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MAY 1997

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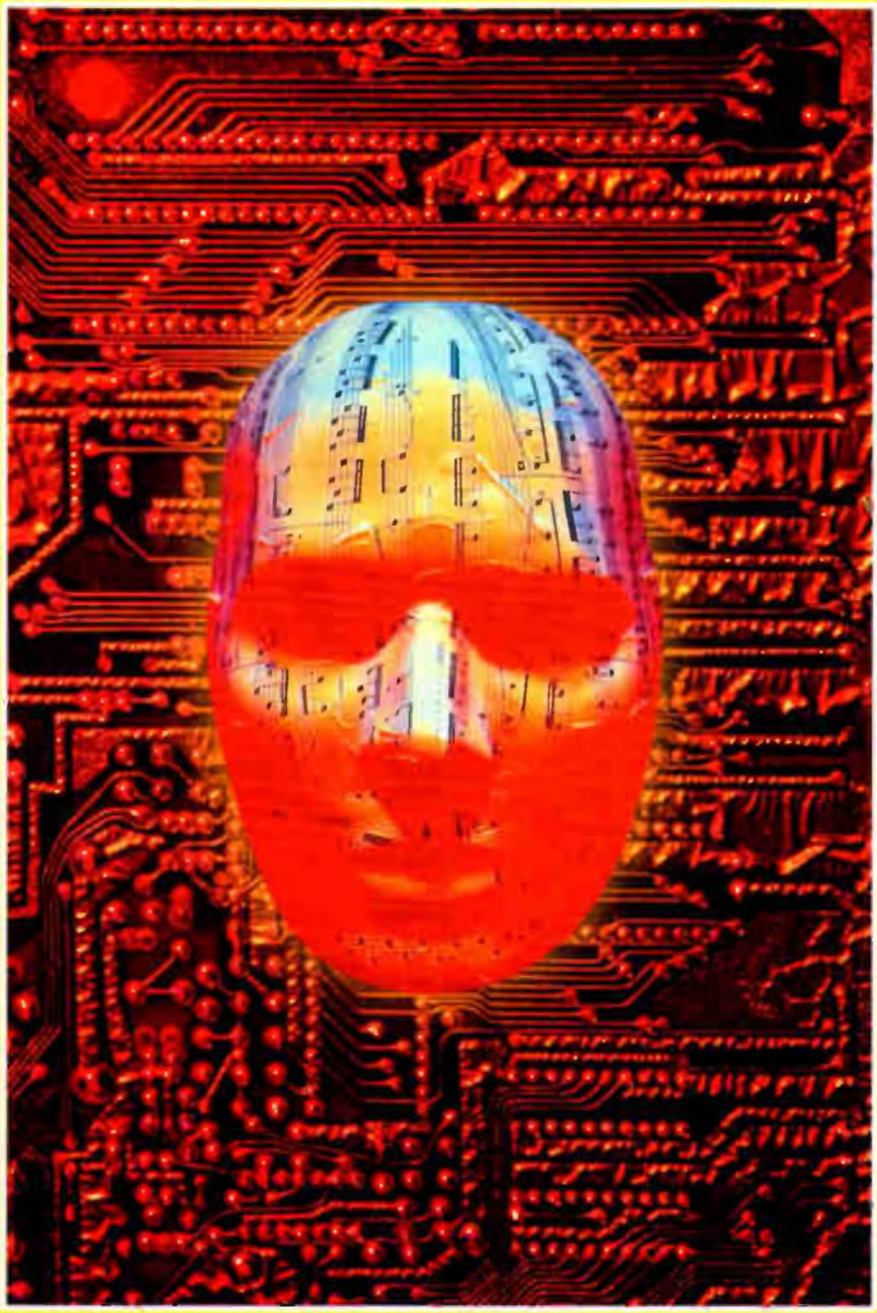

THE No. 1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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PLUS Techniques New Technology Update Innovations Circuit Surgery Ingenuity Unlimited

THERE IS ONE DANGER YOU CAN'T SEE, HEAR, SMELL OR FEEL- ITS RADIATION. THERE ARE OVER 10,000 SHIPMENTS OF RADIOACTIVE MATERIAL IN THE UK EVERY YEAR BY ROAD AND RAIL! WOULD ANYBODY TELL YOU OF A RADIATION LEAK?

NEW GEIGER COUNTER IN STOCK Hand held unit with LCD screen, auto ranging, low battery alarm, audible 'click' output New and guaranteed £129 ref GE1

RUSSIAN BORDER GUARD BINOCULARS £1799 Probably the best binoculars in the world! ring for colour brochure

RUSSIAN MULTIBAND WORLD COMMUNICATIONS RECEIVER Exceptional coverage of 9 wave bands, (5 short, 1 LW, 1FM, 1MW) internal ferrite and external telescopic aerials, mains/battery £45 ref VEGA

NEW LASER POINTERS 4.5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 670nm £29 ref DEC49

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 etc £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

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

PC KEYBOARDS PS2 connector, top quality suitable for all 286/386/486 etc £10 ref PCKB 10 for £65

NEW LOW COST VEHICLE TRACKING TRANSMITTER KIT £29 range 1.5-5 miles, 5,000 hours on AA batteries, transmits info on car direction, left and right turns, start and stop information Works with any good FM radio £29 ref LOT101a

HIGH SECURITY ELECTRIC DOOR LOCKS Complete brand new Italian lock and latch assembly with both Yale type lock (keys inc) and 12v operated deadlock £10 ref LOT99

***NEW HIGH POWER WIRELESS VIDEO AND AUDIO BUG KIT 1/2 MILE RANGE** Transmits video and audio signals from a miniature CCTV camera (included) to any standard television! Supplied with telescopic aerial £169

CCTV PAN AND TILT KIT Motorize your CCTV camera with this simple 12vdc kit 2 hermentically sealed DC linear servo motors 5mm threaded output 5 secs stop to stop, can be stopped any where, 10mm travel, powerful £12 ref LOT125

GPS SATELLITE NAVIGATION SYSTEM Made by Garmin, the GPS38 is hand held, pocket sized, 255g, position, altitude, graphic compass, map builder, nitro filled. **Bargain price** just £179 ref GPS1

CCTV CAMERA MODULES 46X70X29mm, 30 grams, 12v 100mA, auto electronic shutter, 3.6mm F2 lens, CCIR, 512x492 pixels, video output is 1v p-p (75 ohm) Works directly into a scart or video input on a tv or video IR sensitive £79.95 ref EF137

IR LAMP KIT Suitable for the above camera, 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 &rearwaveguides, 1.1"x2.7"x4.6" fits on sun visor or dash £149 ref

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS

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

EASY DIY/PROFESSIONAL TWO WAY MIRROR KIT Includes special adhesive film to make two way mirror(s) up to 60"x20" (glass not included) includes full instructions £12 ref TW1

NEW LOW PRICED COMPUTER/WORKSHOP/HI-FI RCB UNITS Complete protection from faulty equipment for everybody! Inline unit fits in standard IEC lead (extends it by 750mm), fitted in less than 10 seconds, reset/test button, 10A rating £6.99 each ref LOT5. Or a pack of 10 at £49.90 ref LOT6 If you want a box of 100 you can have one for £250!

TWO CHANNEL FULL FUNCTION B GRADE RADIO CONTROLLED CARS From World famous manufacturer these are returns so they will need attention (usually physical damage) cheap way of buying TX and RX plus servos etc for new projects etc £12 each sold as seen ref LOT2

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

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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

RUSSIAN 900X MAGNIFICATION ZOOM MICROSCOPE metal construction, built in light, mirror etc Russian shrimp farm!, group viewing screen, lots of accessories £29 ref ANAYLT

AA NICAD PACK Pack of 4 tagged AA nicads £2.99 ref BAR34

RUSSIAN NIGHTSIGHTS Model TZS4 with infra red illuminator, views up to 75 metres in full darkness in infrared mode, 150m range 45mm lens, 13 deg angle of view, focussing range 1.5m to infinity 2 AA batteries required 950g weight £199 ref BAR61 1 years warranty

LIQUID CRYSTAL DISPLAYS Bargain prices,
16 character 2 line, 99x24mm £2.99 ref SM1623A
20 character 2 line, 83x19mm £3.99 ref SM2024A
16 character 4 line, 62x25mm £5.99 ref SMC1640A

TAL-1, 110MM NEWTONIAN REFLECTOR TELESCOPE Russian Superb astronomical 'scope, everything you need for some serious star gazing! up to 169x magnification Send or fax for further information 20kg 885x800x1650mm ref TAL-1, £249

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

COLOUR CCTV VIDEO CAMERAS, BRAND NEW AND, CASED, FROM £99.

PERFECT FOR SURVEILLANCE, INTERNET,VIDEOCONFERENCING, SECURITY, DOMESTIC VIDEO

Works with most modern video's, TV's, Composite monitors, video grabber cards etc

Pal, 1v P-P, composite, 75ohm, 1/3" CCD, 4mm F2.8, 500x582, 12vdc, mounting bracket, auto shutter, 100x50x180mm, 3 months warranty,1 off price £119 ref XEF150, 10 or more £99 ea 100+ £89

MICRO RADIO It's tiny, just 3/8" thick, auto tunning, complete with headphones FM £9.99 ref EP35

25 SQUARE FOOT SOLAR ENERGY BANK KIT 100 6"x6" 6v Amorphous 100mA panels, 100 diodes, connection details etc to build a 25 square foot solar cell for just £99 ref EF112

CONVERT YOUR TV INTO A VGA MONITOR FOR £25! Converts a colour TV into a basic VGA screen Complete with built in psu, lead and s/ware Ideal for laptops or a cheap upgrade Supplied in kit form for home assembly **SALE PRICE £25 REF SA34**

***15 WATT FM TRANSMITTER** Already assembled but some RF knowledge will be useful for setting up Preamp req'd, 4 stage 80-108mhz, 12-18vdc, can use ground plane, yagi or dipole £69 ref 1021

***4 WATT FM TRANSMITTER KIT** Small but powerful FM transmitter kit 3 RF stages, mic & audio preamp included £24 ref 1028

YUASHA SEALED LEAD ACID BATTERIES 12v 15AH at £18 ref LOT8 and below spec 6v 10AH at £5 a pair

ELECTRIC CAR WINDOW DE-ICERS Complete with cable, plug etc **SALE PRICE JUST £4.99 REF SA28**

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 You get 2 6"x6" 6v 130mA cells, 4 LED's, wire, buzzer, switch + 1 relay or motor **£7.99 REF SA27**

12V DC MOTOR SPEED CONTROL KIT Complete with PCB etc Up to 30A A heat sink may be required £19.00 **REF: MAG17**

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

MEGA POWER BINOCULARS Made by Helios, 20 x magnification, precision ground fully coated optics, 60mm objectives, shock resistant caged prisms, case and neck strap £89 ref HPH1

GIANT HOT AIR BALLOON KIT Build a 4.5m circumference, fully functioning balloon, can be launched with home made burner etc Reusable (until you loose it!) £12.50 ref HA1

AIR RIFLES .22 As used by the Chinese army for training puposes, so there is a lot about! £39.95 Ref EF78 500 pellets £4.50 ref EF80

***NEW MEGA POWER VIDEOAND AUDIO SENDER UNIT.** Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 500m range! (tune TV to channel 31) 12v DC op Price is £65 **REF: MAG15** 12v psu is £5 extra **REF: MAG5P2**

***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range up to 2 km in open country Units measure 22x52x155mm Including cases and earp'ces 2xPP3 req'd £37.00 pr **REF: MAG30**

***FM TRANSMITTER KIT** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £18 REF EF62 (kit) Transmits to any FM radio Built and tested version now available of the above unit at £45 ref EXM34

***FM BUG BUILT AND TESTED** superior design to kit Supplied to detective agencies 9v battery req'd £14 REF MAG14

GAT AIR PISTOL PACK Complete with pistol, darts and pellets £14.95 Ref EF82B extra pellets (500) £4.50 ref EF80

HEAT PUMPS These are mains operated air to air units that consist of a aluminium plate (cooling side) and a radiator (warming side) connected together with a compressor The plate if inserted into water will freeze it Probably about 3-400 watts so could produce 1kw in ideal conditions £30 ref HP1

3 FOOT SOLAR PANEL Amorphous silicon, 3' x 1' housed in an aluminium frame, 13v 700mA ouput £55 ref MAG45

SOLAR/WIND REGULATOR Prevents batteries from over charging On reaching capacity the regulator diverts excess power into heat avoiding damage Max power is 60 watts £27.99 ref S/CA11-/05

FANCY A FLUTTER? SEEN OUR NEW PUBLICATION? Covers all aspects of horse and dog betting, systems etc and gives you a betting system that should make your betting far more profitable! £6 a copy ref BET1

FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1

4X28 TELESCOPIC SIGHTS Suitable for all air rifles, ground lenses, good light gathering properties £24.95 ref R/7

GYROSCOPES Remember these? well we have found a company that still manufactures these popular scientific toys, perfect gift or for educational use etc £6 ref EP70

NICAD CHARGERS AND BATTERIES Standard universal mains operated charger, takes 4 batts + 1 PP3, £10 ref PO11D Nicads- AA size (4 pack) £4 ref 4P44, C size (2 pack) £4 ref 4P73, D size (4 pack) £9 ref 9P12

RECHARGE ORDINARY BATTERIES UP TO 10 TIMES! With the Battery Wizard! Uses the latest pulse wave charge system to charge all popular brands of ordinary batteries AAA, AA, C, D, four at a time! Led system shows when batteries are charged, automatically rejects unsuitable cells, complete with mains adaptor BS approved Price is £21.95 ref EP31

PHOTOGRAPHIC RADAR TRAPS CAN COST YOU YOUR LICENCE! The new multiband 2000 radar detector can prevent even the most responsible of drivers from losing their licence! Adjustable audible alarm with 8 flashing leds gives instant warning of radar zones Detects X, K, and Ka bands 3 mile range, 'over the hill' 'around bends' and 'rear trap facilities micro size just 4.25"x2.5"x.75" Can pay for itself in just one day! £89 ref EP3

3" DISCS As used on older Amstrad machines Spectrum plus3's etc £3 each ref BAR400

STEREO MICROSOPES BACK IN STOCK Russian 200x complete with lenses, lights, filters etc etc very comprehensive microscope that would normally be around the £700 mark, our price is just £299 (full money back guarantee) full details in catalogue

SECOND GENERATION NIGHT SIGHTS FROM £748

RETRON Russian night sight, 1.8x, infra red lamp, 10m-inf, standard M42 lens, 1.1kg £349 ref RET1

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

HI POWER SURVEILLANCE TELESCOPE Continuous zoom control from 20 times to an amazing 60 times magnification 60mm fully coated objective lens for maximum light transmission, complete with tripod featuring micro elevation control £75 ref ZT1

JUMBO LED PACK 15 10mm bicolour leds, plus 5 giant (55mm) seven segment displays all on a pcb £8 ref JUM1 Pack of 30 55mm seven seg displays on pcbs is £19 ref LED4, pack of 50 £31 ref LED50

12VDC 40MM FANS MADE BY PANAFLO, NEW £4 REF FAN12

HELP WANTED WITH MOTORS We have thousands to clear at rock bottom prices! bumper pack of 20 motors (our choice) is just £19.95! Some of these will be 5" or maybe larger!

HELP WANTED WITH MULTI RAIL POWER SUPPLIES Again we have thousands available, most with fans, mostly cased, sold as seen, condition may vary, some working some not Pack of 10 is £19.95

HELP WANTED WITH TELEPHONE COIN BOXES Need we say thousands available! these are units designed to convert an ordinary phone into a coinbox phone They have damaged cases but the electronics and coinslots are ok Speech chip on the board talks to you as you program it! Pack of 10 is £19.95

HELP WANTED WITH EXTERNAL MICRO TAPE STREAMERS 10,000 in stock space needed! brand new cased units with loads of interesting bits (motor, tape heads, PCB etc etc Very smart plastic case useful for projects etc Pack of 20 is £19.95 ref MD2

HELP WANTED WITH YUASHA 12V 6.5AH SEALED LEAD ACID BATTERIES About 10 pallets full just inside warehouse no 2! pack of 5 for just £19.95 also some below spec 6v 10aH at £19.95 for a pack of 8

Check out our WEB SITE full colour interactive 1997 catalogue
http://www.pavilion.co.uk/bull-electrical

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*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

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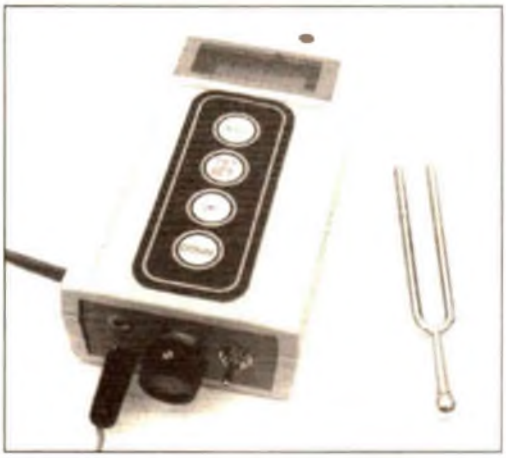

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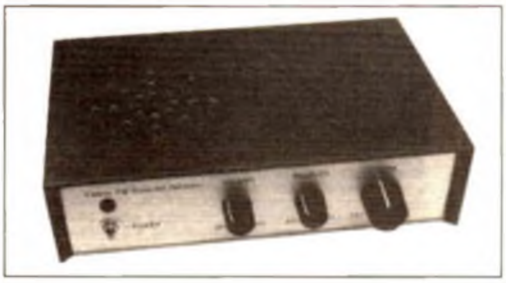

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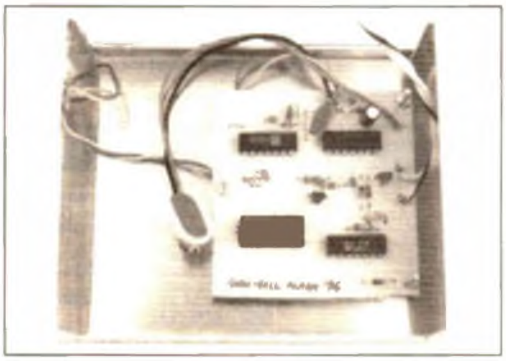

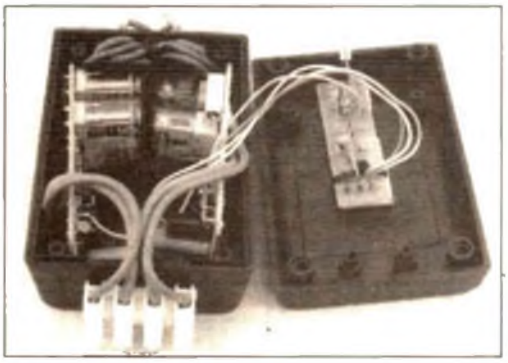

Regulars and Services

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Our June '97 issue will be published on Friday, 2 May 1997. See page 353 for details.

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THE *ORIGINAL* SURPLUS WONDERLAND!

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LOW COST PC's -

SPECIAL BUY 'AT 286'

40Mb HD + 3Mb Ram

LIMITED QUANTITY only of these **12Mhz HI GRADE 286** systems Made in the USA to an industrial specification, the system was designed for *total reliability*. The compact case houses the mother-board, PSU and EGA video card with single 5¼" 1.2 Mb floppy disk drive & **integral 40Mb hard disk drive** to the front. Real time clock with battery backup is provided as standard. Supplied in good used condition **complete with enhanced keyboard, 640k + 2Mb RAM, DOS 4.01 and 90 DAY Full Guarantee**. *Ready to Run!* **Order as HIGRADE 286** ***ONLY £129.00*** (E)

Optional Fitted extras: VGA graphics card	£29.00
1.4Mb 3½" floppy disk drive (instead of 1.2 Mb)	£19.95
Wordperfect 6.0 for Dos - when 3½" FDD option ordered	£22.50
NE2000 Ethernet (thick, thin or twisted) network card	£29.00

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Limited quantity of this 2nd user, supurb small size desktop unit. Fully featured with standard simm connectors 30 & 72 pin. Supplied with keyboard, 4 Mb of RAM, SVGA monitor output, 256k cache and integral 120 Mb IDE drive with single 1.44 Mb 3.5" floppy disk drive. Fully tested and guaranteed. *Fully expandable*
Many other options available - call for details. Only **£399.00** (E)

FLOPPY DISK DRIVES 3½" - 8"

5¼" or 3½" from only £18.95 !

Massive purchases of standard 5¼" and 3½" drives enables us to present prime product at industry beating low prices! All units (unless stated) are ***BRAND NEW*** or removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from standard voltages and are of standard size. **All are IBM-PC compatible** (if 3½" supported on your PC)

3½" **Panasonic** JU363/4 720K or equivalent RFE	£24.95(B)
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3½" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop	£18.95(B)
5¼" **Teac** FD-55GFR 1.2 Meg (for IBM pc's) RFE	£18.95(B)
5¼" **Teac** FD-55F-03-U 720K 40/80 (for BBC's etc) RFE	£29.95(B)
5¼" **BRAND NEW Mitsubishi** MF501B 360K	£22.95(B)
Table top case with integral PSU for HH 5¼" Flopp or HD	£29.95(B)
8" **Shugart 800/801** 8" SS refurbished & tested	£195.00(E)
8" **Shugart 810** 8" SS HH *Brand New*	£195.00(E)
8" **Shugart** 851 8" double sided refurbished & tested	£250.00(E)
Mitsubishi M2894-63 8" double sided *NEW*	£275.00(E)
Mitsubishi M2896-63-02U 8" DS slimline *NEW*	£285.00(E)
Dual 8" cased drives with integral power supply 2 Mb	£499.00(E)

HARD DISK DRIVES

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3½" **FUJI** FK-309-26 20mb MFM I/F RFE	£59.95(C)
3½" **CONNER** CP3024 20 mb IDE I/F (or equiv)RFE	£59.95(C)
3½" **CONNER** CP3044 40mb IDE I/F (or equiv)RFE	£69.00(C)
3½" **RODIME** RO3057S 45mb SCSI I/F (Mac & Acorn)	£69.00(C)
3½" **WESTERN DIGITAL** 850mb IDE I/F *Brand New*	£185.00(C)
5¼" **MINISCRIBE** 3425 20mb MFM I/F (or equiv.) RFE	£49.95(C)
5¼" **SEAGATE** ST-238R 30 mb RLL I/F Refurb	£69.95(C)
5¼" **CDC** 94205-51 40mb HH MFM I/F RFE tested	£69.95(C)
5¼" **HP** 97548 850 Mb SCSI RFE tested	£99.00(C)
5¼" **HP** C3010 2 Gbyte SCSI ***differential*** RFE tested	£195.00(C)
8" **FUJITSU** M2322K 160Mb SMD I/F RFE tested	£195.00(E)
Hard disc controllers for MFM , IDE, SCSI, RLL etc. from	£16.95

THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!

TV SOUND & VIDEO TUNER *CABLE COMPATIBLE*

The **TELEBOX** is an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors **made by makers such as MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD etc. The composite** video output will also plug directly into most video recorders, **allowing reception of TV channels not normally receivable on most television receivers*** (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television channels. **TELEBOX MB** covers virtually **all television frequencies VHF and UHF including the HYPERBAND as used by most cable TV operators.** A composite video output is located on the rear panel for direct connection to most makes of monitor or desktop computer video systems. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

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

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

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Virtually every type of power supply you can imagine.Over 10,000 Power Supplies Ex Stock Call for info / list.

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6,000,000 Items EX STOCK

For *MAJOR* SAVINGS - CALL FOR SEMICONDUCTOR HOTLIST

VIDEO MONITOR SPECIALS

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

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

Tilt & Swivel Base £4.75
VGA cable for IBM PC included.
External cables for other types of computers CALL

Only £119 (E) Order as **MITS-SVGA**

As New - Used on film set for 1 week only!!
15" 0.28 SVGA 1024 x 768 res. colour monitors.
Swivel & tilt etc. Full 90 day guarantee. £145.00 (E)

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

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with **both RGB and standard composite 15.625 Khz video inputs via SCART socket and separate phono jacks. Integral audio power amp and speaker for all audio visual uses.** Will connect direct to **Amiga and Atari BBC** computers. Ideal for all **video monitoring / security applications with direct connection to most colour cameras**. High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested - guaranteed
Dimensions: W14" x H12¾" x 15½" D. **Only £95** (E)

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

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

Only £125 (E)

20" 22" and 26" AV SPECIALS

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

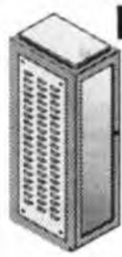
20"....£135 22"....£155 26"....£185 (F)

SPECIAL INTEREST ITEMS

MITS. **FA3445ETKL** 14" Industrial spec SVGA monitors	£245
2kW to 400 kW - 400 Hz 3 phase power sources - ex stock	£POA
IBM 8230 Type 1, Token ring base unit driver	£950
IBM 53F5501 Token Ring ICS 20 port lobe modules	£750
IBM MAU Token ring distribution panel 8228-23-5050N	£95
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE	£550
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
Marconi 6310 Programmable 2 to 22 GHz sweep generator	£6500
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & **HP3782A** Error Detector	£POA
HP APOLLO RX700 system units	£950
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP3081A Industrial workstation c/w Barcode swipe reader	£175
HP6264 Rack mount variable 0-20V @ 20A metered PSU	£675
HP54121A DC to 22 GHz four channel test set	£POA
HP7580A A1 8 pen HPGL high speed drum plotter	£1850
EG+G Brookdeal 95035C Precision lock in amp	£650
View Eng. Mod 1200 computerised inspection system	£POA
Ling Dynamics 2kW programmable vibration test system	£POA
Computer controlled 1056 x 560 mm X Y table & controller	£1425
Keithley 590 CV capacitor / voltage analyser	£POA
Racal ICR40 dual 40 channel voice recorder system	£3750
Fiskers 45KVA 3 ph On Line UPS - New batts Dec.1995	£9500
ICI R5030UV34 Cleanline ultrasonic cleaning system	£POA
Mann Tally MT645 High speed line printer	£2200
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	£1200
Zeta 3220-05 A0 4 pen HPGL *fast* drum plotters	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
Motorola VME Bus Boards & Components List. SAE / CALL	£POA
Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
Fujitsu M3041R 600 LPM band printer	£1950
Fujitsu M3041D 600 LPM printer with network interface	£1250
Perkin Elmer 2998 Infrared spectrophotometer	£POA
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3750
Andrews LARGE 3.1 m Satellite Dish + mount (For Voyager!)	£950
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
TAYLOR HOBSON Tallysurf amplifier / recorder	£750
System Video 1152 PAL waveform monitor	£485
Test Lab - 2 mtr square quietised acoustic test cabinets	£300
Kenwood 9601 PAL Vectorscope - NEW	£650

Please call for further details on the above items

19" RACK CABINETS



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Top quality 19" rack cabinets made in UK by **Optima Enclosures Ltd. Units feature** designer, smoked acrylic lockable front door, full height lockable half louvered back door and louvered removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the most versatile we have ever sold. Racks may be stacked side by side and therefore require only two side panels to stand singly or in multiple bays.
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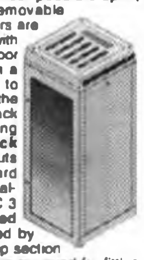
OPT Rack 2 Rack, Less side panels	£225.00 (G)

32U - High Quality - All steel RakCab



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

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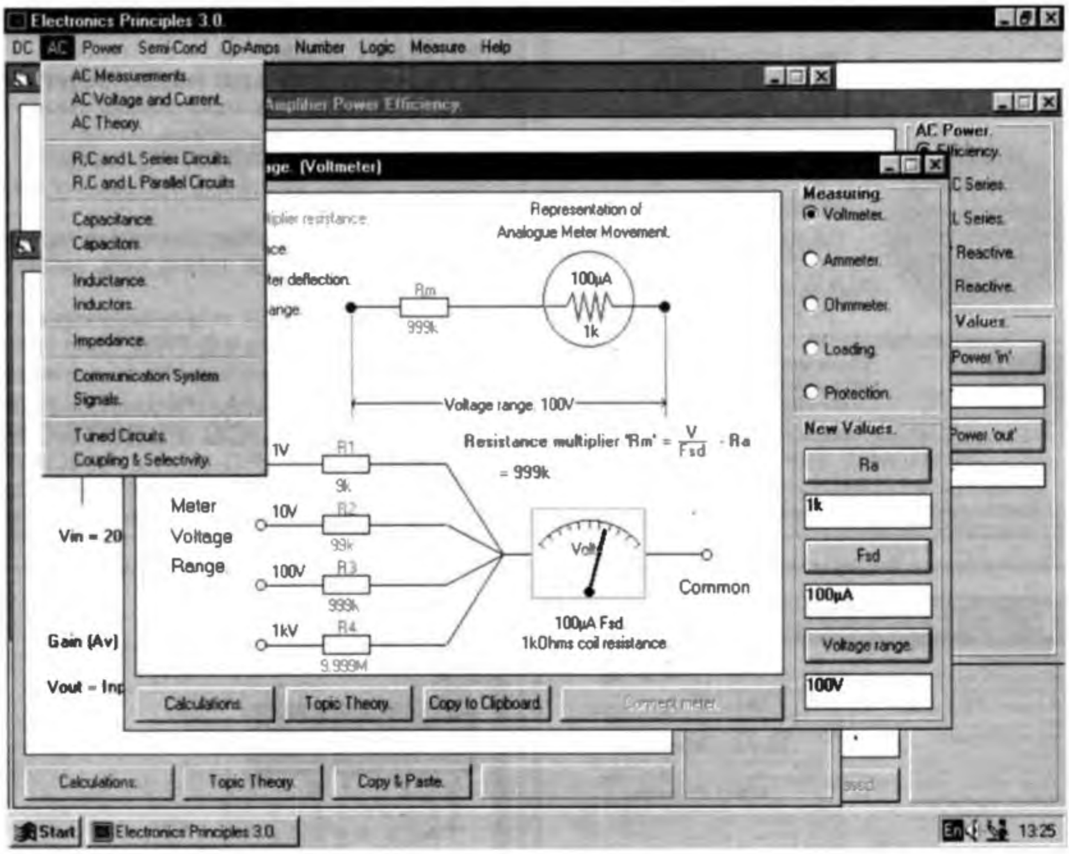

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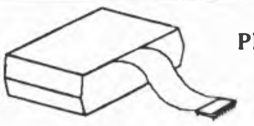

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Miniature Polyester, 250V working vertical mounting *(mfd)*. .01, .015, .022, .047, .068 – **5p**; 0.1 – **6p**; 0.12, 0.15, 0.22 – **7p**; 0.47 – **9p**; 0.68 – **10p**; 1.0 – **13p**
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BC107/8/9 – **18p**; BC547/8/9 – **7p**; BC557/8/9 – **8p**; BC182, 182L, BC183, 183L, BC184, 184L, BC212, 212L – **10p**; BC327, 337, 337L – **8p**; BC727, 737 – **12p**; BD135/6/7/8/9 – **27p**; BCY70 – **28p**; BFY50/51/52 – **32p**; BFX88 – **38p**; 2N3055 – **55p**; TIP31, 32 – **40p**; TIP41, 42 – **40p**; BU208A – **£1.50**; BF195, 197 – **12p**.

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100mA to 5A. Q/blow – **8p**; A/surge – **14p**
Holders, chassis, mounting – **8p**.

CMOS

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D.I.L. HOLDERS

8-pin – **9p**; 14-, 16-, 18-pin – **15p**; 24-pin – **19p**; 28-pin – **22p**; 40-pin – **31p**.

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1A +ve or –ve 5V, 8V, 12V, 15V, 18V & 24V – **61p**; 100mA +ve 5V, 8V, 12V, 15V – **38p**.

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75/150mA 1N4148 – **2p**; 800/1A 1N4006 – **5p**; 400/3A 1N5404 – **14p**; 115/50mA OA91 – **18p**; 100/1A 1N4002 – **4p**; 1000/1A 1N4007 – **5p**; 60/1.5A S1M1 – **7p**; 100/1A bridge – **28p**; 400/1A 1N4004 – **4p**; 1250/1A BY 127 – **14p**; 30/150mA OA47 gold bonded – **24p**.
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3mm and 5mm. Red, Green, Yellow – **14p**; Grommets to suit 3mm – **2p**, 5mm – **3p**; 5mm Tricolour & Bicolour – **22p**; Red flashing L.E.D.'s require 9V-12V supply only, 5mm – **70p**.

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Triggers only when sounds are detected. Very low standby current. Variable sensitivity and delay with LED indicator. Size 20mm x 67mm. 9V operation. 1000m range. £19.45

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Connects to telephone line anywhere, requires no batteries. Output scrambled so requires SCDM connected to receiver. Size 32mm x 37mm. 1000m range......... £23.95

SCDM Subcarrier Decoder Unit for SCRX
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Not technically a surveillance device but a great idea! Connects to the headphone output of your Hi-Fi, tape or CD and transmits Hi-Fi quality to a nearby radio. Listen to your farvourite music anywhere around the house, garden, in the bath or in the garage and you don't have to put up with the DJ's choice and boring waffle.
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TLX 700 Micro-miniature Telephone Transmitter
Best-selling telephone transmitter. Being 20mm x 20mm it is easier to assemble than UTLX. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1000m range.......... £13.45

STLX High-performance Telephone Transmitter
High performance transmitter with buffered output stage providing excellent stability and performance. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line.
Size 22mm x 22mm. 1500m range.......... £16.45

TKX900 Signalling/Tracking Transmitter
Transmits a continuous stream of audio pulses with variable tone and rate. Ideal for signalling or tracking purposes. High power output giving range up to 3000m.
Size 25mm x 63mm. 9V operation.......... £22.95

CD400 Pocket Bug Detector/Locator
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QLX180 Crystal Controlled Telephone Transmitter
As per QTX180 but connects to telephone line to monitor both sides of conversations. 20mm x 67mm. 9V operation. 1000m range.......... £40.95

QSX180 Line Powered Crystal Controlled Phone Transmitter
As per QLX180 but draws power requirements from line. No batteries required.
Size 32mm x 37mm. Range 500m.......... £35.95

QRX 180 Crystal Controlled FM Receiver
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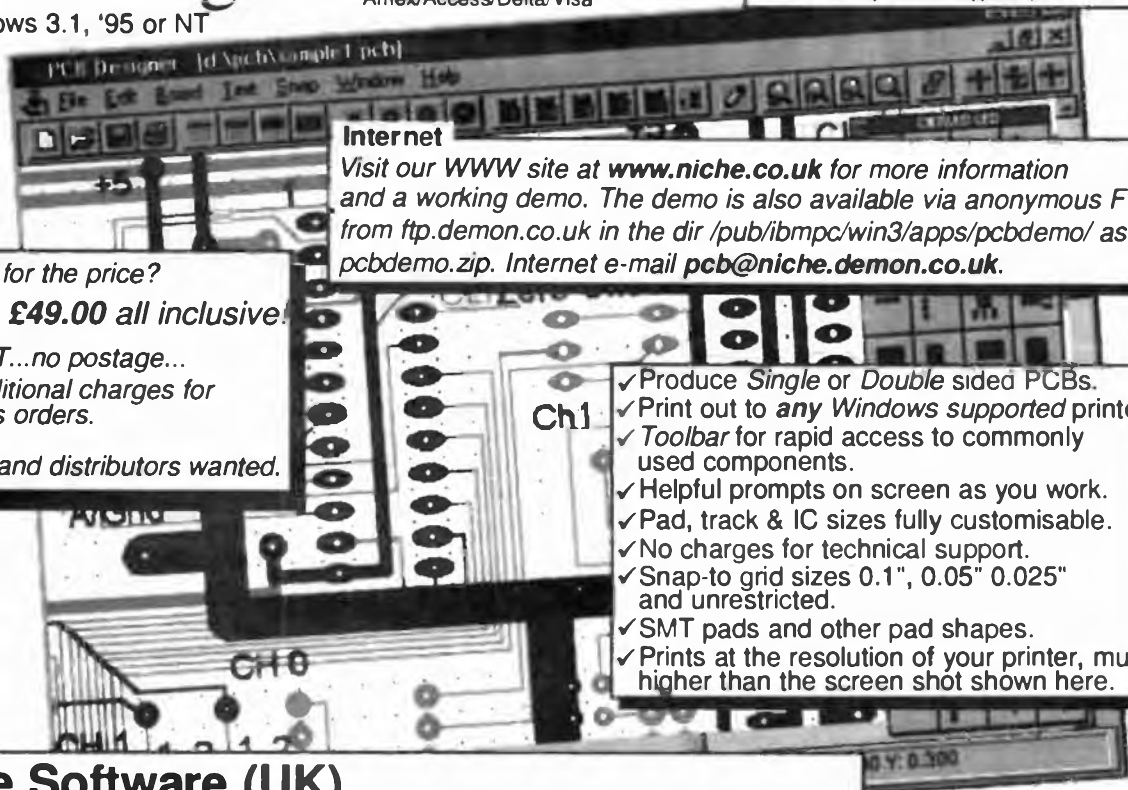

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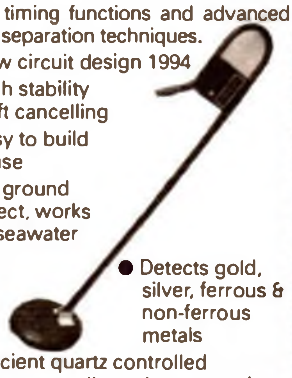

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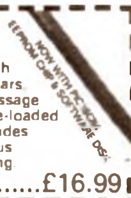

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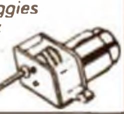

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- SPEED CONTROL POT.
- HARD FIRED TRIACS
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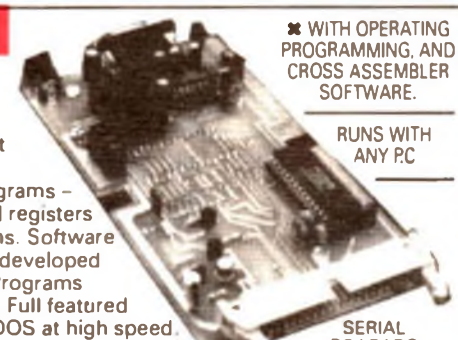

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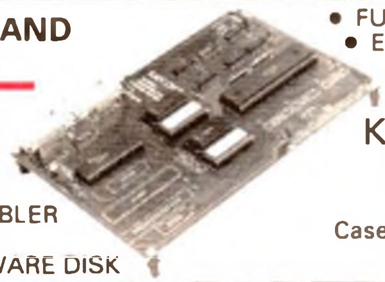

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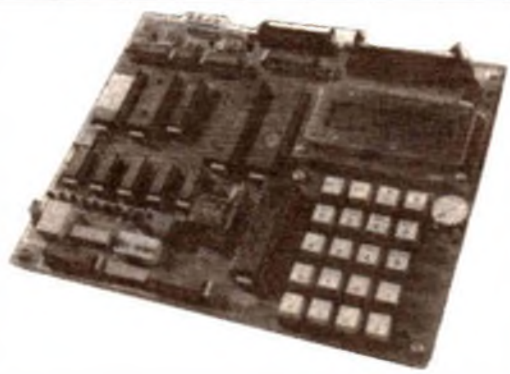
Electronics Teach-In 7



As featured in *EPE* and now published as Teach-In 7. All parts are supplied by Magenta. *Teach-In 7* is £3.95 from us or *EPE*
Full Mini Lab Kit – £119.95 – Power supply extra – £22.55
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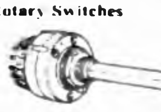

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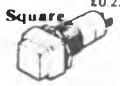

1A 250V
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12mm Ø Mounting Hole
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White PTM £0.60
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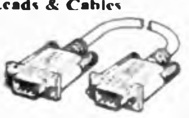
Leads & Cables



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26 SWG Enamelled £0.97
28 SWG Enamelled £0.99
30 SWG Enamelled £1.02
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34 SWG Enamelled £1.10
36 SWG Enamelled £1.14
38 SWG Enamelled £1.20
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5mm Yelow Led £0.10
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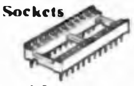
Dimensions 126 x 70 x 24mm
DM830 Digital Multimeter £9.45

DIL Sockets



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28 Pin DIL 0.6" £0.13
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18 Pin DIL 0.3" £0.35
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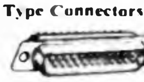
D Type Connectors



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EVERYDAY
PRACTICAL
ELECTRONICS

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TWEAK TWEAK

One or two bits of editorial "tweaking" have gone on this month. As a result of our Readership Survey back in the November 1996 issue we have made a couple of changes to regular items – there will be other changes, mainly on the emphasis given to various types of projects and features, but these will not be instantly apparent to readers. We anticipate, however, that they will ensure *EPE* continues to be the best selling hobbyist magazine in the UK.

