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AUGUST 1999

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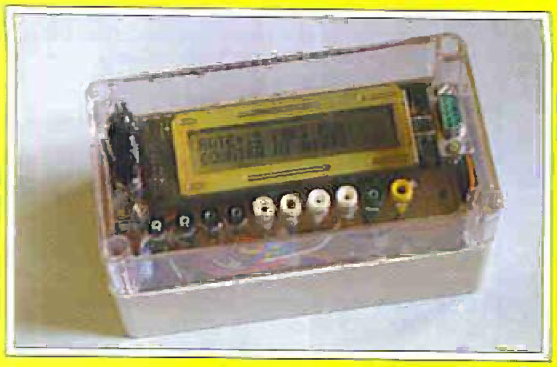
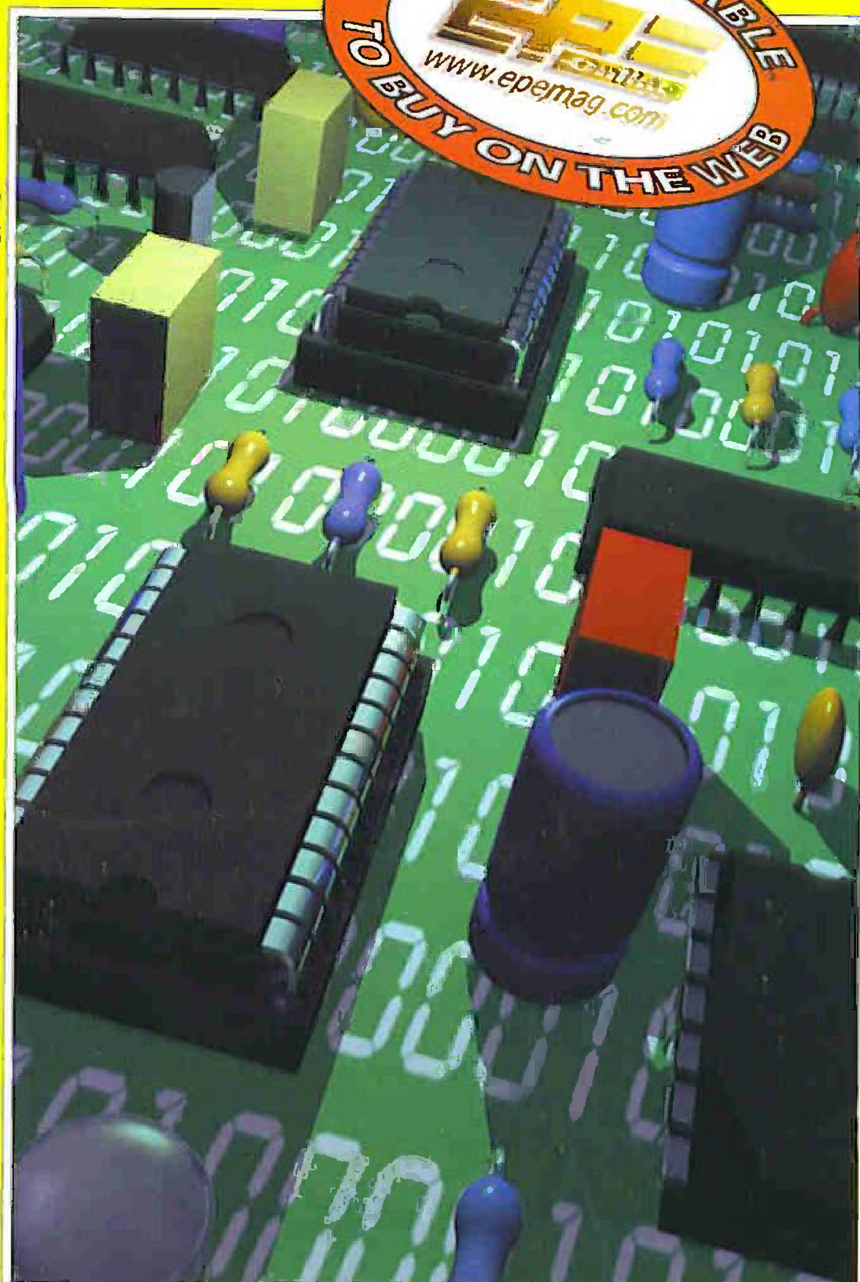
8 CHANNEL ANALOGUE DATA LOGGER

Uses the new PIC16F877





ULTRASONIC PUNCTURE FINDER

Finds bicycle punctures in record time

Starter Project

FREEZER ALARM

Easy to build and inexpensive

FROM PIPELINES TO PYLONS -1

The high tech behind our electricity supply

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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

ECG MACHINES ?/6v 10AH BATTS/24V 8A TX Ex government ECG machines! Measures 390X330X120mm, 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 toroidal 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 293 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. 170x280x220mm, 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 3 mains 30A relay. pack of 20 £20 ref SS34

PIR CAMERA Built in CCTV camera (composite output) IR strobe light, PIR detector and battery backup. Designed to 'squirt' pictures down the 'phone line but works well as a standalone unit. Bargain price £39.95 ref SS81J. These units are brand new modules designed to take "pictures" of intruders and then transmit the pictures down the telephone line. The PIR detects the intruder, fires the strobe light this ensures a perfect picture even in total darkness. The picture is stored in memory inside the module and then sent by modem (not included) down the telephone line. The units also have a nicad battery pack included presumably to maintain operation in the event of mains power failure. Output from the camera is standard b/w composite 320x240 pixels with a 90x65 degree field of view, the picture quality is excellent. Each PIR also contains a video capture and compression unit. The infra red strobe has a range of 15m. The pir has a range of 12m. Power requirements are 12vdc 400mA. Power supplies available at £5 ref SS80. 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 SS80

TELEPHONES Just in this week is a huge delivery of telephones, all brand new and boxed. Two piece construction with the following 'features' - illuminated keypad, tone or pulse (switchable), recall, redial and pause, high/low and off ringer switch and quality construction. Finished in a smart off white colour and is supplied with a standard international lead (same as US or moderns) if you wish to have a BT lead supplied to convert the phones these are also available at £1.55 each ref BTLX. Phones £4.99 each ref PH2 10 off £30 ref SS2

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

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

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS Could be adapted for laserlistener, long range communications etc Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for 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 what's hidden in that magnetic strip on your card! just £9.95 ref BAR31

Hi power 12v xenon strobe variable rate flasher modules and tubes £6 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 70 x 55mm and could be incorporated into many interesting projects! £6 ref FLS1 Pack of 10 is £49 ref FLS2

Hydrogen fuel cells now in stock

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

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

http://www.bullnet.co.uk

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

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

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

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

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

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

12V SOLAR POWERED WATER PUMP Perfect for many 12v DC uses, ranging from solar fountains to hydroponics! Small and compact yet powerful works direct from our 10 watt solar panel in bright sun. Max hd 17 ft Max flow = 8 Lpm 1.5A Ref AC8 £18.99

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

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

SOLAR MOTORS Tiny motors which run quite happily on voltages from 3-12vdc. 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 PV4

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

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

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

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

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

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

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

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

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

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

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

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

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

12V OPERATED SMOKE BOMBS Type 3 is a 12v trigger and 3 smoke cannisters, each cannister will fill a room in a very short space of time! £14.99 ref SB3. Type 2 is 20 smaller cannisters (suitable for simulated equipment fires etc) and 1 trigger module for £29 ref SB2 Type 1 is a 12v trigger and 20 large cannisters £49 ref SB1

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

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

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

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

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

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

SUPER WIDEBAND RADAR DETECTOR Detects both radar and laser, X K and KA bands, speed cameras, and all known speed detection systems. 360 degree coverage, front&rear waveguides. 1.1"x2.7"x4.5" 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 KV25F1U and KV25F1U(BE3D) PCB no's 1-659-827-12 1-659-826-14 1-711-800-11 £20 ref STV1

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

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

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

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

VOL. 28 No. 8 AUGUST 1999

Cover illustration by Jonathan Robertson

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ETI

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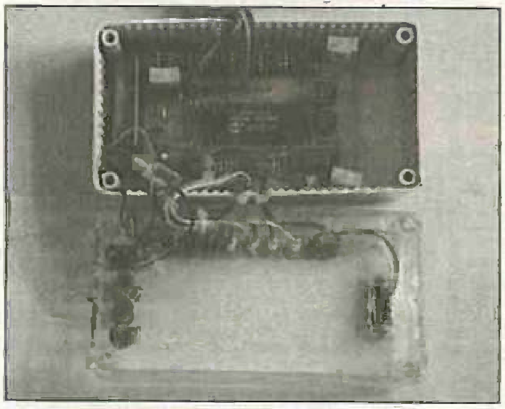
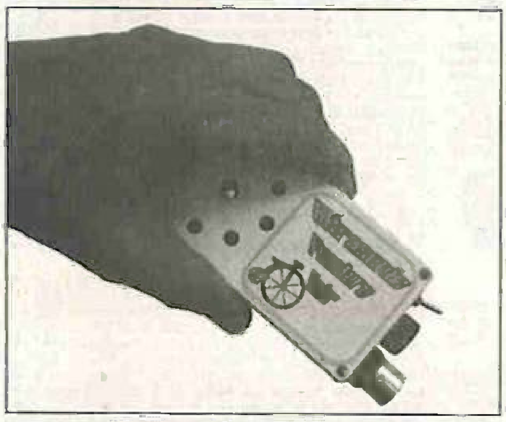
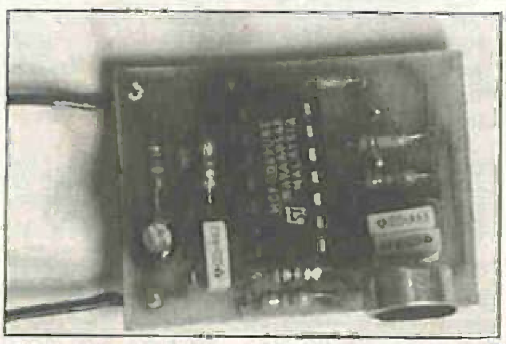
The No. 1 Magazine for Electronics Technology and Computer Projects







Projects and Circuits

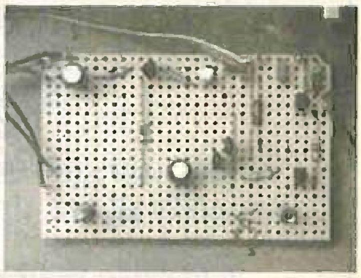
Series and Features

Regulars and Services

Our September '99 issue will be published on Friday, 6 August 1999. See page 547 for details.

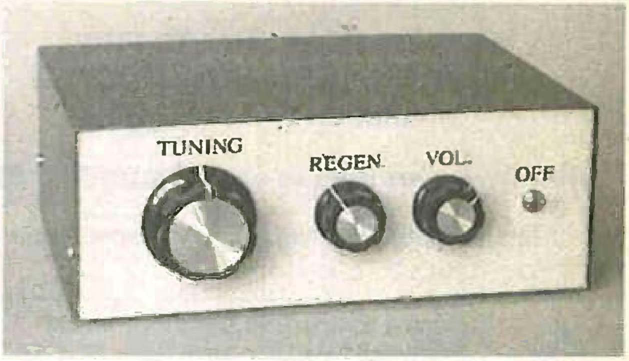
NEXT MONTH

LOOP AERIAL SW RECEIVER



There have been electronic projects for just about everything imaginable published in recent years, but a simple short-wave 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.

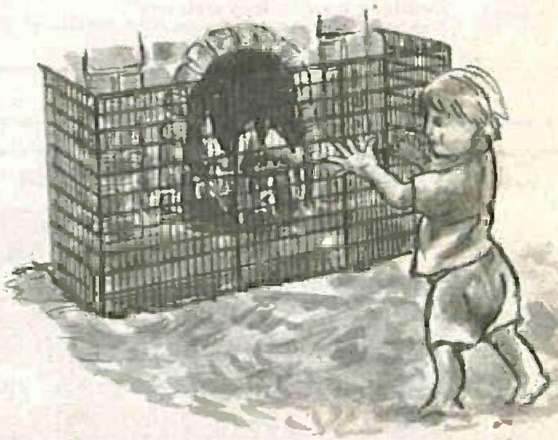
The design featured here is intended for broadcast band reception at frequencies from about 4·5 to 14 megahertz. This provides coverage of the popular 49, 41, 31, 25 and 22 metre bands. It does not require an elaborate aerial or an earth connection, and the aerial is a form of loop antenna.



The term "loop" is perhaps not entirely appropriate in this case, because the aerial is actually a length 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 10 millimetres on the other, rather than a circle of around two metres in diameter.

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.

CHILD GUARD



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 fires, ovens, etc. It is, of course, suitable for helping to protect anyone of any age.

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 heat source. If anyone approaches the fire, a warning buzzer sounds.

PLUS: ANALOGUE DATA LOGGER PART 2
FROM PIPELINES TO PYLONS PART 2
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OSCILLOSCOPES

Beckman 9020 – 20MHz – Dual Channel £150
Gould OS 245A/250/255/300/3000/3351/4000 from £125
Hewlett Packard 180A/180C/181A/182C from £150
Hewlett Packard 1740A, 1741A, 1744A, 100MHz Dual Channel from £300
Hewlett Packard 54100D – 1GHz Digitizing £1250
Hewlett Packard 54200A – 50MHz Digitizing £500
Hewlett Packard 54201A – 300MHz Digitizing £1250
Hewlett Packard 54512B – 300MHz – 1 GS/s 4-Channel £2250
Hewlett Packard 54501A – 100MHz – 100 Ms/s 4-Channel £1250
Hitachi V152F/V302B/V302F/V353F/V550B/V650F from £105
Hitachi V650F – 60MHz Dual Channel £200
Hitachi V1100A – 100MHz 4-Channel £900
Intron 2020 – 20MHz Digital Storage (NEW) £450
Iwatsu SS5710/SS5702 – 20MHz from £125
Meguro – MSO 1270A – 20 MHz Digital Storage (NEW) £450
Lecroy 9304 AM – 200MHz – 100 Ms/s 4-Channel £3000
Lecroy 9450A – 300MHz/400 Ms/s D.S.O. 2-Channel £2250
Philips PM 3055 – 50MHz Dual Timebase £450
Philips PM 3211/PM 3212/PM 3214/PM 3217/PM 3234/PM 3240/PM 3243/ PM 3244/PM 3251/PM 3252/PM 3262/PM 3540 from £125
Philips PM 3295A – 400MHz Dual Channel £1600
Philips PM 3335 – 50MHz/20 Ms/s D.S.O. 2-Channel £950
Tektronix 455 – 50MHz Dual Channel £200
Tektronix 464/466 – 100MHz Analogue Storage from £200
Tektronix 465/465B – 100MHz Dual Channel from £300
Tektronix 468 – 100MHz D.S.O. £500
Tektronix TAS 475 – 100MHz – 4-Channel £995
Tektronix 475/475A – 200MHz/250MHz Dual Channel from £400
Tektronix 485 – 350MHz – 2-Channel £750
Tektronix 2211 – Digital Storage – 50MHz £500
Tektronix 2213 – 60MHz Dual Channel £350
Tektronix 2215 – 60MHz Dual Trace £375
Tektronix 2220 – 60MHz Dual Channel D.S.O. £950
Tektronix 2221 – 60MHz Digital Storage 2-Channel £950
Tektronix 2225 – 50MHz Dual Channel £350
Tektronix 2235 – 100MHz Dual trace £600
Tektronix 2335 – Dual Trace 100MHz (portable) £600
Tektronix 2440 – 300MHz/500 Ms/s D.S.O. 2-Channel £2500
Tektronix 2445 – 150MHz – 4-Channel + DMM £900
Tektronix 2445A – 100MHz – 4-Channel £900
Tektronix 2476B – 400MHz – 4-Channel £6500
Tektronix 5403 – 60MHz – 2 or 4-Channel from £150
Tektronix 7313, 7603, 7623, 7633 – 100MHz 4-Channel from £225
Tektronix 7704 – 250MHz 4-Channel from £350
Tektronix 7904 – 500MHz from £400
Trio CS-1022 – 20MHz – Dual Channel £125

Other scopes available too

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

SPECTRUM ANALYSERS

Ando AC8211 – Spectrum Analyser 1·7GHz £1995
Anritsu MS62B – 10kHz-1700MHz £1995
Anritsu MS3401A – MS3401B – (10Hz-30MHz) £3500 + £3995
Anritsu MS610B – 10kHz-2GHz – (Mint) £4500
Anritsu MS710F – 100kHz-23GHz Spectrum Analyser £5500
Avcom PSA65S – 1000MHz – portable £850
Hameg 6028/5038 – Spectrum Analyser/Tracking Gen + 100MHz Oscilloscope £1000
Hewlett Packard 182T with 8559A (10MHz-21GHz) £2750
Hewlett Packard 152T + 8555B – 0·1 to 1500MHz £1250
Hewlett Packard 853A + 8558B – 0·1 to 1500MHz £2250
Hewlett Packard 3562A Dual Channel Dynamic Sig. Analyser £5750
Hewlett Packard 3580A – 5Hz-50kHz £800
Hewlett Packard 3582A – 0·02Hz-25·6kHz (Dual Channel) £2000
Hewlett Packard 3585A – 20HZ-40MHz £4000
Hewlett Packard 8569B – (0·01 to 22GHz) £4250
Hewlett Packard 85046A – 'S' Parameter Test Set £2500
Hewlett Packard 8753A – Network Analyser from £3000
Hewlett Packard 8753B – Network Analyser from £4500
IFR 7750 – 10kHz-1GHz £2000
Meguro MSA 4901 – 1-300GHz (AS NEW) £750
Meguro MSA 4912 – 1-1GHz (AS NEW) £1000
Rohde & Schwarz – SWOB 5 Polyskop 0·1-1300MHz £1500
Takeda Riken 4132 – 1·0GHz Spectrum Analyser £2100
Tektronix 7L18 with mainframe (1·5-60GHz with external mixers) £2000
Tektronix 495P – 100Hz-1·8GHz programmable £4500
Tektronix 496P – 1kHz-1·8GHz Spectrum Analyser £4250

MISCELLANEOUS

Adret 740A – 100kHz-1120MHz Synthesised Signal Generator £600
Anritsu MG 3601A Signal Generator 0·1-1040MHz £1250
Anritsu ME 462B DF/3 Transmission Analyser £2500
Anritsu MG 645B Signal Generator 0·05-1050MHz £750
Boonton 92C R/F Millivoltmeter £195
Boonton 93A True RMS Voltmeter £195
Dranetz 626 – AC/DC – Multifunction Analyser £500
EIP 331 – Frequency Counter 18GHz £450
EIP 545 – Frequency Counter 18GHz £1250
EIP 575 – Frequency Counter 18GHz £1450
Eltek SMPS – Power Supply 60V-30V £350
Farnell TSV-70 MKII Power Supply (70V – 5A or 35V – 10A) £200
Farnell OSG-1 Synthesised Signal Generator £125
Farnell AP 30250A Power Supply 5V – 250A £1750
Feedback PFG 605 Power Function Generator £150
Fluke 5100A – Calibrator £1950
GN ELMI EPR31 PCM Signalling Recorder £2000
Guildline 9152 – T12 Battery Standard Cell £550
Hewlett Packard 1630D – Logic Analyser (43 Channels) £500
Hewlett Packard 16500A/B and C – Fitted with 16510A/1651A/161530A/16531A – Logic Analyser from £2000
Hewlett Packard 331A – Distortion Analyser £300
Hewlett Packard 333A – Distortion Analyser £300
Hewlett Packard 334A – Distortion Analyser £300
Hewlett Packard 3325A – 21MHz Synthesiser Function Generator £900
Hewlett Packard 3335A – Synthesised Signal Generator (200Hz-81MHz) £2750
Hewlett Packard 3336C – Synthesised Signal Generator (10Hz-21MHz) £800
Hewlett Packard 3455A – 6½ Digit Multimeter (Autocal) £500
Hewlett Packard 3456A – Digital Voltmeter £600
Hewlett Packard 3488A – HP – 1B Switch Control Unit (various Plug-ins available) £550
Hewlett Packard 35660A – Dual Channel Dynamic Signal Analyser £3750
Hewlett Packard 3586A – Selective Level Meter £800
Hewlett Packard 3711A/3712A/3791B/3793B – Microwave Link Analyser £1500
Hewlett Packard 3746A – Selective Measuring Set £500
Hewlett Packard 3776A – PCM Terminal Test Set £1000
Hewlett Packard 3779A/3779C – Primary Mux Analyser from £400
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PRIZES

It was my pleasure recently to be invited to present prizes to electronics students at Radley College. Apart from an interesting afternoon out in a truly wonderful location, it was fascinating to meet the students and see first hand their electronic projects. These, of course, are privileged students, being taught in small groups with one of the best school laboratories I have ever seen. (Fees at Radley are high.) However, what comes across strongly is the enthusiasm for the subject instilled by their teacher Max Horsey.

Radley students have been represented in the finals of YEDA (Young Electronic Designer Awards) in five of the last six years (when they first took part) and have carried off many hundreds of pounds worth of prizes. Whilst the small classes and wide variety of equipment, etc., undoubtedly help – plus the long hours students can spend in the workshop and laboratory if they wish to – it's the original ideas and lateral thinking that goes into each project that makes them winners.

ENCOURAGEMENT

Of course, not every school can obtain such facilities and in most schools class sizes will be three or more times larger, but there is no reason why the enthusiasm and encouragement should not be plentiful. We know that electronics is often at the bottom of the list when it comes to budgets, etc., and is often being taught by those who have not been trained in the discipline (Max Horsey was self-taught in electronics with the help of magazines and books) but, with the right encouragement, the students can generate the ideas, research the circuits and build the projects whilst learning alongside the teacher.

It needs an open mind, the ability to research, and some resourcefulness but it can be done. There is now plenty of educational electronics material available on the Internet and in books, videos, CD-ROMs, etc. – see our sales pages for some of these items – and, of course, in *EPE*. One of the biggest advantages is that a good grounding in electronics can lead to a very rewarding career. We know not many can receive the level of education provided by Radley College, and I do not intend to get into the political arguments over that, but it would be good to see a more positive attitude and particularly some more cash coming from those in Government responsible for UK education.

THE FUTURE

Students represent the future of the UK electronics industry; we need to invest in them now and to continue to invest in them. We believe that the basic ability and enthusiasm exists in most schools – what is lacking is the finance and stimulus from the Government to push electronics. It happened in the eighties but has been sadly lacking since.

This is the technology that now runs the world – it is possibly more important to our future than any other subject.

Mike Kenward

AVAILABILITY

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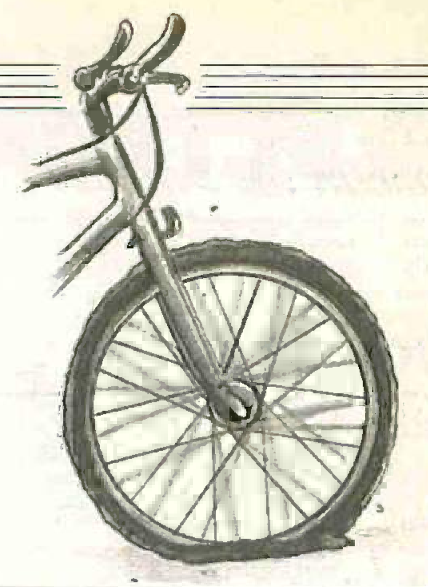
Constructional Project

ULTRASONIC PUNCTURE FINDER



BILL MOONEY

A new "first-aid" tool for your puncture repair kit, uses SMDs and ultrasonics to detect escaping air.

EVERY cyclist will sooner or later need to deal with a flat tyre. After figuring out the intricacies of getting to the inner-tube, the puncture must then be located.

Punctures come in all shapes and sizes from irreparable blowouts to slow punctures where the deflation can take weeks. But the most common type of puncture is from a thorn or a small nail. Such punctures can be quite difficult to find and a basin of water is often used to find the hole (air-bubbles rising to the surface) and to make certain that it is the only one.

FIND-THE-LEAK

The Ultrasonic Puncture Finder fits in here as a much less messy way of finding normal punctures. It will replace the water bowl and with a little skill may even help to locate some slower punctures. In a find-the-leak speed test the ultrasonic finder took only a few seconds whereas the water bowl took several minutes including the time to set it up and clean up.

Other techniques such as lightly running the hand around the tube or passing the tube close the face to feel for the cooling air stream have their merits. But again the ultrasonic device tended to be faster and it is certainly cleaner.

The ultrasonic detector will not solve all puncture problems and can be defeated just like every other method particularly when dealing with very slow leaks. However, it is another useful weapon in the cyclist's armory and it is easy to use.

Apart from finding punctures this low cost device will be of interest to those investigating the properties of ultrasound.

TURBULENT TIMES

A jet of air ejected under pressure from an inflated tube will in most cases flow into the atmosphere in a highly turbulent manner. Because of the scale involved in the case of an innertube puncture a portion of this turbulent energy results in disturbances in the ultrasound region.

The commonly available ultrasound microphones of the type used in this project operate at 40kHz. The speed and the frequency of ultrasound or indeed any waveform are intimately related. In all cases the wavelength can be found by dividing the speed by the frequency.

The speed of sound in air is known to be about 344 metres per second. So the ultrasound detector will respond to wavelengths of about 8mm.

Prediction of the onset of turbulence involves very complex fluid mechanics

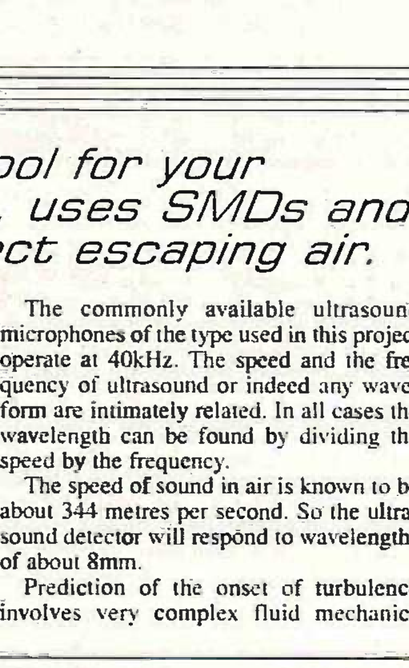


Fig.1. Recovery of audio frequencies from an amplitude modulated signal. (a) 40kHz signal with low frequency amplitude variation (noise), (b) after diode detection before smoothing and (c) recovered audio (noise).

but another science called common sense would suggest that such short wavelength might be associated with a tiny jet of turbulent air from a leaky inner tube. We also get a clue from the fact that several successful companies market ultrasonic leak detectors world wide for diverse use such as in the aircraft and the chemical industries.

Turbulence in the jet of air from a puncture will result in a complex mix of signals varying randomly in frequency and amplitude. The voltage output from the ultrasonic microphone will therefore appear as random noise. Most ultrasound detectors convert the 40kHz signals to the audio frequency range by mixing it with a steady local oscillator.

Some experimentation confirmed that the amplitude of the 40kHz noise from a puncture air stream varied at audio frequency. This electrical signal from the detector can, therefore, be regarded as an amplitude modulated (a.m.) radio signal.

The random ultrasonic noise signals will also mix in the detector to give sum and difference signals and the latter will also appear in the audio range. Put another way noise plus and minus noise equals noise. The design concept for the Ultrasonic Puncture Finder is therefore along the lines of a "straight" radio receiver with a simple detector and audio amplifier.

STRAIGHT RECEIVER

In a straight radio receiver, the signal is first separated from the myriad of signals in the radio frequency spectrum by a tuned circuit. This very weak signal of maybe a few microvolts is then amplified to a level (>100mV) suitable to operate a diode detector circuit. Before detection the signal is balanced and there is no audible component.

The diode acts as a rectifier allowing only positive going signals to pass. This results in a series of positive going pulses at 40kHz, the carrier frequency. A capacitor smoothes these pulses to give an average which varies over time, corresponding to the low frequency audio component of the ultrasonic signal. Final amplification is at audio frequency after the detection process.

In such a line up there is no mixer as such and no intermediate frequency amplification. This is illustrated by the recovery graphs shown in Fig.1.

CIRCUIT DESCRIPTION

The puncture finder relies largely on an ultrasonic transducer to select the input frequency. This is an electromechanical device which converts the ultrasound to what is in effect a v.l.f. (very low frequency) radio signal. From there on the processing is the same as a tuned-in radio signal. The complete circuit diagram for the Ultrasonic Puncture Finder is shown in Fig.2.

The ultrasonic transducer, RX1, is a high impedance device and its output is buffered by the low-noise f.e.t. TR1, which acts as a voltage follower. A simple high-pass filter

With this high gain circuit it is essential to remove any ripple on the supply line to prevent instability. The simplest way to achieve this is with a large electrolytic capacitor, C12 in this circuit. Capacitor C11 is a ceramic device which de-couples high frequency components more effectively than C12.

MECHANICAL FILTER

An essential component in the circuit is the home-made mechanical filter, which de-couples the ultrasonic transducer RX1 from the instrument case. This is, in fact, a small circle of rubber about 6mm thick, which is about one wavelength. At full volume any distortion in the audio amplifier or the loudspeaker results in high frequency harmonics and if they reach the

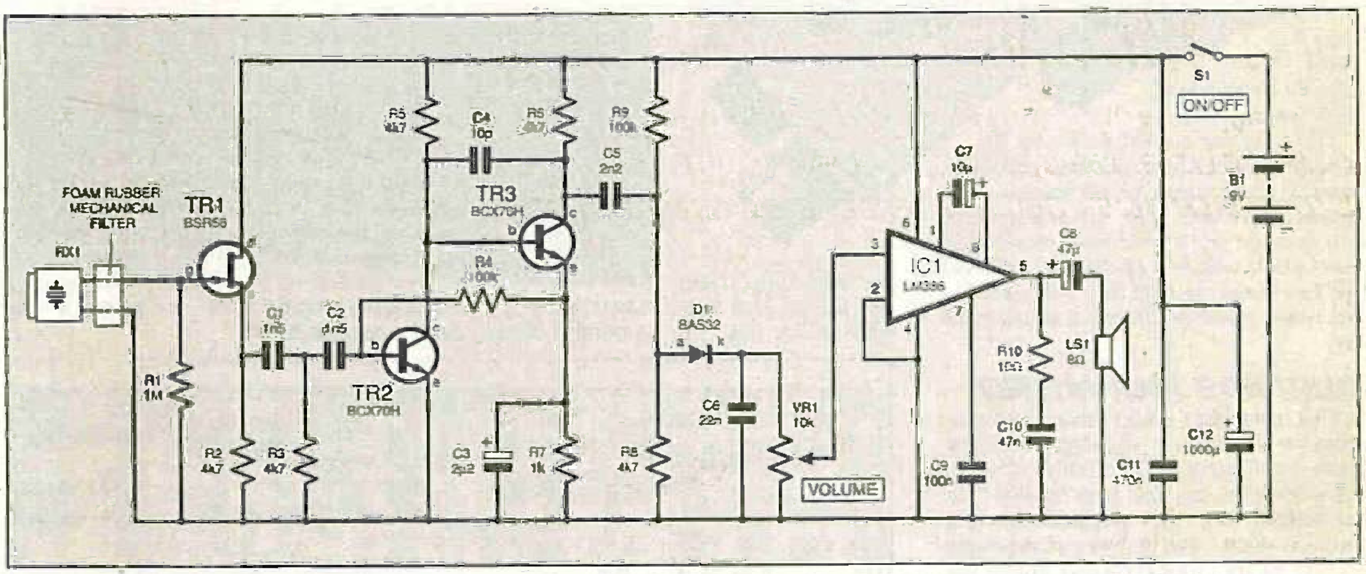


Fig.2. Full circuit diagram for the Ultrasonic Puncture Finder.

consisting of capacitor C1, resistor R3, and capacitor C2 removes any audio frequency components from the signal. This is a major requirement to prevent audio feedback from the loudspeaker and consequent instability.

Transistors TR2 and TR3 provide a gain block to lift the signal to sufficient amplitude to drive the diode detector D1. The feedback capacitor C4 provides top cut and improves the r.f. stability of the circuit.

A strong noise input signal will produce a few millivolts (mV) at most from the transducer. With a gain of some 600 times before the detector the stronger ultrasound sources therefore produce full audio output.

Unfortunately, silicone diodes stop conducting much below about 600mV and sensitivity is lost. The diode detector is therefore slightly forward biased to increases the sensitivity. This is achieved by resistor R9, which injects about 80µA into the diode. With this setup the increase in sensitivity is quite dramatic and very weak sources of ultrasonic noise can be traced.

The audio level to the output amplifier IC1 is controlled by potentiometer VR1. Although VR1 is a linear device the overall loudness control seems even over the track because of the non-linearity of the detection system. Audio amp IC1 is set to a voltage gain of 200 by capacitor C7 and it has sufficient power to drive the small loudspeaker LS1.

COMPONENTS

Approx. Cost Guidance Only £20

Resistors

R1	1M	
R2, R3, R5, R6, R8	4k7	
R4	100k	
R7	1k	
R9	100k	
R10	10Ω	

All surface mount (SMD), case size 1206

See SHOP TALK page

Potentiometer

VR1	10k ceramic knob pot, see text

Capacitor

C1, C2	1n5 ceramic chip, size 1206
C3	2µ2 tantalum 10V
C4	10p ceramic chip, size 1206
C5	2n2 ceramic chip, size 1206
C6	22n ceramic chip, size 1206
C7	10µF tantalum 10V
C8	47µ tantalum 16V
C9	100n ceramic chip, size 1206
C10	47n ceramic chip, size 206
C11	470n ceramic chip, size 1206
C12	1000µ aluminium radial elect. 16V

All SMDs, except C12

Semiconductor

D1	BAS32 signal diode, SMD SOD80 case
TR1	BSR58 low-noise *n*-channel f.e.t., SMD SOT23 case
TR2, TR3	BCX70H low-noise *npn* transistor, SMD SOT23 case
IC1	LM386 audio power amp., SMD SO8 case

Miscellaneous

RX1	40kHz ultrasonic transducer (receiver type R40-16)
S1	miniature on/off toggle switch
LS1	8 ohm 49mm dia. Mylar loudspeaker

Printed circuit board available from the *EPE PCB Service*, code 236; small plastic case, size 111mm x 57mm x 22mm; fine connecting wire (see text); PP3 battery and snap connector; foam rubber disc (mechanical filter – see text); solder etc.

trans-ducer they produce a bad case of "howl-round".

The quiescent current drawn by the complete circuit is less than 9mA and this peaks to about 65mA at full volume. The prototype worked with no performance change down to 7·5V but went on working down to 6V with loss of volume. An alkaline PP3 battery is therefore well suited to power the puncture finder for intermittent use.

SURFACE MOUNTING

This is a surface mount project and construction will involve working with some pretty small devices. The "chip" components specified are the most suitable for hand soldering but they are not the smallest SMDs available. The only requirements for population are a fine soldering iron of the type used for normal leaded components and a pair of tweezers.

Although an SM circuit can be constructed by the simple method described below, several specialized techniques have been developed for hand working. It is important to improve SM skills especially for more complex circuits where reliability can be improved by more appropriate soldering methods.

Non-magnetic or demagnetized tweezers are required for handling SM chip components as their contacts contain nickel and they are magnetic. Because they are so small and light they will stick to magnetised tweezers making accurate placement very tedious.

CONSTRUCTION

The component layout (twice-size) on the small surface mount printed circuit board (p.c.b.), together with the full-size copper foil master, is shown in Fig.3. Here the components are mounted directly on the copper pads; no holes drilled in the p.c.b. This board is available from the *EPE PCB Service*, code 236.

The simplest method of soldering an SM device is to hold it on the circuit board pads with the tweezers and solder one end with a little solder carried on the iron. Having fixed one end the second end, or the remaining contacts in the case of active devices, can be soldered by the more reliable method of applying the iron and solder to the joint at the same time. The anchoring end can be re-soldered if required.

A suggested method of construction is to place all the resistors and then the capacitors, finishing off with the transistors and finally IC1. Ceramic chip capacitors are delicate and require the smallest amount of solder and the shortest heat duration.

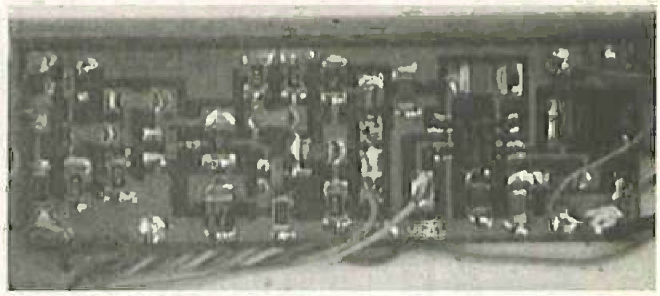
In severe cases the contacts can become detached but this is an indication of excessive stress and only occurs with heavy reworking during fault finding. More problematic perhaps is part detachment of the nickel contact or cracking of the ceramic where the fault may not be seen. It is essential that the tantalum capacitors and the diode are wired the right way around. *(For more information on SM construction see the author's web site at: www.billsSMD.mcmail.com.)*

IN THE BOX

All the elements fit easily into a standard 111mm by 57mm plastic project box. The layout is not critical except for two points.

The loudspeaker and ultrasonic transducer must be as far apart as possible and orientated at right angles to each other. The suggested layout should be followed in this respect.

Secondly, the ultrasonic transducer RX1 *must* be mechanically isolated from the case and hence the loudspeaker. This is simply achieved by using a small disc of non-conductive foam rubber to mount the transducer as shown. A thin layer of adhesive such as Evostick holds the sandwich together.



Completed surface mount p.c.b. Note components are mounted directly on the copper pads.

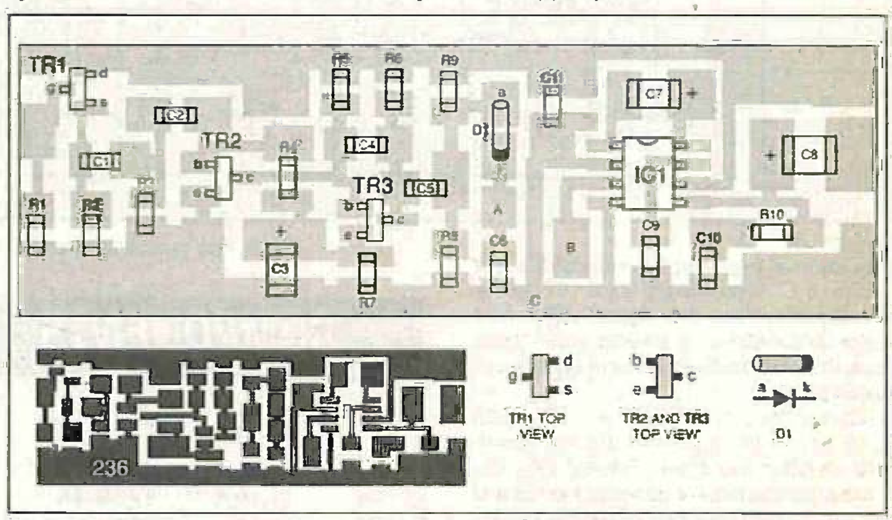


Fig.3. Layout of components on a twice-size surface mount printed circuit board and full size copper foil master pattern. The transistor and diode pinouts are also included.

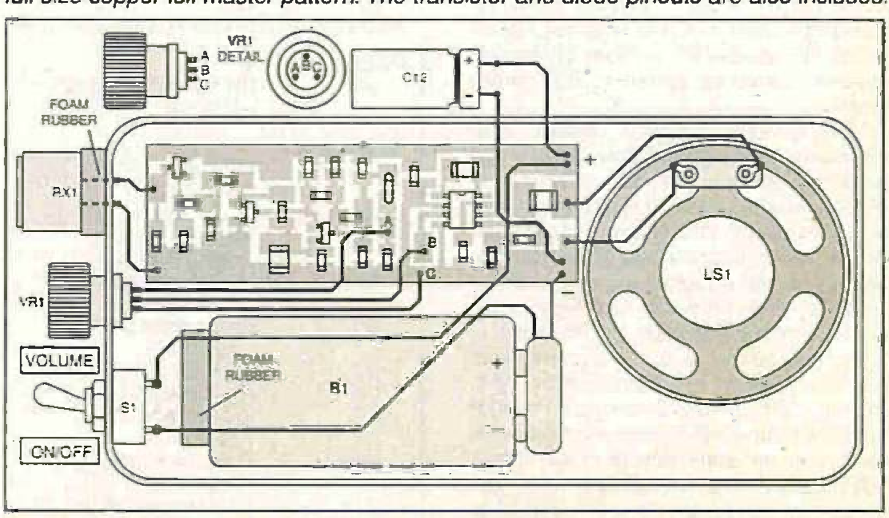
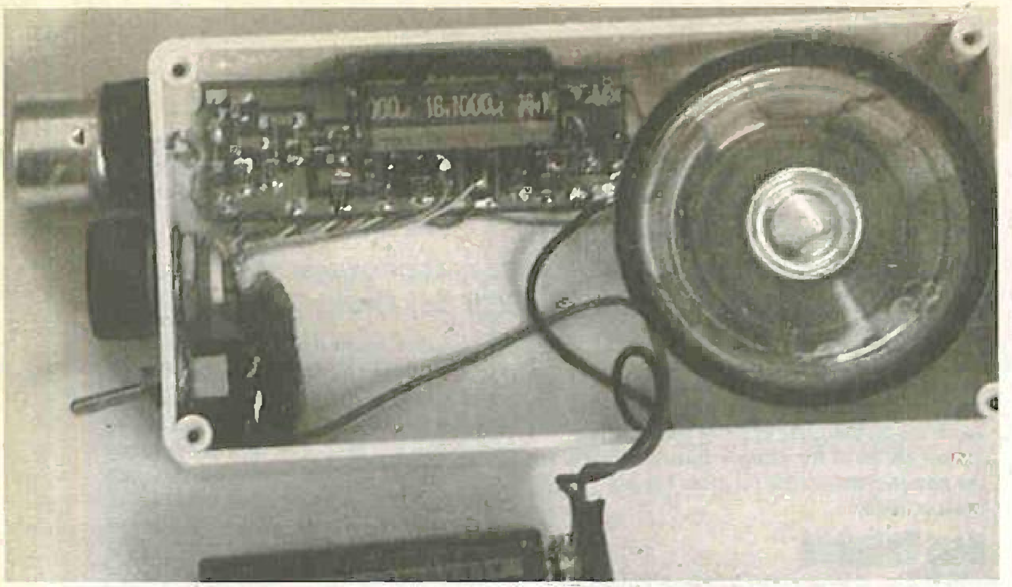


Fig.4. Positioning of components inside the small handheld case. Keep the ultrasonic transducer and loudspeaker as far apart as possible.



The foam disc should be as soft as possible, a rubber gasket material about 6mm thick was used for the prototype. Another source of this type of soft foam is the backing from computer mouse mats.

A small piece of the same foam should be placed over the on/off switch contacts to isolate it from the metal base of the battery. Make certain that the foam is not conductive. The position of the various components in the case is shown in Fig.4.

The small loudspeaker is held in place by a thin layer of glue on the magnet. The speaker type suggested is an exact fit in the prototype case, see photographs. A speaker grille will need to be fashioned from a series of holes in the box lid. The prototype sound outlet consisted of eight equally spaced 6mm holes and a central 8mm hole.

A "knobpot" is suggested for the volume control VR1. These are expensive but made to a very high standard and take up very little space inside the box.

The populated circuit board is also glued in place and does not therefore require any holes to be drilled. The decoupling capacitor C12 is adequately supported by its own leads.

WIRING-UP

The connecting wires to the Volume control, loudspeaker and transducer is a fine, 0·8mm dia., and multistrand (7/0·1) flexible wire rescued from a section of 25-way computer cable. This type of wire is ideal for surface mount projects where a flexible connection is required. The interwiring details are shown in Fig.4.

The ultrasonic transducer specified comes with a metal cut-out grille or a wire mesh guarding the sensing element, the wire mesh type is marginally more suitable for this application. Finally, it is worth decorating the finished device with some labels at least marking the on/off switch positions. Suitable labels can be designed easily with a computer drawing package.

TESTING

If all is well, the Ultrasonic Puncture Finder should work right from switch on as there are no adjustments to be made to the circuit. But it is best to carry out a few spot checks before applying power and putting the lid on the box.

The most obvious items to check are the polarity of the electrolytic capacitors and the diodes. Surface mount transistors can come with a lead-out "joggle" especially the f.e.t. but the drawing shown is by far the most popular. If the device cannot be coaxed to work it may be worth just checking the transistor pins in the usual way, but this really is a last resort.

Reduce the volume to minimum and measure the quiescent current. If this is about 9mA it is very likely that the circuit is working correctly.

Finally, increase the volume and see if you can track down some ultrasound. A low hiss from the loudspeaker is a good indication.

SOUND SOURCE

There are many sources, which can be used as a test signal. A portable and very useful ultrasonic noise generator is your thumb and forefinger, just rub them together in front of the transducer. This source should be detectable at well over a metre distance from the transducer, depending on the dryness of the skin. Other sources include expanded polystyrene and running computers.

If the foam filter is doing its job there should be no feedback instability at full volume. It is possible to induce feedback as a test of sensitivity by reflection of the speaker output back to the input using your hands or a flat surface as a sound reflector. Other fun ideas will no doubt arise.

Finally, it is simple to demonstrate that this circuit is working as a straight receiver by connecting a few feet of wire to the "hot" side of the transducer. Random radio noises and the odd a.m. radio station should emerge from the speaker.

OPERATION

To find a puncture the offending inner-tube must be fully inflated so as to maximize the air flow and increase the chances of turbulence. It is also useful to examine the tyre before the tube is removed as this way the nail or thorn can often be found and the approximate location of the hole determined.

The puncture finder can be a help with this also. Slowly rotate the wheel keeping the detector a couple of centimeters from the tyre until the air exit is detected as a noise from the speaker. In most cases there will be some slight movement between the tube and tyre so that the air escapes randomly from around the rim.

TEST TUBE

Sometimes the leak can be detected in this way but it may not be a good guide to the actual puncture location. The tube must be removed eventually so there is little point in spending too much time looking for the leak beforehand.

Having removed the tube and made sure that it is as fully inflated as possible run the detector around the outer edge first. This is where the hole is most likely to be located. Keep the transducer as close as possible to the rubber surface. If this is not successful then run a check around each side in turn. The three tests on the tube will take only about a minute to complete.

If there is still no success then the action needs to be repeated but at a much slower and more methodical pace, taking care to cover the complete tube surface. Stretching the tube slighly can often open a small hole releasing sufficient air to be detected.

Keeping the transducer close to the tube is also helpful as a small air-flow hitting the grille can induce detectable turbulence, particularly with the wire mesh covered variety of transducer. Keeping the tube well inflated will also improve the chances of turbulent flow from the leak.

If there is still no leak at this stage you may have to resort to the dreaded water test or carry a pump because it is obviously a very slow puncture. □

New Technology Update

Development of field emission display techniques may challenge the role of c.r.t.s. reports Ian Poole.

THE cathode ray tube (c.r.t.) is the most widely used type of display today. However, as a result of the enormous market and potential, development is progressing in alternative display technologies.

A company named Printable Field Emitters Ltd (PFE) is undertaking one interesting development in the UK. Using the field emission display (f.e.d.) they have made some significant developments that will enable this technology to be widely used and possibly replace the c.r.t. in the near future.

