	mains transformer, 15V-0-15V sec, 500mA

Printed circuit board, available from the *EPE PCB Service*, code 242; metal case, size to suit; cable clamp; 20mm panel mounting fuseholder; knob; printed circuit board supports, self-adhesive (4 off); plastic insulating sheet (see text); connecting wire; solder, etc.

Approx. Cost Guidance Only **£31** ***excluding case***



When all the connections to the board from the control panel have been completed and checked, and the mains cable fitted, the unit is ready for testing. Connect a voltmeter, set to a range of about 20V d.c., across the positive output and 0V, and switch on the power supply.

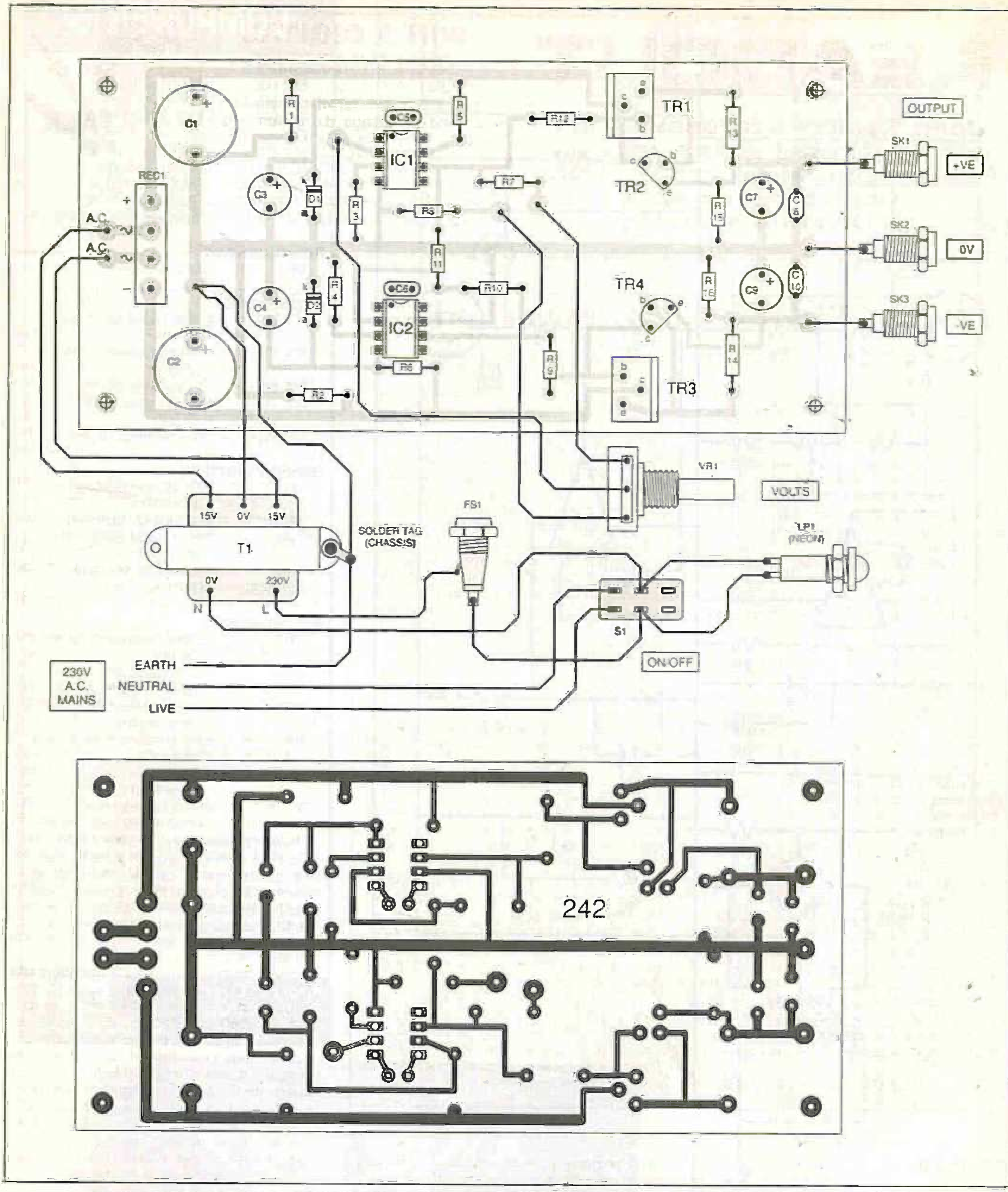


Fig.2. Component layout and full size copper foil master track pattern, plus off-board connection details.

The minimum setting (fully counter-clockwise) of potentiometer VR1 should result in reading of about 3V (2.8V in the prototype). If about 15V is indicated, reverse the outer connecting leads at each end of the potentiometer track.

Now check the negative voltage output. This should (inversely) match the positive output within a few millivolts. Component tolerances will inevitably have some effect here, but the outputs should track together sensibly. Should this not happen, the actual values of resistors R10 and R11 should be re-examined.

If all is well, and assuming that a built-in panel meter is not being used, the Voltage scale for VR1 may now be marked. Use as large a knob as possible with a pointer printed on, so that an easily readable scale may be drawn. Set the control at minimum rotation and, using a water-based pen, mark a reference dot.

Using your multimeter across the positive output, notate this voltage at the minimum scale setting. Do similarly at 1V intervals around the arc of movement of the control. The maximum end will get a bit cramped and for this reason perhaps only the "standard" voltages need to be annotated with figures, at 5V, 6V, 9V, 12V and 15V positions.

A spirit-based pen can now be used to draw small freehand lines to indicate all points at 1V intervals. Next remove the knob and the potentiometer, and gently rub the water-based dots away with a moist cloth.

Now apply rub-down figures, burnish and lacquer. The control potentiometer can then be refitted, setting the knob to the start mark, with the control fully counter-clockwise. The power supply is now ready for use. □

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.

Every month we will give a DMT-1010 Digital Multimeter to the author of the best *Readout* letter.

★ LETTER OF THE MONTH ★

OUT OF AFRICA

Dear EPE,

I have been an avid follower of your magazine for many years under its various titles. Unfortunately, coming from the Third World country of Zimbabwe I could not always get it, what with import restrictions and currency devaluations. Whenever I could get my hands on a copy (old or new) I read it from cover to cover, absorbing all the informative articles and drooling over the supplies available from your advertisers.

However, now that I am resident in England, a subscription to your magazine was top of my birthday wishes list, and thanks to my wonderful wife, I am now a proud subscriber to *EPE*.

Unfortunately I missed out on a large chunk of your publication and am therefore not up-to-date with the new technology which features prominently in *EPE* these days. My main concern is for PIC technology, what does PIC stand for? Programming is obviously involved, is this through a PC? If so what programs and hardware are needed?

Thanks to *EPE*, I have built and fitted two car alarms to my wife's vehicle and mine in Zimbabwe. They were invaluable there as car theft is rife and not once did we have a problem. I also built an amplifier for my mother-in-law who is rather deaf and could not hear the TV without it being turned up so loud as to annoy everyone around. The amplifier plugged into the A.V. audio output on the TV and fed a pair of headphones. All this being achieved with a lot of patience and only an analogue multimeter for testing.

Thank you for an excellent magazine. By the way, novelty circuits such as your *Musical Sundial* (June '99) are always welcome.

P.S. What did the resistor sing when it fell onto the multimeter's dial? *an ohm, ohm on the range!*

Brian Cornish, Ringwood, Hants

We are delighted to hear from you and welcome you as a full-time reader!

The word PIC in this context is a proprietary term owned by Arizona Microchip and used to describe their range of microcontrollers. It probably stands for Programmable In-Circuit microcontroller, although we cannot confirm this. Note that there are other devices which have the prefix PIC as part of their identity coding, but these should not be confused with the Microchip PICs.

Your best low-cost initial route into understanding PIC microcontrollers is through my PIC Tutorial *series of March to May 1998. We have run out of back issues for this, but photocopies of the three parts are available, as stated on our* Back Issue *page. If funds permit, a more sophisticated approach can be taken via our* PICtutor *CD-ROM, see our* CD-ROMs for Electronics *pages.*

We are surprised that you experienced import restrictions over EPE. *We have a number of readers in Zimbabwe who subscribe and regularly renew their subscription. Currency valuation we have no control over, but in UK terms taking out a subscription is an economically viable way of ensuring you receive* EPE *each month (and here begins the "Sponsor's Message"). Subscription details are always printed on the Editorial page, and order forms are published from time-to-time (but you do not need to use a form – any sheet of paper will do, or use any other of the multitude of ways in which you can communicate with us.)*

Another way in which you can obtain EPE, *of course, is through our Internet* EPE Online *site at http://www.epemag.com. (Commercial Break now over!)*

Brian, we can't think of anything to comment on your 'ohmly joke, let alone cap it, so we won't try! We wish you continued success with your designing (and Mother-in-Law)! Hope you find your multimeter reward a good addition to your tools range.

RACEY WIRELESS MONITOR

Dear EPE,

Hello from New Zealand. I'm involved in dirt track Stock Car racing, and we have been having problems lap scoring 25+ cars round the track. Then seeing your Feb '99 issue on the *Wireless Monitoring System* I have a few questions:

1. Can the transmitters send up to 300 different identity codes continuously and for how long? i.e. one per car that comes each race night, and up to five hours before recharging.

2. Can a receiver pick up 25+ different I.D. codes in order, which will pass by at 100km/hour, to allow the PC to display the cars' order over the finish line, 1st/2nd/3rd/etc?

3. How many receivers can a PC monitor? i.e. can we place 10+ around so we can plot the cars' progress around the track?

Frank Korver, New Zealand, via the Net

We passed Frank's E-mail on to the designer, James Humphris, for his comments. He replies:

1. The transmitters presently are limited to 255 different identifying codes i.e. encoded by an 8-bit binary word. However, with an alteration to the source and destination software, this could be increased to 16 bits fairly easily (i.e. 65535 codes).

2. This is the tricky one! Firstly each receiver can only pick up a transmission from a single transmitter at once. This is because all transmitters operate on the same frequency and as such any simultaneous transmissions are ignored (fully explained in the article). This being the case, let's assume that under the conditions of operation, a useful range of 10m can be achieved. Let's also assume that the cars pass the transmitter half-way so we have an effective range of 20m. Let's also assume that the transmission begins as soon as the car enters this useful range.

Each transmission from each transmitter takes 330ms, so each car needs to be in the effective range for at least this time. 100km/h equates to 100,000m/3600s = 27·7m/s, or approximately 28m/s. So, in 330ms, the car would travel 28 × 0·33 = 9·24m. Considering these constraints, theoretically it would be possible to register cars passing the finishing line as long as they were separated by at least 10m, otherwise all information would be lost. The other point is, you would have to ensure that all transmissions began at a specific point. I don't know how you would achieve this.

The transmitter-to-receiver link has only ever been tested in a fairly static environment, i.e. walking pace only, so the effect of 100km/h motion has not been investigated. Possibly a better idea would be to put receivers in the cars, and a single transmitter continuously transmitting. However, the accuracy of this idea would have to be investigated.

The other point is that most modern motor cars are fully EMI compliant, and I don't know if stock cars would be as such. What I mean is that the RFI from the ignition system may well interfere with the r.f. between transmitter and receiver. Have you considered an optical system instead? This could be far more accurate.

3. The receiver can monitor an infinite number of different transmitters as long as all transmissions are independent in time (explained in the article).

James Humphris, via the Net

OU AGAIN

Dear EPE,

Can I add to your answer to Matthew Stuart re TV programs about electronics. The BBC2 programmes (not programs by the way!) post-midnight are called *The Learning Zone* and although much is, not all the content is produced by the OU (Open University), for example *Science in Action*.

Many years ago I asked an OU presenter why they didn't give more publicity to their output as this might encourage more people to think about taking an OU course. His reply was that the programmes weren't designed for the casual viewer and the OU wasn't in the entertainment business! I would hope this attitude has changed but don't bother to contact OU because there's a far easier way.

If Matthew gets in touch with BBC Education Information he can register, as I did a couple of years ago, to receive a free quarterly guide listing every programme under separate categories e.g. Computing, Maths and Number, Music, History etc. along with VIDEOPlus+ numbers. Contact info: Tel: 08700 100222. CEEFAX: Pages 630-636. Web: www.bbc.co.uk/education/lzone.

Hope this helps Matthew find what he wants. By the way, there is an OU maths programme called *Modelling Turkeys* which, if it is ever re-shown, is a wonderful demo using a logarithmic scale to produce a linear graph of turkey weight vs. cooking time. This is followed by more serious applications of the principles which I have made use of from time to time as an electronics hobbyist.

Barry Taylor, via the Net

Thank you Barry, yes the Learning Zone is TV well-worth watching and caters for many interests. You do need (usually) to get up a bit early or stay up late to watch them (I still don't trust preset video recording timers!).

PIC TOOLKIT V2.2

Last month in Readout, *I answered a letter from Dave Buck whose PIC programming problem had been caused by his "illegally" using the TAB key when writing .ASM code for use with* PIC Toolkit Mk2. *We had thought it was general knowledge that when writing in TASM grammar, text formatting control keys were not allowed to be used. It is a point very strongly emphasised in our* PIC Tutorial *(Mar-May '98), and on the* PICtutor *CD-ROM. Erroneously, I had believed DOS EDIT (which is my preferred/suggested text editor) to be free of text formatting control commands, and overlooked the potential threat of the TAB key being used.*

As it happens, Dave was not the only one who used the TAB key instead of spaces, a few other readers reported assembly problems which turned out to be caused by inclusion of the TAB control character (ASCII 9). From Toolkit's *point of view, it was looking for space characters (ASCII 32) from which to make decisions about which columns the program code statements should belong – Labels in column 1, action commands column 2, source/destination column 3, etc. Whereas on-screen TABbed commands look like spaces,* Toolkit *was seeing ASCII 9 instead of 32, and so overlooking the desired column splits. The result was chaos! Virtually every single command line could thus cause an error situation because things were not where they should be!*

However, whilst I could have been hard-hearted and simply left it that text format commands are not allowed with Toolkit, *and that this restriction included ASCII 9 from DOS EDIT, I succumbed to yet another challenge – to allow* Toolkit Mk2 *to accept TABs. This it now does and the revised software version,* PIC Toolkit Mk2 V2.2, *has become the version on our Internet FTP site and on the* Toolkit *disk available from the Editorial office (as detailed on the* EPE PCB Service *page).*

The files have the same names as the original V2.0 *versions, and should be copied to your directories to replace the existing files of the same name. Readers loading the* Toolkit *software for the first time need not concern themselves with this matter, the original V2.0 files have been replaced by* V2.2 *on the disk and FTP site.*

Interestingly, Dave's original .ASM file that he had sent, also showed up a few other matters which I had not anticipated. He was inserting a space immediately following the comma in bit-related command statements. Toolkit *looks for commas in this situation and treats them as another column separator, but because it also uses the spaces as column delineators, the intended bit source/destination that followed the comma was being overlooked. Version* V2.2 *now allows a single space (but no more than one space otherwise you'll have an assembly problem) following the comma in bit-related commands. However, you do not need to use a space, the bit statement can immediately follow the comma.*

Additionally, another matter not expected was Dave's occasional use of hexadecimal values to indicate bit values. Toolkit V2.0 *was seeing a non-decimal value (in this case a statement preceded by a $ sign) and was thus thinking that it should now look for an equated (.EQU) value of the same form as listed with the other specified equates – and not finding one, reporting this an error situation. This has been rectified in* V2.2, *and hex values may now be used to specify bit values.*

As a point of my own making, when extensively using the Send Message to EEPROM routine in connection with another design being worked on, I regretted not having allowed comments to be added on the same line as the message data. The Message routine has now been amended in V2.2 *to allow this to be done (preceded by a semicolon, of course).*

Dave's just E-mailed "Thanks for the revised program files, I've got them up and working and it's 100%".

PERPETUAL CALENDAR

Dear EPE,

Re the letter from Lloyd Kirk in *Readout* of August '99, using my Sinclair microdrive cartridge Calendar program provides evidence that the calendar of 1972 is the same as that for the year 2000.

R.L.A. Latham, Weeping Cross, Stafford

Many thanks Mr Latham for kindly sending printouts which prove the truth of Lloyd Kirk's suggestion. The calendars included on my several PCs also confirm this and, moreover, that 1972 = 2000 = 2028 = 2056 = 2084 = ...? On this short timescale, it seems that the calendar repeats every 28 years. However, on a much greater timescale does anyone know if this continues ad infinitum, or do extra leap days at strategic intervals upset the cyclic uniformity?

As a spin-off from this question, I have found that while my computers are supposed to be Millennium Compliant (as confirmed by a message box on start-up), they are not Millennium 2.1 Compliant! That is, the calendar baulks at going beyond 2099, and reverts back to 1970!

So what?, some of you might exclaim, believing that it won't affect you or most of us around now. Ah, but wasn't similar thinking in earlier years partly responsible for us having a Millennium Bug problem now? Shall our descendents inherent a Y2K1 Bug from us?

DIY PCB PRINTS

Dear EPE,

I have been a very keen follower of *Practical Electronics, Everyday Electronics* and *Everyday Practical Electronics* for the past 30-odd years or so, going back to the early 1960s and have built many of your projects over the years. By studying your projects, and in particular the circuits of *Ingenuity Unlimited*, I have been inspired to investigate and build all sorts of novel and useful devices. I have derived much pleasure in trying many different ways of producing my own p.c.b.s, they have normally been successful although I have not always been totally satisfied with the result.

In the past few years, I have obtained several inexpensive computers, gradually working my way up to a PC. In each case I have attempted to produce (with the aid of a drawing program) printed circuits resembling professional quality. Recently, with the use of the PC and a decent printer, I felt I could be getting close to reaching my final goal, but when I come to print out the results of my work on acetate film to produce a negative, I find that the ink seems to refuse to dry and is very pale, could you suggest a special ink for this purpose?

Another idea I might suggest is, would it not be possible to print out a circuit design onto a backing sheet with some special etch resistant ink, so as to be able to iron the image directly onto plain copper laminated board, therefore doing away with the need for expensive resist-coated board and also the production of an inter-negative, similar to the production of T-shirt motifs. Awaiting with interest any comments you may make in a forthcoming magazine.

N. Dyson, Glossop, Derbys SK13 8EP

Even in the days when I was professionally manufacturing p.c.b.s, I used positive resist-coated material for prototypes, and continue to do so. However, I never did fully solve the problem of achieving 100 per cent quality when using a dot-matrix printer (with inked ribbon) as the image producer.

Since acquiring an ink-jet printer however, I now obtain perfect images when printing onto acetate drafting film (to the "coarser" side). These images are suitable for use directly with photoresist board and a UV exposure unit.

Yes, there is an iron-on material available from some major component suppliers. It's called Press-n-Peel, but I have never used it and cannot comment on its effectiveness.

WELL WEATHERED

Dear EPE,

Referring to *Readout* of August '99 and your question about other reader's projects from past years, I wish to share my experience with two *EPE* projects that I have constructed.

After reading the *Weather Station* of Feb-Apr '90, I started constructing it and finished all the circuits in August '90 and installed it on my roof that same month. From then on, it has worked continuously with accurate readings and has seen wind strengths of Force 9, and still it goes well.

The other is the *Digital Car Tachometer* of June '91. After I had prepared the circuit and a metal box for it, I removed the dashboard of my Fiat 127 car, to place the l.e.d.s and the 8-digit display near the speedometer. I fitted everything in place and it is still working fine. Also, it survived a head-on collision that I had with another car five years ago. I rearranged the components and the metal box and after a while it was working as new on my repaired car.

I am very proud of the above projects. As a result I always refer your magazine to other people as it is gives me what I want, and the know-how to continue in the hobby.

Would it be possible for the author of the *Weather* project to design additional circuits that can be added to it so that I can connect the data signals to a computer for logging the parameters, showing the readout out on the monitor, while still using the original display? This idea has been in my mind for years now, but I have not mastered design techniques yet.

I want this extra facility so that I can utilise my old 8086 or 386 computer. Also, I wish to have an audible signal from the anemometer, adjustable to sound a buzzer when Force 3 or Force 5 is in effect, using a switch to select the wind force alarm.

Joseph Vella, Pieta, Malta

We are no longer in contact with the author of the Weather Station *and so cannot offer additional interface circuits specifically designed for it. However, you might consider the* Data Logger *of Aug/Sept '99 for monitoring the data. It can input up to eight simultaneous analogue signals, and store them as digital values for subsequent output and display on a computer screen.*

Taking a quick look at the original Wind Speed circuit (Fig.8 Feb '90), it seems that you might be able to tap the rotation pulse signal at the output of IC1 and feed it into an AND or NAND gate additionally controlled by the signal line connected to one of the bargraph l.e.d.s. The output from the gate could then be fed via a suitable resistor and capacitor to the input of any ordinary amplifier of any size, even a simple amplifier module such as are sold by various of our advertisers. You could use a switch to select which bargraph output is the gating source.

Great to know of the "impact" that the Tachometer *has had with you!*

PIC ROUTINES

Dear EPE,

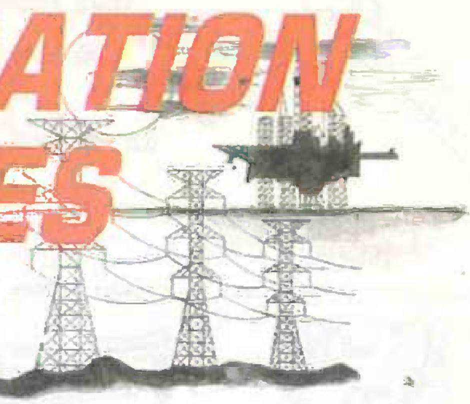
Over the past year or two I have become very familiar with the use of the PIC16C84 and have designed several projects around it. However, I feel a series which discusses programming techniques on an algorithmic level would be very useful. I am sure that most people find trawling through someone else's source code extremely tedious.

A series on subjects such as encoding, decoding, pulse width measurement, serial data transfer etc., would be beneficial and a logical follow-up to your *PIC Tutorial* series.

Richard Cox, via the Net

A very useful suggestion Richard, which we are investigating.

POWER GENERATION FROM PIPELINES TO PYLONS



ALAN WINSTANLEY

Part Two

Supported by the expertise of the international power generation company National Power plc, Alan 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 CONCLUDE our in-depth look at power generation by examining some of the techniques related to the provision of a 230V a.c. supply to our housing and industry.

Power to the People

Let us return to the process of electrical power generation and examine it in greater detail. Previously it was mentioned that each of the three gas turbines in our adopted power station drives an a.c. generator; a steam turbine drives a fourth.

A power generator consists of an electromagnet (*rotor*) which is rotated directly by the turbine shaft. Each revolution of the turbine turns over the generator once. The rotor is surrounded by stator coils in which the moving rotor induces a voltage that will ultimately be delivered to the consumer.

Power Spin

If a simple two-pole rotor is used, this could be likened to a simple electromagnet having a North and a South Pole. The spinning electromagnet induces a voltage in the stator coils each time it passes by, and the stator voltage will therefore reverse polarity with every half-revolution of the rotor. The voltage level generated in the stator coil depends on how far the rotor has travelled during one revolution (its rotational angle).

How a sinewave is generated with this setup is depicted in Fig.9. Because it delivers alternating voltage, this generator is more correctly called an *alternator*. (A *dynamo* produces a d.c. voltage instead.)

To get the most out of each revolution of the rotor, several stator coils are deployed so that multiple sine wave voltages are generated per revolution. In fact, three coils are spaced at 120 degrees apart (see Fig. 10) and the coils are designated by a colour code which will be familiar to every electrician: they are Red, Yellow and Blue. The generator windings produce 15·75kV between the phases.[1]

The overall result can be plotted as a three-phase voltage, see Fig. 11. It can be seen that the voltage in the red phase is 120 degrees behind the yellow phase, which lags 120 degrees behind the blue phase.

By increasing the rotor's speed, the frequency can be increased, although the three phases will always be 120 degrees apart. This simplified approach assumes that there is only one pair of magnetic poles on the spinning rotor as shown, and this is normally the case in practice.

If the rotor spins once per second, then the a.c. voltage generated in each phase will have a frequency of one Hertz (Hz).

1 For reasons which will be clarified later, it is usual in the power industry to talk of "line voltages" as phase-to-phase voltages, rather than the voltage which is generated in a single-phase circuit with respect to a "common" or "earth" reference. In a three-phase generator, the voltage which is generated in an individual phase is 9·1kV, which is 15·75kV/√3. This produces 15·75kV between phases. *ARW*

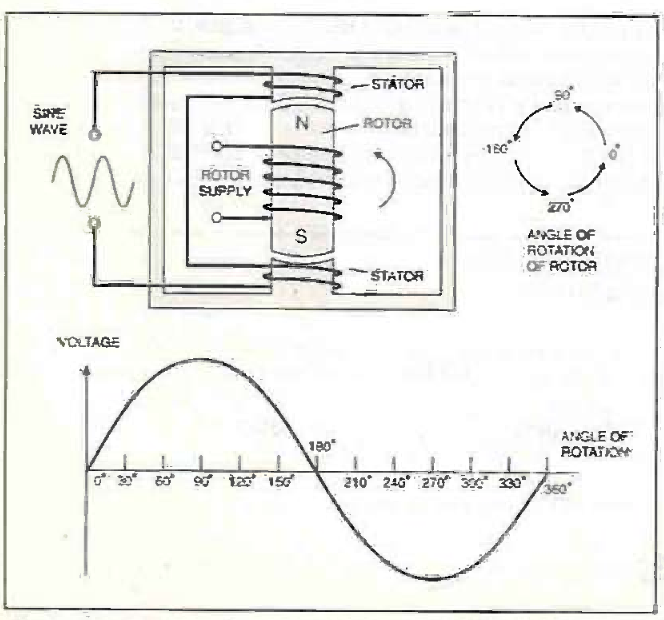
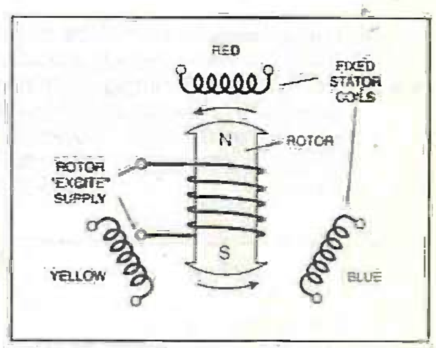


Fig.9. A sinewave is produced in the stator coil by the spinning rotor. The voltage level depends on the rotor's angle of rotation, and it reverses polarity every 180 degrees.

Fig.10 (right). A three-phase generator has three fixed stator windings, placed 120 degrees apart around a spinning rotor, which itself is an electro-magnet, having a North and South pole.



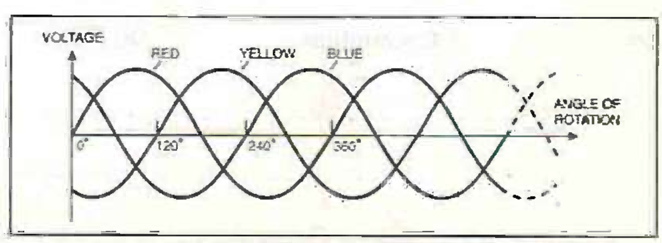


Fig.11. Three-phase electricity generated by the alternator of Fig.10. The three phases are 120 degrees apart.

changing polarity every half second. The frequency of the generated voltage is calculated by:

$$\text{frequency} = \frac{\text{no. of pairs of poles} \times \text{revs. per minute}}{60}$$

From the above formula, a generator with one pair of poles as illustrated must rotate at 3,000r.p.m. to produce electricity at 50 Hertz, which is the *declared system frequency*. The statutory limits defined in the Electricity Supply Regulations of 1937 are 50Hz. ± 1% (i.e. 49·5 – 50·5Hz) although the National Grid (NGC) strives for a variation of no more than 0·1% as best practice. The turbines operate at this speed, 24 hours a day for months on end.

In the mid 1920's before electrical power generation was standardised, several frequencies could be used – anything from what was probably a migraine-inducing 25Hz and must have been murder to read by, all the way up to 80Hz. The Electricity Supply Act of 1926 resulted in a standardisation of supply frequency across Great Britain, at 50Hz, although in the USA and some other countries the supply has been set at 60Hz.

In fact most generators tend to have two poles although certain types e.g. hydro-electric generators may have four or more poles. This allows for a slower rotor speed of 1,500 r.p.m for a four-pole machine which is more appropriate for the medium involved, whilst still generating a 50Hz sinewave.

Frequency Control

The actual method of controlling the supply frequency ultimately boils down to speeding up or slowing down all the generators on the system, by increasing or decreasing their load.

Great effort is made to maintain this value and to eliminate cumulative errors in the consumer's supply, which might otherwise affect electric clocks, time switches, audio equipment etc. Any minor change in frequency is compensated for later on, in order to enable frequency-sensitive equipment to catch up (or slow down).

All power plants interconnected by the National Grid can be considered as part of an enormous "pool" of electricity hooked together on an "infinite busbar", which runs at a set frequency.

A circuit breaker unit connected to the gas turbine. Notice the colour coding "spots".

Every power station thus connected operates at this frequency. If at this time a small isolated power station was *not* connected to the busbar, but was then hooked in later, the frequency of the existing "pool" would easily dominate the generator of the newly-connected power plant. The net result is that *all parts of an interconnected system operate at the same frequency*.

The operating frequency of the rest of the grid is thus physically applied to an individual generator, in what is effectively a contest of wills. Since a generator's stator is synchronised to its rotor (and turbine shaft), it is necessary to ensure that a gas turbine runs at a speed which enables the generator's frequency to be matched to the rest of the grid. Hence, the challenge is to supply just enough fuel to the turbines so that the generator runs at the prevailing system frequency adopted by the rest of the grid.

Any increase in the fuel supply will *not* necessarily cause the turbine to run any faster, because the generator is already synchronised or locked to the frequency of the grid: instead the turbine will simply be "loaded", which is undesirable. The system frequency can be best controlled by ensuring that the generator's MW output constantly matches the consumer MW (megawatts) demand.

Test Run

The best analogy of this is to consider a car which is being driven at a fixed speed. If the car encounters a hill it will slow down, making it necessary to open the throttle to maintain engine speed. If the hill levels out, the throttle can be closed again. If it goes downhill, the engine can be used as a brake to slow the car.

The other key parameter is, of course, *voltage*. For consumers, the statutory limits on their 230V supply is ± 6%. Unlike the system frequency, the voltage levels can vary in different parts of the transmission system. The voltage output of a generator is directly related to the rotor voltage – the excitation voltage, which is controlled by a complex automatic voltage regulation (AVR) system. Every aspect of the generator and the turbine's performance is constantly monitored by the power plant's fully computerised control room.

Down-the-Line

The next part of the electricity generation process relates to the way in which the power generated in the stator coils is transmitted to the user. Typically, the generator outputs 15-75kV and is rated for more than two hundred megawatts (MW).

The three phases – red, yellow and blue – are carried outdoors from the generator by cables using large ducts which resemble pipelines. These pipes are pressurised in order to prevent corrosion or water ingress. The ducts are also colour coded to identify the phases, and this same theme is used all the way through to the end-user's premises.

One major problem is, how to actually switch such high magnitudes of voltage?

Leaps and Volts

All of the high voltage areas at National Power's Killingholme "A" station – just like every other high voltage installation – are surrounded by a perimeter fence or wall. Such areas are padlocked and it is ***strictly forbidden*** to enter the area – even to pick a weed – without the relevant safety permit.

Although much of the equipment is safely earthed, many high tension wires and terminals are of necessity uninsulated. *High voltages can flash over and strike a human being with deadly effect if they stray too close to high voltage power lines, transformers or other electrical equipment.*

For high voltage operations, the industry-standard minimum safe working distances are:

400kV	3·1 metres	66kV	1·0 metres
275kV	2·4 metres	33kV	0·8 metres
132kV	1·4 metres		

Remember that the human body is a walking 3 kilohm resistor and is effectively grounded at one end. If a person unwittingly encroaches within the safe working distance then there is a very serious risk of arcing and flashing over. That person may suffer devastating electrical burns as well as risking death. There may also be an explosion and fire.

It would be impossible for anyone to rescue a person from such a dire predicament because of the same risks *they* would face from arcing by the same high voltages, so any attempt to mount a rescue near to high voltages would be **highly dangerous**.

If you should see a person next to high voltage power lines or equipment whom you suspect may have suffered electrocution or burns, there is nothing you can do except stay a safe distance away and call for help. All rescue attempts must be left to the experts who will insist on making the area safe before entering it. (The separate box-out *"Heartfelt Shock"* is a timely reminder of emergency first aid procedure which can be undertaken for persons who may have received a shock from the domestic 230V supply.)

Every year many people lose their lives by electrocution purely through carelessness and ignorance. Children must never be permitted to play anywhere near an electricity substation, and must never attempt to retrieve, say, a lost ball from within a fenced-off substation compound.

Playing near overhead power lines (including electric train overhead wires) should also be strongly discouraged, so the flying of kites and model aircraft in these areas is exceedingly dangerous. ***The dangers of death caused by flashing over are very real and are ignored literally at one's peril.***

Since these extremely high potential voltages can arc across considerable distances (see the box out entitled *"Leaps and Volts"*), one can image the nightmarish problems which exist in the power plant when trying to switch thousands of volts.

The switchgear concerned must be able to withstand not only their full loads but six-fold overloads which occur when motors are starting. They must also be capable of carrying or interrupting fault currents and must also cope with 17,500 volts peak across the contact terminals. Evidently, we are not talking 6mm (¼in.) toggle switches here!

The solution lies in the use of special gas-filled circuit breakers. These are spring-loaded and motor driven and are designed to quench the high tension arc which develops between opening contacts. The compound sulphur hexafluoride (SF_6) is used and this is six times less conductive than air. Earlier types used oil-filled contacts or compressed air to snuff out the arc.

The 15·75kV (phase-to-phase) generator voltages are stepped up to 400kV by an external transformer – one per generator – for onwards transmission to the National Grid.

Stay Cool

Many readers will be aware that large transformers are oil-cooled in order to aid heat dissipation. With the largest types, the oil will be circulated by pumps and heat will be exchanged with a water-filled coolant circuit.

In the event of a transformer internal failure (e.g. winding shorts, or contacts starting to burn out), hydrogen is one of the first gases to be produced, so by testing for this gas any trends can be spotted early. A device known as a Bucholz relay is used as an automatic switch that responds to increasing levels of gas build-up in the oil.

More accurate tests of oil samples are also undertaken by National Power and other gases such as acetylene can be measured over, say, a month and a good estimate made of the nature of an internal fault. Ultimately the oil can be drained and then the fault can be repaired.

Also worthy of mention is a small digital counter near to the transformer's perimeter steel fence. It displayed "20": when this was queried, the author was cheerfully told that this meant the transformer had been hit by lightning twenty times . . . Er, quite.