The tweaks that we have made so far concern regular editorial pages. Many readers may be surprised that we no longer have a *Fox Report*, but don't be too upset as Barry Fox is now contributing regular news items to *Innovations*. Barry has been writing for the magazine for over 25 years and during that time has established himself as the best known and most respected technical investigative journalist in the UK. You told us that you preferred news items to Barry's "Reports" so we have made the change.

You also told us that you wanted more on practical techniques so we have brought back *Techniques* – which had been rather pushed aside due to lack of space – and we will now alternate it on a monthly basis with *Interface*. We are also gradually introducing a little more colour to the magazine.

In general you seem happy with *EPE* and the changes we are making are, as I have said, really only tweaks that will enable us to continue to produce what we honestly believe is the best magazine of its type.

HUSH HUSH

I will not go into the change of emphasis on projects and features as we believe our research is very valuable and I don't want to tell our competitors what we have found out. Over a period of a year or so anyone will be able to monitor the type of projects and features we publish, and the areas of interest they cover, and so catch up with our tweaks.

But for now please be assured that we will go on publishing a wide range of projects (with at least four in every issue) and that they will, we believe, be even more interesting to a wider range of readers than previously. Stay with us for project and feature packed pages – we will continue to cram as much into *EPE* each month as we possibly can.

Mike Kenward

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2 METRE F.M. RECEIVER

DUNCAN BOYD

Listen-in to the world of amateur radio with this double conversion superhet design. Can be used in the car or from a mains supply.

NOT all that long ago, a few decades perhaps, the average electronics hobbyist would have most likely been involved in designing and building radio receivers and associated equipment like amplifiers etc. This tendency was most likely influenced by the technology of the day. While today there are still many amateurs who build radio equipment, the general emphasis of our subject seems to have shifted to other areas, computers being a prime example.

This is no bad thing although some may argue differently and it does tend to hide the grass roots of technology which we would find difficult to live without in these days of electronic mail and mobile phones. This article describes a double-conversion superhet receiver for the 2 Metre f.m. band which may provide an inexpensive introduction to the subject of amateur radio.

On the v.h.f. band of radio frequencies there are a great many users each with their own portion of the band specially allocated. Operators include Radio Amateurs, Aircraft and public services like the Police and Fire Brigade. The most common mode of operation is f.m.

AMATEUR BAND

A portion of the band which is specifically set aside for radio amateurs is the 2 Metre band from 144MHz to 146MHz. This band allows local radio amateurs to keep in touch about "the latest project" and "events" etc.

Communication can be either direct or via repeater stations which are located around the country. These repeater stations are mainly intended for amateurs operating from cars or portable equipment whose range would be limited otherwise.

The 2M F.M. Receiver described here is tuned by means of a varicap diode and a Squelch control and Automatic Frequency Control (a.f.c.) are included. The project can be powered from a d.c. rail of between 11V and 16V, this allows portable operation or operation from a car, alternatively the project will accept the mains supply. The receiver is relatively inexpensive and so it could be left permanently installed in a car where most people would be reluctant to leave expensive commercial equipment.

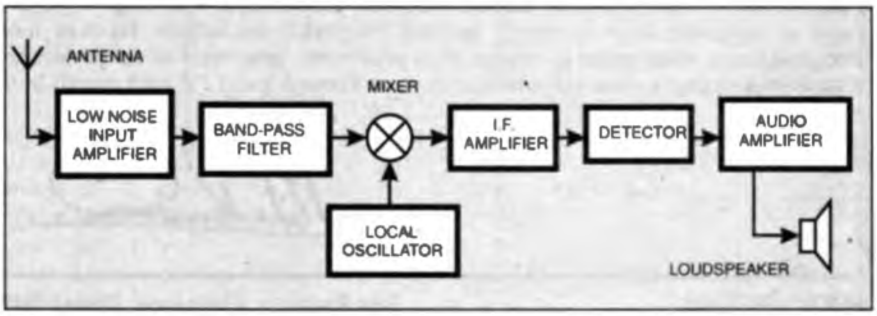


Fig. 1. Block diagram for a basic superhet.

SUPERHET

As with many receiver topologies the superhet was developed in the early 1920s by Major Edwin Armstrong of the US army. The superhet design provides a very cost effective and versatile solution to the radio receiver problem and the majority of receivers that are now available use this topology in some form or other.

Armstrong realised the difficulty of trying to reliably tune many receiver stages. He came up with the idea of putting the majority of the filtering and amplification at one fixed frequency, somewhere between the input frequency and the frequency of the demodulated signal, an Intermediate Frequency, (i.f.). He then converted the desired input frequency down to this i.f. before demodulation etc. Since the majority of the filtering and amplification is done at one fixed frequency the characteristics of the "i.f. stage" could be defined much more easily and accurately.

A block diagram of the superhet is shown in Fig. 1. The mixer is the key to the superhet design. The mixer is in effect a frequency changer, it does this by multiplying the incoming signal with a signal from an oscillator within the receiver (local oscillator).

A well known identity of Trigonometry that can be found in any maths text is $\text{Cos}A \times \text{Cos}B = 1/2\text{Cos}(A-B) + 1/2\text{Cos}(A+B)$. We can see from this that if we multiply two signals (A and B) we will obtain two further signals, one which is the sum $(A+B)$ and one which is the difference $(A-B)$ of the two signals. In receiver designs we can arrange for one of these signals to be at our i.f. frequency.

A mixer can consist of any non-linear device, a diode or transistor could be used. Dual-gate MOSFETS are also quite common, the input signal is fed into one gate and the local oscillator is fed into the other gate. The load for the transistor may consist of a tuned circuit at the i.f. frequency, this provides some of the i.f. filtering.

This type of mixer is a single-ended system since there are single signal and oscillator ports. These mixers are relatively inefficient and as well as allowing the sum and difference signals to pass, the local oscillator (LO) and input signal will also pass through at quite high levels. There will also be a number of components at harmonics of signals A and B, these signals may mix to produce undesirable outputs at the i.f. frequency. Single or double balanced mixers where push-pull stages are employed are usually used to reduce the number of frequency components that are present as well as providing higher efficiency and better signal/noise performance.

FILTERS

Filters for use in i.f. sections are commonly available commercially. Over the years specific i.f. frequencies have been accepted for use in radio receiver circuitry, in general for v.h.f., 10·7MHz is used as the i.f., although sometimes 21·4MHz is used. In a.m. broadcast receivers i.f.s in the region of 455kHz to 470kHz are commonly used, these are chosen because they are in between the Medium wave and the Long wave bands in the radio spectrum.

Traditionally i.f. amplifiers would use an i.f. transformer with the primary and secondary of the transformer tuned to be resonant at the i.f. frequency. In practice, they might be de-tuned in opposite directions in order to give the required bandwidth whilst allowing steep roll off at each side, thus reducing the risk of adjacent channel interference. Many stages may be required to give a suitably steep roll off.

Ceramic and crystal filters are now offering a suitable alternative to the i.f. transformer. These filters are extremely small for the given performance and they don't need setting up or aligning and therefore they are simpler to use, the downside is that they are slightly more expensive.

If we wanted to tune a receiver to 145MHz and our i.f. is to be 10·7MHz then the local oscillator frequency could be $145 + 10{\cdot}7 = 155{\cdot}7$MHz or $145 - 10{\cdot}7 = 134{\cdot}3$MHz. Now let's say that we choose 134·3MHz then we have $145 - 134{\cdot}3 = 10{\cdot}7$MHz which is fine, but unfortunately $123{\cdot}6 - 134{\cdot}3 = -10{\cdot}7$MHz (we can think of negative frequencies reflecting through 0Hz to give positive frequencies). This means that signals at 145MHz and also 123·6MHz will be mixed down to 10·7MHz.

The unwanted signal at 123·6 MHz is termed the "Image" and is the main drawback of the superhet topology. Note that the Image is twice the i.f. away from the desired signal. In the block diagram of Fig. 1 the Bandpass Filter after the Input Amplifier is present to attenuate any signal at the Image Frequency as much as possible.

INPUT AMPLIFIER

In systems at v.h.f. and above, problems with noise and signal loss in cables and receiver circuitry becomes a problem. To combat this, the first stage in high frequency receivers is usually a high quality (low noise) amplifier. This amplifies the signal adding as little noise as possible prior to the signal, being de-graded in other stages of the receiver.

In some cases an amplifier may be placed directly after the antenna to overcome the losses in the coaxial cable connecting the antenna to the receiver. This is the reason that satellite receiver systems have an amplifier located at the antenna dish. In fact, since these systems are used at extremely high frequencies there is also a mixer located at the antenna, this converts the signal to a lower frequency and allows lower cost cabling to be used between the antenna and the set top box.

LOCAL OSCILLATOR

In a receiver the Local Oscillator can take many forms and there are many texts that will provide suitable circuitry, whether the oscillator is to have a fixed frequency or a variable frequency. The important considerations in radio receiver oscillators are that they should be stable in frequency and have low noise and spurious signal content in their output.

One of the troubles when using v.h.f. oscillators is that they tend to drift in frequency slightly with temperature and there are circuits available to combat this, although this usually adds to the complexity and cost. One method is to start with a low frequency oscillator and then multiply the frequency up by tapping off and filtering the harmonics of a non-linear amplifier.

Other methods involve feedback to keep the oscillator's output frequency stable.

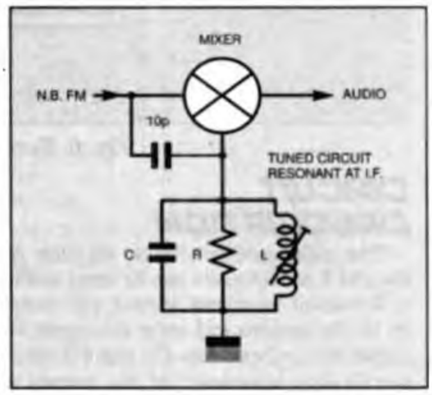


Fig. 2. Demodulator circuit.

DEMODULATION

There are many methods of demodulating a Frequency Modulated (f.m.) signal, one common circuit, which is often missed in the text books, is the Quadrature demodulator. This type of demodulation is far from perfect and is not particularly linear, however it is simple and is used in many communication systems where the quality of the demodulated signal is not the highest priority. Fig. 2 shows the arrangement; here we have a mixer where the two input signals are at the same frequency.

This means that only the difference component is at zero frequency or d.c. The level of the d.c. voltage is proportional to the phase difference between the two signals. When the phase difference is 90 degrees the signals are in "Quadrature" and the d.c. voltage will be zero.

In the circuit of Fig 2 the combination of the 10pF capacitor and the *LCR* parallel tuned circuit give us a 90 degree phase difference between the ports of the mixer when the tuned circuit is resonant. As the frequency deviates from the centre the phase difference will vary from 90 degrees and therefore we have a voltage at the output of the mixer which varies in sympathy with the modulation.

CONVERSION

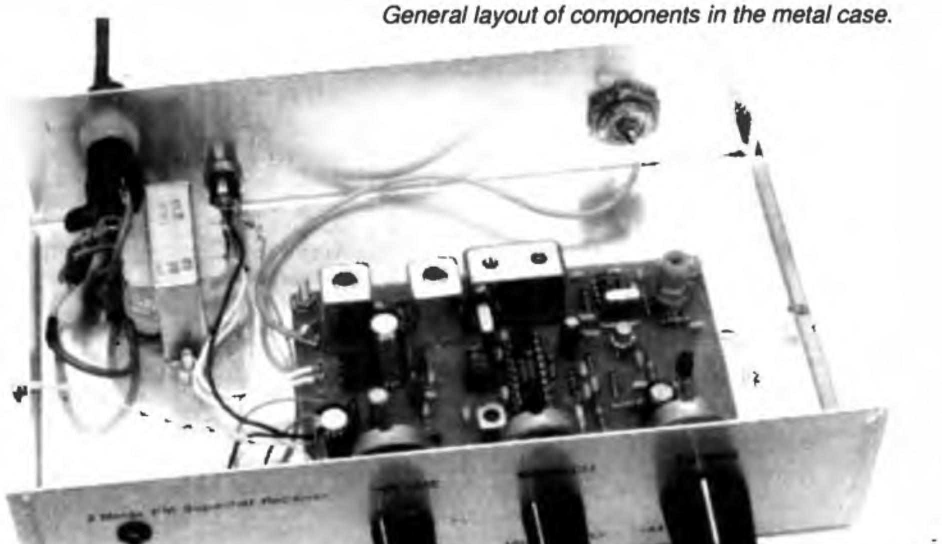
The circuit we have just described is that of a single conversion superhet. This means that there is only one mixer or frequency changer stage. This system is often preferred but if the i.f. frequency is low, i.e. 455kHz, then it becomes difficult to filter out the image frequency which will only be 910kHz away from the chosen frequency.

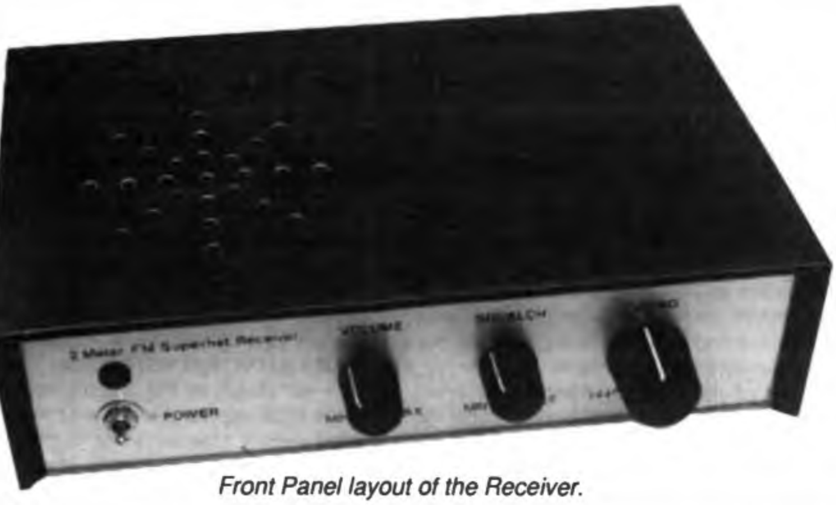
Double or triple conversion designs reduce this problem. In these designs the signal is mixed down in stages before being demodulated. In a three-stage design the i.f.s might be at 21·4MHz, 10·7MHz and 455kHz. This means that the image will now be 42·8MHz away from the desired signal and this is much easier to filter.

HOW IT WORKS

The 2M F.M. Receiver is a double conversion design and the system block diagram can be seen in Fig. 3. The front-end of the receiver consists of a dual-gate f.e.t. tuned r.f. amplifier. This is a low-noise amplifier which provides around 15dB of r.f. gain, although this will be dependant on the actual supply voltage.

General layout of components in the metal case.





Front Panel layout of the Receiver.

Following the amplifier is a 2MHz bandwidth Bandpass Filter which is centred at 145MHz. This filter will considerably reduce the level of any signal at the image frequency as well as any other out of band signals.

The output of the bandpass filter supplies the signal to the input of the first mixer. The mixer and local oscillator are contained within IC1 (Fig. 4), the local oscillator can be tuned from 133·3MHz to 135·3MHz by means of a varicap diode and inductor coil. The output of the mixer will be at 10·7MHz and we have a 15kHz bandwidth crystal filter and some amplification at this frequency.

The output of the i.f. amplifier stage is fed into the second mixer, this and the 10·245MHz crystal oscillator are contained within IC2. A frequency of 10·245MHz was chosen because 10·7 – 10·245MHz will give us a second i.f. frequency of 455kHz.

A ceramic filter is employed here, the output of which is amplified and passed through some limiter stages which are also within IC2. The output of the limiter stages drive the demodulator which consists of IC2 and a Quadrature coil tuned to 455kHz.

The output of the demodulator is fed into an audio amplifier IC3 which drives the loudspeaker. IC2 provides a squelch signal which shorts the input of the amplifier to ground (0V) when there is no signal present, this removes the annoying hiss between channels.

CIRCUIT DESCRIPTION

The main receiver circuit diagram for the 2M F.M. Receiver can be seen in Fig. 4. Received broadcast signals are picked up by the antenna and enter the circuit via socket SK1. Capacitors C1 and C2 match the 50 ohm impedance of the antenna to the dual-gate MOSFET input amplifier TR1. Coil L1 is present to tune the amplifier to have a bandpass characteristic centred around 145MHz.

The output of this tuned circuit (C1, C2 and L1) is fed into one gate of TR1, a low-noise high frequency amplifier, the other input gate is biased at around 4V by resistors R2 and R3, this gives the best combination of high gain and low noise. The output of TR1 is again tuned to a centre frequency of 145MHz, this is done by components L2, C5 and C6. Capacitors C5 and C6 match the output of TR1 to the 50 ohm input impedance of the 145MHz bandpass filter X1. Resistor R4 is present to reduce the possibility of the amplifier oscillating.

The components that make up the input amplifier are contained within a small area on the printed circuit board (p.c.b.) and this gives rise to the situation where energy from coil L2 could be coupled into coil L1, for this reason L1 and L2 are enclosed within metal screening cans; this also helps stop the amplifier oscillating. Resistor R1 and capacitor C4 provide some filtering of the supply line.

The frequency response of the input amplifier can be seen in Fig. 5a, the bandpass characteristic can be clearly seen but it is desirable to have a much greater attenuation at the image frequency of 123·6MHz. For this reason a pre-tuned Helical filter, X1, is inserted after the amplifier, this is centred around 145MHz with a bandwidth of 2MHz. The frequency response of the amplifier and filter together can be seen in Fig. 5b, this shows a much higher attenuation out of band and we can see that any component at the image frequency will be reduced considerably.

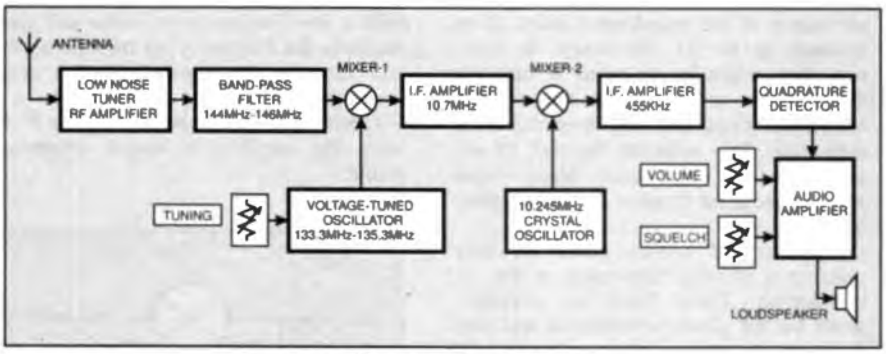


Fig. 3. System block diagram.

MIXER/OSCILLATOR

Signals from the filter X1 are coupled to the first mixer, within IC1, by capacitor C7. The mixer and oscillator are internal to IC1, an NE602 dual balanced mixed/oscillator. However, the oscillator requires the use of an external tuned circuit.

Most of the components to the right of IC1 on the circuit diagram (Fig. 4) are concerned with the oscillator. Resistors R8, R9 and potentiometer VR1 form a variable potential divider, this acts as the tuning control. The output of the divider is filtered by capacitor C14 and applied to VD1 via resistor R7. VD7 is a varicap diode, whose capacitance varies with the reverse voltage across it, this variation in capacitance is used to vary the resonant frequency of the tuned circuit.

Other components fundamental to the tuned circuit are capacitors C12, C13 and ferrite inductor coil L3, the ferrite coil being used to vary the centre frequency of the tuned circuit. With the components shown, the resonant frequency of the tuned circuit can be varied around 134·3MHz.

The MC3359 IC2 provides us with a.f.c. (Automatic Frequency Control), this helps compensate for local oscillator drift due to temperature etc. The output of the a.g.c. is filtered by R12 and capacitor C16 before being applied, via R11, to the base of transistor TR2. TR2 modifies the tuning voltage which is applied to the varicap diode

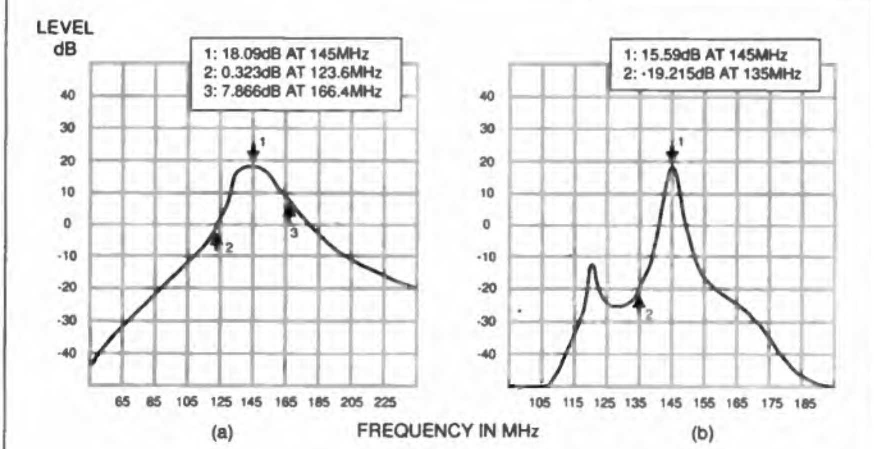


Fig. 5 (a) Input amplifier response and (b) amplifier/filter response.

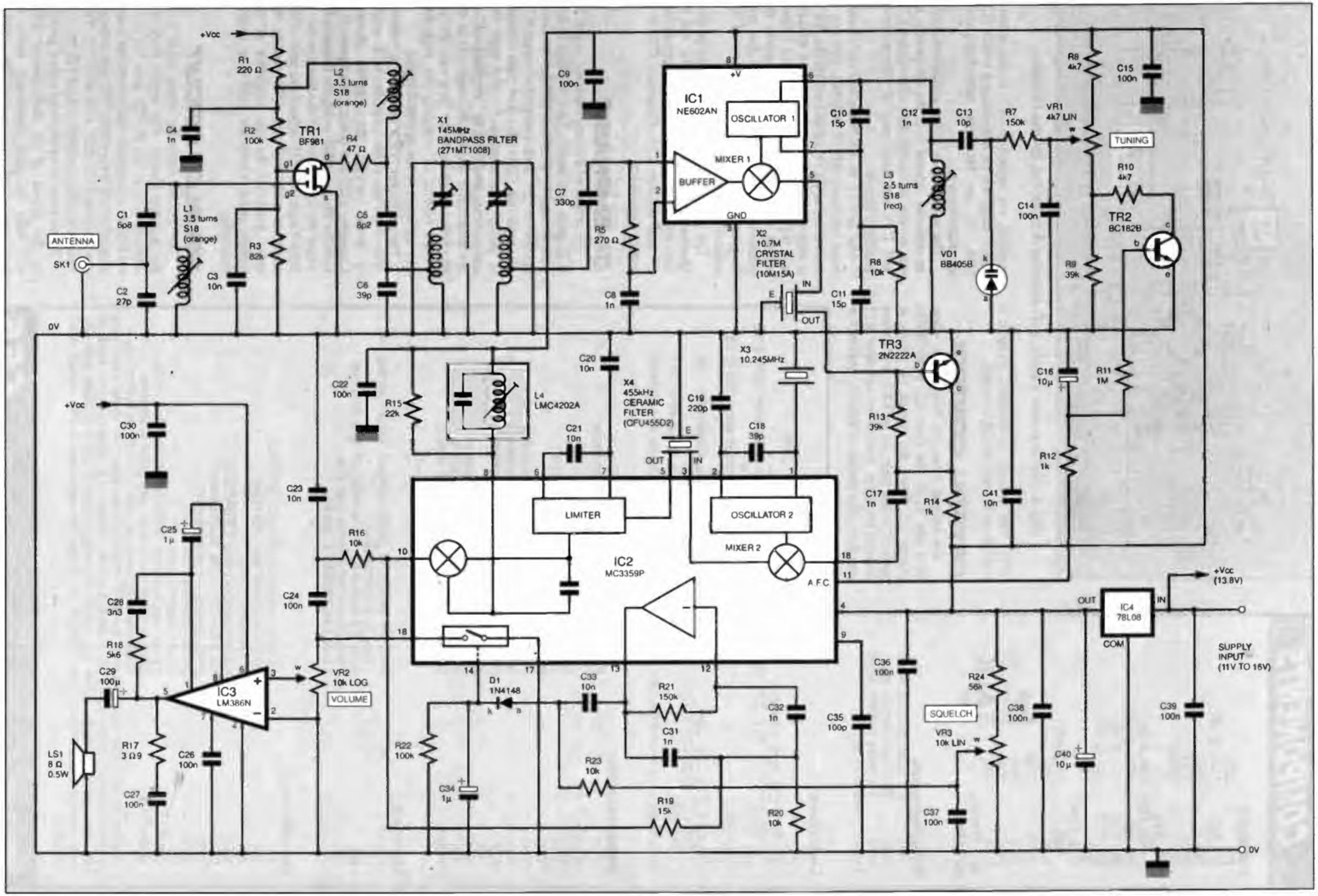


Fig. 4. Complete circuit diagram, except mains supply, for the 2M F.M. Receiver.

COMPONENTS

Resistors

R1	220Ω
R2, R22	100k (2 off)
R3	82k
R4	47Ω
R5	270Ω
R6, R16, R20, R23	10k (4 off)
R7, R21	150k (2 off)
R8, R10	4k7 (2 off)
R9, R13	39k (2 off)
R11	1M
R12, R14, R25	1k (3 off)
R15	22k
R17	3Ω9
R18	5k6
R19	15k
R24	56k

All 0·25W 5% metal film

See SHOP TALK Page

Potentiometers

VR1	4k7 rotary carbon, linear
VR2	10k rotary carbon, log.
VR3	10k rotary carbon, linear

All p.c.b. mounting types

Capacitors

C1	6p8
C2	27p
C3, C20, C21, C23, C33, C41	10n (6 off)
C4, C8, C12, C17, C31, C32	1n (6 off)
C5	8p2
C6, C18	39p (2 off)
C7	330p
C9, C14, C15, C22, C24, C26, C27, C30, C36 to C39, C43, C44	100n (14 off)
C10, C11	15p (2 off)
C13	10p
C16, C40	10μ radial elect. 16V (2 off)
C19	220p
C25, C34	1μ radial elect. 16V (2 off)
C28	3n3
C29	100μ radial elect. 16V
C35	100p
C42	470μ radial elect. 25V

All capacitors are monolithic ceramic with 2·5mm lead spacing, except where stated.

Semiconductors

VD1	BB405B u.h.f. tuning a.f.c. varicap diode
D1 to D4	1N4148 signal diode (4 off)
D5	green l.e.d. with mounting clip
TR1	BF981 low-noise dual-gate MOSFET
TR2	BC182B *npn* silicon transistor
TR3	2N2222A *npn* gen. purpose r.f. transistor
IC1	NE602AN dual balanced mixer/oscillator
IC2	MC3359P mixer/oscillator/demodalator (ULN3859)
IC3	LM386N power amp.
IC4	78L08 +8V 100mA voltage regulator
IC5	78L15 +15V 100mA voltage regulator
REC1	DB005 50V 1A 4-pin d.i.l. bridge rectifier

Inductors

L1, L2	Toko 3·5 turns v.h.f. ferrite core coil, with screening can, type S18 Orange (2 off)
L3	Toko 2·5 turns v.h.f. ferrite core coil, type S18 Red
L4	Toko 7mm 455kHz ferrite core coil, type LMC4202A 7E Black

Miscellaneous

X1	145MHz bandpass filter (271MT1008)
X2	10·7MHz crystal filter (10M15A)
X3	10·245MHz crystal
X4	455kHz ceramic filter (CFU455D2)
LS1	8Ω 0·5W 76mm dia. loudspeaker
SK1	BNC chassis mounting socket
SK2	2·5mm power socket
S1	s.p.s.t. toggle switch
S2	d.p.d.t. toggle switch (mains rated – not on model)
FS1	250mA 20mm mains fuse, with panel fuseholder
T1	230V mains transformer, with 15V 250mA secondary

Printed circuit board available from the *EPE PCB Service*, code 144: metal case, size 203mm × 127mm × 51mm; 8-pin d.i.l. socket (2 off); 18-pin d.i.l. socket; plastic knob (3 off); strain relief grommet; solder tag; p.c.b. mounting spacer (4 off) and fixing nuts and bolts; multistrand connecting wire; length of single-core screened cable; mains lead; solder etc.

Approx Cost Guidance Only **£55**

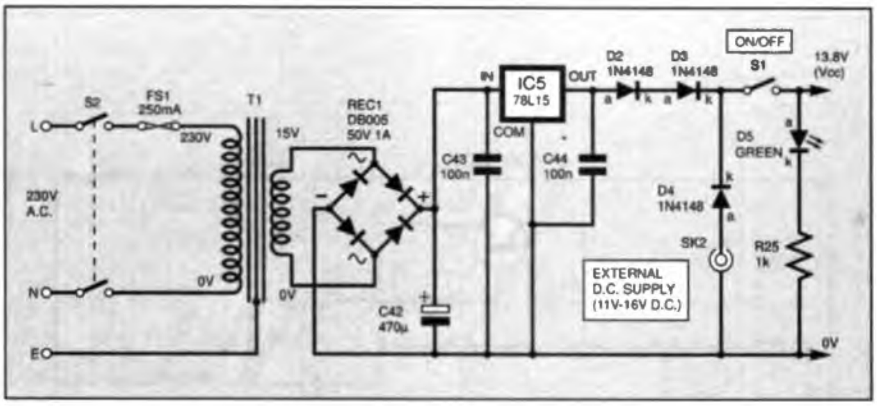


Fig. 6. Mains power supply, with external d.c. socket, for the Receiver.

VD1. The voltage is modified in such a fashion as to track the input signal.

CRYSTAL CONTROL

The output from the first mixer stage (IC1 pin 5) is fed into X2, a 10·7MHz crystal i.f. filter, the output of which is applied to the base (b) of TR3, a common emitter amplifier biased by resistors R13 and R14. The output of this i.f. amplifier is applied, via capacitor C17, to the second mixer stage which is contained within IC2 (pin 18), an MC3359 mixer/oscillator/demodulator i.c.

The oscillator in IC2 is controlled using an external crystal X3, the frequency of this crystal is 10·245MHz. Capacitors C18 and C19 are also part of the external oscillator circuit.

Our first i.f. of 10·7MHz and our second local oscillator of 10·245MHz give us a second i.f. at 10·7 – 10·245 = 455kHz. X4 is a ceramic i.f. filter centred around 455kHz and the output is i.f. amplified and limited within the IC2. The limiting removes the effect of any amplitude variations that may be present on the signal, this is one of the main advantages of F.M.

The output of the limiter circuit is then Quadrature demodulated with the aid of the external tuned circuit consisting of coil L4 and resistor R15. Capacitor C22 is a supply decoupler.

DE-EMPHASIS

The output of the demodulator, at pin 10 IC2, goes two routes. First of all it is low pass filtered by R16 and C23 before being applied to the audio amplifier stage IC3, via capacitor C24. This low pass filtering is called "de-emphasis". The high frequencies are amplified or "emphasised" at the transmitter and the de-emphasis in the receiver compensates for this with the intended benefit of reducing the high frequency noise in the received signal.

Potentiometer VR2 provides a volume control for the audio amplifier IC3, which is based around the LM386 device. Capacitor C27 and resistor R17 provide a load for the amplifier at higher frequencies where the impedance of the loudspeaker is high. Capacitor C25 defines the gain of the amplifier and R18 and C28 reduce the noise produced by the amplifier at the higher gains. Capacitor C30 is a supply decoupler.

SQUELCH CIRCUIT

The second route the signal takes is to the Squelch circuit. The signal from the demodulator, at pin 10 IC2, goes via resistor R19 to a bandpass filter/amplifier based around the op.amp within IC2 and external components R20, R21, C31 and C32. This filter is roughly centred around 12kHz.

When there is no received signal present on the output of the demodulator there will only be high frequency noise or hiss, which is very annoying. The 12kHz filter/amplifier combination will amplify

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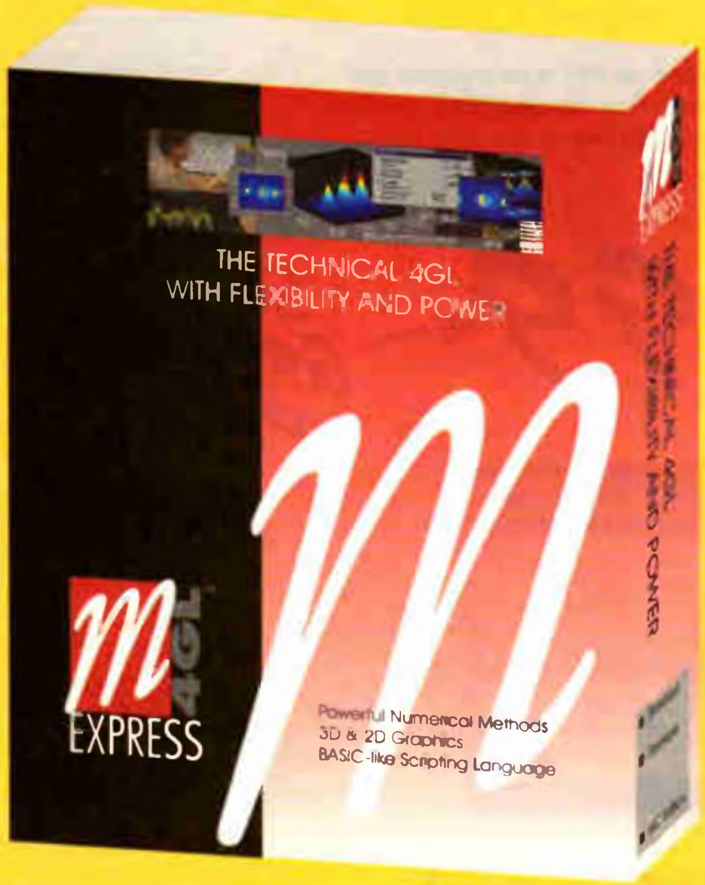

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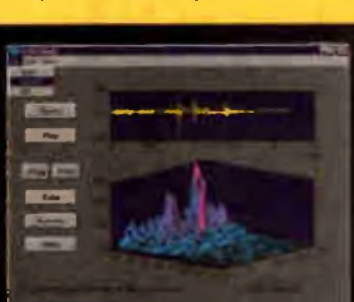

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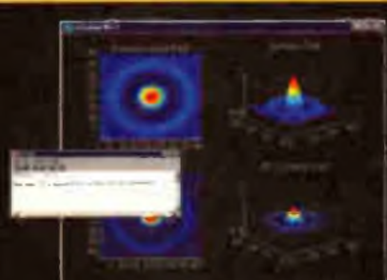

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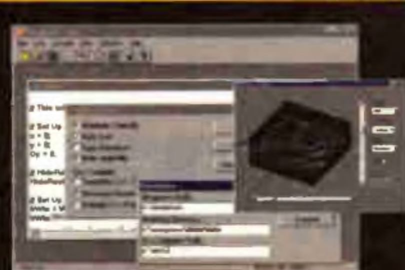

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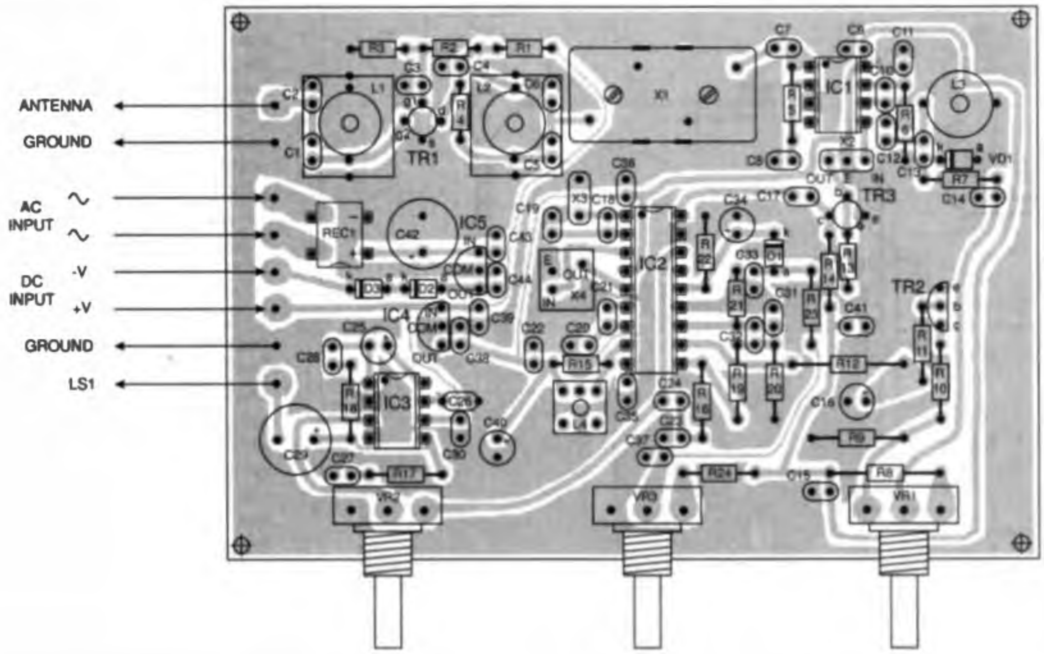
INTERACTIVE



this noise. The output of the filter/amplifier at IC2 pin 13 is coupled to a peak reader circuit by capacitor C33. It is also added to the d.c. voltage generated by the potential divider R24 and VR3. The peak reader circuit consists of diode D1 which rectifies the noise plus d.c. whilst C34 will hold the peak voltage for a short time determined by the time constant of C34/R22.

When the voltage across C34 reaches about 0·7V, this switches on a transistor within IC2 (between pin 16 and pin 14). This transistor takes the input signal of the audio amplifier to ground (0V) and so the hiss isn't amplified and applied to the loudspeaker LS1. When there is a legitimate signal present at the output of the demodulator the voltage across C33 will be less than the 0·7V and so the signal will be amplified and applied to the speaker as normal.

The level of noise that will activate the squelch circuit is varied by means of potentiometer VR3.

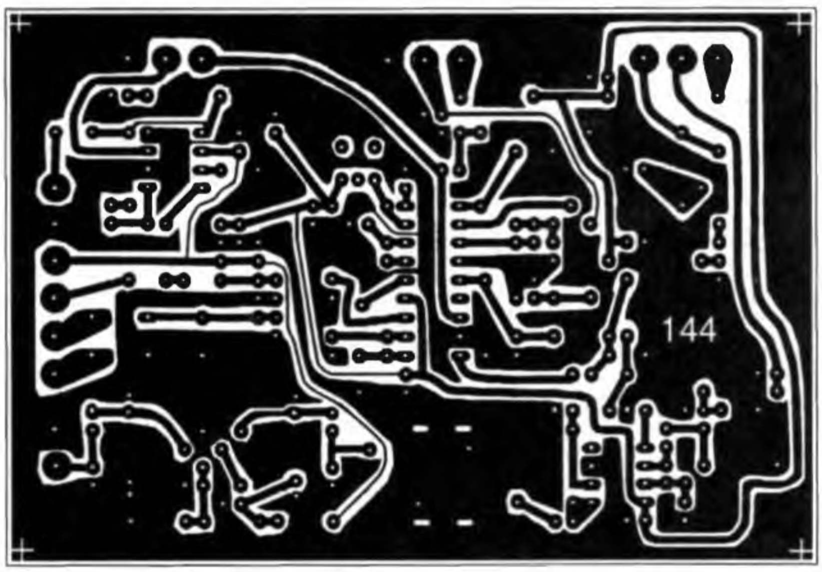


Fig. 7. Receiver printed circuit board component layout and full size copper foil master pattern.