FEDs

It is worth summarising the principle behind field emission displays. They can be considered as an integrated circuit equivalent of the c.r.t. They consist of an array of field emission electron sources with a screen spaced a very short distance away, and having a corresponding array of phosphor dots.

The space between the electron sources and the screen is evacuated. Voltages are applied to the control electrodes to extract the electrons from the cathodes and inject them into a region where they can be accelerated by the voltage on the anode. The electrons attain sufficient velocity such that when they strike the phosphor dots on the screen, they cause light to be emitted.

One of the most important areas where the f.e.d. requires development is associated with the cathode plane and its array of electron sources.

The traditional approach for the emitters is to use arrays of microtips fabricated using semiconductor manufacturing techniques. Several companies offer displays manufactured using this approach. However, as the techniques involved are close to the limits of semiconductor manufacturing processes, these displays are expensive, their size is limited and yields are poor. Although the ultimate aim is to make television sized screens, this is unlikely to be achieved using the technology in its current form.

Idea Development

One idea that is still under development is to use an idea based on broad area field emitters. These materials allow electrons to be emitted at low potentials. The first materials that were developed for this application used thin film diamond, or diamond-like carbon.

Using this technology the sharp points required for the basic f.e.d. were no longer required. As a result the lithography required is much easier, as feature sizes range between 4 and 10 microns instead of less than a micron for the basic f.e.d. designs. Unfortunately development of this has been problematic because the economic deposition of the emitter films that give the required properties on glass has not yet been possible.

New Solution

PFE, based in the UK, has demonstrated a generic class of broad area field emitting materials that are much cheaper to deposit than anything previously seen. They also have the advantage that they can be used on large scale displays that would be suitable for televisions or computer monitors. This results from the fact that the process uses an ink-like material to form the emitters. These can be patterned using printing techniques rather than semiconductor fabrication methods that are far more expensive to implement.

The idea for the technique arose from work undertaken at Birmingham University. Whilst searching for a solution to the problem of flashover in vacuum devices, it was noticed that electrons were emitted in greater quantities around areas where there were impurities in the surface material. The team at PFE investigated the effect with a view to using it for field emission displays.

The company undertook a considerable amount of work to perfect the idea for use. Both the materials and the dimensions had to be optimised to give the results required. The particles that are used are very small, measuring only Angstroms in diameter. They are also clustered together to provide one broad area emitter site.

The work at PFE is progressing towards making the cathode material into a form of ink that can be printed onto a metal-coated substrate. It will then be fired to make a stable cathode plane.

The principle has now been demonstrated using three pixels, red, blue and green, each 2 mm × 2 mm. The standard industry phosphors of yttrium oxysulphide, zinc oxide, and zinc sulphide were used to give the three colours and anode voltages of 7·5kV were used. Subjectively, the results proved that the new f.e.d. would be as bright as an existing television screen.

Implementation

When these f.e.d.s are manufactured, they will need to use three electron guns together to enable the colours for each pixel to be activated separately. This can be likened to a miniature electron gun, each one comprising of a focus grid and gate. In this way they form an electron lens that keeps the beam parallel and in a form that can be accelerated towards the screen and the phosphors.

It is anticipated that the display should be considerably less than 1cm thick. This should enable the depth of televisions and computer monitors to be reduced by a considerable degree. The operating voltages are expected to be around 5kV for the anode and less than 40 volts for the cathode.

This will simplify the power supply requirements when compared to a c.r.t. display, although they are higher than those required for other types such as an l.c.d. Even so, the performance and cost of the f.e.d. meets the requirements for a high volume, high performance and low cost display more closely than any other technology.

Once this latest development has been implemented in a form suitable for production, the new displays should quickly be seen on the market. Further information is available via E-mail from:

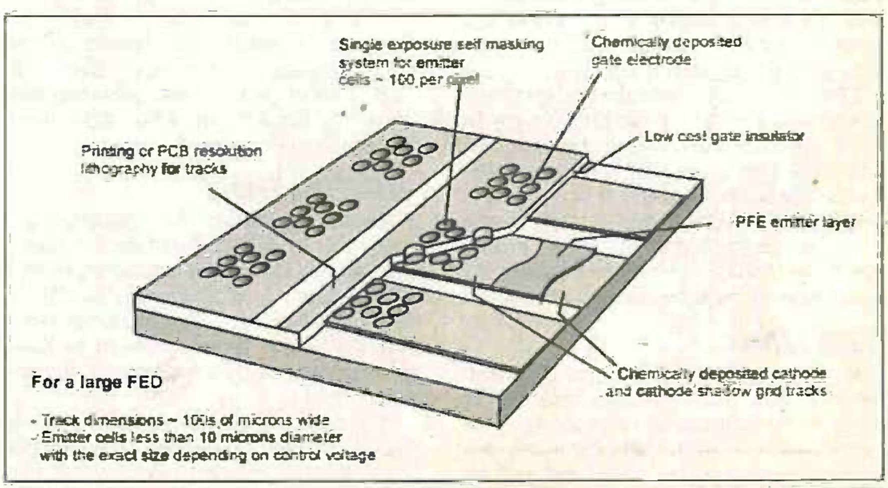


Fig.1. Schematic representation of the construction of an f.e.d.

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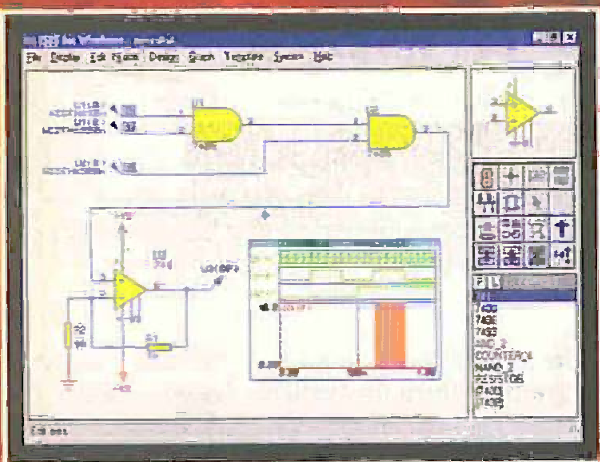

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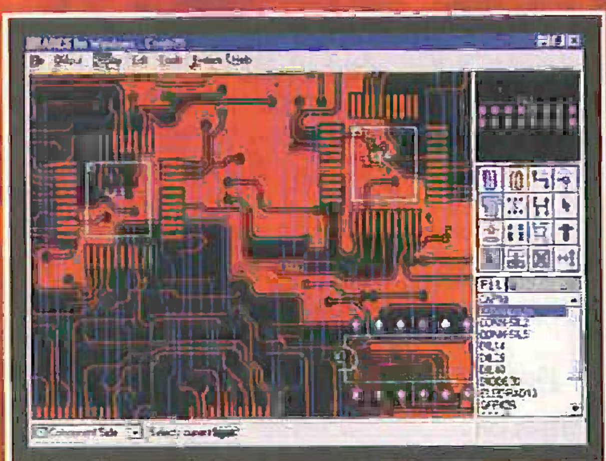

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News . . .

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

THINNER WEB PAGES

Help is at hand for users of Wireless Internet Receivers. Barry Fox reports.

GADGET enthusiasts who wonder why they bought a wireless Internet receiver, small enough to fit in their pocket but with a screen too tiny to read, can take heart. British company Argo, backed by venture capital from 3i, has developed a system which converts Internet data into legible form. At the same time the system, called ActiGate, decimates the volume of data and so accelerates downloading by sluggish cellphone data links.

The new breed of "thin client" personal digital assistants (PDA), from Psion, 3Com and Nokia, either connect to a GSM cellphone or have cellphone circuitry built-in. So they can send and receive E-mail and access the Internet. But web pages are written in HyperText Markup Language, and designed for display on large colour monitors. They contain fine text and graphics detail which is lost on a small, black and white l.c.d. screen.

Even small graphic images need at least one kilobyte, and some pages embed several dozen. A page that takes 30 seconds to download into a PC with a fast telephone modem, takes five minutes by digital cellphone because GSM data speed is limited to 9·6Kbps.

HDML Protocol

Rival industry groups are currently promoting two incompatible solutions. Unwired Planet of California, with Alcatel, propose a new page format called Handheld Device Markup Language. The Wireless Application Protocol Forum, which includes Nokia, Ericsson and Motorola, are backing the WAP format. Both formats deliver Web content in a form suitable for display on a PDA, but all the world's web sites must re-design their pages.

Argo's ActiGate avoids the need to re-write pages. It sits on a proxy server, automatically analysing each HTML web page that passes through and re-formatting it to remove clutter.

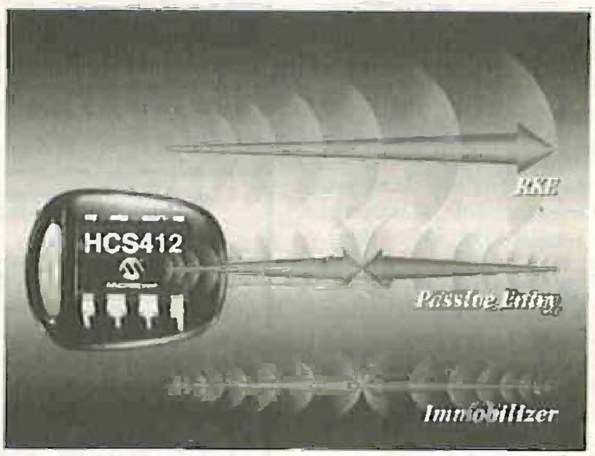
ActiGate removes Java scripts and graphics inserts, using the raw text and link addresses buried inside the graphics to generate short text messages and simple icons pulled from a lookup library. Text font sizes are increased for improved legibility. Colour is replaced by monochrome grey scale.

This reduces data content, and thus download time and memory storage requirements, by a factor of ten. The displayed page can be scrolled and easily read. Even traffic road maps become readable.

PDA users do not have to do anything, except access the Internet through the proxy server. The server recognises each PDA by the responses which are automatically sent by all browser software, and then tailors its output format to suit the PDA and whatever browser it is using.

Says Argo's Chief Technical Officer, Richard Jelbert "We can convert 90 per cent of the content of 90 per cent of the pages on the Internet, which is a lot more realistic than trying to persuade 100 million sites to rewrite all their pages".

CODE HOPPER



FEATURING high on Arizona Microchip's product line is their KEELOQ family of code hopping encoders. Microchip, as you must well know, are the manufacturers of the PIC microcontroller family.

Whilst *EPE* has not yet published any designs based on KEELOQ devices, we know that Microchip are keen that readers should get to know about them (perhaps an enterprising designer might care to offer us a project using them). The latest information received concerns the addition to the family of the HCS412.

The encoder function of the HCS412 can remotely lock and unlock a car door, garage or estate gate using radio frequency. The device provides the necessary control signals to interface directly to popular FSK and ASK phase locked loops. It also incorporates a sensitive passive-entry function which allows vehicle entry without activating the remote control or inserting the key. This feature uses low-frequency bi-directional communication to the keyfob and radio frequency to the vehicle.

If you would like to know more about KEELOQ devices, contact Arizona Microchip Technology Ltd., Microchip House, 505 Eskdale Road, Winnersh Triangle, Wokingham, Berks RG41 5TU. Tel: 0118 921 5858. Fax: 0118 921 5835. Web: http://www.microchip.com.

GIGAHERTZ BARRIER BROKEN

BROWSING Intel's web site revealed that the 1GHz (one billion cycles per second) microprocessor clock speed barrier has been broken. In a demonstration, Intel used a Pentium III processor and special cooling techniques to "wind-up" the clock speed to just beyond the 1GHz mark.

"This is a milestone event," said Albert Yu, Senior Vice President and General Manager of the Intel Microprocessor Products Group. "We will continue to push the frontier of technologies that will deliver processors with superior levels of performance."

Intel expects to introduce commercial production of processors operating at 1GHz in the year 2000.

Intel's web site can be found at http://www.intel.com (access the Press-room for the 1GHz information).

VIDEO WARS II

Two old enemies are at it again, in a re-run of the VHS-v-Betamax, Matsushita-v-Sony, video wars. Barry Fox reports.

IN Japan, Sony is now selling Super Audio CD, the first super hi-fi system to use a variant of DVD, the high density video disc. Philips will help Sony launch SA-CD in the US and Europe before the end of the year. Matsushita, maker of Technics and Panasonic equipment, announced recently that it will launch the rival and incompatible DVD Audio system, worldwide, before Christmas. Neither company has been willing to back down, or agree on a combination system.

Matsushita has already fired two shots. Sony's first SA-CD player costs $5000 and only delivers stereo, but DVD-Audio will give multichannel surround from Day One. Matsushita also believes there is a fatal flaw in the hybrid disc technology that Sony and Philips have dubbed a "defining attribute" of SA-CD because it promises backwards compatibility with the 600 million "legacy" CD players already sold.

Layered Music

The SA-CD hybrid disc will have two recordings of the same music, at different depths in the surface. The lower layer, beneath 1·2mm of clear plastic, carries a conventional CD recording to the so-called Red Book Standard. Another layer, at 0·6mm, conforms to the new Scarlet Book standard and is made of semi-reflective material like a two-way mirror. This layer carries the very rapid stream of single bits that makes up the Direct Stream Digital recording used for SA-CD.

The laser optics in a standard CD player or ROM drive routinely focus at 1.2mm, and should ignore the semi-reflective layer of a hybrid disc. A DVD Video player can focus at either depth, but is not equipped to decode the SA-CD recording so it should ignore the semi-reflective layer, focus down to 1.2mm, and play the disc as a conventional music CD.

At a recent seminar in Austria, Matsushita's engineers hardened concerns that earlier surfaced at the Audio Engineering Society's convention in Munich. They warn that if the laser in a CD player detects the semi-reflective layer, either because the player is cheap or old, or new and designed to read erasable CDs which have lower reflectivity, the player will reject the disc as unplayable. DVD players may not switch to the lower CD layer when they fail to decode the DSD signal.

Hybrid Concerns

Ted Abe, head of Matsushita's Audio Technology Group, is not surprised that Sony is launching SA-CD in Japan without hybrid discs. His engineers have made hybrid discs and tested them on a wide range of real world players. The engineers found that many CD players, from the countless firms round the world now making them, do not exactly meet the Red Book standard.

"We have very serious concerns about backward compatibility of hybrid discs" says Abe. "Our tests suggest that 30 per cent of legacy players will not be able to play them. It's impossible to predict which ones will reject hybrids and it's impossible to do anything about it when they do fail. We stopped research on hybrid discs and said No Way."

David Walstra, General Manager of Sony Europe, accepts that it is unfortunate that Sony's own music division is not releasing hybrids, but he believes other companies soon will. "We are 100 per cent certain that hybrid discs will play on players if they conform to the Red Book CD standard. We have checked our own DVD players and they play hybrid discs. We can't speak for other manufacturers".

Payl Reynolds, Philips' director of new business development, says the company is now starting pilot production of hybrid discs at Eindhoven in the Netherlands to "perfect the technology".

RAC TRACKSTAR

THE RAC and Trafficmaster have added their weight to the battle to reduce fatal accidents involving high speed pursuits. They have launched Trackstar, which is a radically new and innovative vehicle security device which uses satellite tracking to provide the updated location of a stolen vehicle anywhere in the UK. Around 400,000 vehicles were stolen in the UK in 1998.

The device combines GPS satellite tracking with GSM mobile phone network to provide instant communications when the unit is activated. Once triggered, RAC Trackstar's central control is alerted to the vehicle's exact position and direction of travel. The vehicle is then constantly tracked and, after a number of quick security checks, the appropriate police force is notified. Once apprehended and cleared for release, the RAC returns the stolen vehicle to its owner.

RAC Trackstar also offers immediate connection to emergency or breakdown services and provides call operators with details of the vehicle and its pinpoint location. Meanwhile a voice channel is automatically opened for the call operator to speak directly to the caller.

RAC Trackstar prices start from £295 plus VAT for the hardware, with a tracking subscription of £8 plus VAT per month.

For further information contact your local RAC centre, or the RAC Supercentre, PO Box 700, Bristol BS99 1RB. Tel: 01454 208262. Fax: 01454 208267. (No E-mail or Web details quoted.)

FM 1·394GHz TRANSDUCERS

WITH the interest that currently surrounds our projects using the 418MHz transmitter and receiver pairs, a lot of you will no doubt be pleased to hear that radio modules that operate in the 1·394GHz range are newly available from Wood and Douglas.

Their VT1400 and VR1400 transducers provide a high-quality yet economical FM wireless video link. Intended primarily for use with remote security and surveillance cameras, the devices are approved to the MPT1349 standard, which allows licence-free operation in the UK. New techniques have been implemented to permit transmission of colour pictures in the limited bandwidth allowed by MPT1349.

The VT1400 transmitter has an r.f. output power of 500mW and operates from a 12V d.c. supply. Its signal can be received clearly at a range of up to five miles (8km) using the VR1400 receiver and suitable aerials.

For more information, contact Wood and Douglas Ltd., Dept EPE, Lattice House, Baughurst Road, Baughurst, Tadley, Hants RG26 5LP. Tel: 0118 981 1444. Fax: 0118 981 1567.
Email:info@woodanddouglas.co.uk.
Web: http://www.woodanddouglas.co.uk.

Filter Circuits Book

Designing satisfactory filter circuits is a bit of a "black-art" unless you are well familiar with the options and their rules. Butterworth-Heinemann have addressed this problem by introducing a very useful 240-page paperback, *Simplified Design of Filter Circuits*, ISBN 0 7506 9655 9, priced at £22.50.

John D. Lenk is the author, an established writer of international best-sellers in the field of electronics. He has authored more than 80 books, which together have sold well over two million copies in nine languages.

This latest book is a step-by-step guide to designing filters using off-the-shelf i.c.s. It starts with the operating principles of filters and common applications, then moves on to describe how to design circuits using modern chips. The emphasis is on practical, simplified approaches to solving design problems.

The contents include: Introduction; typical switch-capacitor filters; lowpass filters; bandpass filters; active RC filters; simplified design examples.

For more information, ask your local good bookseller, or contact Butterworth-Heinemann, Linacre House, Jordan Hill, Oxford OX2 8DP. Tel: 01865 310366. Fax: 01865 310898.
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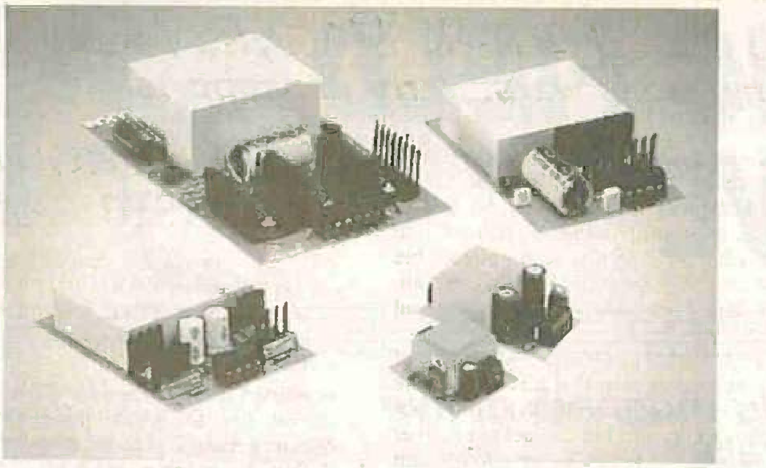
MINIATURE PSUS



LASCAR Electronics has added a new miniature power supply to its existing (and excellent) low cost linear PSU range. The new PSU303 is a compact "open" mains power module featuring +5V (200mA) and −5V (50mA) fixed rails. It uses linear regulator i.c.s with over-current and over-temperature protection.

Like all products in the Lascar range, the PSU303 uses an encapsulated transformer and screw terminal connections. With an overall size of 42mm × 78mm × 29·6mm, this PSU is well suited to compact applications.

For more information, contact Lascar Electronics Ltd., Dept EPE, Module House, Whiteparish, Salisbury, Wilts SP5 2SJ. Tel: 01794 884567. Fax: 01794 884616. E-Mail: lascar@netcomuk.co.uk. Web: lascar http://www.lascarelectronics.com.

Taking the Move out of Movies

An off-shoot of space research could help improve your shaky home videos. By Barry Fox.

SCIENTISTS working for NASA's Space Flight Centre have developed a system that improves poorly shot video tapes. Video Image Stabilization and Registration removes handshake and unwanted zoom and tilt motion, while making fuzzy pictures look sharp. VISAR works by dissecting each image in a motion sequence and rebuilding them in a constant position and size.

David Hathaway and Paul Meyer were working for the FBI, trying to clean up a shaky 13 second video tape of the bomb which exploded at night during the 1996 Olympic Games in Atlanta. They broke each of the 400 picture frames down into several hundred thousand component picture points or pixels, isolated rectangular patches which had constant pixel patterns, and summed the patterns from several different frames. This reinforced the wanted image, while reducing random noise. At the same time the whole image was moved to keep the target pattern at a fixed position on screen, and so remove the effect of handheld camera shake.

NASA has now refined the technique to keep the patterns of constant size as well as position. This corrects for accidental zooming, where a photographer has pressed the wrong button to move between wide angle and telephoto imaging, or tilted the camera by mistake.

NASA is offering VISAR to the police, who can use it to recognise licence plate numbers or faces in a crowd accidentally captured on home video footage. VISAR can also sharpen medical ultrasound scans or calculate tornado wind speeds by tracking objects trapped in a twister.

The prototype system works on a Windows PC, taking around 15 seconds to analyse each frame.

"As computer speeds increase, the processing time comes down", says Meyer. "We are aiming for real time processing so that VISAR can be built into home videos".

Although some modern camcorders have stabilisation circuitry, it works while shooting by comparing successive image scans and compensating for exaggerated shake. There is no chance to correct errors once the tape has been shot. Photographers can use VISAR at leisure after shooting.

UK Space Programme

A pioneering space programme to study the Earth's environment has recently been announced by Lord Sainsbury, Minister for Science and Chairman of the European Space Agency's (ESA) Ministerial Council. The £400m research project, known as the *Living Planet*, will be undertaken by ESA and will be the most comprehensive Earth observation programme ever undertaken.

It will consist of a series of space missions designed to investigate the Earth's environment, using unique global measurements of physical, chemical and biological processes at work in the Earth's atmosphere, oceans and land surfaces.

More details are on web site: http://www.dti.gov.uk.

ELECTRONICS COURSE ON CD

ELECTRONICS Technician CBT has been introduced on CD-ROM as an interactive computer-based training program that makes it easy to gain an in-depth working knowledge of the fundamentals of electronics. It incorporates 23 instructional modules with more than 15 hours of audio material, animated circuits and interactive video examples.

Over 1500 practice problems, exercises and examples provide students with opportunities to explore circuit function and behaviour. Practical challenging design exercises encourage you to apply what you have learned to new situations.

This new training program is produced by the makers of Electronics Workbench, which many of you will recall is the excellent electronics training package we used to illustrate our *Electronics from the Ground Up* series of 1994/95. With Electronics Workbench installed alongside this new course., students have access to over 450 experiments that let them manipulate and simulate circuits in their own virtual electronics laboratory.

Electronics Technician CBT and Electronics Workbench are supplied and supported in the UK by Adept Scientific plc, 6 Business Centre West, Avenue One, Letchworth, Herts SG6 2HB. Tel: 01462 480055. Fax: 01462 480213.
E-mail: ewb@adeptscience.co.uk.
Web: http://www.adeptscience.co.uk.

Byte-sized Computer Guides

"FED UP with computer manuals which are almost the size of your terminal?" asks the opening sentence of a press release from Collins. Well, for those who are looking for a pocket book which will get down to the computing basics without leaving out essentials, Collins believe they have the answer, in the form of four new colour-illustrated guides. They are said to be small enough to fit in your pocket but packed full of information in a readily accessible form. "Ideal for even the most wary of technophobes!".

Collins Gem – Internet provides an overview of the Internet and what it can do for you, with a wealth of practical information, ideas and pointers to help you make the most of E-mail and the Web.

Collins Gem – Your PC aims to help you make the right decisions about what to buy and where to buy it, and to make sense of the technical jargon that will confront you, from CPUs and modems to DAT drives and scanners.

Collins Gem – Using Your Software demonstrates how to organise your computer and its software to keep the system running efficiently and reliably.

Collins Gem – Word Processing includes information on: saving, closing, opening and printing documents; setting up envelopes and labels; tables, sorting text and mail merges; fonts, styles, columns and sections; inserting pictures and creating artwork.

The books are £4.99 each and available through good booksellers (ISBN codes have not been supplied to us). Further information can be obtained by E-mail: elizabeth.allen@harpercollins.co.uk.
Web: http://www.collins.gem.com.

Constructional Project

MAGNETIC FIELD DETECTIVE

ANDY FLIND

Can even detect moving magnets at five metres through brick walls!

FOLLOWING last month's *EPE Mood PICker* project, it was felt that constructors wishing to experiment further with this type of device might welcome a simple method of indicating the relative strength of magnetic fields produced.

Magnetic field sensors are not new to the pages of *EPE* but most of those published recently were intended to indicate the presence of alternating fields emanating from 50Hz a.c. mains operated appliances which have relatively high levels and frequencies.

The tiny, low frequency fields produced by the *EPE Mood PICker* and its predecessor the *EPE Mood Changer* (June '98) are harder to detect, and in fact it is necessary to place the *Mood PICker* practically in physical contact with the author's *Magnetic Field Detector* (Jan '95) to obtain an indication. This makes it impractical to gain any idea of relative field strength from various designs in terms of range for a given level of indication.

WHAT SENSOR?

When designing an instrument capable of detecting the output of devices like the *Mood PICker* the first consideration is which type of sensor should be used to actually detect the field. The obvious type is an inductive device such as a coil. The disadvantage of coils is that they respond not to the absolute strength of the surrounding magnetic field, but to its rate of change, making them relatively insensitive to very low frequency fields.

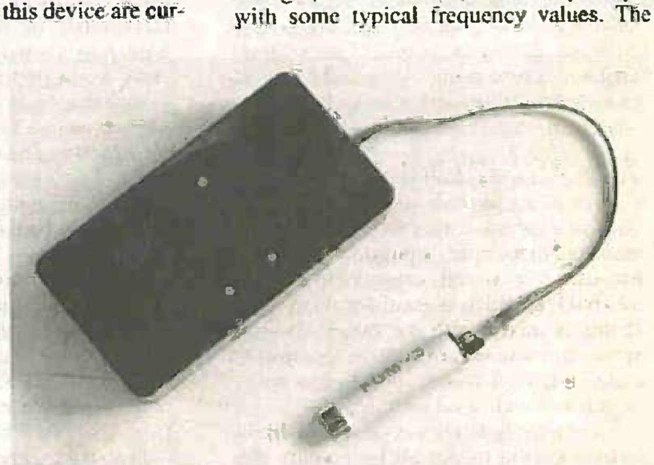
An additional difficulty encountered with the *Mood PICker* and *Mood Changer* is that their outputs are synthesised and therefore change in a series of small discrete steps. This results in the corresponding output from an inductive sensor appearing as a series of spikes, and it is this that the original detector design is indicating rather than the actual strength of the field produced.

A Hall Effect sensor might be more suitable as these produce outputs proportional to absolute field strength, but most are relatively insensitive. One of the most sensitive types that is widely available is the LOHET which is relatively expensive and when tried proved to be still insufficiently sensitive for this project. When sufficient circuit gain was used to obtain the required sensitivity the signal all but disappeared into background noise from the device.

FLUXGATE

A third type of sensor which can be used is the Fluxgate Magnetometer. These also measure absolute field strength, and are renowned for their very high sensitivity. Their construction used to be complex and difficult but a ready-built sensor of this type is now available at reasonable cost which allows experimenters to venture into the area of weak magnetic field detection far more easily.

Two basic versions of this device are currently available, the FGM-1 and the slightly larger and more sensitive FGM-3 (*the latter device was used on* PIC-Agoras – *Bike Computer – Apr/May '97. Ed*). Both operate with a modest current of around 12mA from a single +5V supply so they may be used in battery powered designs having simple regulation.



The output from either is a rail-to-rail rectangular waveform with a period proportional to the polarity and strength of the field such that the centre frequency, found at lowest magnetic field intensity, is about 60kHz. This can be processed directly by a microcontroller such as a PIC or it may be converted into a voltage for use in analogue circuit designs. More about these techniques, perhaps, in future projects.

For the present application, what is required is a simple and inexpensive circuit offering very high sensitivity. The more sensitive FGM-3 sensor is used in this design and, since its output is a high frequency, the simplest way to indicate small changes in this, with excellent sensitivity, is to mix it with the output of a reference oscillator of similar frequency, in the manner of the familiar b.f.o. (Beat Frequency Oscillator) metal detector.

The resulting output doesn't sound very pleasant (nor did the old b.f.o. metal detectors!), but we're not seeking musical excellence here, just simplicity and sensitivity and this technique certainly delivers both.

BLOCK DIAGRAM

A block diagram of the project is shown in Fig.1, which demonstrates the principle with some typical frequency values. The output frequency of the FGM-3 varies considerably as its position changes in relation to the earth's magnetic field.

Although it has a "feedback" coil which can be used for nulling purposes, this

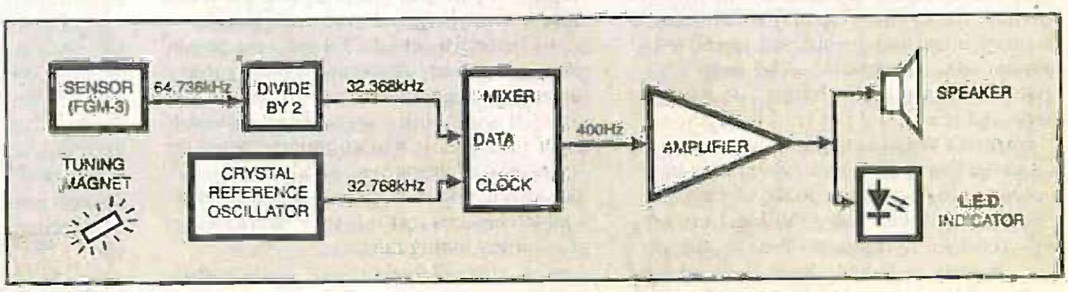


Fig.1. Block diagram of the Magnetic Field Detective.

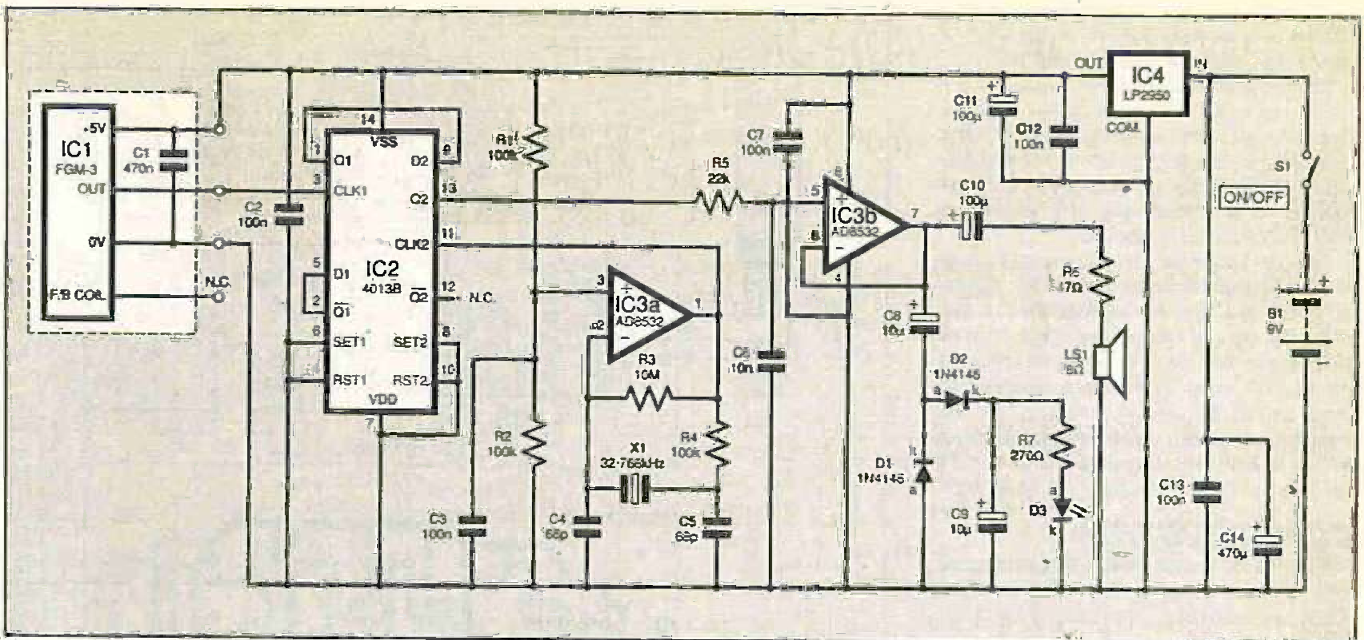


Fig.2. Complete circuit diagram for the Magnetic Field Detective.

requires current and the provision of a dual-rail supply so that it can be driven in either polarity. A much simpler way to achieve the same effect is to place a small magnet nearby and rotate it until it counteracts the earth's field to achieve the required output frequency. This in no way degrades the FGM-3's sensitivity, in fact it probably improves it by ensuring that it is operating close to the centre of its range.

The sensor output is first divided by two, which results in a perfect 50:50 duty cycle at a lower frequency of about 32kHz. The design of a suitable reference oscillator initially presented a problem. Readers who have built b.f.o. metal detectors will no doubt recall how the output of these used to drift and distort as the two oscillators tended to "pull" or lock onto each other through stray coupling.

INSPIRATION

Various simple reference oscillators tried with this circuit exhibited the same problems, but then came inspiration! An oscillator using a watch crystal operates at 32·768kHz, which is ideal for this project. If this is mixed with the output from the sensor the magnet can be used to adjust the audio output frequency, resulting in simple tuning and rock solid stability.

The mixer function is carried out digitally by applying the signal to the data input of a flip-flop whilst clocking it with the reference signal. The output from the flip-flop when the circuit is correctly tuned is a squarewave of audio frequency. This is buffered to provide sufficient power for a small loudspeaker.

If the circuit is not tuned correctly, the output from the flip-flop may be a harmonic of the wanted signal which can sound rather similar to it. Because of some simple low-pass filtering, this will have a lower amplitude, but this is still not readily apparent to the ear so a visual tuning indicator is included in the form of an l.e.d. which only lights when the correct tuning point is found.

The frequencies shown in Fig.1 are fairly typical for normal operation. If the sensor frequency changes by just 100Hz, or less than 0·2 per cent, the output will change by 50Hz, which is easily heard by the user. In practice, much smaller changes than this are clearly audible.

FULL CIRCUIT

The full circuit diagram for the Magnetic Field Detective is shown in Fig.2. At the left is the sensor, IC1, provided with a local supply decoupling capacitor, C1, as recommended by the manufacturer since it is connected through a short length of ribbon cable.

The sensor output signal is applied to the clock input (CLK1) of one of the two flip-flops in IC2, a 4013B dual flip-flop. The $\overline{Q1}$ output of this is connected to the data (D1) input in the classic divide-by-two arrangement, and the Q1 output is connected to the D2 input of the second flip-flop.

Op.amp IC3a operates as an oscillator with crystal X1 setting the frequency to 32.768kHz. The value of 68pF used for capacitors C4 and C5 may seem a trifle high for this type of crystal but experiment proved it to be the best for reliable start-up and operation.

Resistor R3 provides the op.amp with a small amount of negative feedback, and R4 reduces drive power to the crystal to a safe value. The oscillator output is applied to the clock input (CLK2) of the second flip-flop of IC2 and the audio frequency is output from Q2.

Low-pass filter R5 and C6 improve its quality a little before it is buffered by IC3b to drive the speaker LS1. It is possible to eliminate this stage and save supply current by connecting a piezo transducer across the Q2 and $\overline{Q2}$ outputs of IC2, but readers may rest assured that the sound quality obtained in this way is truly horrible, so the use of a loudspeaker is heartily recommended!

Resistor R6 sets the output volume and its value can be altered if required. Finally, a small "charge pump" using capacitors C8 and C9 with diodes D1 and D2 is used to light l.e.d. D3. It will only do so when the amplitude of the output is high enough, and the attenuation of higher frequencies by R5 and C6 ensures that this only happens over the correct tuning range.

The AD8532 dual op.amp IC3 is a recent arrival in the amateur constructor's market and has some rather special qualities. The inputs and outputs can operate at any potential up to and including both supply rails and the outputs can deliver up to

COMPONENTS

Resistors

R1, R2, R4	100k (3 off)	
R3	10M	See
R5	22k	SHOP
R6	47Ω	TALK
R7	270Ω	page

All 0·25W 5% carbon film

Capacitors

C1	470n ceramic
C2, C3, C7, C12, C13	100n ceramic (5 off)
C4, C5	68p ceramic (2 off)
C6	10n ceramic
C8, C9	10µ radial elect. 25V (2 off)
C10, C11	100µ radial elect. 10V (2 off)
C14	470µ radial elect. 16V

Semiconductors

D1, D2	1N4148 signal diode (2 off)
D3	3mm red l.e.d., 2mA type
IC1	FGM-3 fluxgate magnetometer sensor
IC2	4013B CMOS dual flip-flop
IC3	AD8532 dual op.amp
IC4	LP2950 5V micropower regulator

Miscellaneous

LS1	8Ω loudspeaker, 40mm dia.
S1	min. s.p.s.t. toggle switch
X1	32·768kHz crystal

Printed circuit board, available from the *EPE PCB Service*, code 239; 8-pin d.i.l. socket; 14-pin d.i.l. socket; 4-pin wire-wrap d.i.l. socket; 9V PP3 battery and clip; ribbon cable; plastic case (see text); magnet (see text); heat-shrink sleeving (see text); wire; solder, etc.

Approx. Cost Guidance Only £24

250mA of current, sufficient to drive a small loudspeaker at modest volume.

The recommended supply voltage is 3V to 6V, but users should be aware that the *absolute* maximum is stated to be 7V. The versatility of the device can be seen in this circuit, where one of the two amplifiers operates as a crystal oscillator whilst the other drives the loudspeaker.

The supply for the circuit is regulated by IC4, an LP2950 three-terminal +5V regulator. This has a superior performance to that of the 78L05 and can operate from a much lower input voltage. The manufacturers of the FGM-3 state that output depends to some extent on supply voltage, so the improved regulation will help in minimising drift in this project. Capacitors C11 to C14 are included to provide supply decoupling.

CONSTRUCTION

The printed circuit board component and track layouts are shown in Fig.3. This board is available from the *EPE PCB Service*, code 239.

Construction should present no special difficulties – the preferred procedure is to fit low profile components such as resistors and diodes first, followed by the smaller capacitors and then the electrolytics. The use of dual-in-line (d.i.l.) sockets is recommended for IC2 and IC3.

The 32·768kHz watch crystal X1 is readily available from many component suppliers, but constructors with good eyesight might even use one salvaged from an old watch! Commercially supplied versions are usually physically larger though, and have longer leads. Because they look fragile and the leads are thin it is advisable to secure X1 to the board with a drop of glue before soldering.

The four connections to the FGM-3 are shown in Fig.4, along with their functions. Since it will undoubtedly be used in future projects, and also to reduce any possibility of damage, it was decided not to solder directly to these pins. Their spacing is the same as that of a typical d.i.l. i.c. so a suitable socket for them was made by cutting a section from a "wire-wrap" d.i.l. socket with a sharp knife.

These sockets have relatively long and robust connections to which the capacitor C1 and about 300mm of ribbon cable can be soldered as shown in Fig.5. Heatshrink sleeving was fitted over the connections to give them added physical strength. It should be noted that the FGM-3's pins are flat in section and fairly wide, so they will not fit into a turned-pin socket.

Before fitting IC2 and IC3, the board should be powered so that the presence of the regulated 5V supply can be checked on their sockets at pin 14 (IC2) and pin 8 (IC3). After this, these two i.c.s can be inserted and the speaker and sensor connected for testing.

SETTING UP

The current drawn by the circuit varies quite a lot with the field being sensed, but as a rough guide, when tuned, the average is about 25mA to 30mA. Placing a small bar magnet, such as those sold for reed relay operation, about 100mm to 150mm from the sensor (in any position, to either side or behind it) and rotating it slowly should produce various strange noises and, hopefully, at some point the l.e.d. will light.

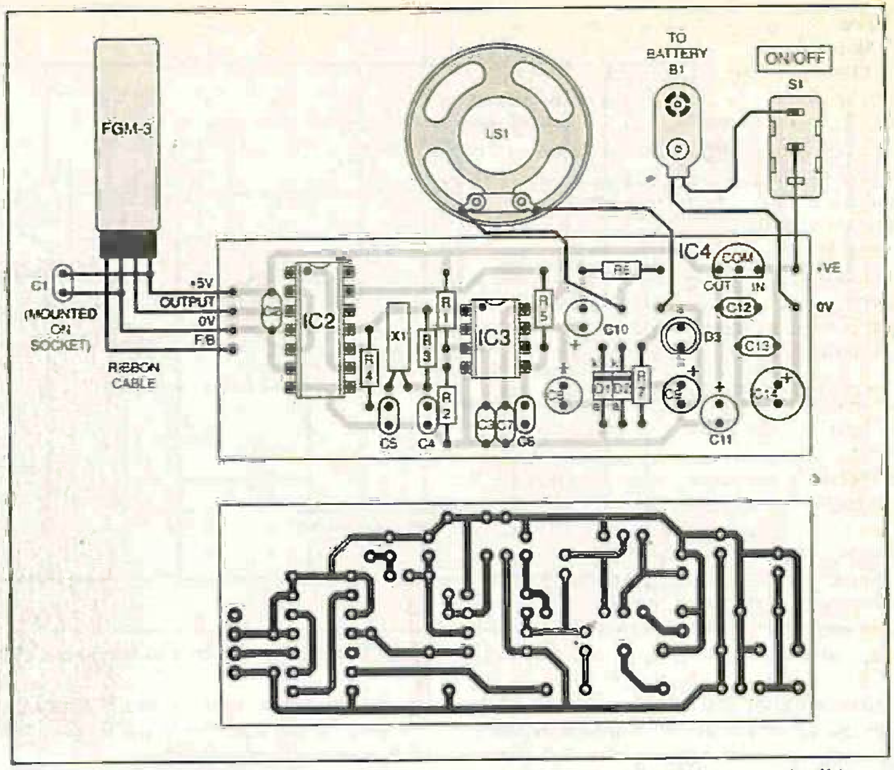
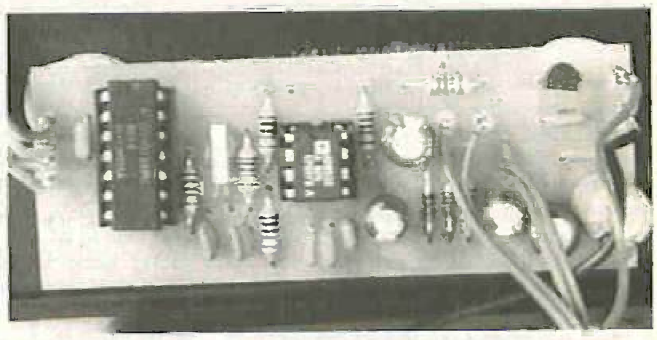


Fig.3. Component layout, full size copper foil master track pattern, and off-board interwiring details.



When this happens the magnet should be adjusted carefully for a steady audio tone of suitable pitch. Blobs of Blu-Tack will be found invaluable for holding the sensor and magnet in position as this is done. Once the operating point has been found, the effect of moving another magnet in the vicinity can be tried.

Most magnets will be easily detectable at more than 300mm and strong ones will produce a response from several metres. If the tone sounds seriously "mushy" and unclear during adjustment attempts, the problem is likely to be 50Hz pickup from mains appliances and wiring in the vicinity, especially transformers, in which case it may be necessary to relocate the unit somewhere magnetically quieter.

ENCLOSURE

Selection of a housing for this project is up to the individual constructor. For efficiency, small loudspeakers really need a case of some kind to prevent sound waves from the rear simply cancelling those from the front.

The prototype has the p.c.b., battery, loudspeaker and on/off switch S1 in a small plastic case with the sensor attached via the ribbon cable. This can be set up on a board with the magnet, using Blu-Tack to keep everything in place whilst allowing easy adjustment.

IN USE

The assembly has to be used in a static position, as small movements relative to the earth's field can take it right off scale. It is placed in the desired position, switched on and the tone set with the permanent

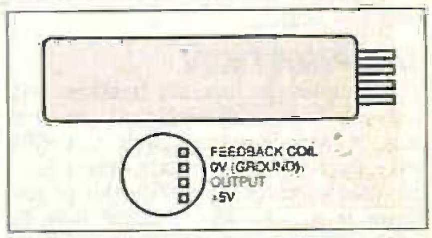


Fig.4. Connections for the FGM-3 sensor.

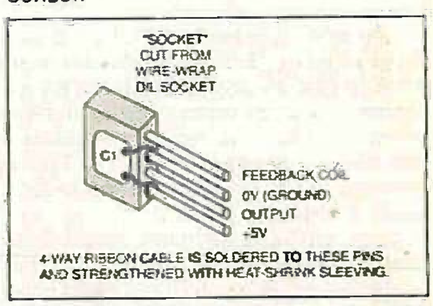


Fig.5. Providing a socket for the FGM-3, with capacitor C1.

magnet, then it is kept in this position for the desired test.

The *Mood PICker* and *Mood Changer* projects are both detectable at several centimetres, producing clearly audible pitch changes and a distinctive quavering note at higher frequencies. In fact, the original

Mood Changer can be detected at up to 500mm.

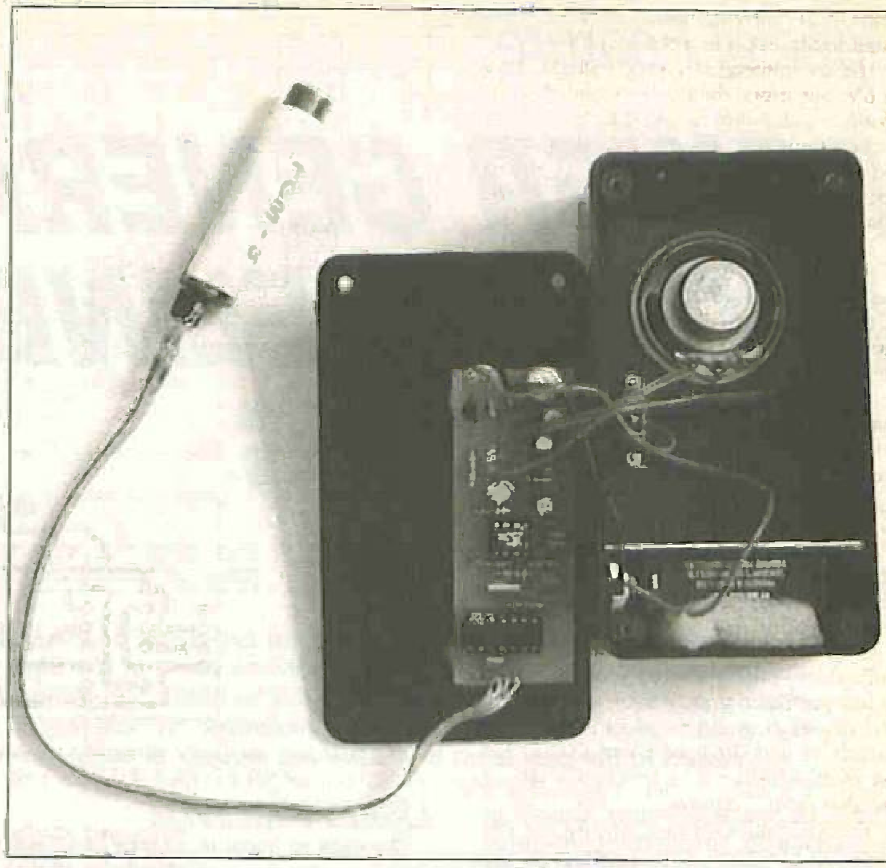
Other uses for this simple project are obviously limited only by the imagination of the constructor. Examples would be detection of moving objects at a distance by attaching magnets to them, and detection of large ferrous objects such as vehicles by the distortion in the earth's magnetic field they cause in passing.