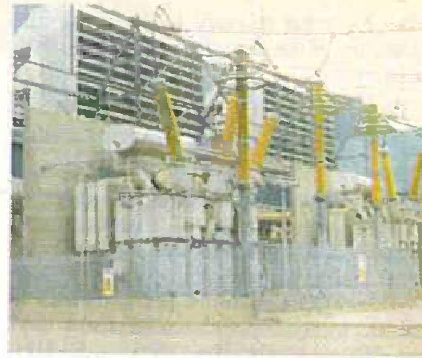
Quite a Buzz

A compound area called the "banking compound" adjacent to the main power transformers contains an array of insulators and busbar isolating switches. Usually, when Killingholme "A" is in full swing, the crackle of high tension voltages fills the air around this bus-bar area. The same compound contains current transformers which monitors the station's output.

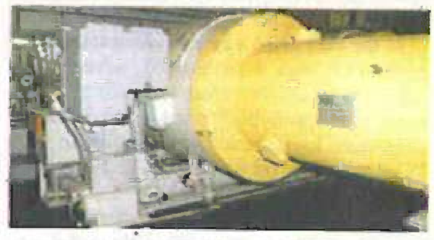
From there, the 400kV supply is fed underground to a nearby sub-station, before finding its way on to a transmission tower, the very first in a series of many hundreds which will be used to distribute the power around the countryside.

Super Grid!

The enormous 400kV supply – known as the Super Grid (275kV in certain



Four 400kV transformers connected to the outputs of the four generators.



A gas-filled circuit breaker, rated at 17·5kV 10,000A, connected to the gas turbine generator.

A Bucholz, safety switch, relay is fitted on oil-cooled transformers and detects any build-up of gases in the oil.

Pylon on the Power

The electricity pylon – more correctly called a *suspension* or transmission tower – carries overhead three-phase electricity between substations in all weathers. *Terminal* towers are located at each end of the route, whilst *deviation* towers enable the wire route to be realigned.

These "lattice" towers are significantly more economical to construct and repair than attempting to bury high voltage insulated cables underground, and the ambient air also acts as a natural cooling system to help with heat dissipation on the wires. Larger towers provide a greater span, needing fewer towers to suspend cables over a distance, but variations in design are used depending on local conditions (e.g. aircraft or natural landscape considerations).

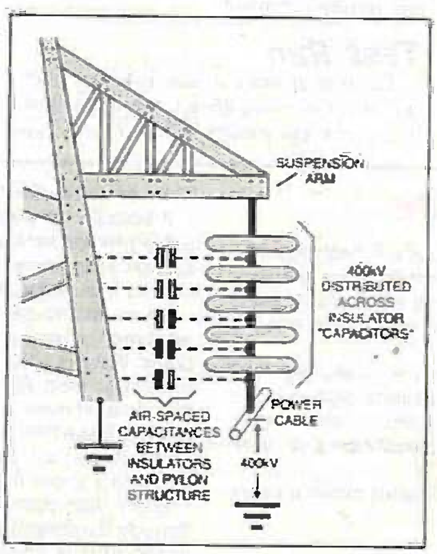
The largest Super Grid towers support wires operating at 400,000V. Fibre optical cables are wrapped around many cables to carry Internet traffic: the light signals are unaffected by the high voltages. The smaller towers seen in the countryside or near towns and villages are usually owned by the Regional Electricity Companies (RECs) rather than the National Grid.

Power cables are uninsulated and usually made of aluminium alloy, which is lighter than comparable conductors so that slimmer, smaller towers can be used. The towers are inherently earthed, and an individual earth conductor wire can often be seen connecting the tops of towers together.

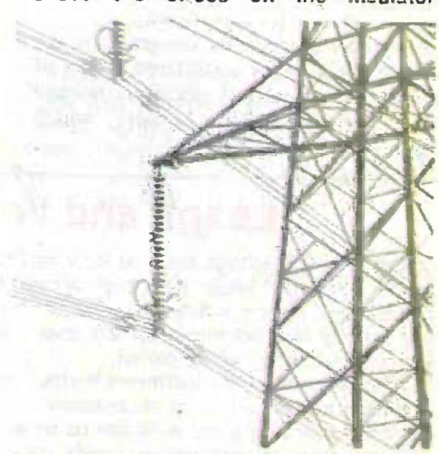
To ensure that the high voltage cable and the earthed tower are separated from each other, chains of porcelain or toughened glass insulators are used. A 132kV wire might use just nine insulators, whilst a 400kV Super Grid power line may demand twin chains of 24 insulators. Atmospheric pollution is another factor which determines how many insulators are needed, because fall-out from industry and salts in the atmosphere can degrade the insulating effect.

Each insulator is actually a *capacitor* having metal end caps separated by the dielectric material of the insulator. This produces a series of air-spaced capacitors between the metal caps and the tower, resulting in an uneven distribution of voltages across the insulators. Hence the power line voltage will be unevenly dropped across the capacitances, but the one nearest the power cable could operate near its maximum voltage breakdown limit.

The addition of a *guard ring* helps relieve the stress on the insulator dielectrics nearest the power cable by shunting their capacitance, and it also ensures that any possible flashover is diverted away from the insulator surfaces to prevent damage, see diagram. Insulators have a undulating cross section to increase their surface area, useful in wet weather.



Porcelain or toughened glass insulators are used in chains to prevent contact with the earthed transmission tower. The voltage on the power line is distributed across all insulators as shown; which have metal caps and therefore form capacitors.



Typical pylon insulator set-up carrying 400kV supplies. Note the guard ring nearest the cable.

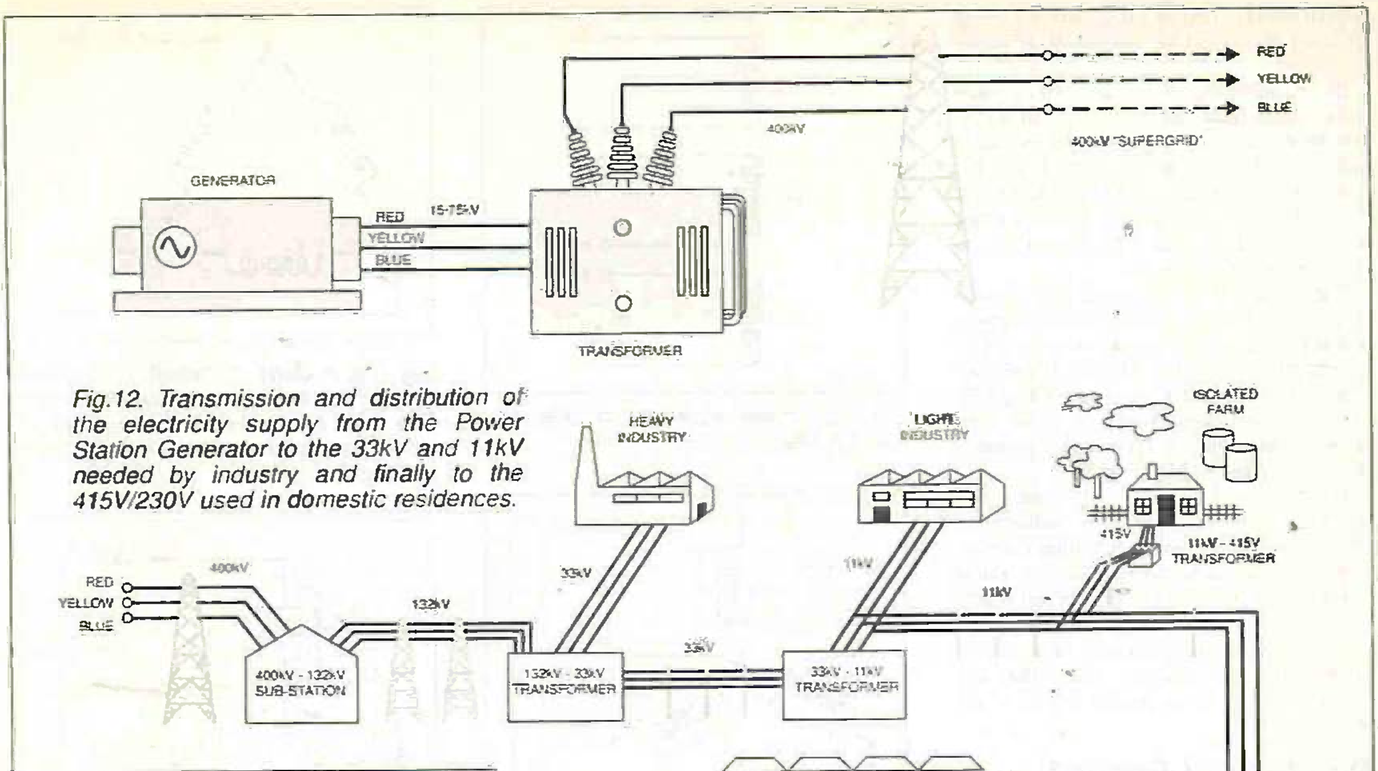
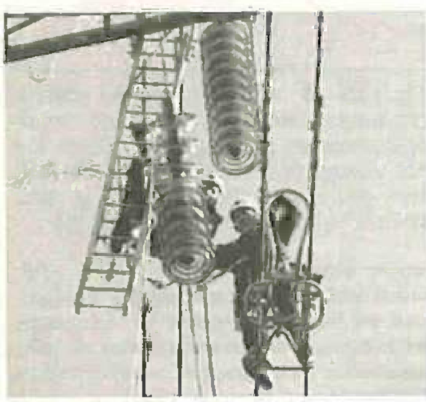


Fig.12. Transmission and distribution of the electricity supply from the Power Station Generator to the 33kV and 11kV needed by industry and finally to the 415V/230V used in domestic residences.



National Grid engineers installing glass insulators on an overhead cable.

regions) will be found hanging off the largest of pylons (as a general rule, the larger the pylon, and the bigger the insulators, then the higher the voltage being carried). The same pylons also carry Super Grid voltages generated by neighbouring power stations.

If ever one wondered why there are three arms to each side of a pylon, the answer is suddenly blindingly obvious: there is one wire per phase, with each tower usually carrying two circuits. Sometimes, wires may be paralleled, which will be witnessed by two wires running next to each other to share the load. (See the separate box out, "*Pylon on the Power*".)

These extremely high voltages are transmitted over considerable distances to regional sub-stations, where they are progressively stepped down by transformers (auto transformers are usually used on the Super Grid). Outline structure of the electricity distribution system is shown in Fig.12.

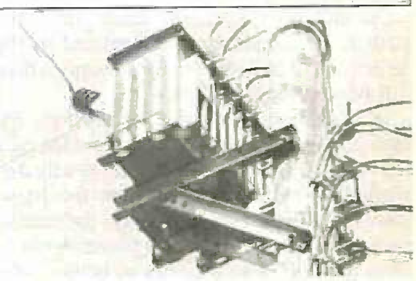
The Super Grid is first reduced to a 132kV grid system and then to 33kV for use by industrial estates and heavy industries. Light industries may require an 11kV supply which is provided by a sub-station. The final reduction occurs in residential areas, where the 11kV is stepped down to three-phase 415V from which single phase 230V a.c. is produced, as we shall see later.

(Officially, UK domestic supplies have been "harmonised" at 230V a.c. for reasons best understood by the European Union. In reality, UK supplies are 240V a.c. just as they always have been, evidenced by taking a quick measurement of 243V!).

In many cases, the customer (say, a farm in a remote locality) will have his own 11kV-to-415V step-down transformer and these are a common site in the English countryside, perched on top of a wooden pole. It is the job of the Regional Electricity Boards to distribute power to commercial and residential properties, and sub-stations with suitable step-down transformers will be used as appropriate. From Fig.12 it can be seen how the Super Grid voltage is systematically stepped-down as the end users' locality is approached.

More on Three-Phase

The red, yellow and blue colour code of the 3-phase system applies from the generator outputs of Killingholme "A" all the way through to the 415V transformer found by residential properties. One could be forgiven for thinking that the use of three very large stator coils to generate three-phase power would demand *six* wires to conduct the current, as shown in Fig. 13a, noting the direction of each winding (or the start/end of the coil) is denoted with a spot symbol.



A typical 3-phase transformer, mounted on a wooden pole. It has an 11kV primary and a 415V secondary, from which 230V a.c. is produced.

After all, a single-phase load requires two supply wires to power it: normally known as Live (or "hot) and Neutral, though the live is more correctly called the *Line* voltage.

However, a three-phase system is able to transmit three times the power of a single phase design without the need for six wires, simply by arranging the windings as shown in Fig. 13b. The start of one winding is connected to the end of another, and the three connections are brought out as shown. Because of its shape, this "triangular" configuration is known as a **delta (or mesh) connection**. Three wires can be used to transmit a three-phase supply in this way.

The alternative arrangement of windings shown in Fig. 14a is called a **star connection** (or Y connection), and the central connection is called the *"star point"* (or the *neutral* point). This is used universally by National Power on the output of all of its generators.

By commoning the "starts" of each phase together as shown, a four wire-system (three "line" voltages or phases, and a neutral conductor) can be created. The net current flowing into or out of the star point is *zero* because each phase uses the other two for its return path. The net voltage is also zero at the star point.

The principles of delta and star circuits are relevant throughout the power transmission network, all the way down to the 230V a.c. supply delivered to a home. In the case of a three-phase 415V supply, see Fig.14b, a step-down transformer is used (not shown) which has a 11kV delta primary and a star-wired 415V secondary.

Therefore, 415V is supplied between any two lines as shown. A voltage of $415V/\sqrt{3} = 240V$ will be developed across a "load" placed between the star point and a single phase. This is precisely how a domestic 230V is derived – connected to the star/neutral point and any of the (nominally) 415V phases. (Note that our "230V" supply is in reality 240V – see previous page.)

On Neutral Ground

Having outlined the overall process of power generation, let's explore in more depth further aspects of power distribution which will be familiar to us all: the need for a neutral wire, and also the requirement for *earthing*.

In order to provide a 230V domestic supply from a 415V three-phase supply, the "live" 230V wire is taken from one of the transformer's 415V phases and the neutral is taken from the star point. The star or neutral point is also *physically* connected to the earth at the transformer, as depicted by the earth symbol in Fig. 14b, for reasons which will become apparent later.

In a typical residential installation, the three 230V supplies which are provided by a 415V three-phase transformer are evenly distributed to balance the load on the transformer. This is achieved by, say, connecting every third house to the same phase. A whole street of small 2 to 3 bedroom houses may have one phase whilst a small development of much larger houses – which will demand more power – might use a different phase to try to balance the loading, and so on.

A significant side effect of this arrangement is that neighbouring premises, whilst each enjoying a 230V supply, may endure a potential of 415V between their respective live supplies: it can be seen in Fig. 14b how 415V exists between any two phases or lines. For this reason, the 230V "live" of one residence should never be used in neighbouring installations because they might not share the same phase.

Each house drawn in Fig. 15 is connected to one of the 3-phase "lines", and the diagram shows how all three houses have their neutral wires commoned together to the star/neutral point of the 415V supply transformer. That same star point is also connected to the earth.

Quite how an individual house will be connected in practice depends on several factors, but assuming that an underground supply is taken to the property, then usually a 230V supply will be routed there using an

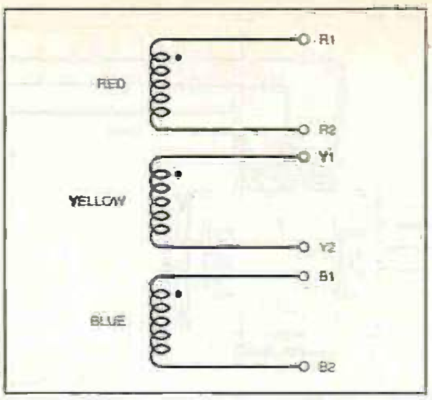


Fig.13a. Three separate phases require a total of six connections.

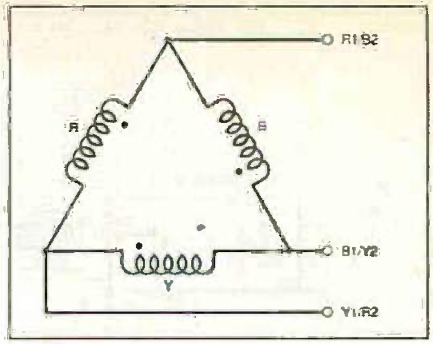


Fig.13b. A delta or "mesh" connection for a 3-phase supply dispenses with the need for six wires. The net sum of voltages around the delta configuration is zero.

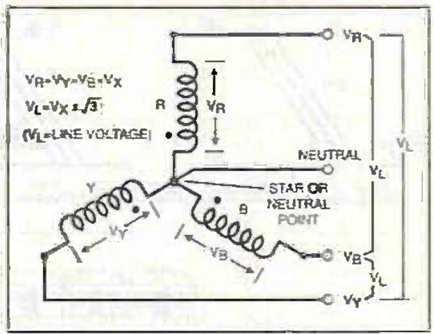


Fig.14a. A star (or "Y") connection with the star being the neutral point.

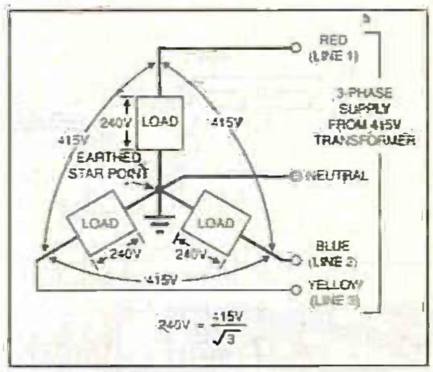
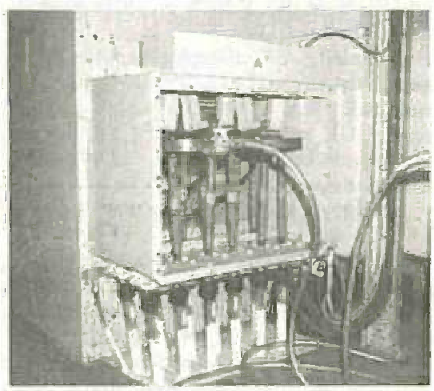


Fig.14b. A 415V 3-phase voltage produces 240V across each "load" connected to the star point. Since the net voltage is zero in the 3-phase system, the star point is neutral, or zero volts. It is connected to the ground.

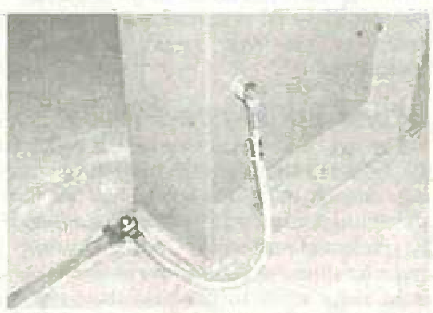
armoured cable, see Fig. 16. The steel armour is wired as a "protective earth" and connects the house earth system to the earthed star/neutral point of the local 415V transformer.

This completes a good quality metal earthing connection between the domestic earth system and the star/neutral point of the 415V transformer. All exposed domestic copper water pipes and other metal work which could possibly become live through a fault, are hardwired together by "equipotential bonding", which ensures that no individual route to earth will be more resistant to a fault current than any other.

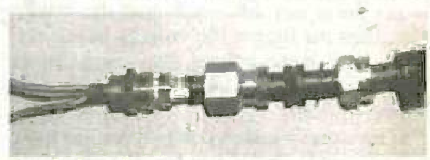
Incidentally, the consumer's neutral may also be directly connected to an earth stake at their incoming supply, but usually this only occurs if the existing earth connection path is found to be inadequate, or if no



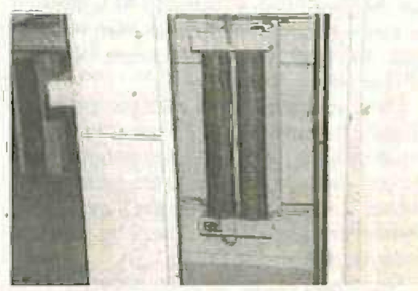
Exposed equipment with safety earth wires fitted during maintenance.



How all exposed steel framework is soundly interconnected with copper bars and also earthed.



A typical armoured-cable terminator, note the steel armour which is the "protective earth".



The "neutral resistor" is designed to limit fault currents in the generator. It connects between the star point and earth.

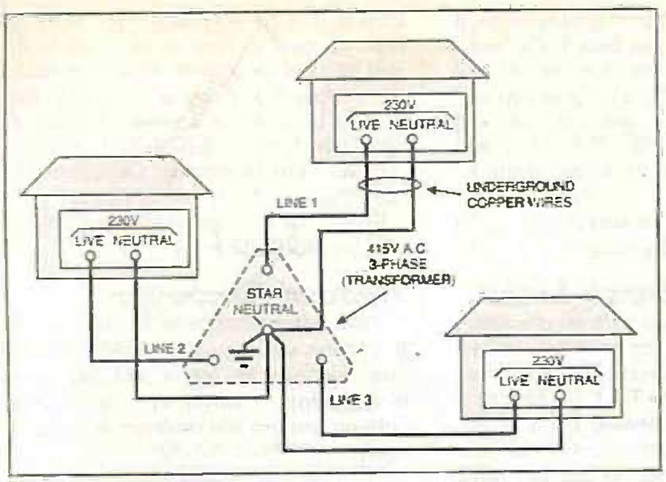


Fig.15. How a 415V 3-phase system is utilised to distribute 230V to the end user. Each "house" uses one phase in order to balance the loading on the substation (ref. Fig.14b).

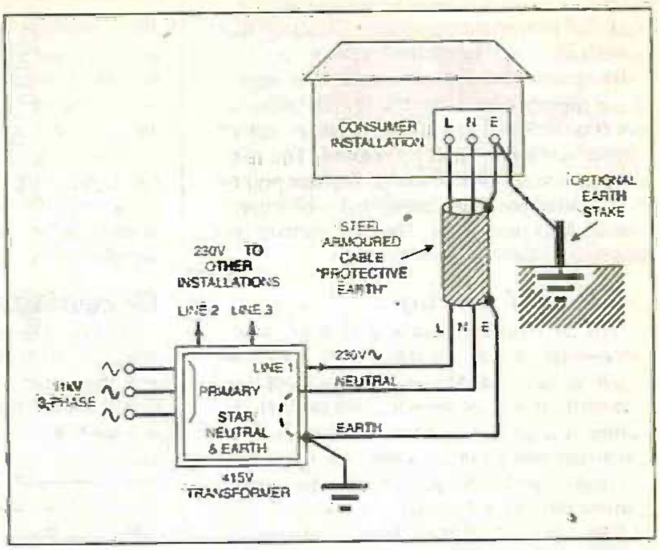


Fig.16. How an earth connection is routed through to a consumer installation. The steel armoured cable ensures a good earth continuity between the installation and the transformer star/neutral earth. It is connected via a brass cable gland which terminates the cable.

earth has been provided at all by the electricity supply authority. There are other variations on house wiring as defined in the *IEE Regulations* with which a competent electrician will be familiar, and who should be consulted if individual doubts exist. In the case of overhead domestic supplies, the earth terminal of the property might only be connected to earth but not to neutral.

Getting Down to Earth

We have now shown how a 230V a.c. supply is derived from a 3-phase 415V transformer, noting also that a consumer's neutral wire connects to the transformer's star/neutral point. A separate "protective" earth (the steel armour of the underground cable) runs between the consumer's earth terminal and the (earthed) star point of the transformer as well. What is the point of all this "earthing"?

It is widely understood that the need for "earthing" (or "grounding" in the USA/Canada) is a safety measure designed to prevent electric shock due to wiring faults or insulation breakdowns. More accurately, earthing is used as a method of ensuring that no open or exposed metalwork can accidentally become "live" should an internal insulation fault arise. This aspect is now examined in greater detail, and it's useful to start (courtesy of National Power) by seeing what happens in our adopted power station, Killingholme "A", before we look at the situation in a domestic residence.

In the field of electricity generation any voltages expressed are always understood to be *between phases* rather than with respect to earth or "ground". A 415V three-phase supply has 415V *between phases*, not between a phase and ground (between which, 230V a.c. exists). Recall how a 9·1kV generator coil produces 15·75kV between phases, and it is this latter voltage which everyone talks about.

However, the ground or earth plays a fundamental safety-related role. Remembering that the power generator's output takes the form of a star connection, the star point has a net voltage and current of zero. In practice, the generator's star point is connected to earth via a *"neutral"* resistor.

In the case of the generators used at Killingholme "A", this resistor fills a metal cabinet (see photo), but in older plants the resistor can actually be in liquid form, made from a tankful of potash and capable of handling kilo-amps of current. *However, it should be realised that the only currents which ever flow to earth are* **fault** *currents.*

All exposed metal work, instrument racking, chassis, cabinets and even the metal girders of the power station's buildings are heavily interconnected with straps and bonding wires and also physically connected to the earth. This "ring of steel" ties all of the open metalwork together to form the escape route down which fault currents can flow. It means also that all earthed parts are at the same potential – zero or very nearly so.

If any fault develops in the generator – such as a failure in insulation – then if any part of the exposed metal work becomes "live" there will be an immediate short to

Heartfelt Shock and First Aid

THE HUMAN BODY is a water-filled resistor of approximately 3 kilohms value, and is a good conductor of electricity. Since one side of the mains power supply is grounded, then it is possible to receive fatal electric shocks if your body comes into contact with high voltages – the body will complete a circuit and current will flow through the body back to earth.

The human heart is a muscle which happens to be most susceptible to stimulation at a frequency of 50Hz. Perversely, this is also the frequency of the UK mains supply.

The effects of shock depend on the level of current which flows from a device (and where it flows through the body). Once a certain threshold is reached, you will have no control over the actions of muscles, which means that you may be unable to release your grip on a device and may suffer electrocution.

A list of effects which would arise if you grasped a "live" apparatus or wire is as follows:

1mA	Tingling
9mA	Probably still able to release the device
16mA	Borderline on ability to release the device
20mA	Unable to release the device
16mA to 50mA	Pain, possible unconsciousness. Heart and respiratory functions probably continue.
> 100mA	Heart tremor, asphyxia due to respiratory paralysis. Severe shock and burns. Possible death.

Burns are caused when current passes through the skin tissue, and because of their penetrating action, electric burns can be much deeper than their size might suggest. Extremely serious burns can result from contact with high voltage power lines.

First Aid

In the event of a person receiving a suspected electric shock from the domestic mains supply, you should act quickly and calmly to help the victim, without exposing yourself to the same risk of electrocution.

- Avoid touching the victim if he or she may still be in contact with the mains. Switch off and unplug, or use an insulating wooden pole or wooden chair to push the victim clear of the supply.
- If the victim has stopped breathing, you should apply artificial respiration immediately.
- Then treat burns immediately. Relieve pain and reduce tissue damage by cooling the affected area with plenty of clean cold running water, or apply ice, frozen produce etc.
- Remove any items of a constrictive nature (rings, watchstraps, bracelets) before swelling starts.
- Apply a sterile dressing for protection from infection. Do not apply lotions, creams or ointments nor prick blisters.
- Seek medical attention.

No attempt should be made to help victims of high voltage electrocution unless it is certified that the power source has been completely isolated. See the section *"Leaps and Volts"* for more information.

earth, because the star point is connected to earth as well. The neutral resistor will limit the current and prevent a serious failure.

Although a fault current will now flow, this will be detected by earth fault relays, current transformers, circuit breakers or other devices. In the case of a major generator fault, the neutral resistor is capable of withstanding many tens of amperes for five seconds, at a potential of some 10kV or more.

Ground Force

In the simple example of Fig.17, a generator phase has shorted to an imaginary steel girder, one end of which is connected to earth. It will be seen that the neutral limiting resistor now forms the load for the winding and a fault current will flow down to earth and through the resistor, which limits the current.

In his several days on-site at Killingholme "A", the author saw countless examples of all kinds of earth straps and leads which are designed to ensure high tension fault currents find their way directly to earth. It clearly makes a great deal of sense to make it easy for fault currents to flow through a massive conductor – the ground – and trip a circuit breaker in the process to disconnect the supply. A similar form of protection is used in the home.

Remembering that the power station also uses electricity itself for its own systems, it is interesting to note that even if the worst happened and power was lost entirely, the power station has a Battery Room containing several very large banks of lead-acid accumulators which offer 48V, 110V and 220V d.c., sufficient to power auxiliary equipment for many hours. Safety regulations (danger caused by sparks) prevented any photography in this area.

Greetings, Earth Links

We can draw parallels with the preceding principles to examine the need for earthing at a domestic or commercial installation. The "neutral" wire of a 230V a.c. supply is provided by the star/neutral point of the transformer and is therefore always close to zero volts with respect to the incoming "live". The star/neutral point is also earthed as shown in Fig.14b and Fig.15. A separate good quality metal earth connection usually runs between the installation's earth circuit back to the transformer (e.g. to its metal body, which is also earthed).

The arrangement for domestic/commercial installations is virtually identical to that used by the power station generators to isolate failures in the insulation or other faults. If every piece of exposed non-live metal is earthed, then it will be very easy for "escaping" fault current to flow to earth as well; it will strive to complete the circuit back to the earthed star point of the 415V transformer. In so doing, a massive current will flow which will melt an in-line fuse or operate a circuit breaker. (A separate box out *"Fuses – The Race to Protect"* gives a little more background to domestic circuit breakers and fuses.)

Heated Exchange

Taking the example of an ordinary electric heater (see Fig.18), its metal casing is connected to the earth terminal of the mains plug. Alternating current flows between the live and neutral wires when the heater functions normally.

If a live wire should come adrift within the heater and touch the metal cabinet, then a heavy current will flow to earth which will melt the fuse in the mains plug, thereby disconnecting the supply. Such action prevents the user from being able to touch a "live" metal cabinet and acquire a potential, because he or she could be fatally injured by the fault current flowing through the human body en-route to earth.

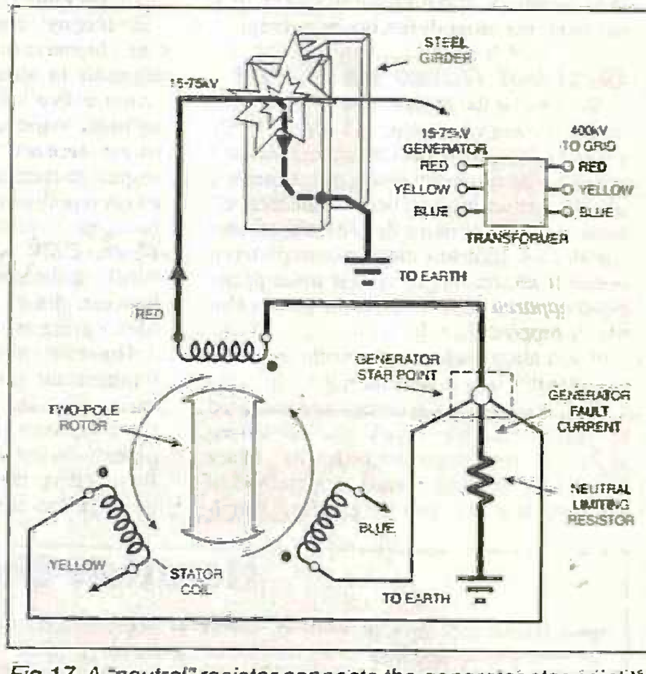


Fig.17. A "neutral" resistor connects the generator star point to the earth to limit any fault currents. Here, the Red phase has shorted to earth, via a steel girder in this simple example.

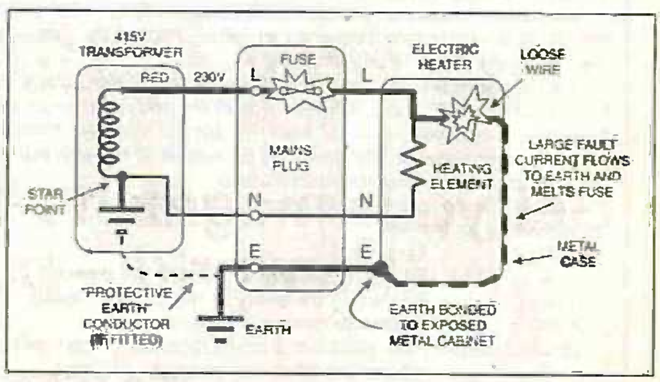


Fig.18. How earthing ensures that any insulation breakdowns will cause a fuse to melt, thereby disconnecting the supply. A large fault current flows to earth, when a loose wire shorts the 230V live wire to earth, via the earthed metalwork.

Fuses – The Race To Protect

Fuses are the "last gasp" and sometimes the only protection found in most domestic electric appliances as well as electronic circuits. A fuse is primarily used in a mains plug-top to oversee the mains cable (power cord) and will "melt" if the cable is severed or damaged, when an excessive current could flow. The fuse is also intended to disconnect the mains supply should an insulation fault, such as a short to earth, arise within the apparatus.

Fuses are the most rudimentary type of over-current protection and rely on a wire melting to interrupt the supply. They offer little protection to human beings in preventing electric shock, other than to disconnect the supply if an overload condition (e.g. a short to earth) occurs.

Old open-type fuses found in some fuseboards contain bare wire which will melt if the rated current is exceeded. However, fuse wire can eventually start to oxidise which may cause premature failure. An HRC (High Rupture Capacity) fuse uses a sand-filled ceramic cartridge to prevent oxidation and also to extinguish the arc. These are typically found in UK mains plugs but larger versions are used in industry. Continental fuseboards use such ceramic cartridge fuses as well.

Electronic equipment often utilises a variety of glass-bodied cartridge fuses: 20mm × 5mm for up to 10A current, whilst larger 32mm (1¼in.) types are produced with ratings exceeding 25A. Some types are anti-surge, meaning that they will not "nuisance trip" when equipment surges during first powered up. *It is always very important that fuses are replaced with the same type, size and rating.* Failure to do so may cause both a fire and an electrocution hazard.

The miniature circuit breaker (or MCB) is a resettable form of fuse or "trip switch" which will act to open the circuit when an excessive current is drawn by the load. The best form of protection though is Residual Current Device or RCD, also known as an earth leakage circuit breaker (ELCB) or Ground Fault Circuit Interrupter (GFCI) in the United States.

These devices "look for" an imbalance between the currents flowing in the live and the neutral wires. If any difference arises, any losses must be due to current leaking to earth, and an RCD will typically trip within 40ms of detecting an earth leakage current of 30mA.

Not to be confused with an MCB, a Residual Current Device offers the best personal protection against electrocution and is a wise investment when using outdoor power tools. Most RCDs now offer "double-pole" protection which disconnects both the Live *and* the Neutral wires to ensure total isolation, and feature a test button. Fuseboards fitted with RCDs are now quite common.

PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

CAPACITORS must rank as just about the simplest form of electronic component, and a capacitor is basically just two metal plates with a layer of insulation in-between. The insulating layer is called the dielectric.

Practical components are usually in the form of two strips of thin metal foil interleaved with two strips of plastic foil. The strips are rolled or folded up to produce small components that have a large plate area. This enables high values of capacitance to be condensed into small physical volumes.

Although capacitors are fundamentally quite simple, they seem to cause more confusion than all other types of component combined. Supposedly, the reason for this is that there are so many different types available. If you look in one of the larger component catalogues for a 1nF capacitor you will probably have about 15 to 20 components of this value to choose from! So how do you select the right one?

Square Pegs Into . . .

When dealing with capacitors you have to take into account the physical characteristics of the components as well as their electrical ratings. Capacitors come in a variety of shapes and sizes, and it might be impossible to fit a component into the available space on the circuit board if you do not choose carefully. Taking a 1nF capacitor as an example, they are readily available in printed circuit mounting versions with various lead spacings, axial versions, and even leadless surface mount versions.