POWER SUPPLIES

There are two power lines used within the Receiver. The 13·8V or the battery voltage (Fig. 6) is used to power the front end amplifier and the audio amplifier sections.

The other stages of the receiver are powered from an 8V regulated supply which is derived from the higher voltage rail. IC4 is an LM78L08 100mA regulator device which is decoupled by capacitors C38, C39 and C40.

The front-end r.f. amplifier and audio output amplifier power supply circuit diagram can be seen in Fig. 6. The 15V secondary winding from the mains transformer T1 is full-wave rectified by REC1 and smoothed by electrolytic capacitor C42. The unregulated voltage is then regulated to 15V by IC5, which is a 100mA voltage regulator. Capacitors C43 and C44 provide decoupling and remove any possibility of IC1 oscillating.

The regulated 15V supply now passes through diodes D2 and D3, this drops the voltage down to around 13·8V, the diodes also isolate the battery supply from the output of the regulator. The External D.C. supply enters the circuit at SK2 and passes through diode D4 to supply switch S1. This means that if a battery and the mains are supplied at the same time then the 13·8V will not appear across the battery. Light emitting diode D5 and resistor R25 provide an indication that the Receiver is powered up.

CONSTRUCTION

The 2M F.M. Receiver is constructed on one single-sided printed circuit board (p.c.b.). The component side layout and full size track pattern can be seen in Fig. 7. This board is available from the *EPE PCB Service*, code 144.

Assembly of the components can be carried out in any order you feel content with, ideally starting with the lowest profile components. The three p.c.b. mounting rotary potentiometers should be left until last since they are quite bulky compared with the rest of the components.

It was chosen to mount these directly on the p.c.b. to simplify construction of the receiver. If, however, you prefer to mount them on the front panel of the chosen enclosure for the receiver this is fine and wires should be taken to the appropriate positions on the board.

If the project is to be battery powered only, the components in Fig. 6 can be omitted. The use of i.c. sockets is strongly recommended.

Take care over the polarities and orientation of the electrolytic capacitors and semiconductors. Following assembly, thoroughly check that the soldered joints

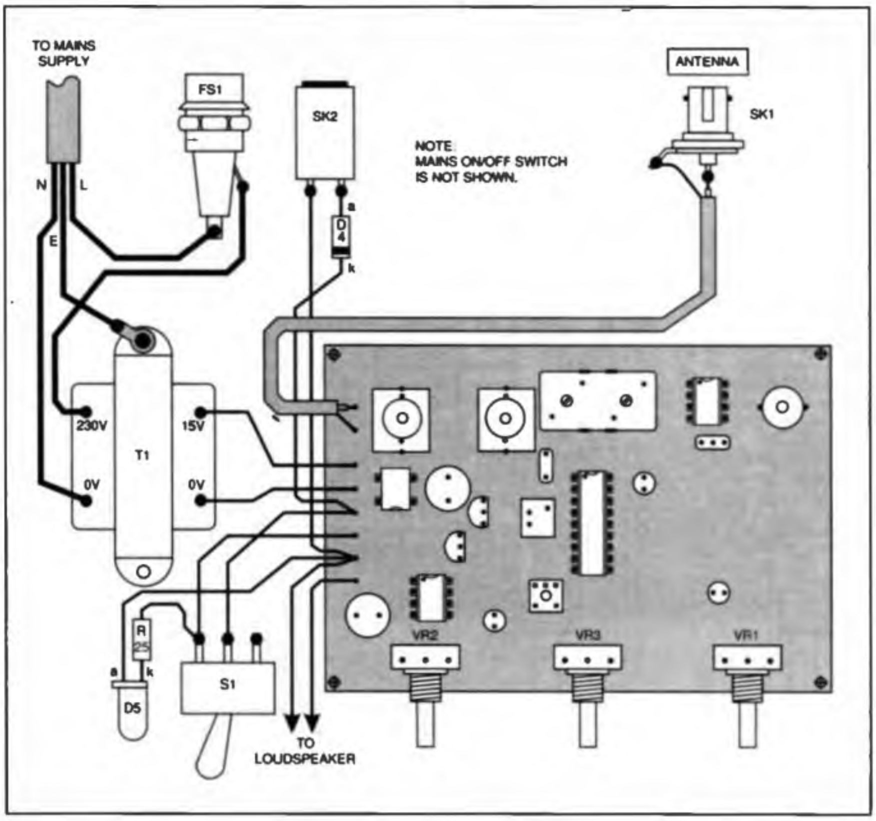


Fig. 8. Interwiring from p.c.b. to off-board components. The double-pole mains on/off switch (S2), shown in the power supply circuit diagram, was not used in the prototype model. This is inserted directly into the Live and Neutral leads of the mains cable before the transformer and fuseholder.

are satisfactorily made and that the components are indeed correctly oriented.

FINAL ASSEMBLY

The Receiver is best suited to a metal enclosure which will provide some screening. Holes should be drilled to suit the antenna connector SK1, the external power connector SK2, the shafts for the potentiometers, the power switch S1, fuseholder FS1 and the loudspeaker LS1 which can be either bolted or glued into position. Before mounting the loudspeaker drill a matrix of "sound exit" holes in the case, see photographs. In addition holes will be required in the base for the mains transformer and for the spacers on which the p.c.b. will be mounted.

Once all the holes have been drilled as required the front panel can be sprayed using car touch-up paint. Rub-down lettering can then be used to provide suitable legends on the front panel which can then be sprayed with clear protective lacquer.

Once the case is complete, the printed circuit board can be fitted in place and wired up as per Fig. 8.

TESTING

Before powering up the receiver, the resistance across the d.c. supply lines should be checked. This should be in excess of six kilohms (6k). If it differs greatly check the position and orientation of all components and ensure that there are no solder splashes on the board underside copper tracks.

With the receiver switched off, plug in the mains lead and check the voltage at the D.C. pin on the board, it should be around 13·8V. Disconnect the mains and apply a battery and again check for the correct voltage on the D.C. pin. If all is well then we can proceed with powering up the receiver.

With the Volume and Squelch controls turned to their minimum positions and the Tuning control set to mid travel, switch the receiver on and advance the volume control clockwise. If all is well there should be a hissing sound from the loudspeaker.

If this does not happen check all the voltage levels on the semiconductors and re-check their orientation. When these voltages are correct and the hissing sound is present the receiver can be tuned up.

ALIGNMENT

Adjust the ferrite "slugs" within L1, L2 and L3 so that they are flush with the tops of their formers. (The ferrite cores in these coils are very fragile and adjustments should only be made with nylon or brass trimming tools – *never use* a steel screwdriver). Adjust L4 for the maximum noise output. Adjusting the first local oscillator is best done with a frequency counter or spectrum analyser if these are available, successful adjustment can, however be achieved without these instruments with a little patience.

Turn the slug in L3 and L4 one quarter turn into the former, with the Tuning control set to mid position, this should correspond to around 134·3MHz (which will result in the receiver demodulating signals at 145MHz). Using a frequency counter or spectrum analyser to "sniff" the r.f. energy from L3 this can be confirmed and the slug can be adjusted to bring the oscillator to exactly 134·3MHz.

With this adjustment complete and with a suitable antenna connected turning the tuning control VR1 should reveal any stations that are operating on the band. If a repeater of known frequency is heard this can again be used to calibrate the local oscillator. Once a station has been successfully located the ferrite core of L4 can be adjusted for the best audio quality (this can be done more easily with one end of R12 disconnected).

FRONT-END

The next stage in the alignment is to adjust the response of the front-end input amplifier. With the receiver tuned into a fairly week station adjust the core of L2 for maximum signal strength. If an oscilloscope is available this can be done very easily by adjusting L2 for the maximum amplitude of the 455kHz sinusoid that should be seen on pin 5 of the IC2. Coil L1 can now be adjusted to give the minimum noise output on the signal.

If all is well with the Squelch circuit the receiver should go silent when the Squelch control VR3 is advanced beyond a certain

Layout of components inside the metal case. Note the loudspeaker is mounted on the underside of the case lid behind a series of "sound holes".

point. If this is not the case, check the voltage on the wiper (moving contact) of VR3 and also on pin 14 of the IC2. When in use the Squelch control should be advanced just beyond the point where the hiss disappears.

AERIALS

There are many commercial aerials available for the two meter band which will work well with the 2M F.M. Receiver but good results can be obtained without going to a great expense in this area. In its simplest mode the aerial need not consist of more than a piece of wire connected to the aerial socket. However, clearly the best performance will be obtained with some sort of resonant aerial located out doors.

One of the simplest aerials is, of course, the half-wave dipole and Fig. 9 shows a suitable arrangement for a dipole resonant on the two metre band. The elements can be made from stiff wire or thin bore copper pipe such as that used in car brake pipes.

Cut the elements to length then solder a large solder tag to one end. Cut a piece of perspex or suitable insulating material to an appropriate size (5cm × 10cm) and drill holes in the positions indicated for two wood screws and for two M4 bolts which will be used to mount the elements. Suitable coax cable can be connected using large solder tags connected to the same bolts.

The perspex insulator can be screwed to some sort of boom, a broom handle with a "flat" cut in one end is very good for this purpose. This boom can be used to mount the aerial as high as possible out of doors perhaps using a TV aerial clamp or similar.

If the receiver is to be used in a car, the standard car aerial can be used. If this is the telescopic type the sections should be adjusted to 49cm in length. This 49cm is half a wavelength at 145MHz it can be calculated by dividing 71·25 by the frequency in MHz, in our case 145.

IN USE

Although this is a simple design with the minimum of parts, the dual-gate MOSFET front end gives the Receiver a sensitivity which should be equal to, if not better than, some commercial equipment and with a suitable aerial connected good results can be obtained throughout the two metre band. The prototype has been in use for some time and has obtained good results in a variety of locations. It does tend to drift slightly when first switched on but after a few minutes it remains stable on the chosen station.

Although it was designed for the 2M Amateur Band the actual frequency of operation can be easily changed by altering the position of the ferrite core in coil L3. Indeed, a different value inductor could be loaded here to give a significantly different frequency coverage.

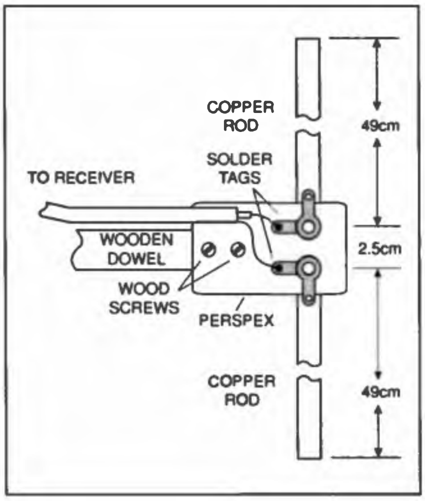


Fig. 9. Detail for a DIY version of a ½-wave dipole aerial.

The filters in this receiver are, of course, at 145MHz and will therefore attenuate signals outside this band. However, adjusting L3 can still allow coverage of local Taxi bands etc.

The 2MHz bandwidth of the receiver is controlled by resistors R8 and R9. These values can be changed to give a wider or narrower bandwidth. Reducing R9 to 390 ohms and removing R8 altogether will give around 6MHz of bandwidth. □

SHOP TALK
with David Barrington

2M F.M. Receiver

We had quite a nightmare when we came to sourcing components for the *2M F.M. Receiver* project. We found that the expected supplier of the MC3359P mixer/oscillator/demodulator chip had exhausted his supplies and was unable to track down further ongoing stocks, even for his own kits.

After several phone calls, even to the manufacturers, we eventually discovered that the **Macro Group** of Slough ***(Tel; 01628 504383)*** have stocks and readers should ring them for latest prices and availability. We understand that the ULN3859 is a similar device but no stockists have been found.

Some of the other components can be classed as "specials" and are carried by **Cirkit** ***(Tel. 01992 448899)***. These include: the BB405B varicap diode, code 12-01055; 4-in d.i.l. bridge rectifier DB005, code 12-01050; BF981 MOSFET, code 60-06981; 2N2222A transistor, code 58-02222; and the NE602AN dual mix/osc., code 61-00602.

They also specialise in Toko coils and can supply all the inductor coils and screening can. They should be ordered as follows: 3·5 turns v.h.f. ferrite S18 Orange, code 35-10303 (plus screening can 21-09105); 2·5 turns v.h.f. ferrite S18 Red, code 35-10203: and the 7mm 455kHz ferrite type LMC4202A 7E Black, code 35-42021.

For the filters and crystal quote: Bandpass 271MT1008, code 17-01008; Crystal filter 10M15A, code 20-10152; 10·24MHz crystal, code 45-10003; and ceramic filter CFU455D2, code 16-45582. The 15V 250mA mains transformer should be generally available.

The Receiver printed circuit board is available from the *EPE PCB Service*, code 144.

Alarm-Operated Car Window Winder

You must use heavy-duty automotive wire where specified when building the *Alarm-Operated Car Window Winder* project. Remember, you *MUST* disconnect the vehicle's battery *before* connecting the unit into the vehicle's electrics.

Also, in view of the high currents present, there is a risk of overheating and even fire if you do not double-check your wiring and make good connections prior to reconnecting the car battery.

Make sure you have provided a good "solid" earth (chassis) connection and that you have placed an in-line fuse in *each* Closer circuit "live" power line cable. Be extremely cautious, watching and smelling for telltale signs of heat etc when setting-up – Warning over.

All components required for the Trigger and Closer circuits should be readily available. However, for the Closer circuit you may experience a little difficulty in obtaining 0·015 ohm resistor rated at 4W. You should find one in the "wirewound" range stocked by advertisers, but you may have to select a 7W type as these seem more readily available.

You must use a relay which has contacts capable of handling currents of at least 16A. A typical example is the **Maplin** 12V d.c. 16A miniature relay, code YX99H. Other similar types may be offered, but check that the relay contact arrangement will suit the circuit board or you may have to "hardwire" it to the board.

The two small printed circuit boards are available from the *EPE PCB Service*, codes 150 (Trigger) and 151 (Closer) respectively. You will need a Closer p.c.b. for each window you wish to control.

PIC-A-Tuner

Only a couple of items for the *PIC-A-Tuner* project give rise to further comment and these concern the PIC microcontroller and display module.

If you intend to program your own PIC, make sure you ask for the 10MHz version of the PIC16C84. Also, we understand from the designer that a 3-key membrane keypad does not appear to be listed by anyone and a 4-key "pad" was used in the prototype, with one key not used. The one in the model came from **Electromail** ***(Tel. 01536 204555)***, code 130-381.

Turning to the l.c.d. display module, you may find that by shopping around you can purchase a 2-line 8-character module at a "bargain basement" price from one of our advertisers. Before buying, check it is a HD44100-compatible device.

For those who wish to purchase a ready-programmed PIC16C84, these can be obtained from **Magenta** ***(Tel. 01283 565435)*** for the sum of £15 inclusive. Alternatively, if you wish to do your own programming, the software is available on a 3·5in disk from the Editorial Offices – see the PCB page for details or, for Internet users, free from our FTP site: **ftp://ftp.epemag.wimborne.co.uk**.

The printed circuit board is available from the *EPE PCB Service*, code 149.

Quasi-Bell Door Alert

No problems should be encountered by constructors of the *Quasi-Bell Door Alert* project. All components appear to be "off-the-shelf" items. Most advertisers stock a miniature, about 76mm dia., 64 ohm loudspeaker. If you wish to use a "telephone" mic. insert you could try contacting **Bull Electrical** or **J&N Factors**, see their advertisement pages.

The printed circuit board is available from the *EPE PCB Service*, code 133.

PIC-Agoras

Fully-programmed PIC16C84 microcontrollers for PIC-Agoras are available from **Magenta** ***(Tel. 01283 565435)*** at £15 each inclusive of VAT, etc. You will need to program in your own wheel size, however, as discussed in the text.

If you have TASM-compatible PIC-programming facilities, you can, of course, program your own chip. The software is available either on disk from the *EPE* Offices or from our Web site (see page 363).

Snow Drifts into C5's Launch

Barry Fox reports

TRANSMISSION tests run by Channel 5 Broadcasting (C5B) to establish likely levels of interference to VCRs, have exposed a completely different practical problem. Many viewers will need to pay at least £100 for a new roof aerial if they are to receive watchable pictures from C5. If viewers cannot watch C5, advertisers will not fund the station.

The Independent Television Commission warned of this both when advertising and granting the C5 licence. But the theoretical warning meant little until C5B started testing its transmitters and a few inquisitive viewers tuned in to the test card.

NTL, the company which transmits for ITV and C4, and will now serve C5, accepts no responsibility for the snowy and ghosted pictures which some people are now seeing. NTL must follow technical rules set by the ITC after international negotiations aimed at preventing interference to stations in mainland Europe which already use the same frequencies as C5.

C5 confirms that its test transmissions have been "at full power, all day". So if viewers get poor pictures now, they can expect nothing better when the full service begins, unless they erect more efficient aerials.

Says Bruce Randall of NTL, "the original international frequency plan was for four channels, which is one more than many European countries have got. So it was a quart in a pint pot already. We are doing our best, but C5 is never going to have the same coverage and power as the other four."

Questionable Validity

The Independent Television Association, which represents the ITV companies, has already warned that C5B is behind with its retuning and questions the validity of C5B's recent tests because of the limited publicity. Says ITVA spokesman Jim Cavanagh, "If C5 thinks the tests are valid, good. I hope they are right. But if they are wrong they could find themselves launching a channel that not many people can receive. Then the proverbial will really hit the fan". Cavanagh had tuned his TV set into C5's frequency and got only very poor pictures.

NTL and the ITC both say it is impossible to put a figure on the number of people who will need new aerials. The true picture will not emerge until C5 has conducted further tests, with much wider publicity, and following the start of its full service over the recent Easter weekend. But industry insiders estimate that four or five million homes will not be able to receive clear pictures with existing aerials.

The UK's four existing TV stations come from 50 main transmitters, and over 900 lower powered relays to boost pockets of bad reception, behind hills and tall buildings. C5 comes from a total of 33 main transmitters only. No relays carry the C5 signal. Some parts of the country will not get C5 at all.

C5 will broadcast to its main audience, in London, from a 250 kilowatt transmitter. This is one quarter the power of the transmitters used by the BBC, ITV and Channel 4.

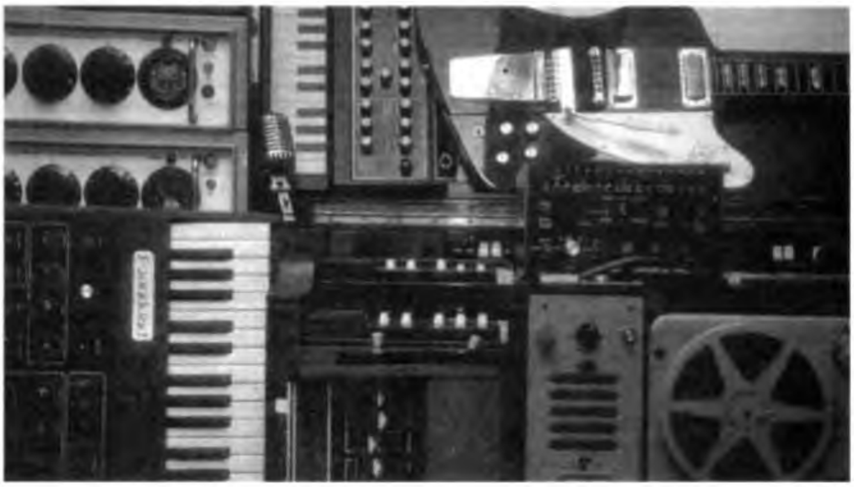
Aerial Combat

The existing four stations come from omni-directional transmitter aerials at Crystal Palace. Because there was no room for more aerials on these masts, C5 will broadcast from the Beulah Hill FM commercial radio mast, a few kilometres away. Receiving aerials which are close to the area and pointed at Crystal Palace will be wildly off-axis for Beulah Hill. So the C5 signal is further weakened and polluted by reflections which cause ghost images.

Existing aerials in London are classified as Group A and designed to receive channels at frequencies up to channel 34. Group B starts at channel 39. In London, C5 uses UHF channel 37. So existing aerials are not suitable for UHF channels 35 and 37, as used by C5. The Group A aerials used in London are very poor at receiving C5's London frequency, channel 37.

NTL says that the signals that viewers get from existing stations are usually so strong that viewers can split their aerial to feed between several TV sets or VCRs, without noticing much difference. But the split feeds will give poorer pictures when they are handling C5's already reduced signal.

Although C5 has done little to publicise its transmission tests, anyone interested can find full details for all parts of the country from the BBC's Teletext pages on Engineering Information (BBC1 page 698).



Musically Vintage Auctions

DID you know that VEMIA (Vintage Electrical Musical Instrument Auctions) are held twice a year in Devon? The next one is between April 6th and 30th (what a Marathon!), that's starting this coming Sunday if you've just acquired this copy of *EPE* on its publication day of 4th April (subscribers should have received it a few days earlier and be able to plan for this weekend's auction a bit more easily).

The info we've received about it is sparse, basically just the following: Vemia, Dept. EPE, Star House, Sandford, Crediton, Devon, EX17 4LR; Tel: 01363 774627; Fax: 01363 777872; Web: **http://www.eclipse.co.uk**; E-mail: vemia@mail.eclipse.co.uk;

The received photo shows a selection of items that will be nostalgia-generating to older readers and remarkable curiosities to younger ones. Apparently, all the major names are represented from Ace-Tone and Ampex, through Gibson, Korg, Rickenbacker, to Wirlitzer and Yamaha, to mention but a few from the list that starts in the 1930s and extends to the '80s. Sounds interesting! For more info, contact Vemia by any of the above means. (There's another auction in November.)

TV'S GOT A DOODLE-DO!

Getting your revenge on politicians – by Barry Fox

IBM has invented new technology which could make the UK's forthcoming election much less of an ordeal for TV viewers. It gives the viewer control over the way someone looks and sounds on screen. This, says IBM, adds entertainment value to even the most boring political speech.

Now that a date for voting in the UK has been announced, British TV stations are obliged to give all the major parties equal free air time for Party Political Broadcasts. Because these are unpopular with viewers they are slotted into the schedules at short notice, and across several channels.

A series of lengthy patents recently filed in Europe by IBM in Armonk, NY describes a system which gives people so much control of their TV sets that they can get their own back on political speakers by ridiculing them (European applications 746 147 - 746 153).

TV'S SPACE-AGE

IBM's researchers have been rethinking the way people will watch home screens in the new digital age. They have coined the term, "television space" to describe a viewing experience which combines pictures, sound and interactive education and entertainment from broadcast, cable, games consoles and pre-recorded discs and tapes. There will be several hundred channels, from sources which require a dozen remote controls, some having fifty separate buttons.

This, says IBM, is "unmanageable". The patented remedy is a master controller, which sits on top of the TV set, connects to all the various sources and responds to a single remote handset with only a few buttons. Instead, it has a "wiggle stick" or "wobble plate" which works like the joystick control for a video game to move a cursor over the TV screen.

The control box generates images on the screen which look like a fanned pack of cards. Each card represents a family of programmes; for instance, weather, sport, comedy or movies. Moving the cursor over a card and clicking "OK" moves to another set of cards which show the choice of programmes.

PRIME-TIME BORING

All the time, the control box is generating what IBM calls "diversions". These are either displayed automatically during commercial breaks or when the viewer gets bored and pushes a button. IBM cites political speeches as a prime example of boring viewing.

Each diversion is like a video game which lets the viewer play with the TV image or sound. "Doodles" freezes the picture and displays a palette of moustaches, beards and spectacles at the side of the screen. The viewer then uses the wiggler or woggler to drag and drop disguises over the unfortunate victim's face. The live soundtrack continues to play so that the viewer can stop doodling and start watching the programme again as soon as it gets interesting.

Another diversion, called "Wall", lets the viewer use graphic blocks to construct a wall which progressively obscures any unwelcome face on screen. "Puzzle" automatically breaks the picture into blocks and rearranges them so that the face on screen becomes unrecognisable. The viewer must then try to get the blocks back into their correct position.

"Voices" lets the viewer replace the boring performer's live speech with the same words heard in the funny voice of a cartoon character. A palette appears on screen to offer a choice of "goofy" characters.

All these diversions, says IBM, will "pass time otherwise spent in an uninteresting fashion".

Tooling-up with Squires

NOW here's a catalogue to delight any ardent DIYer – that from Squires Model & Craft Tools. It's a mail order catalogue, so you don't need to go drudging round the shops on the off-chance that they've got what you need to create your latest brainchild. This catalogue has probably got *far more* modelling tools in it than you could ever dream off!

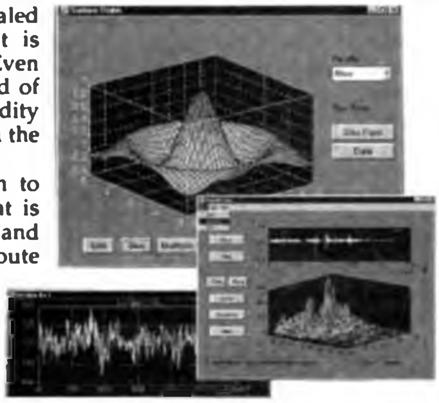
The 1997 edition is a sizeable volume at 100 A4 pages of illustrated products, a mixture of monotone photographs and line drawings. Nearly everything available is shown. Moreover, it is also indexed; probably well over 150 subject headings are quoted. Products include: airbrushes; caliper guages; de-burring wick; electrically conductive paint; fractional drill bits; gas torches; inspection mirrors; liquid poly; needle files; optical centre punch; punch and die set; quick action clamps; rotary cutters; tag boards; universal work holder; vernier guages; wire cutters; X-Acto blades, to mention but an alphabetical few!

The catalogue is admirably and clearly compiled, and all the items have prices quoted. Credit card orders are welcome.

No self-respecting hobbyist, in whatever constructional field – electronics, model cars, aircraft, whatever – should be without this one-stop shopping guide; it's a tool in its own right! And it's FREE! We are told that not even postage is charged for. This desirable Cat will be sent to you almost as soon as you've asked for it. Get a copy!

For more information, contact Squires Model & Craft Tools, Dept. EPE, The Old Corn Store, Chessels Farm, Hoe Lane, Bognor Regis, W. Sussex, PO22 8NW. Tel/Fax: 01243 587009.

BASIC FOR ENGINEERS



BASIC as a programming language has appealed to a whole generation of programmers. It is quick to learn and relatively easy to use. Even programmers who ultimately need the speed of machine code will use it to establish the validity of their program flow logic before starting on the source code programming.

What, then, should be more natural than to expect a similarly constructed language that is tailored to meet the needs of engineers and scientists? That expectation is what QuickRoute Systems have addressed through their introduction of MExpress 1.1.

MExpress 1.1 is a powerful numerical and visualisation package which uses a BASIC-like scripting language. Over 250 functions are built in, covering everything from solving simultaneous equations and signal processing, to advanced 2D and 3D plotting, and creation of user interfaces.

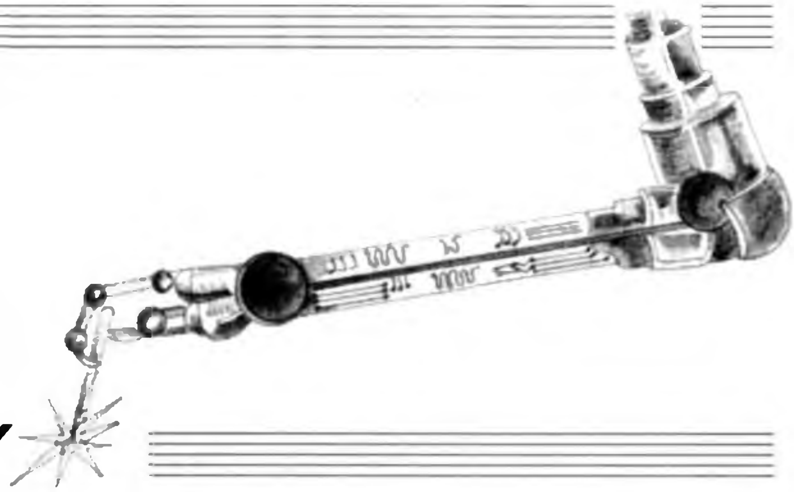
Designed for use with Windows 3.1, 95 and NT, this comprehensive package can be used in various ways. As a "super-charged graphing calculator", for example, simply typing commands and expressions at a familiar prompt. Data can be loaded, processed, plotted or visualised by calling on the powerful built-in functions. Once you are content with the basic commands, you can move on to create simple script files and then functions, updating the Function Library as you wish.

Complete applications can be created, with buttons, sliders, menus, multiple windows, etc. Furthermore, if you are using the Developer's Edition, the applications can be compiled into a Wins32 executable file which can be distributed royalty-free.

Managing Director Dr I.R. Frost says, "We expect MExpress to be popular with industrialists, engineers, scientists and enthusiasts because of its ease of use, power and, best of all, low price of just £99 (excluding VAT)". We feel his optimism is well justified. Other versions are available.

QuickRoute Systems are a company whose name is well established amongst regular *EPE* readers through the range of software products featured in their advertisements, which include the PCB drafting packages *QuickRoute* and *SMARTRoute*.

Much more information is available on this interesting new software tool from: QuickRoute Systems Ltd., Dept. EPE, Regent House, Heaton Lane, Stockport, SK4 1BS. Tel: 0161 476 0202; Fax: 0161 476 0505. E-mail: info@quicksys.demon.co.uk; **Web: http://www.quickroute.co.uk.**



CIRCUIT SURGERY

ALAN WINSTANLEY

Our monthly "Help Desk" takes piezo sounders apart and offers more guidance on resistor colour codes. An appeal too, for an elusive chip.

Buzzers and Sounders

AUDIBLE warning devices come in various flavours and it's worth understanding the differences between them if you're to specify the right parts and generally get the best decibels-per-pound of your money. Some typical questions which have come in over the past few months, include:

"I have some piezo discs (1⅜" diameter) which have two ceramic electrical contacts plus the base, as opposed to the more common type featuring one contact plus the base. What is the purpose of the extra contact?" – ***Leon Vaicius** (on the Internet).*

Meantime, regular reader ***Syd Mercer of Retford, Notts.*** asks:

"Can you help with a drive circuit for a three-terminal piezo sounder? I have obtained some from a few surplus boards, but I can only make them sound at a fraction of the level they are capable of."

I'll start with a general run-down on ways of adding audible warning devices to your circuits. They divide into several groups:

Electromechanical buzzers are nothing more than a coil supplied by a normally-closed (n.c.) contact. When power is applied, the coil turns into an electromagnet, which "attracts" the normally-closed contact and opens it. Power is therefore removed, the contact moves back again and re-applies power. Thus the contact is forced to oscillate on and off, producing a piercing tone. The contacts tend to arc horribly, producing lots of RFI (radio-frequency interference: some commercial units have a suppressor capacitor included) and they are large and crude, but effective. Such a buzzer can be made using a six-inch nail, some enamelled copper wire as a coil, and an n.c. contact formed from an old baked-bean tin! Fig. 1 shows how! (Beware of back e.m.f. which may give you a tingle.)

A more practical device is the common "hammer" buzzer which comes in a small moulded rectangular plastic housing with a grille, costing about £1 each. (Example, Maplin FL39V).

These incorporate a single transistor oscillator circuit driving a small coil. Whilst they have no moving electrical contacts (hence no arcing), they do cause a tiny spring-loaded hammer to vibrate to and fro, which creates the sound like a vibrating reed. They are used in small alarm projects, telephones, etc. and are cheap and cheerful buzzers.

Piezo elements arrived on our scene in the late seventies, the first in the UK probably being manufactured by TOKO. The piezo disc or piezo element is formed from a brass disc, onto which a layer of coated ceramic is deposited. A piezo ceramic element will distort very slightly when a voltage is applied across it.

On their own, they are of no use if you attempt to use them as a free-standing sound generator, so the mechanical aspects of mounting them are critical if an efficient sounder is to be achieved. This is because it is necessary to try to match the "impedance" of the airspace surrounding the disc: open airspace alone has a very low impedance compared with the high acoustical impedance of the disc, but by suspending a piezo disc within a suitable enclosure, see Fig. 2a, you can "compress" the air immediately surrounding the disc and the result will be a clear, crisp note.

Piezo discs are usually ready-mounted within a plastic housing (often being described as piezo sounders), and the brass element is often visible by looking into a sound-exit hole in the moulding. The

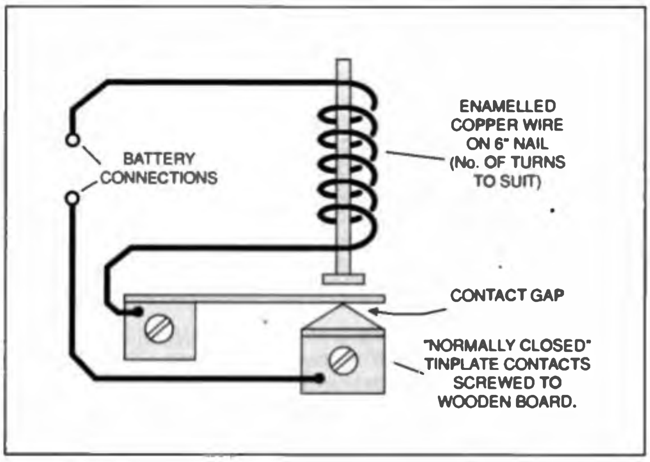


Fig. 1. The time-honoured electrical buzzer technique.

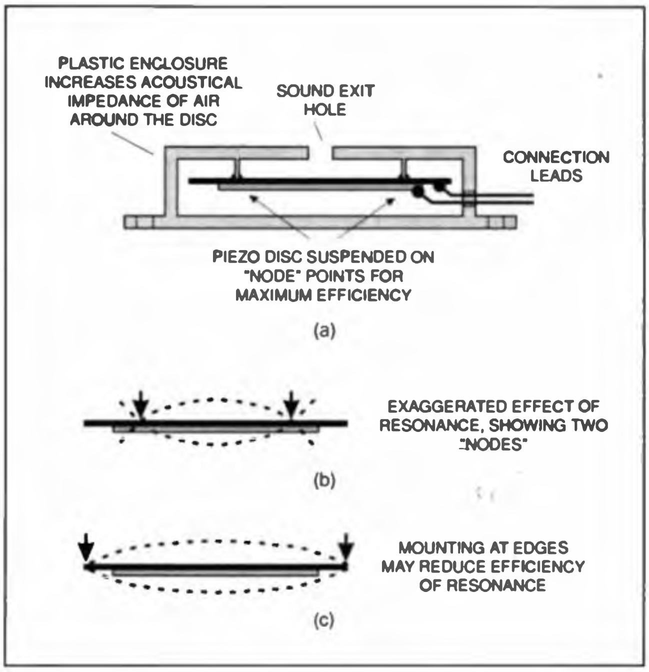


Fig. 2(a) Cross-section of a piezo sounder; (b) mounting of a piezo disc on its resonant "nodes"; (c) mounting a disc on its circumference.

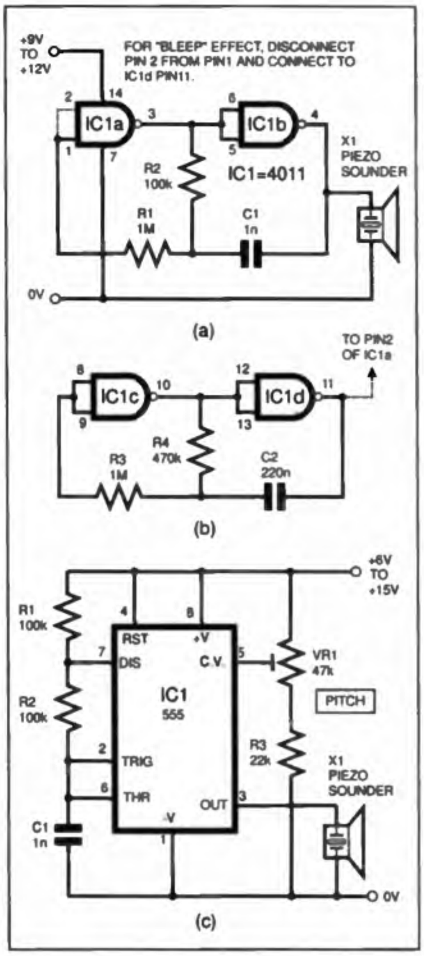


Fig. 3. Typical driver circuits for piezo sounders: (a) continuous tone driver; (b) "bleeps" modulator; (c) 555 generator with variable pitch control.

dimensions of the moulding are carefully calculated by the manufacturer so that the piezo disc will resonate efficiently when driven by a suitable signal.

In Fig. 2b, the disc is mounted at the specific "nodes" where it resonates at maximum efficiency. In Fig. 2c, the disc is fixed down at its circumference, but this is somewhat less efficient and may reduce the output.

In order to utilise piezo elements, it is necessary to apply a drive signal, which can be in the form of a simple square wave. It is best to try to match the drive signal to the resonant frequency of the sounder, to obtain maximum output.

Many manufacturers now produce piezo disc elements and you should check the data to obtain the resonant frequency value. Fig. 3 shows some typical ways of driving a piezo disc with an external oscillator. Note that by using another low-frequency generator to interrupt the continuous drive, the piezo can be made to bleep.

Incidentally, the piezo principle also works in reverse: by tapping a piezo element, a voltage is produced, and this signal can be input to other systems. (This is the basis of a crystal microphone.)

For instance, a piezo disc can form a simple mechanical shock detector. A good example is the *EPE Micro Sense Alarm* (January 1992 issue) by Jason Sharpe, which uses piezo elements as sensors for an anti-theft system. Also, a neat design is M.G. Argent's *Vibration Alarm* (*EPE* November 1992), which used a piezo disc not only as a small alarm tone generator, but as a shock sensor too! (Consult our Back Issues page elsewhere in this issue for ordering details.)

Three Wires

Things can be a little more complex when the manufacturer provides a third wire connection to the piezo disc. This is intended to provide feedback for an external driver circuit, in order to obtain a more piercing tone (see Fig. 4). In our market, it is very rare for this type of disc to be used, but they do find their way into commercial equipment (e.g. smoke alarms).

An alternative to a piezo sounder is a complete self-contained piezo buzzer. These contain all the driver circuitry needed to produce a warning tone. All that is required is an external power source to generate a signal – there is no need for an external oscillator.

Piezo buzzers are extremely convenient to use, of course, and certain models can produce an ear-splitting tone of well over 100dB which will leave your ears ringing for hours afterwards, as I can testify! Typical models include the Maplin FX84F.

Piezo "sound bombs" include several piezo buzzers for extra output. Novel musical buzzers are also available. You may also see three-wire piezo buzzers, where the third conductor is used as a control – connect it to one rail or the other, to produce a bleep or warble. Look out for high-power piezo sirens, too, for use in burglar alarm systems and similar. At least one user I know, employs a piezo siren inside his car, to deafen potential car thieves.

Some final tips: when it comes to purchasing these parts, it is worth checking and clarifying the difference between a sounder and a buzzer. Make sure you are actually buying the right part to begin with – it's easy to be mistaken if catalogues aren't clear.

Also, piezo elements and buzzers are designed to be fixed properly to produce maximum resonance, so mount them rigidly to a base to improve the resonance. I usually stick them down with double-sided adhesive foam strip or I use a dab of hot-melt glue. However, I previously had lots of problems with one particular type of piezo buzzer, which wouldn't work at all if it was fixed down too tightly. I guessed the enclosure was too flimsy and this impinged on the movement of the disc.