It would obviously be possible to add a frequency-to-voltage circuit if a voltage output is required, though for accuracy a circuit converting period to voltage is better.

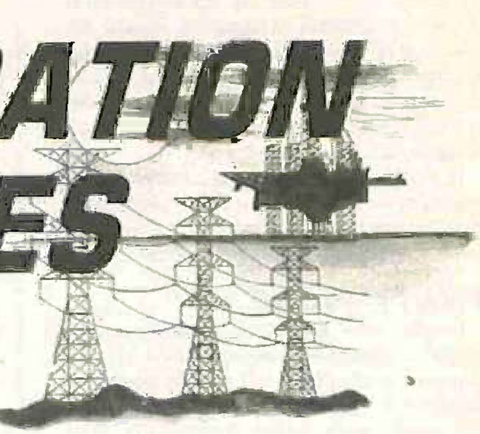
PARTY PIECE

Finally, even non-electronically minded people cannot fail to be impressed by this project's "party piece". If a fairly powerful magnet is suspended on a thread with north and south poles facing horizontally outwards, when set spinning it will generate a sinusoidally varying magnetic field. With the prototype this was done using a ferrite ring magnet of the kind used in loudspeakers, with a diameter of about 50mm.

The resulting alternating field could be detected easily at ranges of over five metres, through brick walls just as easily as through air. This gives rise to the idea of a *Mood Changer* project for a wide area coverage using a spinning permanent magnet, but this one is still on the drawing board at present! □



POWER GENERATION FROM PIPELINES TO PYLONS



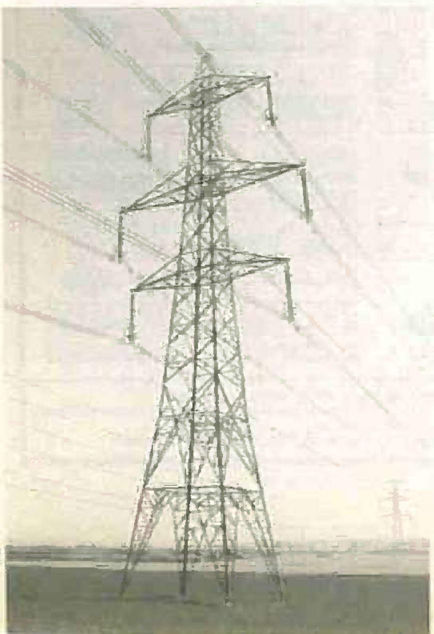
ALAN WINSTANLEY

Part One

In this two-part feature, 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 also examine in close-up some of the techniques related to the provision of a 230V a.c. supply directly to our housing and industry.*

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

National Power generously granted the writer unlimited access to all parts of a modern gas-fired power station – Killingholme "A" near Grimsby – and provided a much-needed insight illustrating where our "juice" actually flows from. If ever you have wondered what "*neutral*" really means, why the earth plays such a vital role in safety, or why an electricity power station would ever need gas, or if you just want to brush up on some fundamental theory, this article provides background which is essential reading for electronics users and consumers everywhere.



Lights Fantastic

The sight of electricity pylons marching alien-like across the countryside is an all too familiar one, yet in spite of their omnipresence it is easy to overlook the feats of heavy engineering and high technology surrounding us which are responsible for delivering electrical energy to illuminate and warm our homes, cook our food and entertain us, as well as powering our industries.

It is something of a paradox that the microelectronics enthusiast can utilise the very latest in silicon chips to create another technological masterpiece, yet if we are honest, many of us would admit to having only a fleeting knowledge about the electricity supply itself. We leave that sort of thing to electricians. We probably know (we think) that *earth* is, as its name suggests, connected to earth somewhere along the line, and perhaps the *neutral* is, er, somehow neutral. We know that the supply is "alternating", but how many have actually stopped to consider what all this really means?

After reading these two articles you will know precisely how the electricity supply is generated, distributed and delivered. Although it is written with the UK 230V a.c. 50Hz. supply in mind, note that many similar principles are utilised abroad, so even if you do not reside in the UK you will find a considerable amount in common between the systems outlined here and those employed in your own country (some of which are undoubtedly British-built).

In The Beginning

The incandescent electric lamp was first produced in 1879 by Joseph Swan in England and Thomas Edison in the USA, and two years later Britain saw the advent of its first public electricity supply. Over the next fifty years some 600 supply undertakings with nearly 500 localised power stations would be created, operating at a variety of frequencies and both a.c. and d.c. voltages.

In 1927 the Central Electricity Board (CEB) was appointed by statute, with a view to standardising frequencies, and also to implement an interconnection plan to improve efficiency and reduce waste. The plan involved hooking together a select number of power stations, and was completed in 1938. Later the industry was nationalised in 1948.

Over the last twenty or thirty years the power generation picture in the United Kingdom has been transformed, so to speak, having moved away from the once heavy reliance on Britain's rich supply of coal to a modern multi-fuelled power industry which is clean, efficient and dependable.

Until the early 1990s, power generation was undertaken and controlled by the Central Electricity Generating Board (the CEGB), which was primarily responsible for producing and selling power for onwards transmission to the regional electricity boards by the National Grid, the organisation which "owns the wires". From there it would be distributed to tens of millions of residential and commercial properties.

Privatisation and the arrival of market competition in 1990 introduced radical changes in the way the UK electrical supply market operated. The CEGB gave way to competing power companies – including National Power, PowerGen and the nuclear arm of the industry, British Energy. There are now some 30 or more power producers, many of which are independent or foreign owned power stations, competing for the business of nearly 23 million domestic customers.

These and millions of commercial and industrial users are served by fourteen Regional Electricity Companies (RECs). The market for buying and selling electrical power has opened up at all levels, so much so that in the UK it is now possible to buy gas from electricity providers and vice versa.

On Demand

Over the many decades in which we have enjoyed virtually uninterrupted electrical supplies, the power providers have accrued much experience of the likely demands which will be placed upon them by their customers. This enables the power distribution companies to plan ahead and allocate, on a daily basis, the various power generation resources which are going to be available to meet the forecasted demands.

How, according to National Power, these various fuel types are available in "layers" to meet this demand, which in the UK totals nearly 70,000 Megawatts (MW), is shown in Fig.1. The graph also shows how the resources are divided amongst various fuel types.

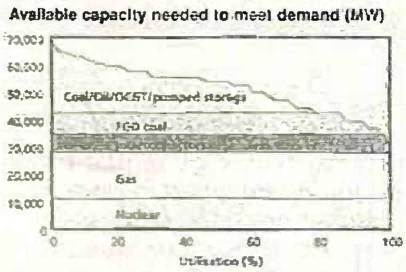


Fig.1. How the demand for electricity in the UK is fulfilled by different types of fuel. Nuclear, gas and "interconnectors" provide the base whilst coal, oil and hydro are only brought on-stream to top up the supply.

–Courtesy National Power

Underpinning the country's supply capability are both gas and nuclear fuel sources which produce a constant 30,000MW between them and form the bedrock of Britain's available capacity. Also providing nearly 5,000MW of capacity are what are termed "interconnectors", which relate to the connections made by the National Grid to both Scotland and France: yes, a certain proportion of our power is imported, though the same wires could be used to export surplus electricity as well. Roughly 2,000MW of interconnected power is available via the Cross-Channel Link, a pair of undersea 45km long cables completed in 1986.

The rest of the UK's electrical capacity is provided by coal, oil and hydro-electric power, noting from Fig.1 that the capacity of these sources dwindles in terms of utilisation: they form the buffer which is primarily used for the "top up" needed to meet peak surges. For most of the time, we rely on nuclear power, gas-fired power plants and imported electricity which are 100 per cent utilised.

The demands for electrical power rise and fall during the day, and the weather and many other events – such as the advertising breaks in favourite TV soaps – can trigger a huge surge in demand when people head for the electric kettle. These TV-related surges are known as "TV pick-ups". The average person will also decide to turn on the electric lights in the evening only when a commercial break occurs!

It is the function of the National Grid Control Centre, based at Reading, to match the demands placed by its customers with the available capacity and to cope with anticipated TV pick-ups. According to National Grid figures, the largest recorded TV pick-up of 2,800MW occurred in the World Cup Semi-Final in July 1990 (England v. West Germany). To maintain stability the control process may also require electricity production to be reduced when demand falls: the funeral of Princess Diana caused a major drop of 1,000MW in normal power consumption when all daily activity stopped in the UK.

Price Matching

The task of matching supply and demand is called "generation despatch" and involves not only the National Grid being kept posted by data links showing the availability of power from all its suppliers, but also at what price: electricity is bargained in Pounds per MegaWatt Hour and power generation companies have to commit to a price for filling half-hour slots for the 24 hours ahead. This bidding process occurs every morning when the power plants notify the National Grid of their availability and pricing for the day.

As you would expect in a privatised market economy, the "bulk" price charged by generators varies depending on demand. On a typical November day (for example) it could rise from around £33 ($54 for American readers) per MegaWatt Hour (MWH) to roughly £45($74)/MWH at peak times of the day – which, incidentally, is at tea time, when demand peaks dramatically at 17:30 hours. By way of comparison, depending on one's location a domestic electrical "unit" costs 6·45 pence (10·6 cents), which equates to £64.50 or $106.42/MWH.

Trends from preceding weeks, months and even years are taken into account as well and forecasts are accurate to within a couple of percentage points. Any event which is forecast to trigger a rise in power demand – say a televised World Cup – is brought into the equation, as are other factors including weather forecasts, seasonal trends and even the day of the week.

In Fig.2, National Power illustrates how peak demands over a typical 24 hour period are gradually topped up as more plant is brought on stream to cope, culminating with the short-term use of pumped storage (water caverns) to generate hydroelectric power at peak times (around 6p.m.). Note that nuclear and gas-fired power provides a constant output, and only as demands soar will larger coal and oil-fired stations be brought onto the system to meet peak surges.

A "pumped storage" installation in Dinorwig, Wales can also be brought on stream within ten seconds, to cater for daily peaks in demand, and this cushion has helped to reduce the need to have spare generator plant constantly running to meet unanticipated surges in demand, see Fig.3. All power plants are identified in an "order of merit" table which highlights the individual cost of power generated by the various power plants.

Hence there are low merit (high cost) and high merit (low cost) plants which depend on the type of fuel used. In addition, the National Grid will take into account the dynamic parameters of the plant, such as loading rates, and whether the turbines are hot or cold. It can be cheaper to run a more expensive "hot" machine than a cheaper cold machine.

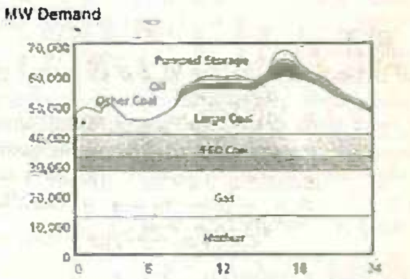


Fig.2. How a 24-hour demand, peaking at 17.30 hours, is met by the electricity industry.

Killingholme "A"

National Power's Killingholme "A" power station is situated near the ports of Immingham and Grimsby in North Lincolnshire, on the banks of the River Humber. It was their first gas turbine plant and was commissioned in 1993.

This 650MW plant runs as a "base load" operation, which means that it provides a constant output that forms some of the everyday "bread and butter" of the United Kingdom's electrical capacity. Its performance won Killingholme "A" the National Power Availability Prize.

National Power has strong international links and is heavily involved with the export of technological know-how, including the construction and joint operation of power plants in other countries, notably the USA, Europe and China. The power station at Killingholme also has an impressive

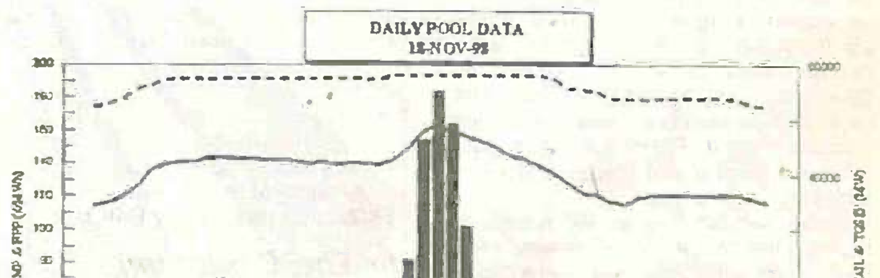


Fig.3. Daily demands are bought in half-hour blocks from electricity producers by the National Grid. The graph, produced daily, depicts several factors including the purchase price of electricity.

General view of the Killingholme "A" Gas-fired Power Station.

array of links with local educational and environmental projects, having funded a wide variety of nature conservation drives in association with both local and national authorities.

A new fully staffed visitor's centre, an educational garden and close associations which have been carefully nurtured with neighbouring schools and further education help ensure that Killingholme "A" plays an environmentally aware and responsible role in the community.

From Pipelines to Pylons

Killingholme "A" is a gas-fired power station. Why gas? When the UK electricity marketplace was forcibly opened up to competition in 1990, the switch from coal to gas became all the rage in what became known as "*the dash for gas*". Whilst coal-fired power stations battled with the logistics of being constantly fed by trainloads of cheap coal, not to mention the enormous cost of upgrading plant to meet pollution targets, one thing which is still in plentiful supply is natural gas, provided from rigs in the nearby North Sea.

Several new power stations were therefore constructed in this locality, some being independently owned and others being built by both National Power and PowerGen. A gas-fired power station is far cheaper and much more compact to build than a comparable coal-fired station, producing less carbon dioxide and virtually non-existent levels of sulphur dioxide, the compound which gives rise to acid rain.

Since the region's petro-chemical industries are handsomely served by major underground gas pipelines, then if there is an immediate need to construct power plants quickly and efficiently, gas is an obvious choice for fuel. Furthermore, by purchasing "off-the-shelf" power plant rather than attempting to design everything in-house, National Power enjoyed a greater choice of supplier and shorter lead times during the dash for gas.

Before we delve under the bonnet of Killingholme "A", it is worth relating a few fairly fundamental principles of electricity, which actually have a most profound impact on the way in which electricity must be distributed. When scaled up to the level of national electricity distribution, it soon becomes apparent why milliohms suddenly matter and kilovolts really count.

A set of rules different from those which the microelectronics enthusiast usually concentrates on, exists in the field of generating and transmitting power and even the hardened electronics enthusiast cannot help being filled with awe when confronted with a 400,000V transformer or a 10,000 amp circuit breaker!

Long Distance Transport

When electric current needs to be conducted over large distances (e.g. dozens of miles), several issues arise. The primary problem is that of unwanted electrical resistance, which results in heating effects that are proportional to the square of the current (I^2R).

If a length of wire has a known resistance, then doubling the current will quadruple the power dissipated in the form of heat. Wasting power in this way is inefficient and equates directly to increased costs, so it is highly desirable to reduce these heating effects.

Since a conductor's resistance is directly proportional to its cross-sectional area, then in order to overcome the resistance inherent in long-distance power lines, the cross-sectional area of a conductor could obviously be increased (Fig.4). This will reduce its resistance to current but will obviously increase costs because of the greater volume of conductor needed.

The solution is to *step up* the voltages being transmitted to much greater levels – tens or hundreds of thousands of volts. The higher the operating voltage, the lower the current, then the smaller the cross sectional area of power lines can be, to deliver the same level of power. This saves material costs, but then introduces yet another factor: the cost of insulating the environment from these extremely high voltages.

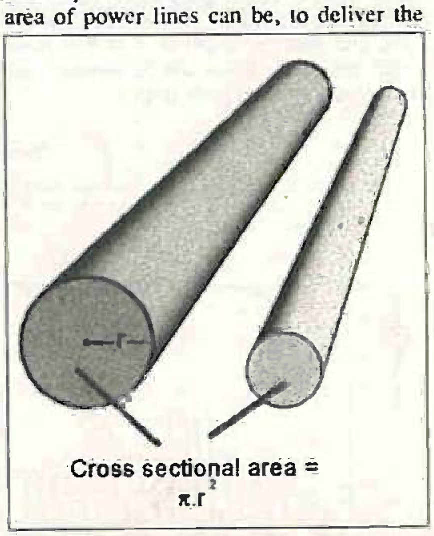


Fig.4. The resistance of a conductor is related to the cross-sectional area (CSA), the smaller the diameter, the higher the resistance.

Transmitting electrical power economically around the country, then, is a finely-calculated compromise between several factors if power is to be transmitted efficiently and also at the most economical price: too *thin* a wire and the I^2R heating losses become unacceptable; however too *thick* a wire results in a formidably high material cost; lastly, too high a voltage implies a greater cost in insulation and other technologies.

The economics of this simple relationship are shown in graph form in Fig.5. Incidentally, in case you've always wondered, those power transmission lines found hanging from pylons are usually made of aluminium alloy.

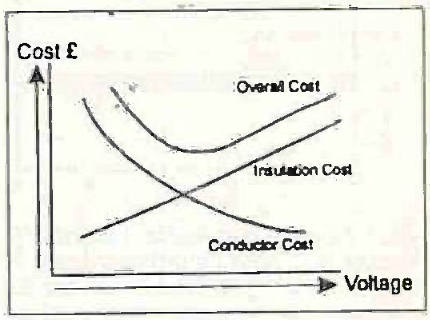


Fig.5. Illustrating the simple relationship between the cost of providing a supply versus the voltage and insulator costs.

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

Transformation

In order to transmit electrical power over considerable distances, great reliance is made on the transformer. Every reader will be familiar with a transformer, and exactly the same principle of "stepping up" or "stepping down" an alternating voltage is used throughout the power distribution network.

It would, of course, not be at all feasible to route high d.c. voltages on overhead or underground cables due to the magnitudes of current involved. Imagine trying to transport 80 amperes per house at 230V d.c. and you can imagine that the conductors would have to be impossibly thick – several metres in diameter – to transmit such power levels to an entire town. (The Cross-Channel Link does however run at d.c., as a way of separating the English and French power transmission systems: converter stations at both ends then produce alternating currents for onwards transmission.)

The main function of a transformer is, of course, to step an alternating voltage up or down. Fig.6a shows the familiar circuit symbol of a typical mains transformer that would be found in a constructional project or consumer equipment. It consists of two or more coils wound on a laminated steel core.

The *primary* winding can be considered as the input and the output is taken from the transformer's *secondary* winding. It is also often important to know the direction or phase of the windings: in electronics a spot-mark may sometimes be used to identify one end of each winding, or they may be labelled as, say, 230V and 0V on the primary, and 12V and 0V on the secondary winding.

Whether the transformer will increase (step up) the alternating voltage applied to the primary, or reduce it (step down) depends on the ratio of the number of turns of both windings. Regardless of which type the transformer actually is, at a simple level it can be assumed that the power (V×I) across the primary is roughly the same as that across the secondary.

A step-down transformer (used in ordinary mains adapters for example) might have a 240V a.c. primary and, say, a 12V a.c. secondary. The *turns ratio* is therefore approximately 20:1. If the voltage across the primary is V_p and that across the secondary is V_s, then $V_p/V_s = N_p/N_s$, where N_p and N_s are the numbers of turns in the primary and secondary windings. As shown in Fig.6a, the primary power (240V×0·5A watts) is the same as the secondary (12V×10A) – ignoring losses.

Therefore, the primary of a typical step-down mains transformer is at a higher voltage but carries a lower current than the secondary. The power (voltage × current) is the same in both windings. Importantly, this means that *thin* wire can be used for the high voltage side. However, the secondary circuit operates at a lower voltage but a much higher current. A *thicker* gauge wire is used on the secondary, to cope with these higher currents.

The auto-transformer can be considered as a single winding with a tapping made somewhere along its length. One

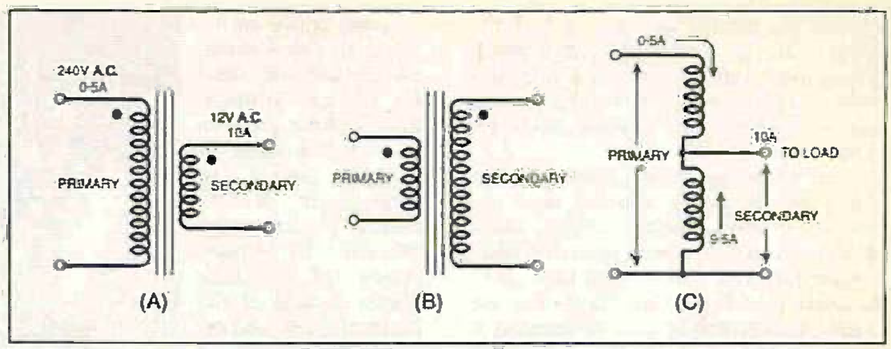
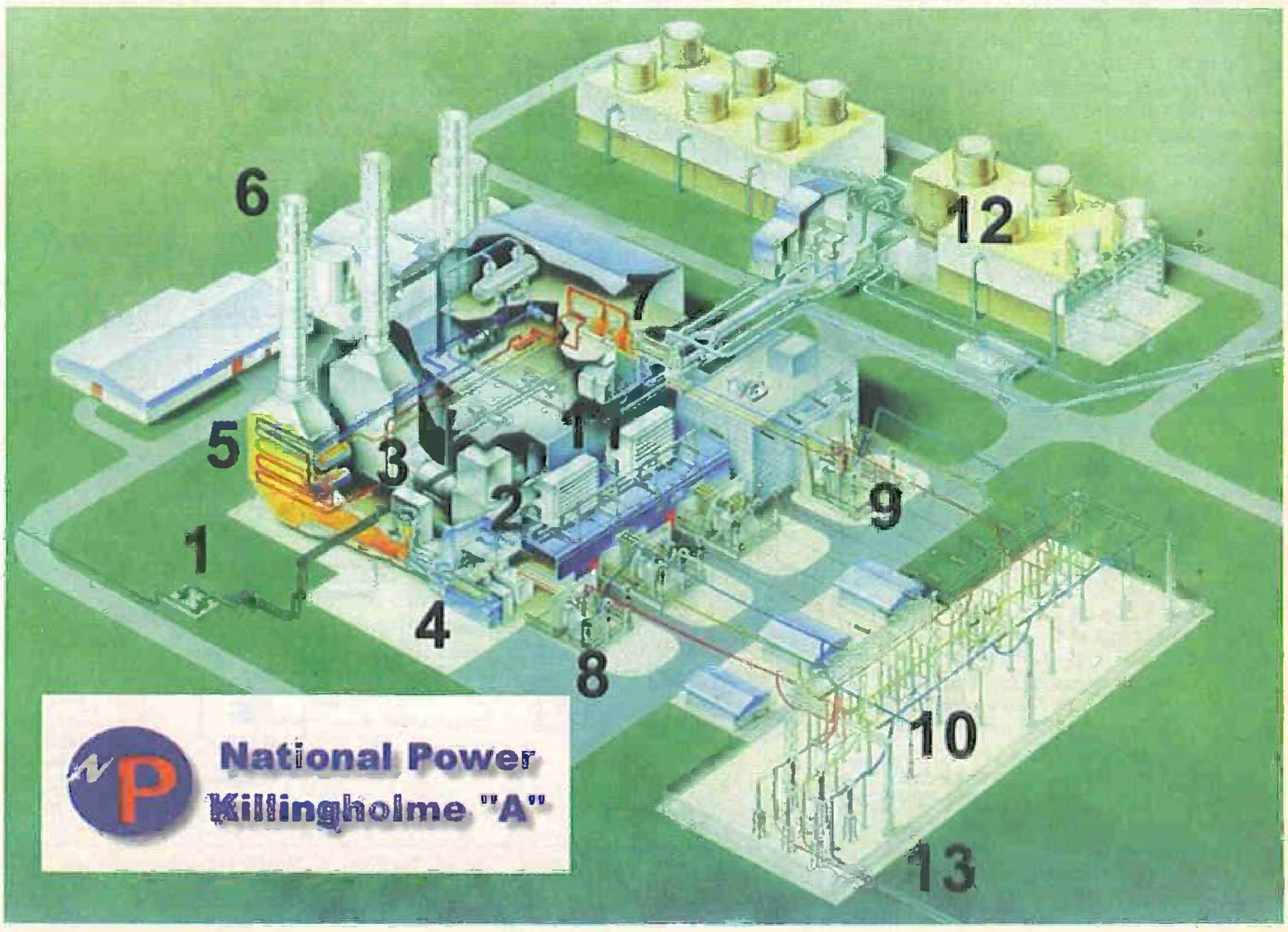


Fig.6a. Step-down transformer symbol. The "spot" indicates the direction of the windings. (b) Step-up transformer, and (c) auto-transformer.

National Power Killinghome "A" near Immingham in North Lincolnshire is a modern gas-fired CCGT power station which produces enough electricity to power a town the size of nearby Grimsby. It uses three gas and one steam turbine which operate non-stop for many months on end. 1: Natural gas is carried by underground pipelines, from offshore rigs in the North Sea. 2: Air is sucked in through large grilles on the front of the building, where it is filtered. 3: The gas/air mixture is swirled and burned in a combustion silo, which produces a force on the turbine blades below, making them rotate. 4: The generator is directly coupled to the rotating turbine shaft. 5: The turbine exhaust is used to heat water in the Heat Recovery Steam Generator, to produce "bonus" steam. 6: Exhaust then passes through the stacks, one per turbine. 7: A steam turbine produces further electricity from the steam created in the HRSG. 8: Each gas turbine outputs 3-phase 15·75kV to a large 400kV step-up transformer, outside the building. 9: The step-up transformer for the steam turbine, located by the main office block. 10: The Banking Compound contains the main isolators for the 400kV supply. 11: The exhaust steam from the steam turbine passes through a condenser, and produces high quality water which is recycled in the HRSG. 12: The cooling towers are used to reduce the temperature of the cooling water utilised in the condenser. 13: The underground 3-phase 40kV cable passes to a sub station, for onwards transmission by the National Grid.



terminal is therefore common to both the primary and the secondary (see Fig.6c). Scaled-down versions are used in workshops or laboratories, and have a moving contact which can be rotated to produce a variable a.c. voltage.

A key advantage of the auto-transformer is that the secondary winding does not "see" all of the secondary current, which means that less copper wire is needed when compared with the classic "double-wound" transformers of Fig.6a and Fig.6b. The use of auto-transformers is quite widespread in the power industry, and these are classed as **voltage transformers (VTs)**. One disadvantage to be remembered at consumer level is that they do *not* provide complete safety isolation from the mains.

A third type of transformer is also utilised in the power generation industry, in order that measurements of current may be made. Since it would be impractical to directly measure the many kilo-amperes which can flow in certain parts of the electricity generation system, a **current transformer (CT)** is used to enable readings or measurements to be taken. A "doughnut" or toroidal-shaped secondary coil can be placed over a conductor which passes through the centre; the current-carrying conductor can then be deemed to be the "primary" of a current transformer whose secondary current can then be directly measured, or used in conjunction with protection equipment.

A series of CTs and VTs are used to constantly monitor the circuits of the power station: an enormous voltage transformer with a 15·75kV primary is positioned to directly measure the output of each of the generators. Transformers are also instrumental (literally) in alerting the power generation and distribution companies to any losses which may occur further downstream in the electrical grid.

In the power generation industry, thin wires at high voltages are used to transport power economically over great distances. Transformers will then be utilised at substations in order to step down the voltages to something more appropriate, using thicker, more expensive wires to carry these higher "secondary" currents. We will look at the aspects of three-phase power transmission and distribution later on.

Talking Turbines

Having introduced these fundamental electrical aspects, let's return to our power station at Killingholme "A" and explore in more detail where electrical power actually comes from. Our adopted power station is fuelled by gas brought in from the North Sea and transported in an underground pipeline. The actual compound area where the natural gas arrives contains just a little surface pipework and is remarkably ordinary-looking, all things considered!

The Killingholme station is known as a Combined Cycle Gas Turbine (CCGT) plant, which utilises gas turbines to drive electrical generators. In a CCGT plant, surplus heat created by the gas turbines is further utilised to produce steam. This drives a steam turbine to generate yet more electricity. The steam turbine is driven by "waste" heat from the gas turbine which results in a vast improvement in overall power plant efficiency. A diagram explaining the overall process is shown in Fig.7.

Aerial view showing gas turbine blades (largest, front) and air compressor (rear) on the shaft, undergoing inspection.

Large grilles on the front of the building are actually air inlets for the gas turbines. Each turbine requires about half a tonne of air per second, so atmospheric air is sucked in and compressed by many stages of spinning blades located at the front of each turbine shaft. The resultant high pressure air is "swirled" along with natural gas within a combustion unit fitted on top of the turbine. Within this "silo combustor" are 54 separate burners which act as gas-jets. The burning mixture reaches temperatures of over 1,000 degrees Celsius.

In the same way that in an internal combustion engine the petrol/air mixture ignites and expands to force down a piston, the resulting continuous expanding force from the burning gas mixture passes over and spins the gas turbine blades. These drive a *generator* through a shaft, which also drives the air compressor blades.

In A Spin

Looking at the generator in more detail, it is much easier to use *stationary* coils rather than attempt to rotate them, so the electrical generator consists of a comparatively small rotating electromagnet (the rotor) surrounded by a series of large fixed coils (stators) in which electrical energy is induced. They output up to 145MW at 15·75kV. The Killingholme power plant has three such gas-turbine driven generators plus a steam turbine as well. We will be looking at what happens to the generator's output in greater detail later on.

To start the system, a "static starting device" (SSD) is utilised in which the generator is actually used in reverse, as a starter motor (consuming some 4MW of power in the process), see Fig.8. Acting as an induction motor, the stator is energised by a variable voltage, variable frequency a.c. supply; the generator's inner rotating windings are powered with a d.c. current (called "exciting" the rotor) through brushes and moving contacts called sliprings.

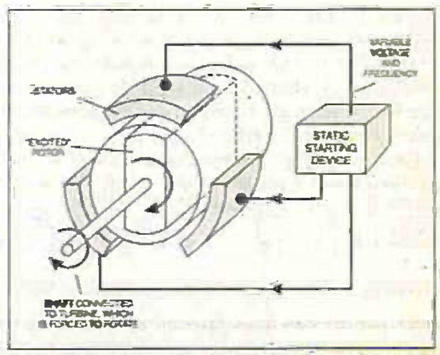


Fig.8. A static starting device (SSD) is utilised to convert a generator into a "starter motor" (consuming 4MW). This causes the rotor to spin, which in turn, turns over the turbine.

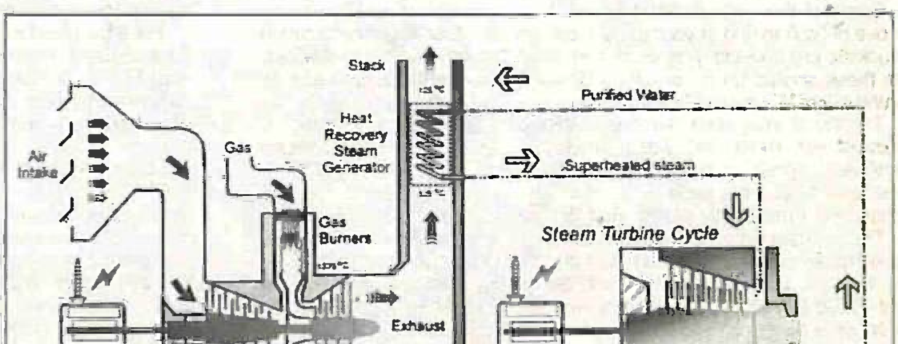


Fig.7. Schematic representation of the Killinghome "A" Combined Cycle Gas Turbine (CCGT) power plant.

Variations on this theme include the use of rectified a.c. exciters, or brushless excitement systems which use a.c. generators and eliminate the need for sliprings altogether.

At a certain point, the rotor's magnetic field "locks" together with the field created in the stator, and the generator (still behaving as a motor) achieves *synchronous* operation: the two magnetic fields are synchronised with each other. Then the supply to the stator is increased in frequency, which causes the rotor to be dragged along at a higher rotational speed. Thus the shaft is forced to rotate.

At 2,500 r.p.m. the gas turbine manages to sustain itself and the SSD is disabled, the turbine's compressor blades now spinning fast enough to maintain the combustion process. The rotor's speed will then be automatically governed up to the critical speed of 3,000 r.p.m. and electricity can then be generated.

To give you an idea of scale, the rotor shaft typically weighs 100 tonnes or so and is machined from one solid casting. It will become apparent later why a speed of 3,000 r.p.m. is significant to electricity users!

The computer control room monitors and records the performance of the plant.

Power Bonus

The power generation process does not stop at the gas turbine. Having passed over the spinning gas turbine blades, the exhaust gases still have a temperature of some 500°C. Rather than letting this go to waste, in a CCGT system this is put to further use in a heat exchange boiler or "heat recovery steam generator" (HRSG).

Each heat exchanger contains over 100 kilometres of finned tubing, which functions like a heatsink in reverse: the hot exhaust gas is used to heat water which is pumped through the core of the heat exchanger. The water turns to steam. The chimney-like structures or stacks, which can be seen from the author's window several miles away, actually vent exhaust from the gas turbines after it has passed through the heat exchanger.

The "bonus" steam produced by the heat recovery steam generators is completely free of water vapour and is invisible, and is piped to a steam turbine to drive a fourth 227MW generator. The steam exhausted from this turbine is condensed by passing it over a bank of titanium tubing through which cooling water is pumped (originally extracted from the nearby River Humber). The resultant condensed water is extremely pure and is recycled for use back in the heat recovery boilers, to be heated back into steam again.

Lastly, the cooling water that has now been warmed by the steam turbine's condenser, has to be cooled down and this is achieved in a cooling tower by spraying it over a large surface area in the face of a rising column of air. The cooled water is then pumped back to the steam turbine's condenser for re-use.

Sometimes, water vapour is produced during this cooling-down process, which will be seen billowing from power station cooling towers. As readers will know, coal-fired power stations rely on steam turbines and require much larger cooling towers for reducing the temperature of their condenser cooling water.

In a CCGT plant, it can be seen that much use is made of recycling and utilising the by-products of the combined cycle process. Exhaust heat from the gas turbine is used to create steam which generates "bonus" power with a steam turbine; the steam is then condensed back into water for further use in the heat exchanger, where it is re-heated by the gas turbine's exhaust to make more steam. The heat recovery cycle has a phenomenal effect on throughput: it increases the overall efficiency of the plant from approximately 33 per cent to 50 per cent or so.

Next Month: In the next part, methods of power distribution and transmission are described, along with the means by which electricity is delivered to a typical home.

SHOP TALK

with David Barrington

Ultrasonic Puncture Finder

Some of the parts needed for the *Ultrasonic Puncture Finder* may prove difficult to find at your usual local source. Most larger component stockists are now carrying extensive ranges of surface mount devices, so these should be no problem. Check out the author's web site at: **www.billsSMD.mcmail.com.**

The small integrated "knob-pot" VR1 only appears to be listed by **Farnell** (☎ ***0113 263 6311***), code 350-655. The semiconductor devices originally came from **Gothic Crellon** (☎ ***01743 788878***). If you wish to use the case pictured in the article, this was purchased from **CPC Preston** (☎ ***01772 654455***), quote code EN55035.

The ultrasonic transducer is usually stocked as a pair, transmitter/receiver, and you may have to shop around to find a stockist willing to part with just the receiver. Having said that, **Electromail** (☎ ***01536 204555***), the mail order arm of RS, list them separately; the receiver is coded 307-367 and costs just over £4 plus any p&p charge. Some companies sell the pair for around £6 plus p&p.

Magnetic Field Detective

The main item of concern regarding components for the *Magnetic Field Detective* will be the fluxgate magnetometer sensor. The FGM-3 fluxgate sensor is obtainable from: **Speake & Co. Ltd., Elvicta Estate, Crickhowell, Powys, NP8 1DF.** Phone: ***01873 811281.*** We understand from Bill Speake that this will cost readers £17 all inclusive, and include the data sheet and application notes.

One source for the LP2950 5V micropower regulator is from **Electromail** (☎ ***01536 204555***), code 648-567. The AD8532 dual op.amp came from Maplin, code OA16S.

8-Channel Analogue Data Logger

The PIC16F877 microcontroller used in the *8-Channel Analogue Data Logger* is so new that supplies will only be appearing during the latter half of July '99. We understand that **Farnell** (☎ ***0113 263 6311***) will be stocking unprogrammed 'F877s. The same source was identified for the 24LCxx serial EEPROM memory chips. To date, we are unable to quote order codes but we will keep you "posted".

For those readers who want a "plug-in and go" ready-programmed PIC16F877 chip, one will be available from **Magenta Electronics** (☎ ***01283 565435*** or ***http//magenta2000.co.uk***) for an expected price of £10 (overseas readers add £1 for postage).

For those readers who wish to program their own PICs, the software is available from the Editorial Offices on a 3·5in. PC-compatible disk, see *EPE PCB Service* page 620. If you are an Internet user, it can be downloaded *Free* from our FTP site:
ftp://ftp.epemag.wimborne.co.uk/pubs/PICS/datalog.

Freezer Alarm

The op.amp for the *Freezer Alarm* must be a low power type and readers are advised to stick with the LF441CN if possible. However, we have just discovered that this op.amp is now in very short supply and some reports suggest it is "discontinued". In view of this, we contacted **Farnell** (☎ ***0113 263 6311***) and they have suggested the AD548JN, code 400-920. You could also try the CA3130E. These have not been tested in the model.

The bead thermistor rating of 47 kilohms at +25°C is its nominal figure and should be quoted when ordering, most of our advertisers should be able to offer a suitable device. It is certainly carried by Maplin, code FX42V. They also list a 6V buzzer, code FL39N.

Sound Activated Switch

The only component to watch out for when selecting parts for the *Sound Activated Switch* is the electret mic. insert, with a "built-in" f.e.t. preamplifier. The model uses a subminiature type from **Rapid** (☎ ***01206 751166***), code 35-0190.

Details of all this month's PCBs can be found on page 620.

PLEASE TAKE NOTE

MIDI Handbells *(May '99)*

Page 327 Fig.3. The negative lead of electrolytic capacitor C2, connected to row K25, is incorrect. It should, of course, ***go to row J25***, the 0V track.

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 ★

WASH AND BRUSH UP

Dear EPE,

A few years ago I wrote to you about a project I was making from *EPE* – the *Washer Bottle Monitor* (Sept '92). You wrote back a very kind and explanatory letter which I still have, and the problem was solved at once. The transistor had the suffix "L", which gave it a different pinout. The design was installed in the car I had at the time, and then transferred it to the next car, which I sold a few months ago, and the monitor, still working great, went along with it.

I have now retired and we moved to a quiet country village about a year ago. I have built a shack and now spend all my time at DIY, the garden and electronics, and have just built myself a UV light box from *EPE* and went on to develop my first p.c.b. using Terry de Vaux-Balbirnie's *Mole-ester* (Aug '96) as a trial project. It is now working on the bench ready to put in a box – $6^{1}/_{2}$ mins to develop and 20-25 mins to etch.

I would like to thank you for the help and for persuading me to keep at it when I was just started. It is a very satisfying hobby at any age, of course. I have always liked to make things. Most of my working life was spent as a fisherman and the last ten years as skipper of a North Sea trawler. I now look forward to getting my teeth into more projects and will keep reading your excellent articles.

Alexander Lovie,
Cornhill, Banffshire, Scotland

Most interesting to hear from you. We wonder if your UV unit was the one by Alan Winstanley, of July '92?

How many more readers have favourite EE/PE/EPE/ETI projects that go years?

QUIBBLES

Dear EPE,

A small quibble with the references to SI units in John Phillips' letter (June '99) and your reply. The convention with SI units based on personal names is that the unit symbols are written with a capital (N, Pa, V, A etc.) while the units names themselves (newton, pascal, volt, ampere, etc.) are not capitalised.

Also I'm a bit doubtful about *Celcius*. I have seen it spelled that way. But my *Chambers Biographical Dictionary* tells me it is *Celsius*, after the Swedish astronomer Anders Celsius (1701-44), who devised that temperature scale in 1742.

More seriously, you can't write *virii* (as appeared in *Network* June '99)! The Latin *virus* originally meant a slimy liquid; the word was used (in French) in its modern sense of an infectious organism by Louis Pasteur in 1880, and reported (in English) in *Scientific American*) in 1881. The plural *viruses* has been in use in English since at least 1908, so there is no reason to use the Latin plural; but if you must use it, it is *viri*, not *virii*.

Peter Kelly,
Woombye, Queensland, Australia

Thanks Peter – we actually commented on the lower case for kelvin in July '99 Readout, *but did not correct the pascal aspect – and shall probably not do so again in the future! As you will see from another letter on this page, the Editor in Chief of Elektor-France is someone else who also chooses to use capital P for Pascal. There are some things which look better with caps in a publication such as ours, even if it's not strictly correct. Celcius was purely my typing error, but by the rules you quote for non-caps should it not be celsius?*

Virus – Fowler's Modern English Usage *states that "The plurals of nouns in -us are troublesome. Most are from Latin second-declension words, whose Latin plural is -i; but when that should be used, and when the English plural* -uses *is better, has to be decided for each separately".*

Personally, I would use viruses (I had Latin thrust down me at school – but little was absorbed and I wouldn't presume to comment on someone else's correct or incorrect use of it). My Hodder and Stoughton Latin-English dictionary gives "slime; poison; saltiness" as the translation for virus.

Don't overlook the fact that we are principally here to publish electronics articles and do not claim to be professors in English (or Latin) – although we acknowledge that correct spelling is desirable in any discipline!

FRENCH BARS

Dear EPE,

I have just read the *Hot Bars* letter of June '99. After decades and even centuries of use of the Imperial system, it seems that a lot of people over there (the Channel, Atlantic Ocean, Pacific Ocean) have problems with the Metric system.

The order is milli, centi, deci, one, deca, hecto, kilo. These translate as one thousandth, one hundredth, one tenth, one, ten, hundred, thousand, and so on. Therefore, a hectoPascal is 100 Pascal and not 0·01 Pascal. It is true that one hectoPascal is the same as one millibar, thus one bar is 1000 hectoPascal.

For your information, the old name of the bar was hectopieze (hpz = 100pz), 0·98 atmosphere. The old name of the Pascal is millipieze, one thousandth of a Pieze.

Further, as far as I know, and I should, I'm a Frenchman, Celsius is written with an **s** not a **c**.

I read your magazine, with professional interest since at least 18 years.

Guy Raedersdorf,
Editor in Chief, Elektor-France

Thanks Guy, we appreciate your professional input. We also note with interest that you also use capitals for some unit terms – we're being criticised for it (see Quibbles letter on this page)! Yes, I can't type accurately, of course it's Celsius (or should it be celsius?) and for some reason my wordprocessing program's spellchecker failed to alert me.

OZ FORECASTS

Dear EPE,

Australian TV weather forecast pressures are always given in hectoPascals. Perhaps not surprising as Australia went about adopting the metric system sensibly and completely rather than the half-hearted way we in the UK have to endure. It would be interesting to know if NZ TV use hPa in forecasts.

I'm in favour of total metrification worldwide. I have a book from the early '50s with nearly four pages of weights and measures at that time still in use around the world. Things have improved since then but there is still confusion over the inequality of US and Imperial gallons, pints and fluid ounces and there are crass mistakes like that in the so-called "British" edition of *Encarta 98* which says 1 gill = 4 fluid ounces (which is correct in US liquid measure) having already stated that there are 20 fl oz in an Imperial pint.

The derivation of the word *barometer* is from the Greek *baros* – weight, *metron* – measure, and relates to the Italian physicist Evangelista Torricelli's concept of the Earth's atmosphere having weight and thus exerting pressure on the Earth's surface, which he first measured in 1644.

The *OED* records the first use of the word as being in 1665 by Robert Boyle. This was well before the report of the Paris Academy of Sciences in 1791 which included the essentials of the metric system and the international treaty in 1875 establishing the International Bureau of Weights and Measures, so the *bar* as a unit of pressure (1,000,000 dynes/sq. cm) had not been devised when *barometer* was first used. Sorry JB, the *bar* in *barometer* has no connection with the unit of pressure.

Barry Taylor, via the Net

Interesting comments, Barry (and we recall that you have spent some time in Southern Hemispheres).

I concur with you on the (Ancient) Greek origin for barometer, *and actually quoted it in my* Altimeter *projects in* EPE *Sept '98 and Nov '92. However, interesting as the history is, I still have no problem with what I actually said in my reply to the* Hot Bars *letter of June '99. Since* bar *also derives from the Greek, irrespective of when the term was formally adopted as a unit, it seemed appropriate to "Anglicise" as I did, although I could have been more formal and made reference to origins of βαρος and μετρον.*

Modern Greek, by the way, still retains the same two words, although baros is pronounced more like "varos" as the modern pronunciation of β (beta) has changed. The word "bar" (as in drinking hostelry!) is now encountered as being spelt "mpar" (μπαρ), the "mp" being pronounced as "b" is in English.

Incidentally, my info gives 1643 as the year that Torricelli made the first mercury barometer, and in doing so made the first vacuum known to science. Apparently it was Otto von Guericke who was the first to use a barometer to forecast weather, in 1660.

Thanks for another interesting contribution to our various debates.

NO TABBING

Dear EPE,

Using *Toolkit Mk2* with a TASM text file I have written for a project I've been working on, I cannot assemble the .ASM file to binary .OBJ, receiving the message "63 Errors".

Dave Buck, via the Net

To cut short the story, I examined Dave's file and found that he had been using the Tab key instead of spaces. The Tab is a command key and is not recognised by the Toolkit software as legitimate ASCII text data. The Tab does not actually create spaces in the file being written but puts in a single control character of ASCII 9.

When Toolkit Mk2 assembles a text file it looks for the space character (ASCII 32) as the separators between fields (columns). If it finds ASCII 9 instead of a space, the correct field separation is not made and data is incorrectly interpreted. in Dave's case many of his PIC commands were being seen as Labels.

I have heard back from Dave who reports success after removing the Tab commands.

(PS please do not send me code files that you have written and can't get to work – I don't offer a debugging service! Dave's situation was different and had me puzzled by what he said in his first E-mail.)

WINDOWS 98 PORT SPOOLING

Dear EPE,

Regarding Thomas Walton's TASM Send problem (*Readout* May '99), it may be that his Windows 98 is spooling data to the printer port. I had a similar problem when programming a parallel relay card in QuickBASIC.

Spooling means that data will be significantly slowed down. It is only really necessary for more advanced Windows programs (MS Word etc). To prevent spooling in MS-DOS programs, go to **My Computer** and open the **Printers** folder. Now right-click the default printer and select **Properties**. In the window that appears click the Details tab and then click **Port settings**. Now uncheck the **Spool MS-DOS print jobs** and click **OK**. I do not know why Windows 95 wasn't spooling Thomas's Send yet Windows 98 was. Maybe the printer driver's defaults were restored during the upgrade.