Printed circuit mounting (pcm) capacitors are usually box-shaped components, but they are sometimes disc-like, cylindrical, or even globular in appearance. Whatever the shape, they have what are usually very short leadout wires emanating from the same side of the component. This makes it easy to fit the capacitor onto a printed circuit board, but only if the spacing of the leads matches that of the corresponding holes in the circuit board.

With the early printed circuit mounting capacitors any attempt to manoeuvre them into a layout having the wrong lead spacing usually resulted in one of the leads breaking off. Modern capacitors of this type are much tougher, but it still pays to be very careful when dealing with the open construction type. Due care needs to be exercised when soldering them in place, since the heat from the iron tends to weaken the joints that hold the leads in position.

The types that are encased in plastic are much tougher, and can usually be manipulated into place without too much difficulty. However, this is only likely to work if you are moving up or down by 2·5mm (0·1in.). Using components having the wrong spacing gives physically weaker results and could compromise reliability.

Axial capacitors are tube-shaped components with a leadout wire at each end, like ordinary resistors. It is sometimes possible to fit an axial component in place of a printed circuit mounting type, but it may be necessary to mount it vertically. This again gives a physically weak construction and is best avoided.

Printed circuit mounting capacitors are unlikely to fit into a layout intended for axial components. It can sometimes be achieved with the aid of soldered-on extension leads, but this type of thing gives scrappy looking results and very poor reliability. This is all right as a stop-gap solution to get a project "up and running" until the proper component can be obtained, but it is not viable as a normal construction method.

Modern component layouts tend to be quite compact, and the amount of space available for each component is usually very limited. The fact that a capacitor has the right lead spacing or the required axial case style does not necessarily mean that it will fit into the layout. Particularly with axial components and the higher value printed circuit mounting types, there are enormous variations in size.

Some capacitors have an overall length that is about the same as the lead spacing, while with others the overhang at each end is so great that they are about 50 per cent longer than the lead spacing. If space on the circuit board is limited it is advisable to check the maximum dimensions of the capacitors in the component catalogue, and to make some measurements to check that they will fit into the layout.

Foiled Again

Having found a capacitor that will fit into the layout correctly, how do you know whether or not it is suitable electrically? The components list should give some basic guidance, and for any out of the ordinary capacitors it should be specific.

In components lists and catalogues you will normally find capacitors referred to as something like "ceramic", "Mylar", or "polyester". This is the material used as the dielectric. The best dielectric depends on the application for the capacitor.

Ceramic capacitors operate well at high frequencies, but their tolerance ratings are usually quite high and their values can change quite dramatically with changes in temperature and the passage of time. Capacitors having a plastic foil such as polyester or Mylar are generally more accurate and stable, but do not work efficiently at very high frequencies. Silvered mica (also known as just plain "mica") capacitors are used where the ultimate in stability is required, but these are only available at low values of up to about 1nF.

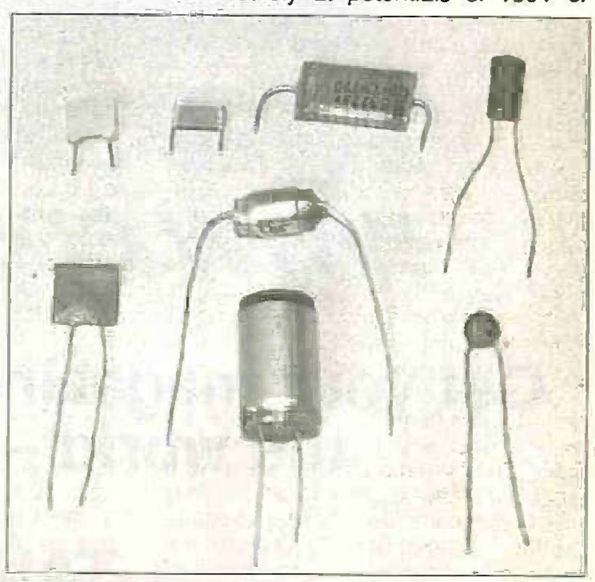
Letters from readers having problems with projects sometimes point out that certain capacitors they are using are not the correct type, and query whether this could be the cause of the problem. Using capacitors of the wrong type is definitely not a good idea, but it is unlikely to prevent a project from working at all.

If a filter requires expensive plastic foil capacitors having a tolerance rating of 5 per cent, but you use lower quality plastic foil or ceramic components, it will still work after a fashion. However, the filter frequency could be well away from the required figure and there could be other anomalies in the frequency response obtained.

If plastic foil capacitors are used instead of ceramic types the circuit could operate inefficiently, and in some cases there is a risk of it becoming unstable. If a radio design requires mica capacitors but inexpensive ceramic plate capacitors are used instead, the frequency coverage could be incorrect, and the tuning could drift.

In many circuits the exact type of capacitor used is not critical, but unless you know exactly what you are doing it is best to use only the specified type. If an unusual capacitor is required the components list should make this clear, and there will probably an explanatory note somewhere in the article as well.

For example, most capacitors can work safely at potentials of 100V or



Eight varied types of capacitor of 1μF or so in value. The disc ceramic one (bottom right) is physically the smallest, but has the highest value.

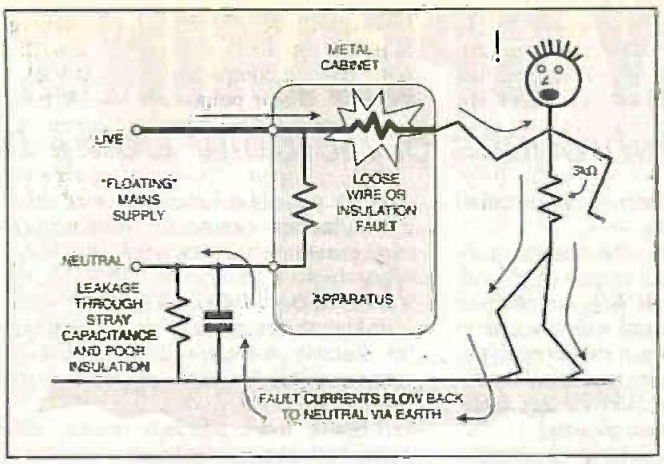


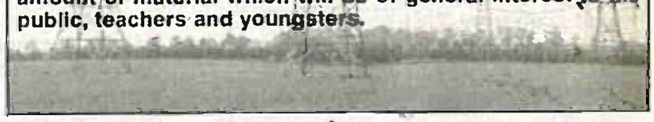
Fig.19. A "floating" (unearthed) supply can still give rise to electrocution risks caused by stray capacitance or poor insulation completing a path back to neutral. *(Adapted from Guide to IEE Wiring Regulations (15th Edition) – J. F. Whitfield.)*

Acknowledgements

The author is extremely grateful to those at National Power Killingholme "A" without whose assistance this article would not have succeeded in its objective of exploring the world of electricity from pipelines to pylons. Thanks again to Station Manager Keith Ulyett and Richard Power for their valuable and enthusiastic support. The National Grid PLC kindly permitted reproduction of several photos.

Several readers contributed technical information to this feature when the subject of mains earthing was raised in our *Circuit Surgery* (Oct. 1997) pages. The author is grateful to I. J. Goldfinch, B. J. Taylor and R. H. Ogilvie for their input.

Internet users can view the National Power PLC web site at www.national-power.com. The National Grid web site at www.ngc.co.uk offers more background information, data, real video clips and more! The web site of the Yorkshire Electricity Group at www.yeg.co.uk contains a considerable amount of material which will be of general interest to the public, teachers and youngsters.



There is a counter-argument which states that if no earth were installed, then even if a human being *did* accidentally touch a live terminal, no ill effects could arise because there would be no reason for current to flow through the body to earth. The body would merely be "floating" at the live voltage but no potential difference would exist across him or her, and no harm would be done.

Anyone who has suffered at the hands of a very cheap open-type mains transformer will know that standards of electrical insulation are sometimes less than 100 per cent, and leakage currents can occur. This means that the earth (or, say, the chassis of an apparatus) could still *not* be completely isolated from the supply even if the supply has no *apparent* direct connection to earth and is supposed to be "floating". Poor insulation allows a leakage current to flow given a suitable opportunity.

There are other ways in which the earth can form a return path for fault currents, even if the supply is supposed to be "floating". As IEE guidelines state, electrical insulation can itself be thought of as a capacitor dielectric, with the live wiring forming one "plate" and the earth forming the other.

This *stray capacitance* could form an adequate route for an a.c. fault current to pass, should a human body accidentally contact a live wire (see Fig.19). There is thus the prospect of receiving an electric shock from earth fault currents even if it is thought that the mains supply is floating and supposedly unearthed.

In Shock

Still on the subject of accidental electrocution, the human body, being full of water, is the walking equivalent of a 3 kilohm resistor and it only takes a current of 20mA to pass through a muscle to cause uncontrollable spasms and render the body unable to release a live wire. A separate box out entitled *"Heartfelt Shock"* explains some things about the human body and its reaction to electric shock, and there is also some useful first aid advice to help with cases of suspected electrocution.

There are various earthing configurations permitted under the UK Institute of Electrical Engineers' Wiring Regulations, but how earthing is achieved in an installation depends on whether the incoming supply is via undergrouod cables or from an overhead supply. Due consideration is also paid by installers to the method by which earthing has been implemented in the locality by the supply authorities.

It should be again emphasised that the domestic electricity supply should NEVER be interfered with except under expert guidance. □

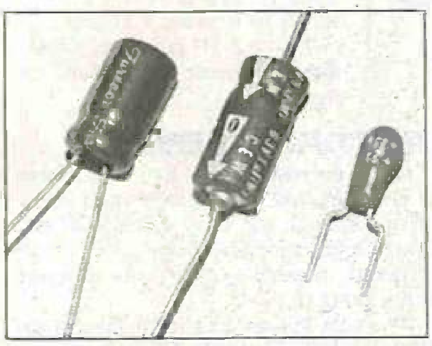
more, whereas most circuits operate at 15V or less. Consequently, maximum operating voltages are not always specified in component lists because they are irrelevant. If a circuit requires a high voltage capacitor then the operating voltage will be specified, and there will probably be a warning note in the text of the article as well.

High Values

Ordinary capacitors are only available in values of up to about 1µF or so. Higher values tend to be rather bulky and expensive to manufacture. Many circuits do actually require higher values though, and these values are available in the form of polarised capacitors.

By far the most common form of polarised capacitor is the *electrolytic* type. Internally an electrolytic capacitor is not much different to a plastic foil type, and it mainly differs in that the dielectric is in the form of a paper like material impregnated with an electrolyte. This enables small components having values of hundreds or even thousands of microfarads to be produced at low cost.

Unlike ordinary capacitors, the electrolytic variety only works properly when supplied with a d.c. potential of the correct polarity. You therefore have to be careful to connect them the right way round. If an electrolytic capacitor is connected with the wrong polarity the circuit will probably fail to work and in many cases there will be a real danger



From left to right, radial electrolytic, axial electrolytic and tantalum capacitors. Although it has a value of 22µF, the tantalum has a maximum diameter of just 3mm.

of a high current flowing and the capacitor literally exploding.

Always be careful to fit electrolytic capacitors with the correct polarity, especially when dealing with high value components. The polarity is indicated by "+" and (or) "–" marks on the components themselves, and on the layout diagrams. With the axial versions there is also an indentation around the end of the body that has the positive leadout wire.

As pointed out previously, maximum operating voltage is not normally a consideration when dealing with capacitors. The situation is different with electrolytic capacitors though, as they often have quite low maximum voltage ratings. Component lists, therefore, usually indicate a suitable "working" voltage rating for each electrolytic capacitor.

From the electrical point of view there is no problem in using a component having a *higher* voltage rating than the one specified. Physical size is again an issue here though, and higher voltage rating normally translates into increased bulk. An electrolytic capacitor having a grossly excessive voltage rating is likely to be far too big to fit into the available space on the circuit board.

Making the Grade

There are alternatives to electrolytic capacitors, but the only common one is the tantalum variety. These are also known as "tantalum beads", due to their round and bead-like appearance.

Electrolytic capacitors provide high values in small physical volumes, but they tend to have high tolerances, high leakage currents, poor high frequency performance, and poor stability. Tantalum capacitors, on the other hand, offer much better performance, but at what is usually a much higher cost.

Like electrolytics, the tantalum variety is polarised and must be connected the right way round. Tantalum capacitors are very intolerant of polarising voltages of the wrong polarity, so be very careful to fit them the right way round.

Most component catalogues now list some superior grade electrolytic capacitors that give improved performance over "bog standard" components. If a component list specifies a tantalum component or an "improved" electrolytic type it is essential to use a high quality component here.

Sometimes an ordinary electrolytic capacitor will not work in place of a superior grade component or a tantalum capacitor. A timing circuit may fail to time-out, or a low frequency oscillator might fail to oscillate. In a less extreme case operation may be erratic, with a timing circuit producing elongated and variable delay times.

If a superior grade electrolytic is needed for a switch-mode power supply there is a risk of the circuit coming to expensive grief if a cheap electrolytic is used instead. If a high quality capacitor is specified in a component list, it has been specified for a reason.

Some polystyrene capacitors look as though they are polarised, because they have one end of the body tinted red (sometimes yellow). In some high frequency circuits it is better if the component is connected one way round or the other, and this is where it would not be a good idea to have the outer plate of the capacitor connected to a sensitive part of the circuit. These capacitors are not polarised though, and in most circuits they can be connected either way round.

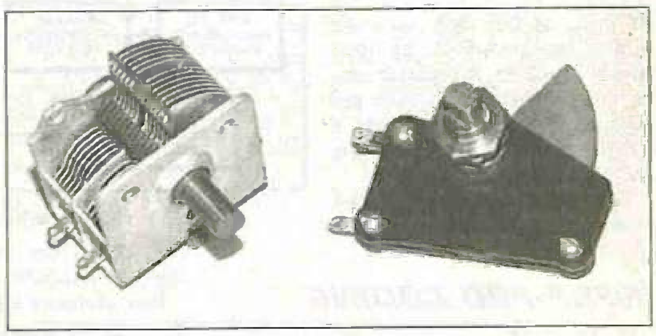
Variable Capacitors

Variable capacitors are little used outside the realm of radio where they act as the tuning controls for radio receivers, signal generators, and so on. Strictly speaking a variable capacitor has two values, which are its *maximum* and *minimum* values. In practice it tends to be only the maximum value that is specified. The values available are quite low, and 500pF is the highest value you are likely to encounter.

There are two main types, which are the air-spaced and solid dielectric varieties. Air-spaced variable capacitors are the most expensive, and use air as the dielectric. There are two sets of metal vanes, one fixed and one that can be rotated via the spindle. Moving the rotating vanes into the fixed ones increases the capacitance of the component, and separating them reduces the capacitance.

It is essential to use the "kid glove" approach with air-spaced capacitors since the slightest distortion of any vane is likely to cause a short circuit at some settings of the component. Some careful straightening will usually redeem the component, but could significantly change its value.

Solid dielectric capacitors are much the same as air-spaced components, but have thin sheets of plastic to ensure



The fixed and moving vanes can be clearly seen on the air-spaced component (left). The variable capacitor on the right is a large solid-dielectric type.

that the two sets of vanes cannot short-circuit. This makes it possible to produce smaller and cheaper components, but with reduced stability. It is tempting to use a cheap solid dielectric variable in place of an air-spaced type, but results are likely to be poor.

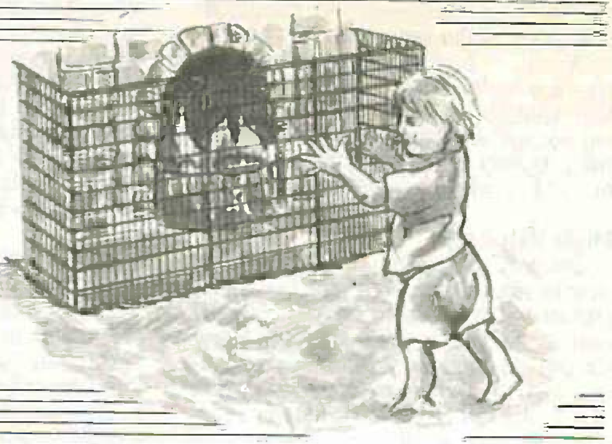
Read the "fine print" before buying one of the very cheap solid dielectric variable capacitors. Some of these have very short spindles of a non-standard diameter.

There are preset versions of variable capacitors, or "trimmers" as they are often called. Some are basically just scaled down versions of variable types.

Compression trimmers are a form of solid dielectric variable capacitor, where the vanes are made from a springy metal. By adjusting a screw the vanes can be forced closer together to give increased capacitance.

Trimmers vary greatly in size and shape, and it will usually be necessary to seek out the exact component specified in the component list. Otherwise physical considerations may make the component unusable.

Constructional Project



CHILD GUARD

TOM WEBB

Provides an audible warning if children (and others) approach a fire.

CHILD Guard is a design intended to help prevent young children from burning themselves. It does so by means of an audible warning if the child approaches a hot fire. The circuit may be used with any equipment designed to produce heat, e.g. electric, gas or coal fire.

The design produces a coded infra-red beam which detects the proximity of a person by bouncing infra-red off them as they approach, yet without being confused by other infra-red sources. A separate sensor detects the random infra-red radiation being emitted from a hot fire. If anyone approaches the fire, a warning buzzer sounds.

The block diagram in Fig.1 shows how the circuit is split up into separate sections.

INFRA-RED CODING

A system based on a *continuous* infra-red signal would not work in this application, since the receiving circuit would be heavily influenced by stray background infra-red emission from lights etc. A coded infra-red signal is better since the receiver can be set up to respond to a specific code.

There are a number of encoding and decoding devices available but two from Holtek are used for this circuit. An HT12B transmitter encodes the signal and adds a 38kHz carrier signal for greater reliability. A separate demodulating sensor detects the coded signal and provides a clean output waveform with the 38kHz carrier removed. An HT12D receiver then decodes the signal to give a steady output.

The HT12B and HT12D devices were discussed in detail in the *Reliable Infra-Red Remote Control* article in *EPE* October '98, to which readers are referred for more detailed information.

CIRCUIT DIAGRAM

The complete circuit diagram for the Child Guard is shown in Fig.2.

The circuit around transmitter IC6 is designed to produce the coded infra-red beam. The 455kHz oscillation frequency required by IC6 is generated across pins 15 and 16 by the ceramic resonator X1, in conjunction with resistor R15 and capacitors C6 and C7.

The HT12B allows for a binary code of between 0 and 255 to be set via its pins A0 to A7. The pins are internally biased high but any may be taken to the 0V line to set a different code. In this application, only pins A0 and A1 are connected to the 0V line.

The D_{OUT} pin provides the coded output superimposed on a 38kHz carrier signal.

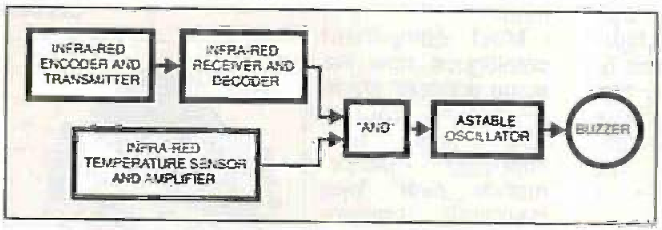


Fig.1. Block diagram for the Child Guard.

This drives the infra-red diode D5 via Darlington transistor TR3.

Potentiometer VR3 is in series with D5, allowing the transmission power to be varied. Ballast resistor R16 prevents a power supply short circuit through D5 and TR3 when VR3 is set to minimum resistance.

Infra-red detector IC4 only responds to infra-red signals that are modulated by a 38kHz carrier signal. When it detects a signal having this frequency, it outputs it to transistor TR1, via resistor R8, which inverts and supplies it to the decoder IC5.

The code to which IC5 responds is set by its pins A0 to A7. Since pins A0 and A1 on the transmitter (IC6) are connected to 0V, the same pins on IC5 are also connected to 0V.

When IC5 receives a correctly coded signal, its pin 17 (VT) goes high. This causes transistor TR2 to conduct, which turns on the reed relay (RLA) and l.e.d. D4. The high output from IC5 pin 17 also causes capacitor C5 to charge up, to provide a delay before TR2 turns off again following the end of the signal from IC5. This ensures that the relay does not go on and off too quickly. Diode D2 prevents C5 discharging into the VT pin.

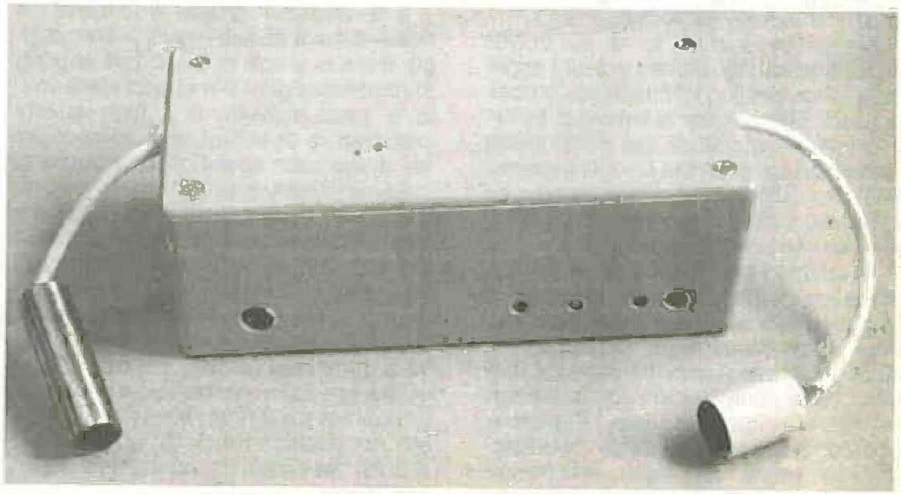
Resistor R10 sets the oscillation frequency for IC5 to the required rate of 150kHz. The value is chosen to suit a power supply of between 4·5V and 5V.

The l.e.d. D4 is used to indicate that the circuit has received the signal.

HEAT/FIRE SENSOR

When the reed relay is turned on, power is now supplied to the temperature sensor circuit through the relay contacts RLA1. Power is conserved by keeping this circuit switched off when a coded infra-red signal is not being received.

Two heat sensors are used in this circuit, IC1 and IC7. They are TSL260 devices, chosen because they are sensitive to lower frequency infra-red, in the spectral range of 350nm to 1050nm, such as that radiated from hot fires. The intention of allowing for two heat sensors is in case there are two heat sources to be watched.



Completed Child Guard with two heat sensors.

The heat sensor outputs are jointly fed to the op.amp comparator stage formed around IC2a and IC2b. The bias voltage at the non-inverting input of IC2b is controlled by preset VR1, which is used to compensate for differences in d.c. output from the sensors. Preset VR2 adjusts the op.amp's gain.

The output from IC2b feeds into IC2a, which acts as an inverting comparator. When the voltage at pin 2 reaches the threshold voltage set on its pin 3 by resistors R3 and R4, the output from pin 1 switches from almost +5V to almost 0V. This triggers the astable IC3, which now starts oscillating, causing warning beeps to be output from the buzzer, WD1.

The output frequency of IC3 is set by the components on its pins 2 and 6. Capacitor C1 charges up through a small value resistor, R5, and then discharges through a larger value resistor, R6. Diode D1 allows the capacitor to charge up quickly, bypassing R6, but discharge slowly via R6. This causes an uneven mark-space ratio so the buzzer (an "active" type) generates a short beep with a big pause, to reduce irritation to the user.

The beep length is calculated as $0{\cdot}7\times100k\Omega\times4{\cdot}7\mu F=0{\cdot}329$ seconds. The pause length is calculated as $0{\cdot}7\times1M\Omega\times4{\cdot}7\mu=3{\cdot}29$ seconds.

ALTERNATIVE PIR OPTION

The use of a passive infra-red sensor (PIR) is another option if you want the device to be triggered more easily, detecting the motion of someone moving near to it. The PIR's own normally-closed internal relay contacts are wired to transistor TR2 via resistor R11. When the PIR detects motion TR2 is turned on, activating relay RLA and its contacts.

Note that R11 is only required if a PIR detector is fitted – **if a PIR is not included it is essential to omit R11.** It is assumed that the PIR contacts are normally-closed, hence TR2 is normally switched off. When the proximity of someone is detected, the contacts open and TR2 is switched on, due to the current flowing via resistors R11 and R12.

If a PIR is used, IC5 is not required (nor

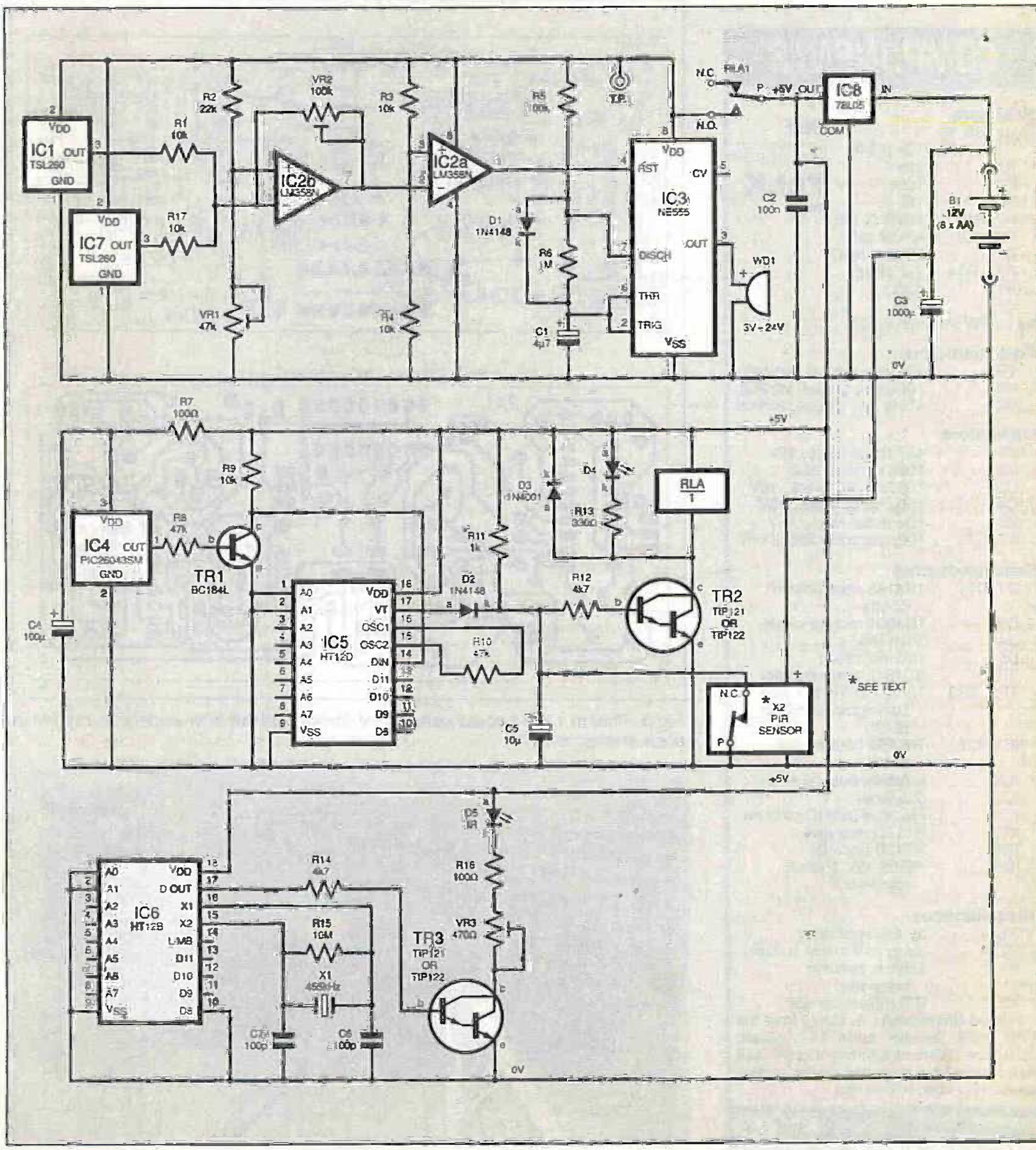


Fig.2. Complete circuit diagram for the Child Guard. The optional PIR sensor is shown in-circuit and is designated X2.

can it be used), i.e. the PIR is an *alternative* to the other infra-red detection circuitry. Consequently, IC4, IC5 and IC6 and all their associate components should be omitted in this application.

POWER SUPPLY

Power to the Child Guard is intended to be from a 12V battery. This is suited to powering the PIR sensor if used. The battery supply is regulated down to +5V by IC8 to suit the rest of the circuit.

Since the standby current is 10mA and the "on" current is 50mA, a battery pack containing eight AA-size 1·5V cells could be used. A 12V d.c. mains adaptor is a suitable alternative. Typically, the latter can supply 300mA.

If a PIR is not used, a lower voltage supply source may be used, such as a 9V battery. Alternatively, a d.c. power supply of 5V (4·5V) could be used by inserting a wire link in the place of IC8.

Note that IC5 and IC6 ***must not*** be supplied with a voltage greater than +5V.

C2 and C3 are decoupling capacitors to help smooth the supply lines.

CONSTRUCTION

Apart from the two temperature sensors, all the components are contained on a single printed circuit board (p.c.b.). The topside component layout and full size underside copper foil track master are shown in Fig.3. This board is available from the *EPE PCB Service*, code 241.

Begin construction by soldering in the resistors and wire links, noting that one link is under the socket for IC2 and another under the buzzer WD1. Ensure that the electrolytic capacitors (C1, C3, C4, C5), transistors, diodes and the buzzer are connected the right way around. Note that on the IR diode (D5) the long leg may be the cathode (k) – check with your component supplier's catalogue. Do not insert the dual-in-line i.c.s until construction has been completed and fully checked.

If a PIR sensor is not being used then R11 must be omitted. If a PIR is being used then be sure to connect its power pins to the +12V supply rather than the +5V regulated supply. Four-core wire can connect the PIR sensor to the circuit.

COMPONENTS

See SHOP TALK page

Resistors

R1, R3, R4, R9, R17	10k (5 off)
R2	22k
R5	100k
R6	1M
R7, R16	100Ω (2 off)
R8, R10	47k (2 off)
R11	1k (see text)
R12, R14	4k7 (2 off)
R13	330Ω
R15	10M

All 0·25W 5% carbon film.

Potentiometers

VR1	47k min. preset, vertical
VR2	100k min. preset, vertical
VR3	470Ω min. preset, vertical

Capacitors

C1	4μ7 radial elect., 16V
C2	100n ceramic disc
C3	1000μ radial elect., 16V
C4	100μ radial elect., 16V
C5	10μ radial elect., 16V
C6, C7	100p ceramic disc (2 off)

Semiconductors

D1, D2	1N4148 signal diode (2 off)
D3	1N4001 rectifier diode
D4	5mm red l.e.d.
D5	infra-red diode
TR1	BC184L *npn* transistor
TR2, TR3	TIP122 or TIP121 *npn* Darlington transistor (2 off)
IC1, IC7	TSL260 heat sensor (2 off)
IC2	LM358N dual op.amp
IC3	555 timer
IC4	PIC26043SM IR receiver
IC5	HT12D decoder
IC6	HT12B encoder
IC8	78L05 +5V 100mA regulator

Miscellaneous

RLA1	5V SIL reed relay
WD1	3V to 24V active buzzer
X1	455kHz ceramic resonator
X2	PIR motion sensor

Printed circuit board, available from the *EPE PCB Service*, code 241; plastic case, size 130mm x 64mm x 42mm, (see text); single-hole insulated power socket; connecting wire; solder, etc.

Approx. Cost Guidance Only £30 excl. PIR Sensor & Case

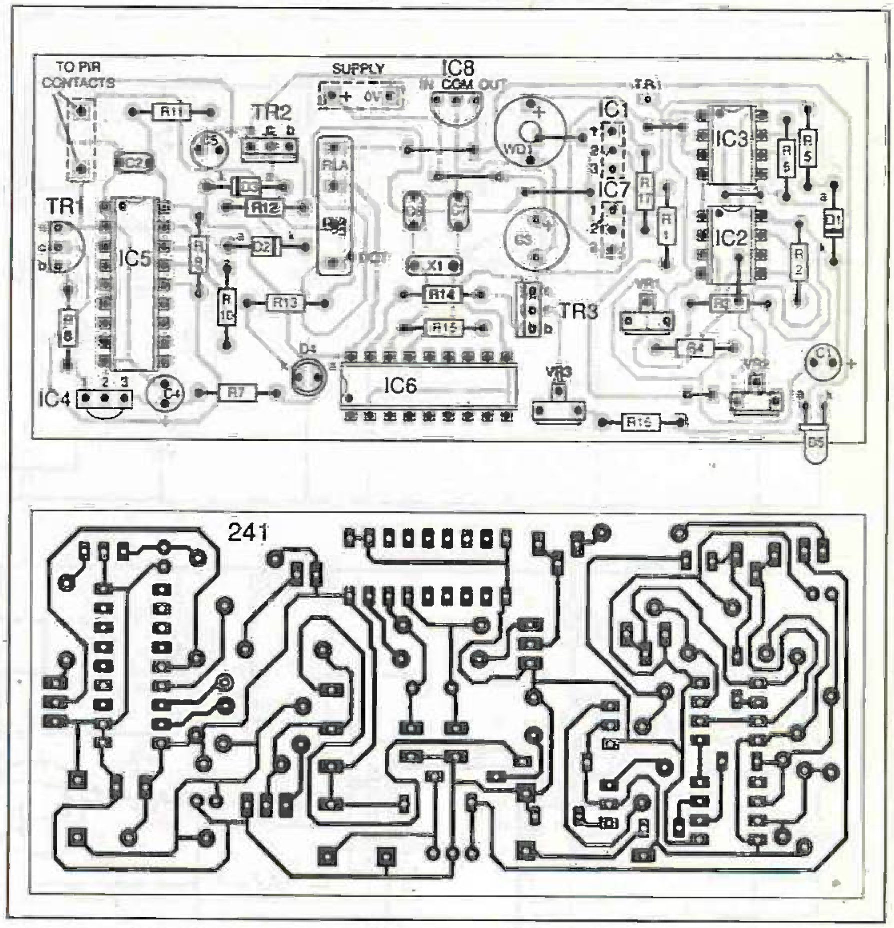
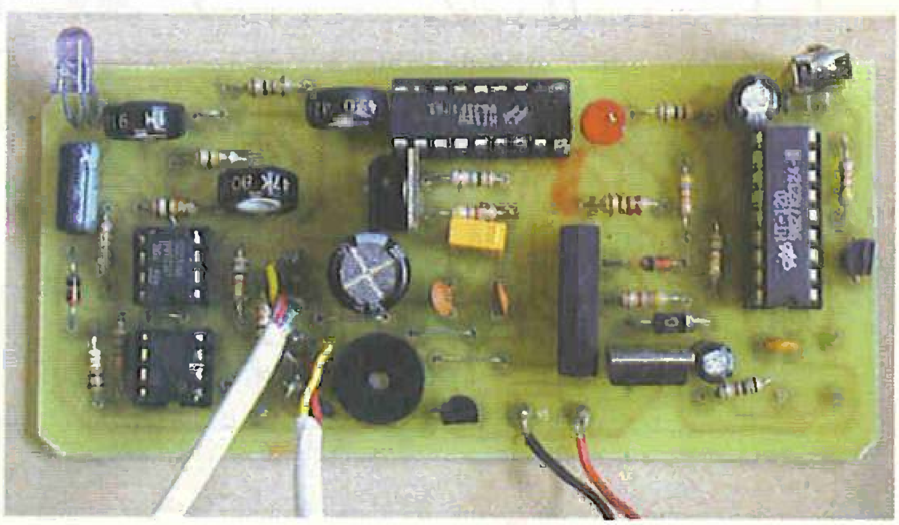


Fig.3. Printed circuit board component layout and full size underside copper foil track master pattern.