Prescaler Chip Blues

By co-incidence, two regular readers, ***Mr. Charles Hill of Carmarthen***, and ***Mr. B.J. Taylor of Rickmansworth*** both asked for help in locating an integrated circuit, the SP8269 Divide-by-100 Prescaler chip with pre-amplifier, made by GEC-Plessey Semiconductors. Mr. Hill is trying to extend the range of a home-brewed DFM, whilst Mr. Taylor is constructing a frequency counter with a minimum input of 150-200MHz.

Unfortunately, it seems to be discontinued and the nearest I managed was a mere Divide-by-10 or 11 Prescaler, the SP8680B (575MHz) listed by RS Components (302-378). Their catalogue has the

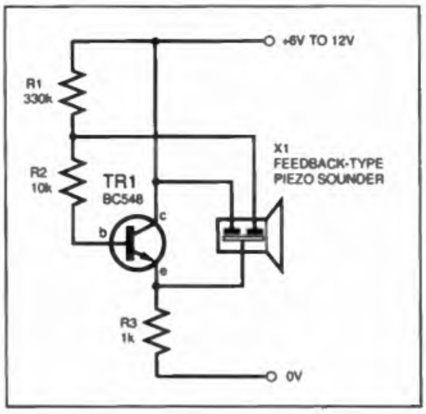


Fig. 4. Driver circuit for a 3-terminal feedback-type piezo sounder.

ominous black square next to the part number, meaning that that chip is likely to be discontinued in the near future too. If anyone has a spare, or knows of a suitable source or alternative, please drop me a line and I'll pass on your advice.

More on Resistors

Last month I described the colour codes for standard 4-band and 5-band resistors. The fourth stripe of a vanilla 4-band resistor is the tolerance, and sometimes – not shown last month – you will see red (2 per cent) or brown (1 per cent).

Just to confuse the issue a little more, 6-band types crop up from time to time, too! Resistor colour codes cause immense problems for beginners at times, and it isn't helped by the fact that some manufacturers may have their own specific code for particular types of resistor.

It's worth repeating that Maplin's popular "Min. Res." range of miniature metal film resistors (order code M+Value) is slightly unusual in that whilst they have a 1% tolerance, (with the 4th band coloured red), they say that a 5th red band may sometimes be present which denotes a 50 ppm temperature co-efficient.

On many other ranges, this would be equivalent to the sixth band of a 6-band type, which denotes the temperature co-efficient of the resistor; usually you can expect to see a red 6th stripe (indicating 50 parts per million) or brown (100 parts per million). My graphics last month seem to hold true for the vast majority of types, though.

Eventually, you will find that it's very easy to "read" a resistor value simply by looking at the coloured stripes. By breadboarding circuits and constructing prototypes, you will soon be able to associate a resistance value shown on a circuit diagram, with the colour code of the physical component itself. Most electronics enthusiasts can do this, it simply takes a little practice – so don't worry if you puzzle with colour codes to begin with – we all did!

Next month: an alternative design for a siren, using a custom siren chip and a loudspeaker. 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. E-mail **alan@epemag.demon.co.uk.** We try to help where possible but a personal answer cannot always be guaranteed.

New Technology Update

Increased processing speeds depend on smaller chip geometries, lower supply voltages and enhanced parallel operation – Ian Poole reports.

THE microprocessor is a little over 25 years old. Since the introduction of the first processor chip by Intel back in 1971 over 50 billion have been made. So successful have they been that barely a household in the western world cannot have one in some piece of household equipment. Businesses are also major users. Offices today bristle with PCs which use microprocessors at their heart. In fact we have become so used to the advantages of processor technology that it is hard to imagine what life would be like without them.

Whilst many changes have been made to everyday life as a result of them, more changes are set to come our way. Many new developments are being researched. Many of these ideas will not be feasible for many years but the seeds of ideas are beginning to show the way technology will progress. Faster speeds, smaller chips, more memory and a host of other ideas will all greatly increase the power of machines in the years to come.

It is possibly easier to see how device technology will move forwards, but what is not nearly as clear is how it will be used. Very few people would have foreseen the success of the PC, and the many other ideas which we take for granted. So, too, it will be difficult to see what we will be using in 25 years time.

Increased Throughput

It is clear that people will be striving for greater throughputs in CPUs. Here clock speeds are being raised at an ever increasing rate. Pentium chips running at well over 100MHz are commonplace now.

In the future, clock speeds will increase further. One of the current aims is to have processors running with clock speeds of around 1GHz. It is likely that this increase can be achieved with the same basic technology which is used today. But, to achieve this, a number of changes will be necessary.

Currently, there is a move to migrate from supply voltages of 5V to 3·3V. These lower voltages are required for two reasons. The first is that any v.l.s.i. (very large scale integration) chips running at very high speeds consume large amounts of current and run very hot. To reduce the power dissipation to acceptable levels, a reduction in the supply rail is needed.

Secondly, the chip geometries need to be made smaller to support the increased speeds. This results in them not being able to withstand the higher voltage rails, and therefore requiring a change to lower operating voltages. Only a few years ago chip geometries of one micron represented the latest in technology. Now most new designs are being launched with geometries of around 0·5 microns or less.

However, the changes required to bring about the speeds of 1GHz will need even lower voltages to be used. Power consumption rises considerably with an increase in speed and this means that even smaller chip geometries and voltages will be needed. The estimates available at the moment indicate that a standard of around 1·65V may be chosen. The chip geometries are falling in line. Manufacturers are installing equipment to make devices with much smaller geometries, 0·18 microns being the next stepping stone, but it is likely that inside a few years even this will be reduced.

Despite these improvements, the dissipation in these large chips remains a problem. To overcome this a number of new ideas are being implemented in order that the heat which is generated can be removed from the chip itself, to ensure that it does not become too hot, thereby reducing its reliability. In addition to this, improved design methods are being employed to reduce the power dissipation to the absolute minimum.

Low Voltage Logic

In the mean time, many new devices are coming onto the market for the latest 3·3V standard. Many of the processors already use 3·3V, and there are families of the familiar 74 series logic which use it. However, designers soon run into problems when they need some of the more specialised functions. Many of them are only available at 5V, and this often means introducing further chips to interface between the two supply standards. Often it is possible to run the 5V chips at a lower voltage, but even when this is possible, there is always a significant speed penalty to be paid.

Even though there are many advantages to be gained by reducing the supply voltage, this approach introduces a number of problems of its own. For high speed processors, one of the main concerns is that bus drivers operating at the low voltages will not be able to drive their lines sufficiently fast, thereby counteracting the speed increases on board the chips. If geometries can be reduced, though, and more placed onto individual chips, this will help to overcome the problem.

This will not all occur quickly because designers are reaching the limits of integration in some areas, and trying to place even more onto the chips cannot always be achieved. One of the main factors to be taken into account when deciding what needs to be placed onto the chip, is to determine how much on-board DRAM is required.

Parallel Processing

Other methods are also being investigated to increase the throughput of the devices. The actual processing speed is obviously dependent upon the clock speed. Increasing this affects the throughput by the same degree. However, if a number of instructions can be run at once, this can increase the throughput several times.

Although the idea sounds easy, it is far from simple to implement. At the very high speeds now being envisaged, even small delays can mean that different parts of the processor may be performing instructions which are meant to be simultaneous but are at slightly different times. These synchronisation problems make the design of parallel systems far more complicated.

One approach to solve this is to distribute the master clock and perform local synchronisation. This requires a modular design to be implemented on the chip as well as new ideas for bus control, and memory access. This type of system can operate up to a maximum of around eight processing elements, saturating above this. To progress beyond this, a totally new style of architecture will need to be developed.

Despite these problems there are many ways forward which are being adopted. Even over the last few years, vast increases in speed have been seen. In many areas the limits of technology have not yet been reached and, as a result, similar increases will be seen in the coming years. In those areas where the limits of existing technologies are in sight, totally new ideas are being investigated so that the relentless increase in the speed of computers will continue for many years to come.

LOWER STILL

Already Texas Instruments have devices that operate at voltages below 3V. Their new 10-bit DACs operate down to 2·7V and interface directly to microcontrollers without the need for "glue" logic. Also, their ALVC devices operate at down to 2·5V and have improved speed characteristics, typically 4·3ns instead of 5·0ns.

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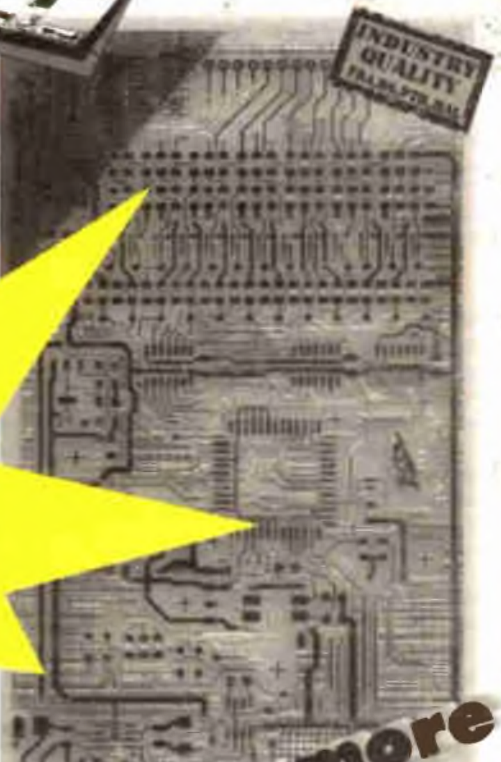

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EPE PIC-A-TUNER

JOHN BECKER

Highly accurate, microcontrolled tuning aid for all electronic and acoustic instruments.

THERE was a time when music tuning accuracy was at the mercy of the individual's ability to "know" pitch, either "recalled" from memory, or imposed by a leading member of an orchestra – what note he or she regarded as being right *was* right as far as that group was concerned: it didn't matter too much, provided they all played the same tune on the same notes, whatever the absolute frequency! The use of mechanical tuning forks helped to keep things within a range of acceptability.

Electronics, however, has for many years allowed us to tune in relation to an *absolute* standard frequency of 440Hz, commonly known as *Concert A*, all other notes being derived from that single frequency. Even 25 years ago, constructional projects for music tuners (which should really be called *tuning aids*) based on i.c.s were being published. But, sadly, the chips which used to be available have long-since disappeared (the good old "AY" and "MK" series, for example), and their passing is grieved.

It's PIC's to the rescue, though! With these simple but sophisticated microcontrollers, it's comparatively straightforward to produce an accurate tuner that listens to what frequency you are playing and tells you how far out you are from the ideal note.

Moreover, it's especially easy to build one if someone else has already worked out the software program – enter the *PIC-A-Tuner*! It's all here: electronics, liquid crystal display and program. You've even got a tactile keypad you can press for a few "Functions" as well. Tune in and read on!

PIC-A-TUNER

PIC-A-Tuner has been designed to accept input signals from three sources: a square wave frequency output from a digital musical instrument, such as a synthesiser; from an analogue electronic instrument, such as an electric guitar; from any acoustic instrument via an internal microphone. In the latter category comes the entire instrumental line-up of any orchestra, band, soloist, singer or pet cat! If it makes a noise, PIC-A-Tuner will respond to it.

Using a microcontroller, the tuner analyses the incoming signals, quantifying the time it takes for eight cycles of the signal waveform to occur. Using look-up tables, it relates each result to an octave range (from −3 to over +7, well to either side of the audio range), determines the nearest note value and name within that octave, and the amount by which the frequency differs from the ideal value for that note.

READING THE MUSIC

The octave and note name are displayed on one line of an intelligent liquid crystal display (l.c.d.). On a second l.c.d. line is displayed a bargraph which shows the actual frequency deviation from the ideal value. When the two values are equal, asterisks appear, confirming the note's accuracy.

A preamplifier with a panel-mounted control allows signal levels from the internal microphone or the analogue input socket to be adjusted to suit different sources.

A frequency filter is included as a switchable option allowing the fundamental frequency of a harmonically-laden analogue note to be extracted. Whereas an instrument such as a flute or acoustic guitar will produce relatively clean waveforms and so not need the filter, other instruments, such as those in the brass and percussion groups for instance, will produce harmonics which can confuse the analysis procedure unless filtered out.

Selection of the filter band is made via a tactile keypad mounted on the case. The band selected is displayed numerically on the l.c.d., the numbers being roughly relative to an octave value. Using the filter requires experimentation to suit differing circumstances, and sensible adjustment of the incoming signal's amplitude.

The analogue processing circuit, including the filter, may be omitted if PIC-A-Tuner is to be used only for monitoring square wave signals.

WELL-TEMPERED

Although the tuner is crystal controlled, the precise tuning relationship between the frequency analysis parameters and the frequencies received can be changed via the keypad. This facility can be used when PIC-A-Tuner is first put into service, adjusting the tuning to correct for any deviation in the crystal's actual frequency and the ideal (even crystals have a manufacturing tolerance). The updated tuning factor is automatically stored in the tuner's EEPROM data memory and is recalled at each switch-on.

The facility also allows the unit to be tuned up or down from the international frequency standard of Concert A = 440Hz (A'). Historically, A' has only been internationally standardised at this value since May 1939; an agreement brought about by the proliferation of broadcasting. Before then, A' as played by musicians and "imagined" by composers could have had a frequency well to either side of 440Hz.

Alexander Wood, in his book *The Physics of Music*, tabulates some historically documented frequencies for A' (many of them established by examining organ pipes). Two extreme examples are the Halberstadt organ of 1351 for which A' = 505·8Hz, and Silberman's organ of 1713 at Strassburg for which A' = 393Hz. Handel's tuning fork of 1751 is set for A' = 422·5Hz.

Some purist musicians still prefer to tune to the frequency which they believe the long-departed composer had in mind. The validity of such arguments may be academic, but PIC-A-Tuner allows these preferences to be catered for.

Note, however, that you do not *need* to adjust the tuning of PIC-A-Tuner. The default parameters set into the software and the accuracy of the crystal frequency provide an inherent tuning accuracy which is well within the needs of most musicians. Nonetheless, the facility for extreme precision is there if you want it.

When PIC-A-Tuner is being tuned, the hexadecimal value of the tuning parameter being set into the software is shown on the l.c.d., slowly changing when the TST/SET and the relevant UP or DOWN keys are pressed. An additional hexadecimal display is also shown, representing the microsecond timing value for a single cycle of any frequency which is being input to the tuner. This latter display can be called at any time by pressing the TST/SET key on its own.

The fourth key, which you will have noticed in the photographs, is marked NIL. That's just what it's for – nothing; tactile keypads do not seem to be available with just three keys, so a four-key one had to be used.

Let's now look at the electronics of PIC-A-Tuner.

SCORING THE PROCESSOR

The circuit diagram in Fig. 1 will probably look familiar to many of you, being similar to others that show the heart of a PIC-controlled processing and display circuit and which have been published in previous issues of *EPE*, the *PIC-Agoras Wheelie Meter* Part 1 in last month's issue, for example.

This is one of the advantages of using a PIC, once the basic circuit configuration has been established, only minor variations are needed to modify the circuit to a slightly different application. The main difference, and a very significant one at that, is that the software requirements will be different. From an end-product point of view, PICs offer enormous possibilities.

From the designer's point of view, though, PICs require far more time to be spent on program writing than on the electronic circuit design. In many instances, this development can take far longer than might be the case for a design having a similar function that is performed purely electronically. No doubt some of you will have found that when designing something, the soldering iron can be far less used than PIC development software!

There are two principal devices in Fig. 1, the PIC16C84 EEPROM-based microcontroller, IC1, and the intelligent l.c.d. module, X2, which is operated in 4-bit mode. Both devices have been discussed at length in previous issues of *EPE* and will not be described in detail here.

SAMPLING

The master clock frequency for microcontroller IC1 is generated at 10MHz, using crystal X1, resistor R4 and capacitors C1 and C2. (When purchasing the PIC16C84, the 10MHz version must be specified.)

The frequency to be analysed by the microcontroller is fed via resistor R3 to IC1 pin 6, the INT/RB0 pin, as a logic-shaped waveform (digital pulses swinging between 0V and 5V). Its source can either be from an external instrument via socket SK1, or from the analogue processing circuit (Fig. 2, later).

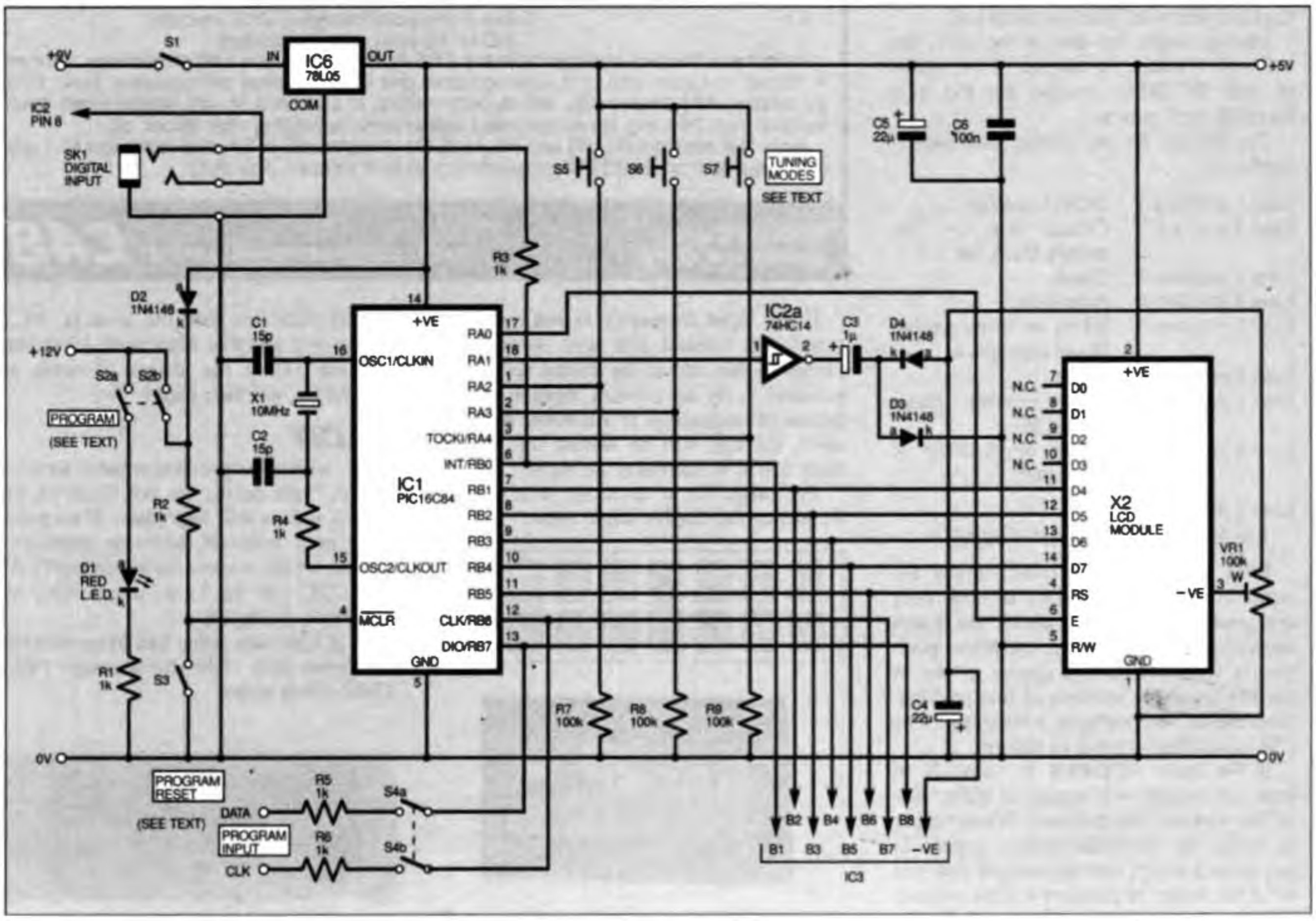


Fig. 1. Circuit diagram of the processing and display stages of the PIC-A-Tuner.

The software within IC1 repeatedly examines the status of pin 6, incrementing a series of counters while it does so. Within a time-out period, each time software detects that eight pulses have been received, the count value is stored and the counters are reset.

Strictly speaking, the counters are not "incremented" (adding one to the value). Rather, the software repeatedly adds the binary equivalent of a decimal number that is accurate to several decimal places. This technique allows PIC-A-Tuner to be extremely accurate in its calculations, and for its reference values to be so accurately set via the keypad.

Each count value is compared against look-up tables which, as discussed earlier, provide the octave number, note name and ideal note frequency values. The difference between the true and actual frequency value is converted into a bargraph value.

COUNTS TO THE BAR

The resulting answers are formatted appropriately for the two 8-character lines of the l.c.d. and output to it as 16 nibbles (1 nibble = 4 bits, 8 bits = 1 byte) via port pins RB1 to RB4 (pins 7 to 10), which are connected to the l.c.d.'s D4 to D7 (pins 11 to 14) data lines. Included in the format is the number of the filter band selected (whether or not the filter is switched on).

As each nibble is output, port pins RB5 and RA0 (pins 11 and 17) toggle the l.c.d.'s RS and E lines respectively. The RS line controls whether the l.c.d. is to receive or transmit data on its D4 to D7 lines. In this instance, RS is set for the l.c.d. to receive data. The data is input to the l.c.d. when its E line is taken low.

Having output the data to the l.c.d., the software resumes its perusal of the status of port INT/RB0, waiting for the next batch of eight pulses.

The format for the tuning information display is:

Line 1 position 1	Octave number
Line 1 position 2	Octave sign (− for minus, blank for +)
Line 1 position 3	Blank
Line 1 position 4	Note letter
Line 1 position 5	Blank or sharp symbol (#) as appropriate
Line 1 position 6	Blank
Line 1 position 7	Filter number (from − 1 to 6)
Line 1 position 8	Blank or flashing X (see later)
Line 2 positions 1 to 8	bargraph display

With the bargraph display, unless the input frequency is correctly in tune, only one position is normally active, the others remaining blank. With this one active position, a vertical line will appear in one of the five available sections of that position. Underneath this position, a horizontal line (the l.c.d.'s cursor) will be shown.

If the input frequency is correctly in tune, an asterisk will appear to either side of the vertical line position. When tuning is exact, the asterisks always appear in positions 3 and 5, and the vertical line will be in the centre of position 4. This position is immediately below the note letter in line 1.

COMPONENTS

Resistors

R1 to R6, R19, R26, R29, R30, R34, R35	1k (12 off)	
R7 to R10, R17, R18, R20, R22, R24, R25, R27, R28, R33, R37	100k (14 off)	
R11 to R13, R16, R21, R23, R32, R36, R38, R39	10k (10 off)	
R14	4k7	
R15	2k2	
R31	220k	
All 0·25W 5% carbon film or better		

See SHOP TALK Page

Potentiometers

VR1	100k min. cermet, round
VR2	2k2 min. cermet, round
VR3	10k rotary, lin.

Capacitors

C1, C2	15p polystyrene (2 off)
C3, C10, C14	1µ radial elect. 16V (3 off)
C4, C5, C7, C9, C13, C17	22µ radial elect. 16V (6 off)
C6, C8, C11, C12	100n polyester (4 off)
C15, C16	33p polystyrene (2 off)

Semiconductors

D1	red l.e.d.
D2 to D4	1N4148 signal diode (3 off)
IC1	PIC16C84 microcontroller (10MHz version), pre-programmed (see text)
IC2	74HC14 hex Schmitt inverter
IC3	DAC08 or DAC0800 digital-to-analogue converter
IC4	LM358 dual op.amp
IC5	LM13600 dual transconductance amplifier
IC6	78L05 5V regulator, 100mA

Miscellaneous

MIC1	min. microphone insert, approx impedance 1kΩ
PL1	Centronics 25-way printer port connector
S1, S3	s.p.s.t. min. toggle switch (2 off)
S2, S4	d.p.d.t. min. toggle switch (2 off)
S5 to S7	4-key (or 3-key) tactile keypad, push-to-make, self-adhesive
SK1, SK2	3·5mm s.p.c.o. jack socket (2 off)
X1	10MHz crystal
X2	2-line 8-character intelligent l.c.d. module (HD44100-compatible controller)

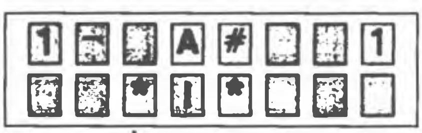
Printed circuit board, available from the *EPE PCB Service*, code 149; plastic case, 150mm × 80mm × 45mm, with l.c.d. viewing cutout and integral battery compartment; knob; PP3 9V battery; PP3 battery clip; self-tapping screws, to suit case (4 off); double-sided 1mm terminal pins; 24 s.w.g. tinned annealed copper wire; connecting wire; solder, etc.

Note that resistors R1, R5 and R6, l.e.d. D1, switches S2 to S4, and connector PL1 are only required if on-board PIC programming is contemplated (see text).

Approx Cost Guidance Only (excl. programming parts) **£48**

If the input frequency is not correctly tuned, the vertical line will appear displaced to one side of the central section of position 4, by an amount relative to the degree of inaccuracy. If it is lower than the ideal, the line will be shifted left; if too high, it will be shifted to the right.

Typically, for a correctly tuned input frequency the display might show:



This indicates that the note is A# in octave − 1 and that filter band 1 has been selected. (Only the sharps of notes are catered for, not their flats.)

TACIT

If, within a pre-determined time-out period, eight pulses are not received, one of two actions will take place. If no pulses have been received, software activates a routine which outputs the statement PLAY A NOTE ! to the l.c.d., overwriting any other data displayed.

If at least one pulse has been received, but fewer than eight, the message FREQ UNSURE is output.

Display showing accurate tuning on E octave 3, filter 1..

Request to "Play a note!" display.

Frequency unsure display.

When the software recognises that port INT/RB0 is inactive, i.e. when no frequency signal is being received, the flashing letter X is displayed in the top right hand position of the display.

To avoid the previous tuning information from being erased immediately an input note ceases, another time-out period allows the tuning information to briefly stay on screen. In such an instance, the flashing letter X will also appear.

MISCELLANEOUS THEMES

For the l.c.d. module used, a negative bias voltage is required to set the display contrast level. This is generated using a standard voltage inversion technique:

Throughout its activities, software repeatedly toggles IC1 line RA1 (pin 18) up and down. This alternating signal is buffered by Schmitt trigger inverter IC2a, and rectified as a negative voltage (about −3·5V) by capacitor C3 and diodes D3 and D4. Capacitor C4 smooths the voltage and preset VR1 sets the level applied to the contrast control (−VE) pin 3 of the l.c.d.

The same negative voltage is supplied to IC3 pin 3.

Switches S5 to S7 are the keypad tactile switches referred to earlier, and responsible for controlling the tuning and filter parameters. Their use will be further detailed later.

The status of the switches is read via port pins RA2 to RA4 (pins 1 to 3). Resistors R7 to R9 hold these pins at 0V when the switches are open (unpressed).

It is intended that PIC-A-Tuner should be powered by a 9V PP3 battery housed within the case. This supply is regulated down to 5V by IC6. It must not be applied directly to IC1 or the l.c.d. Current consumption is about 15·75mA.

ANALOGUE NOTES

The circuit diagram for the analogue processing stages is shown in Fig. 2. It consists of a microphone and preamplifier, a digitally programmed voltage controlled filter (VCF) and a waveform squarer.

The microphone, MIC1, is a small microphone insert mounted on the printed circuit board behind a suitable hole in the case. Its signals are amplified by op.amp IC4a and routed to the switched jack socket SK2. Amplifier gain is set at ×100 by resistors R19 and R20.

At SK2, there is a choice of inputting an external analogue signal, or routing the amplified microphone signal to capacitor C13 and the panel mounted Level control potentiometer VR3.

Switch S8 then provides a choice of routing the signal from VR3 either through the filter, or direct to the waveform shaper. Op.amp IC4b forms the first stage of the waveform shaper, providing a signal gain of ×10, as set by resistors R21 and R22.

From IC4b, the signal is a.c. coupled by capacitor C11 to the input (pin 9) of Schmitt inverter IC2b. The latter is biassed by resistors R24 to R26 so that its input is held at a mid-voltage (2·5V) level to ensure cleaner processing of the op.amp-derived signal.

The output at IC2b pin 8 is a well-shaped logic signal swinging between 0V and 5V. The signal is routed to socket SK1 (Fig.1), which allows for either the processed analogue signal, or an external digital signal, to proceed to microcontroller IC1.

It should be noted that external digital signals should swing between 0V and 5V. Amplitudes less than this may fail to be

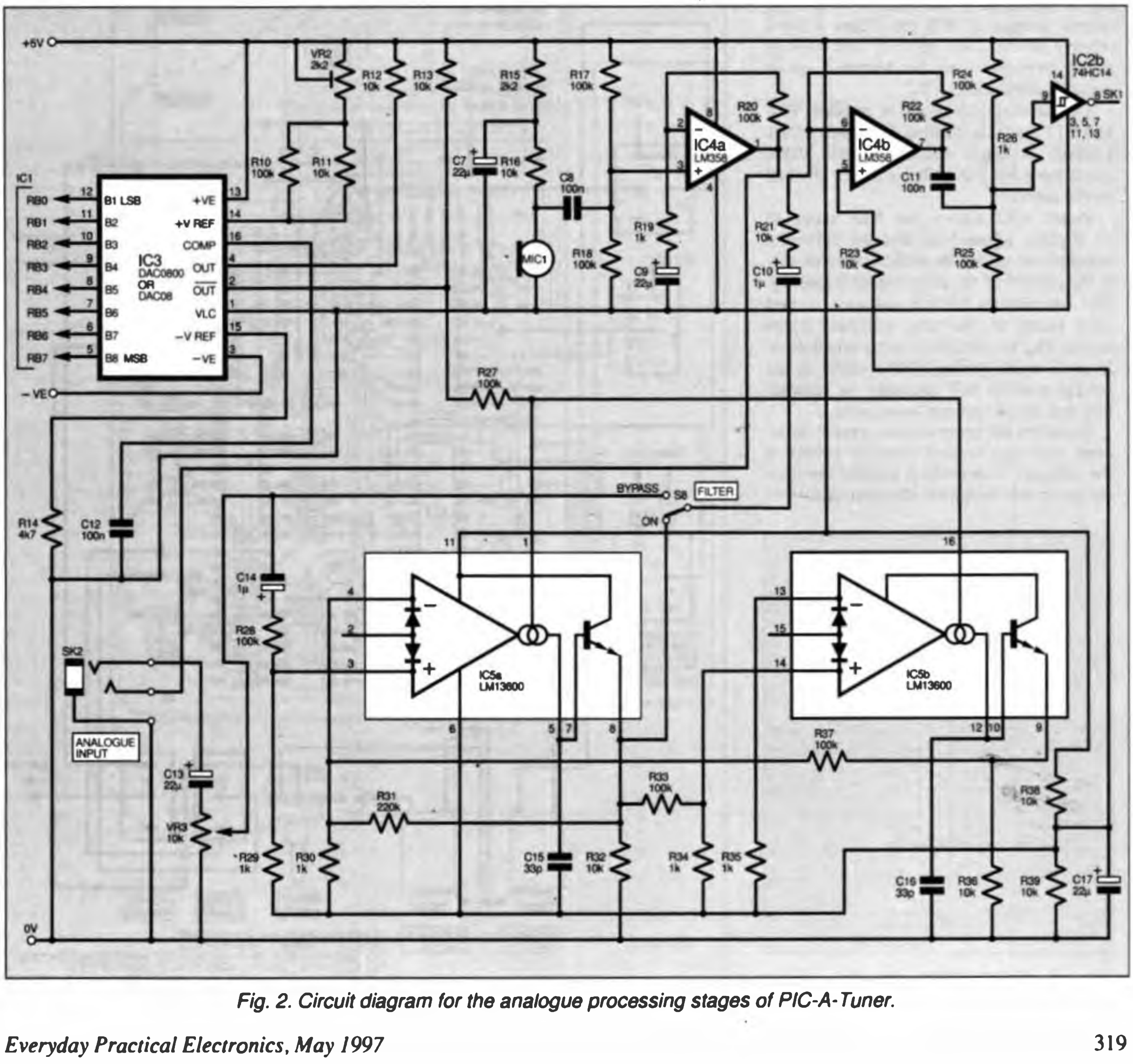


Fig. 2. Circuit diagram for the analogue processing stages of PIC-A-Tuner.

recognised by IC1; signals much greater could damage it, although a degree of buffering is provided by resistor R3 (signals up to about 6V should be OK, but are not recommended).

FILTERING HARMONICS

The filter is a bandpass type based on the conventional configuration for an LM13600 transconductance amplifier (TCA). The LM13600 has featured several times in *EPE* and is very easy to use where voltage controlled gain or filtering is required. It contains two identical sections, each comprising a controllable TCA op.amp and a Darlington buffer.

In this application, the device is configured for its bandpass/lowpass operation, though only the bandpass output at pin 8 is used (lowpass is present at pin 9).

Control of the filter is via pins 1 and 16, the amount of current flowing into them setting the central frequency range. Both control nodes are joined and the current is determined by the voltage differential across resistor R27.

The control voltage is derived via the digital-to-analogue converter (DAC) IC3. Binary control codes generated by the software and output via IC1 port pins RB0 to RB7 (pins 6 to 13) are sent to IC3's digital inputs B1 to B8 (pins 12 to 5). The output voltage at IC3 pin 2 has a level relative to the code applied. The voltage range available can be trimmed using preset potentiometer VR2.

The parallel connection of resistors R10 and R11 inserts a limiting resistance of 9·1 kilohms (a single resistor of this value could have been used but was not stocked by the author!).

Preset VR2 allows the filter range to be slightly adjusted so that the software-selected values can be related more closely to the octaves of the audio signal frequency. The calculations for the software control were based on the total resistance value across VR2 and R10/R11 being 10 kilohms. In most cases, setting VR2's wiper to the central position will probably be satisfactory and adjustment not be required.

Experienced programmers could, however, also play around with the values of the software codes which control the filter ranges to suit their own idiosyncrasies!

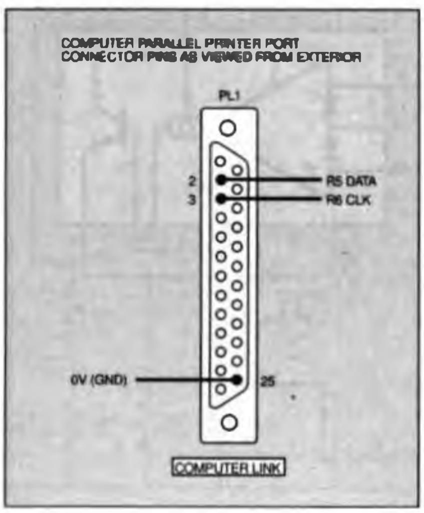


Fig. 4. Connections for the 25-pin D-plug printer-port connector.

COMPOSITION

Details of the printed circuit board for PIC-A-Tuner, and the interwiring required, are shown in Fig. 3. This board is available from the *EPE PCB Service*, code 149.

Note that the following are only needed if you wish to program your own PIC16C84 using this board (see later): resistors R1, R5 and R6, l.e.d. D1, switches S2, S3 and S4.

First of all, insert and solder all the on-board link wires shown; 24 s.w.g. tinned annealed copper wire is ideal for this. Follow by soldering in the sockets for IC1 to IC5. Other components can be assembled in order of increasing size.

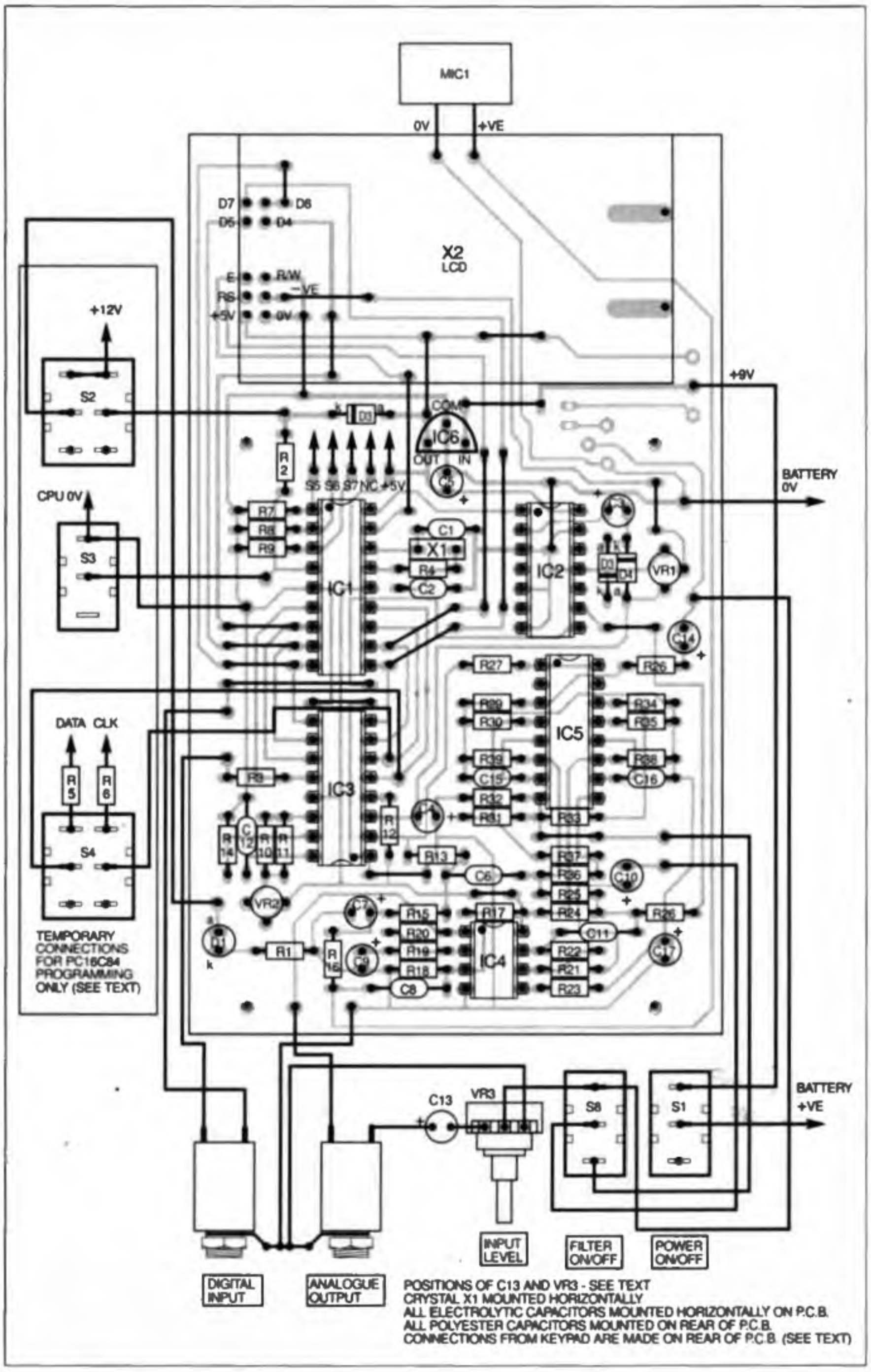
All polyester capacitors should be mounted on the rear of the board (trackside). Leads of the electrolytic capacitors should be bent so that these components lie flat on the board. Crystal X1 should similarly be mounted flat, orientating it to lie above resistor R4 and capacitor C2 (see photograph).

Capacitor C13 is soldered directly between potentiometer VR3 and socket SK2, squeezing it into the tight space between them when the case-mounted components are being fitted.

All connections between the p.c.b. and the panel components are soldered to the trackside of the board, but it is still suggested that terminal pins are used on the p.c.b. (double-sided so that they can be used more effectively).

Mounting the l.c.d. to the p.c.b. is a bit tricky, requiring a bit of patience! First, cover with insulating tape the p.c.b. link wires which will lie below the l.c.d.

Solder 24 s.w.g. wire (as above) into the required ten connecting holes of the l.c.d. module (see Fig.3), allowing about 50mm to protrude on its trackside. Let the solder flow through the holes to allow both sides



to be soldered. Trim the wires to equal lengths for the inner-most row, and to equal but slightly shorter lengths for the outer row.