Graeme Yeo, via the Net

Thanks Graeme for this information. It could well prove useful to many readers who have upgraded to Windows 98.

PC PORT IDENTIFYING

Dear EPE,

I have seen from *Readout* on several occasions that some readers have had difficulty in identifying LPT ports for use with PIC Programmers, etc. The following program may be of help:

```
40 DEF SEG = 0
50 A = PEEK(1032) + 256 * PEEK(1033)
60 B = PEEK(1034) + 256 * PEEK(1035)
70 C = PEEK(1036) + 256 * PEEK(1037)
80 PRINT "LPT1 AT "; HEX$(A)
90 PRINT "LPT2 AT "; HEX$(B)
100 PRINT "LPT3 AT " HEX$(C)
110 DEF SEG
```

The remarks regarding LPT output lines not shifting between 0V and 5V may well be an issue. I think it is a good idea to buffer each line to and from the LPT port as a matter of principle.

David McCloy, via the Net

Thank you. The same information can also be obtained with many machines by typing MSD (standing for Microsoft Diagnostics) from MS-DOS mode. This causes a diagnostic screen to display information about many aspects of your system.

Yes, it is agreed that buffering port I/O lines is beneficial. This was done for the PIC Toolkit Mk2 *(May-June '98) and the* 8-Channel Analogue Data Logger *(this issue).*

DELPHI, CCTV

Dear EPE,

Many thanks for the kind words about my website in the June '99 *Interface*, but more importantly, thank you for promoting the excellent Delphi software. I have updated www.arunet.co.uk/tkboyd/ele1pp.htm so that it now covers how to access a Windows 95 or 98 parallel port.

Also, I bought one of the little CCTV cameras before seeing your special offer for them. Can you point me to an old *EPE* project or some other source for a still frame grabber? I want to work up a security application which will record still images from the CCTV on a PC's hard disk.

Tom Boyd, via the Net

Regrettably, my CCD TV Camera's software (Mar-Apr '94) was specific to the CCD chip I used in it. Whilst frame grabbing was one of the functions available, it would be too complex to re-write the code to suit the little cameras to which you refer. Does any reader know of a circuit Tom might try?

Thanks for the previous informative E-mail about more Delphi port procedures, but perhaps its best if people read such codes via your superb website.

FLOPPY RADIO

Dear EPE,

Regarding the *Mechanical Radio* of April '99, I have found that the stepper motor off an old floppy drive works real dandy! No gear ratios are needed, just attach a simple handle to the shaft and a speed of about 10 r.p.m. is sufficient to generate 3V. Dead right for my little radio. I charge two penlight NiCad cells with it.

Martin Gouws,
Randfontein, South Africa, via the Net

Neat!

PhizzyWIZZ

Dear EPE,

From the deepest corners of darkest Africa, I wish to express my gratitude to all involved with the wonderful *PhizzyB* project (Nov '98 to June '99). It has been gangs of fun.

Graham, via the Net

Graham's E-mail has wizzed around the globe a bit before ending up on my PC. In the process his surname has gone astray (hope it turns up before he misses it!). Ports of call include Max and Alvin in the USA, Alan W in Lincolnshire UK, Mike K here at HQ. We think Graham lives in Zanzibar.

We all express thanks to him for taking the time to let us know that he appreciates PhizzyB. *It's not often readers write to just say how good things are, they usually only write when they have problems (but we are pleased to help where possible). So, Graham, from the rustic corners of Historic Wimborne Minster, salutations!*

ARCTIC SUNDIAL

Dear EPE,

I was horrified to read the following comment in the *Musical Sundial* project of May '99: *"who in their right mind is going to be looking at sundials at 4 a.m.?"*

But what about your faithful readers in Artic Climes, where the sun shines for 24 hours a day for six months of the year. I feel that a Letter to the *Times* is in order.

(We know who he is and shall not give him the pleasure of naming him), via the Net!

Editor Mike's response to the threat is that the publicity would do us good! Yours truly, a Midlunder born and (un?)bred, Articulates that he did not mean to exclude those who live North of the Watford Gap!

CENTURY BUG

Dear EPE,

Now that the general public has adopted the phrase "Millennium Bug", maybe it's too late to tell everyone it should actually be called the "Century Bug"! If technological history had been shifted by a multiple of 100 years in either direction, then we would still have the same fears in changing the year from 99 to 00. The problem would still be apparent if we were now in the 1890s of 2090s.

Perhaps it was named by the same person who labelled the American Cold War deterrent as "Star Wars" when there were no stars involved at all! Just a blue-green planet!

Richard Wilkinson,
via the Net

The Millennium reference inspires my imagination more, perhaps, than the Century would. Whilst, we are aware that the whole concept of the Millennium change leaves some people utterly uninterested, it seems that society in general just loves celebrating anniversaries, so why not this one? I look forward to visiting the Dome, whatever the cost.

Incidentally, it's amusing to see how the word Millennium is spelt wrongly in so many places (we've done so as well). A flower shop sign I saw recently in Jersey stating "Order your Minnellium flowers now", was especially entertaining!

But, no stars? There were thousands of stars – amongst the Generals who were all offering their 10 (billion) cents worth of input!

MILLENNIUM SOLUTION

Dear EPE,

A friend sent this advice to me and I thought it worth passing on: if your VCR doesn't work in the year 2000, do not throw it away, set it on year 1972 because the days will be the same as year 2000!

Lloyd Kirk, via the Net

We too pass it on (but untested)!

RINGING PRAISE

Dear EPE,

The *MIDI Handbells* project (May '99) is great! I have an interest in percussion and so I have changed the project a little to make a MIDI drum kit. I have altered the PIC program to use MIDI channel 10 (drum channel) and to use different notes (one for cymbal, one for snare drum, etc). Also, instead of the "handbells" I am using metal pads connected to resistors R1 to R11 and metal drum sticks connected to +V. When a pad is hit, +V is connected via a resistor to the appropriate pin of the PIC.

Graeme Yeo, via the Net

We like to hear that people are making use of design ideas in order to achieve their "own thing". This is yet another way in which readers benefit from our pages – being shown alternative ways of doing things and then adapting the ideas.

A TOWSON THANKS!

Dear EPE,

I picked up my first copy of *EPE* at my local store here in Towson, USA. I want to let you know that I think your magazine is terrific! The articles are interesting, well written, page layout is clear, schematics detailed. I particularly like the large space allocated for the parts list, which is in stark contrast to the almost afterthought like approach seen in some US periodicals.

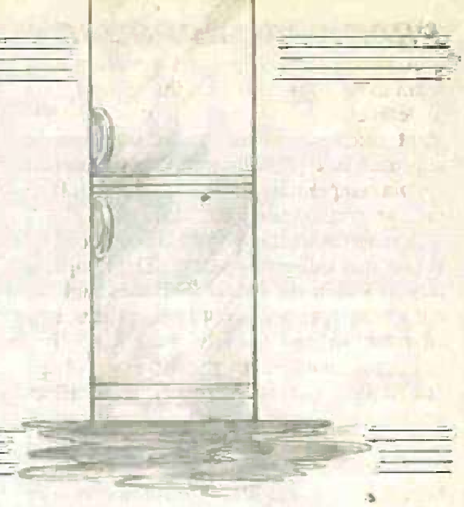
Keep up the great job! Consider me another fan across the big pond.

R. Saffery, Towson, USA, via the Net

Consider yourself well and truly welcomed by the EPE *team!*

Starter Project

FREEZER ALARM



ROBERT PENFOLD

For a small outlay you could save yourself from an expensive "thaw-out".

LIKE most modern gadgets, freezers offer excellent reliability and problems with them are extremely rare. It is easy to be lulled into a false sense of security by this reliability, and like every other gadget freezers can and do go wrong occasionally.

If the problem is not spotted in time the likely result is a great deal of wasted food. Unfortunately, unless smoke starts to pour out the back of the freezer it is unlikely that the problem will be noticed until the food has defrosted and you are confronted with a soggy mess.

This very simple alarm project provides an early warning of problems by sounding an audible alarm if the temperature inside the freezer rises above a preset threshold level. The user is alerted to the fault long before the food has a chance to defrost, and hopefully in time to get the problem fixed before the food is ruined.

The circuit is battery powered and is therefore immune to failure of the mains supply. Although the unit must be left running continuously, the current consumption has been kept to a very low level that ensures each set of battery has virtually its "shelf" life.

CIRCUIT OPERATION

The full circuit diagram for the Freezer Alarm is shown in Fig.1 and is an ideal "starter project" for the newcomer to electronics. The temperature sensor is a negative temperature coefficient thermistor (R3), and this is effectively a resistor whose value changes with variations in temperature. The higher the temperature of the thermistor, the lower its resistance becomes.

A form of bridge circuit is used, with thermistor R3 and resistor R4 forming one arm of the bridge. Resistors R1 and R2 together with potentiometer VR1 form the other section of the bridge circuit.

Each arm of the bridge generates an output voltage that is some fraction of the supply voltage. The output voltage from thermistor R3 and R4 depends on the resistance of the thermistor, and the circuit is designed so that under normal operating conditions the resistance of R3 is very similar to that of R4 (about 680 kilohms).

This gives approximately half the supply potential from this section of the bridge. If the thermistor is made colder its resistance rises, and the output voltage from that side of the bridge reduces. Conversely, if its temperature is increased, its resistance falls, causing the output voltage to increase.

The output potential from the other section of the bridge is dependent on the setting of potentiometer VR1. The wiper (moving contact) voltage of VR1 can be set to anything from one third of the supply potential to two thirds of the supply voltage. In practice this is adjusted for an output voltage that is fractionally higher than the output voltage from the other arm of the bridge.

Consequently, only a minute voltage is needed across the inputs in order to send the output fully positive or negative. The output goes positive if the non-inverting input (pin 3) is at the higher potential, or negative if this input is at the lower voltage.

In this case VR1 is adjusted so that the inverting input (pin 2) is at the higher voltage under normal conditions, which sends the output of IC1 (pin 6) to a very low voltage. This results in switching transistor TR1 being turned off, and no power is supplied to warning device (buzzer) WD1.

However, if the freezer fails and the temperature of thermistor R3 rises slightly, its resistance falls and the voltage supplied to IC1's non-inverting input (pin 3) increases. This takes the non-inverting input to a higher voltage than the inverting input, and the output of IC1 then goes high. This switches on transistor TR1, which in turn activates warning device WD1. The circuit therefore provides the desired effect, with a warning being provided if thermistor R3 is taken above the threshold temperature set using control VR1.

It is possible that buzzer WD1 will provide a highly inductive load for transistor TR1, and protection diode D1 has been included to protect TR1 from any high reverse voltages that are generated. Capacitor C2 and C3 help to prevent electrical noise from giving erratic operation when R3 is very close to the threshold temperature.

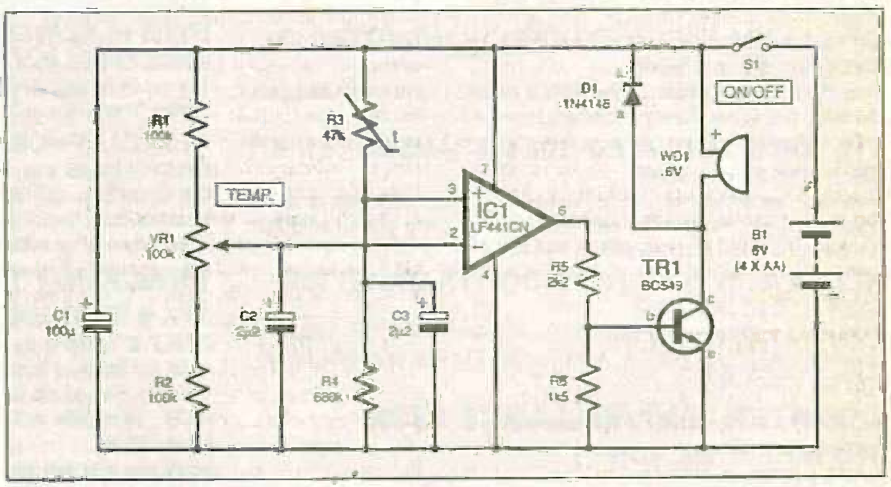


Fig.1. Complete circuit diagram for the Freezer Alarm. Component designated R3 is the thermistor temperature sensor.

VOLTAGE COMPARATOR

In this circuit an operational amplifier (op.amp), IC1, is used as a voltage comparator. An operational amplifier amplifies the voltage difference across its two inputs, and at d.c. it provides an extremely high voltage gain. A theoretical operational amplifier has infinite voltage gain, but a typical "real world" device exhibits a voltage gain of about 100,000.

PRACTICAL APPROACH

A bridge circuit and a thermistor may seem to be a slightly old fashioned solution to temperature sensing, but this arrangement often represents the most practical approach in applications that only require a certain temperature to be sensed rather than precise temperature measurement.

A major advantage of this type of circuit is that it is inherently stable. The temperature at which the bridge balances and the output voltages are equal is not affected by changes in the supply potential. The inevitable changes in the battery voltage due to ageing consequently have no affect on the accuracy of the unit.

For battery operation to be a practical proposition it is essential for the circuit to have a very low current consumption. For this reason IC1 must be a low power op.amp, and it must also be capable of working reasonably well on a 6V supply. The LF441CN works well in this circuit, but the use of alternative op.amps is not recommended.

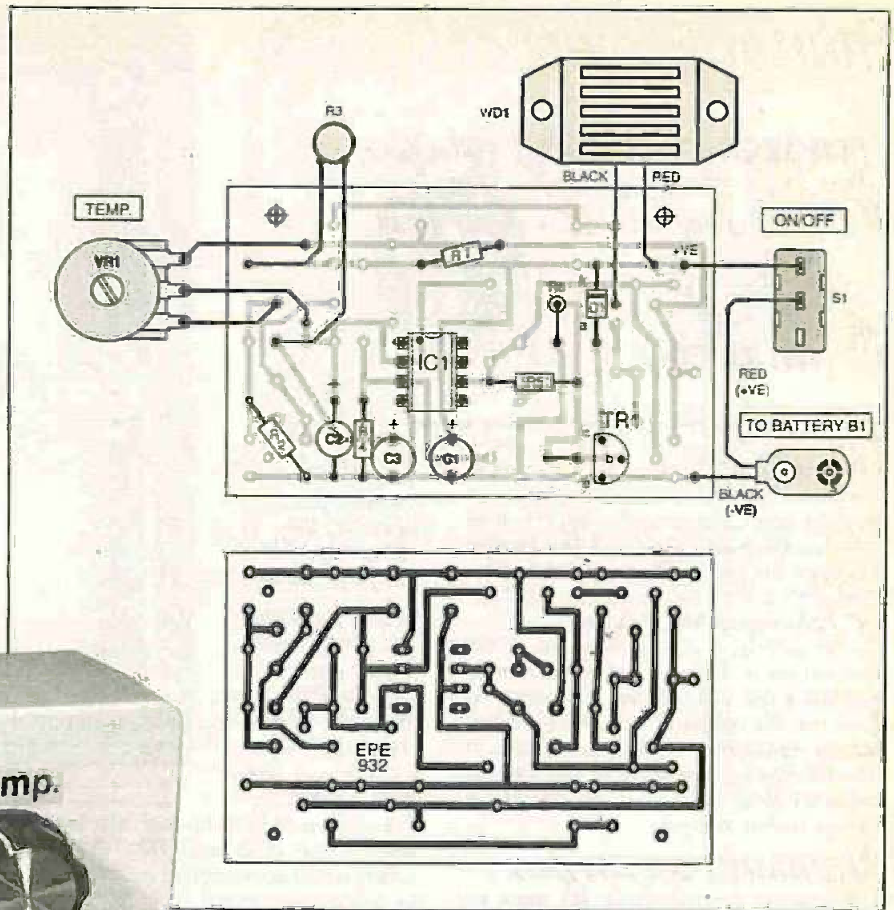
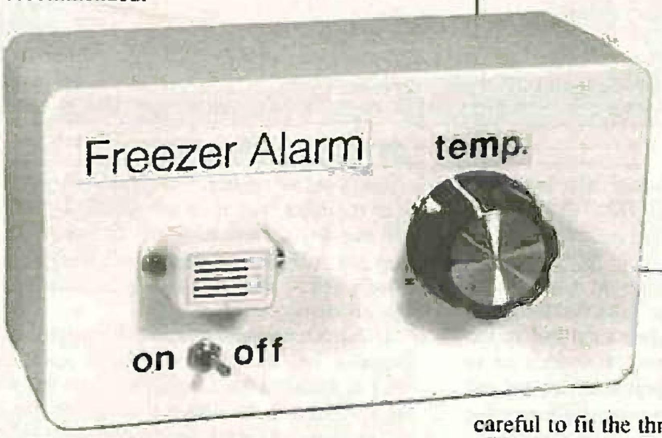


Fig.2. Multi-project printed circuit board component layout, interwiring and full-size copper foil master. Double-check layout as not all holes are used.



The use of a high value thermistor also helps to minimise the battery drain. Although R3 has a nominal resistance of 47 kilohms, this is its resistance at +25°C. In this application it will operate at a much lower temperature of around −20°C where its resistance is over ten times higher.

The high resistance through R1, VR1, and R2 also helps to minimise the current consumption. The total current consumption of the circuit is typically under 200 μA, which should provide many months of continuous operation from even the cheapest of AA batteries.

CONSTRUCTION

The Freezer Alarm project utilizes the *EPE* multi-project printed circuit board (p.c.b.). The component layout and wiring, together with the actual size copper foil master pattern, are shown in Fig.2. This board is available from the *EPE PCB Service*, code 932.

The usual words of caution about using this particular board have to be given. The majority of the holes in the board are left unused, making it relatively easy to get a component in the wrong place. It is therefore essential to take a little more care than usual when fitting the components onto the board.

In all other respects construction of the board is mainly straightforward. The LF441CN used for IC1 has a j.f.e.t. input stage that does not require anti-static handling precautions, but it is still advisable to use an i.c. holder for this component. Be careful to fit the three capacitors and diode D1 the right way round, and leave D1 until last.

Close tolerance metal film resistors are specified in the components list, and it is definitely advisable to use high quality resistors if the unit will be used in a garage or other outbuilding where the ambient temperature is likely to vary over a wide range. Ordinary five per cent tolerance carbon film resistors should suffice if the alarm will only be used indoors.

Capacitor C3 must be a good quality electrolytic or tantalum capacitor. Otherwise any leakage through this component could impair the performance of the circuit.

A single link-wire is needed, and this can be made from a piece of wire trimmed from a resistor leadout. Fit single-sided solder pins at the points on the board where lead-off connections will eventually be made to thermistor R3, buzzer WD1, the battery connector, switch S1 and temperature control VR1. The tops of these pins should be generously "tinned" with solder.

FINAL ASSEMBLY

A small to medium size plastic case is adequate for this project. Very small boxes are unlikely to be suitable as they will not accommodate the battery pack which consists of four AA-size cells in a plastic holder. The connections to the holder are made by way of an ordinary PP3 battery connector.

From the mechanical point of view construction offers little out of the ordinary, but the buzzer (WD1) has unusual mounting

COMPONENTS

Resistors

R1, R2	100k (2 off)
R3	47k bead N.T.C. thermistor
R4	680k
R5	2k2
R6	1k5

All 0·25W 1% metal film except R3 (see text)

See **SHOP TALK** page

Potentiometer

VR1	100k carbon rotary, lin

Capacitors

C1	100μ radial elect. 10V
C2, C3	2μ2 radial elect. 50V (2 off)

Semiconductors

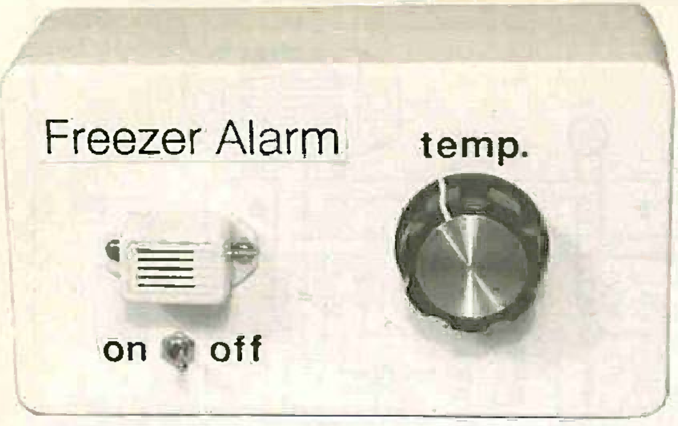
D1	1N4148 signal diode
TR1	BC549 *npn* silicon transistor
IC1	LF441CN low power op.amp

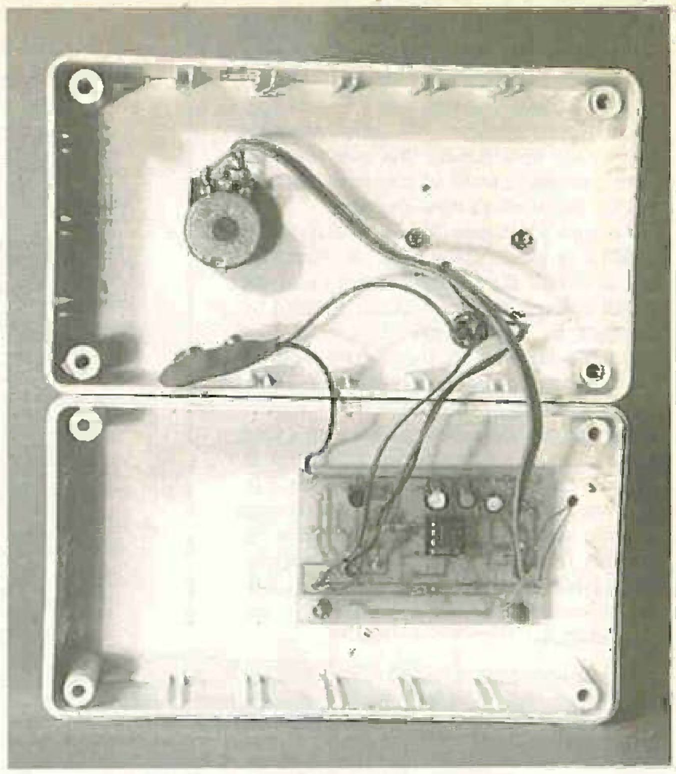
Miscellaneous

B1	6V battery pack (4xAA cells in holder)
S1	s.p.s.t. min toggle switch
WD1	6V min. d.c. buzzer

Printed circuit board available from the *EPE PCB Service*, code 932; medium size plastic case; PP3 battery connector; control knob; approx. 36s.w.g. (0·19mm) enamelled copper wire; multistrand connecting wire; solder pins; solder, etc.

Approx. Cost Guidance Only **£12** *excluding batts.*





(above) Front panel layout showing the mounting of the warning buzzer.

(right) Positioning of components inside the two halves of the case. Note the space for the battery pack.

requirements. The easiest way to mount this device is to fit it on the front surface of the front panel, see photographs. It is then only necessary to make two small mounting holes for the M2·5 or 8BA mounting bolts, plus a third to permit the two "flying" leads to pass into the case.

Alternatively, it can be mounted on the rear surface of the panel if a rectangular cutout for the body of the component is made in the panel. Note that modern buzzers invariably require the supply to have the correct polarity, and that the red and black leads must be connected in the manner shown in Fig.2.

THERMISTOR SITING

Obviously, the thermistor R3 must be mounted *inside* the freezer and not in the alarm unit. It must be connected to the alarm circuit by way of very fine wires that will enable the lid or door of the freezer to shut properly. A thin gauge of enamelled copper wire is probably the best choice and something like 34s.w.g. to 38s.w.g. (0·236 to 0·15mm dia.) wire is a good choice. The connecting wires can be a few metres long if necessary.

Stripping the insulation from the ends of the wires can be awkward because normal wire strippers do not work well (if at all) with thin wire of this type. It is a matter of carefully scraping away the insulation using a modelling knife or a small file. Then "tin" the ends of the wires with solder.

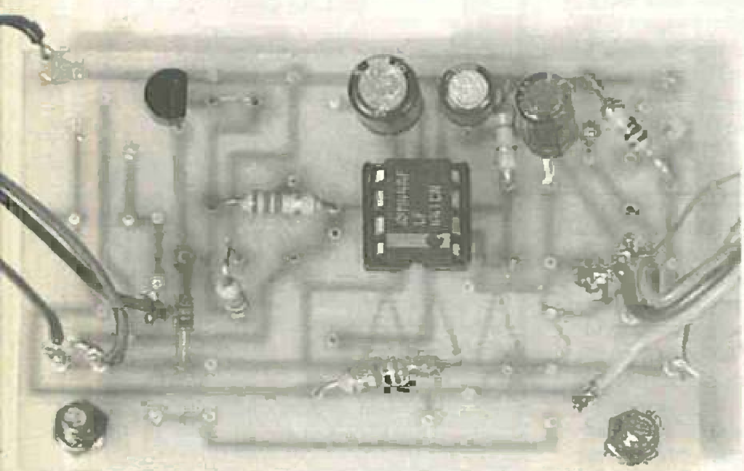
The wires can be connected to the circuit board via a plug and socket or a connector block, but direct connection to the circuit board is cheaper and easier. A small entrance hole about one or two millimetres in diameter must be drilled in the rear panel of the case.

IN USE

It is advisable to position the temperature sensor (R3) well into the freezer where it will not be subjected to large rises in temperature every time the freezer is opened. Leave the sensor in place for a few minutes before switching on the alarm so that the sensor has time to adjust to the temperature inside the freezer. After switch-on it takes several seconds for the voltages to settle down to their normal operating levels.

By adjusting Temperature control VR1 it should be possible to switch the buzzer on or off. Adjust it just far enough in a clockwise direction to activate the buzzer, and then back it off very slowly and carefully in a counter-clockwise direction to switch the buzzer off again. The alarm should now exhibit good sensitivity, and removing the sensor from the freezer should result in the alarm sounding almost immediately.

If the unit seems to be malfunctioning in any way, switch off immediately and recheck all the wiring. If the alarm is found to be too sensitive in use, with frequent false alarms, back off control VR1 fractionally in a counter-clockwise direction.



(left) The completed p.c.b. Note the small link wire at the top left corner, next to the transistor.

POWER CHECK

Each set of batteries is likely to last a year or more, but it is advisable to check the unit about once a month to ensure that they are still in good condition. To do this, simply adjust VR1 in a clockwise direction to activate the alarm.

If the buzzer operates at full volume the batteries are in good condition. Control VR1 is then set back to its normal operating position. If the volume is low, or starts at the normal level but noticeably falls away after a few seconds, it is time to replace the batteries.

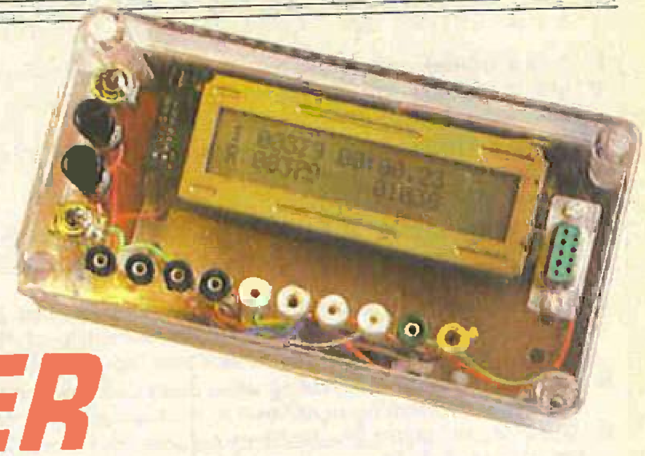
OTHER APPLICATIONS

It should be possible to modify the unit for operation in other applications that require a totally different threshold temperature. It is just a matter of altering the value of resistor R4.

The value of resistor R4 should be approximately equal to the resistance of the thermistor (R3) at the required threshold temperature (e.g. 47k at 25°C and 3k at 100°C). It is possible to obtain satisfactory results with threshold temperatures from about −20°C to +100°C.

However, note that the current through the sensor circuit increases significantly when high threshold temperatures are used, giving reduced battery life. Operation at temperatures in the region of −20°C is possible simply by adjusting control VR1 for the correct threshold temperature. □

8-CHANNEL ANALOGUE DATA LOGGER



JOHN BECKER

The new PIC16F877 microcontroller offers versatile analogue data logging opportunities.

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

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

During this article, reference is made to the following *EPE* subject material:

* *PIC Tutorial* (Mar-May '98)
* *PICtutor* (CD-ROM version of the *PIC Tutorial*)
* *PIC Toolkit Mk1* (Jul '98)
* *PIC Toolkit Mk2* (May-Jun '99)
* *Musical Sundial* (Jun '99)
* *PIC16F87x Review* (Apr '99)
* *Virtual Scope* (Jan-Feb '98)

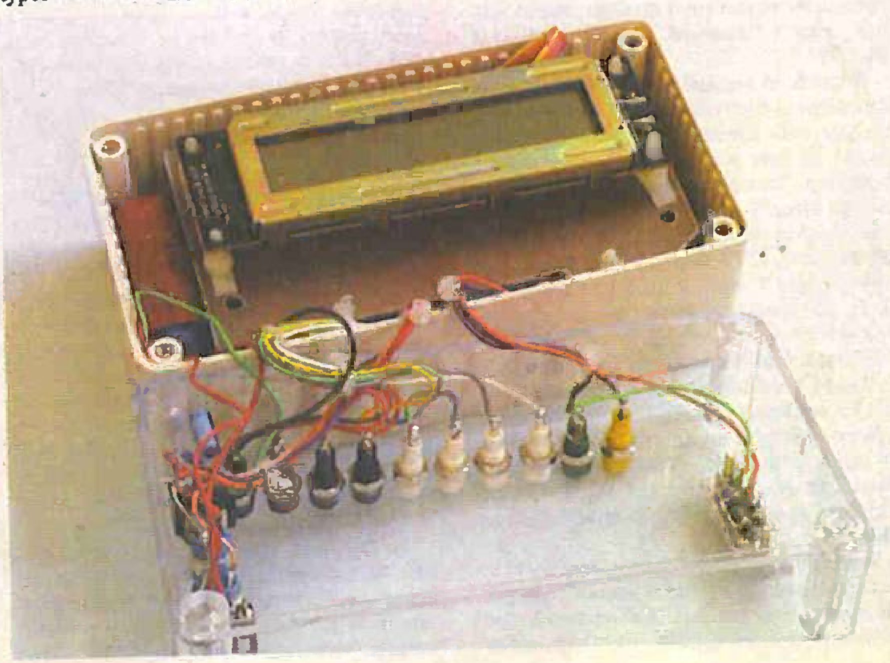
PIC PROGRESSION

Whilst we should not forget that Microchip manufacture many different types of PIC microcontroller, up to now it has principally been the PIC16x84 variants that have dominated the *EPE* readership scene. This is entirely due to the EEPROM-based technology of these PICs, allowing easy in-situ reprogramming and on-going development of program code.

However, as we have been foretelling for some months, we now have even greater programming and control opportunities available, through the new PIC16F87x family. To *EPE* readers, these are likely to find even greater acceptance.

First of all because they can, at the simplest level, be used in place of the PIC16x84s when greater programming memory (up to 8 kilobytes) is required. They can be programmed almost identically using the same set of command codes.

Secondly, they are much more powerful than the '84s, as was outlined in the *PIC16F87x Review*. They have, for example, up to eight channels of analogue to digital conversion available; they can be used for serial communications input/output at controllable baud rates; they can write to and read from addressable serial data memories; apart from enlarged program memories, they also have increased on-chip EEPROM data memory capacity; their special register set is much larger; they can operate at up to 20MHz.



TUTORIALLY SPEAKING

It is some of these attributes that are put to use now in this Data Logger. In a follow-up article (*PIC16F87x Mini Tutorial*), a closer look is taken at how the PIC16F87x family can be programmed to implement them.

This double article, therefore, represents not only a highly useful constructional project, but also a mini tutorial, with particular reference to the PIC16F877. The Tutorial is not full in-depth coverage but, if you already know about using other PICs, it will certainly get you started with using the new devices for yourself.

After reading both articles, you should have a pretty good idea about the following aspects of the PIC16F87x family:

- Using PORTA and PORTE for digital input/output or analogue data input
- Analogue-to-digital conversion (ADC)
- Storing and retrieving data bytes using the PIC's internal EEPROM memory
- Storing and retrieving data bytes using external serial memory chips
- Transmitting serial data bytes to the outside world at different baud rates (up to 9600 baud)

We additionally tell you about:

- Using *PIC Toolkit Mk2* to program PIC16F87x devices
- Using a PC to input serial data from PIC16F87x devices via the COM ports
- Inputting formatted serial data from all PIC analogue channels (up to eight) to Microsoft Excel for display and printout as text and graphs
- Formatting the serial data for display via the *Virtual Scope*
- Monitoring the *Musical Sundial*

Details of the functions the Data Logger can perform are shown in Table 1.

Table 1. DATA LOGGER SPECIFICATIONS

- Up to 8 channels of analogue data input, 10-bit conversion
- Up to 8 channels of serial data storage and retrieval using on-board serial memory (up to 2 megabits)
- Analogue sampling rates selectable from 0·5 seconds to 62 seconds (one-second increments from first second upwards)
- Sample rate adjustable up or down using two switches
- External clock option selectable in place of internal sampling clock (allowing sample taking to be triggered by external source)
- Maximum sampling count limit switch-selectable from 255 bytes to 16K bytes (subject to memory chips actually used – see later), stepped in powers of two. Continuous "no-limit" option
- Automatic cessation of sampling when count limit reached (no over-writing through count roll-over to zero unless required)
- Choice of non-volatile serial memory capacity (chip size), from 32K bits to 256K bits per channel (2 megabits maximum in total)
- 10-bit ADC sampling resolution
- Sampled data value stored as two bytes
- Automatic non-volatile storage of current sampling count value when current data logging session ended
- Automatic non-volatile storage of Rate and Memory factors
- Recommencing data logging from same count at which previous session ended (with 5-byte gap imposed)
- Option to reset logging count and other parameters at switch-on
- Simultaneous alphanumeric l.c.d. display of data value at time of sampling and as a recalled value following serial memory storage
- Switch-pressed selection of which channel's data is shown on the l.c.d. during sampling
- L.C.D. display of elapsed time for current sampling session
- L.C.D. display of current count value
- Automatic recall of current count value plus Rate and Memory limit factors at switch on
- User-selected automatic serial transfer of recorded data to PC at 9600 baud, each channel in turn (data also remains in on-board memory chips – count reset only occurs when requested by the user)
- Asynchronous 2-line (data plus ground line) transfer to PC via COM1 or COM2
- Data transfer to PC automatically limited to current count value
- Sampling can be interrupted at any time for data to be transferred, after which sampling can be resumed from the previous count value. This option available as many times as required
- Data transfer as two bytes, 8-bit protocol, 0 parity, 1 stop bit
- Channel number being transferred displayed on l.c.d.
- Data input to PC via dedicated *EPE* serial-link software (QBasic/QuickBASIC and high-speed machine code sub-routine, at 9600 Baud)
- *EPE* linking software simultaneously formats and stores data on hard disk (drive C) as:
  - Eight uncorrected binary files
  - Eight ASCII-converted numeric-value text files
  - Microsoft Excel tabbed composite (all 8 channels) numeric-text file (8 columns, row count according to sample quantity)
  - Four × dual-channel binary files for *EPE Virtual Scope*
- Choice of how many channels have data recording chips installed, from one to eight – may be upgraded to add more chips if fewer than eight first chosen)
- Data retained when switched off (even if battery removed)
- Digital buffers for data output and external clock input
- Prototype has run under DOS and Wins 3.1/95, on 20MHz '386 to 120MHz Pentium (Win '98 compatibility unknown)
- Analogue signal input range 0V to +5V

LOGGING CIRCUIT

Despite the obvious complexity of what this Data Logger can do, the circuit is remarkably simple, as are so many PIC-based designs. The complete circuit diagram is shown in Fig.1.

Of the five integrated circuits shown, only two are actually essential to the circuit's operation: the PIC microcontroller IC1, and the serial EEPROM memory chip IC4. Apart from the liquid crystal display, X2, all other active devices are just beneficial voltage conditioners, whose roles will be discussed as we progress.

What may not be immediately obvious is that, in fact, there are seven other serial EEPROM memories in parallel with IC4, namely IC5 to IC11. Each of the eight memories stores data for just one analogue channel and their circuit connections are identical to that shown for IC4. Note, though, that pull-up resistor R22 is common to all eight devices.

Analogue data is input to the eight channels via sockets SK1 to SK8 and is fed to five inputs of IC4's PORTA (RA0 to RA3, plus RA5), and to the three inputs of PORTE (RE0 to RE2). These eight port connections are configured in software for analogue data input.

Resistors R1 to R8 provide a degree of signal buffering to prevent data line conflict should the PORTA/E pins ever be active as outputs when coupled to a data source. Resistors R9 to R16 hold the data lines at ground level (0V) in the absence of data input sources.

Op.amp IC12, which in series with the data input line for channel 1, is an example of an active non-inverting buffer. Such a buffer allows signals from a high impedance source to be fed into the Data Logger without placing a significant load on that source.

Ideally, the op.amp should be one suited to d.c. signal input and allowing a rail-to-rail voltage swing at its output. There are many instrumentation op.amps available for this type of function, such as the LT1218 for example (RS/Electromail). However, if the signal level swing required is typically between about 1V and 4V d.c., practically any normal op.amp should suffice, even a "standard" op.amp such as a type 741.

It has been assumed, however, that most data sources likely to be used with the Data Logger will already have low-impedance signal outputs that do not require active buffering. This being the case, their inputs are fed directly into the PIC via the respective resistors R2 to R8. It is also permissible to omit IC12 (and resistor R17) and link channel 1 input from R1 to IC4 RA0. It is not permissible to input negative voltages.

Should your data sources for channels 2 to 8 not be low impedance types, repeats of IC12's configuration can be constructed on a piece of stripboard. Insert a 470Ω resistor in series with each non-inverting op.amp input (pin 3), and take the signal output from its pin 6 to the relevant socket, SK2 to SK8.

The PIC and its software take the +5V and 0V rails as being the reference voltages for A-to-D conversion. (As discussed in the forthcoming mini tutorial article, in other applications conversion can also be referenced to the voltage present on pins RA2 and RA3.)

L.C.D. MONITOR

The liquid crystal display (l.c.d.) is a so-called "intelligent" alphanumeric device having two display lines, each having 16 characters.

The software routine used to drive the l.c.d. is the author's "standardised" routine used with many *EPE* projects – it has become a "library" program that is merely imported to any software that requires an l.c.d. display. It will not be discussed here, other than to point out that the l.c.d. contrast is controllable by use of VR1.

SERIAL MEMORY CHAIN

The chain of serial data chips (IC4 to IC11) is jointly controlled by the PIC's PORTC. Pin RC3 provides the clock signal, and RC4 carries the data. The data line is bidirectional, not only in terms of sending data to the memories or reading it back, but also in terms of exchanging hand-shake signals at strategic points in the automatic software cycles. A fair amount of program code is involved in this and it is considerably more complex than would be the case if parallel-data memories were being used instead of serial access devices.

To the user, though, such complexities are "transparent", as they say. Whilst in some applications the use of serial rather than parallel storage would carry a timing penalty (serial is slower than parallel). This

The configuration for the address pins of all eight possible memories is shown in the inset at the top right of Fig.1. Note that the address pins only need to be connected to the circuit if they are required to be set for logic 1 (connected to the +5V rail). All address pins have an internal pull-down resistor to 0V and can be left unconnected if logic 0 is required on that pin. Hence IC4 not having any apparent connections to its A0-A2 pins.

The p.c.b. has the required address links incorporated as part of its tracking. You do not have to concern yourself with it. However, if you decide to omit some memories, you should omit from the highest downwards.

Instructions on whether the memory is to receive or play back data is also transmitted as part of the address code.

The memory's data pin is an open-collector terminal and requires the use of a pull-up resistor (R22 in Fig.1), typically of 10kΩ (although the data sheet discusses other value choices). Only a single resistor is required, whether the memory count is one or up to eight.

If all eight memories are not used, their locations are still addressed by the software. The data bits read back from non-existent memories will all be at logic 1 because of pull-up resistor R22. In this case, the value read for each of these bytes will be 255 (65535 for a double-byte word as used by the Data Logger).

The prototype Data Logger used six Microchip 24LC256 (256 kilobits each) memories, leaving locations IC10 and IC11 empty. The following Microchip 3-line serial memory choices are suitable:

Device	Bit capacity	Sample limit
24LC256	256 kilobits	16 kilobytes
24LC128	128 kilobits	8 kilobytes
24LC64	64 kilobits	4 kilobytes
24LC32	32 kilobits	2 kilobytes

SWITCHED SELECTION

Setting of the mode choices within the PIC's software (as listed in brief in Table 1 – Specifications) is made via switches S1 to S3. Their use will be discussed more fully later.

All three switches have pull-down resistors connected across them to prevent the PIC pins to which they are connected from going open circuit. Capacitor C10 is included across S1 to inhibit switch-bounce, a matter more fully taken care of in software.

PC LINK

Serial data is output to the PC-compatible computer using two wires – the data line plus a ground connection. Data is output from the PIC's RC6 pin (the one dedicated within this type of PIC for data output under RS232-type serial protocols). An active data buffer is included on the output line, and is comprised of two 74HC04 inverter gates, IC3b and IC3c.

Connection to the computer's COM port (either COM1 or COM2) is via SK11. This socket is a female 9-pin D-connector into which a PC's standard COM port connector cable can be plugged, either directly or via an adaptor (25-pin down to 9-pin). By "standard" is meant the same type of connector cable as is normally used between computers and modems.

COMPONENTS

See SHOP TALK page

Resistors

R1 to R8, R17	470Ω (9 off)
R9 to R16 (RM1)	100k × 8 s.i.l. commoned-resistor module
R19	100k
R18	1k
R20 to R22	10k (3 off)

Potentiometer

VR1	10k min. preset, round

Capacitors

C1	22μ radial elect. 16V
C2, C5 to C9	100n min. ceramic, 5mm spacing (6 off)
C3, C4	10p polystyrene or min. ceramic, 5mm (2 off)
C10	1μ radial elect. 16V

Semiconductors

D1	1N4148 signal diode
IC1	PIC16F877 programmed microcontroller
IC2	78L05 +5V voltage regulator, 100mA
IC3	74HC04 hex inverter
IC4 to IC11	24LC256 serial EEPROM memory (8 off) (see text)
IC12	op.amp (see text)

Miscellaneous

S1, S4	min. s.p.d.t. toggle switch (2 off)
S2, S3	min. push-to-make switch (2 off)
SK1 to SK10	sockets to suit (10 off) (see text)
SK11	9-pin D-type female connector, panel mounting
X1	3.2768MHz crystal
X2	2-line, 16 character (per line) alphanumeric l.c.d. module

Printed circuit board, available from the *EPE PCB Service*, code 237; 8-pin d.i.l. socket (9 off); 14-pin d.i.l. socket; 40-pin d.i.l. socket; plastic case with transparent lid (see text); l.c.d. mounting plate (see text); 9V PP3 battery and clip; p.c.b. supports to suit; connecting wire; solder etc.

Approx. Cost Guidance Only From £43 excl. case and sockets.

Note that although the Data Logger only requires to be connected to pins 2 and 5 of SK11, the COM port lead requires that other SK11 pins should be linked, as shown in Fig.1 and the constructional diagram, Fig.2.

EXTERNAL CLOCK

Sixty-two sampling rates can be selected from the Data Logger's internal clock (as discussed later). An external clocking rate can also be selected, whose voltage swing must conform to the "normal" +5V/0V range. Inverter IC3a buffers the clock input, and software inverts its output so that an externally positive-going signal is that responded to as the sampling trigger.

Note that the elapsed-time clock display is inactive during external sampling (allowing faster sampling in this mode).

MISCELLANY

The PIC is operated at 3.2768MHz, as set by crystal X1. The clock rate is subdivided in the software to control the data sampling rate and the elapsed-time display.

Power is intended to be supplied by a 9V battery, with IC2 regulating the voltage down to +5V as required by the digital circuitry. None of the circuit beyond IC2 should be subjected to a voltage greater than +5V (+6V is definitely not allowed). If a greater voltage were to be applied, not only could the Data Logger chips die, but also the computer's COM port to which it might be connected could seriously suffer. Switch S4 is the power on/off switch.

Also included is the option to program the PIC16F877 while in-situ on the p.c.b., using *PIC Toolkit Mk2* and its software. Resistor R18 and diode D1 allow the +12V programming and 0V reset voltages to be safely applied to the circuit.

The PIC's PORTD is not used by the Data Logger, but there is plenty of program memory space available should readers want to add code to make use of it (for digital data sampling, perhaps).

CONSTRUCTION

Details of the printed circuit board component layout and tracking are shown in Fig.2. This board (as always) is available from the *EPE PCB Service*, code 237.

Commence assembly by inserting the wire links and then progress as you prefer, no doubt in size order. It is recommended that even if you don't want to use eight channels/memories, you still insert the sockets for them all – you could well want to expand at a later date.

It is also suggested that you use pin headers for all the off-board connections, particularly those for the l.c.d. Pin numbers are marked on l.c.d. modules.

Regarding sockets SK1 to SK10, the author used ten 2mm single-sockets because they are compatible with practically every other connection that he is every likely to use in his workshop.

You are free to use whatever type of connector you choose, to suit your own equipment, preferences or whims. The choice might affect the size of case required, though.

ENCLOSURE

Apart from choosing the case size, you also need to decide if you want to use the Data Logger outdoors. If you do, it will need a case that is water resistant, even if not fully waterproof.

Apart from excursions into the garden to monitor the *Musical Sundial* (more in Part 2), it's in the workshop the author expects to find prime use for the Data Logger. Consequently, a low-cost plastic case with a detachable see-through lid was chosen (saving the task of cutting an l.c.d. viewing hole in an ordinary box).

The case seen in the photos measures 150mm × 80mm × 75mm (l, w, h) but was really just a bit too small. It is suggested that the next size up should be chosen.