Components mounted on the prototype circuit board.

The IR receiver IC4 has a "dome" on its sensitive side, this faces outwards from the p.c.b.

Ultimately, if it is found that the beam from the IR transmitter, D5, is being detected by the IR receiver, IC4, through stray reflection inside the case, the transmitter and receiver devices could be partially surrounded by Blu-Tack, or even a small tube could be used.

CASING

A metal box should be used if the device is to be positioned very close to the heat source, but otherwise a plastic case is suitable. If using a metal case, the p.c.b. should be mounted so that it cannot come into contact with it, which could cause a short circuit across the copper tracks.

Drill holes in the case to suit the positions of the IR receiver and IR diode. Suitable holes are also needed for the power supply input, and the cables to the heat sensors. Additionally, three holes in the case are required to allow adjustment access to the three preset potentiometers, using a small screwdriver.

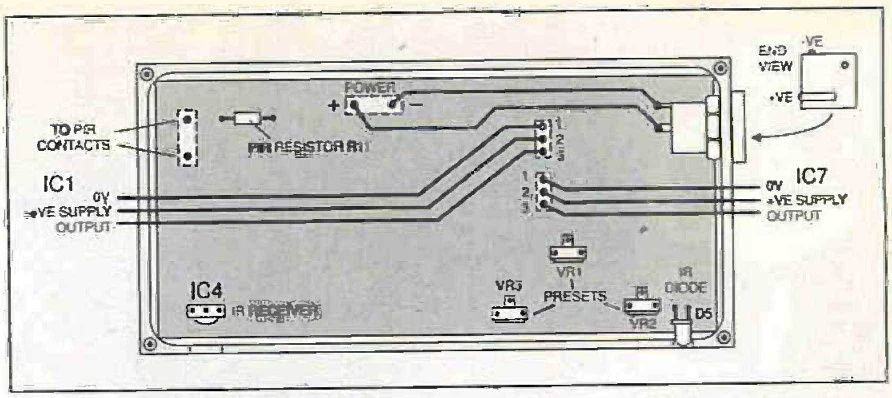


Fig.4. Child Guard p.c.b. and its connections within the case.

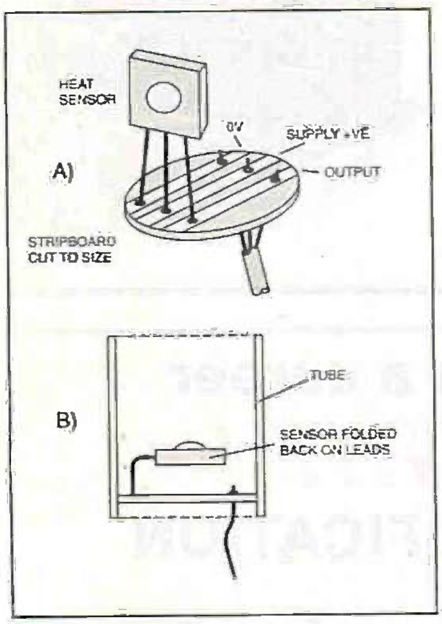


Fig.5. Suggested assembly technique for the heat sensors.

It is advisable to use an input socket for the power supply, plus a switch, although the latter was not used on the prototype. Suitable holes for these should also be drilled. All holes should be drilled accurately to correspond with their respective components.

Position the p.c.b. so that the IR receiver and diode are as close as possible to their case holes, as shown in Fig.4, to prevent any loss in range.

You can either have the heat sensors mounted on the outside of the box or in a separate box attached to 4-core wire. This enables two separate heat sources to be detected.

The heat sensors are each mounted on small pieces of stripboard, as shown in Fig.5a. Since they could receive interference from surrounding lights, causing the circuit to be active all the time, they need to be partially enclosed. One option is to surround them by a metal tube, otherwise a piece of plastic tube may be used if it is covered by some white insulating tape.

The stripboard should be cut to the right size to fit into the tube. Construction of the sensor tubes is shown in Fig.5b. Use small-diameter 3-core cable to attach the sensors to the circuit (or use 4-core cable and trim off the fourth wire at each end).

TESTING

The first check is to make sure voltage regulator IC8 is the correct way round. Connect the circuit to the battery and then check that +5V is present on the output pin of IC8. If it is, disconnect the power and then insert the remaining chips, correctly orientated.

Testing of the infra-red modules presents a problem as if one does not work then the other will seem not to be working as well. If in doubt use a voltmeter or oscilloscope as follows:

Test the voltage on the VT pin (pin 17) on IC5 (receiver). It should be normally at 0V but change to about 5V when a signal is received. If the VT test fails then check that IC4 is fitted the right way round, with its "dome" facing the outside edge of the p.c.b.

Now check three voltages on the pins of IC4. Pin 3 should be +5V and pin 2 at 0V. When a signal is not received, pin 1 (the output pin) should be at just under 4V. When a signal is received this voltage should fall by about 1V.

Note that as the signal is oscillating, a voltmeter provides a rather approximate guide to voltage. If an oscilloscope is available it should be possible to view the encoded signal, in which case the trace will rise and fall between 4V and 0V.

If this test fails then try sending a signal from a TV remote control unit. The signal will not be decoded, but you will at least know if the receiver device is working, and hence determine if the fault lies in the transmitter or the receiver, or both.

If the output from IC4 is working, test the signal at the Data In (pin 14) of IC5. It should be at about 0V when no signal is received, rising to about 1·3V on a voltmeter when a signal is being received. An oscilloscope will show that the signal actually pulses to about 5V.

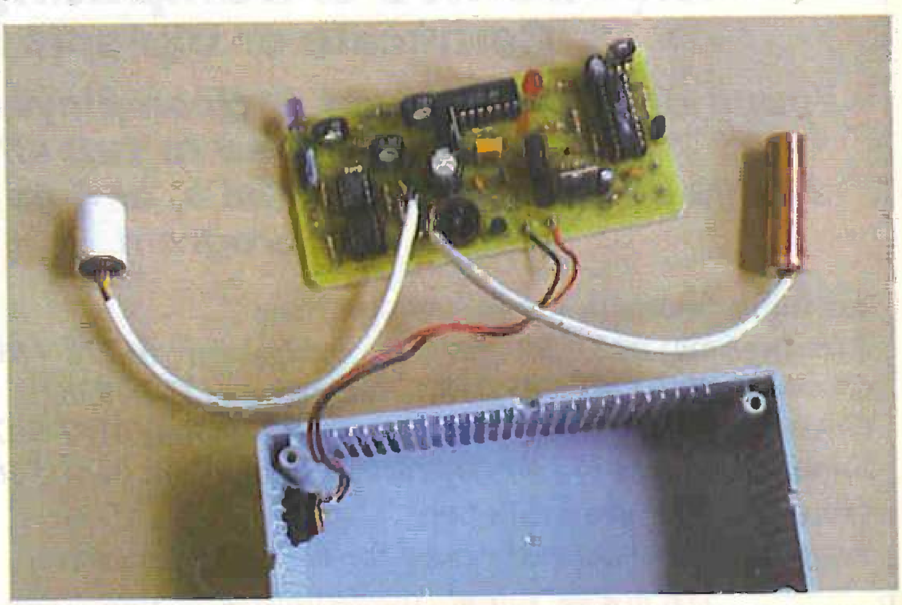
If the VT pin on the receiver is working then simple voltmeter tests should establish the position of any other faults.

While testing the temperature sensing part of the circuit, connect the +5V supply to test point TP1, as this will give that part of the circuit a constant +5V supply, rather than being cut off by the reed relay whenever you move out of the range of the infra-red beam. Use a torch to provide a source of infra-red to the sensors.

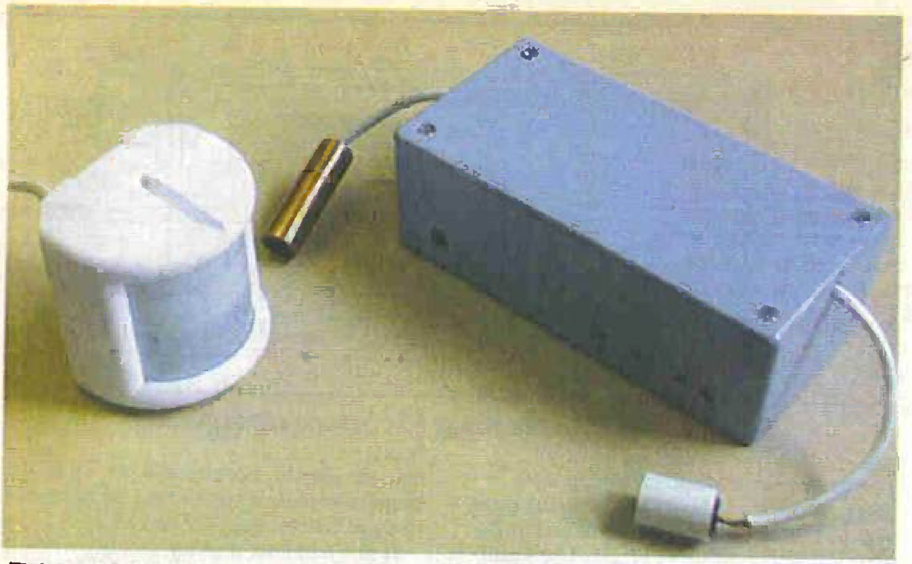
SETTING-UP

All the presets can be adjusted to suit the user's own particular needs. The following is a summary of their functions:

VR1 is in a potential divider circuit which sets the voltage at which the comparator (IC2a) is triggered. Reducing the resistance lowers the voltage being looked



Completed Child Guard showing the heat sensors and power socket wired to the p.c.b.



Finished Child Guard together with a miniature PIR Sensor. The heat sensors are encased in tubes. Note the holes for setting the presets and the transmitter/receiver "windows".

for, which increases the sensitivity. Note that if the resistance is lowered too much, the circuit will pick up background IR radiation.

VR2 sets the feedback resistance for op.amp IC2b, thus setting its gain. If the resistance is increased, the gain is increased, along with the sensitivity. If the reistance is increased too much, the circuit will pick up background radiation.

VR3 adjusts the range of the infra-red beam by decreasing or increasing the power going through IR diode D5. Reducing the resistance extends the range.

COMMON PROBLEMS

Typical construction mistakes include dry joints and bridged pads i.e. adjacent pads accidentally joined together with solder. Other potential problems might include failure to insert wire links, especially the one under IC2 and the buzzer.

Also check that the components are correctly placed, and the correct way round. Note again that some IR l.e.d.s are unusual in that the longer lead denotes the cathode.

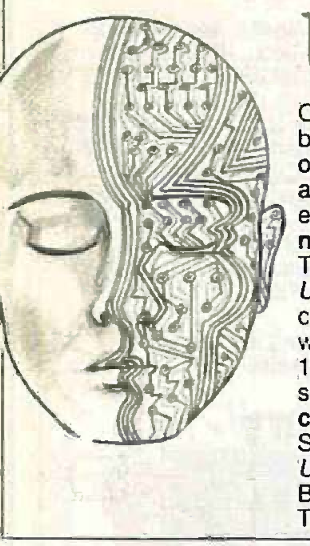
If the PIR sensor is not working, then check that you have connected it to the 12V supply.

IN USE

The system can be used in many ways, but the main intention is to give a parent a warning if their child approaches a heat source, such as a fire. It is especially useful if they have inquisitive babies who are beginning to walk.

Another use could be to warn blind or partially sighted people if they are about to touch something dangerously hot, such as a stove.

The Child Guard could be placed above the heat source (e.g. fire) to be monitored, with both sensors facing it, and the IR diode or PIR detector facing into the room. Another location could be above a stove, this time with the heat sensors pointing towards the hobs. □



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Theatrical Cue Light – In the Spotlight

THE CIRCUIT diagram presented in Fig. 1 will provide a simple but effective means of communication between a theatre stage manager and lighting operator so that the stage manager can "cue" lighting changes. The stage manager controls the "Master Station" and the lighting operator has a "Slave Station". Both stations have a red and green l.e.d. and a pushswitch and are linked by three-core cable.

Communication is initiated when the stage manager presses the "Call" or "Master" pushswitch S2. The red l.e.d.s on both units flash, warning the lighting operator that a lighting change is pending. This "Standby" call must be acknowledged – the operator presses the "Slave" pushswitch S3, and the red l.e.d.s become steady.

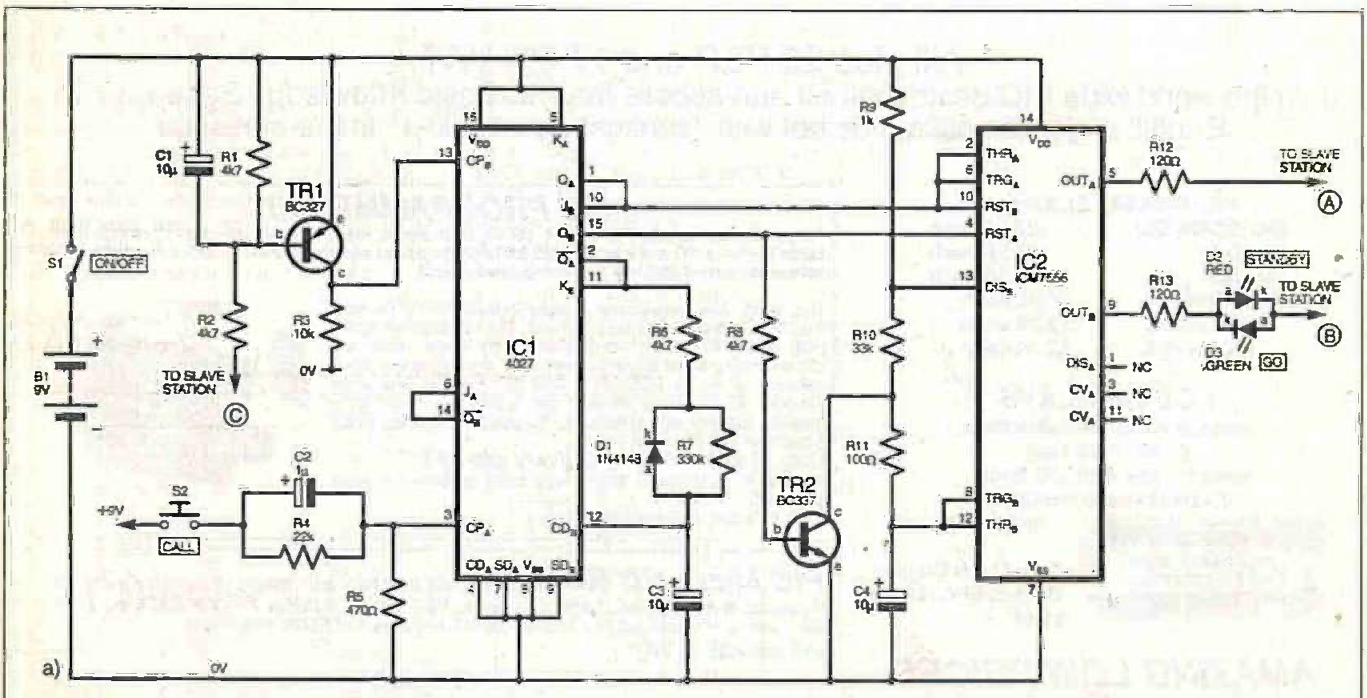
An unacknowledged call may be cancelled by a further press on the "Call" switch. When the lighting change is required, the stage manager presses the "Call" switch again. Both red l.e.d.s extinguish and the green l.e.d.s light to give a "Go" cue.

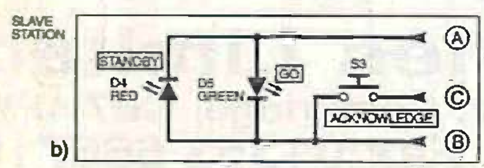
To reset the system ready for further cues, the "Slave" switch is pressed; however, a timer has been incorporated to perform the reset approximately three seconds after the "Go cue" has been issued.

The main circuit is, essentially, a state machine; each state is determined by the two JK flip-flops within IC1. Table 1 explains each state; the order shown depicts normal use with alternate presses of the Master (S2) and Slave (S3) switches. If the Master switch is pressed during state 2, the system will return to state 1.

Flip-flops IC1a and IC1b are clocked by the Master and Slave Station switches respectively. The former is debounced by capacitor C2 and resistors R4 and R5. The Slave switch S3 simply shorts the 'B' and 'C' interconnections; when closed, transistor TR1 will conduct providing a high clock pulse for IC1b. Capacitor C1 removes unwanted spikes when the red l.e.d.s are flashing.

The flip-flops are connected so that their state preceding a clock pulse depends upon the state of their partner. When IC1b is reset, IC1a works in toggle mode, changing state





STATE NUMBER	IC1 Q_A	IC1 Q_B	IC2 OUT_A	IC2 OUT_B	L.E.D.S
1	LOW	LOW	0V	0V	BOTH OFF
2	HIGH	LOW	0V	FLASH	RED FLASHING
3	HIGH	HIGH	0V	+9V	RED STEADY
4	LOW	HIGH	+9V	0V	GREEN STEADY

Fig.1. Circuit diagram for a Theatrical Cue Light.

with every clock pulse. When IC1b is set, IC1a will reset when clocked. IC1b is configured to act as a D-type flip-flop, adopting the state of IC1a after a clock pulse.

The timer circuit is based around the reset pin of IC1b (pin 12). When the green l.e.d.s light, the inverted output of IC1a (pin 2) will go high, and capacitor C3 charges via resistors R6 and R7. After about three seconds IC1b will reset, so the system reverts to state 1. Diode D1 ensures a speedy discharge path for C3, as soon as the inverted output IC1a goes low.

The l.e.d.s are driven by the dual timer IC2. Which l.e.d. is lit depends on which of IC2's outputs is high. When they are both low, neither l.e.d. is lit. IC2b is connected in an astable mode which flashes the red l.e.d.s. The reset input (pin 10) is connected to the output of IC1a which when low, forces the timer's output low. With a high output from IC1b, transistor TR2 will prevent capacitor C4 from charging, which inhibits IC2b. This will result in a steady +9V output.

The other half of IC2 provides a push-pull drive, with the addition of a logic function. The output (pin 5) is at 0V at all times except when the reset (pin 4) is high and the trigger and threshold inputs (pins 2 and 6) are low; i.e. during state 4.

Both sets of l.e.d.s are connected in series. Each pair of l.e.d.s could be replaced with a single bi-coloured l.e.d. and the circuit can be powered by a 9V PP3 type battery.

Steve Teal,
Witney, Oxon.

Keypad Code Controller – Fingertip Control

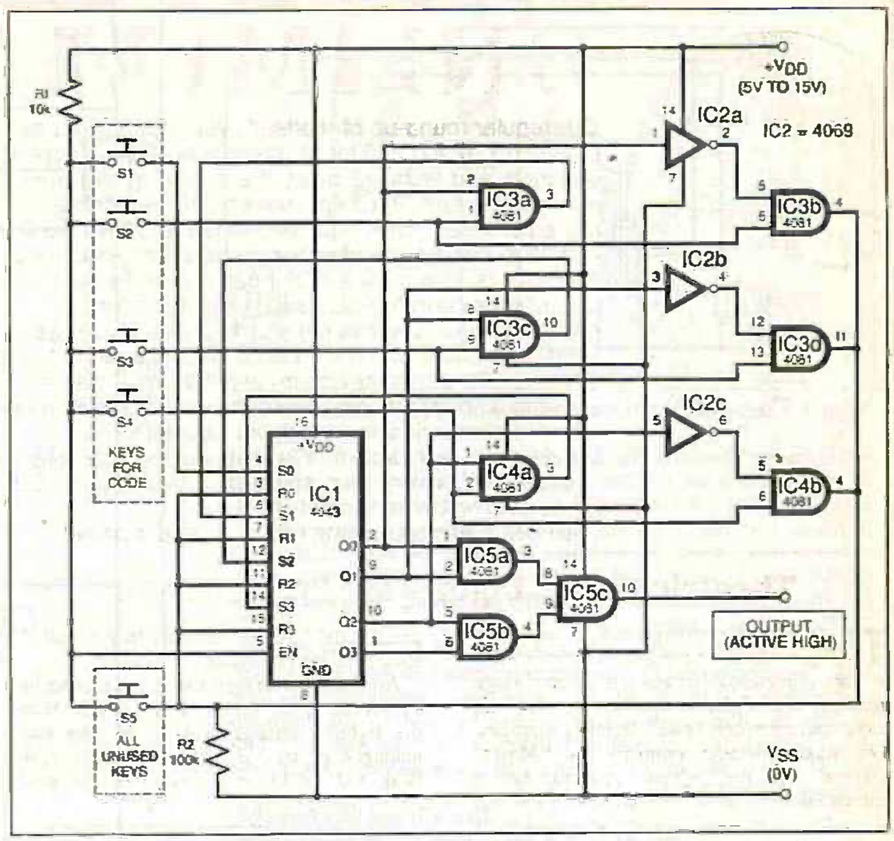


Fig.3. Circuit diagram for the Keypad Code Controller.

The circuit diagram shown in Fig.3 provides a CMOS active high signal at the output following the correct entry of a four digit code on a standard 10-digit keypad. It may be used to control many different circuits and devices.

Assuming that pushswitches S1 to S4 are wired for a code of 1234 for example, the circuit functions as follows: upon the press of "1" the first flip-flop in IC1 is set and its Q0 output (pin 2) goes high. Consequently this sends one input of IC3a high together with one input of IC5a, wired as a 4-input AND gate.

When switch-pad 2 is pressed, the second input of IC3a is brought high, generating a high output and setting the second flip-flop of IC1. This brings the second input of IC5a high and one input of IC3c. When pad 3 is pressed, pin 9 of IC3c goes high thus setting the third flip-flop of IC1. Output Q2 goes high, which brings the third input of IC5 and one input of IC4a high.

Finally, when pad 4 is pressed this brings the second input of IC4a high, setting Q3 of IC1, and bringing the last input to IC5 high. This causes the circuit output to go high at IC5c pin 10, which can be used to control external circuitry.

The circuit is protected from incorrect keypresses because all unused keys (represented by S5) are tied to the Reset inputs of all the flip-flops. Also, in the example, if 4 is pressed instead of 3, this brings the second input of IC4b high, hence its output goes high. All flip-flops will then reset. All other incorrect keypresses will reset the circuit in the same way.

Damien Maguire,
Greystones, Ireland.

Morse Practice Oscillator – Get Keyed Up

Although there is a vast amount of Morse tutoring software available, a small Morse Practice Oscillator is handy for occasions where a little spare time is on hand, and the circuit of Fig.2 was produced for a simple battery-operated device to assist with Morse practice sessions.

The oscillator, centred around IC1, is a phase-shift type, the frequency of which is determined by components C1, C2, R4 and R6. (The equation to determine the actual frequency is $f = 1/2\pi RC$.) A split supply is produced by the voltage divider resistors R1 and R2 and is decoupled by capacitor C3. To make the output a sinewave the gain of IC1a has to be kept at around ×3 and this is accomplished by the feedback resistors R3 and R5.

As the circuit was to be powered by a battery and also drive a loudspeaker, a way to minimise the current consumption was needed and the output stage centred around IC1b was the result. Transistors TR1 and TR2 are a complementary pair which has no base bias; therefore when the key is not pressed the stage consumes practically no current.

Usually, operating a complementary pair in this way would produce severe crossover distortion but as the output is fed back to IC1b inverting input, the heavy negative feedback here almost completely eliminates distortion. None of the device types are critical and those shown could be readily substituted.

Stephen Forsyth,
Gormouth,
Morayshire.

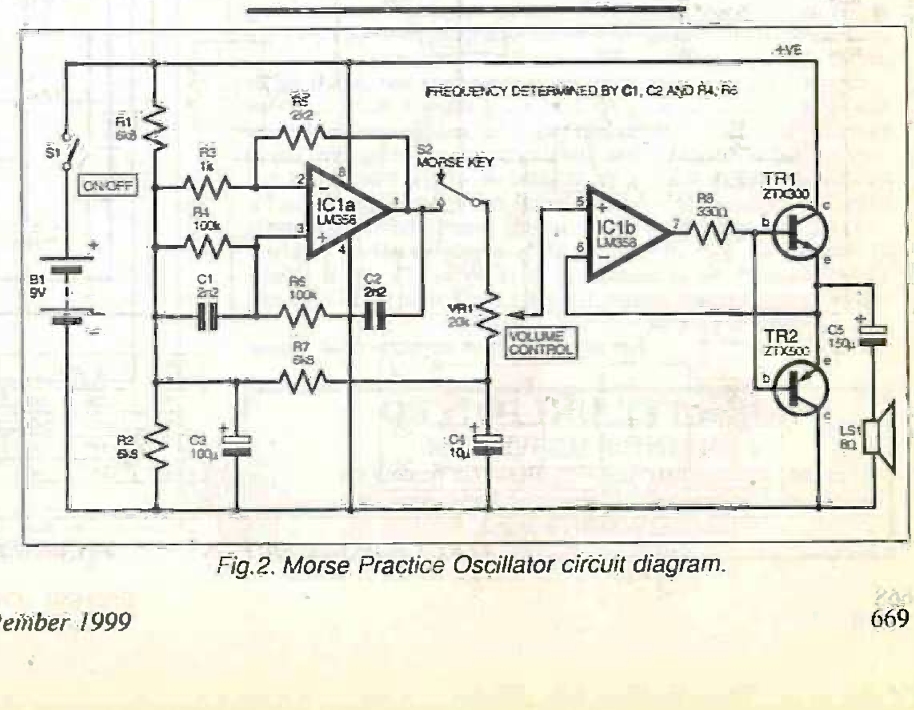


Fig.2. Morse Practice Oscillator circuit diagram.

Intercom/Baby Listener – Baby Talk

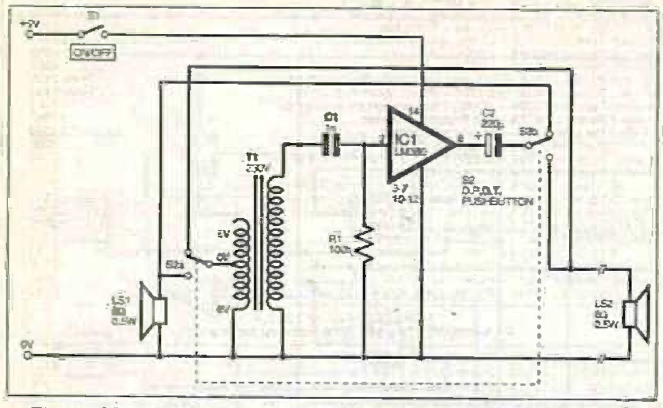


Fig.4. Circuit diagram for an Intercom/Baby Listener unit.

THE simple Intercom/Baby Listener circuit design shown in Fig.4 is based around the LM380. The intercom delivers good tone, and around 500mW ($^1/_2$W) of power. It functions best when one speaks directly into the loudspeaker, but will reproduce sounds a few metres away.

Pushbutton switch S2 switches the intercom from "Listen" to "Talk" mode by reversing the positive connections of the loudspeakers. Therefore, the intercom is normally in listening mode and may be used as a "Baby Listener".

Only a twin-core cable is required to connect the "remote station", LS2. The transformer T1 provides impedance matching between the loudspeakers and the amplifier. (A small mains transformer was used as audio transformers were hard to come by locally). The intercom draws around 10mA current on standby, and should, with a 9V PP9 battery, give more than a fortnight's continuous service, alternatively rechargeable batteries could be utilised.

Rev. Thomas Scarborough,
Fresnaye, Cape Town, Republic of South Africa.

TV Test Pattern Generator – Colour Bands

A LOW-COST solution to testing colour TVs and monitors without having to resort to expensive kits or custom i.c.s is shown in circuit diagram Fig.5. It should satisfy the majority of repair and alignment tasks. The circuit consists of a sync generator, IC1, followed by buffer amplifier transistors TR2 to TR4 and a colour encoder IC2.

A teletext timing chain i.c. (IC1) is used as a sync generator and is driven by a 6MHz master clock source from oscillator TR1. IC1 produces several outputs, including composite sync from pin 5 and field rate signals from pins 19 to 23, which are used for the test patterns.

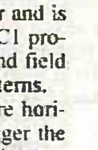
Unfortunately, these field rate signals mean that the bars are horizontal instead of vertical, but provided one remembers to trigger the oscilloscope at *field* rate instead of line rate, no problems should occur. Transistor TR5 is a logic inverter which is used to send pins 19 to 23 into a high impedance state during blanking, and for slightly longer because of the teletext border. Switch S2 is the pattern selector.

The buffer amplifiers TR2 to TR4 match the high impedance outputs of IC1 with the low impedance input requirements of IC2, and they also reduce the 5V logic level outputs to standard 1V peak-to-peak video levels. Presets VR1 to VR3 can be adjusted with an oscilloscope for 1V p-p at their outputs, or by using a TV or monitor for correct colours.

Crystal X2 is the colour subcarrier oscillator reference which can be fine-tuned via timer capacitor VC1 to obtain colour lock on the TV or monitor. The usual 4·433MHz bandpass filter and luminance delay line were omitted to conserve space. The CVBS signal is output from pin 20 of IC2 and fed to the monitor via the video output or to a modulator such as the UM1233 via VR4, which is adjusted for correct contrast on the TV.

If constructing the circuit on stripboard, since the circuit operates at r.f. frequencies, join all unused tracks to ground and no problems should be found. An unregulated p.s.u. of 9V to 12V d.c. at 100mA can be used as a power source. The CXA1145P used for IC2 is available from CPC in Preston.

Lee Archer, Ashton-in-Makerfield, Wigan.



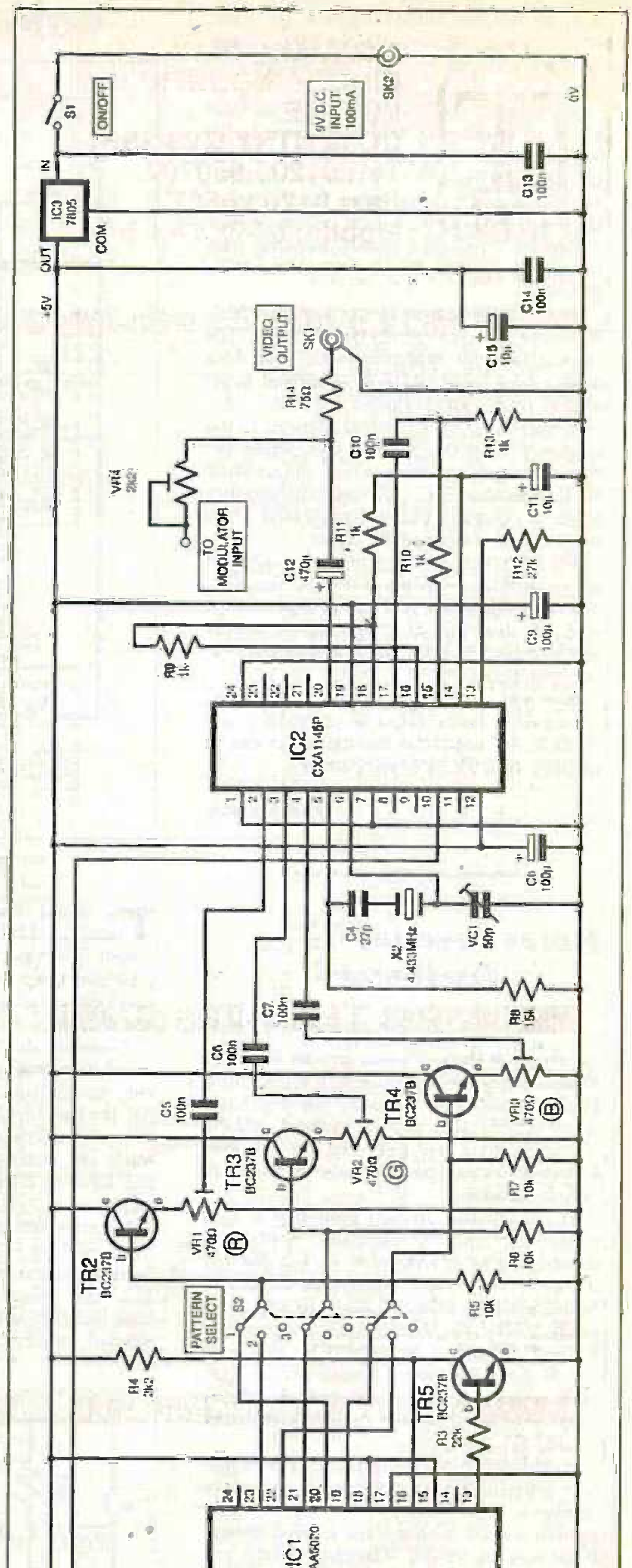


Fig.5. TV Test Pattern Generator circuit diagram.