With a steady hand and the aid of a small screwdriver, carefully get each of the inner-most wires to pass through the relevant hole on top of the p.c.b., being careful not to allow these insertions to be extractions (!), do the same with the outer row.

Gently push down on the l.c.d. so that it sits neatly on the p.c.b., wires protruding on the trackside. Solder and trim the wires on the p.c.b. Ultimately, two additional securing wires could be used at the other end of the l.c.d. if preferred. They will have no electronic function, but merely provide additional rigidity to the assembly. Do not solder them until the tactile switch has been connected (they were not used on the prototype).

Above the IC1 position, four angled wires are required to be soldered, onto which the keypad connector is to be pushed. Insert 24 s.w.g. wire vertically into these holes from the rear of the p.c.b. Solder and cut them to about 25mm long. Trim off any wire which is protruding on the component side.

Using thin-nosed pliers, bend the wire through 90° towards the l.c.d., allowing about 10mm between the p.c.b. and the bend. Trim the leads evenly back to about 10mm. Adjust their spacing so the keypad connector can be pushed onto them. Take care not to stress the p.c.b. and its tracks while doing this.

IMPROVISATION

Before mounting it all in the case, do an improvised "lash-up" wiring job between all the components involved and make sure everything is working.

Also, of course, if you are intending to program your own microcontroller, using the p.c.b.'s optional programming facilities, you need to do that task first.

We'll deal with the programming operation in a moment. Assume for now that it has been done and you are ready to test the tuner.

Do a visual check (preferably with a close-up eye-glass) of the connections on the p.c.b., ensuring that there are no soldering or component placement anomalies, and rectifying them if there are. Leave out IC1 to IC5. Apply power and check that 5V (from IC6) is present where the circuit diagram shows it should be. The l.c.d. will probably remain blank.

When satisfied all is well, switch off and insert the remaining i.c.s. On powering up, adjust preset VR1 until detail is seen on the l.c.d.'s screen. The detail could be anything at the moment, but should correspond to one of the display formats referred to earlier. Any noises you make in the tuner's vicinity should modify the display.

ACROSS THE SCALE

With the l.c.d.'s contrast set, turn up the Input Level control VR3, and then be silent for a while. The screen should revert to its stand-by mode, displaying the PLAY A NOTE ! message with letter X flashing in the top right position and the filter range number beside it on the left.

Click your fingers near the microphone, or sing or talk to it! The display should change, showing an octave number, note name, filter number, and the bargraph line dithering back and forth along the lower display line. The flashing X should have disappeared. Periodically, you may also see the FREQ UNSURE message, accompanied by the flashing X.

Press the UP and DOWN keys individually. The filter number should increment or decrement accordingly at each key press. The action will probably be heard by the tuner and it will respond to the sounds as before.

Turn on a music player near the tuner and observe its response. It will be rapidly changing with the music, but, unless it's only a solo instrument playing, the tuning display will be inaccurate since the microcontroller will be trying to extract single note data from a multi-note signal, and get it all wrong!

(Experiments examining multi-note analysis have been carried out by the author, thousands of lines of code having been written on a high-speed PC in an attempt to crack the problem, but without success. But that's another story!)

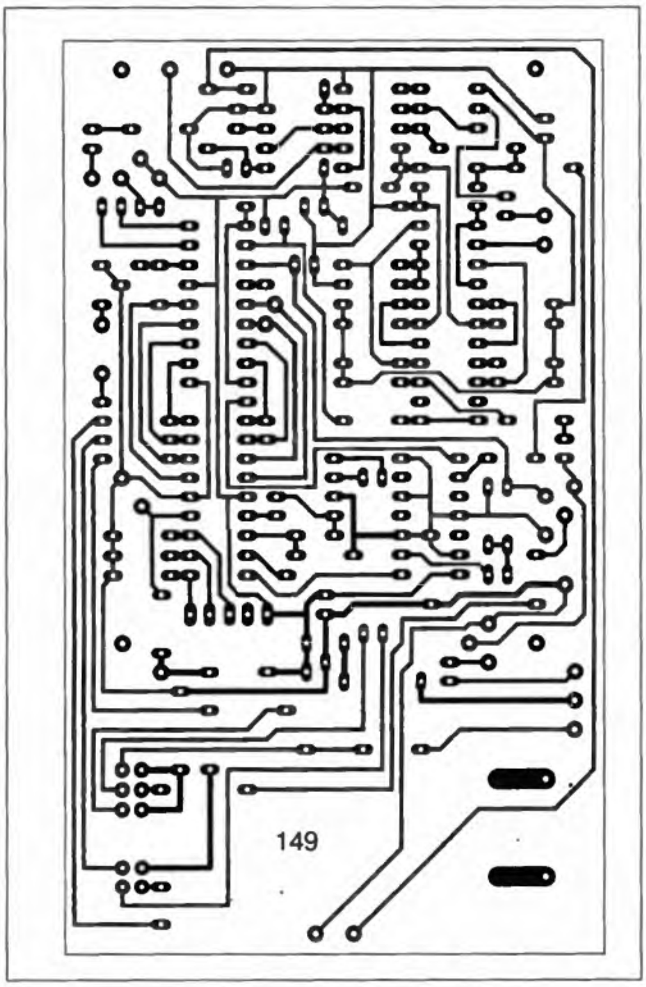
Periodically, while complex music is playing, you will see the "correct tuning" asterisks appear briefly, though that will be more by coincidence.

While music is playing, press the TST/SET key on its own. In the right hand four positions of the two display lines will appear two 4-digit hexadecimal numbers. The upper one will be static, displaying the code associated with presetting the tuning accuracy. The lower will be changing with the music, representing the detected timing period values in microseconds.

If you have the equipment, i.e. a signal generator or mechanical tuning fork, you are now in a position to make use of these numbers.

FINE TUNING

Ideally, plug in a signal generator/counter (the latter having a digital readout) to the digital input socket, setting the output



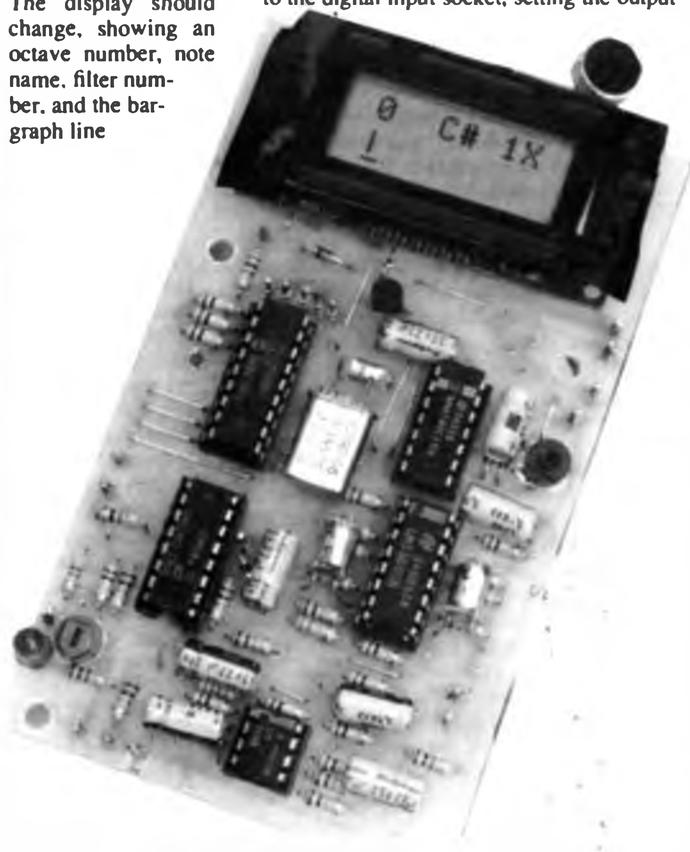


Fig. 3. Printed circuit board and interwiring (left) and full size foil master (above). The completed board is shown right. Note the electrolytics lie flat on the p.c.b.

to a digital waveform of 0V to 5V peak. An analogue waveform may be plugged into the analogue socket instead. Alternatively, but less easily, a mechanical tuning fork can be repeatedly struck and held near the microphone. In both analogue instances, keep the filter switched off (the filter doesn't affect the digital input).

Preferably powering PIC-A-Tuner (9V maximum) from the same power supply as the signal generator, switch on both units. Allow the generator to warm up and stabilise.

Then set the generator for an output of exactly 440Hz. If the counter has decade frequency switching, set it to 44000Hz, and then switch back by two decades, ensuring a really close match to 440·0Hz, rather than the possibility of the actual frequency being closer to 439Hz or 441Hz than 440Hz.

PIC-A-Tuner's screen should show octave 1, note A, with the bargraph line possibly somewhere to one side or the other its central "correct tuning" position.

If the pointer is to the right of the position, simultaneously press the TST/SET and DOWN keys. Holding both keys down, the hexadecimal number displayed at the top right will show a steady increase. *Eventually*, the bargraph line will move into the central region of line 2 position 4 and the two adjacent asterisks will appear. (The hex display may obscure the vertical bargraph line during the early stages of this procedure. Be patient, it will eventually come into view.)

Hexadecimal "in tune" numbers display.

Observing the hex number in line 2 can also achieve the same result – tuning is correct when the number shows 08E0.

Release both keys. Shortly afterwards, the screen will display the message EEPROM UPDATED, and then revert to the normal screen display. PIC-A-Tuner is now set correctly to tune against international Concert A at 440Hz.

Should the tuning pointer be to the left of the correct position, simultaneously press TST/SET and UP keys, and follow the above procedure, in which the hex numbers steadily decrease and the point eventually moves to the right.

CONDUCTING TIME

In the above paragraphs, the word "eventually" is used with purpose. The software allows for such a high degree of accuracy in the tuning set-up that the observed movement of the tuning line will appear tediously slow. Although it may not seem to be changing, the tuning factors are doing so, as evidenced by the changing hex number display in line 1.

In practical terms, there is an amount of "slack" possible when tuning the unit, during which the asterisks will continue to confirm an accurate response.

Also, in practical musical terms, most human ears may find that notes will sound to be correctly and harmonically tuned relative to each other even if the tuning marker is even as much as one or two whole display positions away from optimum. It is up to the individual to decide how accurately a musical instrument should be tuned against the extremely accurate PIC-A-Tuner.

Furthermore, again speaking musically, *precisely* tuning musical instruments to a *really exact* frequency is actually undesirable in an orchestral context. A *very slight* deviation in the tuning between instruments helps to create the fulness of the orchestral sound. If all instruments of the same type were "ganged" to an identical frequency, the resulting sound would be purely an increase in the volume obtainable from a single instrument, rather than an increase in the richness of the sound as well as its amplitude.

This is one reason why the use of vibrato enhances the musical experience; the output frequency of the instrument is being deliberately and repetitively shifted up and down about the "optimum" base frequency.

NOTE THE FREQUENCY

Once the tuner has been tuned, there is an additional use for it, as a form of frequency counter. Pressing TST/SET, the hex number in line 2 can be noted and then translated to decimal and to an equivalent frequency expressed in Hertz. PIC-A-Tuner has not been programmed to perform this operation for itself.

Take the hex number 08E0 displayed for Concert A as an example:

Hex 08E0 = 2272 decimal = 2272 microseconds

Since frequency = 1/waveform period, hex 08E0 represents $1/2272\mu s = 440Hz$.

Any hex number in line 2 can be similarly converted to frequency.

SHARP PRACTICE

As mentioned earlier in passing, PIC-A-Tuner has been programmed to relate frequencies to note values which include sharps (#) but not flats (b). Although not strictly true, it is widely accepted that the sharp of one note can be regarded as the flat of the next one up the scale.

Table 1 shows the 12 notes of octave 1 with their calculated frequencies in Hertz, period timings in microseconds, and hexadecimal conversion value of the latter's integer. By definition, notes one octave apart have a frequency relationship of 2:1 (or 1:2, depending on how you look at it!), thus the values for notes from octaves other than those in Table 1 can be easily calculated.

Table 2 shows the calculated parameters for note A across 12 octaves (the varying number of decimal places shown is due to computer truncation of the calculation answers to stay within the permissible numeric display length of that computer – the ancient workshop-relegated 32K Commodore PET, vintage '79!).

INSTRUMENT CASE

The case used in the prototype includes a preformed l.c.d. viewing cut-out, complete with transparent cover, so avoiding the need to cut your own slot!

Layout of components on one end panel. The other end takes a toggle switch.

Before drilling the other required holes in the case, examine how the assembled p.c.b. will sit inside. If necessary, file the ends and corners so that it sits correctly, with the l.c.d. seen evenly through its slot.

Referring to the photographs, mark and then drill the holes for the switches, sockets, potentiometer VR3 and the tactile switch pad. With the latter, a slot is required so that its flat cable and integral connector can pass through the top of the case, allowing the pad to sit comfortably within the area preformed into the case. Do not remove the adhesive-protecting strip which covers the rear of the switch pad at this stage.

Once you are content with the switch pad's position, insert into the slot provided a photocopy of the legends shown in Fig.5.

Table 1. Octave 1 parameters

Note	Frequency	Period µs	Hex µs
C	261·625566	3822·25643	0EEE
C#	277·182631	3607·72966	0E17
D	293·664768	3405·24335	0D4D
D#	311·126984	3214·12173	0C8E
E	329·627557	3033·72694	0BD9
F	349·228232	2863·45693	0B2F
F#	369·994423	2702·74344	0A8E
G	391·995437	2551·05011	09F7
G#	415·304698	2407·87067	0967
A	440·000000	2272·72727	08E0
A#	466·163762	2145·16889	0861
B	493·883302	2024·76981	07E8

Table 2. Parameters for note A relative to octave number

Octave	Frequency	Period µs	Hex µs
−3	27·5	36363·6364	8E0B
−2	55·0	18181·8182	4705
−1	110·0	9090·90909	2382
0	220·0	4545·45455	11C1
1	440·0	2272·72727	08E0
2	880·0	1136·36364	0470
3	1760·0	568·181818	0238
4	3520·0	284·090909	011C
5	7040·0	142·045455	008E
6	14080·0	71·0227273	0047
7	28160·0	35·5113636	0023
8	56320·0	17·7556818	0011

Now remove the adhesive-protecting strip and *carefully* lower the pad into position on to the case. Beware that once stuck, the adhesive is very reluctant to let go!

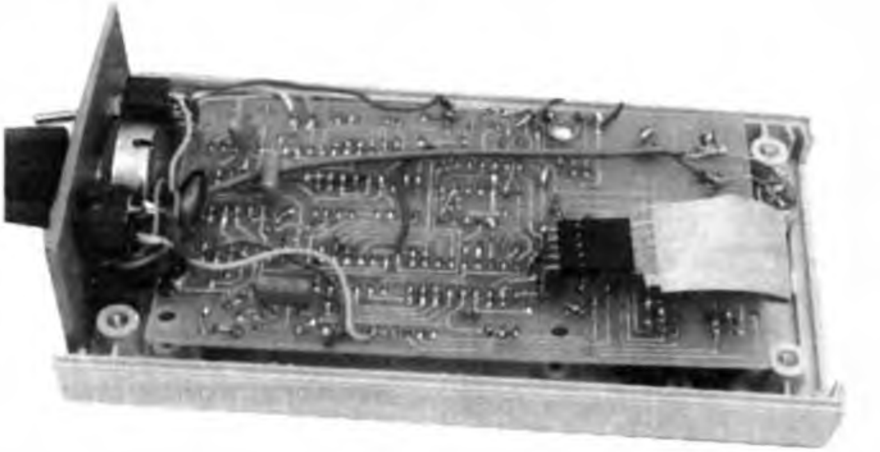
Actually, being aware of this potential problem, the author chickened-out of using the pad's own self-adhesive properties, using instead a couple of strips of double-sided adhesive tape (Selotape) which was known to be easier to remove if necessary. It was stuck first to the keypad's backing strip, and then eased onto the case surface.

Next, insert the sockets, switches and potentiometer into their case holes.

Once this is done, slide the keypad's flat cable between the l.c.d. and the p.c.b. Place the p.c.b. in position in the case, curve the cable (without stressing or kinking it – its internal tracks can be fragile) and gently push its connector onto the mounting wires on the rear of the p.c.b.

Using self-tapping screws, secure the p.c.b. to the holes provided in the case.

Now tidy-up the interwiring to the p.c.b., making it short and neat. Close up the lid and perform the finale: test it to make sure you've tidied up correctly.



Completed PIC-A-Tuner showing the keypad cable connection on the p.c.b. trackside.

Fig. 5. Full size keypad lettering line-up. This diagram can be photocopied and inserted in the tactile switch pad.

ON THE PROGRAM

Those of you who do not have PIC programming facilities can buy a pre-programmed PIC16C84 from Magenta, see *Shop Talk* column on page 309 (thanks to Magenta for again offering this service).

Readers who wish to program their own PICs can acquire the software either on disk from the *EPE* editorial office or download it from our Web site (there is a nominal charge for the former, but the latter is free – again see *Shop Talk* for details). The Web site file is in sub-directory PICatuner.

The software has been written for the TASM assembler (share-ware), but should be fairly readily translatable by experienced programmers for other assemblers, such as the industry-standard MPASM, for instance.

For the benefit of readers having a PC-compatible computer and the *EPE*-available TASM software, but lacking a PIC programmer, PIC-A-Tuner has been designed for the temporary addition of the few extra components required to carry-out on-board programming of the PIC16C84.

Referring back to Fig.1, the extra components are: resistors R1, R5, R6, l.e.d. D1, switches S2, S3 and S4, plus the printer-port connector PL1 in Fig.4.

Connect the components as shown in Fig.3 and Fig.4. Using the TASM software, assemble the supplied source code file TUNER213.ASM under the suggested title TUNER213.COM. Connect the tuner to the computer via the printer port connector.

Run the TASM SEND program in the PIC initialisation mode, setting the PIC parameters to:

HS crystal (10MHz)

Watchdog timer OFF

Power on reset ON

Then, in PIC programming mode, download the assembled TUNER213.COM file to the tuner. It occupies 866 words (85 per cent) of the program memory. In both programming modes, follow the on-screen instructions with regard to the use of switches S2 and S3. Switch S4 is the author's insertion which allows the tuner and computer data lines to be isolated when programming is not taking place.

TABLE NOTES

PIC-programming readers who study the software for this design will see that many look-up tables are used for several different purposes. Some of you may have experienced trouble when trying to embody tables into a program, finding instances when the program crashes for no apparent reason.

In the author's early PIC-learning days, this problem seemed insoluble until it was recognised that in these instances the PIC16C84's in-built program counter was not correctly handling the return jumps from the tables and becoming wrongly addressed.

Experimentation revealed that this did not occur if the tables were only placed within the first 256 program address code locations. Any table overlap beyond this region, even by one byte, could cause a program crash.

Examination of the .LST text file (as generated under TASM) created at assembly time will show whether or not a table exceeds this page boundary. Study of the source code text file (.PIC or .ASM) is unlikely to reveal this situation.

ENCORE

Being an EEPROM-based microcontroller, the PIC16C84 can be programmed and re-programmed as many times as you wish. If you make an initialisation or program downloading mistake, just repeat the operation from the beginning.

For the same reason, PIC-A-TUNER can also have its tuning parameters, as set via the keypad, changed as frequently as you want. Each time you do so, the new data is stored in the EEPROM data memory and automatically recalled at each subsequent switch-on.

Although there are finite limits to the number of times the EEPROM cells can have their data changed, in situations such as those described here, there is effectively no practical limit.

Readers who wish to know more about PIC programming should refer to the *Back Issues* page where previous *EPE* PIC-based project articles are listed and available as stated. You should also obtain PIC data books from Arizona Microchip, Unit 6, The Courtyard, Meadowbank, Furlong Road, Bourne End, Bucks, SL8 5AJ. Tel: 01628 851077. Fax: 01628 850259.

Watch out for our next PIC-based music project, the PIC-OLO. It's a modern equivalent to the Penny-Whistle – and it's got polyphony!

INTERNET

Why not visit the *EPE* Internet site. Among other things you will find details of past and present issues, plus a five year index for *EPE* articles. Our **ftp** site also holds software for most of the PIC based projects we have published.

You can also order back issues or subscriptions and read some comments from readers.

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

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) and full circuit diagram showing all relevant component values. **Please draw all circuit schematics as clearly as possible.**

Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited,* Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. They could earn you some real cash!

"Scrabble" Timer – ten second time-out

THE SIMPLE timer depicted in Fig. 1 was designed to limit the time taken by each player when playing Scrabble, but could be used in any similar role. A metal-cased, mercury-filled, vibration-sensitive switch S1 momentarily closes with a shake of the timer at the start of play. This pulls pin 3 of IC1a down to 0V. On S1 opening, the rising edge at pin 3 enables the monostable built around IC1a, so pin 1 goes high for one to five minutes depending on the setting of preset VR1.

At the end of the cycle, pin 1 of IC1a goes low again, causing a high pulse at the output of IC2a. This drives transistor TR1 and completes the circuit to WD1, a piezo buzzer, for approximately $R_2 \times C_4$ seconds. This is a "ten seconds to go" signal.

The positive pulse from IC2a also clocks a second monostable (IC1b) which, after ten seconds, initiates a longer "bleep" from the piezo via IC2b, indicating that the player's turn has finished. The circuit then requires switch S1 to be closed again, in order to repeat the sequence.

Monostable IC2c/IC2d generates a short signal to confirm timing has commenced, and also it resets IC1b if the next player activates the timer. In the event that a fresh start is needed while IC1a is active, when switch S1 closes electrolytic capacitor C3 will discharge through diode D2 and pin 3 goes high again to re-clock IC1a when the switch opens.

No on-off switch is necessary as standby current consumption is negligible. The original project was built into a small plastic box, but to add further novelty, a furry dice or small toy could be used.

M. L. Unsted,
Hailsham,
East Sussex.

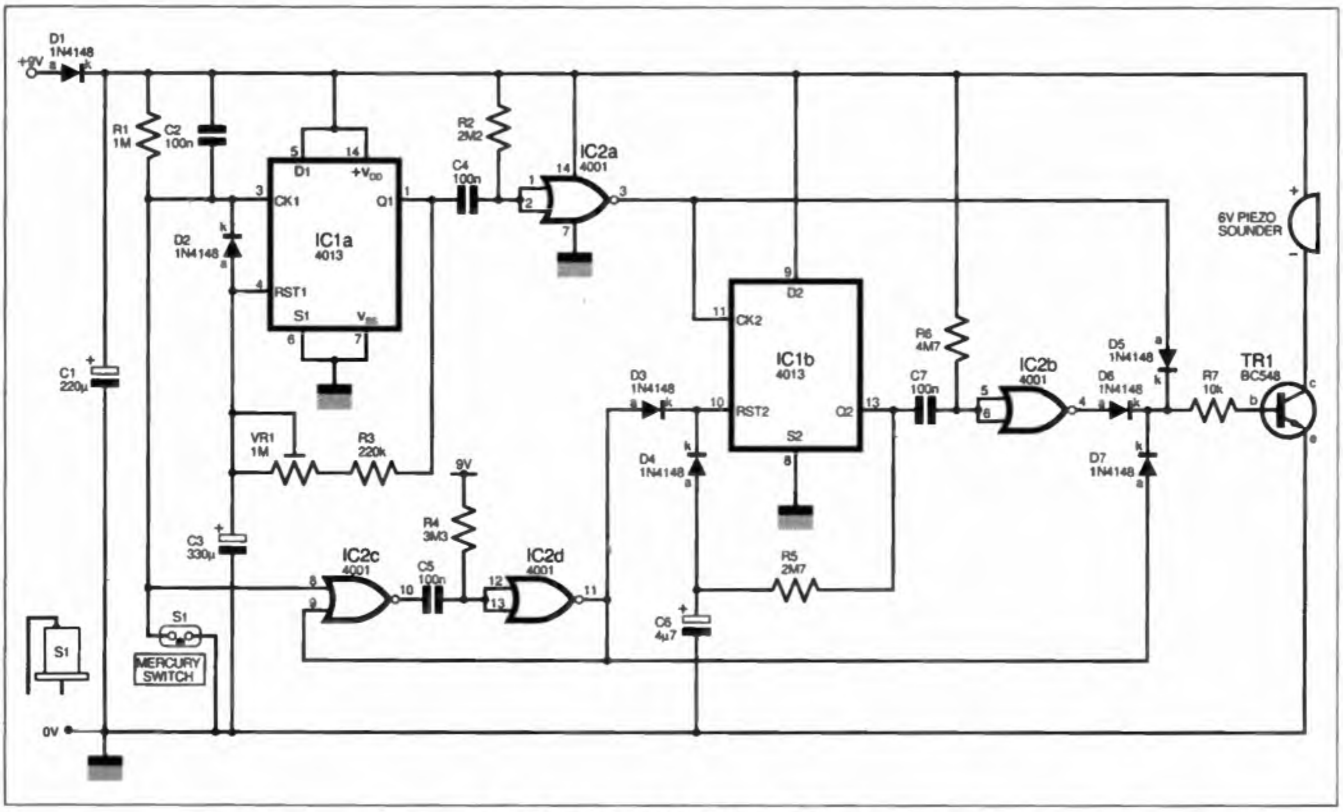


Fig. 1. The simple Scrabble Timer.

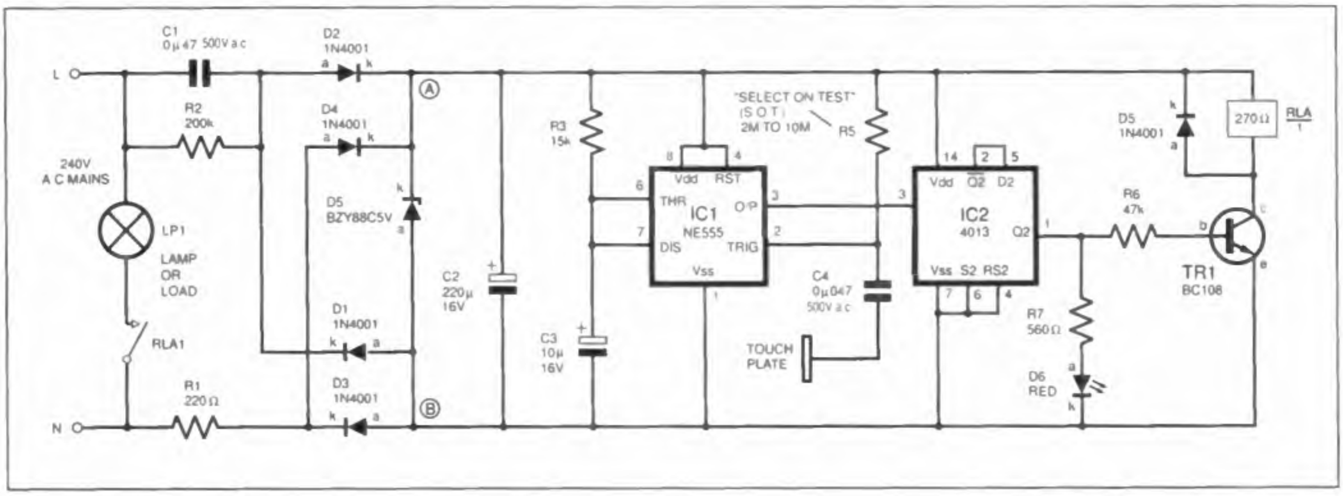


Fig. 2. Mains Touch Switch – note the warnings on construction and use given below.

Mains Touch Switch – fingertip control

WITH only the single touch of a fingertip, the circuit of Fig. 2 will allow the on-off control of a 240V mains load. It uses the 50Hz mains signal which constantly surrounds us, to trigger the circuit which functions as follows.

A transformerless power supply derives a low voltage direct current from the mains a.c. voltage by using the reactance Xc (a.c. resistance) of C1 together with a bridge rectifier D1 to D4 and R1; the result is smoothed by C2 and regulated by 12V Zener diode D5. R2 is included as a bleeder resistor to discharge C1 when power is removed.

Since $Xc = 1/2\pi fC$, assuming a frequency of 50Hz and a value of 0·47µF for C, this produces a reactance of 6,773 ohms. This implies a maximum current flow of 240V – 12V / 6,773 ohms, i.e. 33mA. R1 limits the in-rush current to the bridge rectifier.

IC1 is a 555 timer wired as a monostable with period of approx. 0·9 seconds. Placing a fingertip on the touch plate transmits a 50Hz a.c. signal via C4, to the trigger pin of the timer. This pin is held high by R5, a select-on-test resistor of between 2M to 10M. This is necessary where areas of high electrical noise may otherwise produce false triggering. When triggered, IC1 pin 3 goes high for approximately 0·9 seconds. This output is fed to the clock of IC2, a 4013 D-type flip-flop. The Q2 output (pin 1) is toggled high which switches on TR1 along with the mains relay RLA. Successive touching of the touchpad will turn the relay on and off.

Due to the transformerless power supply, the circuit may only be assembled by experienced constructors and for safety reasons, it is best to test the circuit by applying a 12V supply across points A (+12V) and B (0V) before applying the mains supply; the l.e.d. D6 is included for test purposes. No attempt should be made to test the circuit with an oscilloscope. C1 ***must* be a suitable mains-rated (500V a.c. Class** X) type and C4 must also be mains rated as a precaution. The unit should be housed in a fully insulated enclosure. **It is wise to use this circuit via an RCD circuit breaker.**

Martin Campbell,
Undercliffe, Bradford.

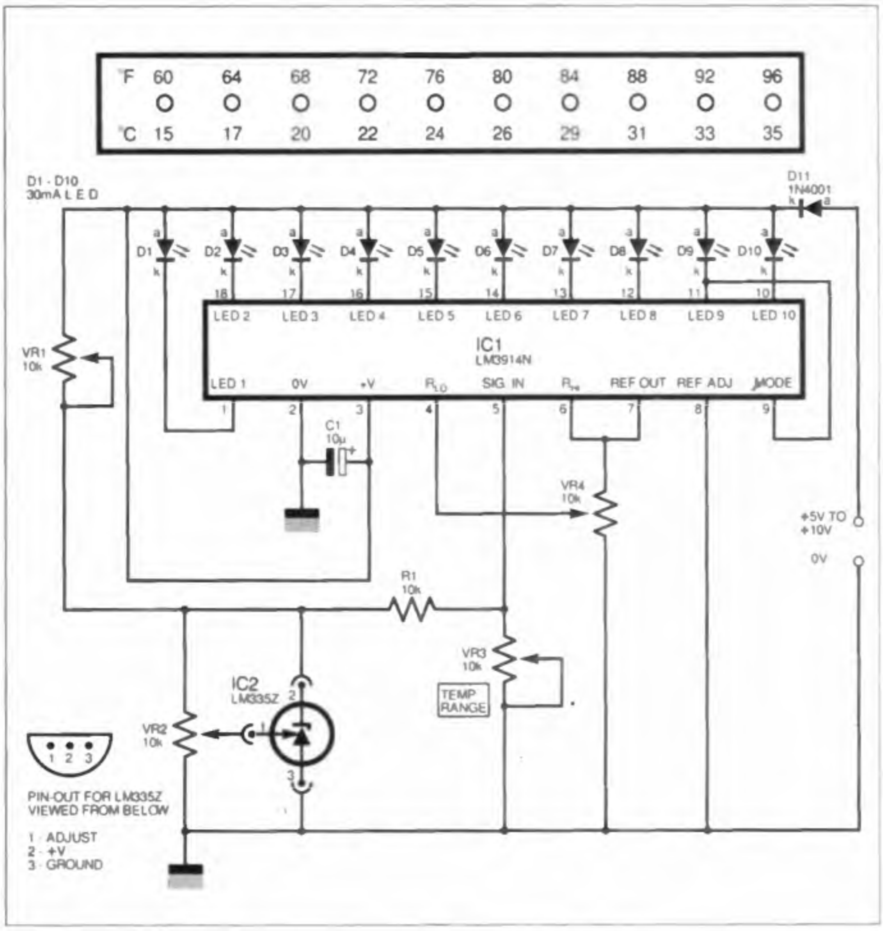


Fig. 3. The Aquarium Temperature Monitor – the circuit can be set up to read other temperatures.

Aquarium Temperature Monitor –

THE Aquarium Temperature Monitor circuit shown in Fig. 3 was designed in order to monitor the water temperature within my tropical fish tank.

The circuit is straightforward and consists of two integrated circuits. IC1 is a National LM3914N bargraph l.e.d. display chip and IC2 is an LM335Z precision temperature sensor. The display chip is wired as an expanded-scale "dot-mode" bargraph driver.

The prototype spans 36°F and displays 60°F to 96°F (15°C to 35°C), but this is adjustable via potentiometer VR3. The resolution of the scale is resolved via VR4 which also sets the l.e.d. current to 12mA. The l.e.d.s can be coloured to suit.

Potentiometer VR2 is used to calibrate the LM335Z: when IC2 is at 25°C then its output will be 2·982V. Resistor R1 and potentiometer VR3 form a voltage divider for the input signal.

The circuit is designed to operate from a commercial 300mA multi-voltage mains adaptor. With the adaptor set to 4·5V d.c., the circuit was supplied with about 7·3V at 22·5mA. Temperature sensor IC2 was connected via a 3-core lead and mounted in a "probe" sealed with silicone sealant.

To set up the circuit, with one of the l.e.d.s illuminated, adjust VR1 so that IC2 is supplied with 1mA. Adjust VR4 to set pin 4 of IC1 to 1·15V. Then with IC2 at 77°F (25°C), adjust VR2 to give IC2 an output of 2·98V. Finally adjust VR3 so that l.e.d.s. five and six are alight.

Michael Jones,
Neath, W. Glams.

Battery Converter – free energy (almost)

A D.C. Converter circuit, operated from a single 1·5V cell to produce a 15V d.c. output, is shown in Fig. 4. When power is initially applied from B1, a 1·5V cell, current flows through resistor R1 causing transistor TR1 and TR2 to conduct.

Current now flows into inductor coil L1, progressively magnetising its core which saturates. Inward current flow now ceases and the magnetic field, which surrounds the coil, collapses.

The back-e.m.f. generated by coil L1 reverse-biases the base (b) of TR1 and both transistors turn off. The action then repeats and the circuit oscillates.

In order to make an effective D.C. Converter, the energy of the back-e.m.f. generated by the choke is stored on electrolytic capacitor C1. The high frequency of the oscillation requires the use of a high-speed diode, and the 1N5822 Schottky rectifier diode is recommended here.

If the whole back-e.m.f. waveform was rectified and allowed to charge C1 then the voltage was found to rise to well above 20V. The desired output voltage was easily obtained using a Zener diode (D2), in this case, a 15V type. The choke L1 used in trials was a TOKO 8RBS type *(available from Cirkit)*.

John Greenbank,
Haslingfield,
Cambridge.

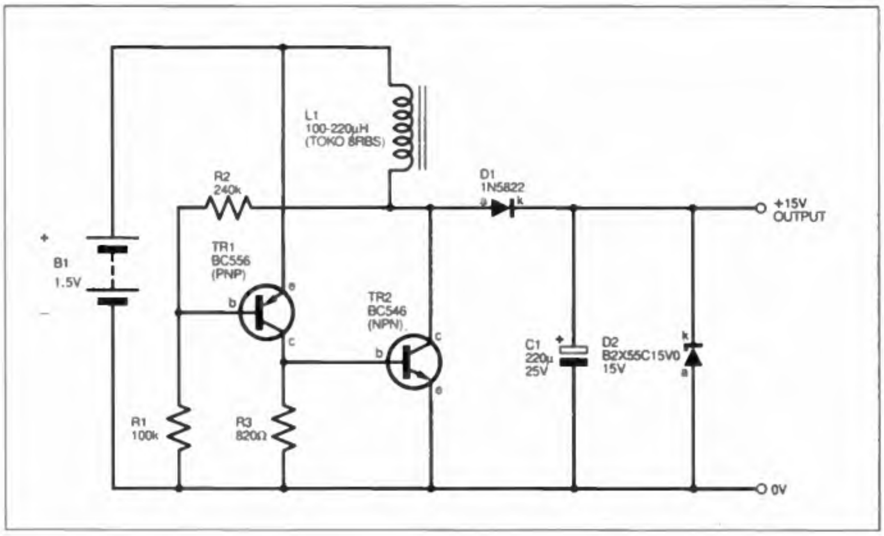


Fig. 4. D.C. voltage converter.

INGENUITY UNLIMTED

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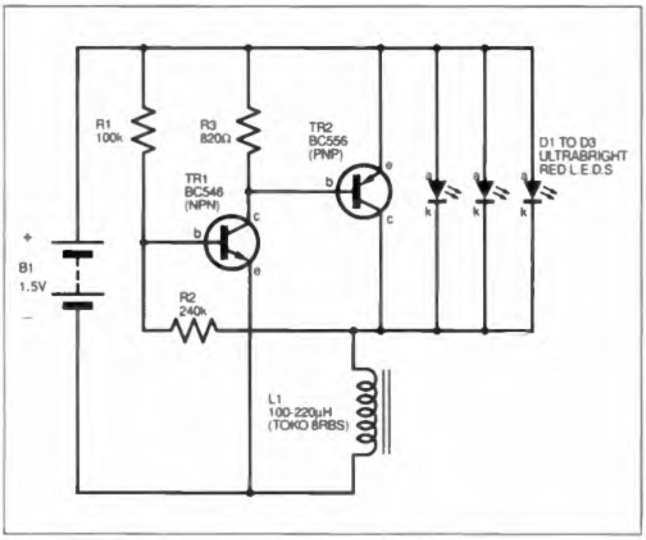

Fig. 5. Experimental Cycle Light.

Experimental Cycle Light – for bright cyclists

CONTINUING on the same basis, Fig. 5 shows how the D.C. Converter circuit may be used to produce an experimental 3-l.e.d. (non-flashing) rear cycle light. This utilises three ultra-bright l.e.d.s in parallel, based upon the circuit of Fig. 4.

A matchbox-sized "lamp" has been produced, operating from a single AAA cell. It could be used for other applications where compact size and low battery usage are important.

John Greenbank,
Haslingfield,
Cambridge.

60 Pence DPDT Relay – switch it

AN electronic version of a double-pole double-throw (DPDT) mechanical relay, with a few significant differences is shown in Fig. 6. It costs a fraction of the price, operates from 3V-15V, draws only 2mA current, and switches thousands of times faster! The disadvantages are that it does not provide isolation, it has a maximum "contact" rating of 25mA, and the "contact resistance" is approximately 100 ohms.

IC1 is a 4066 quad bilateral switch (transmission gate) chip which contains four switches, each with a control signal. When the control voltage is high, the switch turns on and approximates a low value resistance. If the control is low, then the gate assumes a high resistance value. When the relay on/off signal goes high, the "relay" toggles and switches over, with the two "poles" switching over in a DPDT pattern. If a break is made at point "A" then the circuit is converted to two single-pole double-throw (SPDT) relays.

Rev. Thomas Scarborough,
Cape Town,
South Africa.

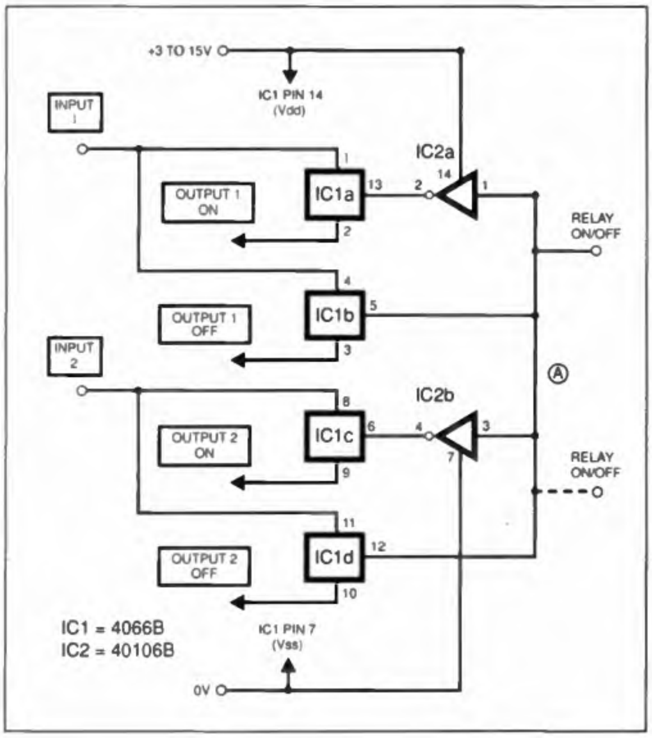

Fig. 6. Inexpensive substitute for a DPDT relay.