The p.c.b. was secured to the base using "normal" p.c.b. supports. A rigid panel (unetched p.c.b. off-cut) was mounted above the p.c.b. using stacking p.c.b. pillars (the panel's holes were first drilled in line

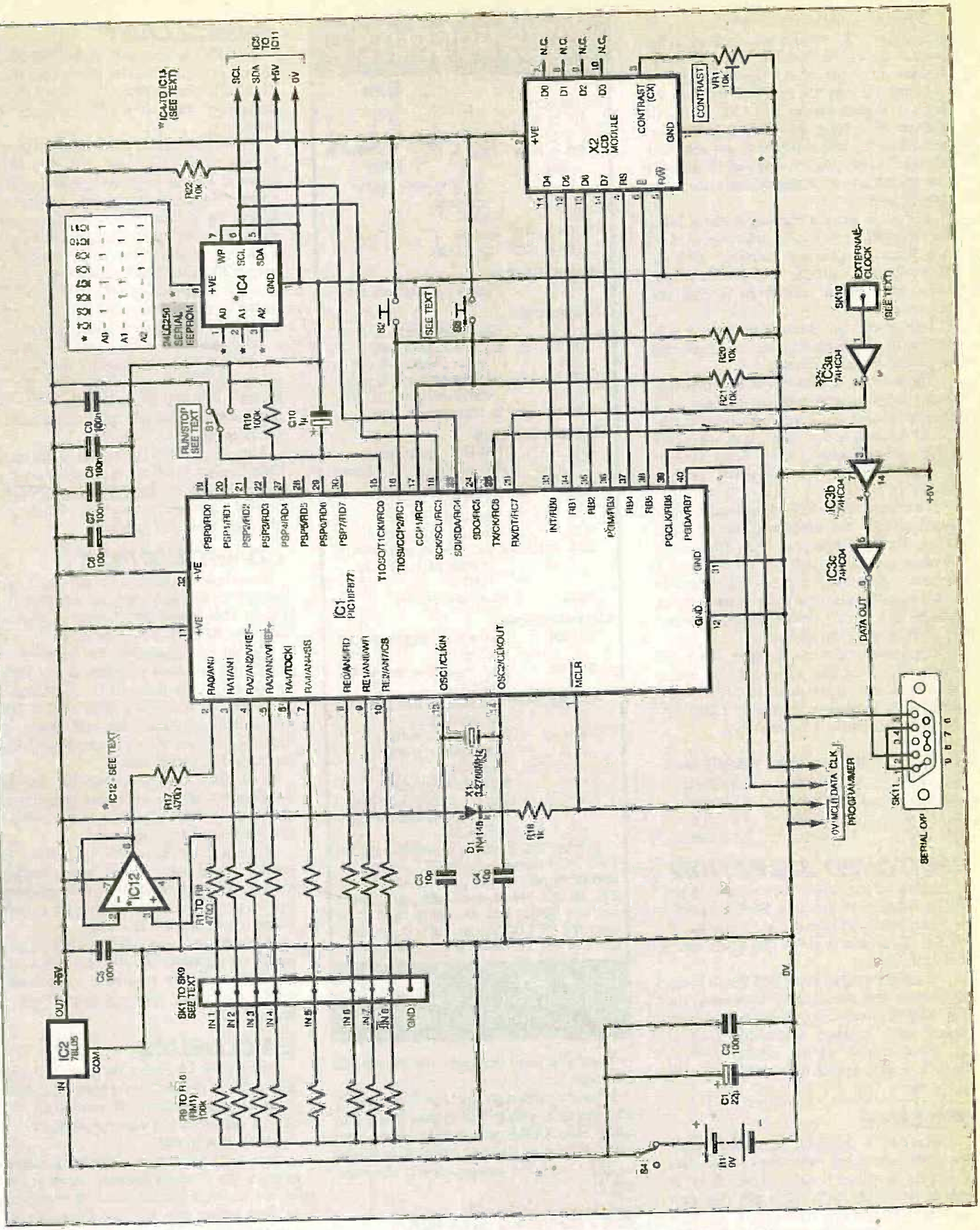


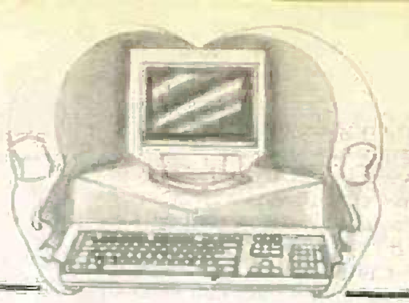
Fig.1. Complete circuit diagram for the 8-Channel Analogue Data Logger.

Data Logger does not require significantly high data exchange rates, consequently, serial devices provide a better data storage solution because of their greatly reduced size, and because fewer data and control lines are needed.

The serial EEPROM devices used here are manufactured by Microchip (who also manufacture the PIC) and require only two control lines (data and clock, plus ground), irrespective of how many there are in the chain (up to eight) or what capacity of data storage they provide.

The memory with which the data is exchanged is determined by an address code sent out prior to each data byte being sent or read back. Eight different address codes are available, allowing up to eight memories to be on the same control line pair. Each memory has three additional pins (A0 to A2) to which a 3-bit code is hard-wired as part of the p.c.b. design (or can be set by switches in other design situations). Only the memory whose hard-wired code matches the code transmitted by the PIC will respond, the others remaining inoperative at this time.

INTERFACE



Robert Penfold

VISUAL PROGRAMMING FOR PC ADD-ONS

THE SUBJECT of using visual programming languages with PC add-ons was considered in the previous *Interface* article, and we continue in the same vein this month. As pointed out in the previous *Interface* article, Delphi 2, 3, and 4 lack the Port function, and do not support direct port accesses. This is perhaps being a little economic with the truth though, because all versions of Delphi are equipped with a neat in-line assembler.

It is therefore possible to both read from and write to ports simply by dropping a few lines of assembly language into Object Pascal routines. This is not quite as convenient as using the Port function, but it is not that difficult either.

Incidentally, Borland's C++ Builder would also seem to be equipped with an assembler, and could presumably be used with user add-ons. However, C++ seems to be rather more involved than Delphi or VisualBASIC, and it is probably a language that is better suited to programming experts than dabblers.

Well Stacked

Using the assembler is very straightforward, and it is just a matter of heading your code with "asm" and finishing with "end". One slight problem is that you must ensure that your assembly language routines do not interfere with the normal operation of the computer. This means that any changes made to the contents of certain registers must be reversed before the routine is terminated.

The simple routine that follows is all that is needed to write to a port. This is equivalent to the speed control example provided in the previous *Interface* (May '99) article.

```
begin
OutVal := ScrollBar1.Position;
asm
push dx
mov dx, 888
mov al, OutVal
out dx, al
pop dx
end;
end;
```

OutVal is the byte-size variable used to store the reading from the scrollbar, and this must be declared in the appropriate part of the program. The assembly language routine uses indirect addressing via the dx register to access the port, and the push instruction stores the current contents of this register on the top of the Stack.

Next a move instruction is used to place the port address in dx. In this example the address is 888, but this can be any valid address. A second move instruction transfers the value stored in OutVal to the al register (the accumulator).

The **out** instruction then outputs the value in al to the address in dx. Finally, the **pop** instruction restores the contents of the dx register from the top of the Stack. Note that two end instructions are needed, one to terminate the assembly language routine and one to end the subroutine as a whole.

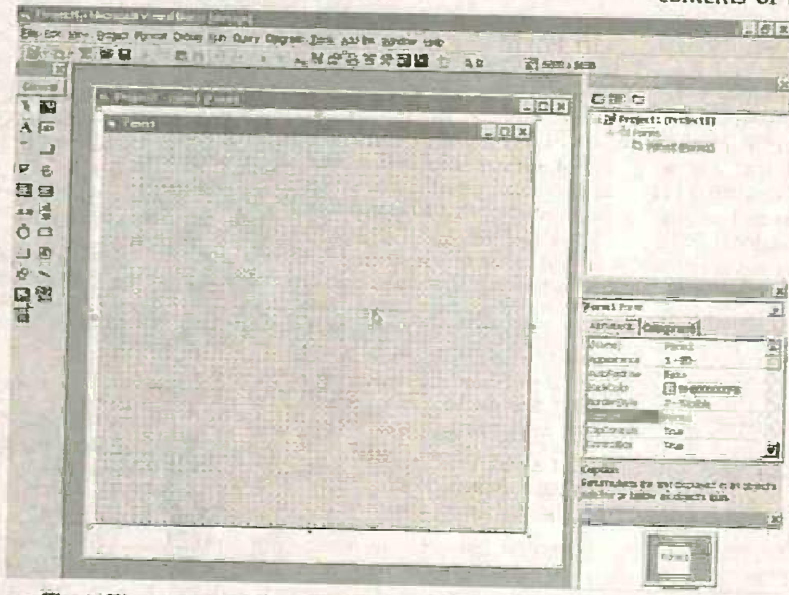


Fig. 1. The Visual BASIC 6 environment is similar to that of Delphi.

For 16-bit transfers the ax register should be used instead of the al register. There is a direct addressing mode where the port address is supplied in the out instruction, but this only supports eight-bit addresses. User add-ons are normally at addresses from 512 to 1023, making direct addressing unusable.

Port Reading

Reading from a port requires a slightly longer routine, but is still quite straightforward. The following short program reads from the printer port at base address 888 (&H378), which must obviously be a bidirectional type. It should be assigned to a timer component having an interval of about 25ms. Note that a label component must be included on the form to provide the program with somewhere to print the readings.

```
begin
asm
push dx
mov dx, 890
mov al, 32
out dx, al
mov dx, 888
in al, dx
mov InVal, al
pop dx
end;
Str (InVal, S);
Label1.Caption := S;
end;
```

As before, the contents of the **dx** register are pushed onto the Stack, after which a value of 32 is output to address 890. This sets the data lines of the port to the input mode. Next the address of the port to be read is loaded into the **dx** register, and the data from the port is read into the al register. The value in al is then moved into variable **InVal**, the original contents of the **dx** register are restored from the Stack, and the assembly language routine is terminated.

Finally, normal Object Pascal instructions are used to place the value in **InVal** into string variable **S**, and this variable is then assigned to the label where it is displayed on the screen. Of course, byte and string variables **InVal** and **S** must be declared in the appropriate section of the program.

These methods of reading and writing will work with Delphi 1, but the Port function would seem to be the better option with this version of the program. With the later versions of Delphi the built-in assembler almost certainly represents the easiest way of obtaining direct port access. It is possible to define input and output functions that can be called up when required, but in most cases it will be easier to simply drop in the assembly language routines as and when they are needed.

Note that Delphi 2, 3, and 4 produce 32-bit programs that are only suitable for use with Windows 95 and 98. Delphi 1 must be used if programs that will run under Windows 3.1 are required.

Note also that Windows NT does not permit direct port accesses, and that it requires the ports to be handled via the approved and indirect routes. These routines will not work under Windows NT, and could adversely affect the stability of the operating system.

BASIC Ins and Outs

Over the past two or three years a steady trickle of letters from readers having trouble using VisualBASIC to control their PC projects have been received. The usual complaint is that the Inp and Out instructions do not work with VisualBASIC. Although many GW and QBASIC instructions are included in VisualBASIC, **Inp** and **Out** have both been omitted.

This is not to say that direct port access is totally impossible with this flavour of BASIC, but it is only possible with some external help. This means using an add-in such as a component or DLL file.

There are numerous add-ins of this type available via the Internet, but these with the p.c.b. mounting holes below it). To this panel was mounted the l.c.d., again using "normal" p.c.b. supports (see photos).

FIRST CHECKS

Once you are content that a close-up examination of the assembled p.c.b. shows no signs of poor soldering or incorrectly placed components, a preliminary power-up test should be made. For this test, regulator IC2 should be the only i.c. inserted. Also leave the l.c.d. unconnected.

Connect a 9V battery or power supply and switch on. With a meter, check that +5V is present at the output of IC2, within about five per cent or so.

If all is well, and with the power off, the PIC can now be inserted. Unless you intend to program it yourself, it should, of course have been pre-programmed, details of which service are quoted on the *Shoptalk* page in this issue.

If you intend to program the PIC yourself then, unless you have a programmer capable of handling the PIC16F87x devices, you will also need *PIC Toolkit Mk2* (which was specifically designed for them and the PIC16x84 devices – *PIC Toolkit Mk1* is not suitable). The PIC16F877 configuration required is stated at the beginning of the source code text file.

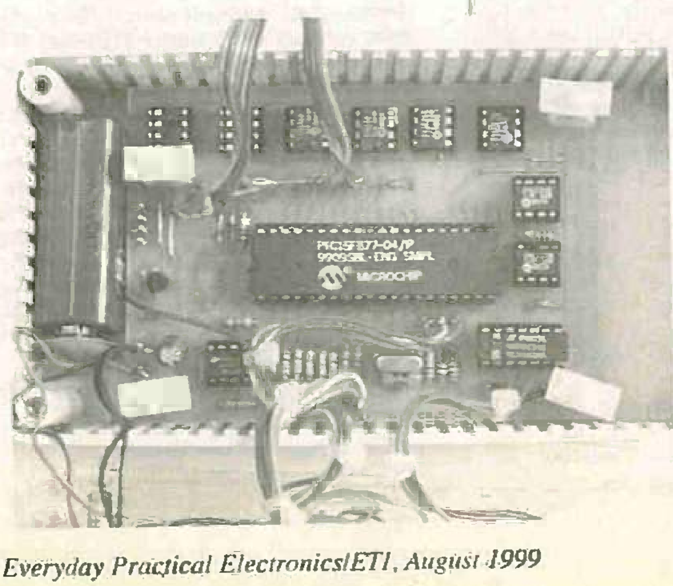
The software has been written in the TASM dialect and is available from the Editorial office on 3.5 inch disk, for which a nominal handling charge is made. Alternatively, it may be downloaded *free* from the *EPE* web site. Details of these two options are also on the *Shop Talk* page.

Follow the instructions supplied with the software when installing it on your computer – there are several files involved, not only for the PIC program but also for inputting the serial data to a PC.

It is intended for running under MS-DOS, not under Windows.

NEXT MONTH

In the concluding part next month we discuss programming the Data Logger, using it, and transferring data to a PC. We also give data sheet numbers and details for contacting Microchip.



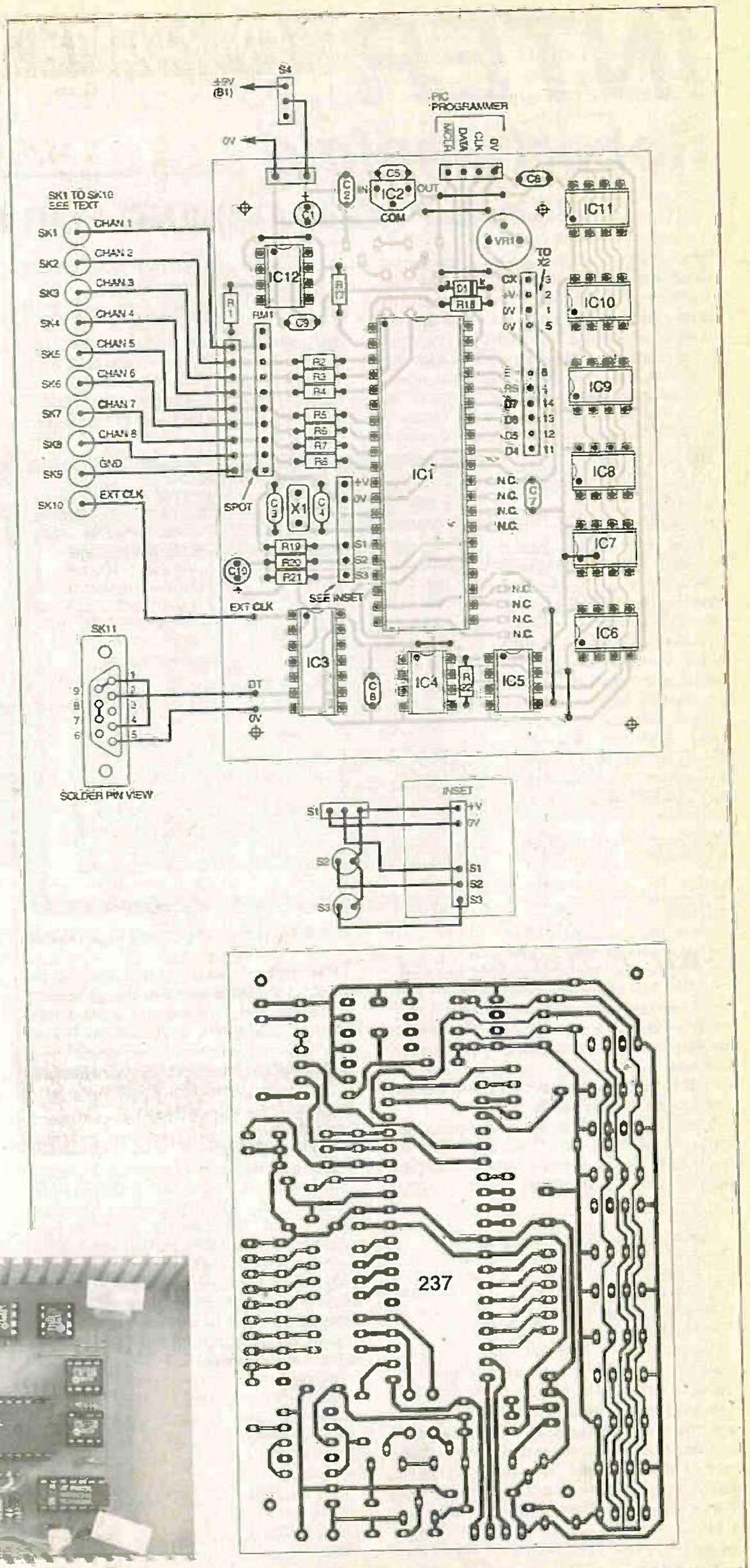


Fig.2. Component layout and full size copper foil master track pattern, plus off-board connection details.

mainly go beyond simple **Inp** and **Out** commands, and can be quite expensive. It is only recently that I have discovered simple and cheap methods of providing basic port accesses.

If you are interested in using VisualBASIC with your PC projects, or if you require information about parallel and serial port interfacing, it is well worthwhile paying a visit to the Lakeview Research web site at **http://www.lvr.com**. Apart from the information, etc. at this site, there are plenty of links to other sites where further software and information can be found.

Having tried various VisualBASIC add-ons, I would suggest you use Lakeview Research's own freeware DLL if you only require simple **Inp** and **Out** instructions. The correct download is "**inpout32**" for the 32-bit versions of VisualBASIC, or "**inpout16**" for the 16-bit Windows versions.

The author has only tried the 32-bit version with VisualBASIC 6, and found it to be very quick and effective. The DLL file is placed in the Windows/System directory of your PC, and the supplied **inpout32.BAS** file is loaded into VisualBASIC before you start programming.

This is done via the "Add File" option, which is under the "Project" menu when using version 6.0 of VisualBASIC. You can then use **Inp** and **Out**, which work in exactly the same way as their GW BASIC and QBASIC counterparts. When the finished program is compiled it will incorporate the DLL file.

One definite drawback of VisualBASIC is that, unlike Delphi, it is not a true compiler. Delphi will compile a program into a stand-alone .EXE file, but VisualBASIC produces a group of files that can be used to install and uninstall the program in Windows 95 or 98. A simple Delphi program consists of one file about 200K or so in size, but with VisualBASIC the total size of all the files seems to be nearly ten times greater than this. VisualBASIC programs are probably somewhat slower than Delphi equivalents as well.

On the plus side, VisualBASIC is somewhat easier to use than Delphi, especially if you have some experience at programming in some other version of BASIC. With the **Inp** and **Out** instructions added it is just about perfect for producing the software for PC projects.

VisualBASIC is something of an industry standard, with a much larger user base than any of its competitors. It is perhaps worth mentioning that some books on VisualBASIC programming come complete with a CD-ROM that contains the "working model" version of VisualBASIC 6. From time to time this is also given away on the cover-mount CDs of computer magazines.

The working model lacks the two CD-ROMs of help files that come with the full program, and the compiler function is disabled. It will save and load your programs though, and they can be compiled and run from within the working model. This is rather like GW and QBASIC, where you have to run programs from within the programming language itself. This is clearly a less convenient way of doing things, but the programs are fully functional when run in this way.

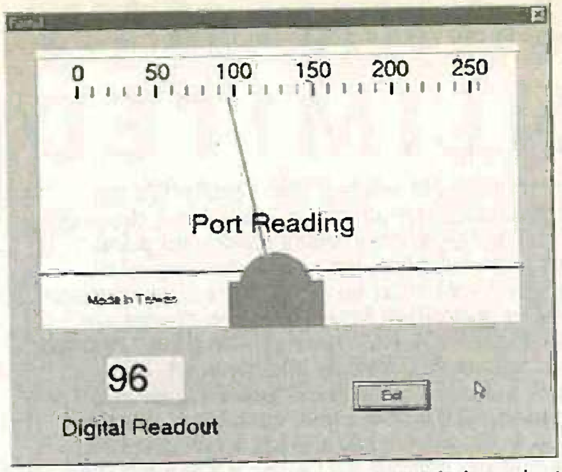


Fig.2. This virtual panel meter and digital readout requires just six lines of conventional BASIC code.

On Form

Using VisualBASIC is very similar to using Delphi, with a similar programming environment (see Fig.1). Like Delphi it is event driven and you have to adopt a more "bits and pieces" approach to programming than you would use for conventional BASIC programming.

In standard visual programming fashion you start by designing the form layout, adding any necessary buttons, labels, etc. Any necessary code for each component is then added. To read printer port one at &H378 and print the results on the screen you could use a timer component (set at about about 25ms) and a label. This code would be assigned to the timer:

```
Out &H37A, 32
InVal = Inp(&H378)
Label1.Caption = InVal
```

The first line sets the port to the input mode, and the next reads the data lines and places the result in the variable called InVal. With VisualBASIC you have the option of declaring variables or simply making them up as you go along. There is little point in declaring them in short programs, but it is otherwise advisable to do so. The third line prints results on-screen via the label component.

In general it is better to print text via a label rather than direct onto the form, as this avoids the need to blank previous readings. If you write text to a label this blanking is done for you. By altering the characteristics of the label via the properties window it is easy to set a large font, change the background colour, etc.

Good Graphics

VisualBASIC has good graphics capabilities, and it is easy to produce pseudo panel meters and the like. In fact minimal programming is needed for this type of thing because VisualBASIC is the most visual of visual programming languages.

Practically everything required can be placed onto the form using components rather than lines of code. The property window can be used to "fine tune" the positions of components. The meter and digital readout program shown in operation in Fig.2 was in fact produced entirely by adding components onto the screen.

Even the pointer is a line component. An advantage of this is that the pointer can be moved simply by altering one co-ordinate. There is no need to erase the previous version of the pointer because VisualBASIC does it for you.

In order to make this program work it only requires the following six lines of code to be assigned to the timer component:

```
Out &H37A, 32
X = Inp(&H378)
Label1.Caption = X
X = X * 20
X = X + 500
Line1.X1 = X
```

The first three lines are basically the same as the previous example. The next line scales the value in X to suit the VisualBASIC co-ordinate system. This does not operate in terms of pixels, and seems to be arbitrary. An offset is then applied to allow for the fact that the meter is offset from the left-hand edge of the screen, and this value is then used as the X1 co-ordinate for the pointer.

Light Work

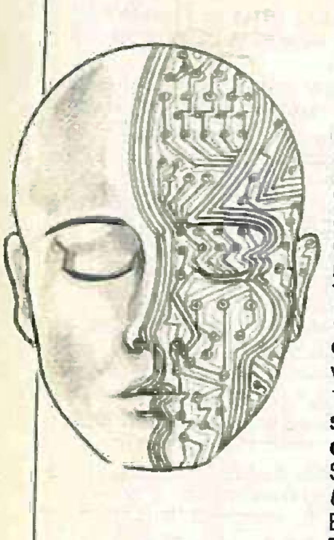
With VisualBASIC it is easy to produce on-screen indicator "lights", and the shape component is the obvious basis for something like this. Various shapes are available, but a circle with a solid fill style is the obvious one to use in this case.

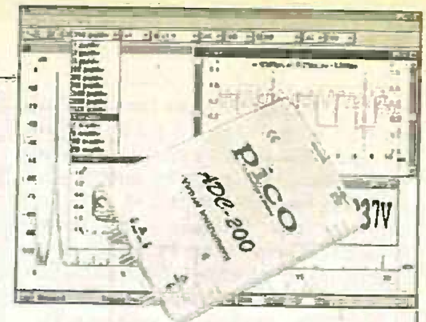
This example routine could be applied to a timer component, and it sets the "light" to red if the value read from the port is over 99, or to green if it is not:

```
Out &H37A, 32
X = Inp(&H378)
If X > 99 Then Shape1.FillColor =
   &HFF& Else Shape1.FillColor =
   &HFF00&
```

It is very easy to produce multi-colour bargraph displays, gauges, etc. Visual programming languages are well suited to control programs for PC add-ons, and some practical examples will be provided in future *Interface* articles.

INGENUITY UNLIMITED





Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit tips, not simply mechanical or electrical ideas. Ideas *must be the reader's own work* and **not have been submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should preferably be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and full circuit diagram showing all relevant component values. **Please draw all circuit schematics as clearly as possible.**
Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BS21 1PF.
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WIN A PICO PC BASED OSCILLOSCOPE

- 50MSPS Dual Channel Storage Oscilloscope
- 25MHz Spectrum Analyser
- Multimeter • Frequency Meter
- Signal Generator

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours.
Every six months, Pico Technology will be awarding an ADC200-50 digital storage oscilloscope for the best IU submission. In addition, two single channel ADC-40s will be presented to the runners-up.

Loop Aerial MW Radio – Back To The Future!

THE radio receiver circuit shown in Fig.1a delivers a powerful 3W to 5W into a 4 to 8 ohm loudspeaker. It has excellent tone, selectivity, high directivity, and good sensitivity.

Although the first stage is a "crystal set" with point contact diode (D1), the radio is self-contained, requiring no earth wire. The design uses a loop aerial, such as were common in the 1930's.

Coil L1 is wound on a wooden H-frame 60cm square, the "H" being turned on its side by 90 degrees (see Fig.1b). Four 11cm long cross-pieces are mounted on each corner of the "H" to carry coils L1 and L2. Wind 12 full turns of 30s.w.g. enamelled copper wire around the H-frame, spaced about 8mm apart. It helps to prepare the cross-pieces by cutting notches for the wire.

The ends of this wire are soldered to a 300pF to 500pF variable capacitor VC1, which serves as the tuner. Terminal "A" is soldered to the capacitor frame/spindle, and terminal "B" is soldered to its fixed fins.

Between turns 6 and 7 of L1, wind one "link turn", L2, of quality braided microphone wire. This improves the directional effect of the antenna. The screening braid, soldered to its core (terminal "C"), is soldered to 0V. At the other end, the core of the wire (terminal "D") is soldered to the centre tap of L3, which is approx. 40 turns of 30s.w.g. wire, with a tap in the middle at 20 turns. It is close-wound on a 5cm (2in.) diameter piece of p.v.c. piping.

The value of tuning capacitor VC1 is not critical – however, the larger it is, the wider the tuning range will be. Preset potentiometer VR1 controls feedback in preamplifier IC1a, and VR2 acts as a Volume control. The output of IC1b is fed via l.f. filter components C7/C8 to power amplifier IC2, which is wired in a standard configuration. It is recommended that longer connections should use shielded wire (the braid being soldered to ground – 0V).

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

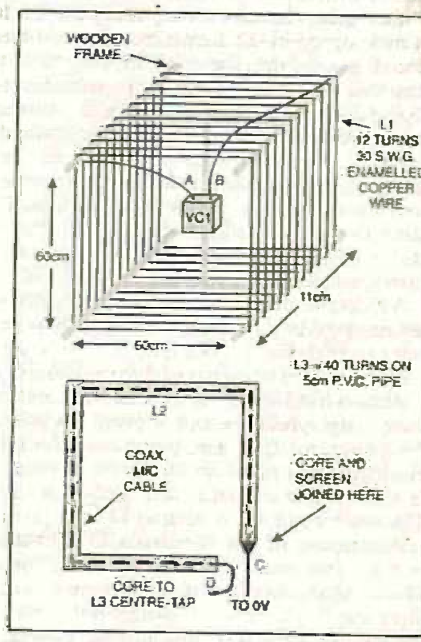


Fig.1b. Loop aerial constructional details. VC1 is soldered in parallel with L1 and mounted on the frame.

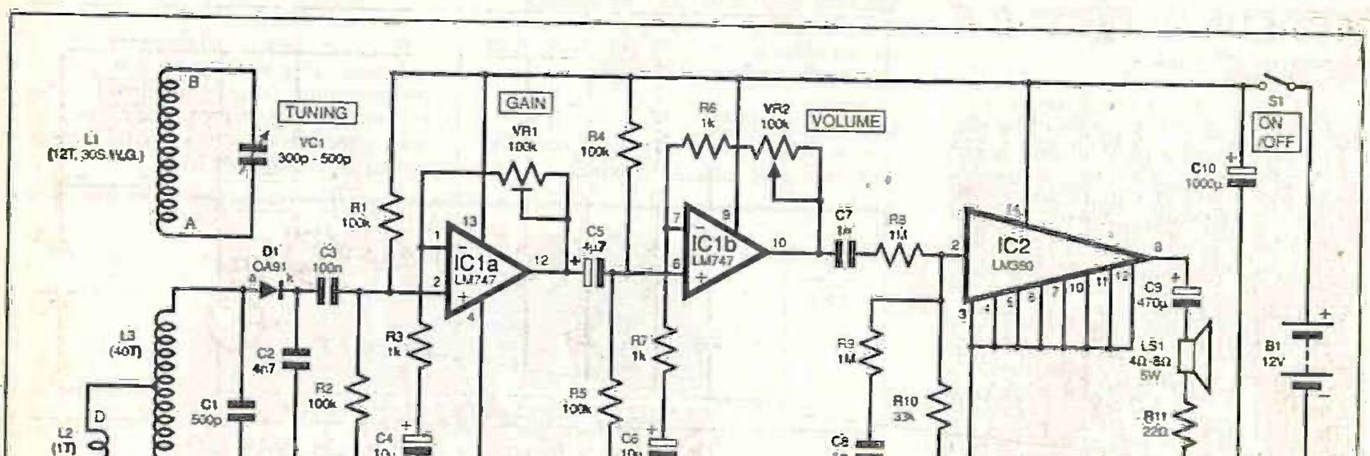
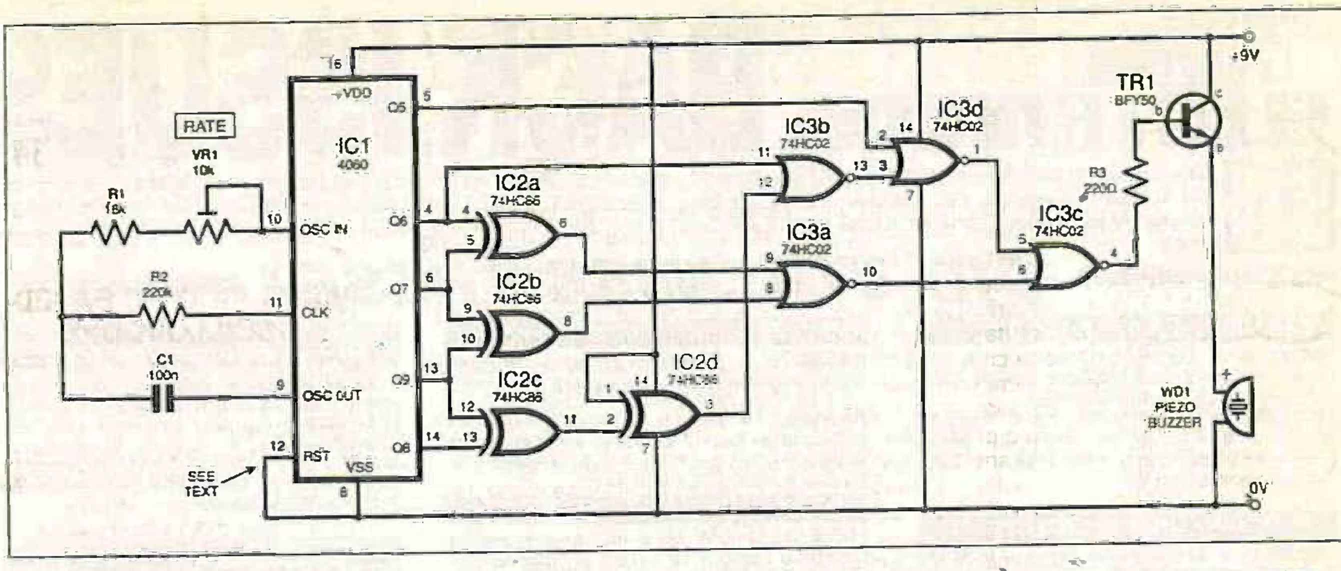


Fig.1a. Circuit diagram for the Loop Aerial MW Radio. L1-L3 are air-coupled, air-spaced inductors.



Mayday Module – Distress Call

A MAYDAY circuit for sending out an S.O.S in Morse code is shown in Fig.2a. The self-running binary counter IC1 generates a low-frequency divide-by-32 across the five selected outputs Q5 to Q8. Encoding logic then passes a series of pulses from Q5 through to the transistor TR1, suppressing or merging them to form the well-known "S.O.S" sequence in Morse. This is sounded on the piezo buzzer WD1. Fig.2b illustrates the counter states used to generate the code.

The encoder divides the 32-count field into four. The first and last quarters are distinguished by Q8 and Q9 being equal, a condition decoded at IC2d pin 3 of the exclusive-OR. This signal is the "letter-select flag" – when high, a sequence of Q5 pulses representing letter "S" is sent, and when low the letter "O" is formed by merging pulses from Q5 and Q6.

A NOR gate IC3a detects the condition (Q6=Q7=Q9) at pin 10. This occurs at the beginning and end of the first and last quarters, where it helps generate the required inter-word and inter-character spacing, and ensuring that "S" consists of three pulses and not four.

Although the timing for the characters and inter-character spacing is correct, the spacing between Mayday signals is only five units in this design instead of the standard seven. Adding the three-diode circuit of Fig.2c. extends the count by three if desired, taking advantage of the fact that states 0, 1 and 2 (=32, 33 and 34) do not produce an output. This emphasises the word-gap.

A start/stop module is shown in Fig.2d. After 16 cries for help, Q14 (pin 3) of the counter will re-set the flip-flop and disable the counter. This circuit *cannot* be used with the "word-gap extender" circuit Fig.2c.

Lastly, on the subject of Morse SOS signals, did anyone notice the "peeps" from *HMS Titanic*'s radio room in the latest movie? And this in 1912! At least the 1958 film was realistic with crashing radio sparks.

Trevor Skeggs, Milton Keynes.

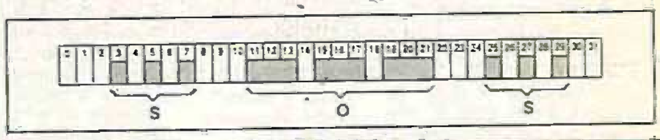
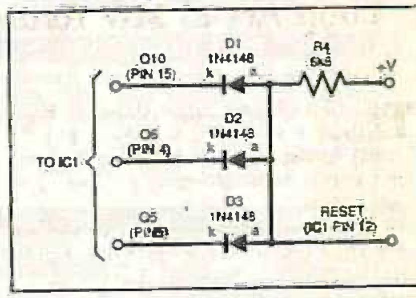


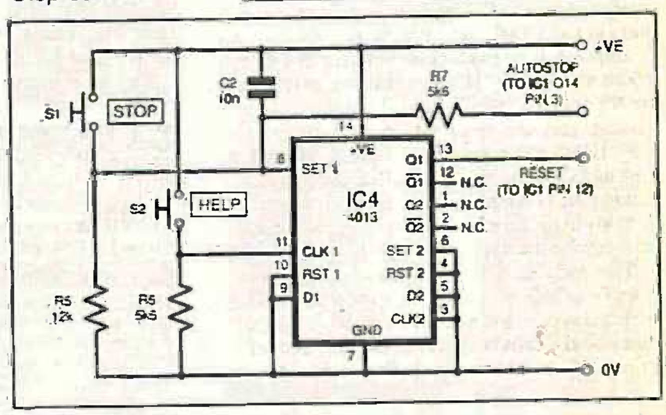
Fig.2a (top) Mayday circuit.

Fig.2b (above) Morse SOS sequence.

Fig.2c (right) Word-gap extender.

Fig.2d (below) Stop control.





NiCad Discharge Unit – In The Dark

IF NiCad cells are used in series, the problem of reverse charging of the weaker cell can arise if the unit is allowed to totally discharge. However, if the cells are not allowed to run down sufficiently, "memory" may set in, reducing the cell's useful working life. This is a particular problem in my pastime of caving, where a flat battery is a nuisance, and two flat batteries can be very dangerous.

Circuit diagram Fig.3 is designed to discharge a 5-cell "Fx5" battery unit which outputs 5×1·2=6V. It should work on four cells, but the relay will not hold for 3·6V (3 cells).

The push-to-make switch S1 allows the Darlington pair, made up of transistors TR1 and TR2, to latch the relay RLA. Current passes through the "load" resistors R4 and R5, which were set to pass about 1A. As each cell delivers 1·2V, the potentiometer was set to turn off the Darlington pair at 5·0V by using a variable supply.

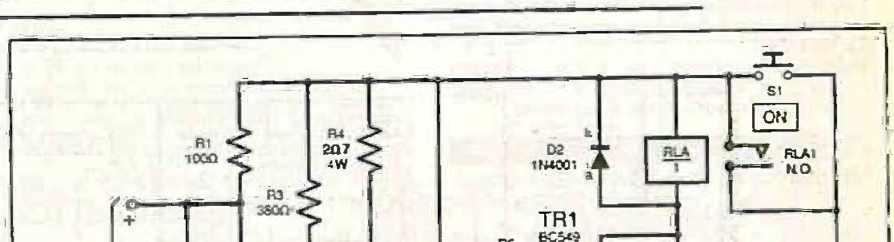


Fig.3. Circuit diagram for a NiCad Discharge Unit.

Current to a cheap quartz clock from the potential divider resistors R1 and R2 enables one to find out how long the unit has been running. Now I can completely discharge the "Fx5" unit without having to watch for the bulb dimming, and while saving the bulb, an expensive halogen type, from unnecessary use.

Mark Lavendar, Catforth, Preston.

EVERYDAY

PRACTICAL

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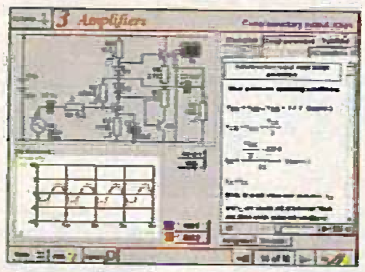

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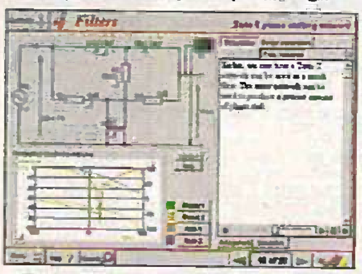

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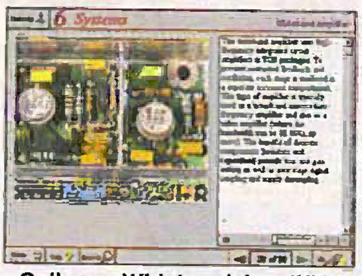

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by Mike Tooley

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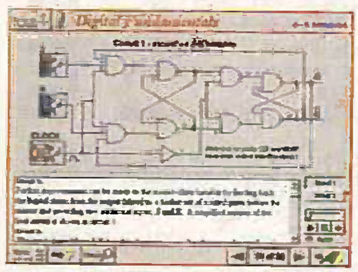
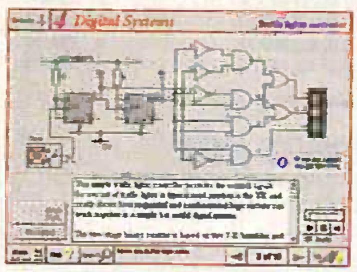


Virtual laboratory – Flip-Flops



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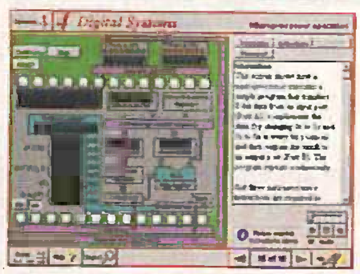

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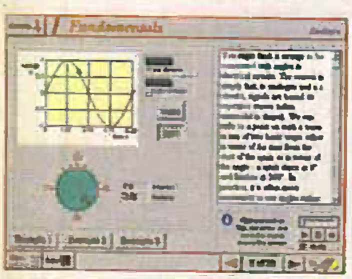

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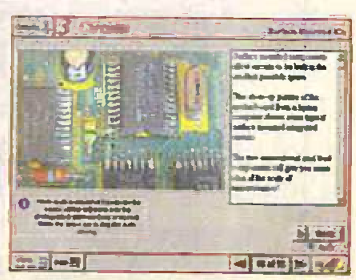

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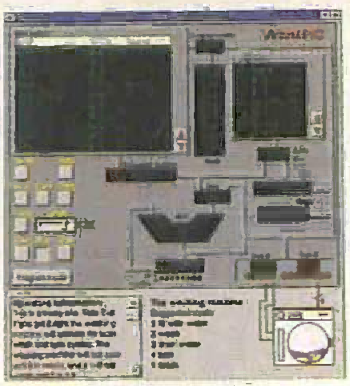

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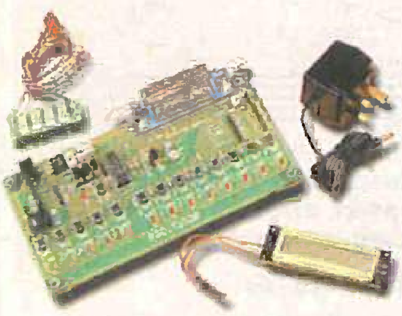

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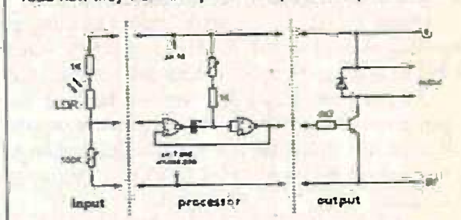

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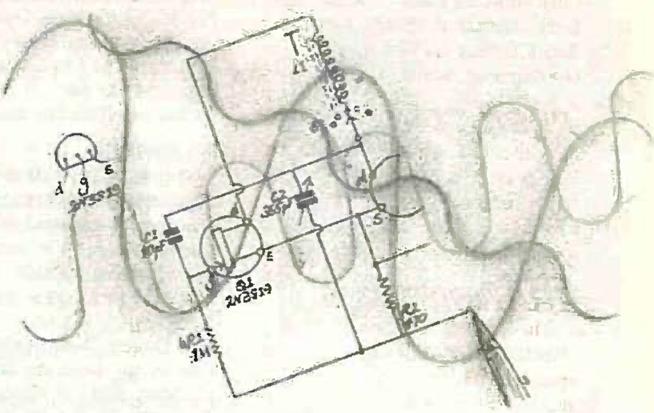

RAYMOND HAIGH

This new series is prepared with the electronics enthusiast and experimenter very much in mind and is intensely practical. Tried and tested circuits are fleshed out with component values, and their vices and virtues are exposed.

PART 2: COLPITTS OSCILLATOR AND ITS VARIANTS

LAST month's article dealt with the history and general principles of oscillators, and covered the Hartley circuit in some detail. This month, frequency stability is considered, and the Colpitts oscillator and its variants are explored.

FREQUENCY STABILITY

Above 5MHz or so, drift becomes an increasing problem with LC oscillators, and above 10MHz frequency stability is almost impossible to achieve without recourse to complex circuitry.

The main causes of drift are mechanical instability, variations in supply voltage, excessive loading on the oscillator tuned circuit, and changes in temperature. Temperature changes can be externally imposed, or they can arise from the consumption of power by the oscillator.

Sound construction, a regulated power supply and the use of a buffer amplifier, will do much to overcome the first three causes. The problem of temperature fluctuations, which modify the characteristics of all of the oscillator's components, is more difficult to overcome.

REDUCING DRIFT

Whether mounted on printed circuit board (p.c.b.), stripboard, or tagstrips, oscillator components and wiring must be rigidly fixed in position. Completed assemblies can be protected against vibration, and made more rigid, by a liberal application of beeswax or by attaching components to the board and to one another by a viscous non-water-based adhesive.

Avoid double-sided printed circuit boards for oscillators. The two layers of foil can form capacitors which vary with temperature and shift the frequency of oscillation. If unscreened coils are mounted on the board, etch away the area of foil beneath them to avoid any possible capacitance effects.

Oscillators should be isolated in a separate metal "screening" enclosure. Again, if unscreened coils are used, make the case sufficiently large for the sides and ends of the coils to be spaced from it by at least one coil diameter in order to limit the reduction in the Q factor caused by the metal screening. Locate the box away from draughts and sources of heat.

INDUCTORS

In the quest for low drift, air-cored coils are the first choice followed, in order of preference, by coils with dust iron cores, then ferrite cores, ferrite cups, dust iron toroids and, least preferred, ferrite toroids. However, the ability to adjust inductance often overrides the desire to minimise drift, and slug and cup tuned coils are widely used. Similarly, the high Q factors and minimal external fields of toroidal coils are advantages which frequently dictate their use.

Coil formers must be rigid and have good dielectric properties. The range of commercially produced items available to the home constructor is now very limited, but plastic pipes used in the plumbing and electrical industries can be pressed into service. P.V.C. electrical conduit is of particular interest, as its thick walls impart rigidity.

Single layer coils should be tightly wound. When adjoining turns are touching, the entire winding can be held in place by the application of a thin coat of clear cellulose without unduly affecting the performance of the coil.

Spaced windings of heavy gauge wire can be secured by applying cyanoacrylate adhesive (Superglue) along the turns of the coil. Piled coils should be held within bobbins and wound with only a light tension on the wire. Unless they are to be exposed to wide humidity changes, it is best not to impregnate them.

Beeswax can be used to lock cores in position, but the effects of dimensional and permeability changes caused by shifts in temperature have to be minimised by the compensating action of the capacitors in the tuned circuit.

CAPACITORS

Variable tuning capacitors should be air-spaced and of good quality. Silver plated brass vanes are to be preferred to aluminium (they are usually only available in values up to 150pF), and double bearing rotors are more stable than the single bearing type.

In the early days of radio, silvered mica components were the first choice when a fixed capacitor had to be connected into a tuned circuit. Their temperature coefficient is, however, rather unpredictable, and modern practice tends towards the use of polystyrene dielectric capacitors, which have a slight negative temperature coefficient. (This can compensate for the positive coefficient of dust iron toroids).

Ceramic capacitors, which are manufactured in a range of positive and negative coefficients, including zero change types, are available in close increments of value from 1pF to 220pF. Avoid, in tuned circuits, ceramic capacitors intended for coupling and

> **Frequency Stability**
>
> Drift becomes an increasing problem in all LC oscillators as the frequency of operation rises through the h.f. spectrum. Its main causes are:
>
> (1) Mechanical instability.
> (2) Power supply voltage variations.
> (3) Excessive and variable oscillator loading.
> (4) Temperature variations, externally imposed or internally generated.
>
> However well constructed, simple LC oscillators cannot, by themselves, be made sufficiently drift free for use in transmitters radiating much above 10MHz. They will, however, give a more than adequate performance in receivers operating up to 30MHz.

decoupling. The lower Q and uncertain temperature coefficient of these components is likely to impair performance.

When all the rules of good construction have been followed, the only simple means of reducing residual drift is to substitute different fixed capacitors until the temperature coefficient has been optimised. The Colpitts oscillator, where several capacitors are wired, directly or indirectly, across the tuned circuit, is ideal for this treatment.

RESISTORS

Although quarter-watt resistors are usually adequate for most low-powered oscillator circuits, the greater bulk of higher rated types reduces the heating effect and the resistance changes which this causes. Increasing the power rating of gate and base bias resistors to one or two watts can prove beneficial.

TRANSISTORS

The internal capacitances and port impedances of transistors are affected by changes in temperature, supply voltage and signal voltage. These effects can be minimised by keeping the supply voltage, and the amplitude of oscillation, as low as possible consistent with reliable operation.

It is usually easier to obtain good results with field-effect transistors (f.e.t.s). Their high gate impedance, and the simpler biasing arrangements which result, are largely responsible for this. However, f.e.t. gate impedance falls as the frequency of operation rises through the h.f. and v.h.f. spectrum, and the advantage is a diminishing one.