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Hewlett Packard 83554A – Wave Source Module 26·5 to 40GHz	£3500
Hewlett Packard 83555A – Millimeter – Wave Source Module 33-50GHz	£4250
Hewlett Packard 8405A – Vector Voltmeter	£350
Hewlett Packard 8620C – Sweep Oscillator Mainframe	from £250
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Hewlett Packard 8642A – Signal Generator (0·01 to 1050MHz) High Performance Synthesiser	£6500
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Hewlett Packard 8656B – Synthesised Signal Generator	£1450
Hewlett Packard 8657A – Signal Generator (100kHz-1040MHz)	£1900
Hewlett Packard 8660D – Synthesised Signal Generator (10kHz-2600MHz)	£3250
Hewlett Packard 8750A – Storage Normaliser	£295
Hewlett Packard 8756A – Scalar Network Analyser	£1500
Hewlett Packard 8757A – Scalar Network Analyser	£2250
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Keytek MZ-15/EC – Minizap 15kV Hand-Held ESD Simulator	£1750
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Leader 3216 – Signal Generator (100kHz-140kHz) AM/FM/CW with built-in FM stereo modulator (mint)	£995
Marconi 1066B – Demultiplexer and Frame Alignment Monitor (new)	£POA
Marconi 2019 – 80kHz-1040MHz Synthesised Signal Generator	£750
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Marconi 2185 – 1-5GHz Programmable Attenuator (new)	£POA
Marconi 2305 – Modulation Meter	£1750
Marconi 2337A – Automatic Distortion Meter	£150
Marconi 2610 – True RMS Voltmeter	£700
Marconi 2871 – Data Comms Analyser	£500
Marconi 2955 – Radio Comms Test Set	£2000
Marconi 6310 – Sweep Generator – Programmable – new (2-20GHz)	£3500
Marconi 6950/6960 – Power Meter & Sensor	from £500
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Marconi 893 – A/F Power Meter	£250
Philips PM5167 MHz Function Generator	£400
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Philips PM5519 – TV Pattern Generator	£350
Philips PM5716 – 50MHz Pulse Generator	£525
Prema 4000 – 6½ Digit Multimeter (NEW)	£350
Quartzlock 2A – Off-Air Frequency Standard	£200
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Racal 6111/6151 – GSM Radio Comms Test Set	£POA
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Racal Dana 9303 – R/F Level Meter & Head	£650
Racal Dana 9917 – UHF Frequency Meter 560MHz	£175
Rohde & Schwarz LFM2 – 60MHz Group Delay Sweep Generator	£950
Rohde & Schwarz CMTA 94 – GSM Radio Comms Analyser	£6995
Schaffner NSG 203A – Line Voltage Variation Simulator	£750
Schaffner NSG 222A – Interference Simulator	£700
Schaffner NSG 223 – Interference Generator	£700
Schlumberger 2720 – 1250MHz Frequency Counter	£400
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Schlumberger Stabilock 4040 – Radio Comms Test Set	£1995
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Stanford Research DS 340 – 15MHz Synthesised Function (NEW) and Arbitrary Waveform Generator	£1200
Systron Donner 6030 – Microwave Frequency Counter (26·5GHz)	£1995
Tektronix AM503 + TM501 + P6302 – Current Probe Amplifier	£995
Tektronix PG506 + TG501 + SG503 + TM503 – Oscilloscope Calibrator	£1995
Tektronix 577 – Curve Tracer	£1150
Tektronix 1240 – Logic Analyser	£500
Tektronix 141A – PAL Test Signal Generator	£250
Tektronix AA5001 & TM5006 M/F – Programmable Distortion Analyser	£1995
Tektronix TM5003 + AFG 5101 – Arbitrary Function Generator	£1500
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Time 9811 – Programmable Resistance	£400
Time 9814 – Voltage Calibrator	£550
Valhalla Scientific – 2724 Programmable Resistance Standard	£POA
Wandel & Goltermann PFJ-8 – Error/Jitter Test Set	£11500
Wandel & Goltermann PCM4 (+ options)	£9950
Wandel & Goltermann MU30 – Test Point Scanner	£1500
Wayne Kerr 4225 – LCR Bridge	£600
Wavetek 171 – Synthesised Function Generator	£250
Wavetek 172B – Programmable Signal Source (0·0001Hz-13MHz)	£POA
Wavetek 184 – Sweep Generator – 5MHz	£250
Wavetek 3010 – 1-1GHz Signal Generator	£1250
Wiltron 6409 – RF Analysers (1MHz-2GHz)	£POA
Wiltron 6620S – Programmable Sweep Generator (3·6GHz-6·5GHz)	£650
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SHOP TALK

with David Barrington

Child Guard

Quite a few items for the *Child Guard* project took some running down and certain parts will be hard to find amongst your local suppliers' stocks. This applies particularly to the "semiconductor" devices, and possibly the heat sensors.

Starting with the 3-pin infra-red receiver chip type PIC26043SM (no, it is not a microcontroller), this is available from Farnell (☎ *0113 263 6311*), code 139-877. Interestingly, the model was built using the PIC12043 but on checking for supplies it was found to be obsolete and we were advised of the suggested "substitute". If you have any PIC12043s you can certainly use these.

In a previous article, the HT12D decoder and HT12B encoder i.c.s were called for and we highlighted **FML Electronics** (☎ *01677 425840*), who bought-in stocks especially. They still have stocks and they cost £1.49 each, plus £1 p&p. The TSL260 heat sensor came from **Electromail** (☎ *01536 204555*), code 176-387.

The "active" buzzer (code 35-0030) and the single in-line (SIL) relay (code 60-0650) were both purchased from **Rapid** (☎ *01206 751166*). The neat little 2·1mm power d.c. socket can be purchased, for the inclusive sum of £1, from **Harrogate Electronic Services, 25 Regent Parade, Harrogate, N. Yorks, HG1 5AZ** (☎ *01423 564353*), quote code DCS21R. They can also supply a matching plug.

The internal PIR motion detector, with *closed* relay contacts, caused a small problem but you might find your local DIY store can help here. The one with the model is a Micromark (MM9466A) type, but they have failed to come back to us with a source. **CPC** of Preston (☎ *01772 654455*) list a similar one and you could contact them for a price and handling charge, quote code SR00090.

The printed circuit board is available from the *EPE PCB Service*, code 241.

Variable Dual Power Supply

First sighting of the parts listing for the *Variable Dual Power Supply* project looked fairly straightforward and we were not expecting any supply problems, until we started looking-up the preferred wirewound potentiometer. This component used to be widely stocked and be reasonably priced, not anymore! We found one listed by **Electromail** (code 812-853) for just over £7. So, it may be wise to rethink and revert to a carbon or conductive polymer track type for about £1 to £2, even though they are rated with a 20% tolerance.

Just in time to get us out of a fix came the welcome news that **Greenweld Electronics** is to continue trading – see *News* page 644. They did carry "quality surplus" components, including wirewound pots, and it might pay to contact them by *Fax* on 01992 613020 or E-mail: greenweld@aol.com. Other companies you could try are: **Bull Electrical** (☎ *01273 203500*), **J&N Factors** (☎ *01444 881965*) and **WCN Supplies** (☎ *01703 226522*).

The mains transformer in the prototype originally came from Cirkit, but this company has now been absorbed by the Deltron Group into their subsidiary Roxburgh, who do not run a mail order operation for small orders. We have not found a 15V-0V-15V 500mA type replacement, but advertisers should be able to offer a suitable alternative rated at around 1A to 2A. Provided it is chassis mounting, will fit in the case and has "flying" leads or wiring tags for connection to the p.c.b., it should do the job.

The same situation applies to the in-line bridge rectifier. You will probably be offered a 1A to 2A at 100V to 200V version. Any of these will work in this circuit.

The printed circuit board is available from the *EPE PCB Service*, code 242 (see page 700).

Loop Aerial SW Receiver

One of the major problems with selecting the components for the *Loop Aerial SW Receiver* project will be the final choice of the tuning capacitor. The price differentials can be quite staggering, ranging from the level of £18 (precision engineered) down to about £2.50 for the "transistor radio" type. So, it is definitely a case of shopping around for the "best buy".

Ideally, the tuning capacitor would be a quality 365pF single-gang, air-spaced, Jackson type "O". Unfortunately, this one tends to be expensive (approx. £18) and the solid-dielectric (Dilecon) types, as used in the model, do not fair much better at £13.50 approx.

A low-cost option in this case (if there is one) is to purchase a quality "surplus" air-spaced item. To this end, you could try contacting the likes of **Greenweld**, **Bull Electrical** and **J&N Factors** who sometimes offer these as "bargain buys of the month" – see *Variable Dual Power Supply* section above. Any maximum value from 250pF to 500pF will do. Another option is to go for a miniature "transistor radio" solid-dielectric type. This will only set you back about £2.50. Don't forget to check the mounting arrangement before purchase.

Finally, you will have to purchase a larger than needed piece of stripboard and cut it down to size.

Data Logger–2

As promised, last month, the latest updated news on the supply of "specials" for the *Data Logger* project is that stocks of the new 'F87x family microcontrollers should *now* be appearing. In fact, an unprogrammed 40-pin PIC16F877, 4MHz version is available *now* from **Forest Electronic Developments** for the sum of £9.50, plus £3 for p&p. Phone 01425 274068 or check their web site at: **http://dspace.dial.pipex.com/robin.abbott/FED** for more details.

We also understand **Farnell** (☎ *0113 263 6311*) will be receiving supplies around mid-August and have quoted us code 300-2690. They also have stocks of the 24LC256 serial EEPROM memory chip, code 300-1696.

The latest news from **Magenta Electronics** (☎ *01283 565435* or ***http://magenta2000.co.uk***) is that they are now producing a complete kit, inclusive of case, eight 24LC256 EEPROM memory chips and a ready-programmed PIC, for the all-in figure of £49.95. The price of £10 for a preprogrammed PIC16F877 quoted last month is correct.

VIDEOS ON ELECTRONICS

A range of videos selected by *EPE* and designed to provide instruction on electronics theory. Each video gives a sound introduction and grounding in a specialised area of the subject. The tapes make learning both easier and more enjoyable than pure textbook or magazine study. They have proved particularly useful in schools, colleges, training departments and electronics clubs as well as to general hobbyists and those following distance learning courses etc

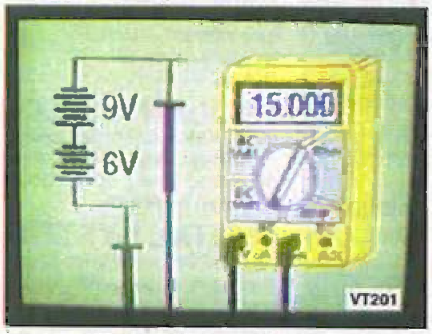
BASICS

VT201 to VT206 is a basic electronics course and is designed to be used as a complete series, if required.

VT201 54 minutes. Part One; D.C. Circuits. This video is an absolute must for the beginner. Series circuits, parallel circuits, Ohms law, how to use the digital multimeter and much more. **Order Code VT201**

VT202 62 minutes. Part Two; A.C. Circuits. This is your next step in understanding the basics of electronics. You will learn about how coils, transformers, capacitors, etc are used in common circuits. **Order Code VT202**

VT203 57 minutes. Part Three; Semiconductors. Gives you an exciting look into the world of semiconductors. With basic semiconductor theory. Plus 15 different semiconductor devices explained. **Order Code VT203**



VT204 56 minutes. Part Four; Power Supplies. Guides you step-by-step through different sections of a power supply. **Order Code VT204**

VT205 57 minutes. Part Five; Amplifiers. Shows you how amplifiers work as you have never seen them before. Class A, class B, class C, op.amps. etc. **Order Code VT205**

VT206 54 minutes. Part Six; Oscillators. Oscillators are found in both linear and digital circuits. Gives a good basic background in oscillator circuits. **Order Code VT206**

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Order 16 get two extra FREE

VCR MAINTENANCE

VT102 84 minutes: Introduction to VCR Repair. Warning, not for the beginner. Through the use of block diagrams this video will take you through the various circuits found in the NTSC VHS system. You will follow the signal from the input to the audio/video heads then from the heads back to the output. **Order Code VT102**

VT103 35 minutes: A step-by-step easy to follow procedure for professionally cleaning the tape path and replacing many of the belts in most VHS VCR's. The viewer will also become familiar with the various parts found in the tape path. **Order Code VT103**

DIGITAL

Now for the digital series of six videos. This series is designed to provide a good grounding in digital and computer technology.

VT301 54 minutes. Digital One; Gates begins with the basics as you learn about seven of the most common gates which are used in almost every digital circuit, plus Binary notation. **Order Code VT301**

VT302 55 minutes. Digital Two; Flip Flops will further enhance your knowledge of digital basics. You will learn about Octal and Hexadecimal notation groups, flip-flops, counters, etc. **Order Code VT302**

VT303 54 minutes. Digital Three; Registers and Displays is your next step in obtaining a solid understanding of the basic circuits found in today's digital designs. Gets into multiplexers, registers, display devices, etc. **Order Code VT303**

VT304 59 minutes. Digital Four; DAC and ADC shows you how the computer is able to communicate with the real world. You will learn about digital-to-analogue and analogue-to-digital converter circuits. **Order Code VT304**

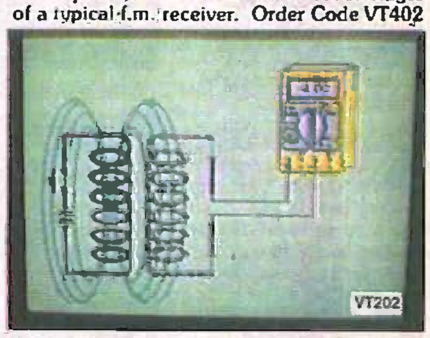
VT305 56 minutes. Digital Five; Memory Devices introduces you to the technology used in many of today's memory devices. You will learn all about ROM devices and then proceed into PROM, EPROM, EEPROM, SRAM, DRAM, and MBM devices. **Order Code VT305**

VT306 56 minutes. Digital Six; The CPU gives you a thorough understanding in the basics of the central processing unit and the input/output circuits used to make the system work. **Order Code VT306**

RADIO

VT401 61 minutes. A.M. Radio Theory. The most complete video ever produced on a.m. radio. Begins with the basics of a.m. transmission and proceeds to the five major stages of a.m. reception. Learn how the signal is detected, converted and reproduced. Also covers the Motorola C-QUAM a.m. stereo system. **Order Code VT401**

VT402 58 minutes. F.M. Radio Part 1. F.M. basics including the functional blocks of a receiver. Plus r.f. amplifier, mixer oscillator, i.f. amplifier, limiter and f.m. decoder stages of a typical f.m. receiver. **Order Code VT402**

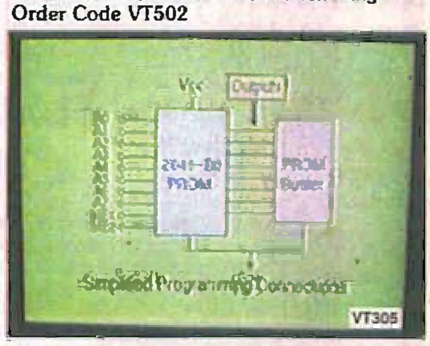


VT403 58 minutes. F.M. Radio Part 2. A continuation of f.m. technology from Part 1. Begins with the detector stage output, proceeds to the 19kHz amplifier, frequency doubler, stereo demultiplexer and audio amplifier stages. Also covers RDS digital data encoding and decoding. **Order Code VT403**

MISCELLANEOUS

VT501 58 minutes. Fibre Optics. From the fundamentals of fibre optic technology through cable manufacture to connectors, transmitters and receivers. **Order Code VT501**

VT502 57 minutes. Laser Technology A basic introduction covering some of the common uses of laser devices, plus the operation of the Ruby Rod laser, HeNe laser, CO_2 gas laser and semiconductor laser devices. Also covers the basics of CD and bar code scanning. **Order Code VT502**



Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes are imported by us and originate from VCR Educational Products Co, an American supplier. We are the worldwide distributors of the PAL and SECAM versions of these tapes. (All videos are to the UK PAL standard on VHS tapes unless you specifically request SECAM versions.)

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ELECTRONICS CD-ROMS

NEW

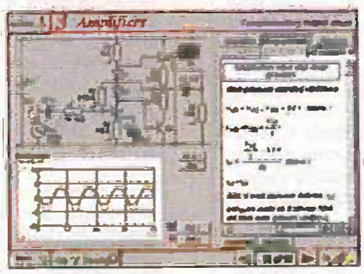
ANALOGUE ELECTRONICS

by Mike Tooley

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

FUNCTIONS

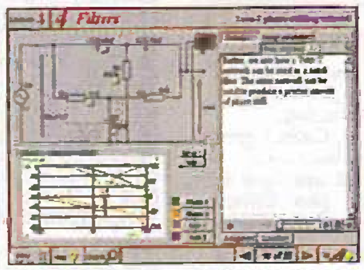
The component values on all circuits can be edited and the user can use the simulation engine to see how the value of each component affects circuit performance. You can, for instance, alter frequency and phase angle and plot outputs on a virtual oscilloscope or show load line graphs etc.



Complimentary output stage.

COVERAGE

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



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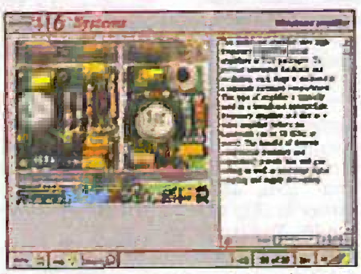
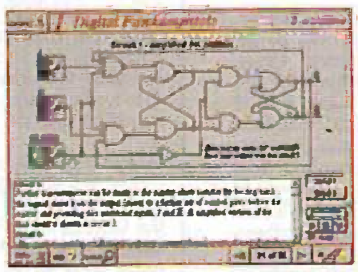


Gallery – Wideband Amplifier

DIGITAL ELECTRONICS

by Mike Tooley

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



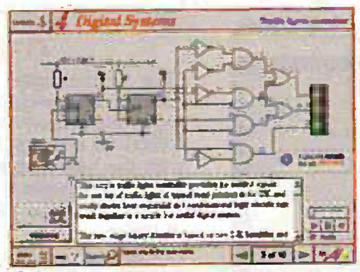
Virtual laboratory – Flip-Flops

FUNDAMENTALS

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

COMBINATIONAL LOGIC

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



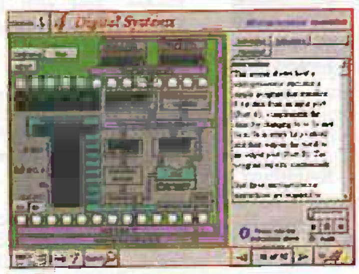
Virtual laboratory – Traffic Lights

SEQUENTIAL LOGIC

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

DIGITAL SYSTEMS

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



Microprocessor

GALLERY

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

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

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

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

TWO APPLICATIONS ON ONE CD-ROM

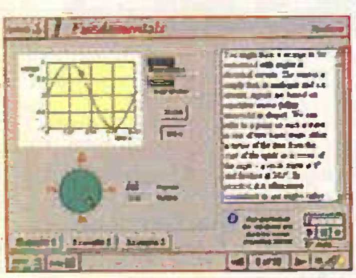
ELECTRONIC CIRCUITS & COMPONENTS + THE PARTS GALLERY *by Mike Tooley*

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

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

The Parts Gallery helps overcome this problem; it will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.

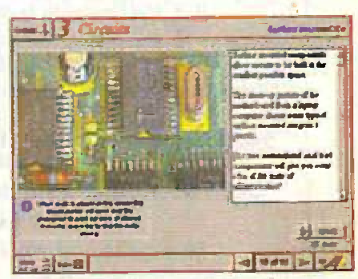
Selections on the disk include: ***Components*, *Components Quiz*, *Symbols*, *Symbols Quiz*, *Circuit Technology***



Virtual laboratory – sinusoids

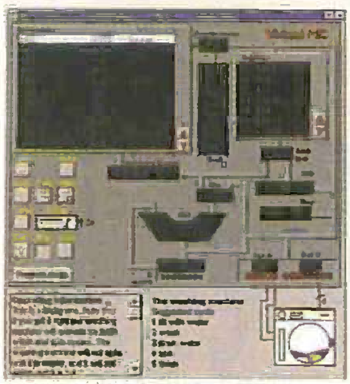
Hobbyist/Student .... £34 inc VAT
Institutional (Schools/HE/FE/Industry) .... £89 *plus* VAT
Institutional 10 user (Network Licence) .... £169 *plus* VAT

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



Circuit technology screen

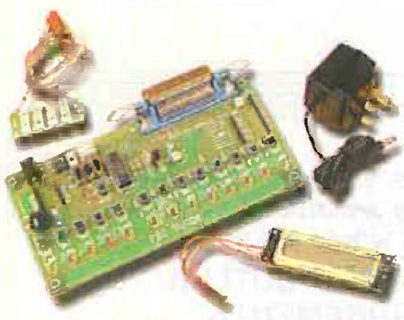
Interested in programming PIC microcontrollers? Learn with **PICtutor** *by John Becker*



The Virtual PIC

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

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



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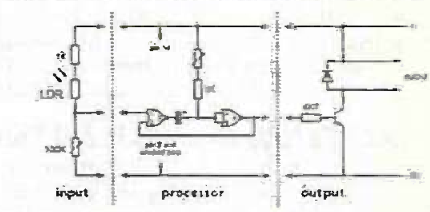

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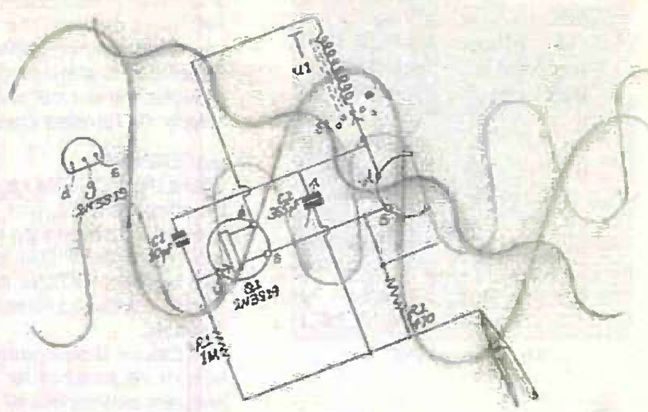

RAYMOND HAIGH

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

PART THREE – THE ARMSTRONG, MEISSNER, FRANKLIN AND BUTLER OSCILLATORS, PLUS PROBES FOR R.F. VOLTAGE MEASUREMENTS.

EARLIER articles covered the Hartley and Colpitts oscillators, and their variants, in some detail. This month, circuits attributed to Armstrong, Meissner, Franklin and Butler will be considered.

With the Hartley circuit, feedback is applied to a tapping in the tuning inductor: with the Colpitts, the tuning capacitor is tapped. Quite apart from questions of performance, these circuits are convenient because of the way they simplify coil design.

ARMSTRONG OSCILLATORS

Oscillators attributed to E. H. Armstrong, the great American radio pioneer, involve more complicated inductor arrangements. Two of his designs rely on a separate winding to feed maintaining energy back to the tuned circuit. Another has a pair of tuned circuits with feedback via the anode/grid capacitance of a coupling valve.

Conceived during the decade following Lee De Forest's invention of the triode, the circuits were of crucial importance to the emerging radio industry and, from 1917 to 1924, there was much acrimonious patent litigation between De Forest and Armstrong. The American courts decided in De Forest's favour on the basis of a legal technicality. However, in Britain, the validity of Armstrong's patents, and of his claim to be the true originator, has generally been upheld.

GETTING IN TUNE

In their original form, with triode valves as the maintaining devices, the circuits became known as tuned grid, tuned anode, and tuned grid/tuned anode. Clearly, the circuits take their names from the way the frequency determining components are connected to the valve.

The tuned grid circuit came to be adopted almost universally as the *local* oscillator in valve superhet receivers. (The superhet receiver was invented by Armstrong whilst he was a US Army Signals Officer stationed in France during the First World War.) No doubt the ability to connect coil and capacitor to ground made it the natural choice for this purpose.

With the growing use of bipolar transistors during the 1960's, the valve tuned grid circuit fell from use as it did not adapt well to the new low-impedance devices, or to the type of mixer/oscillator stages which became standard in mass produced radios. It was, however, replaced by another very early oscillator circuit, the Meissner; more on this later.

The subsequent development of field-effect transistors, with their more valve-like characteristics, saw its resurrection as the local oscillator in simple, wide coverage communications receivers. A typical application of the tuned gate oscillator stage of the radio receiver front end is shown in Fig.1a.

OSCILLATORS IN SUPERHET RECEIVERS

Superhet oscillators operate at a higher frequency than that of the incoming signals. This higher frequency is combined with the incoming signal in a mixer (see Fig.1b), and the difference between the two, the intermediate frequency, or i.f., is selected by tuned circuits and amplified.

Domestic radios have an i.f. of between 455kHz and 470kHz. Older, high-performance valve sets had an i.f. of 1.6MHz, and modern communications receivers have multiple i.f.s which can include 40MHz, 10MHz, 455kHz and lower frequencies.

Tuning of the signal frequency and oscillator stages is via a dual-ganged tuning capacitor, and some provision must be made, therefore, for this frequency difference to be constantly maintained over the tuning capacitor swing. Taking the medium wave band as an example, and assuming an i.f. of 460kHz, the signal frequency tuned circuit will sweep from 1600kHz down to 530kHz, whilst the oscillator must cover 2060kHz (1600+460) to 990kHz (530+460).

The different coverage is achieved by making the oscillator coils of lower inductance than the signal frequency or r.f. coils, and by placing a capacitor in series with the oscillator gang of the tuning capacitor in order to reduce its value when fully meshed. The series capacitor is called a "padder". By this means, the oscillator circuits can be made to track the signal frequency circuits almost perfectly, and the 460kHz difference is maintained over the full swing of the variable tuning capacitor. (Strictly speaking, absolutely perfect tracking is achieved at three points on the dial.)

ARMSTRONG OSCILLATOR – Tuned Gate F.E.T. Version

We can now consider the functions of the various components of the Armstrong oscillator stage (Fig.1a) in our receiver "front-end" circuit of Fig.1, where the tuned circuit formed by L2 and variable capacitor VC1a determines the frequency of oscillation. The swing reducing padder capacitor C2 is connected in series with the coil L2

PLEASE NOTE

In the "Tuned Circuit Calculations" panel in Part 1 (July '99 issue) page 522, the third and fourth equations for *f* should be as follows and not as printed:

$$f = \frac{5.033}{\sqrt{LC}} \qquad f = \frac{159.155}{\sqrt{LC}}$$

to simplify band switching (this has virtually the same effect as connecting it directly in series with VC1a). Trimmer capacitor VC2 permits the precise matching of the minimum capacitance in the r.f. and oscillator circuits, and fixed capacitor C3 is required to optimise tracking only on the longwave band.

Coupling or "reaction" winding L1 must be connected so that the feedback is in-phase, and the correct arrangement is indicated on the circuit diagram. Resistor R1, capacitors C1 and C7 decouple the oscillator from the supply rail, and the tuned circuit is connected to the gate (g) of transistor TR1 via capacitor C5. Gate resistor R3 ensures correct biasing.

Valve and f.e.t. versions of this circuit are prone to "squegging", i.e., the transistor goes in and out of oscillation, usually at a low radio frequency. Resistor R2 is included to inhibit this. If the problem is encountered despite the inclusion of R2, modify the time constant of the gate input circuit by reducing the value of C5 and/or R3. Increasing the value of R1 may also effect a cure.

BIASING

Biasing has to be optimised or the circuit will not oscillate over the full swing of a 365pF tuning capacitor on the highest shortwave range (10MHz to 30MHz). The source bias resistor is, therefore, made up of R4 and preset potentiometer VR1. If such extensive coverage is not required, a single fixed resistor of around 2·2 kilohms can be substituted when 2N3819 transistors are used, or 4·7 kilohms when J310s are wired into circuit.

The output is taken from the "hot" end of the tuning coil via a low value capacitor C4. It must be fed into a high impedance load or oscillation will be inhibited. Output voltage is reasonably constant over the full swing of a 365pF variable capacitor, and the waveform is of excellent quality.

Connecting a diode from gate to ground/0V (diode cathode (k) to ground) to limit forward conduction of the j.f.e.t.'s gate makes oscillation weak and erratic on the highest shortwave range, and, for this reason, it has been omitted. If extended high frequency coverage is not required, connecting a diode will limit oscillation amplitude and prevent a slight flattening of the waveform which can occur at low frequencies.

ARMSTRONG INDUCTORS

The feedback or reaction winding L1 must be tightly coupled to the tuned winding L2. The rule-of-thumb adopted for valve versions of the circuit was to make the number of turns on the feedback coil between 30 per cent and 50 per cent of the turns on the tuned winding. It was also recognised that the capacitance across the feedback winding had to be kept to an absolute minimum in order to avoid "squegging" and other forms of erratic operation.

With the f.e.t. version of the circuit, a ratio of 10 per cent up to 2MHz, then progressively increasing to 50 per cent on the highest shortwave range, should ensure reliable oscillation. Wind feedback windings over the "earthy" end of tuned windings, separating the two by a layer of insulating tape: coupling must be tight or oscillation may not be maintained over the full tuning range.

MOSFET MIXER

A well tried mixer circuit completes our receiver circuit and is illustrated in Fig.1b, where incoming signals, tuned by L4 and VC1b, are applied to gate 1 (g1) of the dual-gate MOSFET TR2. The oscillator voltage is fed to TR2 gate 2 (g2).

For best results, mixers of this kind require an oscillator injection of at least 1V, and preferably close on 2V r.m.s. Clearly, therefore, the output voltage of the tuned gate oscillator, and the high input impedance of the MOSFET mixer, make this an effective combination. The whole arrangement is reminiscent of the old triode-hexode valve frequency changers, where the grid of the triode section was extended into the electrode stream of the hexode mixer in order to inject the local oscillation.

ARMSTRONG'S OSCILLATORS

Three early valve oscillators are attributed to Edwin Howard Armstrong: the tuned grid, the tuned anode and the tuned grid/tuned anode. They were all used in transmitters, and the tuned grid circuit was adopted, almost universally, as the local oscillator in superhet receivers until bipolar transistors began to take the place of valves.

When field-effect transistors (f.e.t.s), with their more valve-like characteristics, were introduced, it saw a revival in receivers with some pretensions to high performance. A typical circuit is given in Fig.1.

The f.e.t. version of Armstrong's circuit oscillates readily from audio up to 50MHz or more. A near perfect sinewave is produced, and output is reasonably constant over the tuning capacitor swing. On the downside, a separate feedback winding is required on the tuning coil, and output impedance, with this particular circuit, is high.

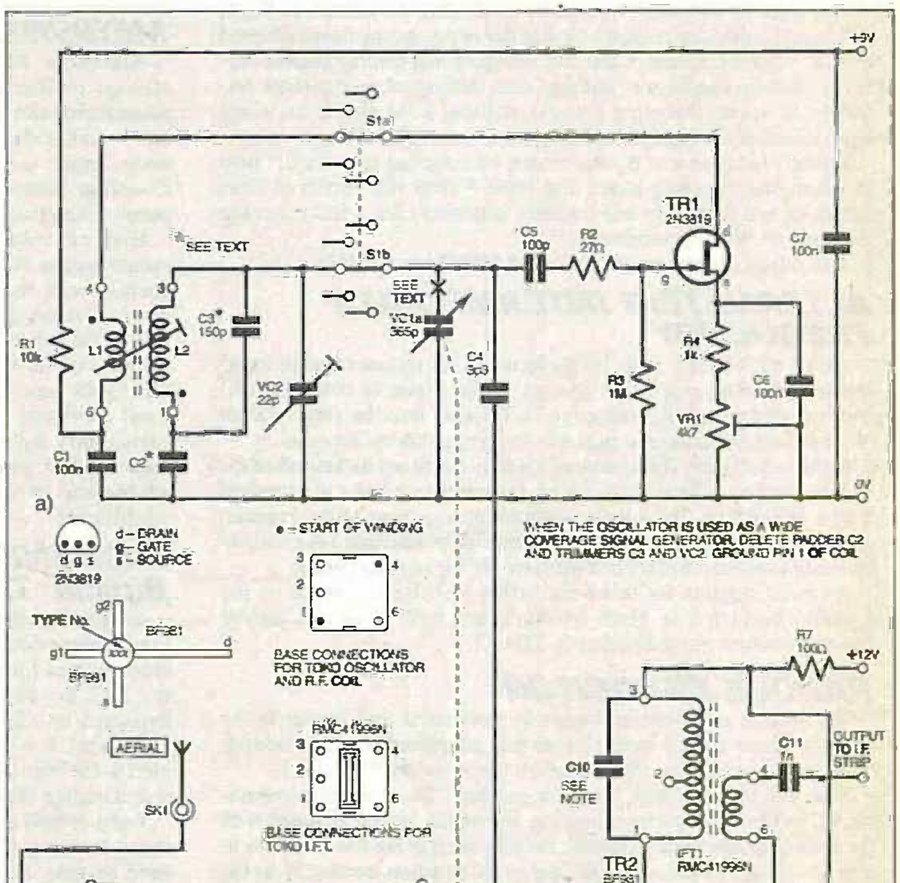

Fig.1. Radio receiver "front-end" using an f.e.t. version of an Armstrong oscillator. Suitable for receivers covering 150kHz to 30MHz. See Table 2 for details of tuning coils and capacitors.

Here the two circuits are coupled by means of capacitor C4. Readers who have coil packs from old valve receivers will find that they usually work well with this dual f.e.t. arrangement.

INPUT CIRCUIT

The aerial is coupled to the r.f. tuned circuit by means of coil L3 and potentiometer VR2 acts as a simple, but effective, input attenuator to prevent strong signals causing cross modulation. Trimmer capacitor VC3 matches the minimum capacitance in the r.f. tuned circuit to that of the oscillator section. Capacitor C8 is required only on the longwave band to ensure good oscillator tracking.

Source (s) bias for TR2 is provided by resistor R6, which is bypassed by capacitor C9. Bias on TR2 gate 2 is fixed at around 1V (the optimum level when MOSFETs are used as mixers) by connecting it to the source via resistor R5. If difficulty is encountered in securing oscillation at the maximum tuning capacitor setting on the highest shortwave range, try increasing the value of this resistor to about 220 kilohms.

Supply line decoupling is effected by R7 and C12, and the mixer output is taken from the secondary of IFT1, at pin 4. The primary of this r.f. transformer forms the drain load of TR2 and is, of course, tuned to the intermediate frequency. In practice, the setting of the adjustable core, within the coil former, is very broad.

MIXER/OSCILLATOR COMBINATION

Our receiver front-end, formed by combining the circuits in Fig.1, will significantly out-perform the bipolar or i.c. arrangement adopted in most domestic radios. Correctly set up, it will display greater sensitivity, reduced oscillator "pulling" (the shifting of the oscillator frequency by strong incoming signals), reduced noise and, if the aerial input attenuator is used judiciously, lower cross-modulation.

Readers may wish to try the circuit by coupling it to the i.f. strip in a domestic transistor radio, and Table 1 gives full details of Toko inductors and trimming and padding capacitors for a full coverage (150kHz to 30MHz) receiver.

The values quoted are for an i.f. of 450kHz to 470kHz.

ALTERNATIVE INTERMEDIATE FREQUENCY

An i.f. of 1·6MHz is to be preferred. This reduces image interference (spurious responses spaced, in the main, at twice the i.f.) and it would permit the output to be injected into the aerial socket of a car radio or domestic portable to form a double superhet.

Unfortunately, the Toko range of inductors does not include all of the double-winding coils required for an Armstrong oscillator in a receiver with a 1·6MHz i.f. The simpler inductor arrangement of the Franklin oscillator does, however, permit the windings of standard Toko coils to be series connected to produce inductors of the required value.

A circuit suitable for receivers with a 1·6MHz i.f., based on the Franklin oscillator, is given in Fig.3, and coil types and padder capacitor values are scheduled in Table 3.

PADDER CAPACITOR

The padder capacitor is invariably connected into circuit in the manner shown for C2 in Fig.1a, as this simplifies range switching. (Coil and capacitor are controlled by the same switch bank.)

With this arrangement, however, padder C2 and variable capacitor VC1a form a capacitive tapping across L2, which changes with the setting of the tuning control, thereby increasing the variation in output voltage. Locating the padder in the position marked X on the circuit diagram avoids this, and if single band operation is all that is required, this is the preferred option.

With the padder connected as shown, oscillator output on MW varies between 2·5V and 3·6V r.m.s. With the padder located in the alternative position, output changes by only 0·1V from 3·5V to 3·6V.

ARMSTRONG AS SIGNAL GENERATOR

The tuned gate Armstrong oscillator, together with the buffer stage described in Part 2 (Aug '99), would make an excellent signal generator. Constructors wishing to use it in this way should substitute the coils listed for the r.f. stage, and delete the padder and trimmer capacitors (C2, C3, and VC2).