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ALARM OPERATED CAR WINDOW WINDER

ROBERT HUNT

Automatically winds up your car windows when setting the alarm. Includes safety cut-out feature.

THE AUTHOR, being a self-confessed lazy person, preferring all kinds of electronic gadgetry to perform boring or irritating tasks rather than complete them himself, found it a constant irritation that when setting the car alarm, which automatically locked all the doors, he would still have to bother with manually winding up the electric windows.

In moments of forgetfulness, after getting out of the car and pressing the alarm remote to lock the doors, he was frequently aggravated to find that the windows were not closed! Here, now, is the complete solution for those busy people who, like the author, hate sitting in a parked car holding down a window button or two whilst in a hurry to depart.

By building this device, you too will be able to jump out as soon as the engine has stopped, pressing your remote button and thankfully noting that your electric windows are closing, whilst you put away your keys and begin to walk off.

Commercially manufactured units are available, of course, but these often depend on the alarm having a suitable connector or output to signal the window closer electronics. The design presented here has the advantage that it depends on the alarm's indicator l.e.d. (which almost all alarms have) to control it, making it possible to be used on almost any alarm.

The "Before" and "After" block diagrams in Fig. 1 illustrate how simple this window closer is to install.

CIRCUIT DESIGN

The system comprises two basic circuits, the Trigger circuit (see Fig. 2) which connects to the alarm in whatever way is decided upon during installation, and the Closer circuit(s) (see Fig. 3) which is (are) triggered by the Trigger circuit. You need one Closer circuit for each window.

The purpose of the Trigger circuit is two-fold. Firstly, to generate a trigger pulse to the Closer circuits which is short enough for them to function properly. Secondly, to prevent spurious triggering from electrical "spikes" occurring in the vehicle's wiring.

Zener diode D1 in Fig. 2 reduces the total input voltage, from wherever an "alarm set" signal is going to be obtained, to around two volts. In the author's unit it was obtained from the same part of the alarm circuit which controlled the alarm's l.e.d. (You are recommended to establish a suitable signal source in your own car's alarm system *before* obtaining parts for this project.)

The Zener value of diode D1 needs to be chosen to suit your car's alarm trigger source. Use a meter to measure the voltage present at the point from which you are planning to taking the signal. If it is above two volts, then select a Zener diode whose value matches the difference in voltage level.

If the signal being input to the circuit is a pulsating one, rate diode D1 according to the highest voltage present and choose component values for resistors R2 as zero ohms (a link wire), R3 as 10kΩ and capacitor C1 as 470μF.

If, however, the signal is a steady output, then choose an appropriate Zener diode for D1 to suit the steady voltage, and use 10kΩ for resistor R2, zero ohms (link wire) for R3, and 10μF for C1.

Signals coming in through diode D1 are rectified by D2, and smoothed by capacitor C1 in conjunction with resistors R2 and R3. The resulting signal provides a clean switch-on voltage for Darlington transistor TR1, after a short delay, imposed by the rectifying network, which prevents spurious triggering.

Once TR1 switches on, capacitor C2 passes a negative-going pulse to the output which lasts for about a tenth of a second and is used to trigger a timer in the Closer circuit.

CLOSER CIRCUIT

The negative-going pulse from TR1 triggers timer chip IC1, which stays triggered for a time set by capacitor C3, resistor R6 and preset potentiometer VR1. When triggered, the output of the timer, pin 3, goes high (near to the power rail positive voltage) and switches on relays RLA and RLB via diode D4. The contacts

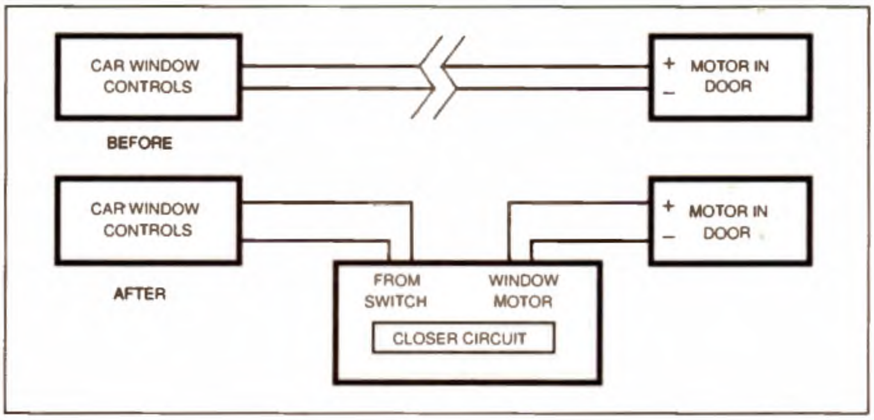


Fig. 1. Basically, all you need to do is to insert the Alarm Operated Car Window Winder between the window controls and the window motor.

of the relays disconnect the output from the window switch and then connect the window motor to its voltage supply lines.

Note that IC1 must be the "standard" 555 timer version; a low power type would not be able to supply the current required by the relays.

If the window shuts before the timing cycle ends, or if the window is already shut when the circuit is triggered, the comparator circuit around IC2 trips-out (resets) the timer, an action determined as follows:

The motor current passes through resistor R11, creating a voltage drop across the resistor which is relative to the current flowing. Comparator IC2 compares this voltage, applied to its pin 2, with a reference voltage supplied to its pin 3. The reference voltage is set by the network comprising resistors R7 to R9, Zener diode D7 and potentiometer VR2.

This technique provides the circuit with the ability to detect if the window is shut, since a shut window causes the motor to stall, which in turn greatly increases the current flowing through the motor.

Capacitor C6 prevents spurious surges in the motor current from tripping out IC2. Capacitors C7 and C8 provide a small amount of smoothing to the reference voltage circuit.

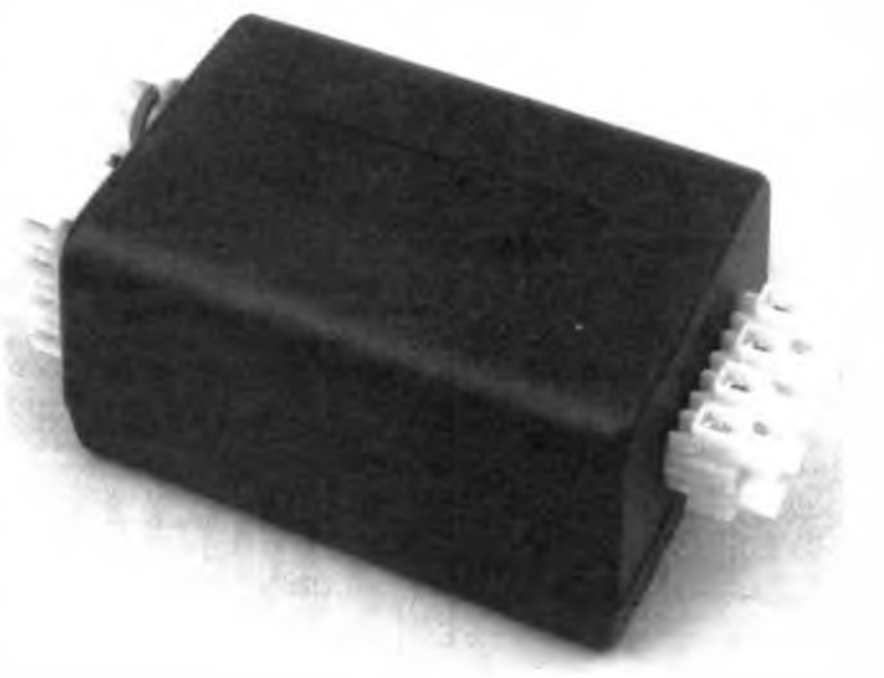
After installation, VR2 is used to set the trip current to a level that causes the circuit to trip out approximately 0·75 seconds after the motor stalls.

CONSTRUCTION

One Closer circuit is needed for each of the window motors you wish to control. Only one Trigger circuit is needed, irrespective of the number of Closer circuits used. The size of case should be chosen to suit the number of circuit boards to be installed.

Printed circuit board (p.c.b.) details for the Trigger and Closer circuits are shown in Fig. 4 and Fig. 5. These boards are available from the *EPE PCB Service*, codes 150 and 151, respectively.

Assemble the p.c.b.s, starting with the smallest components and working up to



The size of case you use will depend on how many windows you want to automate. This case holds the circuits for two windows.

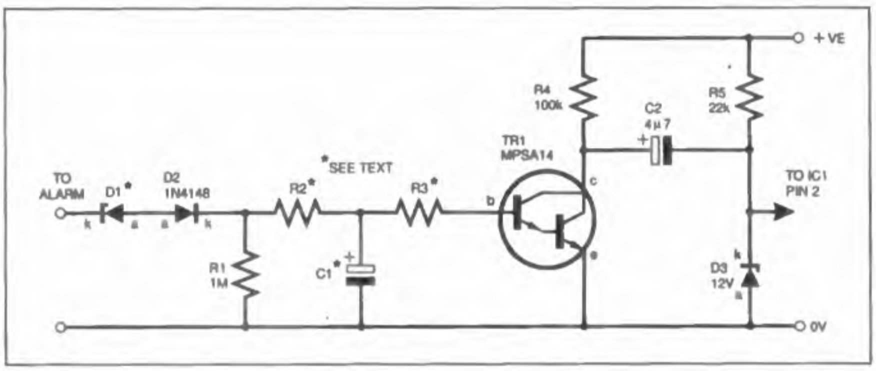


Fig. 2. The Trigger circuit simply generates a control pulse which is of adequate length and amplitude. The source of the pulse must be established by the constructor to suit the vehicle in question.

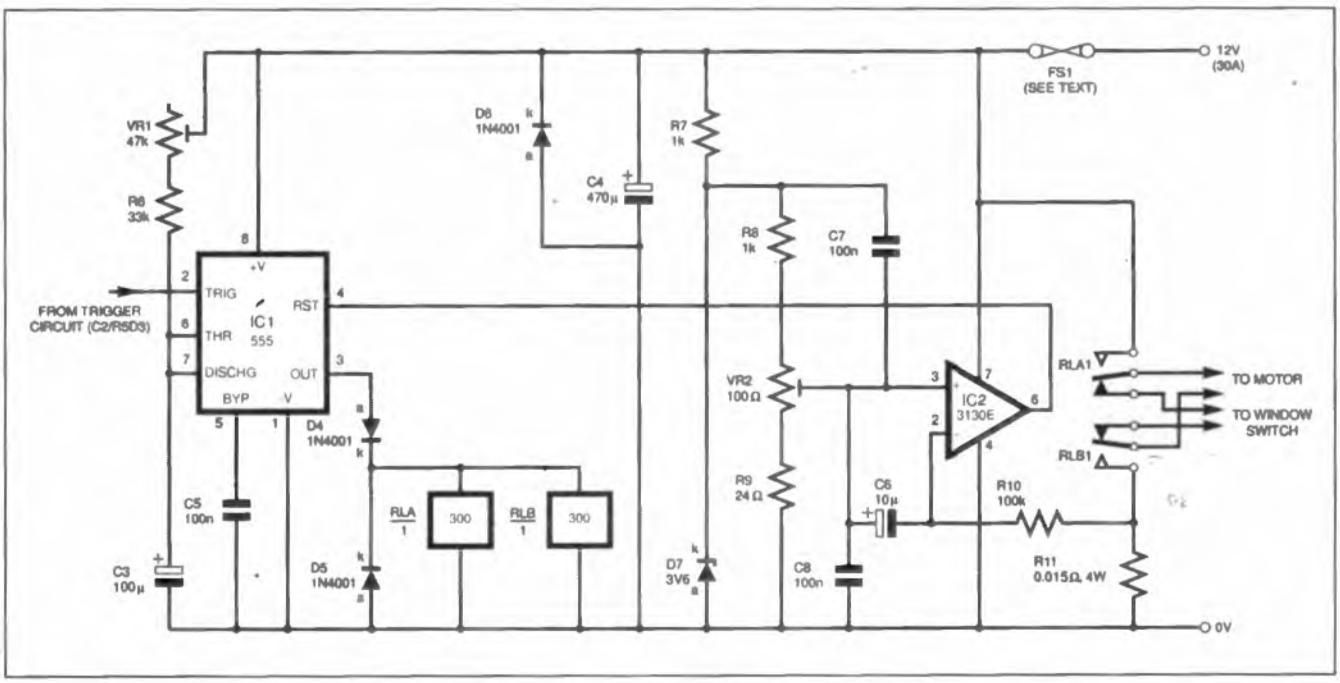


Fig. 3. Circuit diagram for the Closer circuit. Up to four of these circuits may be driven by a single Trigger circuit. One closer circuit is needed for each window.

the biggest. Note that IC2 is a static sensitive device, therefore take the usual precautions when handling it, i.e. briefly earthing yourself through a suitable contact. Make sure that all polarity-conscious components are oriented correctly on the boards as indicated.

WIRING-UP

Solder heavy-duty wire to the appropriate power line tracks underneath the boards, flowing plenty of solder around them as they must carry large currents.

COMPONENTS

TRIGGER CIRCUIT

Resistors

R1	1M
R2	10k or link wire (see text)
R3	10k or link wire (see text)
R4	100k
R5	22k

All resistors 0·25W 5% or better

Capacitors

C1	470µ or 10µ radial elect. 25V (see text)
C2	4µ7 radial elect. 25V

Semiconductors

D1	400mW Zener diode (see text)
D2	1N4148 signal diode
D3	12V 400mW Zener diode
TR1	MPSA14 *npn* Darlington transistor

Miscellaneous

Printed circuit board, available from *EPE PCB Service*, code 150; terminal pins; connecting wires.

CLOSER CIRCUIT

See SHOP TALK Page

Resistors

R6	33k
R7, R8	1k (2 off)
R9	24Ω
R10	100k
R11	0.015Ω 4W

All resistors (except R11) 0·25W 5% or better.

Potentiometers

VR1	47k min. horiz. preset
VR2	100Ω min. horiz. preset

Capacitors

C3	100µ radial elect. 25V
C4	470µ radial elect. 25V
C5, C7, C8	100n ceramic (3 off)
C6	10µ radial elect. 25V

Semiconductors

D4 to D6	1N4001 (3 off)
D7	3V6 400mW Zener diode
IC1	555N timer
IC2	CA3130E comparator

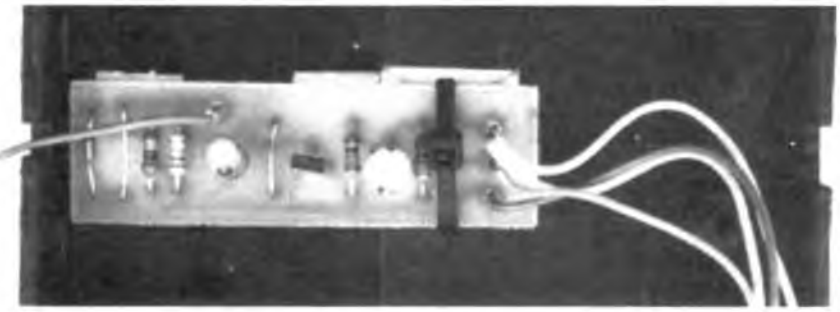
Miscellaneous

RLA, RLB	300Ω s.p.c.o. relay, p.c.b. mounting, 16A (2 off)
FS1	line-mounting fuseholder plus 30A fuse (see text)

Printed circuit board, available from the *EPE PCB Service*, code 151; terminal pins; 4-way terminal block (3 off); cable ties; heavy duty wire; connecting wire; nuts and bolts; solder, etc.

Also required: box to suit number of Closer circuits in use.

Approx Cost Guidance Only £30 for two windows excl. case.



A cable tie with a self-adhesive base secures the Trigger p.c.b. to the case lid. There are various component use options available which is why this board appears to differ from the detail in Fig. 4.

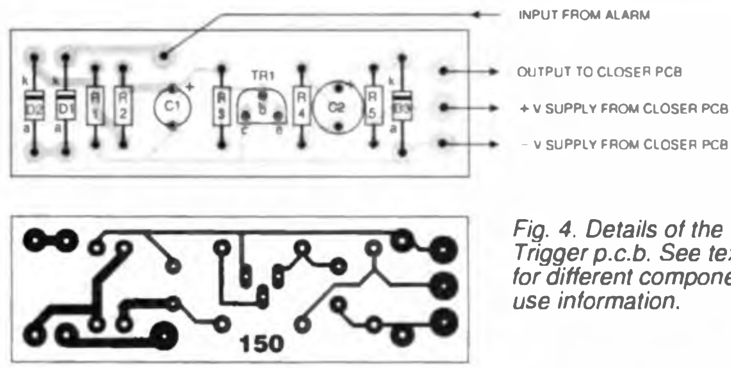


Fig. 4. Details of the Trigger p.c.b. See text for different component use information.

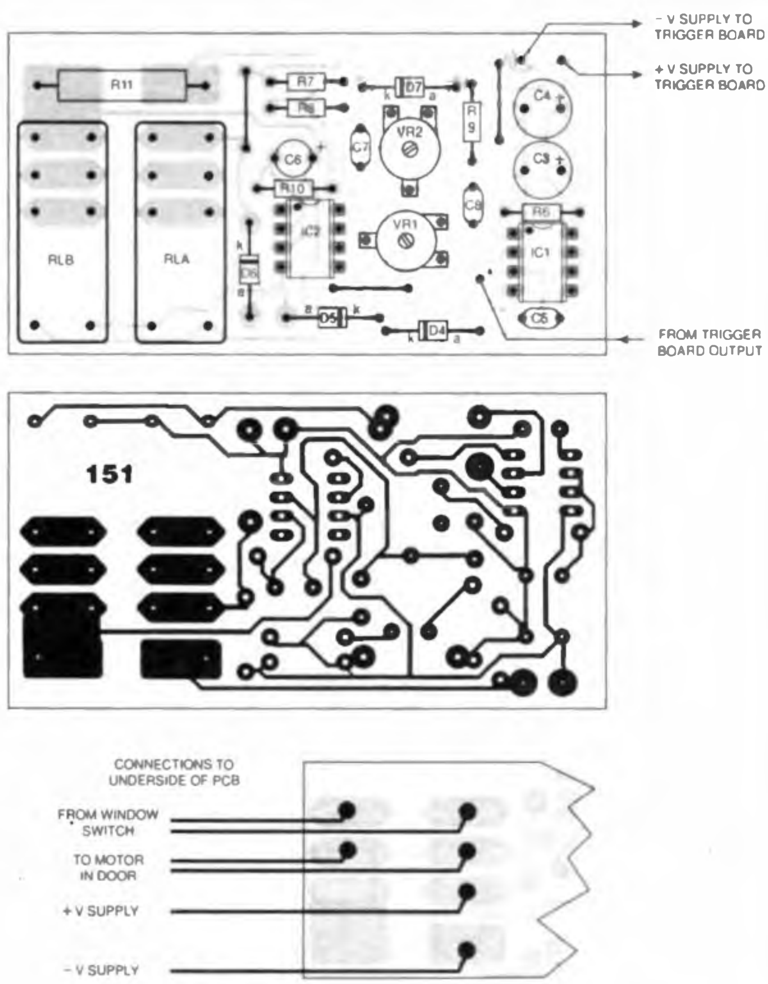


Fig. 5. Details of the Closer p.c.b., also showing where the heavy duty cables are soldered directly to the trackside.

Leave their other ends unconnected for the moment.

After assembly is complete, check that there are no solder bridges anywhere, and that all components are installed correctly.

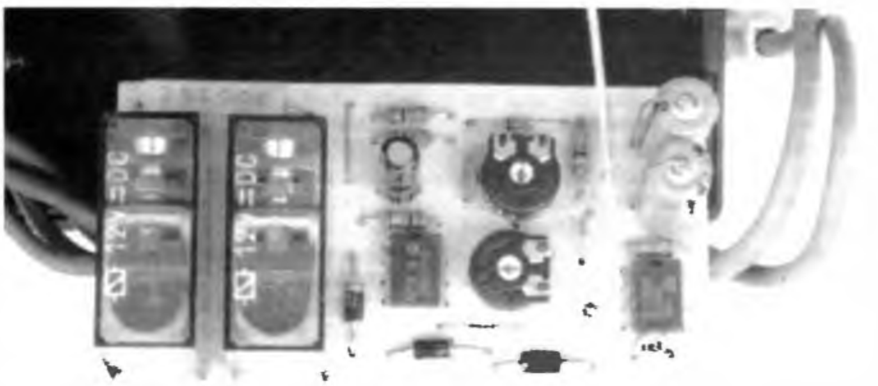
Drill the case for the terminal blocks, which should then be bolted to the case. Assemble the boards into the case, allowing room for easy access to the adjustment potentiometers. Connect the heavy current wires into terminal blocks.

If you are using more than two Closer circuits, you will need to make the power connections in at least two pairs. This is because each Closer circuit must be fused; each will draw up to about 15A and you cannot get fuses above 30A! A cable mounting fuseholder should be used (not illustrated), inserted into the power cable at a convenient point between the unit and its power source.

All trigger inputs on the Closer circuits are wired together back to the output of the Trigger circuit, with the positive and negative leads soldered onto the power pins respectively. Connect another flying lead to the Trigger circuit's input pin and route this outside the case, allowing plenty of length for the wire to reach the alarm unit.

As seen in the photos, the Trigger circuit was mounted in the lid of the prototype's case.

Careful attention must be paid to enclosing the p.c.b.s in a case and to the satisfactorily wired connections, ensuring that the lid can be properly closed without causing stress or electrical shorting inside.



The board-mounted relays and enclosed presets give stability to the Closer p.c.b. It is recommended that i.c. sockets and axial electrolytic capacitors be used, contrary to the assembly shown here.

INSTALLATION

It is recommended that you disconnect the car battery before connecting the unit's wires to the car electrics.

Establish where you will place the unit. You will need a high current feed available, probably a new one from the battery, allowing for each Closer circuit to take around 15A. This feed must be live all the time, even when the ignition is switched off.

You will need to interrupt the wires going to the window motor in the door, cutting both of these and leaving four ends to connect into the unit for each window.

It is best to mount the unit as near as possible to the high current feed because the four wires to each window motor can be a bit longer if they are the correct current rating. Trace the cable to the window motor in the door, and find a suitable point on these two wires that comes *after all other devices* before the window motor itself (refer back to Fig. 1). Cut these wires and connect into the unit.

You may find difficulty working out which way round to connect the two wires. This is best done by trial and error. Connect them either way for the time being, ensuring that the motor wires go into the motor connections on the unit, and that the "from switch" wires go into "from switch" on the unit. For now, connect only one window and identify which Closer p.c.b. is connected to it.

SETTING UP

Connect the power feeds, ensuring that you get a *very solid* earth connection. In view of the high currents involved, *there is a risk of overheating and even fire if you do not make very good connections.* Once the fuse has been inserted and the car battery is being reconnected, be very cautious, watching and smelling for heat, and other signs of malfunction.

Rotate both potentiometers fully anticlockwise. Trigger the input circuit by touching the input wire to the positive line. If the window momentarily moves down, reverse the motor connections. Switch on the ignition and make sure that your window switch still works the correct way. If not, then reverse the "from switch" connections.

Wind the window fully down and switch off the ignition. Adjust potentiometer VR2 to its fully clockwise setting, and trigger the unit as before. Now adjust VR1 to a position which allows enough time to close the window from fully open, plus about a second or so to spare. Now for the fun bit, setting up the trip level!

All you really need to do is leave the window shut and trigger the unit, adjusting VR2 so that the unit trips out about three-quarters of a second after triggering.

Repeat the above procedure for each Closer p.c.b. and then wind down all windows, switch off the ignition, and trigger the unit. Observe for correct operation. Now wind down the windows by various amounts, repeat the tests, and watch that each Closer p.c.b. trips out when each window is closed.

If this functional test fails, the probable reasons are that the power feed wire is too long or too thin, or that the trip level potentiometers (VR2) have not been set quite right. Experiment by adjusting for a slightly different trip out delay.

Remember that in normal use the unit will be operating just after the battery has had a long charge, and also that the windows will be faster when the engine is running because the battery voltage is higher, whereas now you probably have a tiring battery after repeatedly winding the windows up and down!

WIND UP

Now connect the trigger wire to the alarm point you have already decided upon and check that it all works! Note that neither the author or *EPE* can take responsibility for flat batteries caused by lengthy set up procedures! □

Techniques

ACTUALLY DOING IT!

by Robert Penfold

TECHNIQUES has been reintroduced after a few months absence from the pages of *EPE*. The aim of this column (which will now appear every other month) is to help newcomers to get started in project building.

Who Dares Wins

Probably few novices take the attitude that there is "nothing to it" and jump straight in with their first project without a moments hesitation. Most people are naturally a bit cautious about trying anything new, and afraid of failure. With electronics there is the added problem of the techno-phobia that many people seem to suffer from.

Electronic project construction can be pursued as a craft by someone with little or no technical knowledge, but it is probably not a pastime that is suited to those who genuinely hate virtually all things technological. However, provided you are reasonably practical, and are prepared to use a bit of ingenuity from time to time, it is a hobby that should be within your capabilities.

You do not need a degree in electronics in order to start, and you really need very little in order to get under way. The main requirement is the gumption to buy some components and a few basic tools, and make a start.

Now You See It

It is a common misconception that you need space for a proper workshop in order to build projects. It is certainly an advantage to have good facilities with plenty of space to work in, but it is by no means essential.

I began constructing electronic projects when very young, and built dozens of them sitting cross-legged on the bedroom floor, using an unused corner as a workbench. Old newspapers served to protect the carpet against the inevitable fall-out of solder blobs, wire trimmings, etc. Some of my early published projects were put together using this improvised workbench!

Going Mobile

Obviously the "yoga" method of construction is not suitable for most people, but it is not difficult to improvise a more sophisticated temporary set-up. A popular method is to have a piece of plywood or thin particle board measuring about 750mm × 500mm.

This can act as a temporary "mobile" worktop that can be used on (say) the kitchen table. Many constructors have the soldering iron stand permanently fixed to the board, possibly together with other items such as a box to take screwdrivers and other small tools, and a multimeter.

The basic idea is to have a workbench that can be stored away in a cupboard somewhere when it is not needed. Preferably, it should be possible to get the workbench set up and ready for use with a minimal amount of fuss and bother, and to whisk it back into the cupboard in a similar fashion. *Remember to let the soldering iron cool down before replacing the unit in a cupboard.*

Solder Dispenser

Some years ago I used a temporary workbench, and found it useful to have a large reel of solder mounted on the base board using the basic arrangement outlined in Fig.1. This helps to keep the workbench as a single and easily managed unit, and it also acts as a convenient solder dispenser provided the reel of solder is free to rotate.

In fact, it can be useful to build a dispenser of this type for use on an ordinary workbench. Simply use a heavy steel or wooden base in place of the temporary workbench.

The base must be quite heavy so that the unit stays in place on the workbench when solder is pulled off the reel. Alternatively, the unit could be fixed to the bench using something like Bostik Blu-Tack or double-sided adhesive pads.

I will not claim that a temporary workbench is as good as having a large workbench which is used for nothing but project construction. On the other hand, many people have successfully pursued the hobby in this way, building many projects, including some quite large and complex ones. A neighbour of mine once built a computer based on dozens of TTL integrated circuits using this method.

Tools for the Job

Another common misconception is that you need a vast array of tools in order to build electronic projects. Unlike many modern hobbies, electronics is one that can be undertaken with surprisingly little equipment, and at relatively low cost.

I suppose that over a period of time I use quite a range of tools when building projects, but initially a relatively small number will suffice. Start with a basic toolkit and add to it as and when necessary.

Initially, it is probably best to settle for quite simple projects that are free from unusual aspects of construction, and that do not require any "out-of-the-ordinary" tools. Apart from avoiding the need to buy tools that may not be required again for some time, it keeps things simple and straightforward.

The beginner has plenty of new things to master, and it makes sense to avoid any unnecessary complications. The usual recommendations are simple household gadgets or car projects, but anything will do provided it is simple, you understand exactly what it is

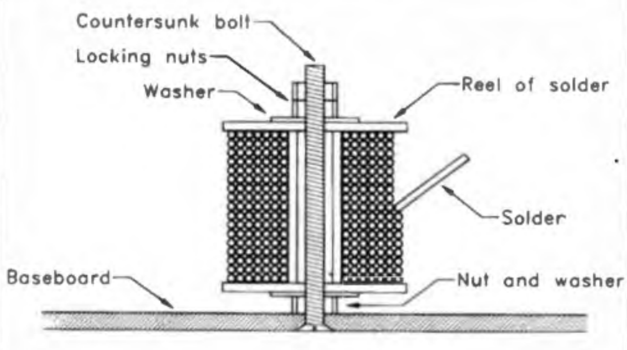


Fig.1. A simple but effective solder dispenser which can be built onto a portable worktop.

All that is needed to assemble circuit boards: two sizes of solder, small electric iron with stand and wire cutters/strippers.

supposed to do, and can test it out easily.

Avoid projects such as obscure pieces of test gear which are often quite simple, but not really intended for beginners. Also avoid old projects, particularly those from more than about five years ago.

Being given some very old electronics magazines seems to be a standard method of entry into this hobby. The problem is that the projects they contain often require components that have become difficult or impossible to obtain. With any project that is more than a few months old it is advisable to ascertain that *all* the components are still available before actually buying.

It's a Snip

Many of the tools required are the type of thing that can be found in the average household toolbox, such as pliers, a hacksaw, and screwdrivers. These may not all be ideal for the job though. The average screwdriver is too large for most electronic construction work, and it will probably be necessary to buy some miniature electrician's screwdrivers.

Fortunately, these cost very little. It is advisable to have a least one small cross-point screwdriver.

The best type of pliers are, as one would expect, the electrician's variety. It is possible to make-do with other types initially though, and long-nose pliers are very useful.

One of the most important tools is a good pair of wire cutters and insulation strippers. The cheapest way of obtaining these is to buy them in a combined tool. These mostly work quite well, and the wire strippers often seem to be easier to use than dedicated wire strippers.

In general, the wire cutters are perhaps less effective, and are sometimes not very good a cutting fine wires, but they are adequate for circuit board construction and wiring-up controls, etc. However, I would advise buying a good pair of wire cutters when funds permit, and these should work well for many years.

No excuses are offered for repeating once more the warning against using scissors, knives, or other improvised methods of cutting and stripping wires. Apart from the fact that these methods do not do a very good job, you are quite likely to damage the tools and harm yourself.

Improvised methods of wire stripping are particularly ineffective, and tend to nick the wires. This makes them very prone to breaking, and gives very unreliable results. A pair of wire strippers or a combined stripper and cutter tool has to be regarded as an *essential* item for the project constructor.

Soldering On

A soldering iron is obviously central to electronic project building, and is not something that will already be present in the average household toolbox. For modern electronic work a small electric iron having a rating of about 15W to 25W is required.

There is no need to buy an expensive temperature controlled iron. The Antex C series irons are widely available at quite attractive prices, and I have used these successfully over a period of nearly 30 years.

With any soldering iron the bit will need occasional replacement, but otherwise the iron should last for many years. The iron will probably be supplied with a bit of about 2·3mm in diameter, which is about right for most work on circuit boards and the "hard" wiring. However, a wide range of sizes are available, and for work on intricate circuit boards some constructors prefer a small diameter bit (about 1mm to 1·5mm).

A matching stand for your selected iron should only cost a few pounds and should be regarded as an essential rather than an optional extra. It is not difficult to improvise a stand, but this has to be regarded as slightly risky, and is hardly worth it with the "real thing" costing so little. Also, a proper soldering iron stand will conduct excess heat away from the iron, which helps to extend the operating life of the bit and the heating element.

Joint of Solder

Obviously some solder will be needed, and for electronic work it is a 60% tin/40% lead type containing a non-corrosive flux that is required. This is available from most electronic component retailers in two thicknesses. These are 18s.w.g. (1·22mm dia.) and 22s.w.g. (0·71mm dia.).

For circuit boards and most other joints it is the thinner gauge that is easier to use. It is useful to have a small pack of thicker solder for the occasional large soldered joint.

I would suggest buying a reasonably large pack of the thinner gauge, say about 10 metres or more. When I first started building projects I bought small packs of solder, and had to endure the frustration of forever running out of solder with projects 99 per cent finished. Of course, this always happens just after the shops have closed!

Hole Truth

Some form of drill is essential, and a heavy-duty hand-drill is perfectly adequate. An ordinary electric drill is also suitable, but is much easier to use if it is fitted in a proper stand. Otherwise the relatively soft materials used in electronic project construction can be rather awkward to work on.

It is probably best to avoid cheap drill bits, but medium quality types are adequate for drilling into the plastics, aluminium, etc. encountered in project construction. A set of a dozen or so HSS drills should be sufficient, or you could settle for the most frequently used sizes to start with. The ones I wear out most frequently are the 3·3mm, 5mm, 6·35mm (0·25in) and 10mm diameter drills.

For larger and more awkward holes it is useful to have a set of miniature files, or an "Abrafile". This is a small round file which is slightly flexible. I have never found their flexibility to be an advantage, but they are relatively coarse which enables holes to be cut relatively fast. The standard "Abrafile" is better suited to electronic work than the really small type.

A vice is more than a little useful, and even one of the larger "hobby" vices will suffice. This is basically just a small vice that is secured to the workbench via a large suction cup.

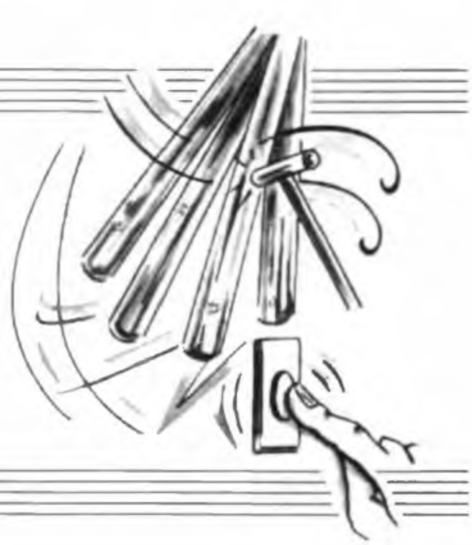
If you have short fingernails, or your fingers are not as nimble as they used to be, one or two pairs of tweezers will make it easier to handle small components such as resistors. A large blob of Bostik Blu-Tack or plasticine is useful for all manner of things, such as holding awkward components in position while they are soldered into place.

Although complaints about the cost of project building are not unknown, it really is a hobby that can be pursued at quite low cost. Even starting from scratch, it is possible to buy the components and tools for a simple project for well under £50.

Most people will have a few tools to start with, and could probably build their first project for little more than half that figure. There are probably few other modern hobbies that can be started so cheaply.

Some essentials for project construction. An assortment of electrician's screwdrivers and a pair of pliers.

Constructional Project



QUASI-BELL DOOR ALERT

WILLIAM E. CHESTER

A no fuss, no nonsense, straight as they come 16-tone doorbell.

THIS project arose from a friend's requirement for a no fuss, no nonsense, straight as they come doorbell. In fact, the design brief included the constraint that the sound emitted should be fairly invasive, having an almost bell-like noise to attract urgent attention.

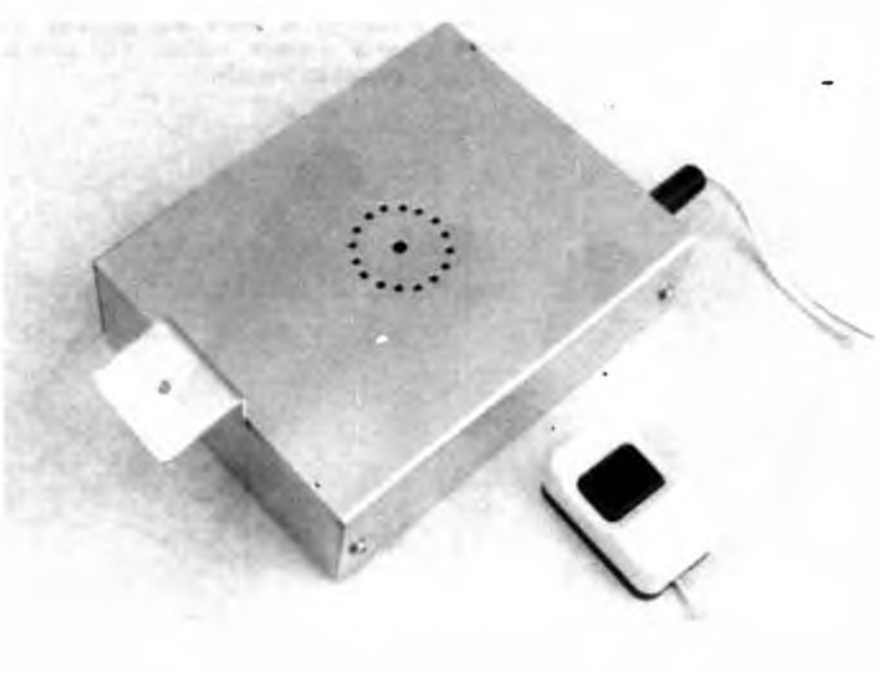
The trouble with electro-mechanical bells is that while of robust construction, they do make heavy demands on the power supply. Many people do not like the idea of wiring to the domestic mains supply, so large expensive batteries are the order of the day.

Thus is born the final requirement. The battery should be small, concealed and relatively cheap. What's more, it must last for an admirable length of time in normal usage.

Of course, electronic door alarms have been around in many varied forms for years. This particular design seeks to justify its existence by employing a novel technique to emulate the traditional bell.

Additionally, the circuit offers room for modification, something not available with a bell dome.

This alarm outputs 16 tones, one at a time in smooth succession. The chosen sequence of tones or notes is then repeated, like in a loop. A slow loop time gives an unexciting result. At an increased repetition rate the tones exhibit a bell-like quality. The musical note of individual tones can be altered by resistor changes as can the speed of loop repeat.



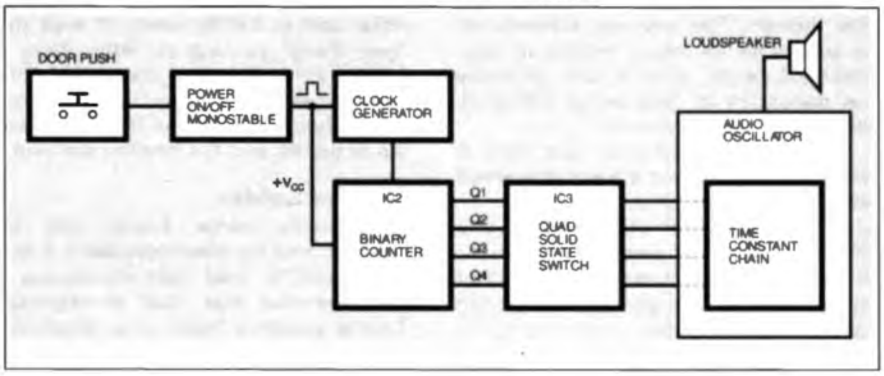


Fig. 1. Function block diagram for the Quasi-Bell Door Alert.

HOW IT WORKS

A block diagram for the Quasi-Bell Door Alert is shown in Fig. 1. In the idle state, only a small part of the circuit is permanently connected to the battery, or other supply.

This circuit portion is the On/Off Monostable switch. It draws only a tiny standby current since it is implemented from CMOS logic. When the door pushbutton is pressed, the monostable powers-up the remaining circuit blocks.