With care, bipolar transistors can give very acceptable results. Circuits based on the use of semiconductors of this type have, therefore, been included.

Whether using a f.e.t. or a bipolar transistor, always choose a type with the highest transconductance (Y_{fs}) or gain (h_{fe}) for a given f_T. Whilst transistors will often oscillate up to their rated upper frequency limit or f_T (the frequency at which gain falls to unity), it is good practice to select a device with an f_T at least three times, and preferably four or five times, as high as the maximum operating frequency. These measures will ensure reliable starting and oscillation, and permit supply voltages to be kept low to minimise drift.

OSCILLATOR LOADING

Some energy has to be taken from the oscillator, and the resultant loading affects the Q factor and operating frequency of its tuned circuit. The loading must, therefore, be constant and as light as possible in order to maximise frequency stability.

A buffer amplifier, placed between the oscillator and the load, is essential if high performance is to be achieved. Even when the oscillator incorporates isolating circuitry (e.g., the Dow variant, see Part 1) it is still desirable for additional buffering measures to be provided.

BUFFER AMPLIFIER

A buffer amplifier should have a high input impedance to minimise damping on the oscillator circuit. Its output impedance should be low to enable it to maintain a reasonably constant signal level over a range of load impedances. The signal voltage produced by a few of the oscillators is modest and some gain is, therefore, desirable.

Readers may wish to use one of the oscillator circuits to form a signal generator, and provision for modulating the r.f. output will also be useful. A buffer amplifier capable of meeting these requirements, and of modification to suit the needs of individual constructors, is detailed in Fig.1.

A two-stage circuit, where transistor TR1 is a dual-gate MOSFET configured as a source follower, is shown in Fig.1a. Arranged in this way, it presents a very high impedance to the oscillator, and an appropriately low impedance feed for the bipolar, common emitter amplifier TR2. Although the dual-gate MOSFET does not yield any voltage gain in this mode, it does provide a significant power gain.

INPUT CIRCUIT

Oscillator input to the MOSFET TR1 is via d.c. blocking capacitor C1. This component should have the lowest possible value consistent with sufficient output being obtained from the buffer amplifier. It is best selected by experiment, and for this reason no provision is made for it on the buffer amplifier p.c.b. Its value will range from 1pF to 100pF. Gate resistor R2 ensures correct biasing.

The gain of TR1 is controlled by preset potentiometer VR1 which sets the voltage on gate 2. The r.f. signal can be modulated, on its way through TR1, by varying the gate 2 voltage at audio frequencies. A suitable modulation oscillator is described later.

Switch S1 connects bypass capacitor C2 into circuit when modulation is not being applied. This switch should be ganged with the

Buffer Amplifiers

A buffer amplifier is essential if drift is to be reduced to a minimum, and a circuit diagram which can be widely adapted to suit individual needs is given in Fig.1. All versions feature a high input and low output impedance.

The full circuit has a voltage gain of approximately 26dB, an output of 2V r.m.s., and a reasonably flat response from 100kHz to 100MHz. Provision is made for gain adjustment and the application of audio modulation.

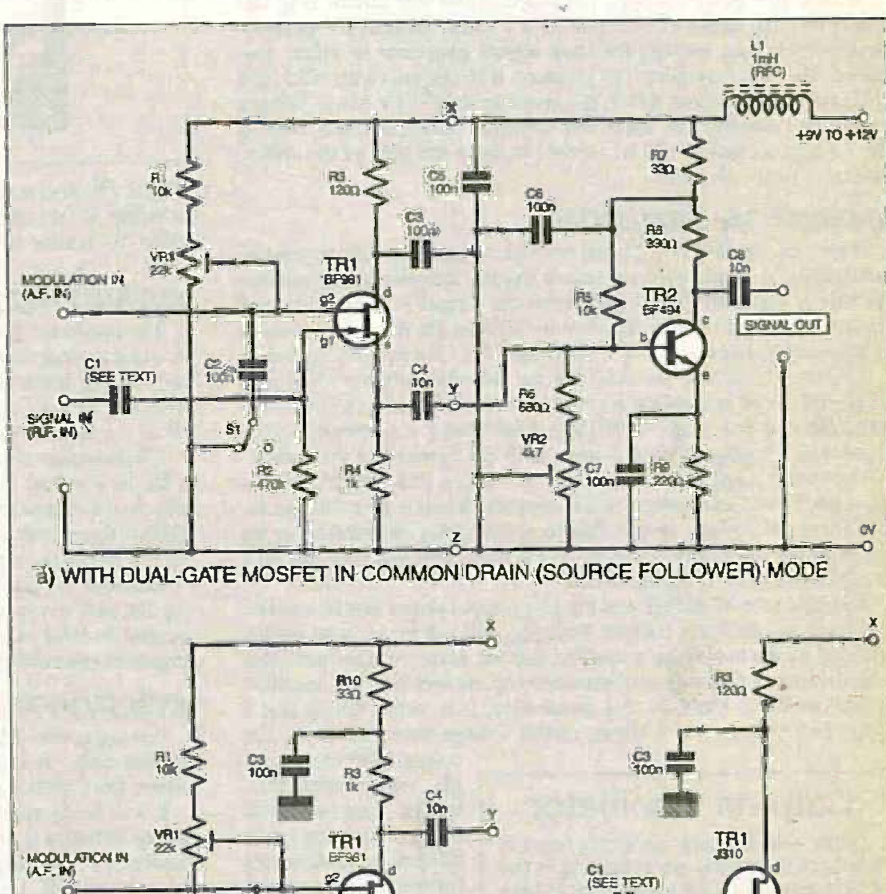

Fig.1. Circuit diagram for a buffer amplifier with alternative front ends.

switch which connects the power supply to the modulation oscillator. Resistor R3 and capacitor C3 decouple the input stage from the supply line, and the signal output, developed across source (s) resistor R4, is coupled to the base of transistor TR2 by d.c. blocking capacitor C4.

OUTPUT CIRCUIT

Bipolar transistor TR2 is arranged as a common emitter stage. Bias is applied to the base (b) by a resistor chain formed by R5, R6 and preset potentiometer VR2. The inclusion of VR2 enables the voltage to be optimised for a wide range of transistor types. Emitter (e) bias is provided by R9, and C7 functions as a bypass capacitor.

The buffer circuit output is developed across TR2 collector (c) load resistor R8. The value of this component has been chosen to ensure a reasonably constant gain over a 100kHz to 100MHz frequency range, and an acceptably low output impedance. Its value can be reduced in order to lower output impedance, but this will be at the expense of signal voltage. Capacitor C8 acts as a d.c. blocker.

Resistor R7 and capacitor C6 decouple the stage, and the r.f. choke, L1, and capacitor C5, isolate the entire buffer amplifier from the power supply. The inclusion of a radio frequency (r.f.) choke is very much a good-practice measure in circuitry of this kind and, in almost every case, a low value resistor (10 to 100 ohms) could be substituted without any deterioration in performance.

With a 12V power supply, the output from this circuit (Fig.1a), just before the onset of overload, is 2V r.m.s. (almost 6V peak-to-peak): more than enough for most signal generator or mixer purposes. The input required to produce this output (with VR1 and VR2 set for maximum gain), is approximately 0·1V r.m.s. Voltage gain of the amplifier is, therefore, some 20 times, or 26dB. Setting the voltage on gate 2 of TR1 to zero reduces the gain of the unit to around 6 times, or 15dB.

COMMON SOURCE

If desired, MOSFET TR1 can be made to provide voltage gain by configuring it in the common source mode. The circuit arrangement for this is depicted in Fig.1b, where the output is now developed across drain load resistor R3. Source resistor R4 has a lower value in this circuit, and resistor R10 and capacitor C3 decouple the stage.

This configuration should only be adopted when a dual-gate MOSFET stage is used on its own, or when the gain (h_{fe}) of transistor TR2 is *low* (e.g., a BF199). Combining a common source input with a high gain output stage is likely to result in instability.

The buffer amplifier also works well with a j.f.e.t. arranged as a source follower input stage, and a suitable circuit is given in Fig.1c. It will not, of course, be possible to apply audio modulation to the buffer in the same way if this circuit is used, nor will it be possible to adjust the gain of the amplifier.

The dual gate MOSFET and the j.f.e.t. input stages can be used on their own as oscillator buffers. Isolation will not be as great as that afforded by the two-stage amplifier, and the output voltage available with the source follower configuration will be less than that supplied by the oscillator itself. In this connection, it is worth noting that a J310 j.f.e.t. will deliver a higher output voltage than a 2N3819. The output from these simple, single stage f.e.t. buffers can be varied by substituting a 1 kilohm potentiometer for the drain or source load resistor.

Colpitts Oscillator

With the Colpitts oscillator circuit, feedback is applied via a tapping in the tuning capacitor. Like the Hartley (where the inductor is tapped – see Part 1), it can be configured in either parallel or series fed modes, and simplified circuit diagrams depicting the two arrangements are given in Fig.3.

The shunting of the ports of the maintaining device with fairly large amounts of capacitance contributes to the circuit's reputation for frequency stability, and it is widely used by radio amateurs as a narrow band oscillator. Output does, however, tend to vary with the setting of the tuning capacitor to a greater extent than with other *LC* circuits.

The basic Colpitts oscillator has, perhaps more than any other, been modified and developed by a succession of designers who have all attempted to reduce even further its already low level of drift.

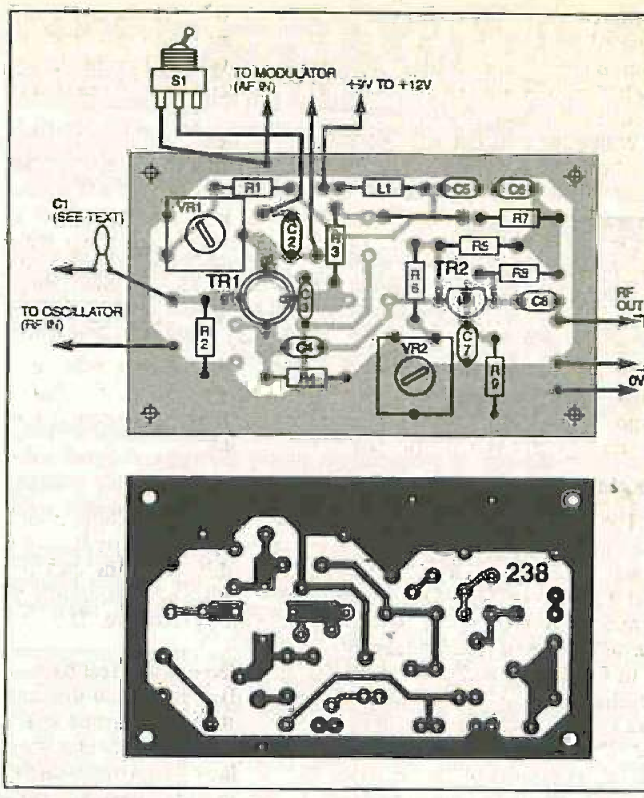

Fig.2. Printed circuit board component layout and full-size foil master for a dual-gate MOSFET buffer amplifier. The p.c.b. also caters for different front ends. (See EPE PCB Service.*)*

CONSTRUCTION – BUFFER AMP

The two-stage buffer amplifier is best assembled on a small p.c.b. A suitable component layout, based on Fig.1a, together with a full size copper track master is given in Fig.2. This board is available from the *EPE PCB Service*, code 238. Provision has been made for all of the alternative front-end arrangements described earlier.

Construction should be fairly straightforward and should start with the smallest components working up to the largest. It is probably best to leave the transistors until last. Check the finished board against the circuit diagram. Note that capacitor C1 is off-board and do not forget the single link wire.

Connect the buffer to its own regulated output from the power supply, and house it in a separate metal enclosure, which should be located as close as possible to the oscillator in order to minimise the length of connecting leads.

COLPITTS OSCILLATOR

Having covered the measures which have to be taken in order to combat drift, we can now consider the next oscillator circuit in the series, the Colpitts and its variants.

It will be recalled that feedback was applied to a tapping on the tuning inductor in the case of the Hartley circuit. With the Colpitts, feedback is applied via a tapping in the tuned circuit capacitance. Because of this, untapped, single winding coils can be used, and band switching is even simpler than with the Hartley.

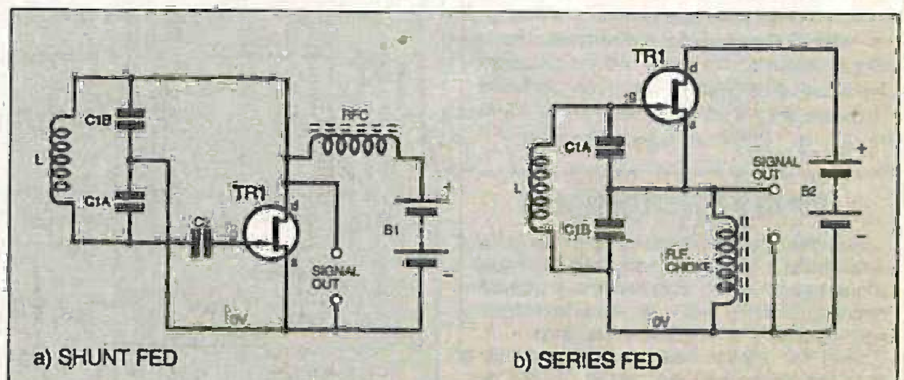

Fig.3. Simplified circuits for parallel (shunt) and series fed Colpitts oscillators.

Moreover, the transistor ports connected to the tuned circuit are shunted by fairly large amounts of capacitance, and this tends to swamp temperature related capacitance changes within the device itself. The Colpitts and its variants can, therefore, be made less prone to drift than other circuits.

With most (but not all) Colpitts arrangements, the need to have fixed capacitors across the tuned circuit in order to maintain oscillation restricts the frequency coverage produced by a variable capacitor. Whilst this can be an advantage in circuits designed to cover a narrow band of frequencies, it is a drawback when wide coverage is required. Moreover, the signal output from the Colpitts oscillator is more dependant upon the tuning capacitor setting than some circuits, and this also militates against wide coverage.

Despite these drawbacks, the opportunity to minimise drift has made the Colpitts and its variants popular when narrow frequency bands (e.g., the amateur bands) have to be covered. It is adopted almost universally when a simple variable frequency oscillator is required in receivers operating at v.h.f. and u.h.f.

BASICS

The commonly encountered versions of the basic Colpitts circuit are shown in Fig.3. In Fig.3a, the tuned circuit formed by inductor *L* and capacitors *C1A* and *C1B* is connected between the gate (g) and drain (d) of TR1. The source (which is grounded) is, in effect, connected to the tapping in the tuned circuit capacitance. This is a *parallel* or *shunt* fed arrangement.

In Fig.3b one end of the coil *L* is grounded and the feedback is developed across an r.f. choke. The drain (d) is connected into circuit via the power supply, and this circuit is, therefore, termed *series* fed. The impedance of the tapping point can be varied by changing the relative values of the two capacitors. Reducing *C1A* and increasing *C1B* will lower the impedance presented to the feedback connection and the damping on the tuned circuit.

The capacitors are often of equal value, especially with the version depicted in Fig.3a. However, when the oscillator is used for more demanding applications, better performance can usually be achieved by making the relative value of *C1B* as large as possible consistent with reliable operation.

SPOT-ON COLPITTS

A Colpitts circuit suitable for generating a 1kHz spot frequency is given in Fig.4. Bipolar transistor TR1 is used as the maintaining device in this shunt fed arrangement, and the tuned circuit formed by L1, C1 and C2 determines the frequency of oscillation.

Bias is applied to the base (b) of TR1 by resistor R1, and the signal is developed across R2, the collector (c) load resistor. C3, C4 and C6 are d.c. blocking capacitors, and potentiometer VR1 permits the adjustment of the output voltage. Bypass capacitor C5 makes the unit immune to changes in supply impedance (ageing batteries), and its value is related to the low operating frequency of the circuit.

The unit is suitable for applying modulation to an r.f. signal generator, and it works well with the buffer circuit described previously. When used in this way, VR1 sets the modulation depth.

Output voltage falls as the load impedance is reduced, but frequency remains pretty constant. (The signal level is 0·25V r.m.s. when the load is reduced to 1k). Because of this there is some interaction between the output control potentiometer and the buffer amplifier (Fig.1) gain control preset VR1.

The circuit oscillates vigorously, and can be used to generate spot frequencies with a tolerably good waveform from below 100Hz up to 10MHz. Above 10MHz, operation becomes erratic.

WIDE RANGE COLPITTS

A Colpitts oscillator with fixed feedback capacitors is not particularly suitable when wide and continuous frequency coverage is required. A version of the shunt fed circuit, in which feedback is applied to a tapping in the variable tuning capacitor, is, however, sometimes used as a wide coverage oscillator, and this arrangement is depicted in Fig.5.

Because of the grounded feedback connection, a twin-gang variable capacitor, VC1a and VC1b, can provide the feedback tapping and also tune the switched inductors. The moving vanes, connected by the spindle, form the tap, which is conveniently connected to ground. The fixed vanes are connected to either end of the inductor.

The effective swing of a 360pF unit is, of course, reduced to 180pF, but continuous coverage from 150kHz to 15MHz can be obtained with five switched inductors (six Toko coils will probably be required if coverage between 300kHz and 500kHz is included).

A high input impedance f.e.t., TR1, has to be used in order to ensure reliable starting and oscillation over the full swing of the tuning capacitor V1 on all ranges. C2 is a d.c. blocking capacitor, resistor R1 ensures correct biasing, and diode D1 limits oscillation

Parallel or Shunt Fed Colpitts Oscillators

Two examples of the shunt fed Colpitts oscillator arrangement are given. The first, depicted in Fig.4, generates a 1kHz audio tone and can be used for modulating an RF signal generator or for providing a test signal.

A good output voltage is developed with a waveform of reasonable purity. The circuit has the virtue of great simplicity, and an untapped, single winding inductor is all that is required.

It could, with advantage, be substituted for the Hartley oscillator in the metal detector circuit given in Part 1. With appropriate tuned circuit components, it will oscillate from below 100Hz to above 10MHz. However, above 10MHz its operation becomes erratic.

How the basic Colpitts oscillator can be configured to give continuous coverage from 150kHz to 15MHz is shown in Fig.5. Although this arrangement generates a near perfect waveform, the Hartley (last month), Butler and Franklin (next month) circuits are to be preferred when a simple, wide coverage oscillator is required. Output from these circuits is more constant over the tuning capacitor swing, and they will operate up to 30MHz and beyond.

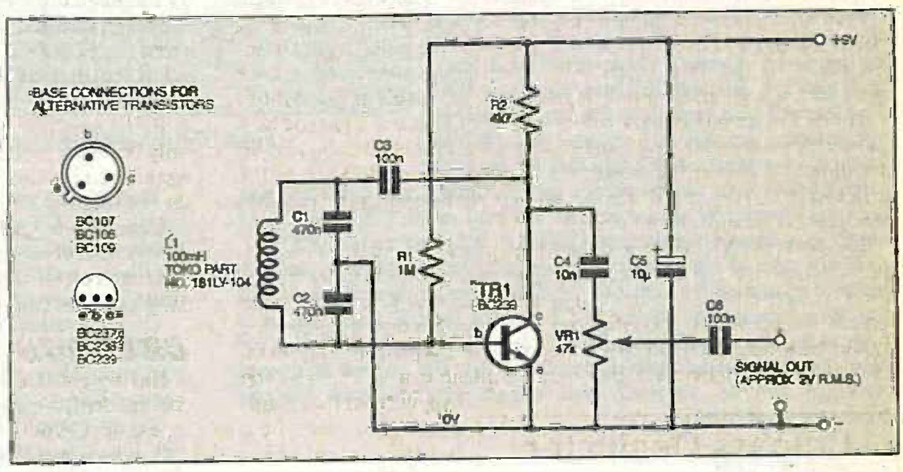

Fig.4. Circuit diagram for a Colpitts 1kHz a.f. oscillator for modulating an r.f. signal generator.

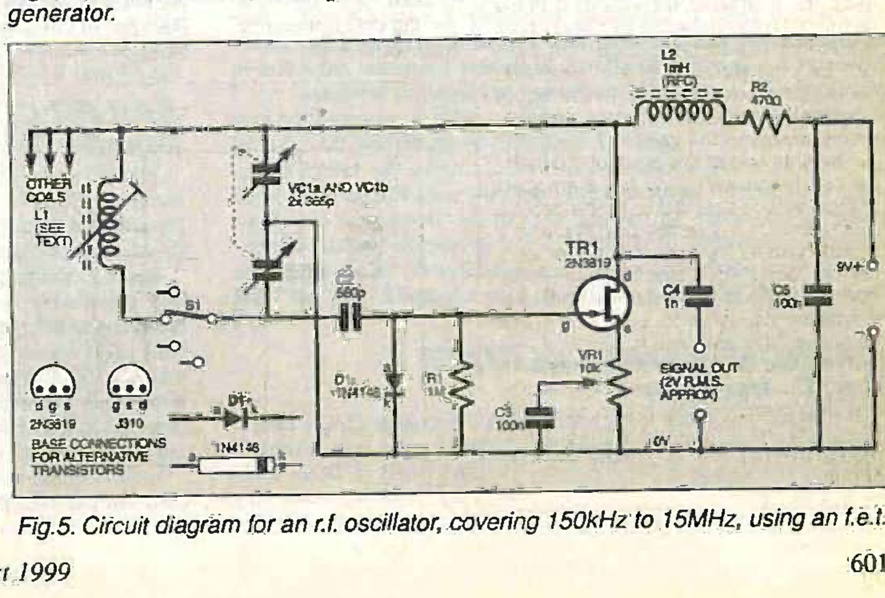

Fig.5. Circuit diagram for an r.f. oscillator, covering 150kHz to 15MHz, using an f.e.t.

amplitude in order to prevent forward conduction of the f.e.t.'s gate. An output is developed across L2, a radio frequency choke, and resistor R2 functions as a Q spoiler preventing erratic operation being triggered by its natural resonances. C4 is a d.c. blocking capacitor.

Potentiometer VR1 acts as the source bias resistor, and its slider (moving contact) is connected to the r.f. bypass capacitor C3. Moving the slider towards earth (0V) leaves an increasing portion of the resistor unbypassed. The resulting negative feedback reduces the gain of TR1 and improves the output waveform.

By this means the circuit can be adjusted to produce a near perfect sinewave, but this is at the expense of output voltage. Signal output also varies with the setting of the tuning capacitor (it reduces by approximately 60 per cent as the vanes are rotated from half mesh to fully open). The quoted output voltage is with the tuning capacitor set at half mesh and VR1 adjusted to give the best waveform.

Above 15MHz, the circuit will not oscillate over the full swing of the tuning capacitor, and operation becomes increasingly erratic as frequency is raised. More refined versions of the circuit could, no doubt, be persuaded to give coverage up to, and beyond, 30MHz.

Wide coverage can be obtained with much less bother with the Hartley, Butler and Franklin oscillators, and new twin-gang capacitors are expensive. The circuit has, however, been included for the sake of completeness.

NARROW BAND COLPITTS – Bipolar Transistor Version

In the bipolar transistor version of the narrow band Colpitts oscillator, shown in Fig.6, the tuning capacitance is made up of a pair of series connected feedback capacitors, C3 and C4; and two capacitors, C1 and C2, which limit the effect of variable tuning capacitor VC1. By restricting coverage in this way, the full 180 degree swing of the variable capacitor is required in order to traverse the band, and this ensures the lowest possible tuning rate (a very desirable feature when attempting to resolve weak, amateur single-sideband transmissions).

Capacitor C5 acts as the d.c. blocking capacitor (because of the comparatively high value of this component, the circuit cannot be regarded as the Seiler variant, which is covered later), and resistors R1 and R2 bias transistor TR1. Resistor R3 and capacitor C6 are decoupling components, and C6 also ensures that TR1 collector (c) is connected directly into the feedback circuit rather than via the power supply. Output and feedback voltages are developed across emitter (e) load resistor R4 and the r.f. signal is extracted via the low-value d.c. blocking capacitor C7.

Every port of the transistor is shunted by a capacitor, and this helps to minimise the effect of small changes in capacitance within the device itself. The values of C3 and C4 should, therefore, be as high as possible consistent with reliable starting and oscillation, but they may have to be tailored to ensure that the desired frequency coverage can be obtained with a particular coil and variable capacitor combination.

START-UP

Tuned circuit components for this standard Colpitts arrangement, are listed in Table 1. The values quoted for C3 and C4 will ensure reliable starting and operation with a wide range of transistor types. However, the use of a BF494 r.f. transistor limits the reduction in output which occurs as the frequency of operation increases.

Individual constructors may find it possible to improve the output waveform and/or further reduce drift by increasing the value of one or both of these capacitors. If this is done, the values of the other tuned circuit capacitors (and possibly the inductor) may need changing in order to restore the stated frequency coverage. Increasing the values of C3 and C4 will reduce the output voltage.

On ranges where swing reducing capacitor C1 is not fitted, the fixed vanes of VC1 must, of course, be connected to the "hot" end of inductor L1.

NARROW BAND COLPITTS – F.E.T. Version

A Colpitts oscillator with a field-effect transistor (f.e.t.) as the maintaining device is shown in Fig.7. The tuning and feedback capacitor arrangements are the same as those listed in Table 1 for the bipolar version.

Table 1: Narrow band Colpitts oscillators
Tuned circuit components for bipolar and f.e.t. versions.
(See Fig.6 and Fig.7 for circuit diagrams.)

Band MHz	*Toko coil L1*	*Base wiring*	*C1 pF*	*C2 pF*	*C3 pF*	*C4 pF*
1·8	154FN8A6438EK	A	–	–	180	470
3·5	154FN8A6439EK	B	–	–	180	470
7	KXNK3767EK	B	22	–	180	470
10	KXNK3767EK	A	27	–	180	470
14	KXNK3767EK	A	22	–	82	270
18	8·5 turn type S18	–	10	18	82	270
21	8·5 turn type S18	–	15	–	56	180
24-28	5·5 turn type S18	–	–	–	39	82

Notes: (1) The type S18 coils have ferrite cores. (2) See Fig.17 for base wiring details. (3) When a swing reducing capacitor, C1, is not provided, the fixed vanes of tuning capacitor VC1 must be connected directly to the "hot" end of the inductor.

The gate (g) of the f.e.t. is grounded (0V) through coil L1 and the usual gate bias resistor is not required. Diode D1 should, however, be wired into circuit to limit oscillation amplitude and prevent forward conduction of the gate.

A radio frequency choke, L2, has to be used as a source (s) load in order to ensure reliable oscillation with the f.e.t. version of the circuit. Resistor R2 spoils the Q of the choke and avoids any tendency for its resonances to affect the operation of the circuit.

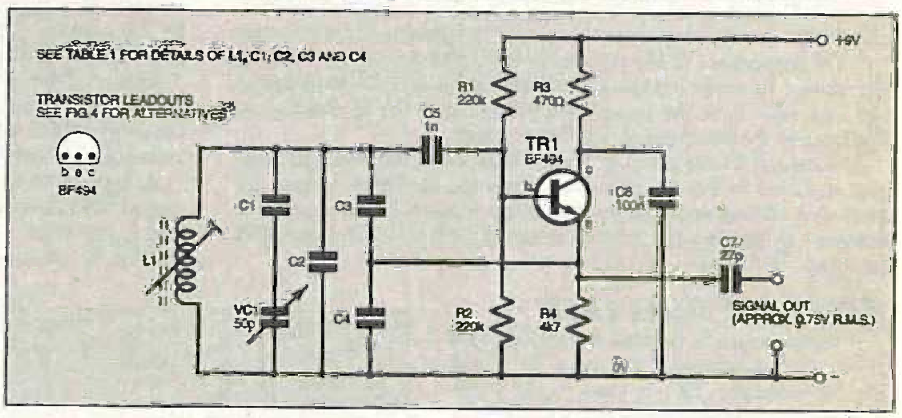

Fig.6. Circuit diagram for a narrow band Colpitts oscillator

Resistor R1 and capacitor C5 decouple the circuit from the power supply, and C5 also ensures that the drain (d) of the transistor is effectively connected into the feedback circuit. (This is a series fed oscillator, and feedback would otherwise depend entirely upon the drain being connected through the power supply.)

Output is taken from the source of TR1 via d.c. blocking capacitor C6. In order to minimise loading on the oscillator, this component should have the lowest possible value consistent with sufficient voltage being supplied to the accepting circuit.

Signal output from this oscillator is significantly higher on the two lower frequency ranges (approximately 2·5V r.m.s.). Making the value of C6 small will, therefore, also have the desirable effect of evening out the signal level, as it will impede the lower frequencies more. (Output is greater because the values of feedback capacitors, C3 and C4, have been reduced in order to ensure coverage of the 1·8 and 3·5MHz bands with a 50pF variable capacitor.)

SEILER COLPITTS VARIANT – Bipolar Transistor Version

A radio amateur, E. O. Seiler, published a variant of the Colpitts oscillator in 1941. Developed during the valve era, he originally described it as a "Low-C Electron-Coupled Oscillator". Two updated semiconductor versions are given in Fig.8 and Fig.9.

Seiler's modification provided for the "grid" of the valve (now the base (b) of a bipolar transistor or the gate (g) of a f.e.t.) to be tapped down the tuned circuit by adding another capacitor, C3, to the feedback chain connected across the coil L1. In the original valve version, this is a 100pF preset component which can be reduced until oscillation is only just maintained. By this means, the isolation of the valve, from the tuned circuit, is made as great as possible, thereby enhancing the frequency stability of the basic Colpitts circuit.

It can be likened to the Lampkin variant of the Hartley oscillator (see last month), where the base or gate of the maintaining

Table 2: Narrow band Seiler oscillator
Tuned circuit components for bipolar transistor version.
(See Fig.8 for circuit diagram.)

Band MHz	Toko coil L1	Base wiring	C1 pF	C2 pF	C4 pF	C5 pF
1·8	154FN8A6438EK	B	–	–	120	270
3·5	154AN7A6440EK	D	–	–	82	270
7	154FN8A6439EK	A	27	–	120	270
10	KXNK3767EK	B	15	–	120	270
14	KXNK3767EK	A	47	–	120	270
18	8·5 turn type S18	–	47	–	120	270
21	5·5 turn type S18	–	–	–	82	180
24-28	5·5 turn type S18	–	–	–	56	56

Notes: (1) S18 coils for the 18MHz and 21MHz bands have ferrite cores. The coil for the 24MHz and 28MHz bands has an aluminium core. (2) A parallel, fixed tuning capacitor, C2, is not required on any range with the bipolar version. (3) See Fig.17 for base wiring details.

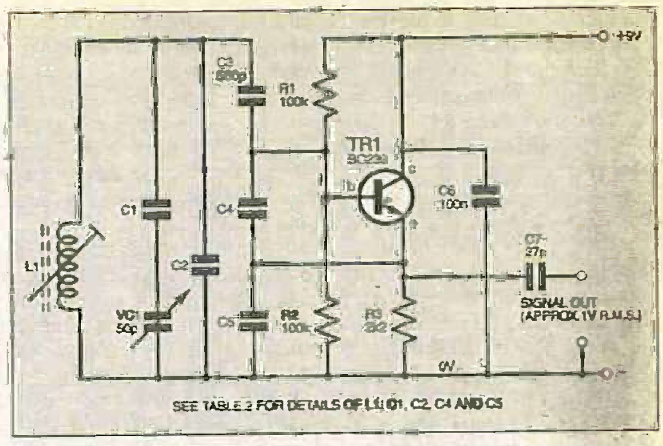

Fig.8. Circuit diagram for a narrow band Seiler variant of Colpitts oscillator.

device is tapped down the tuning inductor to achieve the same result.

Because of their low base impedance, bipolar transistors do not lend themselves as readily as f.e.t.s to this circuit, and reducing the value of C3 below 500pF excessively attenuates the signal available at the base and inhibits oscillation. In the interests of consistent performance with a range of transistor types, the value of the additional capacitor has, therefore, been fixed at 560pF for the bipolar version of the circuit.

This is only a modest improvement over the 1nF capacitor specified for the basic Colpitts oscillator. However, any reduction in tuned circuit damping is worthwhile, and constructors interested in experimenting with the bipolar version can use this value as a starting point and reduce it until reliable oscillation is only just maintained. Table 2 gives the values for the remaining tuning capacitors when C3 is 560pF. One or more of them will, of course, need increasing if C3 is reduced in order to restore the stated coverage.

SEILER VARIANT – F.E.T. Version

The valve-like characteristics of field-effect transistors (f.e.t.s) makes them more suitable for the Seiler variant. A circuit diagram is given in Fig.9, and the functions of the various components have already been described in connection with other f.e.t. maintained oscillators. There is no d.c. path between the gate of TR1 and ground, and resistor R1 has to be provided in order to ensure correct biasing.

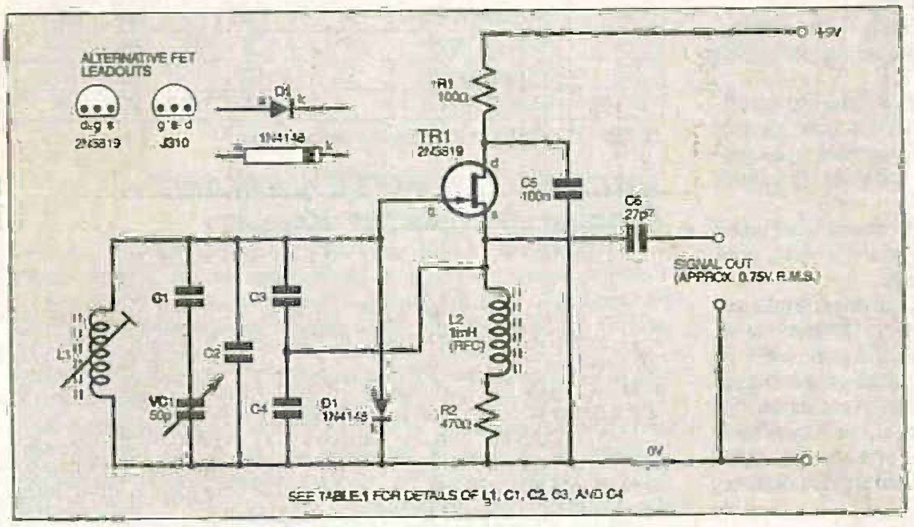

Fig.7. Narrow band Colpitts oscillator using an f.e.t.

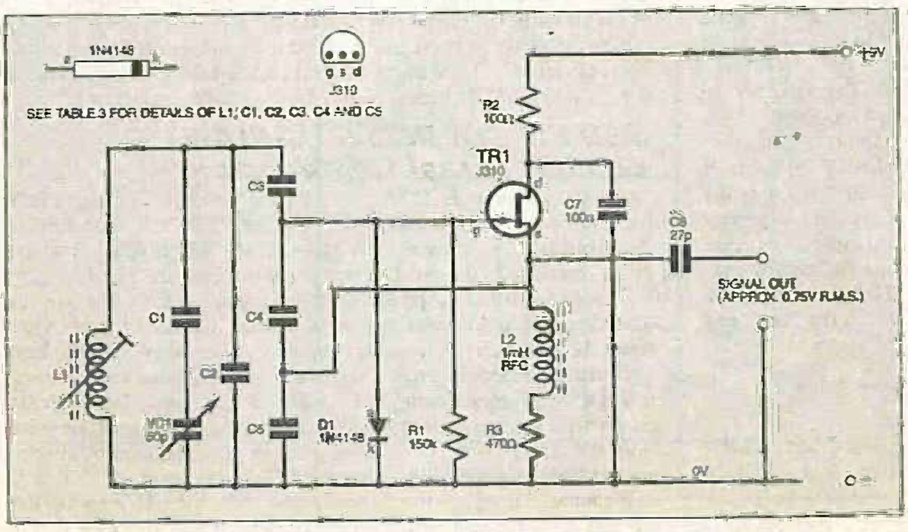

Fig.9. Narrow band Seiler variant of Colpitts oscillator using an f.e.t.

Narrow Band Oscillators

The Colpitts oscillator is widely used for coverage of the h.f. amateur bands. Bipolar and f.e.t. versions of a basic Colpitts circuit are illustrated in Fig.6 and Fig.7.

Seiler's adaptation, which attempts to further improve frequency stability by tapping the grid, base or gate of the maintaining device down the chain of feedback capacitors, is depicted in Fig.8 and Fig.9.

Clapp tried to improve on the basic circuit by adopting a series tuned, as opposed to a parallel tuned, *LC* network. Bipolar and f.e.t. versions of Clapp's modification (sometimes known as the Gouriet-Clapp circuit) are given in Fig.10 and Fig.11.

Another variant which attempts to improve on the basic Colpitts oscillator by modifying the tuning arrangements is the Vackar. Alternatives are given in Fig.12 and Fig.13, where a π network has been substituted for the original parallel tuned circuit.

The various Colpitts arrangements all have their advocates. Performance differences between them are slight, but they have probably been listed above in ascending order of improvement, with the Vackar as the most drift free. They must, however, be buffered, well constructed, and the tuning and feedback capacitors selected with care, if the claimed low levels of drift are to be achieved.

Table 1 to Table 5 list the values of tuning components for all of the narrow band Colpitts variants. These circuits will, however, cover wider bands if desired, oscillating over the full swing of a 365pF variable capacitor, and down to 100kHz and below, if appropriate inductors and feedback capacitors are fitted.

Table 3: Narrow band Seiler oscillator
Tuned circuit components for field-effect transistor version.
(See Fig.9 for circuit diagram.)

Band MHz	*Toko coil L1*	*Base wiring*	*C1 pF*	*C2 pF*	*C3 pF*	*C4 pF*	*C5 pF*
1·8	154FN8A6438EK	B	–	82	47	120	270
3·5	154FN8A6438EK	A	56	–	47	120	270
7	154FN8A6439EK	B	10	27	47	120	270
10	KXNK3767EK	B	15	15 (56)	560 (47)	82 (120)	120 (270)
14	KXNK3767EK	A	22 (27)	18 (56)	560 (47)	82 (120)	120 (270)
18	8·5 turn type S18	–	22	120 (47)	560 (120)	82 (120)	120 (270)
21	5·5 turn type S18	–	82 (47)	82 (39)	560 (120)	82 (120)	120 (180)
24-28	5·5 turn type S18	–	82 (120)	– 56*	560 (82)	39 (82)	82 (120)

Notes: (1) The S18 type coils all have ferrite cores. (2) The figures in brackets are the component values for the Dow and Goral versions. (3) On the 24MHz to 28MHz bands, the *56pF capacitor, C2, is required only for the Goral version. (4) See Fig.17 for base wiring details.

The ubiquitous 2N3819 is likely to prove too docile for this circuit with the capacitor values specified in Table 3, so a J310 is strongly recommended. If difficulty is encountered in obtaining this particular f.e.t., a dual-gate MOSFET (e.g., a BF981) with its gates strapped together will probably perform well.

Dow and Goral versions of Seiler's modification are discussed later. These variants oscillate more vigorously than the basic f.e.t. arrangement, and enable the value of C3 to be kept low.

CLAPP'S COLPITTS VARIANT

Our next modification to the Colpitts oscillator is the Clapps' variant. Depicted in Fig.10 and Fig.11, it was also conceived during the valve era.

An American engineer, J. K. Clapp was the first to publish the circuit. However, a British inventor, Geoffrey Gouriet, had already developed it during the early 1940's, but wartime restrictions prevented him making his findings known. Strictly speaking, therefore, it should be called the Gouriet-Clapp variant.

It involves the substitution of a series tuned for the parallel tuned circuit used in the original design. Advocates of the arrangement claim that it displays improved frequency stability.

The formulae relating frequency, inductance and capacitance are the same as those used for parallel tuned circuits. However, with series tuned circuits, maximum Q is realised when the ratio of inductance to capacitance is as high as possible (with parallel tuned circuits, capacitance should be kept high in order to maximise Q). The series tuned circuit presents a low impedance to the base or gate of the maintaining device, and this results in a better match, especially when a bipolar transistor is used (parallel tuned circuits present a high impedance at resonance).

CLAPP'S VARIANT – Bipolar Version

A bipolar version of the Clapp circuit is given in Fig.10, where C3 and C4 are the feedback capacitors, and the series tuned circuit is formed by L1, C1, VC1 and C2.

Transistor TR1 is biased by resistors R1, R2 and preset potentiometer VR1. Preset VR1 allows adjustment of the base voltage to suit individual devices. Details of the tuned circuit components are given in Table 4.

CLAPP'S VARIANT – F.E.T. Version

The circuit diagram of a f.e.t. maintained Clapp oscillator is given in Fig.11. There is no d.c. path between the gate of TR1 and ground, and resistor R1 must be provided to ensure the correct biasing of the transistor.

The functions of the other passive components have been described in connection with earlier circuits. The inductors and capacitors scheduled in Table 4 also apply to the f.e.t. version.

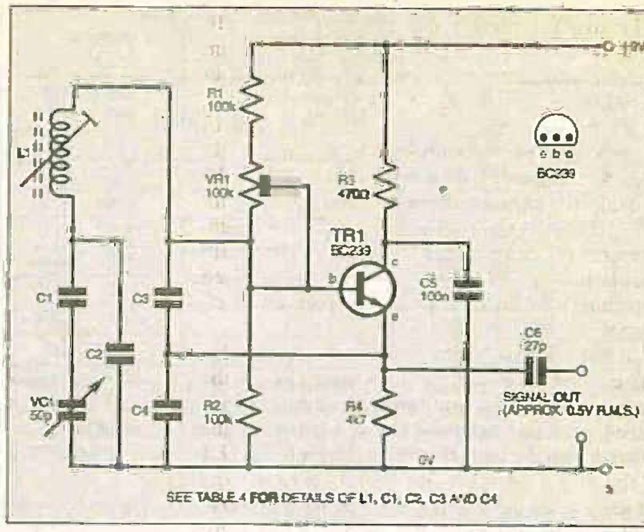

Fig.10. Circuit diagram for a narrow band Clapp variant of Colpitts oscillator.

Table 4: Narrow band Clapp oscillators
Tuned circuit components for bipolar and f.e.t. versions.
(See Figs.10 and 11 for circuit diagrams.)

Band MHz	*Toko coil L1*	*Base wiring*	*C1 pF*	*C2 pF*	*C3 pF*	*C4 pF*
1·8	154FN8A6438EK	B	–	100	680	1500
3·5	154FN8A6438EK	A	–	56	270	470
7	154FN8A6439EK	B	27	82	270	470
10	154FN8A6439EK	A	27	68	180	270
14	154FN8A6439EK	A	10	22	120	180
18	KXNK3767EK	B	10	27	82	120
21	KXNK3767EK	B	10	15	82	100
24-28	KXNK3767EK	A	18	15	47	82

Notes: (1) See Fig.17 for base wiring details.

VACKAR COLPITTS VARIANT – Bipolar Transistor Version

First published in 1945, the Vackar oscillator, like the Clapp, is a Colpitts variant involving a modification to the original tuning arrangements. With the Vackar, a π-section tuned circuit is used to achieve the necessary 180 degree phase reversal in the feedback loop.

A circuit designed around a bipolar transistor is given in Fig.12, where the combination of capacitors C1, C2 and variable capacitor VC1, together with L1 and C4, comprise the π-section tuned circuit. Trimmer capacitor VC2 and C3 form an attenuation network, limiting the amount of feedback applied to the base of TR1. Keeping feedback as low as possible, consistent with reliable starting and oscillation, does much to ensure a good, harmonic-free waveform, minimal loading on the tuned circuit, and reduced drift.

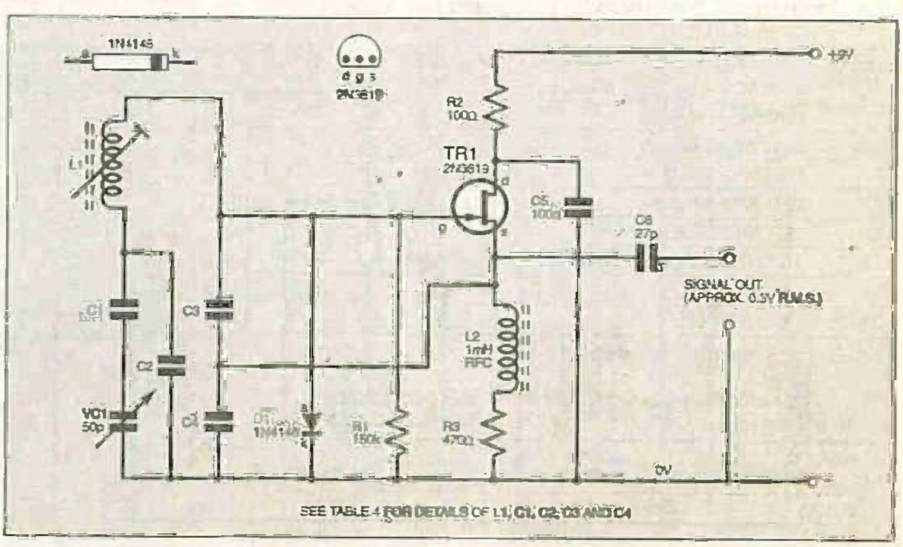

Fig.11. Circuit diagram for a narrow band Clapp oscillator using an f.e.t.

Feedback coupling capacitor VC2 is traditionally a high quality air-spaced trimmer. These components are expensive and no longer so readily available, and constructors may wish to try substituting a modern (and inexpensive) miniature preset capacitor with a film-dielectric. A component of this kind would not be suitable for permanent inclusion in the circuit, but it could be used to determine the minimum amount of capacitance needed to maintain oscillation and then be replaced by a fixed capacitor with an appropriate temperature coefficient.

In the original Vackar oscillator, the relative values of the two capacitors which form the "legs" of the π-section tuned circuit are maintained, as closely as possible, at a 6:1 ratio (the capacitor at the collector (c) end of inductor L1 is the larger of the two). The two capacitors which act as the attenuation network are also kept at approximately this ratio (the capacitor between base or gate and ground is the larger).

Ensuring reliable oscillation and securing the desired frequency coverage with a particular coil and variable capacitor combination tends to shift the relationships away from this ideal. Nevertheless, even compromised versions of the circuit are capable of good frequency stability and of producing a waveform of excellent purity.

The emitter and base biasing components shown in Fig.12 should ensure satisfactory operation with a wide range of bipolar transistors. In this design, the output signal is developed across L2, the radio frequency choke which forms the collector load for TR1.

Tuned circuit and feedback attenuation components are scheduled in Table 5.

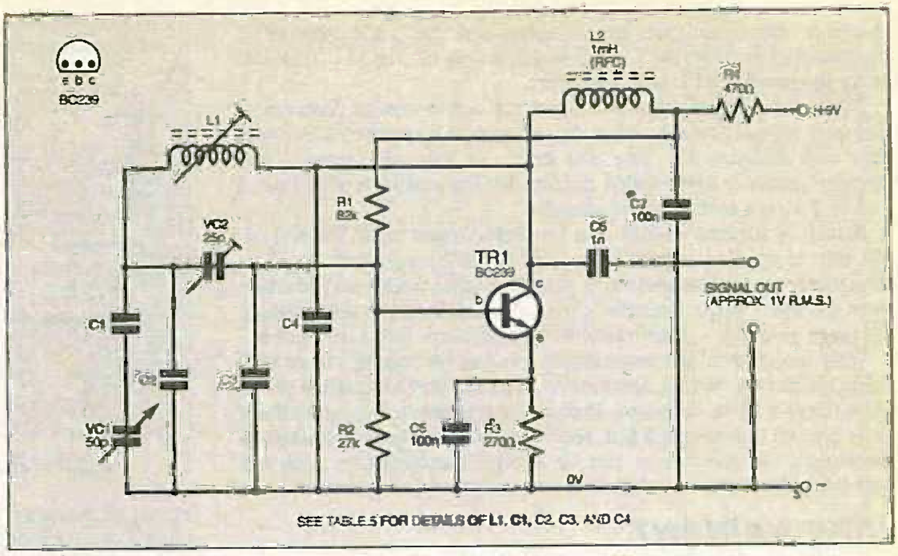

Fig.12. Circuit diagram for a narrow band Vackar variant of Colpitts oscillator.