The bottom end of coil L2 should, of course, be connected to ground (0V line). This will ensure continuous coverage from around 150kHz to 30MHz if a 365pF variable capacitor is used. Output coupling capacitor, C4, will have to be kept very small, and attenuation circuitry may have to be provided, in order to prevent the overloading of the buffer stage.

TABLE 1:
Tuned-Gate F.E.T. Version of Armstrong Oscillator
Tuned circuit components for r.f. and oscillator stages of a superhet receiver with a 460kHz I.f. (See Fig.1)

Band	*R.F. Coil L3/L4 Fig.1b*	*Oscillator Coil L1/L2 Fig.1a*	*Padder C2 (pF) Fig.1a*	*Range MHz*
LW	CAN1A350EK	RWR331208N2	150	0·14 - 0·3
MW	RWR331208N2	YMRS80046N	330	0·53 - 1·6
SW1	154FN8A6438EK	154AN7A6440EK	680	1·5 - 4
SW2	154FN8A6439EK	154AN7A6441EK	1500	3·5 - 12
SW3	KXNK3767EK	KXNK3766EK	2000	10 - 30

Notes:

(1) The quoted tuning ranges are approximate. The tuning capacitor should have a minimum capacitance of not much more than 10pF and a maximum capacitance of at least 300pF.

(2) To improve tracking on the LW band only, a 56pF capacitor is connected across the r.f. stage tuned winding, L4. (C8 in Fig.1b).

(3) To improve tracking on the LW band only, a 150pF capacitor is connected across the oscillator stage tuned winding, L2. (C3 in Fig.1b).

(4) The coil reference numbers are for Toko inductors.

MEISSNER OSCILLATOR

Alexander Meissner's valve oscillator represented an early attempt to increase the isolation of the tuned circuit from the maintaining device. In its original valve form, coil windings in the anode and grid circuits provide the necessary feedback, and a separate tuned winding determines the frequency of oscillation. Coupling between the valve and the tuned circuit is, therefore, purely inductive.

High r.f. voltages are developed across the tuned circuit in the output stages of transmitters, and the elimination of a direct connection with the valve reduces the risk of inter-electrode break down. Despite this advantage, the circuit fell out of use before the end of the valve era.

Once again, the gradual shift from valves to transistors during the 1960s saw the re-introduction of Meissner's circuit in the local oscillator stage of radio receivers. It seems to have been particularly suited to the then new, low impedance devices with their modest gains. Single transistor mixer/oscillators, using an adaptation of Meissner's feedback system, became standard world-wide.

MEISSNER OSCILLATOR – *Bipolar Transistor Version*

Simple superhets invariably incorporate the front-end shown in Fig.2, where coils L3 and L4 couple transistor TR1 to the oscillator tuned circuit formed by L5 and tuning capacitor VC1b. Base bias for TR1 is provided by resistors R1 and R2; and resistor R3, bypassed by C2, sets the bias voltage on the emitter (e). Signal input, via L1, is tuned by the combination of L2 and VC1a, and coupled to the base of TR1 via a low impedance tapping to avoid excessive damping on the resonant circuit.

Long aerials are connected to the receiver via L1, again to minimise damping. (The input attenuator VR2 shown in Fig.1b could be used to great advantage here.) Short whip aerials present a high impedance at frequencies up to 30MHz or so, and they are usually connected to the "hot" end of L2, through socket SK2. Connections to a ferrite rod aerial are shown in Inset A.

Signal mixing (strictly speaking combining) takes place within TR1, and the required 460kHz output is selected by i.f. transformer IFT1. The tuned primary of this transformer is tapped to ensure a reasonable match with the collector circuit. Resistor R4 and capacitor C4 decouple the circuit from the supply line.

Trimmers, VC2 and VC3, enable the minimum capacitances in the r.f. and oscillator tuned circuits to be matched, and C5 is the padder capacitor which modifies the frequency coverage of the oscillator stage.

REWIND

In order to simplify coil production, the emitter of TR1 is sometimes connected to a tapping on the tuned winding. Whilst this arrangement compromises the best feature of Meissner's oscillator, the feedback paths are the same. Commercially produced three winding coils are no longer available to the home constructor, and readers who wish to experiment with this circuit will have to either wind their own coils or adopt the emitter tapping modification so that standard Toko inductors can be used.

Base connections for Toko coils are also given in Fig.2. and type numbers and padder values are scheduled in Table 2. Readers who wish to wind their own coils should give the collector winding 10 per cent of the number of turns on the tuned winding up to 2MHz or so, then gradually increase the ratio to 25 per cent on the coils for the highest shortwave range.

The emitter winding should have between two and three turns on all ranges. The three windings must be tightly coupled, and connected as shown in Fig.2.

PERFORMANCE

The circuit is effective in simple transistor radios where the swing of the tuning capacitor VC1 is usually less than 300pF and shortwave coverage does not extend much above 18MHz. However, oscillation is not likely to be maintained on the shortwave ranges when the tuning capacitor setting approaches 300pF. On the highest range (10MHz to 30MHz), oscillation will probably fade when the tuning capacitor is set above 150pF.

To avoid these problems, the oscillator in some early transistor radios ran at half the normal frequency on the highest shortwave range, and the second harmonic was used for mixing purposes.

TABLE 2:
Bipolar Transistor Version of the Meissner Oscillator
Tuned circuit components for r.f. and oscillator stages of a simple superhet receiver with a 460kHz i.f. (See Fig.2 with Inset B for circuit diagram)

Band	*R.F. Coil L1/L2*	*Oscillator Coil L3/L5*	*Padder C5 (pF)*	*Range MHz*
LW	CAN1A350EK	RWR331208N2	150	0·14 - 0·3
MW	RWR331208N2	YMRS80046N	330	0·53 - 1·6
SW1	BKANK3333R	BKANK3426R	680	1·5 - 4
SW2	BKANK3334R	KANAK3337R	1500	3·5 - 12
SW3	BKXN3335R	MKANK3428R	2000	10 - 30

Notes:
(1) The quoted tuning ranges are approximate. The tuning capacitor should have a minimum capacitance of not much more than 10pF and a maximum capacitance of at least 300pF. A miniature polythene dielectric capacitor would be appropriate for this circuit
(2) The coil reference numbers are for Toko inductors.

Even this modest level of performance may prove difficult to achieve if TR1 emitter resistor R3 is not selected to suit the transistor used. In the modified emitter circuit given in Inset B, the

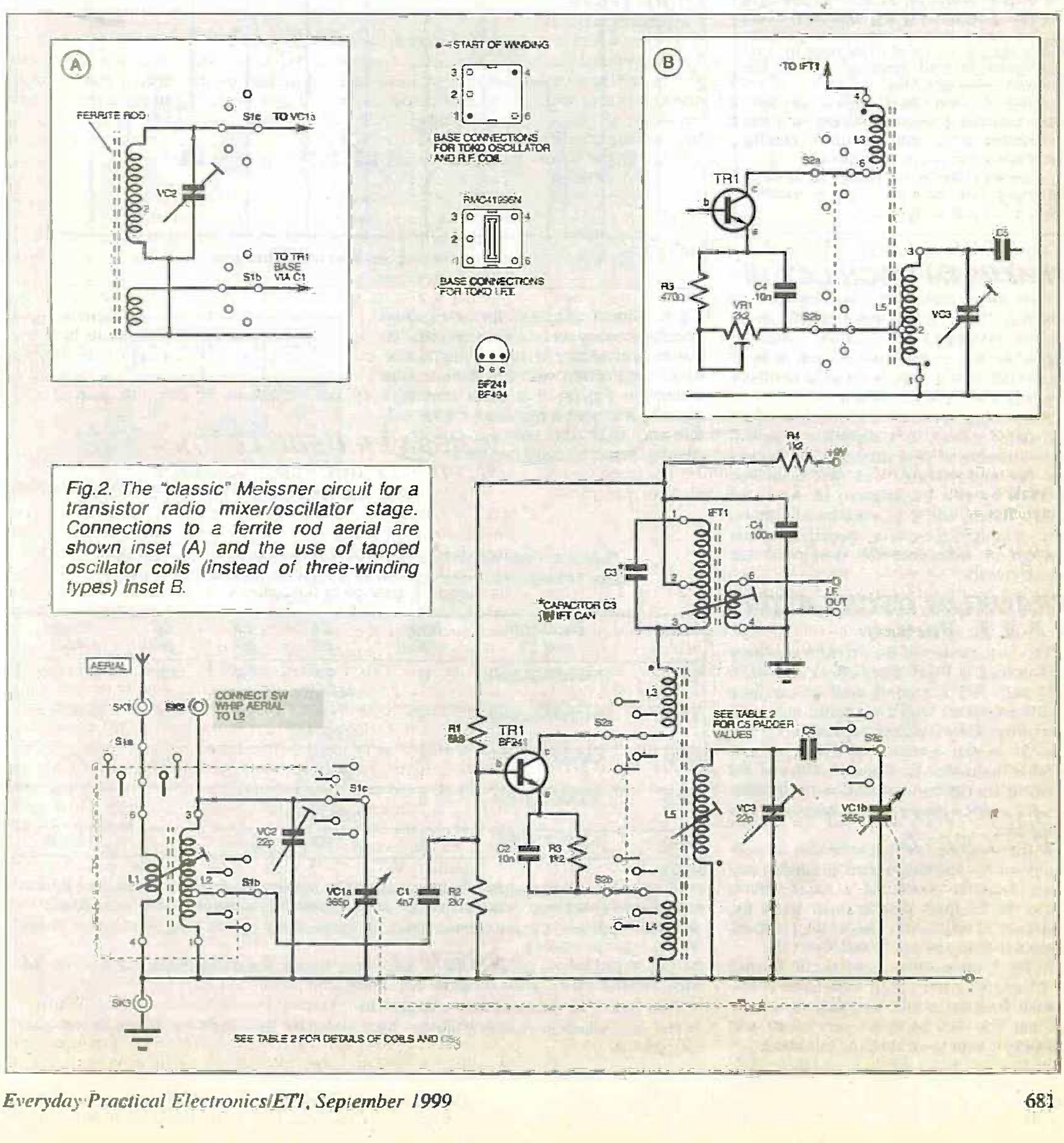

Fig.2. The "classic" Meissner circuit for a transistor radio mixer/oscillator stage. Connections to a ferrite rod aerial are shown inset (A) and the use of tapped oscillator coils (instead of three-winding types) Inset B.

value of R3 has been reduced and a preset potentiometer, VR1, has been added in series with it so that the biasing can be optimised.

Only one low cost transistor is used, and it is probably this, more than anything else, that has made the circuit so popular with radio manufacturers for almost 40 years. Readers who wish to experiment with simple superhets would be well advised to adopt the circuit based on the Armstrong oscillator, shown in Fig.1, or the adaptation of the Franklin given in Fig.3.

Although field-effect transistors are more expensive, these circuits are more willing to oscillate with adverse *L/C* ratios, band switching is simpler, and performance is superior.

In the original valve version, these capacitors were no more than 1pF, and the oscillator was renowned for its low level of drift. To ensure reliable oscillation down to 150kHz with this wide-range f.e.t. version, the value of C4 and C5 has to be increased to 10pF. If the circuit is to be used exclusively at higher frequencies and maximum frequency stability is important, these components should be reduced in value until oscillation is only just maintained.

This circuit is decoupled from the power supply by resistor R5 and capacitor C8. Signal output is taken from the drain (d) of TR2 via d.c. blocking capacitor C7. If the oscillator is to be used in a radio receiver, the output should be applied to gate 2 of the dual-gate MOSFET TR2 shown in the mixer stage in Fig.1b.

FRANKLIN OSCILLATOR

British radio engineer, Charles S Franklin, added an *L/C* tuned circuit to Abraham and Bloch's multivibrator and produced his oscillator. The tuning inductor comprises an untapped single winding, and range switching is considerably simplified.

Waveform quality is acceptable for radio receivers and simple signal generators, but the output voltage varies with the setting of the tuning capacitor to a greater extent than is the case with some other circuits. Measures can be taken to regulate the output, but this is at the expense of more complicated range switching.

Loading on the tuned circuit is very light, even with the transistor version, and this contributes to the good frequency stability for which the circuit is renowned.

Operation below 100kHz or so tends to be erratic. The circuit will, however, oscillate up to 60MHz and beyond.

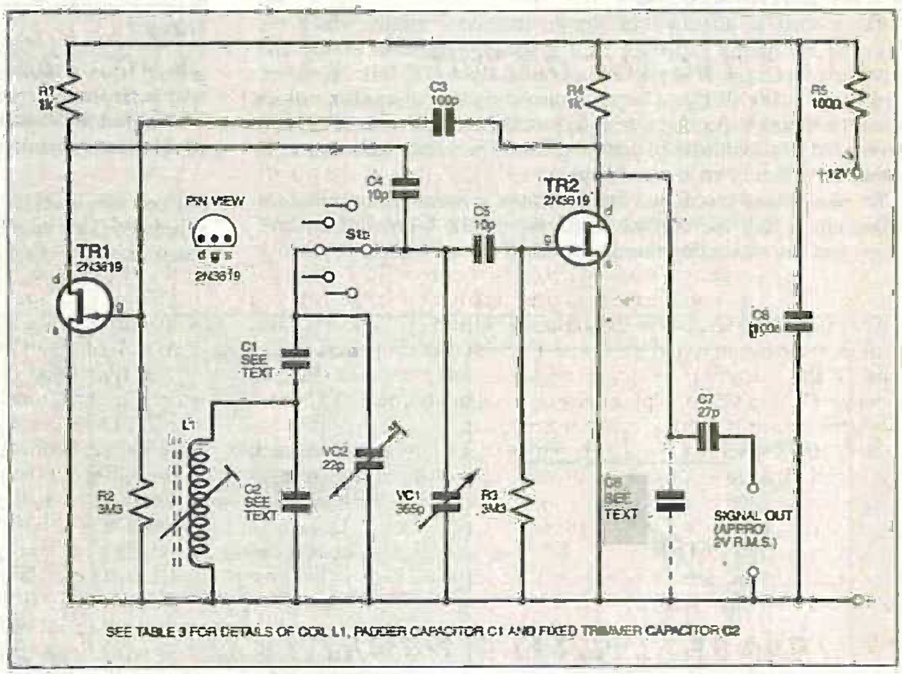

Fig.3. Circuit diagram for a Franklin oscillator using an f.e.t. Can be used as the local oscillator in a superhet receiver in conjunction with the mixer stage shown in Fig.1b. If a wide coverage signal generator is required, delete C1, C2 and VC2 and connect coil(s) L1 directly across tuning capacitor VC1.

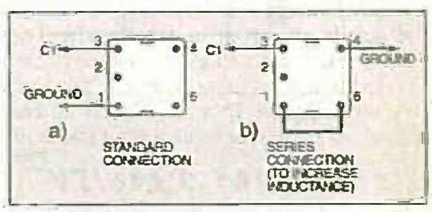

Fig.4. Connections to Toko coils listed in Table 3.

FRANKLIN OSCILLATOR

Involved for much of his working life with Marconi, C. S. Franklin was a prolific inventor. He originated the variable capacitor, ganged tuning, coaxial feeders and, of more direct interest to us here, a versatile oscillator that is renowned for its stability.

His design involves the addition of an *L/C* tuned circuit to a capacitor coupled, i.e. an astable or free running, multivibrator. The multivibrator was first described in 1918 by two Frenchmen, H. Abraham and E. Bloch, and it is a matter of conjecture whether Franklin modified their concept or independently developed the whole circuit.

FRANKLIN OSCILLATOR – F.E.T. Version

The f.e.t. version of the Franklin oscillator is illustrated in Fig.3. Field-effect transistors TR1 and TR2 are configured as common source amplifiers with their drains and gates cross coupled by feedback capacitors, C3 and C4/C5, in the manner of Abraham and Bloch's multivibrator. Resistors R1 and R4 are the drain (d) load resistors and gate resistors R2 and R3 ensure correct biasing of the transistors.

A free running multivibrator can be synchronised by injecting pulses at almost any point. Franklin connected a tuned circuit across the feedback path in order to fix the frequency of oscillation, one of the feedback capacitors being tapped to facilitate this.

In Fig.3, the parallel tuned circuit formed by L1 and VC1 has a high impedance at resonance. Because of this, feedback capacitors, C4 and C5, can be made very small and damping is kept to an absolute minimum.

TABLE 3: Field-Effect Transistor Version of the Franklin Oscillator
Table of tuned circuit components for a superhet radio with a 1·6MHz I.F.
(See Fig.3 for circuit diagram).

Band	*Oscillator coil L1*	*Base wiring*	*C1 pF*	*C2 pF*	*C6 pF*	*Range MHz*
LW	154FN8A6438EK	B	74 (47+27)	39	220	0.16 - 0.45
MW	154FN8A6438EK	B	110 (100+10)	18	82	0.53 - 1.6
SW1	KANSK4960EG	A	335 (330+5)		6·8	1.6 - 5
SW2	KXNK3767EK	B	950 (680+270)		–	4 - 13
SW3	KXNK3766EK	A	1500	-	-	10 - 30

Notes:
(1) The quoted tuning ranges are approximate. The tuning capacitor should have a minimum capacitance of not much more than 10pF and a maximum capacitance of at least 300pF.
(2) Fixed capacitors, C2, are connected across the oscillator coil, on Long and Medium Waves only, to improve tracking.
(3) See Fig.1b for the circuit of the r.f. and mixer stages. Fixed capacitors, C2, are not connected across the r.f. tuned circuit on any range.
(4) See Table 1 for details of the r.f. stage coils.
(5) The coil reference numbers are for Toko inductors. See Fig.4 for details of the base connections.

It should be noted that J310 transistors will not work in this circuit: 2N3819s should be used.

FRANKLIN SUPERHET OSCILLATOR

The tuning arrangements depicted in Fig.3 enable the circuit to be used as the local oscillator in a superhet receiver. Tuning coil L1 has a single winding, and this makes it possible to series connect coils in the Toko range to create inductance values appropriate to the production of a 1·6MHz intermediate frequency.

Padder capacitor C1 limits the swing of tuning capacitor VC1. Trimmer VC2 permits the matching of minimum capacitances in the r.f. and oscillator circuits, and C2 is required to ensure correct tracking only on the long and medium wave bands. Suitable Toko inductors and capacitor values are listed in Table 3. Oscillator coil connections are shown in Fig.4.

REGULATING THE OUTPUT

The output from Franklin's circuit varies with the setting of the tuning capacitor to a greater extent than the Armstrong or Butler oscillators and, with swings of 10pF to 365pF, the variation can be significant. (The impedance of the tuned circuit falls as the capacitance ratio is increased, and this reduces the level of feedback from the drain of TR1 to the gate of TR2, especially at low frequencies.)

Output can be made more constant between 150kHz and 5MHz by connecting capacitor C6 (shown dashed) between TR2 drain and ground (0V). The improvement is particularly noticeable between 150kHz and 450kHz, where the variation is from 1·25V to 4V r.m.s. without the capacitor, and 2·9V to 3·1V with the component in circuit. If this capacitor is not provided, it may be necessary to increase C4 and C5 to 27pF to ensure oscillation down to 150kHz when the circuit is used as a signal generator.

Including capacitor C6 will, of course, necessitate another switch bank, and this detracts from the extreme simplicity of the arrangement. However, the circuit will function perfectly well with the mixer stage shown in Fig.1b without this component. Used in a radio receiver with a 1·6MHz i.f., the lowest oscillator frequency is 1750kHz when tracking a signal input of 150kHz. Fade at low frequencies is not, therefore, a problem.

I.F. TRANSFORMER FOR 1·6MHz

Toko do not list a 1·6MHz i.f. transformer, but one can be contrived by tuning a medium wave r.f. coil with an external capacitor. The details are given in Fig.1b. The 1·6MHz i.f. output can be injected, via a short length of coaxial cable, into the aerial socket of a car radio tuned to the extreme h.f. end of the medium wave band. This combination forms a double superhet which, if properly aligned, is capable of quite a high standard of performance.

WAVEFORM QUALITY

Waveform quality varies with the setting of the tuning capacitor VC1. A perfect sinewave can be obtained when the values of C4 and C5 are as low as possible, consistent with reliable oscillation. A fairly high ratio of capacitance to inductance in the tuned circuit will make the selection of the feedback capacitors less critical.

Only spot-frequency or narrow-band versions of the oscillator can be made to produce a perfect waveform in this way. Fortunately, radio receivers are tolerant of a measure of local oscillator waveform distortion.

FRANKLIN SIGNAL GENERATOR

If Fig.3 is to be used as a simple signal generator, the output should be buffered; the amplifier described last month would be suitable. In view of the output level at low frequencies (approximately 3V r.m.s.), it would be prudent to locate a switched attenuator between oscillator and buffer and gang it with the range switch. By this means a reasonably constant output could be ensured.

Use the tuned windings of the coils listed for the r.f. stage when the circuit forms a signal generator. Readers who like to wind their own coils should refer to the first part of the series for details of a suitable range of inductors.

EXTENDING THE RANGE

Operation of the circuit becomes erratic below 100kHz. It will, however, oscillate above 100MHz with the appropriate tuned circuits.

Constructors can hand-wind self-supporting coils for these frequencies, or purchase S18 type coils from the Toko range. Toko inductors for v.h.f. working were scheduled in connection with the Colpitts oscillator, and a Jackson 25pF C809 type variable capacitor would be suitable for tuning purposes.

The circuit displays an increasing reluctance to oscillate above 35MHz unless a 22pF capacitor is wired in the C6 position.

BUTLER OSCILLATOR

Also known as the cathode-coupled oscillator, Frederick Butler developed his circuit whilst he was serving with the RAF during World War Two. He published details of it in 1944.

The original design was, of course, based on the use of valves. It shares the advantage, with the Franklin, of only requiring a single winding, untapped coil. The tuned circuit is not, however, isolated from the active devices to the same degree.

Variants of Butler's circuit sometimes form the basis of the oscillator stage in domestic radio i.c.s in order to simplify coil design and switching (e.g., the CA3123E and the TDA1083).

BUTLER OSCILLATOR – Series Fed F.E.T. Version

The Butler oscillator can be configured in either the series or shunt fed modes and a typical series fed arrangement, with field-effect transistors (f.e.t.s) as the active devices, is given in Fig.5.

Configured as a source follower, f.e.t. TR1 has a high input impedance at the gate, and a low output impedance at the source. Grounded gate stage TR2 has a low input impedance at the source and a high output impedance at the drain. In this way, the circuit ingeniously ensures a good match for the direct coupling of the active devices and imposes minimum damping on the tuned circuit formed by L1 and VC1.

The frame and moving vanes of VC1 are grounded for convenience, and the tuner is connected across the coil via bypass capacitor C3. Output from the drain (d) of TR2 is coupled to the gate (g) of TR1 via feedback capacitor C1. Signal output is developed across source resistor R2 and C2 acts as a d.c. blocking capacitor.

Despite the indirect connection of the tuning capacitor, which places the supply voltage across its vanes, this circuit is to be preferred to the shunt fed version depicted in Fig.6, which is more reluctant to oscillate at range extremes.

Substituting J310s for the 2N3819 field-effect transistors increases the output but biasing is more critical and operation can be erratic. Readers wishing to try J310s should reduce the common source resistor R2 to 150 ohms.

Output is pretty constant from 150kHz to 10MHz, but falls at higher frequencies when the ratio of tuning capacitance is high, and when 2N3819s are used. This fall in output is avoided when J310s are the active devices.

Shunt Fed – F.E.T. Version

The shunt fed Butler oscillator circuit depicted in Fig.6 is usually adopted when there is a need to ground the tuning coil. With this version, the tuned circuit is connected to the high impedance gate of

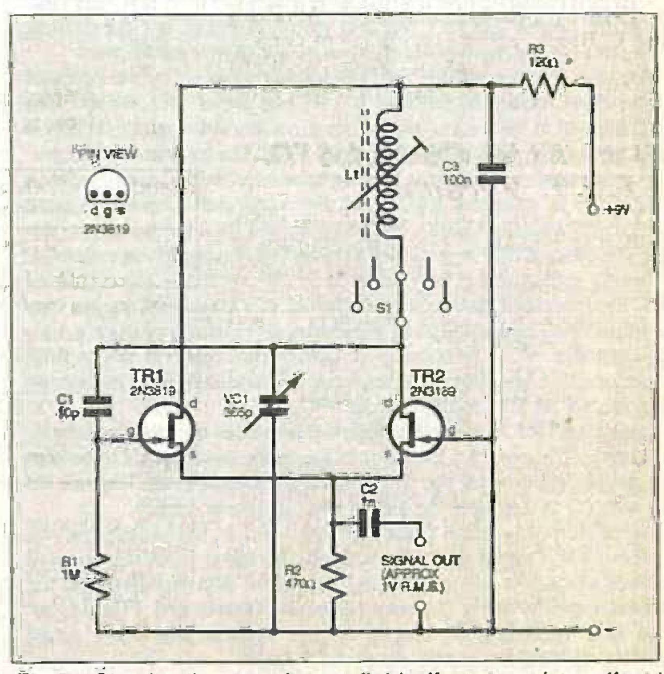

Fig.5. Circuit diagram for a field-effect transistor (f.e.t.) version of the series fed Butler oscillator.

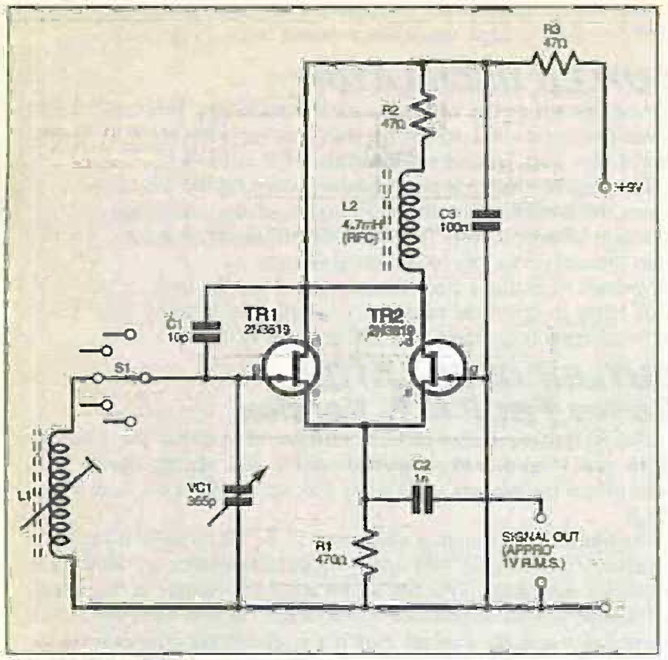

Fig.6. Circuit for a parallel (shunt) fed f.e.t. version of the Butler oscillator.

TR1 and feedback is developed across an r.f. choke, L2, which acts as the drain load for TR2.

Resistor R2 is a "*Q*" spoiler included to prevent the internal resonances of the choke triggering erratic operation. Even when this precaution is taken, there is a tendency for the oscillator to malfunction below 500kHz or so, and the circuit will not oscillate over the full swing of a 365pF capacitor on the 10MHz to 30MHz shortwave range.

Unless there is a compelling need to connect the tuning inductor to ground, the series fed circuit given in Fig.5 is much to be preferred. However, between 500kHz and 15MHz, the shunt fed circuit works well, providing a reasonably constant output with a tolerable waveform.

Series Fed – NPN Transistor Version

Butler's ingenious combination of a grounded grid (grounded gate or base with transistors) and a cathode follower stage (source or emitter follower) makes it possible for bipolar transistors to function well in this circuit. Configuring bipolar transistors in this way increases their normally low base and modest collector impedances, thereby limiting damping on the tuned circuit to the point where oscillation can be maintained, over a wide frequency range, and with reasonably large ratios of capacitance to inductance in the tuned circuit.

A design based on *npn* transistors is given in Fig.7. It is very similar to the series fed f.e.t. version given in Fig.5, but the biasing arrangements for the bipolar transistors are more complicated.

The base (b) bias voltage for both transistors is set by the potential divider chain formed by resistors R1, R2 and preset VR1, the d.c. bias being applied to TR2 via signal isolating resistor R4. Emitter (e) bias is developed across resistor R3 and preset VR2. The inclusion of the preset potentiometers enables the biasing to be adjusted to accommodate a wide range of transistor types, and the compromise between output voltage and waveform purity can be optimised for a particular application. The base of TR1 is grounded at radio frequencies by capacitor C1.

Tuning inductor L1 is connected in the collector (c) circuit of TR1, the grounded base configuration of this stage making the output impedance high enough to avoid excessive damping. Again, tuning capacitor VC1 is connected across the coil via decoupling capacitor C3. Capacitor C2 completes the feedback loop by linking the collector of TR1 to the base of TR2.

Arranging TR2 as an emitter follower increases the base impedance of the stage. This enables the value of feedback capacitor C2 to be kept low, thereby minimising the damping on the tuned circuit. Resistor R5 acts with C3 to decouple the circuit from its power supply.

Signal output is taken from the "hot" end of the tuning coil via capacitor C4. Output can, alternatively, be taken from the coupled emitters via a low value blocking capacitor. Signal voltage at the emitters remains fairly constant between 500kHz and 15MHz, but there is a reduction in output on the highest shortwave range (10MHz to 30MHz) and below about 500kHz.

Moreover, the quality of the waveform at the emitters is poor: a chain of rounded pulses which cannot be improved by adjusting the bias potentiometers.

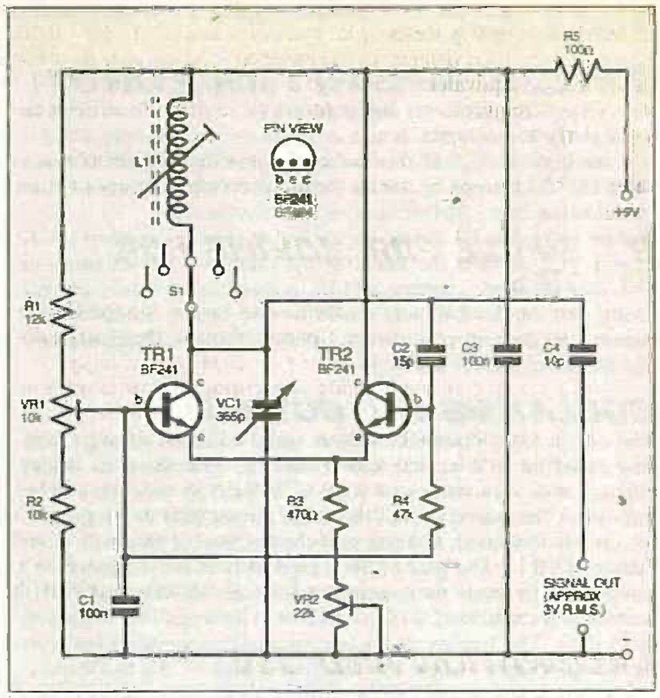

Fig.7. Bipolar npn transistor version of the series fed Butler oscillator.

Series Fed – PNP Transistor Version

By substituting *pnp* transistors, it is possible to invert the circuit and connect the tuning inductor to a negative ground. Most small signal *pnp* transistors with a high enough f_T will work in this circuit, but some, particularly medium power types, have high internal capacitances, and this limits the high frequency coverage for a given output voltage. (Coverage can be maintained by adjusting VR2, but signal output falls.) BC557s work well, and *pnp* transistors designed for r.f. working should be particularly suitable.

Biasing, feedback and decoupling arrangements are identical to those adopted in the circuit using *npn* transistors.

With appropriate tuned circuits, the bipolar transistor versions of Butler's oscillator will function from 20kHz to above 60MHz. Purity of waveform is excellent if the bias potentiometers are adjusted to hold the output below 1V r.m.s. (approximately 3V peak-to-peak).

MEASURING R.F. VOLTAGES

Some means of detecting the presence, and assessing the magnitude, of r.f. voltages, is essential when conducting experiments with oscillators.

Conventional digital or analogue test meters will not measure voltages alternating at much above a few hundred Hertz. The addition of a simple and inexpensive diode probe will, however, enable basic test meters to be used for the detection and measurement of r.f. voltages into the u.h.f. region.

SEMICONDUCTOR DIODES

Semiconductor signal diodes, which rectify the r.f. and produce a d.c. voltage which can be measured by conventional meters, are used in probes of this kind. Germanium diodes begin to conduct heavily at a lower voltage than their silicon counterparts (0·2V as opposed to 0·6V), and they are to be preferred for this purpose.

If a probe is to be used with a moving coil meter, OA47 diodes will be found to produce a marginally greater output at very low voltages, but any germanium or Schottky diode should prove suitable. Silicon signal diodes, e.g., the 1N4142, can be used successfully if their reduced small-signal sensitivity is taken into account.

R.F. PROBE FOR DIGITAL TEST METERS

The circuit given in Fig.8a shows how the diode is connected in probes to be used with high input resistance digital or electronic test meters. The input resistance of instruments of this kind is usually 10 megohms, and the diode must be shunt connected in order to maintain sufficient current flow for the rectifying action to take place.

The d.c. voltage developed at the diode's cathode (k) is approximately equal to the peak value of the applied a.c. voltage (i.e., 1·414 times its r.m.s. value). Resistor R1 forms a potential divider with the 10 megohm input resistance of the meter to reduce the peak voltage to its r.m.s. equivalent. (Strictly speaking, a resistor of 4·14 megohms is required, but the reduced value offsets inefficiencies, particularly at low signal levels.)

If the input resistance of the meter is less than 10 megohms, the value of R1 must, of course, be reduced proportionately to ensure an r.m.s. reading.

R.F. PROBE FOR MOVING COIL METERS

The low input resistance of moving coil meters, on the low current and voltage ranges, makes it possible to use the voltage doubling circuit given in Fig.8b in order to maximise sensitivity.

Current flowing through diode D1 during the negative-going half-cycle charges capacitor C1 to the peak value of the applied r.f. voltage. This is added to the voltage supplied by D2 during the positive-going half-cycle, and approximately twice the peak value of the r.f. voltage is developed across C2, which removes residual r.f.

Used in conjunction with this probe, inexpensive moving coil test meters become quite sensitive detectors of the presence of r.f. voltages. If regard is had to the gradual fall in efficiency below 0·5V or so, reasonably accurate estimates of the actual magnitude of the voltages can be made.

CALIBRATION AND USE

If desired, the probes can be calibrated, at 50Hz, against known a.c. voltages. Temporarily increase the value of capacitor C1 to 100nF to avoid attenuation of the low frequency input before undertaking the calibration.

The input impedance of the probes is sufficiently high to permit readings to be taken without excessive disturbance to the circuit under test. Remember, though, that the maximum reverse voltage of an OA47 diode is only 25V, and this limits the input to the probe. No problems should be encountered with the signal levels produced by the oscillators in this series. If a higher reading capability is required, substitute a diode with an appropriate PIV rating.

Next month: Construction of a stabilised power supply and negative resistance oscillators will be covered.