The clock generator causes the Binary Counter (IC2) to step continuously through all its output state combinations. The Q1 to Q4 output lines are presented to the quad solid state switch (IC3).

The "closed" or "open" status of these switches is then used to continuously alter a *CR* timing network within the Audio Oscillator, or astable.

Finally, the resultant sound is output, via a buffer, to the loudspeaker.

CIRCUIT OPERATION

The full circuit diagram for the Quasi-Bell Door Alert is shown in Fig. 2. Three gates of IC1, a CMOS 4011 Quad NAND, form an astable multivibrator which is used as the regular clock source for IC2. The square wave enters IC2, a binary counter, at pin 1.

The binary outputs appear at pin 3 to pin 6 inclusive. It is the 1 (high) or 0 (low) state of these lines that either "press" or hold "released" each of the four solid-state switches S1, S2, S3 and S4 (IC3a to IC3d).

Logic 1 always closes the associated switch causing a short-circuit across the relevant resistor in the chain R6 to R9. Actually, the "short" is not perfect since the switch elements always exhibit a finite on-resistance, R_{ON} – this being the channel resistance of the f.e.t. devices within IC3.

Even so, a typical R_{ON} of 100 ohms constitutes a sufficient short in comparison with the much larger values of the discrete resistor chain.

In conjunction with resistor R10 and capacitor C3, the resistor chain R6 to R9 completes a simple square wave astable built around gate IC4a. The Schmitt trigger action of this gate is desired since slow rise and fall voltages appear across C3 during the astable timing. Table 1 shows the status of S1 to S4 for each of the sixteen possible output tones.

TONE GENERATOR

Gate IC4a is actually the tone generator. Looking at the circuit should reveal that by shorting one or more of the chain resistors the tonal output at that instant is changed. What we have are tones produced in binary combination at an output rate determined by astable IC1. Table 1 shows the status of S1 to S4 for each of the sixteen possible output tones.

The binary count from 0 to 15 is constantly repeated. In practice the initial count state of IC2 is irrelevant. The Reset input, pin 7 is therefore taken down to the 0V line, "grounded".

Gate IC4c works to buffer the output tone before it is fed on to the base (b) of transistor TR2. This is used in switch, rather than linear mode.

A good burst of tone, nearly supply rail magnitude, appears across loudspeaker LS1. Transducers such as this are not generally designed to be connected across supply lines but the presence of transistor TR2 switching rapidly at audio frequencies does no harm. A loudspeaker impedance of at least 64 ohms keeps the current peaks down to acceptable levels while preserving battery life.

Table 1: IC3 switching status for the 16 possible output tone steps.

TONE No.	SWITCH STATE			
	S1	S2	S3	S4
1	0	0	0	0
2	0	0	0	1
3	0	0	1	0
4	0	0	1	1
5	0	1	0	0
6	0	1	0	1
7	0	1	1	0
8	0	1	1	1
9	1	0	0	0
10	1	0	0	1
11	1	0	1	0
12	1	0	1	1
13	1	1	0	0
14	1	1	0	1
15	1	1	1	0
16	1	1	1	1

NOTE: 1 = SWITCH ON   0 = SWITCH OFF
One complete loop (1-16) – repeated while TR1 is turned on.

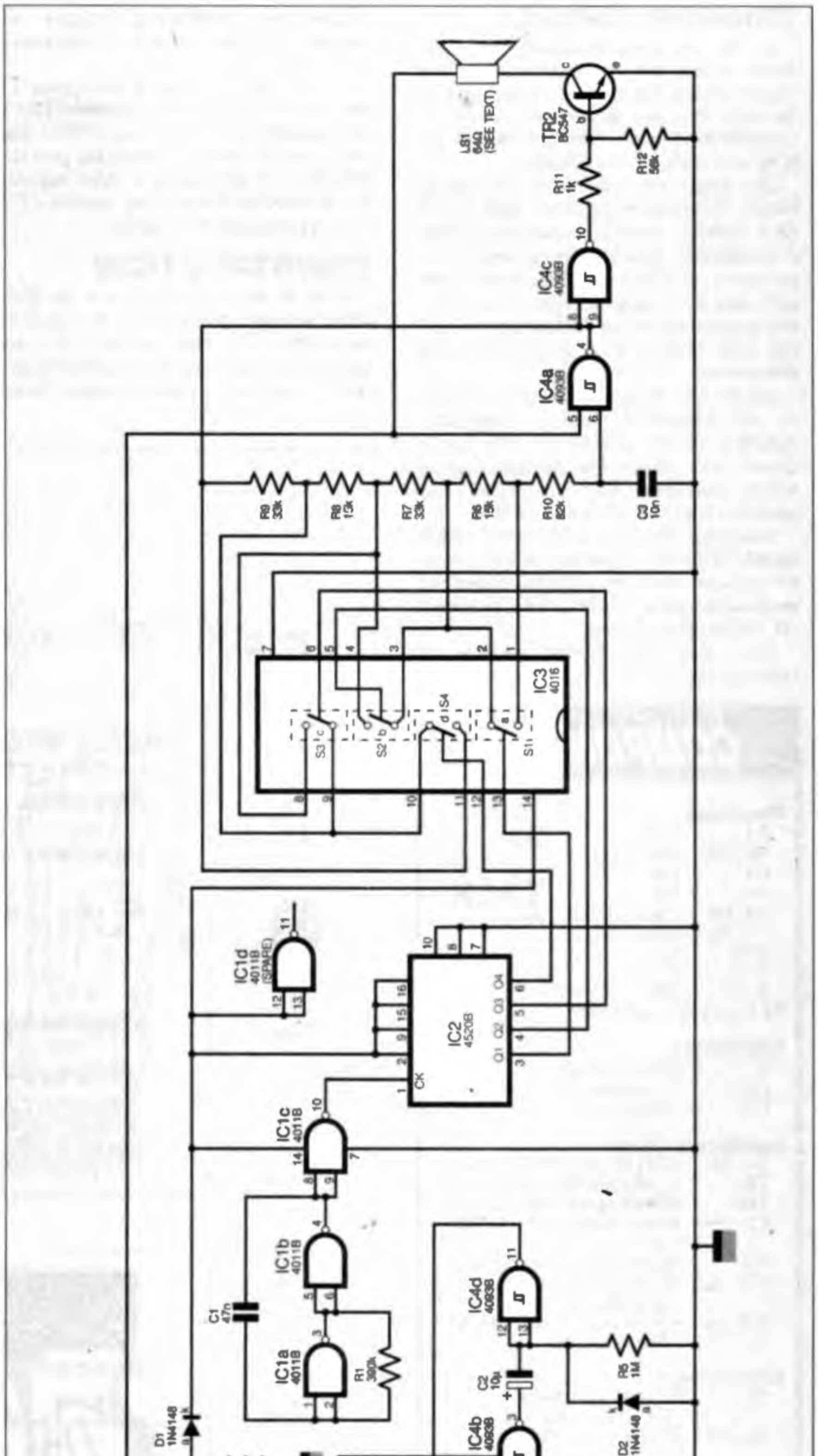


Fig. 2. Complete circuit diagram for the Quasi-Bell Door Alert.

TRIGGER CIRCUIT

So far we have described the basic alarm circuit, we now move on to the trigger section. For reliable triggering from the door mounted pushbutton switch S5, components around transistor TR1, IC4b, IC4d and diode D2 are needed.

The single wire-pair from door pushbutton S5 connects to mono jack socket SK1. Schmitt gates IC4b and IC4d form a monostable which gives a single output pulse of fixed and consistent width each time S5 is pressed. This action effectively prevents button contact bounce and impatient visitors from giving unwanted retriggering.

Alarm ON time is determined solely by the monostable timing components capacitor C2 and resistor R5. The values shown give about five seconds during which transistor TR1 is pulled into saturated conduction via resistor R3.

Transistor TR1 acts as the power on/off switch, with 9V appearing at the collector and the alarm is sounded. When the monostable pulse expires, TR1 is turned off and the alarm ceases.

Note that the battery voltage is connected directly to IC4 pin 14 only. This ensures that pushbutton presses are detected while the remainder of the circuit is dormant.

Resistor R2 provides a pull-down for one input of IC4a when transistor TR1 is off. Uncontrolled oscillation of IC4a may result if R2 is omitted. Diode D2 provides protection by preventing a large negative voltage (due to discharge of capacitor C2) from appearing at IC4d inputs.

CONSTRUCTION

Most of the components for the Door Alert, with the exception of the Doorbell pushswitch S5, jack socket SK1 and loudspeaker LS1, are accommodated on a small, single-sided, printed circuit board (p.c.b.). The topside component layout, interwiring and underside copper track master are shown in Fig. 3. This board is available from the *EPE PCB Service*, code 133.

It is best to begin assembly by inserting the three wire links, followed by all the resistors since these parts have the lowest profile. Diodes D1 and D2 should also be mounted at this stage. Be careful to place these in the correct orientation – the dark band denotes the cathode (k) connection.

All sockets for the integrated circuits can now be inserted and soldered in place. Next, position capacitors C1 and C3, then electrolytic C2; ensuring that this is orientated correctly.

COMPONENTS

Resistors

R1	390k	
R2, R3	22k (2 off)	
R4	10k	
R5	1M	
R6, R8	15k	
R7, R9	33k (2 off)	
R10	82k	
R11	1k	
R12	56k	

All 0·25W 5% metal film

See SHOP TALK Page

Capacitors

C1	47n polyester
C2	10µ radial elect. 16V
C3	10n ceramic

Semiconductors

D1, D2	1N4148 signal diode (2 off)
TR1	BC557 *pnp* silicon transistor
TR2	BC547 *npn* silicon transistor
IC1	4011B quad 2-input NAND gate
IC2	4520B dual binary counter
IC3	4016B 4-pole 1-way analogue switch
IC4	4093B quad 2-input NAND Schmitt trigger

Miscellaneous

S5	doorbell pushswitch, press-to-make
SK1/PL1	2·5mm mono chassis mounting jack socket and plug
LS1	miniature 64ohm loudspeaker, see text
B1	9V battery, with clips

Printed circuit board available from the *EPE PCB Service*, code 133; aluminium box, size 133mm x 102mm x 38mm approx; 14-pin d.i.l. socket (3 off); 16-pin d.i.l. socket; multistrand connecting wire; aluminium mounting strip, size 30mm x 70mm x 1·5mm thick (see text); 5mm high plastic/nylon spacers (3 off); M2·5 x 15mm pan-head screws, with nuts (3 off); solder pins; solder etc.

Approx Cost Guidance Only £14 *excluding speaker & batt.*

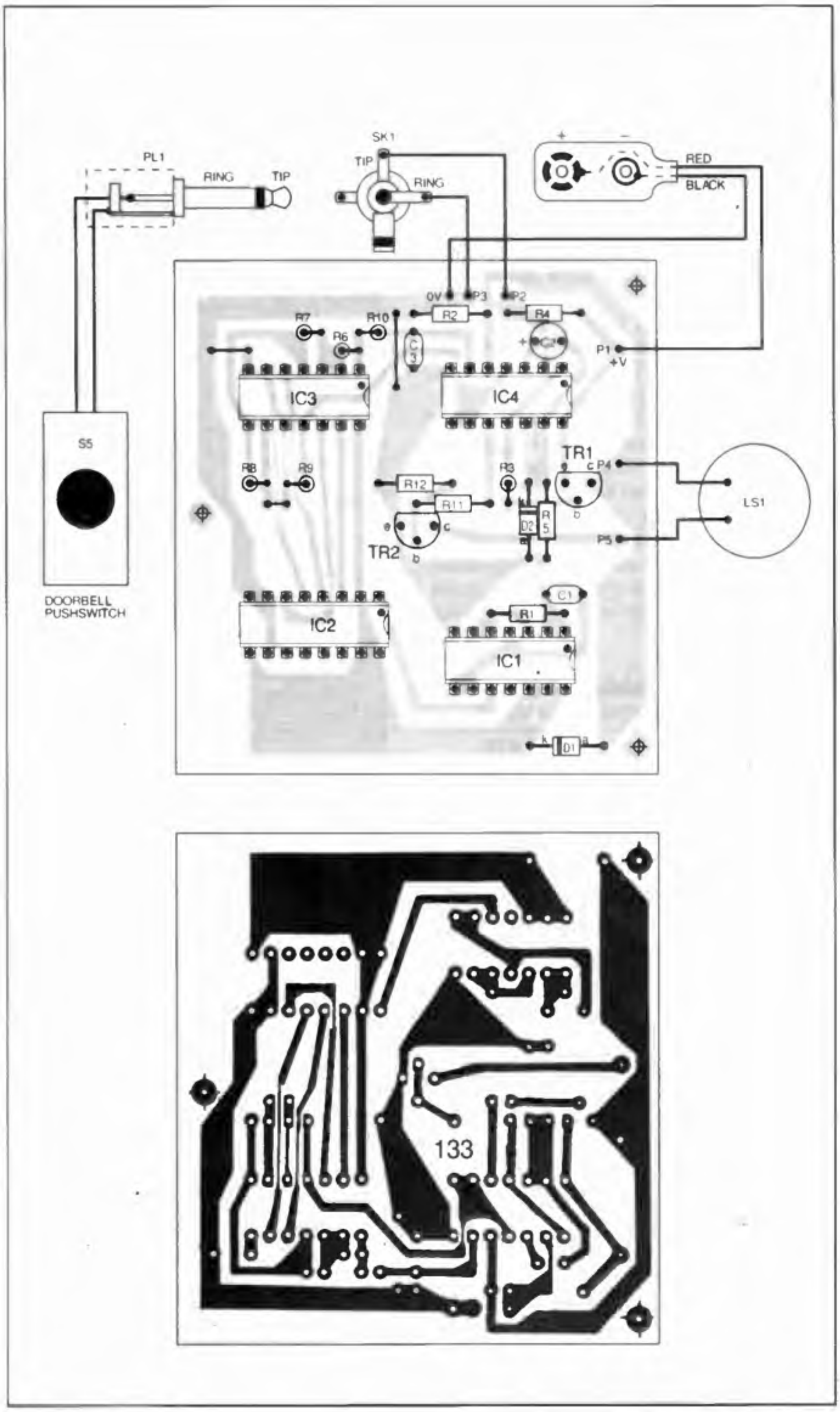


Fig. 3. Printed circuit board component layout, interwiring and full size copper foil master for the Quasi-Bell Door Alert.

Finally, insert transistors TR1 and TR2. Make sure that TR1 is the BC557 (not the BC547!). Solder the three capacitors in place, then take care soldering the transistor leads. Do not let the iron tip dwell too long on each lead, or thermal damage might be done to the semiconductors.

Terminal pins can be soldered in position at points P1 to P5 if desired. They will allow easy access when doing final assembly wiring to battery connector B1, jack socket SK1 and loudspeaker LS1.

If flying leads are your preference, solder adequate lengths to copper pads P4, P5 (a twisted pair about 200mm long) and to pads P2, P3. The red (+) lead from the battery clip is soldered directly to pad P1. The black lead to the 0V or P3 pads.

Before final assembly solder two lengths (120mm to 150mm each) of stranded connecting wire to the appropriate tags of socket SK1. Be sure that the tags chosen will be electrically extended to "bell-push" switch S5 when the jack plug is pushed home.

Layout of components on the two halves of the metal case.

CASE

The finished p.c.b. is fixed inside an aluminium case (measuring 133mm × 102mm × 38mm approx.) by three M2·5, 15mm long pan-head screws.

It is a good idea, before mounting any components on the board, to use the unpopulated p.c.b. as a template to mark the position of the three 3mm holes that must be drilled into the case base. The position chosen for the p.c.b. should be one that avoids components fouling with the loudspeaker or input socket, when the case halves are held together.

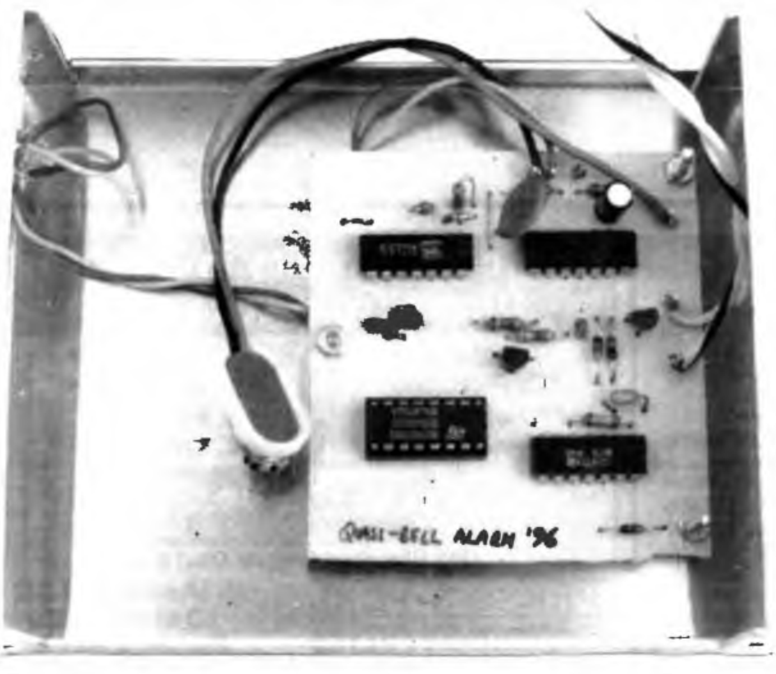
The remaining hole needed in the base section is that for jack socket SK1. This is made in what will become the alarm bottom panel, see photographs. Positioning SK1 to one side allows space inside for battery B1 to rest. Use a 4mm drill bit and deburr the hole once made.

The only holes required in the "U-shaped" lid cover are those that allow the alarm sound to permeate from the loudspeaker diaphragm. The general arrangement shown on the prototype has proved to be a good one.

It does depend, to some extent, on the actual transducer type employed. The model used a surplus telephone handset receiver (earpiece) from a modern instrument. The holes made in the case mimic those in the transducer itself.

A neat and effective means of fixing speaker LS1 to the lid underside is achieved using double-sided sticky tape. Mark the circumference of LS1 on the lid underside then mark the numerous sound holes to lie within a smaller radius (say 5mm to 8mm less than that of LS1). The clear circular margin created is then filled with sections of double-sided tape that butt snugly together.

The aim is to produce an almost air tight seal when LS1 is stuck onto it. Sound pressure can then only escape through the sound holes.



The p.c.b. mounted to one side of the case to accommodate the battery.

FINAL ASSEMBLY

Once the case preparation has been finalised, the completed p.c.b. can be bolted into the case using plastic, 5mm high, spacers dropped over each screw first inserted into the pre-drilled holes in the case base. If you are using flying leads instead of terminal posts, be sure these are in place before tightening the p.c.b. fixing nuts.

Next fit input socket SK1 into its base side panel hole. One of the leads from SK1 will be in electrical contact with the case metal. Solder *this* lead to p.c.b. solder pin P3 (0V). The other lead, which will make contact with the plug tip, is soldered to terminal P2.

Solder the battery clip, black (negative) wire to 0V, then red wire to terminal P1.

Now is a good time to peal off the remaining protective backing on the double-sided tape, previously stuck around the bedding area for LS1 in the case lid. Carefully offer up the front face of LS1 to the tape and secure it in place using a little pressure, when you are satisfied with the final position.

If you have not already done so, solder two wires (each about 150mm long) to the terminations on LS1. Twist the pair together, for say six to ten times, before soldering one free end to p.c.b. terminal pin P4 (+Ve) and the other to P5.

TESTING

Assuming none of the semiconductors are defective, testing should proceed in a logical fashion.

First, remove the pushbutton jack plug PL1 from socket SK1. With the battery disconnected do a measurement of resistance between collector and emitter of transistor TR2. This should give quite a high reading (20 kilohms) and provides some confidence that transistor TR2 is not waiting to put LS1 permanently across the supply lines. Reconnect battery B1.

Make checks, using a multimeter, for full battery voltage at transistor TR1 emitter and pin 14 of IC4. The same voltage should be observed at pin 2, IC4b. Pin 11 of IC4d should be high, at 8·7V or more.

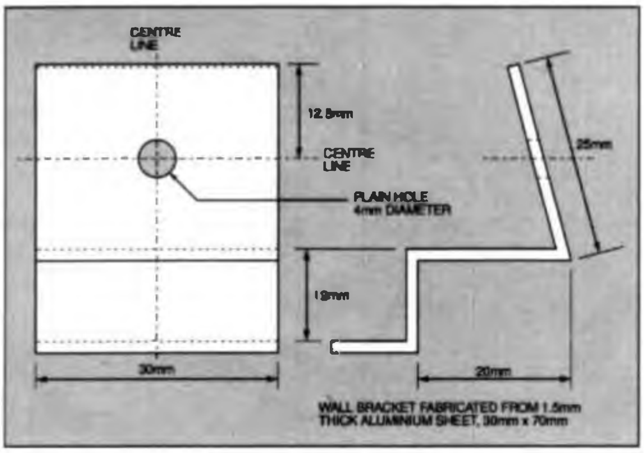
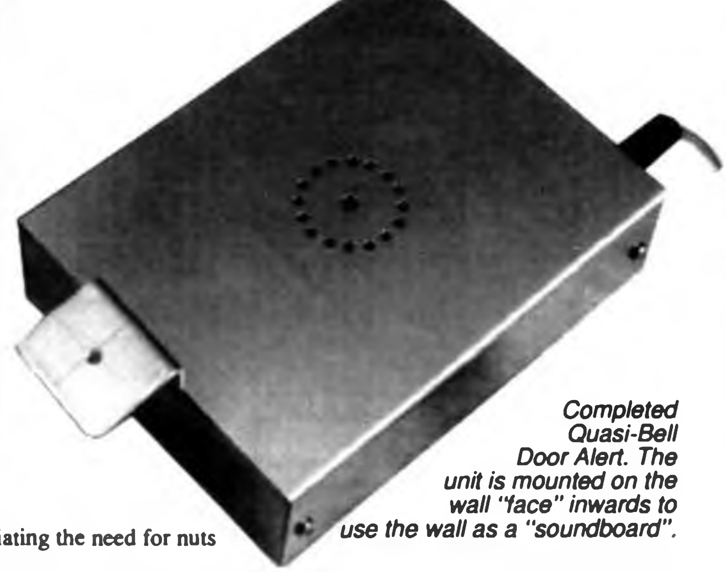


Fig. 4. Drilling and bending details for the wall-mounting fixing bracket.



Completed Quasi-Bell Door Alert. The unit is mounted on the wall "face" inwards to use the wall as a "soundboard".

In the off-state nothing approaching 0·6V will appear between transistor TR1 base and emitter. In consequence, the level at TR1 collector should be very low, no more than 0·2V. This measurement can be taken across resistor R2.

At this point reconnect the doorpush S5, via socket SK1. This action alone may well trigger the alarm; if not proceed to press S5.

If all is well the alarm sound will provide self evidence. After a nominal period of about five seconds the noise should be automatically silenced; proof that monstable IC4b, IC4d is doing its job.

Due to the momentary action of IC4, this can be by-passed, to aid fault diagnosis by applying a short across TR1 emitter to collector. Absence of ringing sound can mean that IC2 is unwell or capacitor C1 or resistor R1 values are inappropriate (as may be the case if only a long single tone is heard). The C1/R1 values shown in Fig. 2 give a moderate to fast loop time that renders the sound produced with a characteristic trill. Of course, if TR2 is reverse connected, sound will also not reach LS1.

INSTALLATION

The alarm can be fixed to a vertical wall using the fixing bracket shown in Fig. 4. This is designed to be clamped between the case halves, obviating the need for nuts and bolts.

Connect the battery, insert the bracket, screw the case halves together. The alarm need only be fixed to the wall by a single No. 8 wood screw and Rawlplug.

IN USE

As already touched upon, in construction, some discretion or experimentation can be exercised in the choice or loudspeaker LS1. It was found that certain discarded or surplus telephone handset receivers (earpieces) operate in this application with excellent earpiercing results.

This despite the fact that they are designed primarily for outputting low-level audio signals. The nominal impedance of these receivers is mostly in the range 100 ohms to 200 ohms, again making them ideal for this project.

A particular feature to note, and not a mistake, is the way the alarm is mounted so that sound is ejected straight into a wall surface. Experimentation demonstrated that the wall face acts like a "reflector", providing a dispersal effect that results in a more intense sound level than with the sound radiating into free space with no immediate obstructions.

Resistor R1 alters the tone loop speed. This resistor could be changed to a preset potentiometer or even an externally adjustable rotary potentiometer to allow speed variation to suit personal preference.

When a very quick loop speed is set, the Door Alert tends to exhibit sound effects properties. Some of the strange sounds emitted could well be mistaken for an alien spacecraft landing!

While varying fixed resistors R6 to R9 will alter tones more on an individual basis, a shift in fundamental or base frequency is attained by changing capacitor C3. A lower value will increase frequency; a higher value decrease.

Resistor R4 determines the input trigger sensitivity, so much so that if it is increased in value from 10 kilohm to, say 820 kilohm, the alarm can be triggered by a finger across p.c.b. pins P2 and P3. This is because the skin resistance acts with R4 to form a potential divider. When the voltage appearing at IC4d pin 2 falls to less than 30 per cent of the battery voltage capacitor C2 begins to charge while transistor TR1 turns the alarm on for the monostable pulse duration.

In practice, such a touch switch might be tricky to implement successfully; the Bell Alert will have you running for the door every time it rains! □

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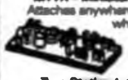
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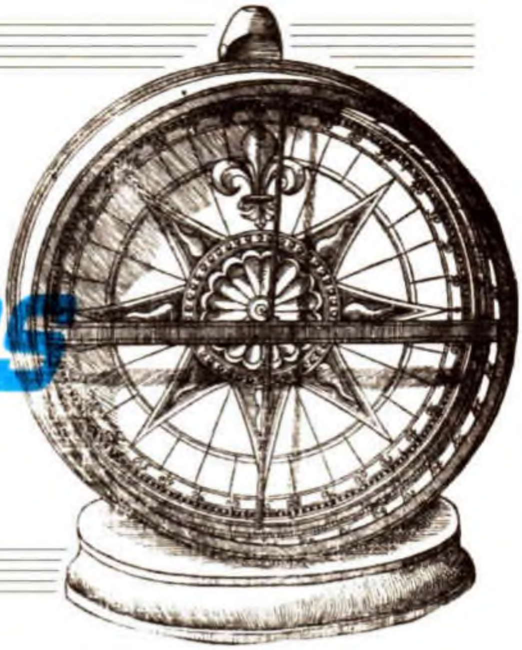


STEVE KNIGHT

Aristotle's philosophy held sway for 2,000 years but, once questioned, many experimenters then began to deduce the truth about electrical forces.

IN MY schooldays I often asked myself (and my teachers) the question "What is electricity?" As far as I can recall, I never received a satisfactory answer at that time, and to tell the truth I remain, fundamentally, none the wiser today.

This fact is of little importance. Nobody gave a definitive answer to my question (of the kind I was hopefully looking for) because there was no such answer and the whole question was about as silly and unanswerable as asking anyone for the length of a piece of string.

It would possibly have been of more value to me, and less frustrating to the teachers, if I had directed my enquiries to the *effects* electricity produces and to what practical purposes these effects might be put. Further, who were the men who discovered and investigated these effects and how did they set about it?

This seems the logical approach that no doubt "Mr Spock" would have approved of, because we can derive and obtain more useful applications from any branch of science by knowing the way it developed and *what it does* than we can by just asking *what it is*. This way, too, my own abiding interest in electrical science and its major offspring, electronics, might have got off to a less confused beginning.

But, to go back to other beginnings:

GREEK CONNECTION

I suppose the Greeks were the first to derive some very elementary knowledge about magnetism and frictional electricity. Thales, who lived about 600BC, observed that a piece of amber (the Greek word, for which is *elektron*) when rubbed with a piece of suitable material, attracted such things as small scraps of paper or straw, much as a plastic pen case, for example, when rubbed on the sleeve will do the same for us today.

These effects of "static electricity" must have been observed much earlier than the classical Greek period, of

Title illustration (above): The Dip Circle, from William Gilbert's De Magnete, *1600.*

course, but the Greeks were the first to make mention of it and to undertake some elementary studies of its effects. They were aware also of the magnetic properties of "loadstone", a naturally occurring ore. A piece of this ore, floated on water by means of corks, was in use early in the thirteenth century as a compass, though no one at that time knew why the compass always pointed in one direction.

It was, in fact, not until the end of the eighteenth century that progress was made beyond the observations of the Greeks. Across this vast range of time,

Magnetising an iron rod, as illustrated in William Gilbert's De Magnete, *1600.*

practically nothing of value had been established beyond the bare facts of electrification by friction and the basic attraction and repulsion effects of primitive magnets.

The Greeks never progressed very far in either of these subjects for the reason that the ideas evoked by these two phenomena were mingled in their minds with the fancies of magic. Thales asserted that both were possessed of "soul" and this kind of influence was typical of the ideas held by philosophers right through to the fifteenth century.

The lodestone, for example, was accused of inducing dejection and gloom in those who handled it; it reputedly had the ability to generate love potions (though the procedure for this has never been revealed); it supposedly lost its magnetism when rubbed with garlic and increased it when dipped in the blood of some unfortunate goat; and so on.

It is patently obvious that there could be little advancement in any meaningful study of electricity and magnetism under the yoke of such fanciful stuff as this. In schools and colleges today, with our organised scheme of things, integrated with experimental work in well equipped laboratories, the circumstances under which fifteenth century students encountered the subjects must seem very curious and inhibiting.

ARISTOTELIAN

The difficulties were almost entirely those brought about by the teachings of the Greek philosopher Aristotle who lived round about 350BC. In his discourses on *physics*, which is our concern here, and using the word in its widest sense, we find that Aristotle's pronouncements contain a remarkable mixture of good sense and what appears to us now as complete nonsense. The trouble with Aristotle's "science" was that he never checked by experiment anything he looked at and commented on.

Up to the sixteenth century, therefore, all college text books were almost entirely translations of Aristotle, some of them of doubtful quality; all the lectures given were Aristotelian in direction and any experimental approach to science was completely absent. Laboratories did not exist. When any problem arose, obtaining a solution became merely a matter of looking up what Aristotle had to say about it.

Nobody, as recorded, ever seemed to say "Well, let's try an experiment, if only to check what Aristotle says". If they did, they were soon made to understand that there was, against the ancient philosopher, no appeal or even the thought of an appeal.

We should not be too harsh on Aristotle, however, for he was one of the outstanding figures in antiquity; the fault must lie with those teachers who slavishly copied him without question.

So it is little wonder, that science in general and electricity and magnetism in particular, stayed static over the centuries, awaiting the appearance of someone who would break the chains of conformity and try things out for himself. One of the earliest men who saw to this was William Gilbert.

GILBERT - FATHER OF ELECTRICITY

William Gilbert, who lived from 1544 to 1603, was what we might call a "modern" scientist. He was known as the father of electricity; he was certainly the father of magnetic science and of the necessity of scientific verification by experimentation. In fact, he was probably one of the first men to break with the "head-in-the-sand" philosophy of the pure thinker. Not that there is anything wrong with being a thinker, but there have to be moments when the hand comes into use as well as the head.

It has to be kept in mind that up until Gilbert's time, all science workers were wrapped up under the general heading of "philosophy", and scientific subjects were themselves listed as "natural philosophy", not "science" or "physics".

Gilbert's claim to fame is found mainly in a treatise on magnetism called *De Magnete* which was published in 1600. Quite apart from the words of this treatise throwing a completely new light upon the mysteries of the magnetic lodestone, it placed a great emphasis on the necessity of an experimental approach to scientific enquiry. This much-needed appraisal of the experimental method, which was throughout the tract supported by Gilbert's own work, gives him a foremost place in scientific history.

When an argument or a statement can be studied by experiment and observation then, Gilbert said, its truth must stand or fall by the result of the experiment; and that this experiment must be repeated not once but many times over to make certain that all possible causes of error and mischance are eliminated.

As he himself put in the preface: "To the founding fathers of philosophy let due honour be given, for by their work wisdom has been handed down to posterity. But our age has unearthed many facts which they, were they with us now, would gladly have accepted. Therefore I have not hesitated to show by demonstration and theory those things which I have discovered by long experimentation and concern".

NOT ONLY AMBER

But Gilbert's work was not restricted to the mere rebuttal of statements made by others. Taking the case of frictional electricity as an example, he made extensive tests to demonstrate that the beloved amber of the Greeks was not the only substance which when rubbed attracted light-weight objects. Using a carefully balanced light-weight needle as the attracted object, he introduced it to various substances which had been rubbed with other materials such as silk and fur.

He found that some of these substances attracted the needle, such as glass, sealing wax, resin and sulphur, and he gave these the general name of "electrics". Other substances such as metals, wood and flint did not attract the needle and he called them "non-electrics".

Such a classification we now know to be a wrong one; but Gilbert knew nothing of the properties of electrical conductivity and insulation, or it would have occurred to him that those substances he referred to as non-electrics would in fact have acquired a static charge by rubbing, provided they were properly insulated from an earthed object such as the hand.

EARTH'S MAGNETISM

It was on the subject of magnetism that Gilbert made his most important contributions; this was his realisation that the loadstone behaved as it did because the earth itself was an enormous magnet. The mariner's compass made up, as most of us will have seen demonstrated, from a piece of lodestone floating on corks in water (clearly an erratic device in stormy weather) had been in use for several centuries, with no reason for its behaviour being advanced.

A further phenomenon had also been recorded about this time; when an iron needle was freely suspended about its centre of gravity so as to be able to rotate about a horizontal axis, it came to rest in a horizontal position whatever its orientation, rather as Fig. 1a shows.

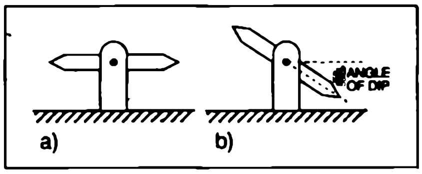


Fig. 1. Response of (a) non-magnetised and (b) magnetised needles to the earth's magnetic field.

When, however, the iron needle was magnetized by rubbing it with a piece of lodestone, it was found that if placed in line with north and south poles of the earth, it came to rest at an angle to the horizontal, this angle being known as the "magnetic dip", as shown in Fig. 1b.

It also soon became general knowledge that this magnetic dip depended upon the location of the needle upon the earth's surface, being zero in the region of the equator and tending towards ninety degrees as the polar regions were approached.

FUNDAMENTAL QUESTIONS

Gilbert pondered an explanation for these effects by asking the questions: is the earth a magnet? Could a magnet be of spherical shape, anyway? Experiment would provide an answer.

By fashioning an iron sphere and magnetizing it by rubbing it with lodestone, Gilbert found that not only did it behave as a spherical magnet, exhibiting magnetic poles as lodestone did, but also that, by bringing up a small carefully suspended magnetic needle, two observations could be made: one, the needle always came to rest with one of its poles pointing directly to the opposite pole of his sphere, and two, the suspended needle came to rest at various angles of dip with respect to the sphere, changing from ninety degrees at the poles to zero dip at the midway point (the equator) between the poles.

The significance of these observations was that the earth *did* behave as a giant magnet, with magnetic poles roughly coinciding with the geographical poles, and from his interpretation Gilbert concluded that an explanation of both the phenomenon of the compass and its dip had here been obtained.

Since like poles repelled and unlike poles attracted, a suspended magnet would clearly come to rest with its *north-seeking* pole pointing to the north magnetic pole of the earth. Gilbert went to great lengths to insist on the correct use of the terms *north-seeking* and *south-seeking*; even today we loosely say that the pole of a magnet marked with an *N* will point to the earth's north magnetic pole when the end of a magnet facing north must in reality be the opposite *south* pole, that is, unless we heed Gilbert's words and introduce the term *north-seeking* into our vocabulary.

Although Gilbert himself was unaware of the "shape" of the magnetic field around the earth (and his magnetized sphere) we can appreciate how, when the earth is considered as a bar magnet, the angle of dip indicates the direction of the force lines, as Fig. 2 indicates. Gilbert produced a device similar to this which he called a "Terrella".

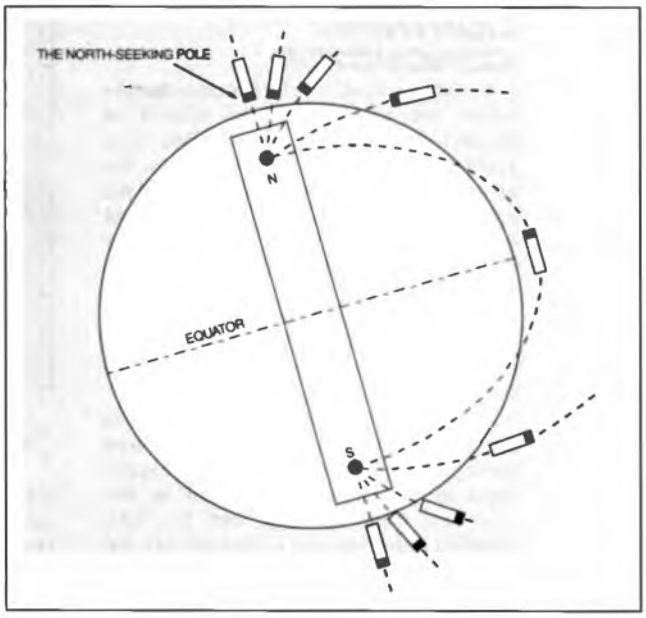


Fig. 2. How the earth's magnetic field is like that of a bar magnet and accounts for the magnetic dip.

So, by the logic of experiment, Gilbert swept away all the myth and superstition which had hitherto plagued the true explanation for the mariner's compass.

Until the introduction of the MKS (Metre-Kilogram-Second) system, Gilbert's name was honoured by being given to the electromagnetic unit of magnetomotive force.

Following Gilbert's example, other experimenters produced their own Terrelas; this one was made by G. Adams in about 1765.

ELECTRICAL CLASSIFICATION

So far as the study of electricity and magnetism after Gilbert went, the following century was one of progress in the development of electrostatics only. From what has been said above, Gilbert had classified substances as electrics and non-electrics, depending upon whether or not the substances were capable of being electrified by rubbing.

Two men turn up at this stage, who are not so popularly known as some who followed later on, like Faraday and Ampere, but who nevertheless contributed to the advancement of the science.

One of these was Stephen Gray, an English experimenter, who developed an accurate grouping of conductors and insulators. He also showed that the human body was a conductor by charging a lad after standing him on an appropriately insulated surface.

The other man was a Frenchman, Charles du Fay; he showed that Gilbert's classification was in error, since all bodies could be given an electrical charge.

Those substances which Gilbert had marked up as non-electrics were actually such good conductors that they were losing any charge placed on them as fast as they were receiving it. The problem of a substance holding a charge was simply a problem of providing insulation - from a true Gilbertian non-electric. Hence, a metal rod clasped in a rubber handle, for example, could be charged by friction just as readily as amber could.

Charles du Fay also demonstrated that electricity came in two "sorts" or "fluids", what we now know as "positive" and "negative" charges, but to which du Fay gave the names "vitreous" and "resinous". He noticed this by the attraction which came about between certain substances when rubbed, and the repulsion which occurred between others; and the way a charge could be neutralized by connecting it to "earth" or touching it with an equal and opposite charge.

Thus were the phenomena of electrostatic attraction, repulsion and neutralization established. The mathematical laws which determined the forces of attraction and repulsion had to wait until a later date.

DISCOVERING CAPACITANCE

Another little-known man now enters the fray. In 1746, a Dutch physicist named Pieter van Musschenbroek discovered by accident the principle of the capacitor in an assembly which was known as the *Leyden jar*. This was a glass jar, similar to our familiar wine fermenting varieties, to the inside and outside walls of which were glued sheets of metal foil, so that two plates were effectually placed on each side of a non-conducting material – what we now call the "dielectric".

The thing that Pieter was apparently trying to do was to electrify water contained in the jar. In this he was so successful that he received a powerful electric shock from the charged jar, afterwards confessing that he would not take the experience again "for all the kingdom of France". Many would-be modern experimenters have no doubt uttered words to the same effect when carelessly handling circuits and boards containing charged capacitors!