VACKAR VARIANT – F.E.T. Version

An f.e.t. version of the Vackar oscillator circuit is given in Fig.13. The source bias resistor R2 and its bypass capacitor C5 must be provided when a J310 f.e.t. is used or the circuit will not oscillate. They can be dropped when a 2N3819 is the active device.

The tuned circuit and attenuation network components listed in Table 5 are also suitable for this version.

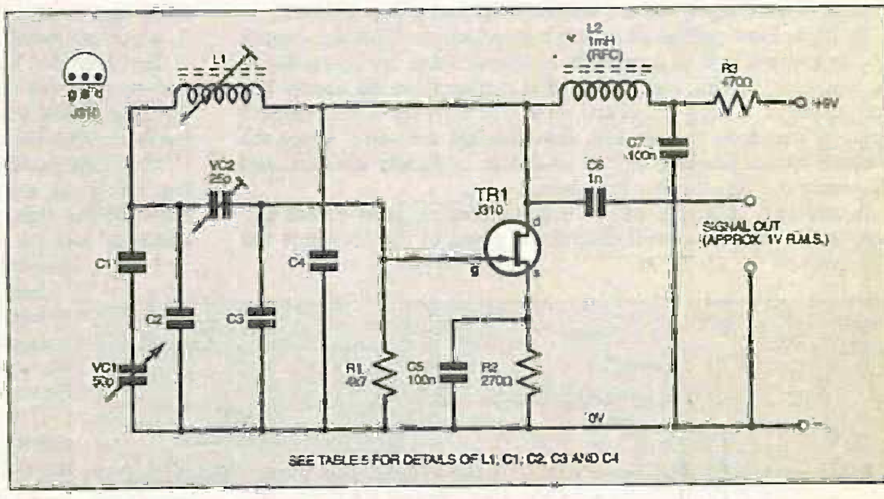

Fig.13. Narrow band Vackar oscillator using an f.e.t.

EXTENDING FREQUENCY COVERAGE – Using Colpitts at V.H.F.

The Colpitts oscillator is often encountered in equipment working at v.h.f. and u.h.f. Indeed, it is almost a standard feature in the front-ends of VHF-FM receivers.

Table 5: Narrow band Vackar oscillators
Tuned circuit components for bipolar and f.e.t. versions.
(See Figs.12 and 13 for circuit diagrams.)

Band MHz	Toko coil L1	Base wiring	C1 pF	C2 pF	C3 pF	C4 pF
1·8	154FN8A6438EK	B	–	82	47	800
3·5	154FN8A6438EK	D	–	82	47	800
7	154FN8A6439EK	A	–	100	47	800
10	154FN8A6439EK	D	33	100	27	470
14	KXNK3767EK	A	47	82	10	470
18	KXNK3767EK	A	47	82	10	220
21	KXNK3767EK	A	47	56	10	220
24-28	KXNK3767EK	A	–	27	10	100

Notes: (1) See Fig.17 for base wiring details.

Table 6: Colpitts oscillator for V.H.F. operation
Tuned circuit components. (See Fig.14 for circuit diagram.)

Frequency range MHz	Toko coil L1	Core material
30-50	8·5 turn type S18	ferrite
50-85	3·5 turn type S18	no core
85-120	1·5 turn type S18	no core

A basic Colpitts circuit where the component values have been chosen to ensure reliable oscillation between 30MHz and 120MHz or more is shown in Fig.14. It is very similar to the narrow band bipolar circuit given in Fig.6, but here the value of the feedback capacitors, C1 and C2, is lower, the variable tuning arrangements are simpler, and the emitter resistor has been replaced by a radio frequency choke in order to ensure sufficient feedback.

Many v.h.f. versions of the Colpitts circuit are often configured in the parallel, or shunt fed, mode depicted earlier in Fig.4, and the internal capacitances of the transistor can function as the tapped

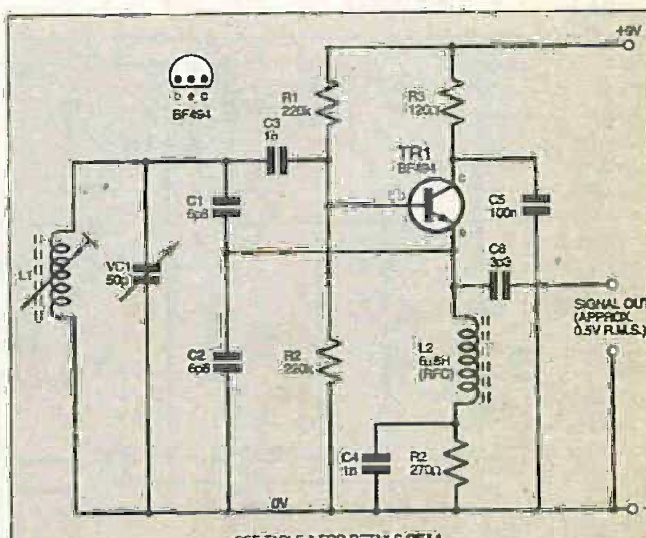

Fig.14. Circuit diagram for a v.h.f. Colpitts oscillator.

feedback capacitor (the base/emitter and the collector/emitter capacitances replace the C1/C2 combination of Fig.14). This can make the circuit difficult to recognise.

When the internal capacitances of the active device function in this way, and particularly when the tuning coil is connected between base and collector (or gate and drain, or grid and anode), this Colpitts variant is often called an ultra-audion oscillator after one of Lee de Forest's earliest valve circuits.

Inductors for this circuit can be hand-wound with 18s.w.g. to 22s.w.g. enamelled copper wire, and be self-supporting. Readers who prefer to use commercially produced coils could use inductors from the Toko range. Suitable types, together with the approximate coverage given by a 50pF variable capacitor, are listed in Table 6.

Stray inductance and capacitance have an increasing effect with rising frequency, and connections must be as short as possible or the upper limit will be curtailed. Frequency stability leaves something to be desired (the simplest f.m. receivers incorporate drift correction measures), but the circuit can be used, in conjunction with the buffer amplifier described earlier, as a simple signal generator.

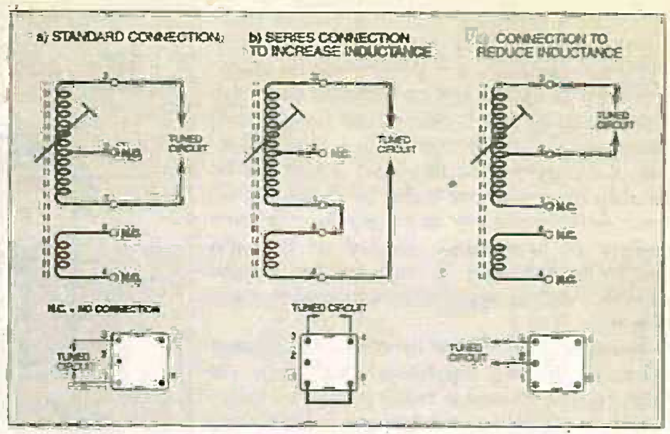

Fig.17. Base connection details for Toko Coils.

DOW VARIANT

Dow's system of electron coupling was described last month in connection with the Hartley oscillator. The technique can also be applied to the Colpitts circuit and its Seiler and Clapp variants.

In 1931, Dow published a circuit in which the cathode, control grid and screen grid of a pentode or tetrode valve are connected in an oscillatory circuit, and the signal is extracted via the anode. The only medium linking the actual oscillator with the signal take-off point is, therefore, the electron flow through the valve, hence the circuit's name. Loading on the oscillator is greatly reduced, and frequency stability thereby improved.

A dual-gate MOSFET can be used to simulate Dow's modification, and a suitable circuit diagram is given in Fig.15 where the technique has been applied to a Colpitts/Seiler oscillator. The tuned circuit arrangements are identical to those already described and depicted in Fig.9. Here, however, a double-gate MOSFET, TR1, has been substituted for the j.f.e.t., and the output is developed across drain load resistor R4. Resistors R2 and R3 fix the potential on gate 2, which is grounded at r.f. by capacitor C6.

The dual-gate MOSFET oscillates more readily than the j.f.e.t., and the values of C3, C4 and C5 can be modified in order to reduce damping on the tuned circuit and improve impedance matching at the feedback injection point. Alternative values are quoted in Table 3.

The isolation afforded by the structure of a solid-state device is not likely to equal that achieved with an evacuated valve. Nevertheless, this circuit is superior to the basic bipolar and f.e.t. versions, and the reduced tuned circuit damping improves frequency stability and makes output level more constant.

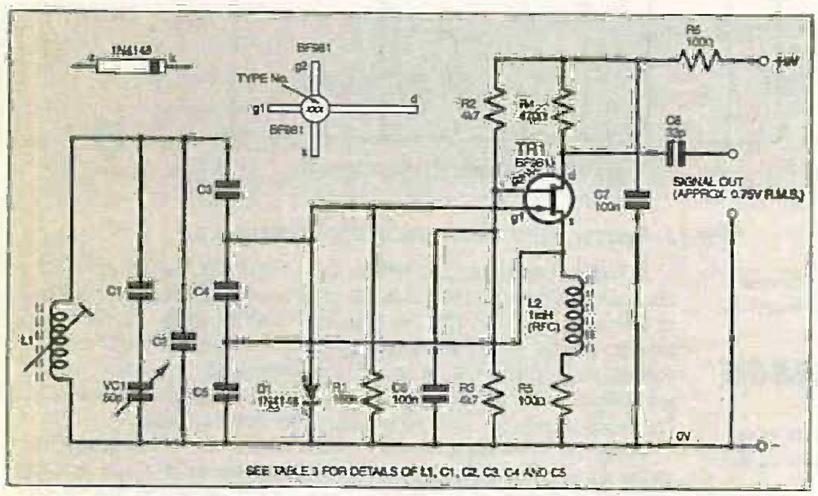

Fig.15. Circuit diagram for a narrow band Dow/Seiler variant of Colpitts oscillator.

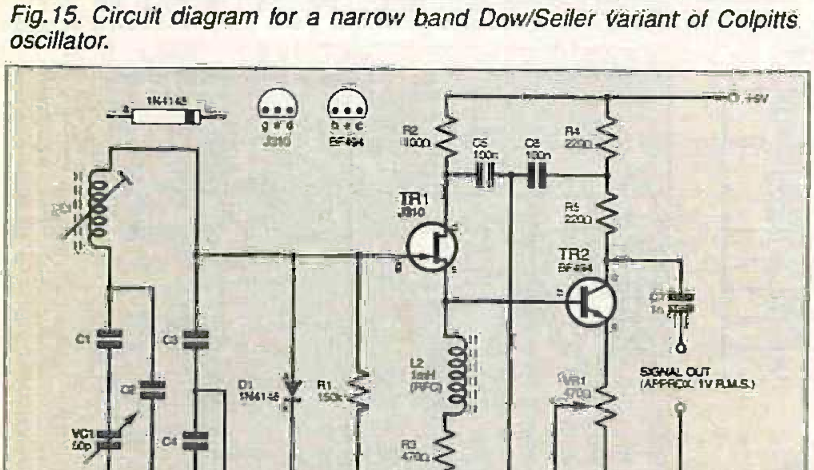

Fig.16. Circuit diagram for a narrow band Goral/Clapp variant of Colpitts oscillator.

Solid-state Dow circuits can display a tendency towards frequency doubling. This problem was not encountered when the modification shown in Fig.15 was made to the basic Colpitts circuit (Fig.7), or to the Seiler and Clapp variants (Fig.9 and Fig.11).

If frequency problems do arise, try reducing the supply voltage. If this fails to effect a cure, change the radio frequency choke to one of different inductance, and/or increase the value of the *Q* spoiling resistor R5.

GORAL VARIANT

The Goral oscillator circuit development involves the insertion of an emitter follower stage into the feedback loop and is shown in Fig.16, where the modification has been made to the Clapp/Colpitts oscillator. It can also be applied, with equal success, to the basic Colpitts circuit, and to the Seiler variant.

The improved power gain of the two transistor combination makes the circuit much more ready to oscillate, and the values of feedback capacitors, C3 and C4, can be optimised for minimum tuned circuit damping and drift. This process is further assisted by the low impedance of the feedback connection from the emitter (e) of TR2, via potentiometer VR1.

Signal output is developed across collector (c) load resistor R5, and the isolation, although slight, of the take-off point, from the tuned circuit, also helps to reduce damping and drift.

Resistor R4 and capacitor C6 decouple the additional stage, and C7 functions as a d.c. blocking capacitor. Potentiometer VR1, which forms the emitter load for TR2, enables the level of feedback to be set as low as possible. Minimising feedback improves the output waveform (it can be made near-perfect with this arrangement), reduces its harmonic content, and improves the frequency stability.

Although a 2N3819 f.e.t. will function in this circuit, the J310 specified enhances performance and is very much to be preferred.

Next month: The construction of a stabilised power supply, simple probes to enable r.f. voltages to be measured with ordinary test meters, and the Armstrong, Butler, Franklin and Meissner oscillators will be described.

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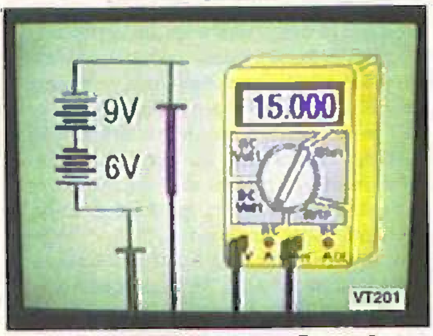

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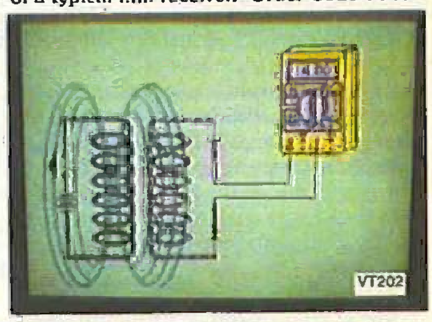

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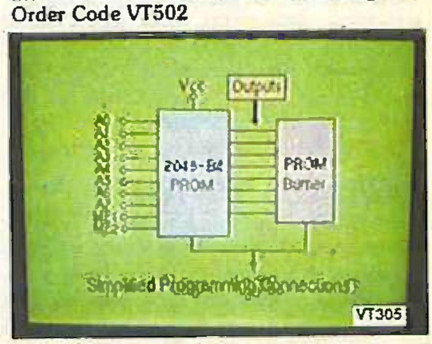

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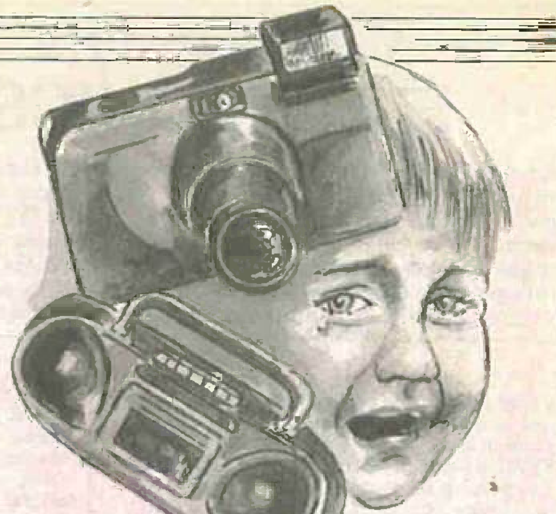
SOUND ACTIVATED SWITCH



BART TREPAK

Showing how a logic gate can be used as an audio amplifier and a voltage switch.

SOUND activated switches are useful in many circumstances, especially when "hands free" operation of a piece of equipment is required. They are often used, for example, to automatically switch on a tape recorder (or a digital solid state equivalent) to record a sound or conversation without "wasting" tape during quiet periods.

Many inexpensive cassette recorders have a remote switch input to enable the recorder to be switched on from the microphone and a circuit of this type can easily be connected to it to start the recording automatically.

As well as this, sound activated switches can be useful in applications such as intercoms, baby alarms, security alarms or photographic work, and there are no doubt many others.

This circuit arose from a requirement for a basic microphone interface to logic circuits without having to build one from scratch each time. Since it was not built for any specific application, a number of outputs were provided, including an amplified version of the sound waveform. With a few additional components, however, the circuit can easily be used as a sound-operated switch with other equipment.

It is suited to being supplied by a 9V PP3 battery. The choice of case has been left to users, to meet their own requirements.

CONSIDERATIONS

Most circuits of this type published over the years use a microphone signal which is amplified to a suitable level by an op.amp. The signal is then rectified and fed to a comparator which switches when the signal exceeds a certain level. This is then used to switch a relay or other device, which in turn controls an appliance.

The problem with using op.amps with digital logic is that the output of most op.amps does not switch fully between the supply rails. Thus, with a 5V supply for instance, the output will typically switch between 0·5V and 3V. This is not too much of a problem if a relay driver transistor is to be connected to the output, but it may not work satisfactorily with a logic circuit unless extra interface components are used.

Many of the low-cost op.amps (e.g. 741) also require a supply voltage greater than that at which most logic circuits operate. This means that a separate supply would need to be used, together with level shifting components to bring the output swing within logic levels.

As well as this, differential inputs, although improving performance as regard to hum or interference, require a positive and negative supply which is not often available in logic circuits.

This circuit overcomes the difficulties encountered in using op.amps and provides a variety of outputs for virtually any application. The component count is very low – only 17 low cost components are required (and that includes the microphone).

The circuit will operate down to about 3V, drawing a current of less than 0·5mA. At 5V, the supply current is around 1mA and even at 9V is only around 5mA, which compares quite favourably with an op.amp design. The circuit can be used at up to 15V, although the current drain is then a bit excessive.

LOGICAL AMPLIFIER

Since a logic level output is required and we are not after hi-fi standards, a logic gate is used as the input amplifier. The circuit uses two of the six inverters inside a 4069 CMOS chip to amplify the signal, which is picked up by a small electret microphone. The 4069 is one of the cheapest devices in the CMOS range and with the addition of a single feedback resistor, which effectively biases the output to mid-supply voltage, it makes a very useful amplifier.

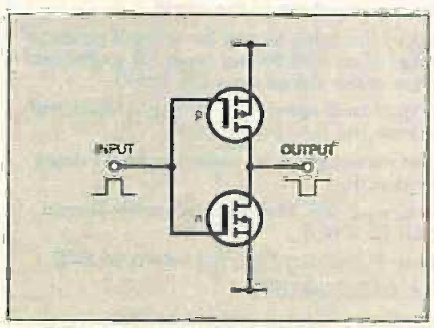


Fig.1. Basic CMOS 4069 inverter.

The internal circuit of one CMOS 4069 inverter (excluding the input protection components) is shown in Fig.1 and consists of two transistors: a *p*-channel and an *n*-channel MOSFET.

It must be noted, however, that most devices in the 4000 CMOS series contain a buffer following the logic function, utilising two cascaded inverters of the type shown to achieve sharper input-output voltage characteristics and reduced switching times. They are labelled "B" for buffered (e.g. 4049B), whereas the unbuffered types are labelled "UB" (e.g. 4069UB).

In normal operation, if the input is held at 0V, the output of a logic inverter will be at the positive supply rail with the *p*-channel transistor conducting and the *n*-channel device cut off, with the device drawing only a minute leakage current.

This will also be the case if the input voltage is increased slowly until (typically) the mid-point is approached, when the *p*-channel device will begin to turn off and the *n*-channel device turn on. The supply current will also begin to rise because both transistors are now conducting. The device will now operate as a linear amplifier and as the input voltage is further increased, the output will continue to fall.

SLOPING OFF

Because a buffered device has a fairly high gain (especially if two such devices are cascaded) a small increase in the input voltage will cause such a large output swing that the output will switch completely, with the *n*-channel device hard on and the *p*-channel transistor hard off (see Fig.2a) and the circuit drawing a microamp or less.

With the UB device, this action is more gentle (as shown in Fig.2b) and a situation can easily be arranged where both

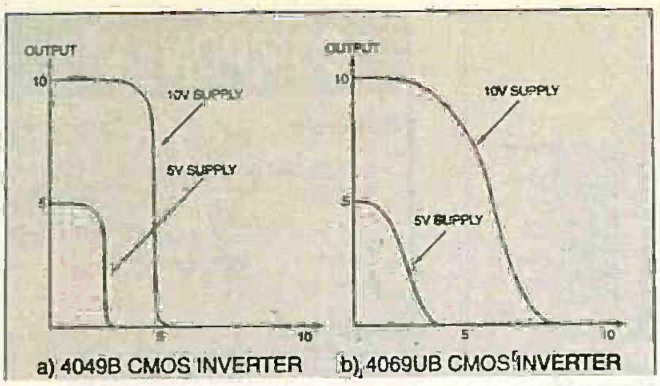


Fig.2. Comparison of switching slopes for buffered (a) and unbuffered (b) CMOS inverters.

transistors are conducting and the device functions as a stable linear amplifier, with the output at about the mid-supply voltage. Since both transistors will be conducting in this state, the current flow will be in the low milliamps range and will depend on the supply voltage.

The major limitation of this circuit as an amplifier is that its gain also depends to a large extent on the supply voltage, as does its relatively high output impedance which, together with any load capacitance, determines the bandwidth.

At higher voltages, the output impedance is lower, giving an increased bandwidth. It is also not the last word in hi-fi from the point of view of distortion or noise but, despite this, the sensitivity of the unit is sufficient to enable it to respond to a sound at normal conversation level within one or two metres.

The electret microphone used also has a built-in amplifier to reduce its output impedance and noise pick-up, and this no doubt helps. A problem is that, because the gain tends to be somewhat higher at low voltages, the sensitivity of the unit is higher with a 5V supply than at 9V. This can also be seen from Fig.2b, which shows the transfer characteristic for the 4069UB at 5V and 10V.

CIRCUIT DIAGRAM

The circuit diagram of the Sound Activated Switch is shown in Fig.3. The microphone is biased by resistor R1 and the a.c. signal coupled to the input of the first inverter, IC1a, which is biased into its linear mode by resistor R2.

The output of this stage consists of an amplified version of the sound signal and this is fed to a similar stage built around another inverter (IC1b), which amplifies it further. The output signal from IC1b can be tapped at test point TP1, from where it may be used to feed a suitable power amplifier, depending on the application.

As mentioned earlier, this signal is not by any means in the hi-fi category. It will be about 1V peak-to-peak for normal conversation levels. Louder sounds will obviously result in a larger output (with increasing distortion) limited by the supply voltage.

Interestingly, while distortion obviously increases as the output approaches the upper and lower supply limits, this amplifier progressively "rounds off" the signal peaks in a manner more reminiscent of a valve amplifier, rather than clipping them, as would occur in an op.amp.

OUTPUTS

CMOS inverters, even the UB types, have a relatively steep input logic transfer characteristic. With a 5V supply, an input change of less than 1V produces an output swing of nearly the full supply. With a 10V supply, an input change of around 3V is required to do this.

Since the transition occurs at around the mid-supply voltage, connecting the output of the amplifier stage (which is biased to the mid-supply rail voltage) to another inverter would result in the output of this stage oscillating between the two supply rails, due to stray noise (both audio and electrical) reaching the input.

By placing a potential divider (R4/R5) at the output of amplifier IC1b, the input of the next stage, IC1c, will be held slightly below its threshold voltage and the output of this stage will remain at the positive supply (logic 1 level) when there is no sound reaching the microphone.

When a sound is picked up by the microphone, the output of the amplifier stage will swing between the logic levels in sympathy with the signal and, since the threshold of the next inverter, IC1c, is at around half the supply rail voltage, each time this voltage is exceeded, the output of this stage will switch to a low level. This is illustrated in Fig.4, which shows the waveforms at different points in the circuit.

Inverter IC1c, therefore, provides faster switching, with its output pulses coinciding with the peaks of the sound picked up by the microphone.

This may be useful in some applications where, for example, the frequency of the sound needs to be measured, but could not

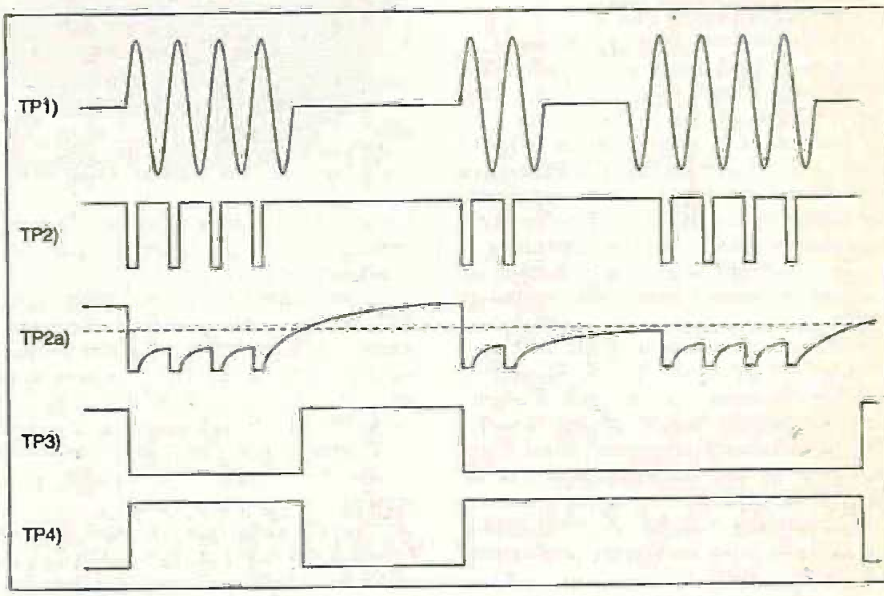


Fig.4. Waveforms at the circuit test points.

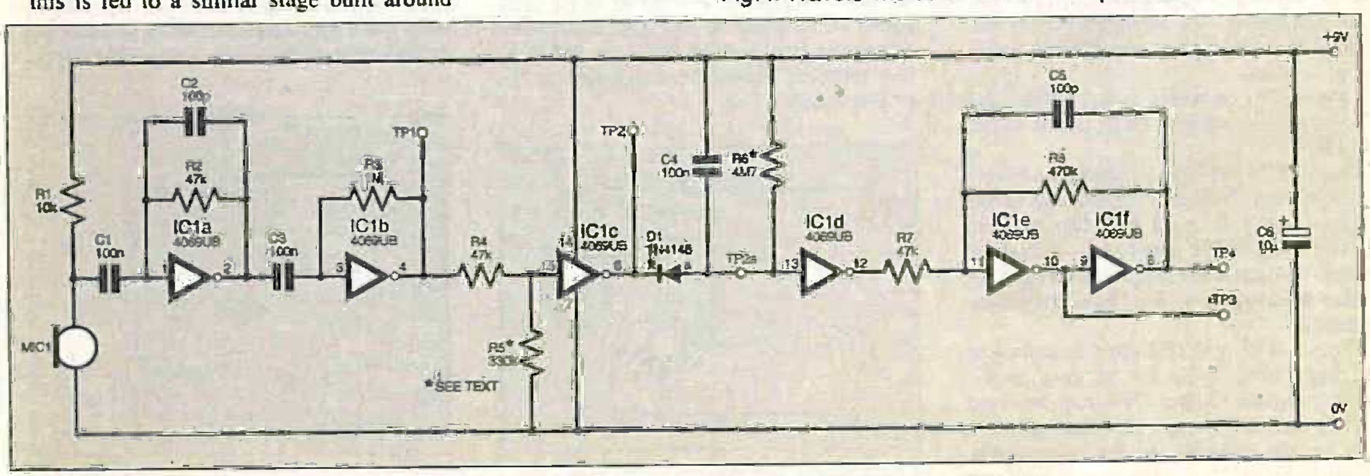


Fig.3. Complete circuit diagram for the Sound Activated Switch.

be used to switch on a tape recorder, for which a steady "on" signal is required. This condition is achieved by using the negative-going output of IC1c to charge up capacitor C4 via diode D1.

The diode prevents the capacitor from discharging when the output goes high again. When a sound is picked up by the microphone, the voltage on this capacitor will therefore fall to the negative supply, causing the output of inverter IC1d to go high.

When the sound ceases, capacitor C4 discharges via resistor R6, until the voltage at the input of IC1d eventually rises above the logic threshold, causing the output of IC1d to switch low again. By varying the value of R6 and/or C4, the length of time for which the output of IC1d stays high after the sound has ceased can be varied to suit the application.

The relatively gentle nature of the input/output characteristics of the unbuffered 4069 inverter, coupled with the slow discharge of C4 via R6, means that the output of IC1d tends to switch uncleanly. With the inverter now spending more time in the linear region while C4 discharges, intermittent oscillation can occur and its output is not suitable for connecting to other logic circuits. The two final inverters, IC1e and IC1f are therefore combined with resistors R7 and R8 to form a Schmitt Trigger circuit, which uses positive feedback to sharpen the response.

CONSTRUCTION

Component and track layout details of the printed circuit board are shown in Fig.5. This board is available from the *EPE PCB Service*, code 240.

Assemble the components in order of size, and use a socket for IC1. Remember that the i.c. is a CMOS device and should be handled accordingly, discharging static electricity from yourself before handling it.

Two short pieces of tinned copper wire, such as discarded resistor leads, need to be soldered carefully to the two pads on the back of the microphone capsule. Although it is not apparent from the circuit symbol, electret microphones have a built in amplifier and must therefore be connected to the circuit with the correct polarity. The 0V terminal is the one connected to the metal body of the capsule.

Use terminal pins for off-board wiring connections to other circuitry, as required by the application.

APPLICATIONS

Depending on the application, the outputs of the unit can be connected to a variety of devices.

Output TP1 provides the amplified, but otherwise unmodified, microphone signal from IC1b.

Output TP2 provides a roughly rectangular waveform having the frequency of the original signal. Since it switches between 0V and the positive supply rail, it may be used as an output to other logic circuits for further processing, such as frequency measurement.

Outputs TP3 and TP4 provide logic low and logic high levels for as long as the sound persists. Output TP4 can be used directly for interfacing with other logic circuits or, for example, to the relay driver shown in Fig.6.

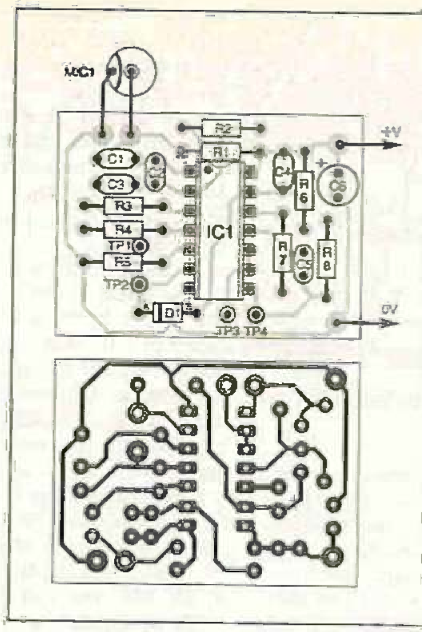
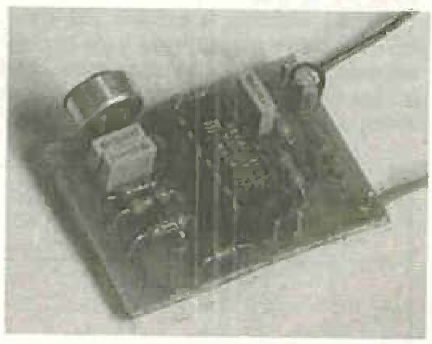


Fig.5. Printed circuit board component layout and full size copper foil master track pattern.



The relay can be used to switch on any appliance, e.g. tape recorder, lamp etc., depending on its ratings.

To prevent the relay from switching on and off during short periods of silence, the value of resistor R6 or capacitor C4 may need to be increased. This should be done by trial and error: too small a value will cause the relay to keep switching on and off very often, while too high a value will result in the relay staying on for a long period after the sound has ceased.

For applications where a longer delay is required, and where the device may be triggered by a loud initial sound which then dies away, the value of C4 may be increased to allow lower values of R6 to be used. It is possible to use electrolytic capacitors here and, in this case, the positive terminal should be connected to the positive supply line.

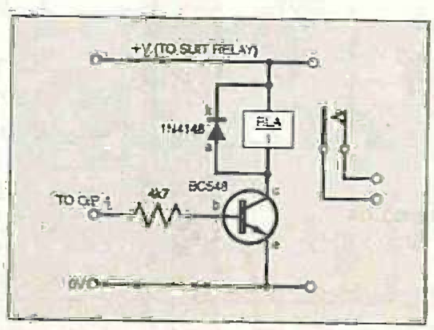


Fig.6. Interfacing to a relay.

COMPONENTS

Resistors

R1	10k	
R2, R4, R7	47k (3 off)	
R3	1M	
R5	330k (see text)	
R6	4M7 (see text)	
R8	470k	

See **SHOP TALK** page

Capacitors

C1, C3, C4	100n ceramic (3 off)
C2, C5	100p ceramic (2 off)
C6	10µ radial elect. 16V

Semiconductors

D1	1N4148 signal diode
IC1	4069UB hex inverter

Miscellaneous

MIC1 electret microphone, 2-terminal

Printed circuit board, available from the *EPE PCB Service*, code 240; terminal pins, 14-pin d.i.l. socket; connecting wire; solder, etc.

Approx. Cost Guidance Only £9

PHONE TRIGGERED

A useful application for this circuit would be to switch on a lamp to signal that the telephone is ringing. This would be helpful in a noisy office or workshop, or perhaps at home for someone who is hard of hearing.

For this sort of application to be successful, it is important to ensure that there are no "false alarms". Frequent trips to the telephone, only to find that the lamp has been triggered by a passing car or some other noise and not the phone, will not endear you to your granny!

Place the microphone close to the telephone and reduce the circuit's sensitivity so that only the telephone can make a loud enough sound. This can be done by decreasing the value of R5, using trial and error or by fitting a preset. The maximum value should not exceed 470k (with R4 as specified) as values greater than this may prevent the circuit from operating properly.

Performance could be further improved by choosing a value for R6 to keep output TP4 high only for the duration of each ring (around 2·2MΩ with C4 at 100nF). This will cause the lamp to flash in the characteristic UK telephone ringing pattern, making it not only more noticeable, but easier to recognise in the event of triggering due to other noises.

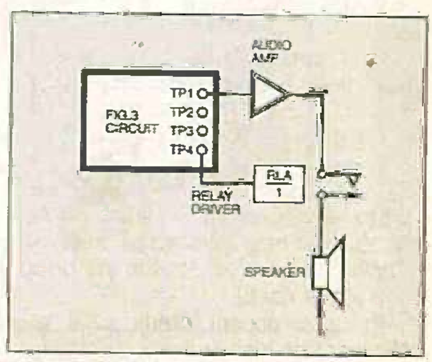


Fig.7. Baby alarm application.

which would cause the lamp to flash in a different way.

BABY MINDER

Another application would be as a baby alarm, as in Fig.7. Here, output TP4 would be used to control the output of an audio amplifier switching it (or the loudspeaker) on when a sound is detected.

The actual sound (from output TP1) would be fed to the amplifier input allowing the baby sitter to hear if the baby was crying or simply stirring and thus determine whether or not it needed attention.

P.A. CONTROL

A similar application could be devised where, for example, public announcements need to be made during which the normal background music has to be interrupted. It should be appreciated, however, that although the circuit is fast, it still takes time to operate, especially if a relay is used for the switching. It could be found that the beginning of any announcement is not transmitted.

In such applications, the use of a transmission gate such as the 4066 quad analogue multiplexer is recommended to switch the signal. A possible scheme is shown in Fig.8. Here the four gates within the 4066 are used in pairs and controlled by outputs TP3 and TP4.

Since TP3 is normally high, the signal at the music input will be transmitted to the volume control, while its lower end will be held at 0V by the other transmission gate connected to output TP3. Whenever an

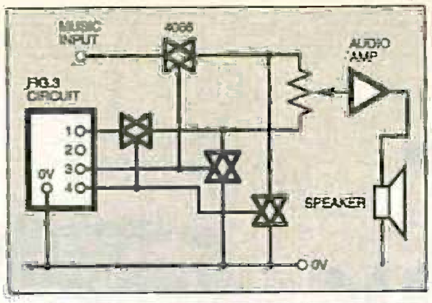


Fig.8. Suggestion for P.A. control.

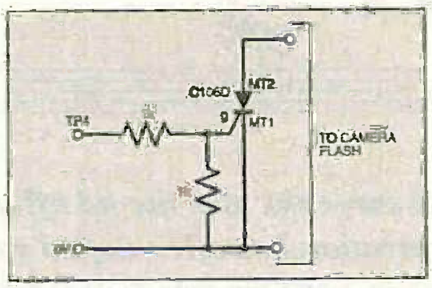


Fig.9. Application as a camera flash trigger.

announcement is made, these two gates will switch off and output TP4 will go high switching on the other two gates.

The audio signal from the microphone will then be applied to one end of the volume control potentiometer, while its other end will be grounded. The relative volume of the music and announcement signals can therefore be set as required.

Note that neither of these circuits take into account any d.c. offset voltages which may exist in the signal path. These would, of course, have to be decoupled to ensure that there were no sudden thumps when the speaker or the inputs were switched. The values of R6 and/or C4 may also need to be adjusted for best results.

In this application, the person making the announcement would, no doubt, be very close to the microphone and so the sensitivity would need to be suitably reduced by using a lower value for R5.

FLASH TRIGGER

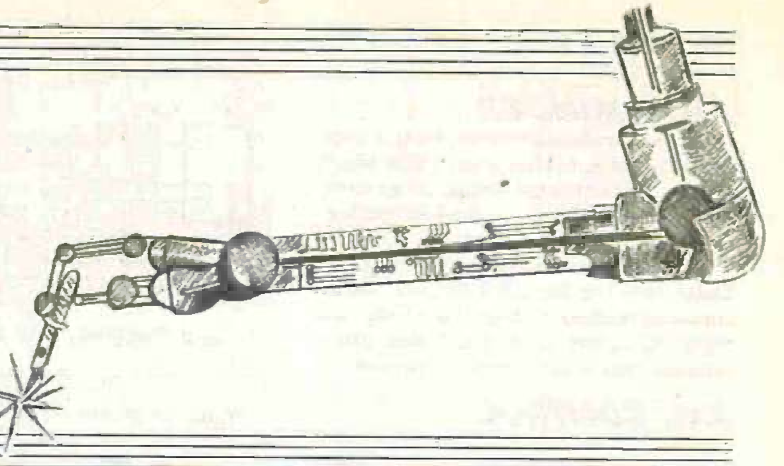
Finally, the circuit could also be used as a sound-operated flash trigger to photograph such things as bursting balloons, breaking glass etc. Most flash guns operate by placing a short circuit on an input and, as in this case the speed of operation is important, a thyristor is a better device to use than a relay.

As shown in Fig.9, The thyristor can be connected to output TP4, which will take the gate positive (via a resistor of, say, 1kΩ) when a sound is detected, triggering the thyristor and operating the flash. The operation must, of course, be carried out in a darkened room with the camera shutter open so that the film is only exposed when the flash operates.

However, since such uses were not the author's primary reason for building the circuit, the above applications are only given as "design ideas" and have not been built or tested. Other uses for the circuit will no doubt occur to readers. □

Regular Clinic

CIRCUIT SURGERY



ALAN WINSTANLEY and IAN BELL

Our team of in-house circuit surgeons take the lid off an apparently simple-looking multivibrator circuit whose operation has often defied explanation until now. More on Live Supplies and transistor substitutes as well.

LET us sift through this month's post bag and commence with a comment regarding the mains supply.

Electric Enlightenment

Apropos your item "Live Supplies" in the July 1999 Circuit Surgery, *in the mains-power designation L,N,E the* L *stands for "line" – not "live". It is an abbreviation of "active line" which describes that conductor from the supplying transformer's secondary winding which is at an elevated electrical potential and which provides active power; and distinguishing it from the neutral conductor providing the return path to the other end of the transformer's secondary winding, and which neutral conductor is held at or near zero or earth potential by being connected also to earth at the supplying transformer and usually at intermediate points.*

The neutral (N) *conductor is not intended to provide a route for active-to-earth faults. The absorption of earth faults is the safety function of the appliance's earth terminal, which may be connected usually to a separate earthing conductor or directly to earth at the consumer's supply terminal.*

Active Line

The electrical potential difference between the active line of the a.c. supply and the neutral conductor is maintained by control at the generating source at a specified value (now 230V r.m.s. single phase in Britain as subjugated by the European Union).

"Live" means that which is living as opposed to dead. Far from being a supplier of life, contact with the active line can have just the contrary effect!

The explanation may be considered pedantic by some of your readers but designations have the meanings properly ascribed to them which should not be adulterated even though it is currently often thought clever to do so (although, of course, excuse may be made for those who have not been exposed to enlightenment as per Epeeti!) **J.H. Eastaugh, Chesham.**

The information provided last month concerning earthing is correct, but hopefully this month's follow-up article on power distribution will clarify the techniques of earthing and other aspects of the mains power supply. Whilst you are, of course, right to say that "Line" is the correct technical term applied to a phase, it can be a virtually meaningless expression to the average electronics hobbyist or non-electrician. Everyone knows what the "Live" is, hence I deliberately used *Live* in Fig.3 last month and not *Line*. Manufacturers of British mains plugs manage to skirt around this problem by simply designating the live terminal as "L".

In actual fact, electrical engineers talk in terms of *line-to-line* voltages. Thus, a 415V three-phase transformer has 415V *between any two phases*. An actual voltage of 240V ($415 \div \sqrt{3}$) exists between the star point and an individual line. Similarly, the 15·75kV (line-to-line voltage) power generator I talk about in this month's feature actually has 9·1kV induced into the individual star-wired windings.

In Harmony

The domestic supply is still provided at 240V but due to the murky workings of the EU, and because areas of Europe still use 220V, the European supply was officially "harmonised" at 230V. (Imagine if they applied the same methodology to British roads, we'd be told that officially, we drive on the right.)

Your final sentence caused a wry smile. I do hope you will agree that far from "adulterating" any terminology for the sake of it, it is considered part of the job to interpret and translate into *Everyday* language the often esoteric jargon and highly complex practices used in the electricity industry.

I would perhaps add that generally speaking, it is actually much harder to write such material because no prior technical knowledge on the part of the reader could be assumed. *ARW.*

Mysterious Multivibrator

Some very simple-looking circuits have an operation which is more complex (or hard to explain!) than their apparent simplicity would suggest. *M.L. Unsted, East Sussex* writes:

Although I find EPE *an excellent magazine for someone new to the subject, with usually good explanations of circuit operation, sometimes though, a relatively simple circuit design comes along which does not behave as I would expect!*

One such article is the Lighting Up Reminder, *in the March 1998 issue. I tried the circuit on a prototype board, measuring voltages at different points with a meter and an oscilloscope.*

Could you explain why transistor TR1 turns off when its base is being pulled negative by TR2 collector, and the already positive base-emitter voltage of TR2 is further enhanced via capacitor C1, by the rapidly rising voltage across resistor R2 as TR1 turns on? I can see that when TR1 does turn off, the base of TR2 will be driven several volts negative, thus giving a delay between pulses. A question worthy of Circuit Surgery *I think!*

In view of our new series on *Practical Oscillator Designs*, we felt this design was worth revisiting. The *Lighting-Up Reminder* circuit is re-drawn in Fig. 1. The Editor tells us that the circuit description was deliberately omitted because there was more than one opinion concerning how the circuit operated in reality!

The *Surgery* writers were interested to discover another published use for this type of circuit that also lacked the accompanying explanation. It is a *Variable Speed Metronome* by B.B.Babani in *First Book of Practical Electronic Projects* (published 20 years ago).

The l.e.d. D1 and resistor R2 are replaced by a 16Ω loudspeaker, R1 is a 250kΩ pot plus a 22kΩ resistor and capacitor C1 is 15µF. The transistors are different too, of course. No text accompanies the circuit, only the schematic is given in the book!

Relax

The circuit is actually an *astable multivibrator*, because it continuously switches between two states. However, it could also be described as a *relaxation oscillator* as it spends almost all of its time in one of the states. The transistor multivibrator circuits we will describe here are perhaps good examples of simple circuits that have a large number of possible applications for the hobbyist (limited only by your creativity!).

There has been some debate in the *EPE* Letters pages on the merits of such simple circuits compared with more sophisticated PIC based projects. Apart from being useful in themselves and simple to construct, a big advantage of experimenting with small transistor circuits is they can help understanding of fundamental concepts that can be put to good use in a wide variety of designs (*including* interfacing PICs to the "real world").

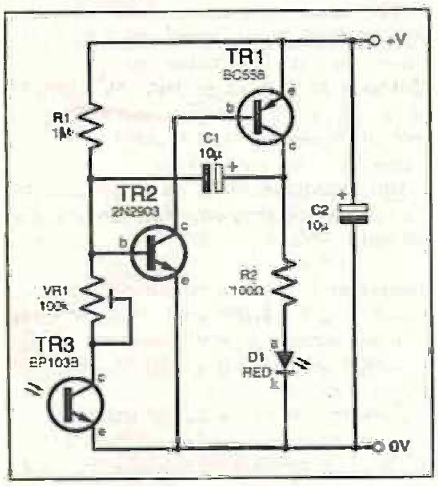


Fig.1. Redrawn circuit diagram for the basic Lighting-Up Reminder, *taken from the March '98 issue of* EPE.

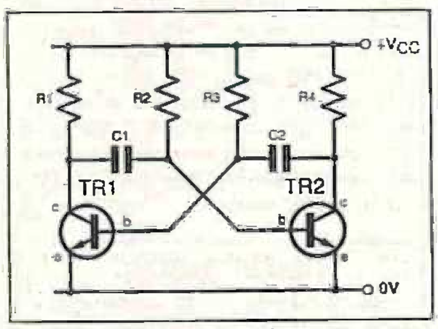


Fig.2. A well recognised astable multivibrator circuit.

Classic Astable

For the benefit of readers unfamiliar with multivibrators, it is worth taking a look at a more popular (and possibly easier to understand) circuit for a classic two transistor astable multivibrator. The circuit diagram is shown in Fig. 2: old hands will know straight away that the "crossover" in the middle of the circuit is a hallmark of such a multivibrator: the transistors are wired in a cross-coupled fashion – i.e. the collector of one is connected the base of the other via one of the capacitors.

If one transistor is switched *ON* (it does not matter which one) its collector (c) will be at a low voltage, and hence it will tend to turn the other transistor *OFF* by sending its base (b) terminal low. It is, therefore, reasonable to assume that one transistor is off and the other is on, and that the circuit oscillates by periodically switching between these two states. Thus we can start by assuming that TR1 has just switched off and TR2 has just switched on.