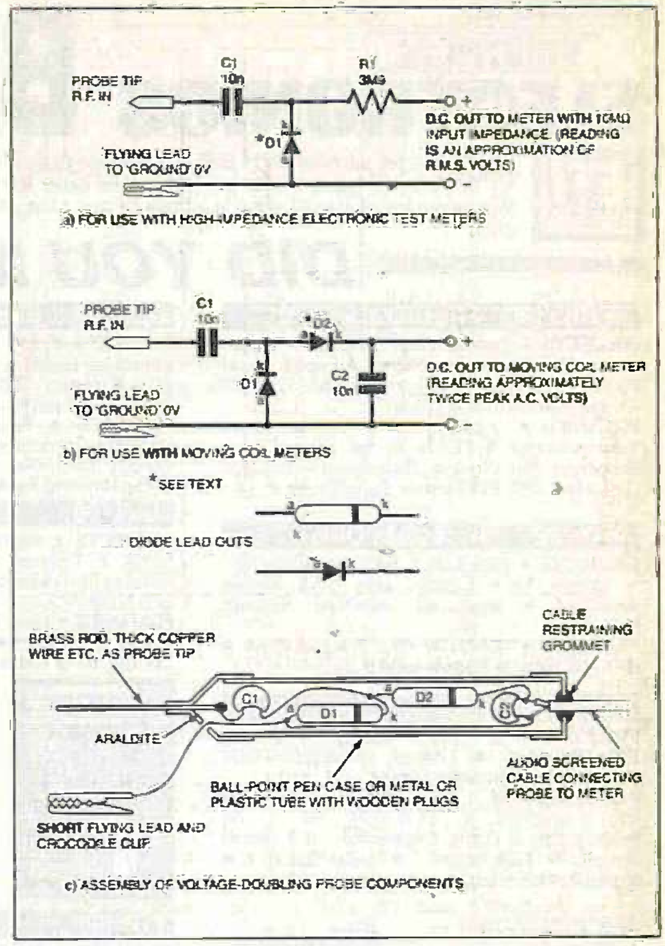

Fig.8. Alternative r.f. probe circuits and suggested constructional details.

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M9/99

Constructional Project

8-CHANNEL ANALOGUE DATA LOGGER

JOHN BECKER — Part 2

The new PIC16F877 microcontroller offers versatile analogue data logging opportunities.

HAVING discussed the circuit and constructional details last month, we now describe how to use the Data Logger and view its recordings.

PROGRAMMING THE PIC

To program IC1 using *PIC Toolkit Mk2* (May and June '99 issues), connect the CLK, DATA, MCLR and 0V pins on the Data Logger board (near top centre as shown in Fig.2 – last month) back to the RB6, RB7, MCLR and 0V pins (in that order) on the *Toolkit Mk2* board.

Switch on power to both units. From the *Toolkit Mk2* software, select main menu Option 1 – Configure PIC Factors.

Accept the first three default options (XT, WDT no, POR yes), select the 'F87x option instead of the '84 option, then accept the remaining defaults, through to and including sending the configuration data to the PIC.

The PIC's configuration register bits affected are shown in Table 2. The data is read from left to right, bit 13 to bit 0. A full explanation of the bit functions is given in the PIC16F877 data sheet.

Now call up *Toolkit Mk2* main menu Option 2 (Program PIC with TASM Binary code), key in **DATLOG01** and send the data to the PIC as instructed on screen.

Note that *PIC Toolkit Mk1*, *PIC Tutorial* and *PICtutor* cannot supply the full configuration data required by the PIC16F87x devices and that their program handling capacity is 1023 bytes (the Data Logger program is in excess of that length).

SECOND CHECKS

With the programmed PIC in-situ, and with the power off, insert all the remaining i.c.s. As said last month, not all the memory chips IC5 to IC11 need to be used, just insert those you want in ascending numerical order position. Connect the l.c.d. and set the wiper of preset VR1 fully anti-clockwise. Switch off S1 (Run/Stop).

If you have a signal generator (one that can output a waveform whose min-max peaks lie between 0V and +5V – even a square wave will do), couple it into channel 1 (SK1). Set the generator for its lowest possible rate, ideally of much less than the 1Hz sampling rate about to be selected.

Alternatively, you could connect a potentiometer (10kΩ lin, say) across the +5V/0V rails and connect its wiper to channel 1, adjusting the rotation while sampling.

As a last resort, just connect a temporary link between the Data Logger's +5V supply and channel 1.

Switch on power again, and double check that +5V still exists on the output of regulator IC2. Look at the l.c.d. and check that seemingly meaningful data is shown on its screen – never mind the actual content at the moment just check that something is there on both lines. Adjust VR1 to change the contrast if preferred.

Switch off the power again, and wait a few seconds before following the actions for the next stage – Reset.

RESET

Sample Counter Reset

With switch S3 (Reset) *pressed*, switch on the power and look at the l.c.d. Now release S3 (but don't touch any of the switches again until we've explained matters a bit further).

Note that the Data Logger's Reset mode can only be entered in this fashion, i.e. at switch on.

(Actually, if the Data Logger is connected to the *PIC Toolkit Mk2* board at this time, Reset mode can be entered by just pressing and releasing *Toolkit's* Reset switch (S1) while Data Logger S3 is pressed, which avoids having to power down and then up again. The action resets the PIC's internal program counter, as also occurs when power is switched on.)

Immediately power is switched on, the software should recognise that S3 is pressed and the l.c.d. should display the information shown in Photo 1.

Photo 1. Reset mode screen, phase 1.

The l.c.d. screen should show RATE=.5 on the top line. This is the default rate at which samples will be taken unless you set it otherwise (as in a moment). It means that all eight data channels will be sampled as a group once every half-second.

In the lower l.c.d. line, the words COUNTER RESET will be seen. It means exactly what it says, the sample counter has been reset, to zero.

Sample Rate Changing

At this point in the Reset procedure, you can change the sampling rate. Press switch S2 (Up) once: the rate will be seen to change to 1 – one sample group (all eight channels) per second. Press again to show a Rate of 2 – one sample group every two

Table 2. Configuration setting for the PIC16F877.

CP1	CP0	DBG	NIL	WRT	CPD	LVP	BOR	CP1	CP0	POR	WDT	OS1	OS0
1	1	1	1	1	1	0	0	1	1	0	0	0	1

Photo 2. Typical l.c.d. display following Reset.

Photo 3. Typical l.c.d. display during sampling.

seconds. Keep pressing a few times more and note that each press increases the period between each batch of eight samples by one second. The maximum period between samples is 62 seconds, about 10 days-worth of continuous data sampling, if you wish it and have the 24LC256 chips installed!

The Rate counter setting is bi-directional – up or down. Down-counting is controlled by switch S3 (Down). Press it and observe the sampling Rate descending. Once you reach RATE=.5 again, the next press of S3 will roll the internal counter over to 63, but instead of seeing RATE=63, you will see the statement RATE=EXT. In this mode the sampling rate is determined not by the software's controlling clock routines, but by any digital signal (+5V/0V) fed into the Data Logger at socket SK10.

For the moment, return the sample rate to show RATE= 1.

Maximum Sample Quantity Setting

Even though you may have installed memories of considerable data storage capacity, there are times when you might wish to leave the Data Logger running unattended but want to restrict the number of samples that it can take before you return.

This is where the next phase of the setting up will be useful, setting the maximum count limit. Switch S1 (Run/Stop) on to enter this phase.

To the right of l.c.d. line 1, the message M= followed by a value will be seen. Letter M stands for Memory and the value is likely to be 16384 (although this may differ the first time the program is run). The value is the maximum count that can occur on this setting before the sampling is automatically ceased.

To reduce the count limit, press S3 (Down). At each press, the count limit will be lowered by a factor of two. The order is 16384, 8192, 4096, 2048, 1024, 512, 256, FREE RUN, and then rolls over back to 16384 etc. In reality, the actual limit for the first seven values is always one byte less than that shown – the software is written to detect when the counter, which is incremented *after* each sample, reaches the limit set, and then refuses to take any more.

Pressing switch S2 increases the count limit selected.

Be especially aware that if you set a count limit which is greater than the capacity of the memory chips you have used, once the sample count has reached the chip's capacity, the chip's own counter will roll over to zero and start over-writing the previously recorded data. This, though, could be beneficial in some sampling situations where the signal data you want to record could occur at any unexpected time.

This is the purpose of the FREE RUN setting, which does not impose a maximum limit and sampling goes on and on indefinitely until you stop it.

Leave the count limit set on 16384. Now switch off S1.

When in Reset mode, if you do not want to change any of the parameters but just reset the sample counter, simply switch S1 through its two-phase sequence, returning to the Run/Hold mode.

Note that the Reset function does not actually reset the serial memory chips to hold zero values. This action would seriously shorten the lifetime of the devices, which is about 100,000 write cycles (there is no limit to the number of read cycles).

RUN/HOLD MODE

The act of switching off S1 when in Reset mode phase 2 terminates the Reset mode and puts the Data Logger into its Run/Hold mode. Had you not entered the Reset mode by pressing S3 while switching on power, Run/Hold is the mode that would have been entered instead.

The l.c.d. screen now shows the Rate and count limit on the top line, and line 2 shows the message HOLDING AT 00000, the zeros confirming that the sample counter has been reset. Photo 2 shows the l.c.d. in this condition.

Simultaneously with S1 being switched off, the new rate, sample limit and count values are stored in the PIC's internal EEPROM memory. The first two are retained there until you initiate the Reset sequence at some future date. (The count value will be updated from time to time as described shortly.)

To start sampling, just switch on S1 (Run/Hold).

After a very brief pause, sampling starts and its progress is displayed on the l.c.d. On the far left of the top line is shown the channel number whose sampled data is displayed immediately to the right of it. On the right of the top line the elapsed time is shown in HH:MM.SS format, on a 24-hour basis. It increments at one second intervals, irrespective of the sample rate selected (except in EXT CLK mode, see later).

The elapsed time counter is always reset when power is first switched on.

The sample data value shown on the top line is that immediately received from the analogue-to-digital converter, prior to it being stored in the serial memory. If a signal generator is being used the value could be any between 0 and 1023. If a +5V link provides the data voltage, the value will be about 1023.

The value of 1023 is the maximum value that the 10-bit ADC sampling will produce when the channel is at the same voltage as the ADC's internal upper reference voltage. The minimum possible value is zero, for a 0V input.

READ BACK

Following storage of the data, it is read back and displayed on line 2, prefixed by the letter R (for Read). Provided that a memory chip has been installed for the channel on display, this number should be the same as the one on the top line.

However, if the channel does not have a memory chip installed, the value displayed on line 2 will be 65535. This is because the memory routine has found nothing but logic 1 on the data line when each bit for that memory location is read. It is the presence of resistor R22 that causes this result, pulling the data line high.

At the moment, with channel 1, you should see identical sample and replay values on the top and bottom lines.

You will also observe that the clock counter is busy incrementing, as is the sample counter at the right of line 2. A typical screen display is shown in Photo 3.

To stop the sampling, switch off S1. If you watch carefully, when you switch off S1, the sample counter fairly rapidly increments by five counts. This action places zeroes in the next five memory locations, an aid to later determination (when the data has been transferred to the computer) of where sample batches start and end.

When the five zeros have been written, the sampling process for this batch has ended and l.c.d. line 2 shows the message HOLDING AT, followed by the current count number.

Additionally at this point, the software stores the current count value in the PIC's own internal EEPROM memory, and this value is retained even after the Data Logger has been switched off. It is recalled when the Logger is switched on again, although the value shown then will be one higher than that on display at the moment of power switch off.

Switch off the power, wait a few seconds and switch on again. The software now retrieves the last-used Rate, count limit and sample count values from its EEPROM memory, and displays them on the l.c.d. The message that should greet you on this occasion is RATE= 1 M=16384 on the top line, with line 2 showing HOLDING AT followed by the count value retrieved. Photo 4 shows a typical screen.

To start sampling once more, switch on S1, switching it off again when you want to

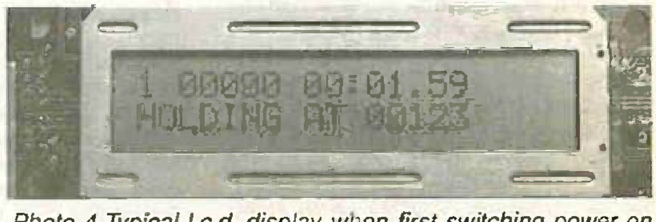


Photo 4. Typical l.c.d. display when first switching power on after a previous batch of data has been sampled.

Photo 5. Typical l.c.d. screen during data transfer to PC, the baud rate is confirmed as 9600.

stop sampling. Try it. Then we'll tell you about viewing the other channels.

CHANNEL VIEWING

With the Logger running, briefly press switch S2. Within one second (the rate of sampling) the switch status will be read and the channel number on display will be incremented. Release S2 when the number changes to indicate channel 2.

On the top line, the sample value should show zero since this channel does not have a signal source connected, only the 0V connection via its pull-down resistor.

If you have a memory in location IC5, the bottom line should show a value of zero. If the location is empty, though, a value of 65535 will be seen (as explained earlier).

Press S2 again, but this time keep it pressed. Each time a sample occurs, the channel displayed will increment, up to 8 and roll over to 1. Pressing S3 instead will decrement the channel number.

It is important to note that all eight channels are always sampled as a batch, irrespective of which channel is on display.

Note also that the current channel number on display is not stored in EEPROM memory and will always default to channel 1 when power is first applied.

When you have finished sampling, switch off S1.

MEMORY FULL

When a limit has been imposed on the sampling count and that limit has been reached, sampling ceases and the l.c.d. advises on line 2 that a MEM FULL condition exists.

The only action that can be performed when the memory is full is to transfer the data to the PC. When you see the message, switch off S1. You may also switch off the power, since even on power-up the full memory condition is recognised.

To clear the full memory condition, the Reset sequence has to be performed during power up.

TRANSFER TO PC

Data can be transferred to the PC computer at any time that S1 is switched off (except in Reset mode).

The Data Logger's serial data acquisition program that is run on the computer is centred around a machine code routine the author has written specifically for the Logger. It is accessed from Basic (QBasic or QuickBASIC), which also does all the formatting and sending of the processed data to the hard disk.

The machine code configures and reads the computer's internal serial registers via interrupt calls. Its source code can be read as a text file, DATLOG01.J. It was written for the shareware A86/D86 (8086 *et al*) assembler, which generated the loadable DATLOG01.COM binary file.

(There are additional notes as a text file with the software – these should be read through your text editor.)

The 10-bit data samples are transmitted by the Data Logger as two 8-bit bytes each limited to a maximum value of 127, plus Stop bit. The computer's internal interrupt routine receives the data as an inverted byte of twice the value transmitted. The software inverts and reformats the data to its original value as stored in the serial memory chips.

From the MS-DOS screen, enter the directory in which your QBasic or QuickBASIC software is held.

If you are using QuickBASIC, type QB/L to load QuickBASIC complete with its library routine that allows Basic programs to be run with the associated machine code program.

With QBasic (which has its own machine code access facility built in), just type QB.

From within the loaded Basic, load the Data Logger program DATLOG01.BAS.

COM PORT SETTING

Near the head of the program you have the option to set which PC COM port is to be used. Find the statement in which the variable COMPORT% is given a value (COMPORT% =). To use COM port 1 set COMPORT% = 0. To use COM port 2 set COMPORT% = 1. If you now resave the program, that same COM port value will be the one selected each time you run the program.

Immediately the program is run (starting it in the usual way for Basic), the author's serial-reading machine code routine is automatically loaded. The Basic program then enters that routine and waits for the serial data from the PIC to start being sent.

To start sending data to the PC, press switch S2 (Up/Send) – S1 must be switched off for the software to recognise that S2 is pressed.

Once S2 has been pressed, the PIC's software first sends six zero value bytes and then proceeds to read and transmit all the stored data from each memory in turn, starting at channel 1 (see Photo 5). The double-byte (word) data for each sample is sent as LSB (least significant byte) first, with each bit being sent in ascending order from bit 0 to 7.

ALL EIGHT CHANNELS

All eight channels will be read even though some may not have memories installed. However, when the software detects the value of 65535 (as produced from an empty memory location, the routine for reading that channel is terminated).

Normally, for installed memories, the same quantity of samples will be sent as the number of samples taken since the Data Logger was last reset (i.e. from sample 0 upwards). When FREE RUN is selected, the software attempts to read back from 16383 memory locations, but terminates that channel if a memory is uninstalled. If memories having a lesser capacity than 16384 samples (less than 256 kilobits) are installed, their contents will be read more than once – intelligent inspection of their PC files must be applied to find the start of duplication.

TERMINATION CODE

When the last sample from each channel has been sent, a termination code is sent, consisting of two bytes each having a value of 127. The next channel is then transmitted, until all eight have been dealt with.

Each time the machine code recognises the termination code of a channel, the routine returns to Basic and the block of sampled data is output to the hard disk as a binary data file named C:\PICLOG\DATLOGx.DAT, where x is the channel number. (Directory C:\PICLOG is created during program installation.)

When each channel has been read, the computer screen shows the values of the first nine samples received for that channel. When all eight channel blocks have been saved to disk, they are each recalled and their first and last ten samples are displayed. Photo 6 shows a typical display.

TEXT FILES

Next, the same .DAT binary files are again recalled in turn and eight new files are created, each holding the sample values as individual numbers expressed in text format. The files are named C:\PICLOG\DATLOGx.TXT, where again x is the channel number.

A third stage follows in which all eight .TXT files are opened simultaneously and a composite single file, C:\PICLOG\DATLOG10.TXT, is created in which the values of each channel are combined into lines of eight columns separated by a TAB character (ASCII 9). This suits the file for input to Microsoft Excel for subsequent graphing and analysis (more on this later).

The .TXT files can (probably) also be read by any word-processing program. MS-DOS EDIT is well suited to this.

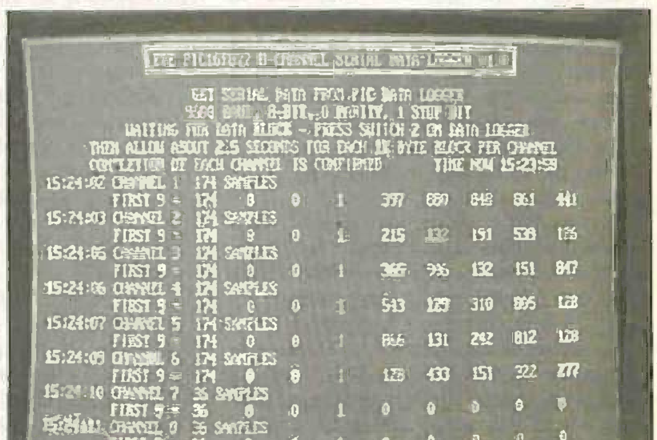


Photo 6. Typical PC screen display during serial data input from the Data Logger.

V-SCOPE FORMAT

That's not all – four more files are now created, suited for display using the *Virtual Scope* (Jan. and Feb. '98) software (you only need the software, the hardware is not required).

Each file holds the data for two channels, the pairs are 1/2, 3/4, 5/6, 7/8 and the files are named 0110000x.Y00 where x is a value of 0 to 3 in order of each pair of channels. These files are stored in the same directory in which your Basic program resides.

The apparently unusual file names (originally intended to be date and time related) allow the files to be accessed and viewed as oscilloscope-type traces through the V-Scope's Directory facility. They may be manipulated in the same way as any other V-Scope files.

Once the V-Scope files have been created, the transfer process is complete and you can come out of Basic in your usual way.

So, then, if that selection of data file options doesn't suit you, nothing will! (But do tell the author via *EPE* if he's wrong on this point, and make practical suggestions.)

A final point on the files, however: the file names used are fixed in the software. It is suggested, though, that in normal use of the Data Logger, you rename the recorded files to those of your choice, allowing fresh batches of sampled data to be imported without overwriting the previous batch. It is preferable that the same extension names should be retained (especially with the V-Scope files).

VIEWING VIA EXCEL

Microsoft's Excel software offers an excellent way in which the Data Logger data can be examined and graphically displayed. The following is one way in which it can be used (determined from the author's Excel 7).

From the Windows desk-top display ("main menu") perform the following steps (all "clicks" are left-hand mouse button clicks unless stated):

- Open My Computer (double-click)
- Open [C:] drive (double-click)
- Open MS Office (double-click)
- Open Microsoft Excel (double-click)
- In Excel, open File menu (top left)
- Click Open
- Click arrow to right of My Documents panel
- Click on [C:]
- Open PICLOG directory (double-click)
- Click arrow to right of Files of Type panel
- Click Text Files
- Select DATLOG10 (double-click)

The file is now loaded and Text Import Wizard screen displayed

- Click Finish (bottom right)

This last action formats and displays the DATLOG10.TXT file as eight columns of numerical data with a row count corresponding to the sample count. At the head of each column is also displayed some textual information. Box 1 states the number of samples (N =) for that column. Boxes 2 and 3 just show zeros. Box 4 states the Logger channel number. Box 5 shows the sample rate that applied when the recording was made. The final box in the column simply states END. Now do the following:

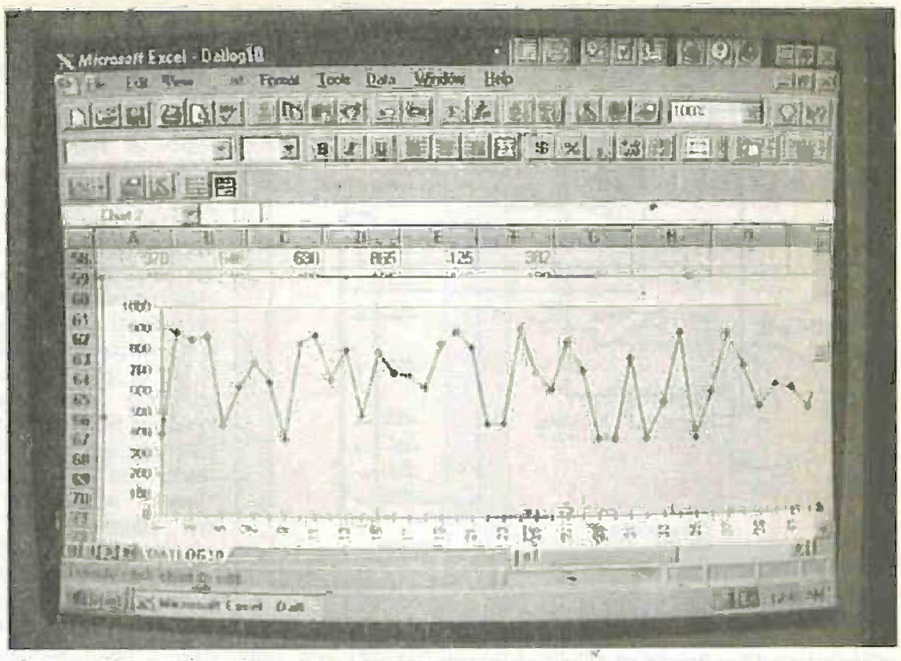


Photo 7. Typical Excel graph display of data recorded during first examination of the Data Logger.

- Click box in column 1 row 5 (box 5A)
- Hold down shift key
- Press cursor down arrow
- Allow cursor to scroll down the rows, with the selected boxes being highlighted
- Stop scrolling on last box before the word END (if you go too far, press cursor up key instead)
- Release cursor key but keep shift key pressed
- Press cursor right key once to highlight column 2 as well
- Release shift key

In one of the panels above the tabulated data an icon showing a graph should be seen – its position and style has been found to be slightly different between computers. (If it is not on display, click on View in the top line then click on Chart to make a tick mark. Click OK then proceed as now described.)

- Click the small arrow immediately to the right of the graph symbol.
- From the graph selection revealed, click on the waveform-like image
- Shift the cursor arrow (which now looks like a graph symbol) over the highlighted data area and click to reveal the Chart Wizard box
- Click on Finish

A coloured graph of the data in columns 1 and 2 now appears, representing the values of the first two channels of data you have recorded.

Only the line for channel 1 should show waveform changes, representing the instantaneous values captured from the signal generator waveform (or just a straight line near the top if a +5V link was used). Photo 7 shows a typical example.

Channel 2 should be represented by a constant value of zero (this should be the case whether or not channel 2 has a memory chip installed).

The height and width of the graph can be changed by positioning the mouse cursor on one of the corners of the graph box so that a "diagonal" cursor appears. Hold down the mouse left-hand button and drag the cursor in any direction, the box size and shape will change accordingly.

All four box corners can be used in this way, plus midway-points on the box sides. The box can be extended way beyond the limits of the screen area. To end the re-sizing, release the mouse button. Keyboard scroll and pan keys can now be used to examine various parts of the graph. The graph can also be moved around by click/hold somewhere within it and dragging to a new position.

The data and graph can be jointly printed to paper via the Print option of the File menu (top left). Just the graph on its own can printed too – explore the tool bar options to find out how.

To clear the graph, right-click the mouse over it and select Clear from the revealed menu.

There are many functions that Excel can perform, including all sorts of manipulations of the data and displays. But this mini intro to Excel is not going any further. Explore for yourself!

SUNDIAL MONITORING

If you have built the *Musical Sundial* (June '99), it is an ideal subject on which to use the Data Logger in a real-life situation. Although not stated in the *Sundial* text, it can be very easily coupled to the Logger and monitored either at a rate set by the Logger, or as triggered by the *Sundial* itself.

Hopefully, you will have seen in *Sundial's* Fig.4 (bottom right) the reference to its test switches being used with the Logger. In which case you simply make connections between *Sundial* switches and Logger as shown now in Fig.3.

When *Sundial's* switches S4 and S5 are switched off, two voltage sources are routed to the Logger. S5 routes the l.d.r. voltage (relative to the level of sunlight illuminating the sensor) at the output of the multiplexers IC1 and IC2 to Logger channel 1. S4 routes one of the multiplexer selector lines (DA7) to channel 3 and provides a

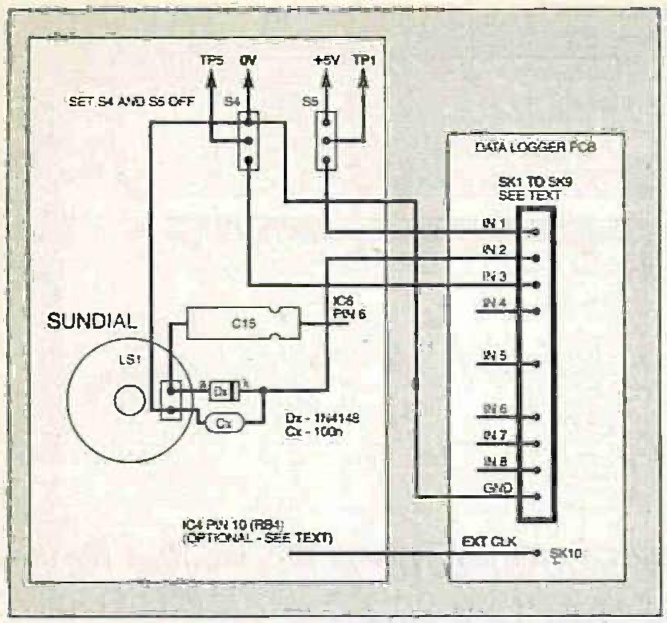


Fig.3. Connections between the Musical Sundial *and Data Logger.*

sync marker relative to *Sundial's* 16-step cycle.

Monitoring of when *Sundial* goes into one of its several musical modes can be monitored directly from the speaker LS1, but requires the temporary addition of a 1N4148 diode (Dx) and a 100nF capacitor (Cx), as shown in Fig.3. These two components rectify the signal level present on the speaker when an audio signal is being output. The rectified signal is input to Logger channel 2.

AFTER-THOUGHT

After *EPE* went to press with *Sundial*, the author decided to allow its software to generate a trigger pulse on RB4 suited to use as the Logger's external clock. To this end, an RB4 pulse is generated at the start of each of *Sundial's* 16 sampling steps, allowing each sensor's voltage to be synchronously monitored through the full cycle.

It is recognised that you may have already sealed your *Sundial's* p.c.b. and can no longer gain access to its pin RB4 (IC1 pin 10), in which case this synchronous monitoring option is not available to you. However, if you can get to RB4, link it to the Logger at its external clock input (SK10).

To monitor *Sundial* synchronously, set the Logger's rate value to EXT. When running, the positive-going pulses from *Sundial* RB4 will cause the Logger to sample the respective l.d.r. voltage at each cycle step, plus the voltage present on the multiplexer control line. The start of this pulse going high signifies the start of *Sundial's* cycle. *Sundial's* audio output is not monitored in this mode.

For non-synchronous monitoring of *Sundial*, set the Logger's sampling rate to any value you fancy, but a one-second rate is probably best for a trial run through. In this mode, it can never be accurately determined which l.d.r. is actually being monitored at the point of sampling, but the data can still provide a good indication of prevailing sunlight conditions. The multiplexer pulse voltage will be recorded at each sample but is really of little value when you come to analyse the recording.

What does become interesting, though, is the recording of the audio output in relation to sunlight conditions. It is even possible (with a bit of practice) to recognise when the hours are being marked (chimes, pips and full tune), and when the "Sun's brightening" and "Sun's going" mini-themes are played.

The time at which these events occur can be calculated from the sample count value at that point on the graph in relation to the known sampling rate.

When graphing the recording through Excel, highlight columns 1, 2 and 3. If your recording is very lengthy it might be best to examine it in sections.

An example display of data recorded from the *Sundial* is shown in Photo 8.

DATA SHEETS

The full data sheets for the Microchip devices used in the Data Logger are available from Microchip: PIC16F87x family, code DS30292A, serial EEPROM memories: DS21203D (24LC256), DS21191C (24LC128), DS21189B (24LC64), DS21162C (24LC32). There are three ways to obtain them from Microchip: as downloads from their web site, from their fully inclusive CD-ROM (all products data and applications info), or as individual booklets.

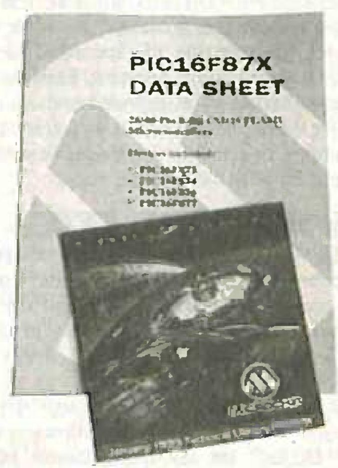
For further information contact Arizona Microchip Technology, Microchip House, 505 Eskdale Road, Winnersh Triangle, Woking, Berks RG41 5TU. Tel: 0118 921 5858. Fax: 0118 921 5835. Web: http://www.microchip.com.

ACKNOWLEDGEMENT

We express our gratitude to Arizona Technologies Ltd for their helpful co-operation in connection with our introduction to and use of the PIC16F87x microcontrollers and associated serial EEPROM devices. The willing assistance of Gordon MacNee is greatly appreciated.

MINI PIC TUTORIAL

Those of you who are interested in programming PICs are recommended to read the *Mini PIC16F87x Tutorial* which is to be published next month. It discusses how to use some of the options offered by the PIC16F877 and, by implication, the other three PICs in this family, the '873, '874 and '876. All four devices were discussed in the *PIC16F87x Review*. □



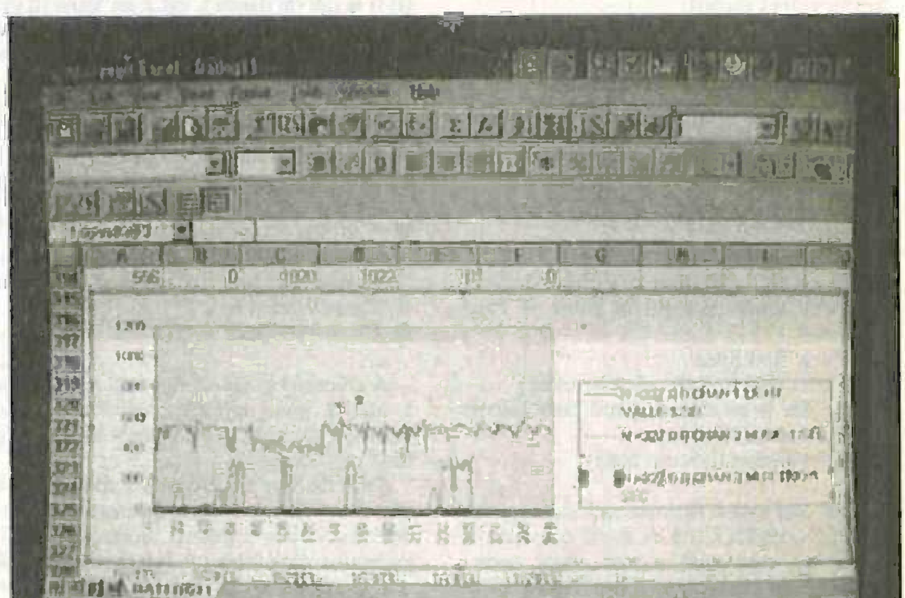
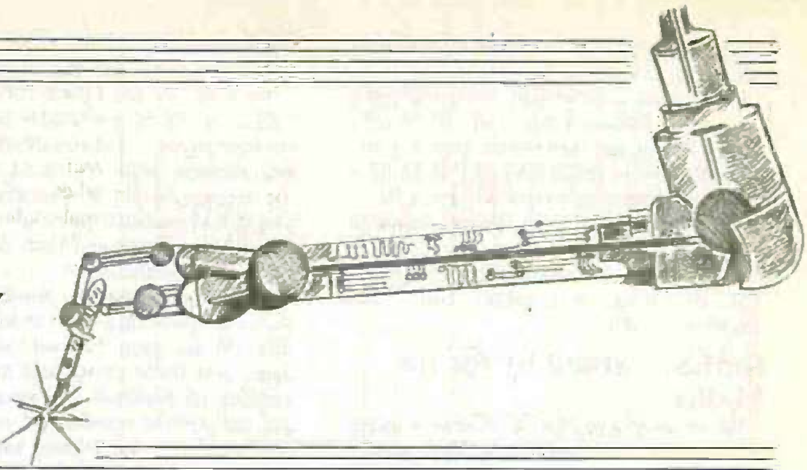


Photo 8. Example of data recorded from the Sundial and graphed by Excel.

Regular Clinic

CIRCUIT SURGERY



ALAN WINSTANLEY and IAN BELL

An interesting photo-sensitive amplifier comes under scrutiny in this month's round-up of readers' queries. Our resident team offers a new definition of P.M.P.O. ratings and a maths-intensive approach to R.M.S. values.

THIS month's column is somewhat maths-intensive but we hope there's something for everyone, starting with a straightforward query from a reader involved with car electrical systems.

Transducer User

I'm more of a car mechanic than an electronics engineer and need help using piezo sounders in various car projects. I understand these sounders need a "driver" circuit, could you explain?

I would also like to use 3mm and 5mm l.e.d.s on the 12V supply but I am unable to find the correct resistor. I have a good understanding of car electrics but am a bit lost with some electronics! John Learmonth, Catrine, Ayrshire.

Piezo (pronounced either *"peet-zo"* or *"pee-ayt-zo"*) sounders are solid-state transducers which can be used as alarm tone generators as well as high-impedance microphones. They fall into two categories: a piezo transducer is nothing more than a disk of piezo ceramic material, and it is this which requires a separate driver circuit (in the same way, a loudspeaker will not make a warning sound unless you drive it with a suitable audio signal.)

What you need is a piezo buzzer, or piezo siren, which is a completely self-contained unit that will generate a warning tone as soon as a supply is connected. It already contains the driver circuit, and some will produce an ear-splitting sound. They are readily available from good mail-order vendors, but be sure to choose a buzzer and not a "dumb" transducer. There are some practical details in *Circuit Surgery*, May 1997.

Light Work

Typically, a "forward voltage" of about 2V appears across a correctly-biased l.e.d. when illuminated. You must, therefore, *"drop"* the remaining 10V (of your car electrics supply) by using a series resistor, which must be of a suitable value to limit the current to the required level (say, 10mA to 25mA) as well. How this is achieved is explained in Fig.1.

However, the most practical way of utilising l.e.d.s for what you're doing is to buy the type which has a built-in series resistor. They can be bought for 5V and 12V operation from some mail-order suppliers. Light-emitting diodes are not always much use on car dashboards, though, as they can be "washed out" by direct sunlight. (*ARW*.)

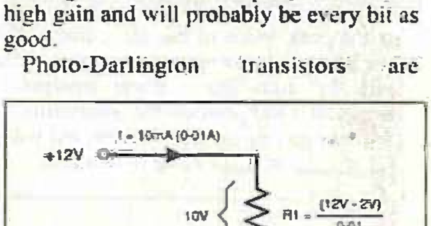


Fig.1. Calculation of a typical series resistor if using an l.e.d. on a 12V car electrical supply, assuming 10mA forward current.

Photo-sensor

Some time ago I used the 2N5777 photo-Darlington transistor which now seems to be obsolete. Is an equivalent available? P. Jenkins, Liverpool.

Yes it does appear to be obsolete – I have one in stock and I'm hanging on to it! It has a completely transparent TO92 body and was a popular choice of photo-sensor ten years ago.

An old 1995 Cricklewood Electronics catalogue lists them at £5.50 even then! An alternative would be the MEL12 photo Darlington transistor (Maplin) which has a high gain and will probably be every bit as good.

Photo-Darlington transistors are extremely sensitive, relying on the energy imparted by incidental light onto the semiconductor junction to "trip" the device into conduction. (Old germanium transistors performed the same way, whether you liked it or not. The glass-bodied OC71 transistor was painted black and could be converted into a simple phototransistor by scraping away the paint! Hence, I think, the OCP71, a very early photo-transistor.)

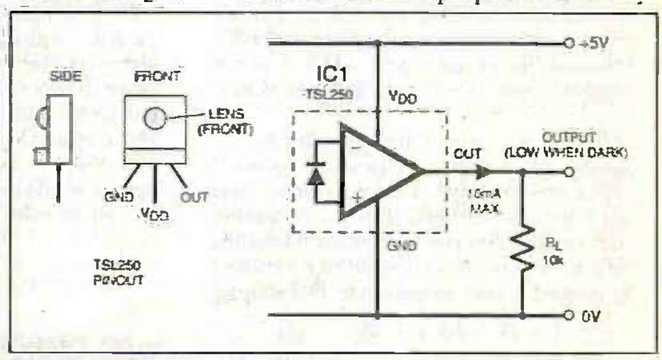


Fig.2. Simple light-to-voltage converter circuit using the Texas TSL250 visible light sensor chip.

Texas Instruments offers an interesting range of CMOS light-to-voltage converters including the TSL250 (for visible light – the TSL260s are tuned for infra-red). They are housed in transparent single-in-line three-pin packs containing a 1mm square photodiode and amplifier behind a lens, all on a single monolithic i.c. The output voltage is directly proportional to the incidental light level. They are very easy to set up and they operate from 2·7V to 5·5V at 10mA absolute maximum load.

A practical light sensor circuit, which outputs a voltage that is proportional to ambient light, is shown in Fig.2. I measured about 3·4V output at maximum brightness, down to 300mV in near darkness.

All that is needed is, say, a comparator or Schmitt trigger and you have an instant snap-action switch without the trial-and-error biasing arrangement that is often associated with photo-Darlington circuits. The TSL250 range is also useful for data reception systems, or by using them to measure light reflected from an object, a simple proximity sensor may be constructed.

Data sheets can be had from Farnell's free data sheet service (tel. 0113 231 0160). Farnell also sell the devices, e.g. the TSL250 I tested (code 460-898) is £1.87 + VAT, *minimum credit card order is £10.*

Another product from Texas seems to have gone the same way as your 2N5777, Mr. Jenkins – I couldn't find the useful TSL220 voltage-to-frequency chip listed anywhere. (*ARW*)

R.M.S. – Stand by for the Maths

We received a number of queries relating to the subject of audio amplifier power output and volume. We hope the following covers most of the concerns addressed by these readers – our reply gets a bit mathematical in places but we have aimed to describe the concepts so that readers who dislike maths can just ignore the equations!

If you have any difficulties understanding it please let us know and we will try to help. There are also some nifty little maths books available from bookstores, including the *Collins Pocket Gem* series which act as a useful memory aid for rusty mathematicians everywhere.

How can I make the output of a 555 timer, drive an 8 ohm 11W speaker at full power from a 12V rail without any complex audio amplifier i.c. or circuitry? The output from pin 3 of the 555 is a short-duration (3 second) tone of about 300Hz. The maximum I can obtain is 5V a.c. which equates to roughly 3 watts. **P. Male,** *Worcs.*

Before we answer this specifically we need to discuss what we mean by "power" when dealing with a.c. waveforms, and also make some comments on measuring a.c. signals. The power in watts dissipated in a resistor when a constant (d.c.) voltage is applied is easy to calculate. It is simply:

$$P = IV = I^2R = V^2/R \qquad (1)$$

This calculates the dissipation in watts for a resistor R (ohms) with a voltage V (volts) across it and a current I (amps) flowing through it. Any of the three equations can be used, depending on which circuit values are known.

When we have any form of *varying* voltage or current (that is, an a.c. waveform) the situation is more complicated. The case usually considered is that of a sinusoidal varying voltage, or sinewave. This is a signal which changes in time in accordance with the mathematical sine function (see Fig. 3).

On Average

The power dissipated in a resistor driven by a sinewave varies from instant to instant in accordance with the equations given above. However, we often need to know what the *average* power dissipated over a period of time actually is.

This is not simply a matter of taking the average voltage or current – it is zero for a sinewave, but practical experience quickly demonstrates that a resistor will get hot if an *a.c.* source of sufficient magnitude is connected across it – so the resistor's average power is obviously *not zero*! In fact, the heating effect produced in a resistor traditionally forms the basis of how we define power for non-d.c. signals.

To work out the power for an arbitrary cyclic waveform, we need to add up all the "contributions" for instantaneous power and average them over the cycle. To find the average height of a number of people you would measure the height of each, add up all the heights and then divide by the number of people.

To find the average power of an a.c. waveform, it would seem to follow that we take I^2R for each "instant" of the waveform, add them all up and divide by the number of instants. Unfortunately, there are an *infinite number* of instantaneous power values – the current varies continuously, unlike our "people example" where there are a *finite* number of individuals. So we have to use a special mathematical technique called **integration** to find our average power.

The average power dissipated in a resistor, R, for a cyclically varying current, i, over the cycle time T of a waveform is given by the equation below. We *integrate* (indicated by the symbol $\int$) the waveform over one cycle (0 to T) to add up all the "instantaneous contributions" and divide by T to get the average. The dt in the equation represents an instant of time (t).

$$P = \frac{1}{T}\int_0^T i^2 R\,dt \qquad (2)$$

If we compare this formula with $P=I^2R$ for a d.c. signal we can find a value of d.c. current which would give the *same heating effect* (power dissipation) as i averaged over one cycle. This is obtained by dividing the above equation by R and taking a square root (if this is hard to follow note we would get I if we did the same to I^2R, which is our d.c. power value). The result is:

$$I_{DCequivalent} = \sqrt{\frac{1}{T}\int_0^T i^2\,dt} \qquad (3)$$

This means that $P = R \times I_{DCequivalent}$. This equivalent current is called the Root Mean Square or r.m.s. value of the a.c. current. Observe that the current is being *squared* (i^2 in the equation), averaged by integration and division by T (hence *mean*) and square-rooted (the $\sqrt{}$ in the equation) – which is where the name comes from. We can define an r.m.s. voltage in the same way.

If we have a sinewave then $i=I_{peak}\sin(2\pi t/T)$ where t is time and I_{peak} is the peak value of the a.c. current. Now we have to do some more maths – substitute the sinusoidal current equation in equation 3 and perform the integration. We will not go into the details here, but we get $I_{DCequivalent} = I_{peak}/\sqrt{2}$ or $0{\cdot}707I_{peak}$.

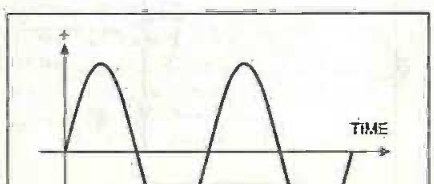


Fig.3. A sinewave, so called because of its mathematical sine function.

This is a formula that may be well known to many readers – to find the r.m.s. value of an a.c. voltage or current, divide peak value by the square root of 2. The ratio of a waveform's peak value to its r.m.s. value is known as the crest factor. The crest factor is $\sqrt{2}$ for sinewave.

At this point it is worth noting that mains electricity voltages are usually quoted as r.m.s. values. For example, an actual 230V a.c. (the UK mains voltage) implies a peak value of 325V a.c. or 650V peak-to-peak. The r.m.s. value is quoted because people are usually interested in heating effect, light output, or power consumption in general when dealing with the mains.

From our equations it should be evident (even if the actual calculation is a bit difficult) that if the waveform is *not* a sinewave, then when we apply equation 3 to get the equivalent current we will not get the same answer. The formula $I_{RMS} = 0{\cdot}707I_{peak}$ is only true for pure sinewaves. For any other wave shape we have to apply equation 3 from scratch.

Watts On

This brings us back to the problem posed by the reader. Let us assume that the output of the 555 (or the driver circuit) is a 50 per cent duty-cycle square wave switching between 0V and 12V (this may be not be exactly the case, but it will serve our purposes). This waveform is nothing like a sinewave, so what is the r.m.s. value of the voltage?

Fortunately, in this case (now we understand the principles involved) the situation is simple enough to bypass equation 3. The average heating effect of the waveform is intuitively half that of 12V d.c. – our square wave is like a 12V d.c. signal which is only on for half of the time. So the r.m.s. voltage is 6V. If this was applied directly to an 8 ohm load the power would be $6^2/8$ or 4·5W.

It is also worth noting that a 6V peak sinewave (i.e. 12V peak-to-peak) would dissipate 2·25W in 8 ohms. A 12V peak sinewave (you would need a dual rail ±12V supply to handle this) would deliver 9W into 8 ohms. These figures should indicate why the reader is having difficulty, and why power amplifiers often have large supply voltages. For a given maximum drive voltage, the power can be increased by reducing the load resistance (e.g. using a 4 ohm speaker instead of 8 ohm) if the drive circuit is able to cope.

It is not clear how the values were measured in the circuit. Measuring a.c. signals using meters poses some problems. Traditional moving-coil a.c. meters respond to the average of the absolute value of the current (known as the rectified mean) but are calibrated to show the r.m.s. value for a pure sinewave. (An "absolute" value simply means ignoring the sign, for example, the absolute values of +2 and −2 are both 2.)

Such meters will not give accurate readings for signals other than pure sinewaves, however, it is possible to calculate correction factors for other waveshapes. Particular care must be taken if measuring a.c. waveforms with d.c. components (i.e. containing a d.c. offset voltage – perhaps an a.c. signal swinging around a d.c. bias voltage rather than 0V) as the d.c. part may influence the measurement.

It is also possible to use a "true r.m.s." converter, and these may be incorporated into digital multimeters. You can purchase r.m.s. to d.c. converter chips which give a d.c. output proportional to the true r.m.s. value of the input waveform. Some of these chips are quite expensive (over £20), but the SSM2110 from Analogue Devices is only around £7, for example.

Measuring Up

Returning again to the reader's query, our calculations above assumed a 12V square wave (equal to the supply) signal applied to the load, however it was stated that only 5V a.c. was obtained. We do not know how this was measured (i.e. if this is a meter reading, or the peak value of a square wave). The low value may be due to measurement error as the waveform is not sinusoidal, or due to the driver circuit, or a combination of the two.

For the driver circuit we basically need a switching device capable of handling 1·5A (12V into 8 ohms) so a typical low voltage power transistor should do the job. A suitable Darlington driver should be able to achieve this, particularly as the 555 timer can sink or source up to 200mA. It therefore seems likely that the problem is with the measurement of the output power or interpretation of the power available. (*IMB*).

Powerless to Help

At the same time, we received a related query from a Malaysian reader asking: *"Can you tell me the differences between the P.M.P.O and r.m.s? I found the first terms on most hi-fis and the latter used in the* 20W Stereo Amplifier *published in May, 1998. It seems that both words are related to the output power of an amplifier, but I don't understand the differences between them and how to calculate the P.M.P.O.". **N. J. How, Malaysia*** (by E-mail).

The term P.M.P.O. stands for *Peak Music Power Output* and is often seen emblazoned on consumer electronics – stereo systems, CD players etc. – sold in the High Street. The problem with p.m.p.o. figures is that they only indicate the maximum power that can be output for a very short time (usually less than one second) so the figure does not really relate to sustained loudness over normal listening periods. Multimedia loudspeakers are a good example, with 240W to 300W p.m.p.o. being quoted.

On the other hand, the r.m.s. figure for an audio amplifier or loudspeakers gives the ***continuous*** power that can be handled – which ***does*** directly relate to "perceived loudness". Although p.m.p.o. figures sound impressive and manufacturers love to quote them, they do not really mean much.

There is no agreed industry standard for p.m.p.o. nor is there an accurate way to relate it to r.m.s. figures. A rule of thumb some people use is to divide p.m.p.o. by a factor to get an approximate r.m.s. figure, but we have seen values from 2 to 20 quoted for this factor!

Quoting p.m.p.o. figures can be very dubious, and may be measured at unacceptably high *distortion* levels, and more impressive-looking still, "total p.m.p.o." ratings can be classed as the sum of the two stereo channels combined (usually r.m.s. *per channel* is quoted on stereo amplifiers). Furthermore, what does "music power" mean? Music signals are very variable. R.M.S. is usually (and should be) quoted for a pure sinewave at a low output distortion value.

In general, if audio equipment specifications quote a p.m.p.o. figure and no r.m.s. value you should be wary. Maybe p.m.p.o. should stand for **Pretty Meaningless Power Over-exaggeration**. *(RMS – Rated More Sensibly? – ARW). (IMB.)*

* *In August 1999* Circuit Surgery, *P. 614, fourth paragraph, the text should read: "The value of R2 must be large enough to prevent excessive current flowing in* TR1's *collector."*

CIRCUIT THERAPY

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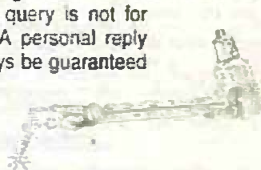

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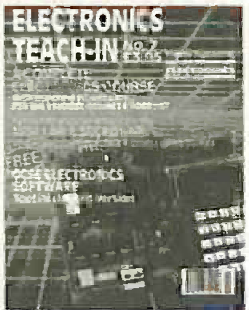

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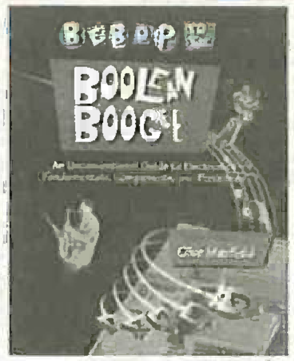

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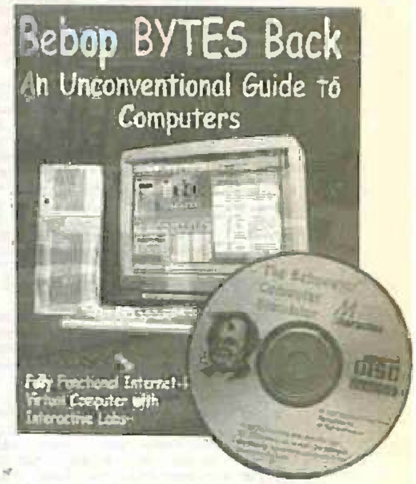

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The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

Also included is the circuit and layout of an inexpensive but highly successful twin-notch filter, and details on how to operate it.

92 pages **Order code BP310** £4.99

Testing, Theory, Data and Reference

SCROGGIE'S FOUNDATIONS OF WIRELESS AND ELECTRONICS – ELEVENTH EDITION
S. W. Amos and Roger Amos
Scroggie's Foundations is a classic text for anyone working with electronics, who needs to know the art and craft of the subject. It covers both the theory and practical aspects of a huge range of topics from valve and tube technology, and the application of cathode ray tubes to radar, to digital tape systems and optical recording techniques.

Since *Foundations of Wireless* was first published over 60 years ago, it has helped many thousands of readers to become familiar with the principles of radio and electronics. The original author Sowerby was succeeded by Scroggie in the 1940s, whose name became synonymous with this classic primer for practitioners and students alike. Stan Amos, one of the fathers of modern electronics and the author of many well-known books in the area, took over the revision of this book in the 1980s and it is he, with his son, who have produced this latest version.
400 pages **Order code NE27** £19.99

ELECTRONICS MADE SIMPLE
Ian Sinclair
Assuming no prior knowledge, *Electronics Made Simple* presents an outline of modern electronics with an emphasis on understanding how systems work rather than on details of circuit diagrams and calculations. It is ideal for students on a range of courses in electronics, including GCSE, C&G and GNVQ, and for students of other subjects who will be using electronic instruments and methods.

Contents: waves and pulses, passive components, active components and ICs, linear circuits, block and circuit diagrams, how radio works, disc and tape recording, elements of TV and radar, digital signals, gating and logic circuits, counting and correcting, microprocessors, calculators and computers, miscellaneous systems.
Page 199 (large format) **Order code NE23** £12.99

TRANSISTOR DATA TABLES
Hans-Günther Steidle
The tables in this book contain information about the package shape, pin connections and basic electrical data for each of the many thousands of transistors listed. The data includes maximum reverse voltage, forward current and power dissipation, current gain and forward transadmittance and resistance, cut-off frequency and details of applications.

A book of this size is of necessity restricted in its scope, and the individual transistor types cannot therefore be described in the sort of detail that maybe found in some larger and considerably more expensive data books. However, the list of manufacturers' addresses will make it easier for the prospective user to obtain further information, if necessary.

Lists over 8,000 different transistors, including f.e.t.s.
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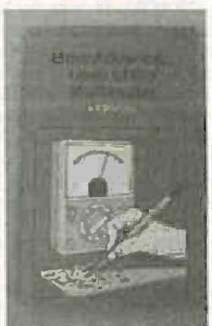
MORE ADVANCED USES OF THE MULTIMETER
R. A. Penfold



This book is primarily intended as a follow-up to BP239, (see below), and should also be of value to anyone who already understands the basics of voltage testing and simple component testing. By using the techniques described in Chapter 1 you can test and analyse the performance of a range of components with just a multimeter (plus a very few inexpensive components in some cases). Some useful quick check methods are also covered.

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

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.
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NEWNES ELECTRONICS TOOLKIT – SECOND EDITION
Geoff Phillips
The author has used his 30 years experience in industry to draw together the basic information that is constantly demanded. Facts, formulae, data and charts are presented to help the engineer when designing, developing, evaluating, fault finding and repairing electronic circuits. The result is this handy workmate volume: a memory aid, tutor and reference source which is recommended to all electronics engineers, students and technicians.

Have you ever wished for a concise and comprehensive guide to electronics concepts and rules of thumb? Have you ever been unable to source a component, or choose between two alternatives for a particular application? How much time do you spend searching for basic facts or manufacturer's specifications? This book is the answer, it covers resistors, capacitors, inductors, semiconductors, logic circuits, EMC, audio, electronics and music, telephones, electronics in lighting, thermal considerations, connections, reference data.
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Robin Pain
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The book covers: Basics – Voltage, current and resistance; Capacitance, inductance and impedance; Diodes and transistors; Op-amps and negative feedback; Fault finding – Analogue fault finding, Digital fault finding; Memory; Binary and hexadecimal; Addressing; Discrete logic; Microprocessor action; I/O control; CRT control; Dynamic RAM; Fault finding digital systems; Dual trace oscilloscope; IC replacement.
274 pages **Order code NE22** £18.99

AN INTRODUCTION TO LIGHT IN ELECTRONICS
F. A. Wilson
This book is not for the expert but neither is it for the completely uninitiated. It is assumed the reader has some basic knowledge of electronics. After dealing with subjects like Fundamentals, Waves and Particles and The Nature of Light such things as Emitters, Detectors and Displays are discussed. Chapter 7 details four different types of Lasers before concluding with a chapter on Fibre Optics.
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R. A. Penfold
This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including:

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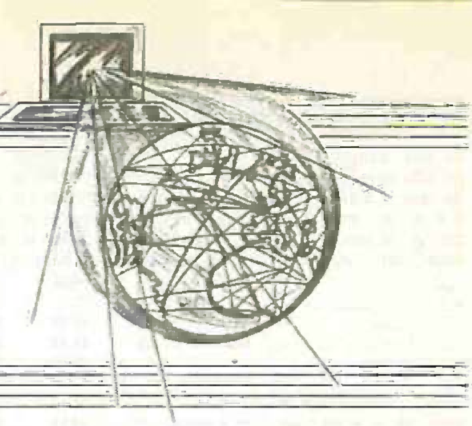
SURFING THE INTERNET



NET WORK

ALAN WINSTANLEY

THERE are several new uploads to the *EPE* web site (**www.epemag.wimborne.co.uk**), including a new series of pages devoted to the *Modern Electronics Manual* and the *Electronics Service Manual*. Both Manuals are constantly updated A4 ring binders designed for students or hobbyists, or those seeking training or re-training in basic electronics. The web pages provide a comprehensive listing of each Manual's contents, and there is also a new facility for secure on-line ordering with world-wide shipping. You can view these pages by going to **manuals.htm** on the *EPE* web site, or follow the links.

DESOLDERING GUIDE

The author has finally created the sequel to the popular *Basic Soldering Guide*, an on-line resource which is used by colleges, students and technicians. The "BSG" is linked by the Edinburgh Engineering Virtual Library and is a well-established educational resource. The new follow-up is the *Basic Desoldering Guide*, which illustrates simple techniques of using desoldering pumps as well as copper braid. There is also the new *Black Museum of Bad Soldering* which depicts some real-life examples of poor soldering technique (the author is collecting more). You can catch up with all of this – fourteen colour photos in all – at **desolderpix.htm**.

ZOOM THROUGH THE HAYES

If you're out looking for a new modem, read the box carefully! One classed as a "Winmodem" relies on the processor power of a Windows PC instead of its own built-in signal processing. They will only work in Windows. The giveaway is that they are usually cheaper than "fully blown" modems by £10 or £20 or more. 3COM/US Robotics is the best known brand of Winmodem which appear as OEM internal modems favoured by Dell and others.

An alternative type of Winmodem uses the Lucent chipset and is manufactured under many brands: Zoom (**www.zoomtel.com**) produces such a PCI card (hence the telltale "LT" Winmodem label). Look closely in the specifications or ads for talk of "using the power of Windows" or "only works in Windows" – sure signs that you're holding a cheaper Winmodem rather than a completely stand-alone device.

A Winmodem will be perfectly adequate for many users, but some brands are evidently more highly regarded than others. One major advantage of the budget Zoom PCI internal Winmodem, apart from the fact that unlike a traditional ISA card it will happily share Interrupts, is that it is easy to upgrade the Windows driver without needing to "flash" the modem firmware. It may simply require copying over a new **.vxd** driver file into Windows. Unlike a firmware flash upgrade, which is a one-way street, this means that the old drivers can be restored by the user if desired, so you can experiment to obtain the best overall performance. The most comprehensive resource on Lucent chipset modems and others is available on **http://808hi.com/56k/x2-lucent.htm**

Hayes Corporation is usually the name associated with computer modem technology, and many experienced users will have grappled with the arcane delights of the Hayes Command Set when trying to coax a modem into operation at one time or another. Modem settings can be customised with the addition of the appropriate command in the "init string" – the chain of Hayes commands which initialises the modem each time it dials. Windows 95/98 users can add extra settings by going to **Device Manager/Modems** *(select yours)*/**Properties/Connection/Advanced**. Modem handbooks often quote the available Hayes command switches.

In April, Zoom announced that it had acquired much of Hayes Communications' modem assets. This includes well-known brands such as Hayes and Accura. Bundled into the deal was the entire assets of Hayes Europe along with Hayes' UK headquarters.

I have been pretty encouraged by my own experiences with Zoom modems. Close examination inside a recent desktop PC revealed its modem was actually an old US Robotics X2 Winmodem, a 33·6K version at that, "flashed" up to 56K. I decided to "flash" it further to V.90 using the latest patch from USR (now 3COM) to see if it would improve its negotiation. Doing so can be a nerve-wracking experience, because applying the wrong patch can render a modem totally unusable. Since ISP's V.90 compatibility standards are gradually being refined, it is wise to get in the habit of checking for the latest modem driver or firmware upgrades, the latter usually being "flashed" into the modem's PROM chip using a simple on-screen procedure. In my case the upgrade didn't make much difference to reliability. Time for a change.

I decided to experiment with a Zoom Dual-Standard 56K/X2 flash-upgradeable internal modem. The Zoom has a five-year guarantee with improved built-in lightning protection and it installed immediately without hesitation. Performance and negotiation was generally more reliable than the USR, although this could partly be due to the type of modem racks in use at the other end: perhaps they didn't like my USR card much.

Later I handed the Zoom over to another user along with a V.90 flash upgrade file, which somehow turned out to be the wrong one. After running the upgrade the modem was crippled, but praise goes to Zoom UK who graciously provided another (V.90) PROM chip, and now it works fine. Rather than revert to the earlier ISA modem, though, I settled for another off-the-peg Zoom, this time a 56K/V.90 Dual Standard PCI Winmodem. This also installed easily, and it will have to do until ISDN2e or ADSL comes along, as wireless modems and cable modems are frustratingly out of reach. In the meantime I can busy myself fiddling with different version of Windows drivers.

BIG FOOTED E-MAIL FOR LIFE

If you have several E-mail addresses, or indeed if you keep changing your Internet Service Provider, one useful way to keep things under control is to use an E-mail re-direction service. One which has been running for a couple of years now is Bigfoot (**www.bigfoot.com**), an unfortunate name perhaps but a proven and reliable service!

One drawback to changing ISPs is the often longwinded task of informing everybody of your change of address. Bigfoot has several free options to help make life a little easier. Mail can be forwarded to a single E-mail address or forwarded on to a maximum of five addresses, the latter is useful if you travel and use Compuserve or AOL to log in whilst abroad.

The addresses to which you would like your mail redirected are set up through the members' page at Bigfoot's web site, and when you need to alter any of the addresses it is a straightforward task to input a new E-mail address. After registering you are given an address in the form of **yourname@bigfoot.com** which you then hand out to all and sundry, safe in the knowledge that your true address can change whenever you like.

For those people who post messages to Usenet (newsgroups) the Bigfoot service also offers a Spam (unsolicited E-mail) blocking option so that mail from known sources of Spam is not forwarded. Something to check out next time you are on-line.

VIRUS UPDATES

Much has been written about Windows viruses, especially Melissa (June '99 *Net Work*) and **Worm.Explore.Zip** (first unleashed in Israel in June '99, also see August '99 *Net Work*). Microsoft has posted a fix which discourages Outlook users from opening a possibly harmful E-mail attachment, thereby also reducing the virus' propagation to the addresses contained in the Address Book. Go to **officeupdate.microsoft.com** for the patches (Outlook 97, 98, 2000).

Don't forget to check the *Net Work* page of the *EPE* web site for this month's round up of suggested URLs. My E-mail address is **alan@epemag.demon.co.uk**

BABANI BOOKS

We now supply *all* the books published by Bernard Banani (Publishing) Ltd. We have always supplied a selected list of Babani books and you will find many of them described on the previous pages or the next two issues of *Everyday Practical Electronics* (all books with a BP prefix to the order code are Babani books). Many readers have asked us to also supply various other Babani books, which have a reputation for value for money.

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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**

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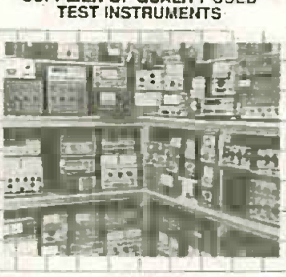

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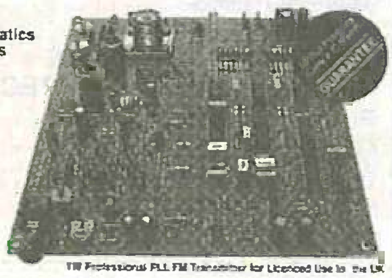

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NEW SPECIAL OFFERS

Amiga genlock pcb (uncased) for using videos it has a 23pin D lead to plug into the computer and pcb pins for composite video in and out. When no video input is connected the normal computer display is shown on the composite video out when the video input is added the white areas on the screen are replaced by the video image. The pcb is powered from the computer ____ £19.98

WATCH SLIDES ON TV "Liesgang diatv" automatic slide viewer with built in high quality colour tv camera, composite video output with a BNC plug. In very good condition with few signs of use ____ £108.00

Board cameras all with 512x582 pixels 4.4x3.3mm sensor with composite video out. All need to be housed in your own enclosure and have fragile exposed surface mount parts and require 10V to 12V dc power supply.

47MIR size 60x36x27mm with 6 infra red leds (gives the same illumination as a small torch would) ____ £50.00+vat=£58.75

MP size 39x38x23mm spy camera with a fixed focus pin hole lens for hiding behind a very small hole ____ £57+vat=£66.98

40MC size 39x38x28mm camera for 'C' mount lens this gives a much clearer picture than with the small lenses ____ £68.79

Standard 'C' mount lens F1.6 16mm for 40MC ____ £26.43+vat=£31.06

Waterproof camera with stylish lid & swivel case ____ £92.76+vat=£109.00 or 10+ £89.32+vat=£104.95

DTA30 Handheld transistor analyser it tells you which lead is the base, the collector and emitter and if it is NPN or PNP or faulty. HMA20 handheld MOSFET analyser identifies gate drain and source and if P or N channel. DTA30 & HMA20 ____ £38.34 each

DCA50 component analyser with lcd readout identifies transistors, mosfets, diodes & LEDs lead connections ____ £69.95

Speaker cabinets 2-way speaker systems with Motorola tweeters

speaker dia	15"	12"	8"
power rating	250W RMS	175W RMS	100W RMS
impedance	8ohm	8ohm	8ohm
freq. range	40Hz-20kHz	45Hz-20kHz	60Hz-20kHz
sensitivity(1W@1M)	97dB	94dB	92dB
size in mm	500x720x340	452x540x345	315x460x230
weight	21.0kg	15.8kg	7.4kg
price each for black vinyl coating	£139.95	£99.96	£54.94
grey felt coating	£159.97**	£119.97**	£64.99

(**not normally in stock allow 1 week for delivery)

Power amplifiers 19" rack mount with gain controls
STA150 2x160Wrms (4ohm load) 14kg £202.11
STA300 2x190Wrms (4ohm load) 11kg £339.00
STA900 2x490Wrms (4ohm load) 15kg £585.00

LEDs 3mm or 5mm red or green ____ 7p each yellow 11p each
Cable ties 1p each. £5.95 per 1000 £49.50 per 10,000

Rechargeable Batteries
AA(HP7) 500mAH ... £0.99 AA 500mAH with solder tags £1.55
AA 950mAH ... £1.75 C(HP11) 1.2AH ... £2.20
C 2AH with solder tags £3.60 D(HP2) 1.2AH ... £2.60
D 4AH with solder tags £4.95 PP3 8.4V 110mAH ... £4.95
1/2AA with solder tags £1.55 Sub C with solder tags ... £2.50
AAA (HP16) 180mAH £1.75 1/3 AA with tags (Philips CTV) £1.95
Nickel Metal Hydride AA cells high capacity with no memory. If charged at 100mA and discharged at 250mA or less 1300mAH capacity (lower capacity for high discharge rates) ... £2.95

Special offers please check for availability stick of 4 42x16mm Nicad batteries 171mmx16mm dia with red & black leads 4.8V £5.95

5 button cell 6V 280mAh battery with wires (Varta 5x250DK) £2.45

Orbitel 866 battery pack 12V 1.6AH contains 10 sub C cells with solder tags (the size most commonly used in cordless screwdrivers and drills 22 dia x 42mm tall) it is easy to crack open and was manufactured in 1994 ... £3.77 each or £110.50 per box of 14

SCI box 190x106x50mm with slots to house a pcb the lid contains an edge connector (12 way 8mm pitch) and screw terminals to connect in wires and 5 slots in cable blanks ... £2.56

7-segment common anode led display 12mm ... £0.45

GaAs FET low leakage current S8873 £12.95 each £9.95 10+ £7.95 100+ BC547A transistor 20 for £1.00

SL952 UHF Limiting amplifier LC 16 surface mounting package with data sheet ... £1.95

DC-DC convertor Reliability model V12P5 12V in 5V 200mA out 300V input to output isolation with data £4.95 each or pack of 10 £39.50

Airpax A82903-C large stepping motor 14V 7.5° step 27ohm 68mm dia body 6.3mm shaft ... £8.95 or £200.00 for a box of 30

Polyester capacitors box type 22.5mm lead pitch 0.9µF 250V dc 18p each, 14p 100+, 9p 1000+. 1µF 250Vdc 20p each, 15p 100+, 10p 1000+

Polypropylene 1µF 400V dc (Wima MKP10) 27.5mm pitch 32x29x17mm case 75p each 60p 100+

Philips 123 series solid aluminium axial leads 33µF 10V & 2.2µF 40V 40p each, 25p 100+

Solid carbon resistors very low inductance ideal for RF circuits 27ohm 2W, 68ohm 2W 25p each 15p each 100+, we have a range of 0.25W 0.5W 1W and 2W solid carbon resistors, please send SAE for list

MXD180 Digital multimeter 17 ranges 1000V dc 750V ac 2Mohm 200mA transistor Hfe 9V and 1.5V battery test ... £9.95

Hand held ultrasonic remote control ... £3.95

CV2486 gas relay 30x10mm dia with 3 wire terminals will also work as a neon light ... 20p each or £8.50 per 100

Verbatim R300NH Streamer tape commonly used on nc machines and printing presses etc. it looks like a normal cassette with a slot cut out of the top ... £4.95 each (£3.75 100+)

Heatsink compound tube ... £0.95

HY3-2405-E5 5-24V 50mA regulator ic 18-264V ac input 8 pin DIL package ... £3.49 each (100+ £2.25)

All products advertised are new and unused unless otherwise stated. Wide range of CMOS TTL 74HC 74F Linear Transistors kits, rechargeable batteries, capacitors, tools etc always in stock.

Please add £1.95 towards P&P (orders from the Scottish Highlands, Northern Ireland, Isle of Man, Isle of Wight and overseas may be subject to higher P&P for heavy items). VAT included in all prices.

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