When transistor TR2 was *OFF*, its collector would have been almost at the supply voltage $+V_{CC}$, whereas TR1 which was switched *on*, would only have had a base voltage of, say, 0·6V. Thus, the voltage across capacitor C2 just before TR2 turned on would have been nearly equal to the supply voltage $+V_{CC}$ (ignoring the 0·6V base-emitter voltage for simplicity).

At the instant that TR2 turns on, C2 still holds its charge and has a voltage of $+V_{CC}$ across its plates. Note that the transistors switch much faster than the capacitors can either charge or discharge, so that the voltage across C2 *just before* and *just after* the transistors have switched, is the same.

Transistor TR2 is fully on and its collector voltage is very low, in fact for simplicity we can assume TR2's collector is at 0V. Remember that C2 still has V_{CC} across it, but now the more positive plate is fixed at 0V, so the other plate must be at a voltage of (V_{CC} less than this), which is $-V_{CC}$.

Fundamental

This is a pretty fundamental point. The negative voltage may seem strange in a circuit which only has a single rail power supply (+Vcc) but occurs because capacitors are able to store charge, and hence have a certain voltage "across" them while we switch the fixed voltage at one plate.

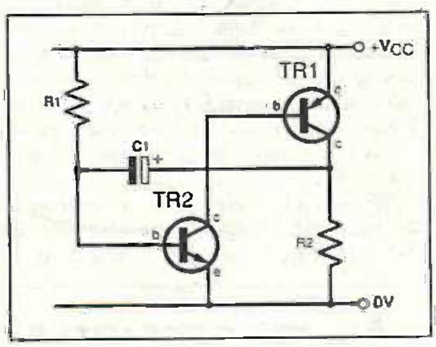


Fig.3. Circuit diagram for the multivibrator part of the Lighting-Up Reminder.

The voltage "across" it remains the same, so a new fixed voltage for one plate must mean a new voltage relative to 0V for the other plate. Such voltage shifting is put to good use in some circuits, for example to generate different voltages from those available directly from the power supply, however, in this case the negative voltage is just a consequence of the circuit's switching action.

Returning to our analysis of Fig.2. We recall that as transistor TR2 has just turned on the base of TR1 which is at $-V_{CC}$ due to the voltage across C2 and note that this is also consistent with our assumption that TR1 has just switched off.

The situation does not stay like this forever because capacitor C2 now starts charging from $-V_{CC}$ towards $+V_{CC}$ through resistor R3 (remember the TR2 collector side of C2 is fixed at 0V at this point). However, C2 never manages to charge all the way to $+V_{CC}$ because as soon as it reaches about +0·6V TR1 will turn on causing the circuit to switch again. The process just described is repeated, but this time with C1 charging to turn TR2 back on.

The speed at which the circuit oscillates can be determined using the standard exponential charging equation for a capacitor. We can estimate the time TR1 is off by using a time constant of C2R3, charging from a voltage of $2V_{CC}$, until it reaches V_{CC}, giving a time of 0·7 C2R3. The total period of the oscillation is 0·7 C2R3+0·7 C1R2.

This is only approximate, as we have ignored the 0·6V base voltage. This formula is only valid if the transistor's base-emitter junctions are not driven into reverse breakdown by the negative base voltage, which will happen if you use a sufficiently large V_{CC}.

All Together

The first point to make about the "Lighting-Up" multivibrator of Fig.1 is both transistors are either on or off *together*. Note that the circuit uses complementary transistors (one *npn* and one *pnp*), unlike the classic circuit in Fig. 2 which has two transistors of the same type. It also employs a single capacitor for timing, rather than two.

For the purposes of understanding the multivibrator action we can simply remove preset pot VR1 and transistor TR3 as these serve only to hold both multivibrator transistors off when the light level is high. We can also remove the l.e.d. (D1) and the supply decoupling capacitor C2, as these are not essential to description of the oscillation process. This leads to the simpler version of Fig.3 which can be analysed as follows.

Start by assuming both transistors are fully *ON*, so TR1's collector is pulled up to $+V_{CC}$ and TR1 base is just 0·6V below the supply rail (TR1 being a *pnp* type, remember). This is not a stable situation because capacitor C1 will continue to charge – base current flowing out of C1's negative plate while an equal current flows to the positive plate via TR1's collector.

While the transistors are switched on, the collector of TR1 will stay fairly constant at its V_{CEsat} (collector-emitter saturation voltage, about 0·2V) below V_{CC}, so as C1 charges, the base-emitter voltage V_{BE} of TR2 will drop. At some point this will cause TR2 to start to turn off, which in turn will turn off TR1.

As TR1 turns off, its collector voltage will drop towards 0V, the voltage across C1 will not be able to change quickly enough to keep up with this, and so the voltage at the base of TR2 will be pushed lower by C1. This *regenerative* action will turn TR2 off even more and hence TR1 off more still, *a positive feedback effect* resulting in a very rapid switch-off of both transistors.

This happened so quickly that the voltage across C1 will still be about ($V_{CC} - V_{BE} - V_{CEsat}$) volts, but now TR1's collector is at 0V so TR2's base will be at approximately – (V_{CC} – 0·8) volts. At this point C1 will start to charge towards $+V_{CC}$ via resistor R1, but as soon as it reaches about +0·6V TR2 will turn on causing TR1 to turn on as well and pulling TR2's base even higher via C1 (again this is positive feedback effect giving fast switching between states).

Capacitor C1 will rapidly charge towards +0·6V on its negative plate and (V_{CC} − V_{CEsat}) on its positive plate due to the high base current in TR2 and collector current of TR1. This brings us back to the point where we started and thus the circuit oscillates.

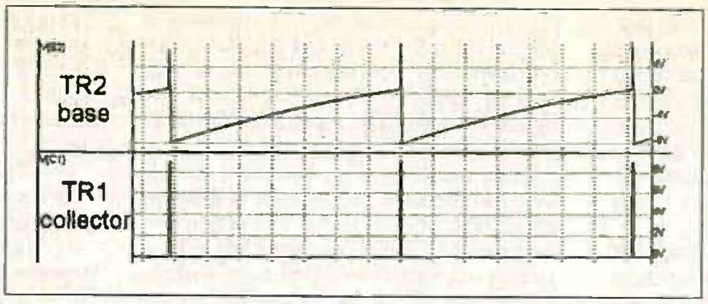


Fig.4. Screen waveform for a Lighting-Up style astable (9V supply, arbitary timebase).

Simulation

When any doubt exists over the operation of a circuit, it is common to analyse it by using a computer-based simulator package. The circuit is "built" on-screen and can then be tested and sampled. We did this with the oscillator and simulated circuit waveforms are shown in Fig. 4. The upper waveform is a simulation of TR2's base; TR1's collector is below. An arbitrary timebase and 9V supply are assumed.

As long as C1 and R1 are reasonably large the time during which TR1 and TR2 are on will be very short compared to the time which they are off. The current taken from the power supply will be small during the off period (if R1 is large) but may be very high during the on period (if R2 is small). This is one reason why the circuit is suitable for the lighting-up reminder – it provides short high current pulses to the l.e.d. but does not have a large continuous current drain.

The value of R2 must be large enough to prevent excessive current flowing in TR2's collector. The value of R1 must be large, not only to give the long time period described, but also to ensure oscillation occurs. If R1 is too small it will provide enough current to turn TR2 fully on all the time, preventing oscillation. If you want a longer "on" period then a resistor can be placed in series with C1, however, if this value is too large the circuit may fail to oscillate.

The multivibrator used in the *Lighting-Up* circuit (and the *Metronome*) is just one of a number of similar circuits which employ two complementary transistors to a make a multivibrator. In general these circuits are used to provide short pulse waveforms (which can provide flashes or clicks), they also provide sawtooths if the capacitor voltage is used.

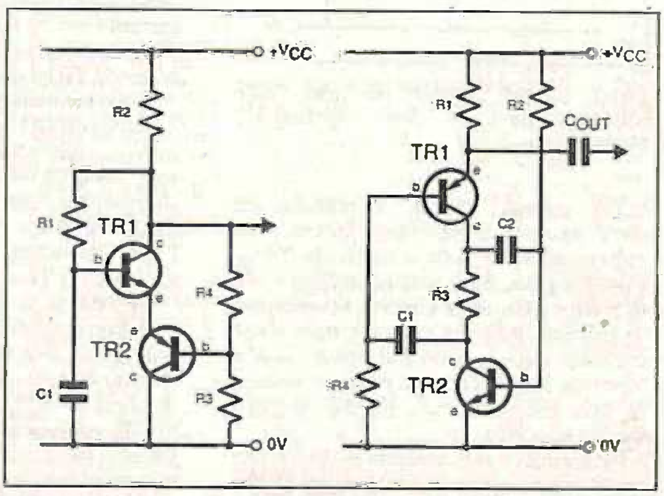


Fig.5. More complementary transistor multivibrator circuits. Can you figure out how they work?

A couple of other examples are shown in Fig. 5, which you might like to experiment with. Unlike the earlier circuits, both these circuits have the transistors in *series*.

You can find yet more multivibrator circuits of various types on 4QD's web pages of "interesting circuits" at: www.4qd.co.uk/ccts/mvibs.html. *IMB.*

Transistors in a PICkle

From a reader of our Internet-only edition of the magazine *EPE On-Line* (www.epemag.com) came the following query:

I want to build your Mind PICkler *but could not find the transistors over here in the USA. Do you have different product numbers in the UK? If you do, this will make your projects harder for us to build – I have been very happy with your magazine until I tried to build the* Mind PICkler *project. (Via AOL.)*

Yes, in Europe we do have our own semiconductor ranges that may seem pretty alien compared to the devices you're accustomed to in the USA. Europe does have a very active semiconductor industry of its own you know!

Most of our project contributors use European devices plus a small number of 2N types. A range of 2N transistors is available from larger UK vendors but BC device types are as common over here as your 2N types are in the States. We also have a number of readers in Japan, though I must confess that we have never, as far as I can recall, used Japanese "2S" transistors.

My main reference – *Towers' International Transistor Selector* (ISBN 0-572-02121-6) – describes the European "Pro Electron" type numbering system for transistors as follows.

First letter – material used: A – Germanium; B – Silicon; C – Gallium Arsenide; R – Special compound (example, Cadmium Sulphide as used in light-dependent resistors).

Second letter – function: C – low power audio; D – power transistor audio; F – HF low power; L – HF power; S – low power switching; U – power switching.

A suffix letter may be used (as in the BC184L and BC214L used in the *Mind PICkler*) but this has no standardised meaning.

American devices use the "JEDEC" (Joint Electronic Device Engineering Councils) code of 2N prefixes for all transistors, thyristors and triacs and it is from this family that you are seeking an equivalent. I'm afraid it's part of the "deal" of hobby electronics that one may need to be resourceful at times and perhaps find alternatives to devices used in a prototype.

This applies not only to semiconductors but perhaps some hardware items (e.g. relays or transformers) as well. The designer will always make it clear if device types are critical, and the *Shoptalk* column must also be consulted as regards component-buying matters.

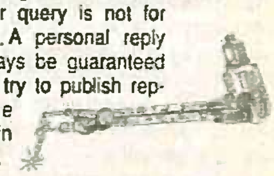
Concerning the *Mind PICkler*, according to Towers' equivalents are as follows: BC184L – 2N5210; BC214L – 2N5087. There seems to be nothing special about these small-signal transistors. Other types should work equally well. The collector-emitter voltage is 50V maximum rating, collector current rating 200mA and gain h_{FE} 250.

However, it is obviously important to observe the pinouts, and it will be seen from the p.c.b. layout that we made the transistor connections crystal-clear. The collector is the centre pin in the p.c.b. design, and alternative devices will probably need to be orientated to make their wires fit. Both the 2N5210 and 2N5087 are *e-b-c* (standard TO92 plastic packages) not *e-c-b* per the board which means twisting the transistor body so that its leads fit correctly.

It is true that occasionally there are minor problems for overseas readers when "special" transistors are called for. If this causes a problem we will try to suggest an equivalent upon request but they may not have been tried and tested in the design. *ARW*

CIRCUIT THERAPY

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



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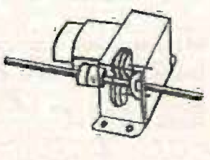

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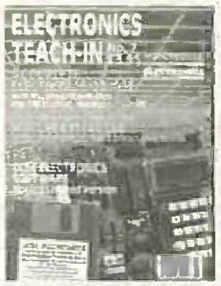

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This book describes in detail how to construct some simple and inexpensive but extremely useful, pieces of test equipment. Stripboard layouts are provided for all designs, together with wiring diagrams where appropriate, plus notes on construction and use.

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R. A. Penfold

Deals with the simple methods of copying printed circuit board designs from magazines and books, and covers all aspects of simple p.c.b. construction including photographic methods and designing your own p.c.b.s.

66 pages **Order code BP121** £3.99

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; Resistor colour codes, capacitor value markings, etc; Advice on buying the right tools for the job; Soldering, with advice on how to produce good joints and avoid "dry" joints; Making easy work of the hard wiring; Construction methods, including stripboard, custom printed circuit boards, plain matrix board, surface mount boards and wire-wrapping; Finishing off, and adding panel labels; Getting "problem" projects to work, including simple methods of fault-finding; In fact everything you need to know in order to get started in this absorbing and creative hobby.

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R. A. Penfold

This book provides a number of practical designs for video accessories that will help you get the best results from your camcorder and VCR. All the projects use inexpensive components that are readily available, and they are easy to construct. Full construction details are provided, including stripboard layouts and wiring diagrams. Where appropriate, simple setting up procedures are described in detail; no test equipment is needed.

The projects covered in this book include: Four channel audio mixer, Four channel stereo mixer, Dynamic noise limiter (DNL), Automatic audio fader, Video faders, Video wipers, Video crispener, Mains power supply unit.

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SETTING UP AN AMATEUR RADIO STATION
I. D. Poole

The aim of this book is to give guidance on the decisions which have to be made when setting up any amateur radio or short wave listening station. Often the experience which is needed is learned by one's mistakes, however, this can be expensive. To help overcome this, guidance is given on many aspects of setting up and running an efficient station. It then proceeds to the steps that need to be taken in gaining a full transmitting licence.

Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

An essential addition to the library of all those taking their first steps in amateur radio.

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H. C. Wright

Although nearly a century has passed since Marconi's first demonstration of radio communication, there is still research and experiment to be carried out in the field of antenna design and behaviour.

The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-life apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc. These materials are, in general, cheap to obtain and easily worked with simple tools, encouraging the trial-and-error philosophy which leads to innovation and discovery.

Although primarily a practical book with text closely supported by diagrams, some formulae which can be used by straightforward substitution and some simple graphs have also been included.

72 pages **Order code BP278** £3.50

25 SIMPLE INDOOR AND WINDOW AERIALS
E. M. Noll

Many people live in flats and apartments or other types of accommodation where outdoor aerials are prohibited, or a lack of garden space etc. prevents aerials from being erected. This does not mean you have to forgo shortwave listening, for even a 20-foot length of wire stretched out along the skirting board of a room can produce acceptable results. However, with some additional effort and experimentation one may well be able to improve performance further.

This concise book tells the story, and shows the reader how to construct and use 25 indoor and window aerials that the author has proven to be sure performers.

Much information is also given on shortwave bands, aerial directivity, time zones, dimensions etc.

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TWO EXCITING BOOKS

Specially imported by *EPE*

Bebop To The Boolean Boogie

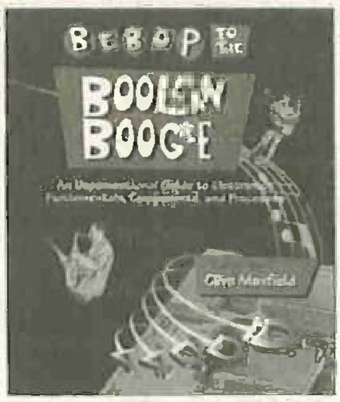
By Clive (call me Max) Maxfield

ORDER CODE BEB1 £24.95

An Unconventional Guide to Electronics Fundamentals, Components and Processes

The Foreword by Pete Waddell, Editor, *Printed Circuit Design*, reads:

"Personally, I think that the title of this tome alone (hmmm, a movie?) should provide some input as to what you can expect. But, for those who require a bit more: be forewarned, dear reader, you will probably learn far more than you could hope to expect from *Bebop to the Boolean Boogie*, just because of the unique approach Max has to technical material. The author will guide you from the basics through a minefield of potentially boring theoretical mish-mash, to a Nirvana of understanding. You will not suffer that fate familiar to every reader: re-reading paragraphs over and over wondering what in the world the author was trying to say. For a limey, Max shoots amazingly well and from the hip, but in a way that will keep you interested and amused. If you are not vigilant, you may not only learn something, but you may even enjoy the process. The only further advice I can give is to 'expect the unexpected'."



This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more (including a recipe for a truly great seafood gumbo!).

Hundreds of carefully drawn illustrations clearly show the important points of each topic. The author's tongue-in-cheek British humor makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. A great reference for your own shelf, and also an ideal gift for a friend or family member who wants to understand what it is you do all day. . . .

By importing these books ourselves we have managed to make them available in the UK at an exceptional price.

Bebop Bytes Back

By Clive "Max" Maxfield and Alvin Brown

ORDER CODE BEB2 £29.95

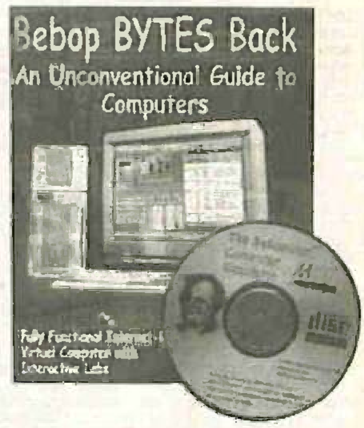
An Unconventional Guide To Computers

Plus **FREE CD-ROM** which includes: Fully Functional Internet-Ready Virtual Computer with Interactive Labs

The Foreword by Lee Felsenstein reads:

"1. The more time you spend with this book and its accompanying CD-ROM, the more you'll get out of it. Skimming through it won't take you where you want to go. Paying serious attention, on the other hand, will teach you more about computers than you can imagine. (You might also see a few beautiful sunrises.)

2. The labs work on two levels: on and under the surface. When you're performing the labs you'll need to look for patterns that build up from individual events.



3. When you're done, you won't look any different. You won't get a trophy or a certificate to hang on your wall. You'll have some knowledge, and some skill, and you'll be ready to find more knowledge and develop more skill. Much of this will be recognisable only to someone who has the same knowledge and skill."

This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the accompanying CD-ROM (for Windows 95 machines only) contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the book contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers.

If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this one!

Audio and Music

VALVE & TRANSISTOR AUDIO AMPLIFIERS
John Linsley Hood

This is John Linsley Hood's greatest work yet, describing the milestones that have marked the development of audio amplifiers since the earliest days to the latest systems. Including classic amps with valves at their heart and exciting new designs using the latest components, this book is the complete world guide to audio amp design.

Contents: Active components; Valves or vacuum tubes; Solid-state devices; Passive components; Inductors and transformers; Capacitors. Resistors. Switches and electrical contacts; Voltage amplifier stages using valves; Valve audio amplifier layouts; Negative feedback; Valve operated power amplifiers; Solid state voltage amplifiers; Early solid-state audio amplifiers; Contemporary power amplifier designs; Preamplifiers; Power supplies (PSUs); Index.

250 pages **Order code NE24** £19.99

AUDIO AMPLIFIER PROJECTS
R. A. Penfold

A wide range of useful audio amplifier projects, each project features a circuit diagram, an explanation of the circuit operation and a stripboard layout diagram. All constructional details are provided along with a shopping list of components, and none of the designs requires the use of any test equipment in order to set up properly. All the projects are designed for straightforward assembly on simple circuit boards.

Circuits include: High impedance mic preamp, Low impedance mic preamp, Crystal mic preamp, Guitar and GP preamplifier, Scratch and rumble filter, RIAA preamplifier, Tape preamplifier, Audio limiter, Bass and treble tone controls, Loudness filter, Loudness control, Simple graphic equaliser, Basic audio mixer, Small (300mW) audio power amp, 6 watt audio power amp, 20/32 watt power amp and power supply, Dynamic noise limiter.

A must for audio enthusiasts with more sense than money!

116 pages **Order code PC113** £9.95

MAKING MUSIC WITH DIGITAL AUDIO
Ian Waugh

In this practical and clearly-written book, Ian Waugh explains all aspects of the subject from digital audio basics to putting together a system to suit your own music requirements. Using the minimum of technical language, the book explains exactly what you need to know about: Sound and digital audio, Basic digital recording principles, Sample rates and resolutions, Consumer sound cards and dedicated digital audio cards.

On a practical level you will learn about: sample editing, digital multi-tracking, digital FX processing, integrating MIDI and digital audio, using sample CDs, mastering to DAT and direct to CD, digital audio and Multimedia.

This book is for every musician who wants to be a part of the most important development in music since the invention of the gramophone. It's affordable, it's flexible, it's powerful and it's here now! It's digital and it's the future of music making.

256 pages **Order code PC114** £14.95

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CIRCUITS AND DESIGN

AN INTRODUCTION TO PIC MICROCONTROLLERS
Robert Penfold

Designing your own PIC based projects may seem a daunting task, but it is really not too difficult providing you have some previous experience of electronics. The PIC processors have plenty of useful features, but they are still reasonably simple and straightforward to use. This book should contain everything you need to know.

Topics covered include: the PIC register set; numbering systems; bitwise operations and rotation; the PIC instruction set; using interrupts; using the analogue to digital converter; clock circuits; using the real time clock counter (RTCC); using subroutines; driving seven segment displays.

166 pages **Order code BP394** £5.99

PRACTICAL OSCILLATOR CIRCUITS
A. Flind

Extensive coverage is given to circuits using capacitors and resistors to control frequency. Designs using CMOS, timer i.c.s and op.amps are all described in detail, with a special chapter on "waveform generator" i.c.s. Reliable "white" and "pink" noise generator circuits are also included.

Various circuits using inductors and capacitors are covered, with emphasis on stable low frequency generation. Some of these are amazingly simple, but are still very useful signal sources.

Crystal oscillators have their own chapter. Many of the circuits shown are readily available special i.c.s for simplicity and reliability, and offer several output frequencies. Finally, complete constructional details are given for an audio sinewave generator.

133 pages **Order code BP393** £4.99

PRACTICAL ELECTRONIC CONTROL PROJECTS
Owen Bishop

Explains electronic control theory in simple, non-mathematical terms and is illustrated by 30 practical designs suitable for the student or hobbyist to build. Shows how to use sensors as input to the control system, and how to provide output to lamps, heaters, solenoids, relays and motors.

Computer based control is explained by practical examples that can be run on a PC. For stand-alone systems, the projects use microcontrollers, such as the inexpensive and easy-to-use Stamp BASIC microcontroller. These projects are chosen to introduce and demonstrate as many aspects as possible of the programming language and techniques.

198 pages **Order code BP377** £5.99

PRACTICAL ELECTRONICS HANDBOOK – Fourth Edition. Ian Sinclair

Contains all of the everyday information that anyone working in electronics will need.

It provides a practical and comprehensive collection of circuits, rules of thumb and design data for professional engineers, students and enthusiasts, and therefore enough background to allow the understanding and development of a range of basic circuits.

Contents: Passive components, Active discrete components, Discrete component circuits, Sensing components, Linear I.C.s, Digital I.C.s, Microprocessors and microprocessor systems, Transferring digital data, Digital-analogue conversions, Computer aids in electronics, Hardware components and practical work, Standard metric wire table, Bibliography, The HEX scale, Index.

440 pages **Order code NE21** £14.99

COIL DESIGN AND CONSTRUCTIONAL MANUAL
B. B. Babani

A complete book for the home constructor on "how to make" RF, IF, audio and power coils, chokes and transformers. Practically every possible type is discussed and calculations necessary are given and explained in detail. Although this book is now twenty years old, with the exception of toroids and pulse transformers little has changed in coil design since it was written.

96 pages **Order code 160** £3.99

OPTOELECTRONICS CIRCUITS MANUAL
R. M. Marston

A useful single-volume guide to the optoelectronics device user, specifically aimed at the practical design engineer, technician, and the experimenter, as well as the electronics student and amateur. It deals with the subject in an easy-to-read, down-to-earth, and non-mathematical yet comprehensive manner, explaining the basic principles and characteristics of the best known devices, and presenting the reader with many practical applications and over 200 circuits. Most of the i.c.s and other devices used are inexpensive and readily available types, with universally recognised type numbers.

182 pages **Order code NE14** £14.99

OPERATIONAL AMPLIFIER USER'S HANDBOOK
R. A. Penfold

The first part of this book covers standard operational amplifier based "building blocks" (integrator, precision rectifier, function generator, amplifiers, etc), and considers the ways in which modern devices can be used to give superior performance in each one. The second part describes a number of practical circuits that exploit modern operational amplifiers, such as high slew-rate, ultra low noise, and low input offset devices. The projects include: Low noise tape preamplifier, low noise RIAA preamplifier, audio power amplifiers, d.c. power controllers, opto-isolator audio link, audio millivolt meter, temperature monitor, low distortion audio signal generator, simple video fader, and many more.

120 pages **Order code BP335** £4.95

A BEGINNERS GUIDE TO CMOS DIGITAL ICs
R. A. Penfold

Getting started with logic circuits can be difficult, since many of the fundamental concepts of digital design tend to seem rather abstract, and remote from obviously useful applications. This book covers the basic theory of digital electronics and the use of CMOS integrated circuits, but does not lose sight of the fact that digital electronics has numerous "real world" applications.

The topics covered in this book include: the basic concepts of logic circuits; the functions of gates, inverters and other logic "building blocks"; CMOS logic i.c. characteristics, and their advantages in practical circuit design; oscillators and monostables (timers); flip/flops, binary dividers and binary counters; decade counters and display drivers.

The emphasis is on a practical treatment of the subject, and all the circuits are based on "real" CMOS devices. A number of the circuits demonstrate the use of CMOS logic i.c.s in practical applications.

119 pages **Order code BP333** £4.95

AUDIO AND MUSIC

INTRODUCTION TO DIGITAL AUDIO (Second Edition)
Ian Sinclair

Digital recording methods have existed for many years and have become familiar to the professional recording engineer, but the compact disc (CD) was the first device to bring audio methods into the home. The next step is the appearance of digital audio tape (DAT) equipment.

All this development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.

This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory is avoided, other than to state the end product.

128 pages **Order code PC102** £7.95

PROJECTS FOR THE ELECTRIC GUITAR
J. Chatwin

This book is for anyone interested in the electric guitar. It explains how the electronic functions of the instrument work together, and includes information on the various pickups and transducers that can be fitted. There are complete circuit diagrams for the major types of instrument, as well as a selection of wiring modifications and pickup switching circuits. These can be used to help you create your own custom wiring.

Along with the electric guitar, sections are also included relating to acoustic instruments. The function of specialised piezoelectric pickups is explained and there are detailed instructions on how to make your own contact and bridge transducers. The projects range from simple preamps and tone boosters, to complete active controls and equaliser units.

92 pages **Order code BP358** £4.95

MIDI SURVIVAL GUIDE
Vic Lennard

Whether you're a beginner or a seasoned pro, the MIDI Survival Guide shows you the way. No maths, no MIDI theory, just practical advice on starting up, setting up and ending up with a working MIDI system.

Over 40 cabling diagrams. Connect synths, sound modules, sequencers, drum machines and multitracks. How to budget and buy secondhand. Using switch, thru and merger boxes. Transfer songs between different sequencers. Get the best out of General MIDI. Understand MIDI implementation charts. No MIDI theory.

104 pages Temporarily out of print

PRACTICAL ELECTRONIC MUSICAL EFFECTS UNITS
R. A. Penfold

This book provides practical circuits for a number of electronic musical effects units. All can be built at relatively low cost, and use standard, readily available components. The projects covered include: Waa-Waa Units; Distortion Units; Phaser; Guitar Envelope Shaper; Compressor; Tremolo Unit; Metal Effects Unit; Bass and Treble Boosters; Graphic Equaliser; Parametric Equaliser. The projects cover a range of complexities, but most are well within the capabilities of the average electronics hobbyist. None of them require the use of test equipment and several are suitable for near beginners.

102 pages **Order code BP368** £4.95

LOUDSPEAKERS FOR MUSICIANS
Vivan Capel

This book contains all that a working musician needs to know about loudspeakers; the different types, how they work, the most suitable for different instruments, for cabaret work, and for vocals. It gives tips on constructing cabinets, wiring up, when and where to use wadding, and when not to, what fittings are available, finishing, how to ensure they travel well, how to connect multi-speaker arrays and much more.

Ten practical enclosure designs with plans and comments are given in the last chapter, but by the time you've read that far you should be able to design your own!

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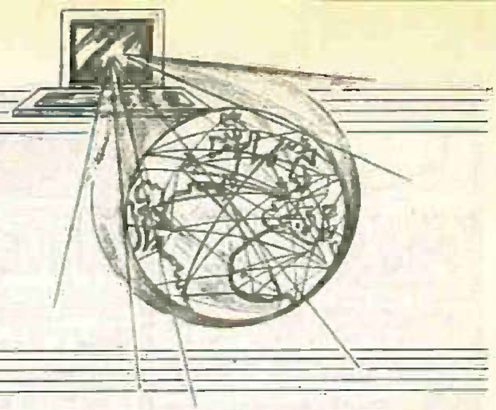
SURFING THE INTERNET

NET WORK

ALAN WINSTANLEY



WELCOME to our monthly column written specially for users of the Internet – which includes most of our readership. New on the *EPE* web site (**www.epemag.wimborne.co.uk**) is the arrival of the *Modern Electronics Manual* (MEM) and the *Electronics Service Manual* (ESM), the two constantly-updated manuals which are available on a no-risk subscription basis from the publishers of *EPE*. You can now read about the contents and structure of each Manual, and by the time you read this it will be possible to purchase on-line via a secure order form.

EXPLORER 5 COMES OF AGE

The war of the browsers seems to have rather subsided as the distinctions between different types are becoming increasingly blurred. In many cases, mainstream consumer users have adopted Internet Explorer by default because it arrived with their desk top operating system, and they know of no alternatives nor how to install them. The rise of Microsoft Internet Explorer together with the adoption of "URLs with everything" are examples of how Microsoft turned on a sixpence and re-invented itself to embrace the Internet. Hewlett Packard is currently doing the same as regards e-commerce.

About five years ago the National Center for Supercomputing Applications at the University of Illinois created amongst the first popular browsers (NCSA Mosaic) for Windows and also for Unix users. Access to the Internet from a Windows PC needed some tinkering under the bonnet with Mosaic .ini files and separately installed Winsocks, but much of this was simplified when Windows 95 came along.

It is Netscape, originally founded on NCSA Mosaic know-how which was then rewritten, which did most of the running in the early days of web browsing with its Navigator browser. Spry persevered with the Mosaic browser and this was to be made available to CompuServe users for a time. All in all, getting Internet access was a tricky operation involving a lot of perseverance and some software skills, with flaky software, slow connections and a tiny handful of ISPs.

The earliest screenshots of browser windows taken in the mid 90s had neither a Microsoft Windows logo nor a Netscape "N", but the distinctive Mosaic "S" globe taken from the NCSA logo (examples of which are at **http://www.ncsa.uiuc.edu**). Netscape then embarked upon the progressive development of its browser, which at the time became the best browser bar none. I have a copy of Netscape 1.22 for Windows 3.1 which fitted onto a single floppy disk, and was in use before Microsoft even appeared on the Internet browser scene, at a time of 9,600 or 14,400 access speeds!

Early versions of Internet Explorer were best held and used at arm's length, and regular readers will know that I deliberately hesitated before installing MSIE 4.0, especially as I had taken a strong disliking to the loathsome "Active Desktop". It was, therefore, with some foreboding that I decided to take the plunge and use Explorer 5. I have to say that I have been very pleasantly surprised.

Installation was somewhat slow but flawless, and I have yet to see any error messages or problems. Surfing seems slightly more reliable, with fewer Javascript error messages. Much of what MSIE 5.0 is about is hidden behind the familiar-looking Explorer interface, but one improvement which readers will enjoy is the browser's treatment of FTP sites, which now appear as familiar-looking Windows folders. The process of anonymous FTP is much more reliable and easier than before. Off-line browsing also works well, so that you can view web pages held in your cache, even when disconnected. The browser seems at last to have come of age.

HIDDEN WORMS

In previous *Net Work* columns I explained the differences between computer viruses, Worms and Trojan Horses. These are malicious codes which are easily transmitted via the Internet, both by E-mail and also by file transfers. Remember the golden rule that no file attachments should ever be run unless you are quite certain that they are from a known, trusted source. Recall that you cannot suffer a virus attack merely by reading an E-mail, but you can introduce a damaging virus by running an attachment. Opening Microsoft Word to read an attached .doc file constitutes running an attached file.

Hot on the heels of computer viruses reported in earlier *Net Work* articles, the latest Worm to escape is **Worm.ExploreZip**, also known as **W32.ExploreZip**. This has some Melissa-like characteristics in that it propagates itself by using the Inbox of Microsoft Outlook (including Express) or Exchange mail systems to send a message in reply to any unread mails. It also launches Windows Explorer whenever Windows is booted up, and it contains a Trojan Horse, an invitingly innocent-looking file which will cause damage when executed.

The originating message will arrive in the form of the message "Hi *<username>. I received your email and I shall send you a reply ASAP. Till then, take a look at the attached zipped docs. Bye*". An executable file is attached to the message.

Incredibly, people fall for it. It has already reportedly damaged some major institutions' networks and E-mail systems which had to be shut down until they could be disinfected. The Worm will also seek out and infect any mapped drives on a network, and those machines will in turn mail out the Worm to its own unread mails. Thus the Worm multiplies and infects other systems.

Once again it is stressed how dangerous it can be to open and run an attached file from an untrusted source. In the case of **Worm.ExploreZip**, a file called **zipped_files.exe** is attached to the innocent-looking E-mail. If it were a Zip file then it would have a .zip extension, and the .exe is an obvious clue that the file is really an executable program.

When the attached **.exe** is run, the Worm will not only reside on the infected system and launch itself every time the Windows PC is booted up, but it will also seek and destroy a variety of file types. *EPE* readers may be dismayed to note that one susceptible file type has the .asm extension, the source code files used in PIC microcontroller programs. The Worm will also hunt out and delete any *.c, or *.h or *.doc files (and more besides) both on the host machine and any others attached via a local area network, so if ever there was a reason to create regular backups, this Worm illustrates it.

Escaped Worms now make big news and this one was reported on CNN a day or so before it made it to the quality press. You should make a point of checking the anti-virus web sites as described previously. A utility file called **kill_ez** is provided by Symantec, who also describe a manual method of deleting the Worm: an update for Norton Anti Virus quickly became available but for some the news came too late.

TROJAN TROUNCED

As a final warning – half an hour before writing this I fetched the latest virus update for my Norton software from Symantec. I then ran a check over my small network, and lo and behold, Norton reported a Trojan Horse. It turns out that it is the Pentium P3 serial number I.D. exploit about which I reported last month. It is there, residing on a hard disk (of an old Pentium pre-MMX machine) and I didn't even know about it. Hard disks are getting bigger, programs can contain thousands of files and eat prodigious amounts of space: it is so easy to forget about individual files which in a moment of forgetfulness (lasting several *ohnoseconds*) could be launched and inflict damage. Here's one Trojan Horse which has been firmly put down.

As always I have listed some interesting URLs on the *Net Work* web page of the *EPE* web site. Please do get in touch if you know of any sites which may be of interest to our readers. My E-mail address is **alan@epemag.demon.co.uk**.

PCB SERVICE

Printed circuit boards for certain EPE constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to The PCB Service, ***Everyday Practical Electronics***, **Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749; Fax 01202 841692 (NOTE, we cannot reply to orders or queries by Fax); E-mail: orders@epemag.wimborne.co.uk** . Cheques should be crossed and made payable to *Everyday Practical Electronics* (Payment in £ sterling only).

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Print Timer, 874; Stereo HiFi Controller – Power Supply, 886 – Main Board, 887 – Expansion/Display Boards, (pair) 888; Power Controller, 905; Active Guitar Tone Control, 907; TV Off-er (pair), 908/909; Video Modules – 1 Simple Fader, 910; Video Enhancer, 912; 12V 35W PA Amplifier, 930; ★National Lottery Predictor, 935; MIDI Pedal, 938; Club Vote Totaliser, 939; Ramp Generator – Logic Board (double-sided p.t.h.), 944 – Analogue board, 945; Microcontrolled 3-Digit Timer, 933; Low-Range Ohmmeter Adaptor, 926; Vandata – Boot Control Unit, 953 – Display Unit, 954; Capacitor Check, 955.

Any of the above for just £2 each inc. VAT and p&p.

Back numbers or photostats of articles are available see the *Back Issues* page for details.

PROJECT TITLE		Order Code	Cost
Digital Delay Line	NOV'95	958	£8.04
50Hz Field Meter		959	£8.32
Temperature Warning Alarm (Teach-In '96)		960	£6.15
Stereo "Cordless" Headphones	DEC'95		
Transmitter		961	£8.04
Receiver		962	£7.66
★EPE Met Office – Sensor/Rainfall/Vane		963/965	£11.33
Spiral transparency free with above p.c.b.			
★EPE Met Office –	JAN'96		
Computer Interface (double-sided)		964	£7.69
Audio Signal Generator		969	£6.58
Automatic Camera Panning (Teach-In '96)		972	£6.63
Printer Sharer		973	£9.93
Vari-Speed Dice (Teach-In '96)	FEB'96	974	£5.69
Mains Signalling Unit – 2 12V Capacitive PSU		975	£6.07
Multi-Purpose Mini Amplifier	MAR'96	976	£6.12
High Current Stabilised Power Supply		979	£6.62
Mind Machine Mk III – Sound and Lights		980	£7.39
Infra-Zapper Transmitter/Receiver (Teach-In '96)		981/982 (pr)	£8.01
Bat Band Converter/B.F.O.	APR'96	984a/b	£5.80
Hearing Tester		985	£6.87
Event Counter (Teach-In '96)		986	£8.39
B.F.O. and Bat Band Converter	MAY'96	984a/b	£5.80
Versatile PIR Detector Alarm		988	£6.76
Mind machine Mk III – Tape Controller		989	£6.70
Midi Analyser		992	£6.74
Countdown Timer (Teach-In '96)		993	£9.44
Sarah's Light	JUNE'96	996	£7.17
Home Telephone Link		997 (pr)	£10.72
★PulStar		998	£6.60
VU Display and Alarm		999	£7.02
Ultra-Fast Frequency Generator	JULY'96		
and Counter – Oscillator/L.C.D. Driver		994/995 (pr)	£12.72
Timed NiCad Charger		100	£6.99
Single-Station Radio 4 Tuner		101	£7.02
Twin-Beam Infra-Red Alarm – Transmitter/Receiver		102/103 (pr)	£10.50
★Games Compendium		104	£6.09
Mono "Cordless" Headphones	AUG'96		
– Transmitter/Receiver		990/991 (pr)	£10.16
Component Analyser (double-sided p.t.h.)		105	£12.18
Garden Mole-Ester		106	£6.07
Mobile Miser		107	£6.36
Bike Speedo		108	£6.61
★PIC-Tock Pendulum Clock	SEPT'96	109	£6.31
Power Check		110	£6.42
Analogue Delay/Flanger		111	£7.95
Draught Detector		112	£6.22
Simple Exposure Timer		113	£6.63

PROJECT TITLE		Order Code	Cost
Video Fade-to-White	OCT '96	114	£6.98
Direct Conversion 80m Receiver		116	£7.52
Vehicle Alert		117	£6.55
10MHz Function Generator– Main Board		118	£7.33
– PSU		119	£5.39
Tuneable Scratch Filter	NOV '96	115	£7.83
★Central Heating Controller		120	£7.85
D.C. to D.C. Converters – Negative Supply Generator		122	£5.95
– Step-Down Regulator		123	£6.01
– Step-Up Regulator		124	£6.12
★PIC Digital/Analogue Tachometer	DEC '96	127	£7.23
Stereo Cassette Recorder			
Playback/PSU		128	£7.94
Record/Erase		129	£9.04
★Earth Resistivity Meter	JAN '97		
Current Gen. – Amp/Rect.		131/132 (pr)	£12.70
Theremin MIDI/CV Interface (double-sided p.t.h.)		130 (set)	£40.00
Mains Failure Warning		126	£6.77
Pacific Waves	FEB '97	136	£9.00
PsiCom Experimental Controller		137	£6.78
Oil Check Reminder	MAR '97	125	£7.16
Video Negative Viewer		135	£6.75
Tri-Colour NiCad Checker		138	£6.45
Dual-Output TENS Unit (plus Free TENS info.)		139	£7.20
★PIC-Agoras – Wheelie Meter	APRIL '97	141	£6.90
418MHz Remote Control – Transmitter		142	£5.36
– Receiver		143	£6.04
Puppy Puddle Probe		145	£6.10
MIDI Matrix – PSU		147	£5.42
– Interface		148	£5.91
Quasi-Bell Door Alert	MAY '97	133	£6.59
2M F.M. Receiver		144	£7.69
★PIC-A-Tuner		149	£7.83
Window Closer – Trigger		150	£4.91
– Closer		151	£4.47
Child Minder Protection Zone	JUN '97		
– Transmitter		153	£6.58
– Receiver		154	£6.42
Pyrotechnic Controller		155	£6.93
★PIC Digilogue Clock		156	£7.39
Narrow Range Thermometer		158	£6.37
Micropower PIR Detector – 1	JULY '97	152	£6.69
Infra-Red Remote Control Repeater			
(Multi-project P.C.B.)		932	£3.00
Karaoke Echo Unit – Echo Board		159	£6.40
– Mixer Board		160	£6.75
Computer Dual User Interface		161	£6.70
★PEsT Scarer		162	£6.60
Variable Bench Power Supply	AUG '97	932	£3.00
Universal Input Amplifier		146	£6.55
Micropower PIR Detector – 2 Controller		163	£6.72
★PIC-OLO		164	£7.02
Active Receiving Antenna	SEPT '97	140	£6.59
Soldering Iron Controller		157	£6.63
★PIC Noughts & Crosses Game		165	£7.82
Micropower PIR Detector – 3			
Alarm Disarm/Reset Switch		166	£5.72
Ironing Safety Device		167	£5.12
Remote Control Finder	OCT '97	168	£6.32
Rechargeable Handlamp		169	£6.23
★PIC Water Descaler		170	£6.90
★EPE Time Machine	NOV '97	171	£8.34
Auto-Dim Bedlight		172	£6.63
Portable 12V PSU/Charger		173	£6.61
Car Immobiliser	DEC '97	175	£7.00
Safe and Sound (Security Bleeper)		179	£7.32
Surface Thermometer	JAN '98	174	£7.64
Disco Lights Flasher		178	£8.30
Waa-Waa Pedal (Multi-project PCB)	FEB '98	932	£3.00
★Virtual Scope – Digital Board		176	£14.49
Analogue Board (per board)		177	£7.34
★Water Wizard		180	£7.69
Kissometer		181	£7.67
★EPE PIC Tutorial	MAR '98	182	£7.99
The Handy Thing (Double-Sided)		183	£6.58
Lighting-Up Reminder		184	£5.90
★Audio System Remote Controller – PSU		185	£7.05
Main Board		186	£8.29
Simple Metal Detector	APR '98		
(Multi-project PCB)		932	£3.00
Single or Dual-Tracking Power Supply		187	£7.90
★RC-Meter		188	£7.66
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Stereo Tone Control plus 20W Stereo Amplifier			
Tone Control		190	£7.78
20W Amplifier		191	£8.58
★Dice Lott		192	£8.05
EPE Mood Changer	JUNE '98	193	£7.75
★AT89C2051/1051 Programmer			
Main Board		194	£8.50
Test Board		195	£8.69
★Reaction Timer Software only		–	–
★PIC16x84 Toolkit	JULY '98	196	£6.96
★Greenhouse Computer			
Control Board		197	£9.08
PSU Board		198	£8.10
Float Charger	AUG '98	199	£6.59
Lightbulb Saver		202	£3.00
Personal Stereo Amplifier	SEPT '98	932	£3.00
(Multi-project PCB)			
★Greenhouse Radio Link		200	£8.32
★PIC Altimeter		201	£8.15
Voice Processor	OCT '98	203	£7.18
★Digiserv R/C Expander		204	£7.69
IR Remote Control			
Transmitter		205	£3.00
Receiver		206	£3.50

PROJECT TITLE		Order Code	Cost
★PIC Tape Measure	NOV '98	207	£6.82
Electronic Thermostat			
T-Stat		208	£4.00
PhizzyB			£14.95
A–PCB B–CD-ROM C–Prog. Microcontroller		Bee (A)(B)(C)	each
15-Way IR Remote Control			
Switch Matrix		211	£3.00
15-Way Rec/Decoder		212	£4.00
Damp Stat	DEC '98	209	£4.50
Handheld Function Generator		213	£4.00
★Fading Christmas Lights		215	£5.16
PhizzyB I/O Board (4-section)		216	£3.95
Twinkle Twinkle Reaction Game	JAN '99	210	£7.55
★EPE Mind PICkler		214	£6.30
PhizzyB I/O Board (4-section)		216	£3.95
Alternative Courtesy Light Controller		217	£6.72
Light Alarm	FEB '99	218	£6.78
★Wireless Monitoring System – Transmitter		219+a	£9.92
Receiver		220+a	£8.56
★PIC MIDI Sustain Pedal Software only		–	–
★Wireless Monitoring System–2	MAR '99		See
F.M. Trans/Rec Adaptors		219a/220a	Feb'99
★Time and Date Generator		221	£7.37
Auto Cupboard Light		222	£6.36
Smoke Absorber		223	£5.94
Ironing Board Saver	APR '99	224	£5.15
Voice Record/Playback Module		225	£5.12
Mechanical Radio (pair)		226A&B	£7.40 pr.
★Versatile Event Counter		207	£6.82
★PIC Toolkit Mk 2	MAY '99	227	£8.95
A.M./F.M. Radio Remote Control			
Transmitter		228	£3.00
Receiver		229	£3.20
★Musical Sundial	JUNE '99	231	£9.51
PC Audio Frequency Meter		232	£8.79
★EPE Mood PICker	JULY '99	233	£6.78
12V Battery Tester		234	£6.72
Intruder Deterrent		235	£7.10
L.E.D. Stroboscope		932	£3.00
(Multi-project PCB)			
Ultrasonic Puncture Finder	AUG '99	236	£5.00
★8-Channel Analogue Data Logger		237	£8.88
Buffer Amplifier (Oscillators Pt 2)		238	£6.96
Magnetic Field Detective		239	£6.77
Sound Activated Switch		240	£6.53
Freezer Alarm (Multi-project PCB)		932	£3.00

EPE SOFTWARE

Software programs for *EPE* projects marked with an asterisk ★ are available on 3.5 inch PC-compatible disks or *free* from our Internet site. Four disks are available: **PIC Tutorial** (Mar-May '98 issues); **PIC Toolkit Mk2** (Mar-Jun '99 issues); **PIC Disk 1** (Apr '95–Dec '98 issues); **EPE Disk 2** (Jan '99 issue to current cover date). The disks are obtainable from the *EPE PCB Service* at £2.75 each (UK) to cover our admin costs (the software itself is *free*). Overseas (each): £3.35 surface mail, £4.35 each airmail. All files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk.**

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