By contrast with Musschenbroek's words of wisdom, a story has passed into legend that a Professor Bose of Wittenberg "was ready to die by electric shock" so that his demise would provide an article for the immortal memoirs of the French Academy of Science!

The "jar" became the unit of capacitance for quite a long period. Now, of course, we use the Farad and its sub-multiples. For the record, $1\mu F$ equals 900 jars!

Human nature being what it is, the electrical discharge of the Leyden jar was soon utilized as a form of executive toy by itinerant fair ground showmen for the delight of the masses. Exhibitions were staged in which the discharge was passed through a line of hand-holding volunteers who seemed willing to experience this kind of thing; each member of the line gave a simultaneous twitch as the jar was discharged. Whether they all enjoyed it remains a matter of conjecture; by all accounts the ludicrous proceedings were thoroughly appreciated by the audience.

BENJAMIN FRANKLIN

Much of the progress which followed, particularly about the middle to late years of the eighteenth century, came from three men: an American, Benjamin Franklin; an Englishman, Henry Cavendish, and a Frenchman, Charles Coulomb.

Most of Franklin's work extended our knowledge of electrostatics. He first drew attention to the fact that discharge from a charged body took place more rapidly if the body had sharply pointed protuberances. He referred to this as "the marvellous effect of pointed bodies, both in drawing off and throwing out the electrical fluid".

At the same time he introduced his famous "one fluid" theory of electricity, replacing du Fay's "two fluid theory". According to Franklin, all bodies normally possess electricity and only display electrical characteristics when they acquire an excess of the "fluid", when they exhibit "positive" or "plus" charges.

When they lose some of the "fluid" to other bodies, they exhibit "negative" or "minus" charges. This theory, which on examination anticipated the possibility of a movement of electrical "fluid" (which we now call current electricity) from a positive to a negative condition, explained all the then known elementary features of static electricity and was generally accepted by scientists until the discovery of the electron replaced the "fluid" a hundred years later on.

Franklin devised his theory about positive and negative charges by noticing that if a glass rod was rubbed with silk and suspended from a thread, as Fig. 3 shows, then a second glass rod, similarly rubbed, when held close to the rubbed end of the first rod caused the rods to repel each other. On the other hand, an ebonite or hard rubber rod rubbed with fur attracted the suspended glass rod. Clearly, the charges on the glass and on the ebonite must be different in nature.

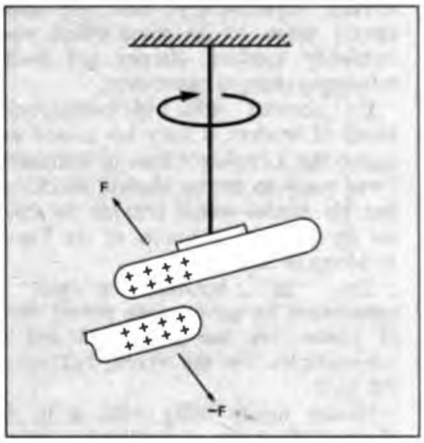


Fig. 3. Positively charged glass rods repel each other.

Franklin called the charge on the glass "positive" and that on the ebonite "negative". The result of his experiments can be summed up by saying that like charges repel and unlike charges attract, which was similar to the way magnetic poles behaved.

Franklin's choice of sign was, of course, quite arbitrary. We now know that materials in their normal or neutral state contain equal amounts of positive and negative charge, though (neglecting ionized gases and solutions) only one form of charge can move.

When two bodies are rubbed together, a small amount of this moveable charge is transferred from one to the other, upsetting the electrical neutrality of each. In Franklin's experiment the glass became positive and the silk negative; electrons moved from the glass to the silk.

LIGHTNING CONDUCTOR

Franklin's work on electrostatic charges turned his attention to the subject of thunder storms. These had hitherto been accepted as the explosion of gases in the upper atmosphere, but Franklin noticed the resemblances between lightning and the spark discharges of the Leyden jar. These similarities, he noted, were the production of light, a crack or noise accompanying the light, the haphazard direction of the spark and its swift motion through the air, and its ability to shock the bodies of humans and animals.

Experimenting on this, he flew a kite connected to his hand by a thin metal wire during a thunderstorm. Such an experiment as this could have ended in disaster for both Franklin and his kite; Franklin, however, had a charmed life and demonstrated that electrical discharges in the form of sparks were obtained between the end of the wire and a key he held in his other hand. Thunderstorms were therefore electrical phenomena.

Combined with the knowledge that pointed objects emit a charge "leakage", the thunderstorm adventure soon led to the introduction of lightning conductors on high buildings and steeples. It should be appreciated in this context that the so-called lightning conductor (an erroneous name) is not placed where it is to attract lightning; that would be defeating its purpose which is protecting the property. The atmospheric electrical charge is actually neutralized in a gradual manner by the presence of the upturned points of the conductor and so the chance of a violent discharge is greatly diminished.

CAVENDISH

As a result of Franklin's experiments into electrical charge, the way was paved for giving the subject a proper quantitative footing. At about the same time as Franklin was trying to commit suicide, a great deal of work was being done in this field by Henry Cavendish in England and Charles Coulomb in France.

Cavendish carried out investigations into the subject of the capacity of isolated bodies and parallel plate assemblies representing the Leyden jar form of capacitor in a different and more convenient shape, and came close in the process to anticipating Ohm's law.

COULOMB'S LAW

For his part, Coulomb was the first to measure the forces of attraction and repulsion between charged bodies in mathematical terms and deduce the law that covered these forces. His apparatus is shown in a skeleton form in Fig. 4. This resembles the hanging rod in Fig. 3, except that the charges are confined to small spheres *a* and *b*.

If these spheres are charged, then the force either of attraction or repulsion will cause *b* to move towards or away from *a* respectively and the thin fibre thread (or ribbon) will be twisted from its initial or neutral position.

By having a calibrated restoring head at the top of the fibre, Coulomb brought sphere *b* back to its initial position with respect to *a*. The angle θ through which

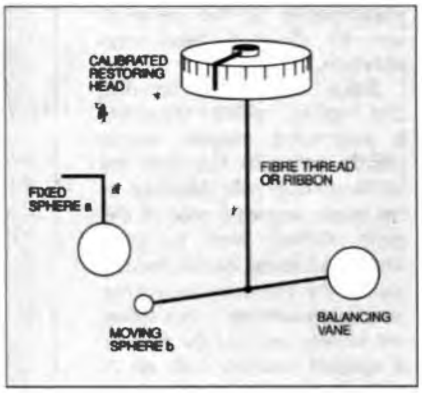


Fig. 4. Basic constructional features of a Torsion Balance.

the head was turned was then a relative measure of the electric force acting between the spheres. This apparatus is known as a *Torsion Balance* and this kind of instrument was used by many other workers in a variety of investigations, notably as we shall see, by Simon Ohm.

Coulomb found that the force between the charged spheres could be expressed as being inversely proportional to the square of the distance between the charges, that is, $F \propto 1/r^2$ where r is the spacing.

Coulomb also studied how the force varied with the relative strengths of the charges on each of the spheres; he found that the expression for the force now became $F \propto Q_1Q_2/r^2$ where Q_1 and Q_2 are the relative measures of the charges on spheres *a* and *b*.

This relationship is known as Coulomb's law; it holds strictly only if the spheres have very small diameters and the spacing between them is very much greater than these diameters.

In honour of his work, the SI unit of charge is called the Coulomb, and one coulomb of charge passes through a circuit when a current of one ampere flows for one second.

PART TWO

In Part Two of this short history, next month, we will turn to current electricity and meet up with the invention of the galvanic battery and see how the science of electro-magnetism came into being through the researches of Andre Marie Ampere, the great French experimenter, whose portrait is shown below.

AKNOWLEDGEMENT

The illustrations used in this article have been kindly supplied by the Science Museum, London.

READOUT

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

TRANSPARENCIES

Dear EPE

I'm puzzled by your reference to "transparentising sprays" in *Build Your Own Projects Part 3*, Jan '97. Surely the toner side of the transparentised copy should be in contact with the board, but which would result in a mirror image being printed onto the p.c.b. material? If it is the other way up, the thickness of the paper will be between the image and the board, with a good chance that the image will be less than sharp.

B. J. Taylor, Rickmansworth

You are correct in every respect, and you will not get an image that is as sharp as the original. The system is satisfactory, though, to readers who recognise the limitations and are prepared to do a bit of "doctoring" to the p.c.b. once the image has been etched. The technique may sometimes result in very thin tracks being etched away and other tracks blending in with each other if they are too close together, requiring hardwiring between the affected sections, or scraping with a knife.

Obviously, discretion and experience must be used in choosing which published layouts are suitable to the process. The ideal solution to obtaining first-class p.c.b.s is to buy them ready-made from the EPE PCB Service. *Nonetheless, some readers like to do things for themselves (full marks to them!) and are content to have to fiddle a bit with the final result.*

Where the process can come into its own is with genuine design prototyping work. For many years I always used to set up a plate camera in front of the taped-up double-size p.c.b. artwork, created on transparent acetate from the component side viewpoint. In conjunction with a photographic enlarger, a life-size litho-film image was produced, from which the p.c.b. was then made in the conventional photosensitised way. Then I heard about ISO-Draft transparentiser, and tried it.

A life-size photocopy of the double-sized artwork was made (which was the correct way round because of the way it had been taped), and then sprayed. The image was placed toner-side down onto the p.c.b. and exposed as before, though at a much longer exposure time (typically five minutes instead of about 30 seconds). I was sufficiently impressed to be still using this technique many years later, despite the occasional need to "clean up" the etched p.c.b. It has since been discovered that WD40 achieves similar acceptable transparentising results.

Since going over to using a p.c.b. design package on a PC, the dot-matrix printed image (correctly orientated) is first photocopied onto normal paper, and I continue to use transparentising for all *my prototypes, including those with 10-thou tracks going between i.c. pins. The photocopy stage has to be used since the tranparentising spray makes the dot-matrix print "run".*

The secret to using the technique acceptably is to obtain a good black image without the white areas being degraded (becoming grey), and then to expose for an optimum period which has been previously established using the test-strip method. Fresh developing solution is also a pre-requisite to good imaging. Incidentally, I find that Farnell's photosensitised boards require much longer exposures than those from RS Components (Electromail), typically three times as long.

JB

BOARD DRILL

Dear EPE

I recently bought a set of p.c.b.s from you and successfully assembled most of the components, until I came to the preset potentiometers. Their legs would not go into the holes. Using a sharp point tool I attempted to prise open the holes to make the legs fit; this eventually worked but I found that I had damaged the solder pads irreparably. Link wires had to be used to cure the situation. Could you not supply your boards with all the holes drilled to the right sizes for each component?

Anonymous phone call

In a strictly-controlled component-source environment, p.c.b.s are drilled to suit the components they are required to take. Regrettably, absolute standardisation of component lead diameters is not practised by the various component manufacturers; indeed, it never can be since some components are designed for use in different situations, with some situations demanding heavier-duty leads than others.

For the hobbyist constructor, the problem is more significant than for an equipment manufacturer. The latter can specify which component sizes are required for specific applications and have the p.c.b.s. drilled accordingly. The hobbyist, though, usually buys components from the most convenient or inexpensive retail source. Each source will possibly have bought in components from different manufacturers, again according to convenience or pricing imperatives. Furthermore, the retailer may well change manufacturing sources, depending on availability of supply, and special offers etc. It is obviously impossible, therefore, for us to specify to our p.c.b. manufacturer what hole sizes should be drilled to allow for each component's lead size; readers will be buying components having different sizes.

We cannot specify a single source for components since this would alienate all advertisers except the chosen one. Nor can we tell the p.c.b. manufacturer to drill all holes large enough to accept all possible component variations; drilling i.c. pads at 1·3mm instead of 0·8mm could cause severe breaks in adjacent tracks. The best he can do is standardise on a minimum size, typically 0·8mm, and expect the reader to drill out any holes which need a larger diameter. Frankly, though, it is the exception when this needs to be done. Nearly all small components, resistors, capacitors, transistors, i.c.s, many preset pots, etc. will fit into 0·8mm holes. The principal exceptions are 1mm terminal pins (needing a 1·0mm hole!) and some presets, notably the open carbon ones which need 1·3mm holes. Bridge rectifiers, resistors of 1W or greater and large electrolytic capacitors are also exceptions.

It is never advisable to use the wrong tool to do a job (although we all do it from time to time). To increase the size of a hole to suit the components you have, the correct drill bit should be used. Battery operated handheld drills designed for p.c.b. work are readily and cheaply available. They should be regarded as an essential workshop tool, together with a selection of drill bits, including sizes 0·8mm, 1·0mm and 1·3mm.

If you don't have a drill and are faced with a hole size problem, you have two other options open to you. If the existing holes are 0·8mm, insert resistor cut-off wires into them and solder the component to them. If the holes are 1·0mm, insert 1mm terminal pins to which the component can be readily soldered. The same principle can be used if the component's leads are wider apart than the p.c.b. has allowed for. Never try to brutalise a hole to make a component fit.

JB

CURRENT SHORTS

Dear EPE

I have taken your magazine ever since it was first published as *Everyday Electronics* over 25 years ago. Even after all this time, though, I still consider myself to be very much an amateur and simply use electronics as a hobby.

What I have greatly missed over the last few years, however, is the wealth of really simple projects which you used to publish in the early days. Even those projects which you now describe as "simple" are much more complex than those which I used to enjoy. Surely there must be many potential electronic enthusiasts who would be persuaded to join your readership if only some of the projects could be built with a *really* minimum of components, expense and time? Not all of us want to spend time and money on the type of sophisticated projects you currently seem to be publishing. A regular selection of simple gadget circuits would be nice to tinker with again.

P. Price, Doncaster

Food for thought, indeed! Yet, we recall that in those distant days, most designs were based on transistors and it was not feasible to do a great deal more with a handful of transistors than come up with circuits whose function was of a simple nature.

Are we really mistaken in feeling that with the ready availability of i.c.s which incorporate functions you could only dream of twenty-odd years ago, that we should not take advantage of their capabilities and share their varied and ingenious applications with you all. Do some of you want *to return to simplistic basics, preferring to dabble with less-than-optimum ways of doing things? If you do, then let us know.*

We will be publishing some relatively inexpensive, easy to build projects over the coming months. But we have no intention of dispensing with sophistication, using state-of-the art i.c.s where appropriate in some of our designs, but perhaps we could mingle them with a few very *simple circuits to build if enough of you would welcome it. Interestingly, our recent survey indicated that most readers think our projects are at the right degree of simplicity/complexity and price. But, it must be acknowledged, this may not be surprising since only readers who like* EPE *as it is will have responded to the survey. We admit that the opinions of* non-readers, *who may be potential electronics enthusiasts but view* EPE *differently, were not sought.*

We would be interested to hear what your opinions are on this subject. And, if you know of anyone who would be glad to become regular reader if only more very simple projects were to be published on a frequent basis, tell us their opinion too. We have designs on pleasing you!

JB

Special Feature

TYPE 7660 VOLTAGE CONVERTERS

ANDY FLIND

With a little ingenuity, negative supplies, voltage doubling and simple alarm circuits are possible with these low-cost chips.

THE RECENT use of a type 7660 voltage converter as a voltage doubler in a circuit design led to queries about its operation, which in turn prompted the idea for a more comprehensive description of this i.c. and some of the uses to which it can be put. In general it is a very simple device requiring few external components for operation. The SI7660 is taken as a readily available example.

It is ideal for battery-powered designs since it can work with supply voltages from 1·5V to 10V and draws a quiescent current of "micro-power" proportions. This is usually quoted as being about 170μA, but several examples tested drew less than half of this. At low output currents the voltage conversion is very efficient, often in excess of 90 per cent.

FLYING CAPACITORS

The intended application for the 7660 is for provision of an auxiliary negative supply for devices such as op.amps which require dual supplies, by generating this from the single 5V positive supply often found in digital systems. To do this it uses a method sometimes referred to as a "flying capacitor" circuit.

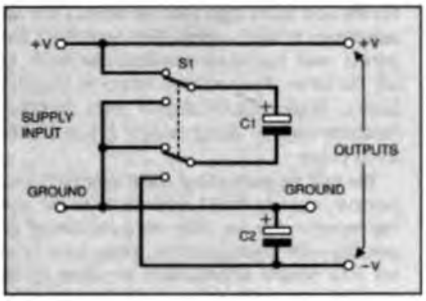


Fig. 1. Principle of "flying capacitor" voltage converter circuit.

This is shown in its simplest form in Fig. 1, with the two-pole changeover switch S1 alternately connecting capacitor C1 across the incoming supply and the output capacitor C2. Whilst the switch poles are in the position shown, C1 charges to the supply voltage. When they change to the opposite position, C1 dumps some of the charge into capacitor C2, thereby creating the additional *negative* supply rail.

For successful operation the switching action must be rapid and continuous so the "switches" must in fact be electronic devices. MOSFETS, with their high speed and low "on" resistances, are ideal.

INTERNAL STRUCTURE

A simplified block diagram of the internal structure of the device is shown in Fig. 2. It contains an oscillator which operates at a nominal frequency of 10kHz, although this can be externally altered through the "oscillator" connection (pin 7). This is followed by a divider stage to ensure a 50:50 ratio drive waveform. These two sections have an internal voltage regulator to reduce the supply voltage to them slightly, but with low supply voltages this should be disabled through the "LV" connection (pin 6).

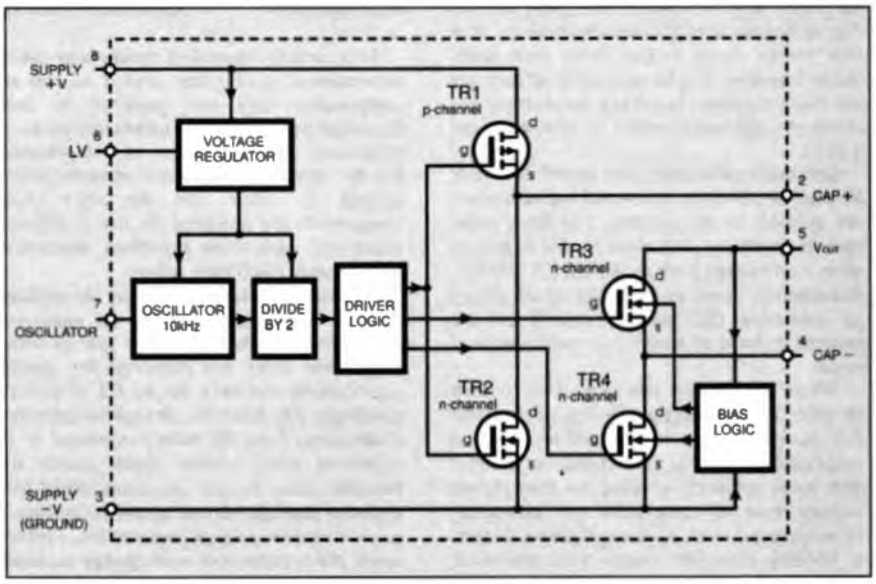


Fig. 2. Simplified block diagram of the internal structure that goes to make up the type 7660 voltage converter chip.

Logic is then used to provide drives to the four output switching transistors TR1 to TR4, configuring them for use in the "flying capacitor" circuit described earlier. When used this way, unacceptable voltage levels might appear across the gates of TR3 and TR4, so "bias logic" is provided within the i.c. to ensure that the gate junctions are always correctly biased.

PINOUTS

A descriptive tour of the eight pins of the d.i.l. version of the i.c. will be useful to anyone wishing to use it in their own designs. Pin 1 is simple to describe as it is not used! Pin 2 is for the positive end of the "flying capacitor", but a glance at Fig. 2 will show that it is connected to the junction of the internal transistors TR1 and TR2, a point which alternates between the positive supply voltage and ground at half the oscillator frequency, nominally about 5kHz. These two transistors can provide a reasonable amount of current, certainly to beyond 50mA without too great a voltage drop across them, making this output useful for driving "charge-pump" circuits and even loudspeakers in simple alarm systems.

Pin 3 is the supply "ground" or negative input, and is also "ground" for the auxiliary negative output if the i.c. is used to generate this. Pin 4 is intended for the other end of the "flying capacitor" and goes to the junction of TR3 and TR4.

When used in this way the output is taken from pin 5. When not used, as in a "charge pump" circuit, pin 5 should be grounded. For supply voltages below 3·5V the "LV" connection, pin 6, should be grounded to disable the internal regulator.

OSCILLATOR

The oscillator (pin 7) is of the *RC* type, with the resistor and capacitor both provided within the i.c. The value of *C* is necessarily very small and that of *R* correspondingly large, so the external connection through pin 7 should be treated as a high impedance point. Any connections made to it should be designed in a way that will minimise stray capacitance or interference pickup.

It can be used for reducing the oscillator frequency by connecting an external capacitor from it to ground. A 100pF capacitor will reduce the frequency at pin 2 from 5kHz to about 500Hz. Alternatively, it can be forced to run at an externally generated frequency by driving this pin, the high impedance allowing direct drive from a single CMOS gate output.

It is also possible to control the oscillator through pin 7, stopping it by pulling it to either supply rail. When stopped in this way the quiescent current drain drops to only a couple of microamps. The collector of an external transistor is useful for this as wiring to it can be kept short to prevent adverse effects upon performance. Pin 8 is the positive supply input, with an acceptable range of 1·5V to 10V.

NEGATIVE RESPONSE

The SI7660 can be used in several ways. The simplest is as an auxiliary Negative Rail Generator, as shown in Fig. 3.

Two requirements should be observed with this circuit, both related to supply voltage. For voltage supplies below 3·5V pin 5 should be "grounded" to negative supply. For supplies above 6·5V, diode D1 should be added. Both these modifications are shown as dashed lines.

The output is normally stated as being similar to a perfect voltage source in series with a resistance of 70 ohms, so with a 5V supply a drain of 10mA would result in a "minus" voltage of −4·3V. Many modern op.amps actually draw much less.

Application notes for the SI7660 point out that devices can be connected in parallel for increased current, though this would cancel out the benefit of simplicity and low cost to some extent. Where the diode D1 is used, this will add an additional voltage drop of about 0·6V.

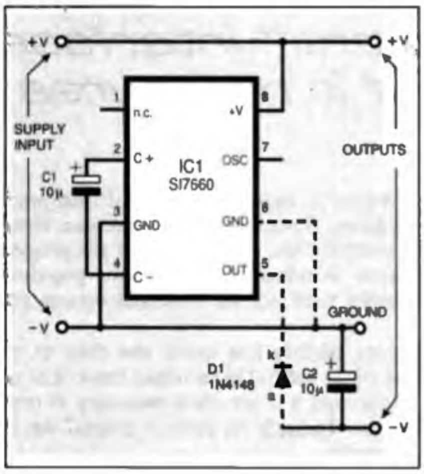


Fig. 3. Basic Negative Rail Generator circuit.

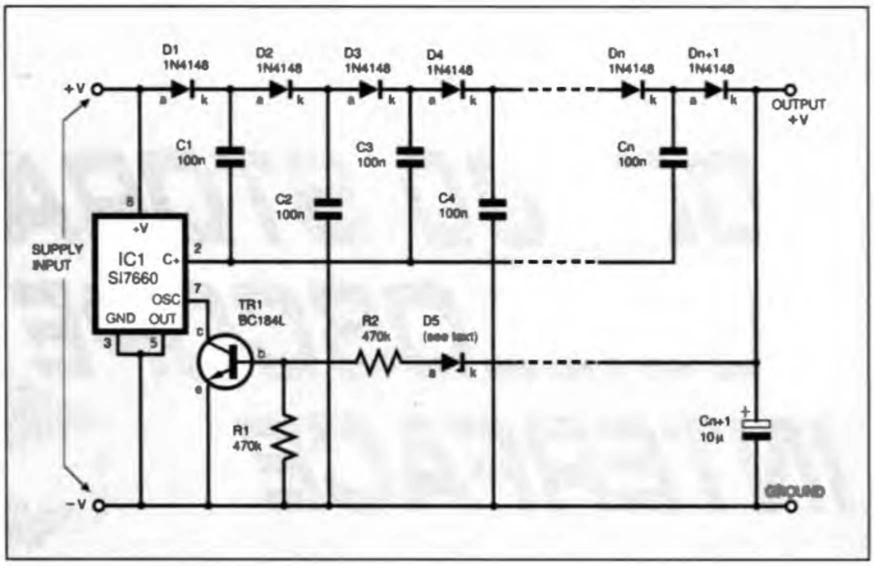


Fig. 5. Circuit diagram for a Regulated Voltage Multiplier using the SI7660.

VOLTAGE DOUBLER

The next application shown is a Voltage Doubler, using the "charge pump" principle as shown in Fig. 4. The output drive from pin 2 is used on its own here, through capacitor C1, to alternately draw current in through diode D1 and push it out through D2 into C2, increasing the voltage across this capacitor to nearly twice the supply.

A drop of about a volt will be present due to the two diodes. Note that pin 5 is grounded in this circuit.

With a 10V supply a test circuit provided around 10mA at 17·9V and 20mA at 17·5V, a drop from the no-load value of less than 10 per cent. In fact, it still produced nearly 16V at 50mA.

VOLTAGE MULTIPLIER

A development of the voltage doubler is a Voltage Multiplier circuit, Fig. 5. This consists simply of more pairs of diodes and capacitors, each pair adding roughly the supply voltage less two diode drops (1·2V) to the total.

This is best suited to applications where tiny currents of only a few microamps are drawn but a reasonably high voltage is needed. Example applications might be detecting the closing of contacts liable to oxidation, or medical applications such as TENS, etc. Most of the capacitors can then be small, cheap ceramic types.

The multiplier circuit diagram shown in Fig. 5 also includes simple voltage regulation. Sufficient stages are provided to ensure that the target voltage will be reached at the lowest expected supply voltage, such as 6V or 7V if the power is to be from a 9V battery.

Zener diode D5 has a voltage of about the required output, though the low operating current may call for a little trial and error here. In operation, as soon as the intended output voltage is reached the Zener starts to conduct. Current from it turns on transistor TR1 and the collector (c) stops the oscillator by pulling it to ground.

The quiescent current drawn by the circuit will be little more than that needed to maintain sufficient collector current through TR1, and although in terms of supply current this is multiplied by the number of stages in the diode and capacitor chain, for an output as high as 50V it should still be far less than 1mA.

ALARM SIREN

The last circuit shown, in Fig. 6, is an Audio Generator for an alarm system. Capacitor C1 reduces the output frequency of pin 2 to about 1kHz and transistor TR1 controls the circuit. A positive voltage applied to resistor R3 turns on TR1 which then stops the oscillator.

With a small 8-ohm loudspeaker this simple circuit is capable of making a lot of noise, ideal for simple alarm applications. The volume can be set to the preferred value by adjusting the value of resistor R1.

These simple circuits should provide some idea of the versatility of the SI7660 device, and perhaps suggest further possibilities to designers. In some situations the low power output capability may be a disadvantage.

The ICL7660, LMC7660 and TC7660 are equivalent devices. The type 7661 is a pin-compatible version designed for operation with supplies of up to 20V, with increased current output in the negative rail generation mode of 20mA, and may be worth considering in some cases.

Another possible alternative is the Maxim MAX665. Intended for use with supplies of 1·5V to 8V, this can supply up to 100mA with a much smaller voltage drop from the unloaded value. The main disadvantage of this device at present is cost; at around £7 for a one-off it is expensive, though this may well improve in time.

Meanwhile, it is hoped that this article will inspire some interesting and creative solutions for readers' design problems. □

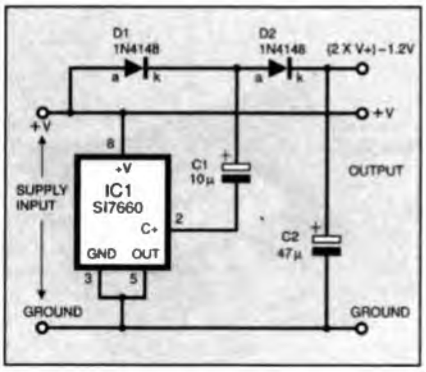


Fig. 4. Circuit for a Voltage Doubler.

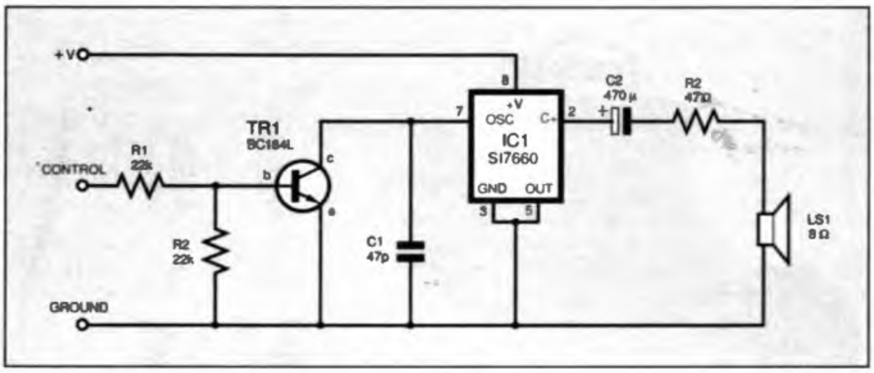


Fig. 6. Using the SI7660 in a simple Alarm Siren circuit.

ADC200 STORAGE OSCILLOSCOPE INTERFACE

ROBERT PENFOLD

Putting Pico's PC "virtual instrument" interface module through its paces to see if it measures up to its claims.

AN EARLIER review in *EPE* covered the Velleman PCS32 twin-channel digital storage oscilloscope interface for PCs. The unit described here is a broadly similar device which converts a suitable PC into (amongst other things) a virtual 2-channel Storage Oscilloscope. Like the PCS32 it can also operate as a Spectrum Analyser.

The Picoscope ADC200 can additionally operate as a Frequency Meter and an A.C./D.C. Voltmeter. As an A.C. Voltmeter it can provide readings in either r.m.s. volts or decibels. Using the Windows version of the software it will provide all these functions simultaneously!

Virtually Virtual

The hardware is a neat box which has sockets for the mains adaptor and the computer lead at the rear. The unit can operate with printer port one or port two using the lead supplied.

On the front panel there is an indicator light which switches on while sampling is in progress, and BNC input sockets for channel A, channel B, and an external synchronisation signal. The only controls on the hardware are the a.c./d.c. coupling switches for the two channels.

Windows and MS/DOS versions of the software are provided. If you have a relatively simple PC it might be necessary to run the MS/DOS version, but otherwise the Windows program is the better option.

It is the Windows software that we will consider here, but the MS/DOS program offers the same basic features. The MS/DOS software has a relatively crude user interface though, and is a bit cumbersome to use. Installation from the single 3·5 inch floppy disk is quite straightforward, and it is just a matter of running the installation program from Program Manager (or the "Run" option from the "Start" button in Windows 95).

The software implements a rather less virtual instrument approach than some systems. There are few on-screen virtual controls, and no fancy control dials, etc. Control of the program is largely in conventional Windows fashion, with pop-down menus and tool-bars being used set the required sweep rate, sensitivity, etc.

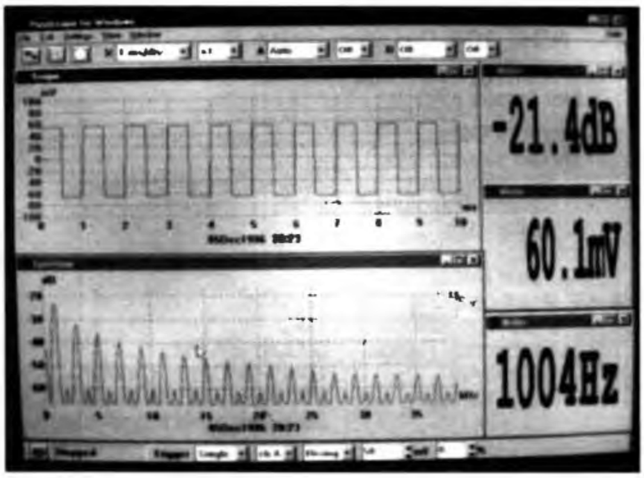
This makes the program slightly less quick and easy to use, especially when you first try to use it. On the other hand, it is still quite straightforward to use, and it is not often necessary to resort to the on-line help screens. There is no printed manual for the Windows software incidentally.

An advantage of not adopting virtual controls is that the vast majority of the screen is available for displaying data. With some form of SVGA screen it is possible to have three or four functions running simultaneously and visible on the screen. When used in this way the oscilloscope and spectrum analyser programs still produce decent sized displays that are detailed and easy to interpret.

Tremendous Scope

Probably most purchasers of the ADC200 will buy it first and foremost as a Dual-Channel Digital Storage Oscilloscope. The ADC200-20 received for review has a maximum sampling rate of 20MHz, but a 50MHz version is also available.

The ADC200 has two fully independent channels, and the sampling rate therefore remains at 20MHz when both channels are used. The software offers "chop" and "alternate" dual channel modes, but with the ADC200 these both give normal two channel operation. With the 50MHz version the sampling rate is halved to 25MHz for dual channel operation. Apparently two 25MHz ADCs work in tandem to give a 50MHz bandwidth, or independently to provide two channels having a bandwidth of 25MHz.



It's all go! The left section of the screen shows a 1kHz waveform (top) and its spectrum analysis. The right hand section shows the signal level in dB and millivolts and the input frequency. All three can be active simultaneously.

Bear in mind that the bandwidth is much less than the sampling rate. The bandwidth of the 20MHz version is sufficient to handle PAL video signals. Vertical shift controls are provided in the form of scroll-bars. In the dual channel mode these enable the two traces to be separated. The scroll-bars seem to be a bit "flashy" at times, but nevertheless worked reliably.

"The Oscilloscope software provides excellent results, with a large clear display."

The timebase can be switched from 100ns per division to 50s per division using the usual 1 - 2 - 5 - 10 sequence. The sensitivity can be set automatically, and is set separately for the two channels in a dual trace mode.

It runs from plus and minus 50mV (10mV per division) to plus and minus 20 volts (four volts per division). Again the normal 1 - 2 - 5 - 10 sequence is used.

There is 8K of memory per channel, which gives far more samples than can be displayed on a normal Windows screen. A magnification facility enables part of the waveform to be viewed so that it can be examined in detail. The standard Windows scroll-bar enables the desired part of the waveform to be selected.

The zoom factor can be switched from one to 200. Of course, at high sweep speeds the sampling rate limits the resolution to a level that prevents meaningful magnification of the trace. When I tried to use the magnification feature at a sweep rate of 100ns per division the program crashed! However this bug has subsequently been fixed, and should not present a problem in the software supplied to customers.

Trigger Points

There is a useful facility which enables the trigger point to be shifted from the beginning of the trace to a specified point further along. In other words, you can view the waveform prior to the trigger point as well as after it. Triggering can be on the rising or falling edge, and the modes available are single, repeated, automatic, or none.

Trigger voltage can be set at any sensible figure, and can be a positive or a negative voltage. Triggering can be via channel A, channel B, or the external synchronisation socket. In fact this aspect of the system is very comprehensive, and seems to work quite well even on slow waveforms.

The oscilloscope software provides excellent results, with a large and clear display. Being a storage oscilloscope it is ideal for catching fleeting events, but is less good for repetitive triggering.

Storage oscilloscopes operate on the basis of taking in a full set of samples and then updating the display. This can give rather "flickery" results, but the Picoscope is generally very good in this respect, and gave very smooth results when used with a 75MHz Pentium PC. For sweeps of more than one second in duration the trace is drawn as samples are taken, which gives totally flicker-free results.

"The meter facilities are more than just afterthoughts, and are useful instruments in their own right."

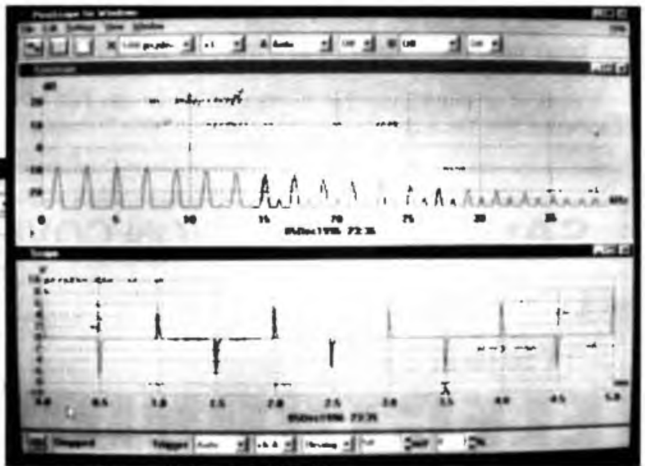
An interesting feature of the Picoscope is its ability to accumulate traces on the screen so that it is easy to spot changes in the waveform. This feature has a couple of slight weaknesses in that it only seems to work with sweep durations of less than one second, and the accumulated waveforms are erased if the Y scaling is changed by the automatic sensitivity circuit. It is better to set the sensitivity manually when using this mode.

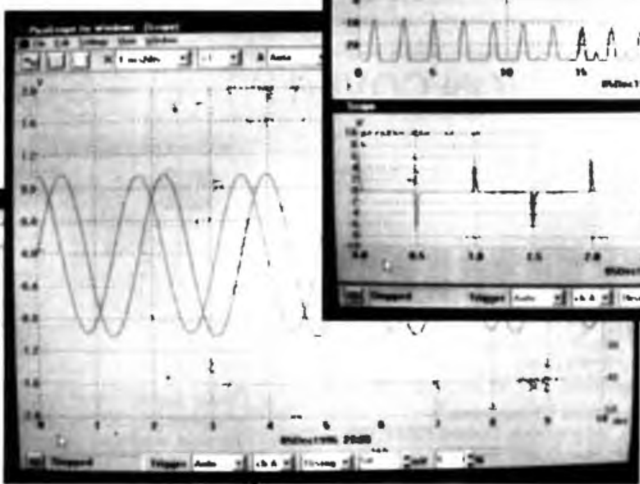
Analysis

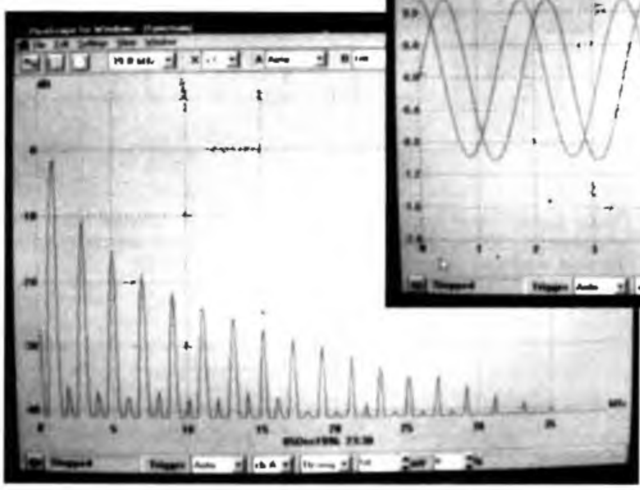
The Spectrum Analyser function can operate with a range of maximum frequencies from 610Hz to 10MHz. In many ways this program is similar to the oscilloscope software, and it has the same trigger options for example. Horizontal (frequency) scaling is linear or logarithmic, and the vertical scaling is in decibels or volts.

The frequency components present in the input signal are determined by mathematic analysis of the stored sample. This process is known as fast fourier transformation, or FFT. The eight-bit resolution of the hardware limits the dynamic range to about 40dB or so, but this is sufficient for most purposes.

Results on test signals were much as expected, and the spectrum analyser software seems to work very well at audio frequencies. At higher frequencies the 20MHz sampling







(Above). A pulse waveform (bottom) and its spectrum analysis (top). Control of the program is via pull-down menus plus some on-screen controls.

(Above). A dual trace display showing direct and phase-shifted sinewaves. There are no Y shift controls, but the traces are different colours.

(Left). Any of the program will expand to fill the screen properly.

frequencies limits the accuracy of results. The frequencies of strong components are still shown quite accurately, but the weaker components seem to become overlooked.

The meter function provides a simple on-screen digital display. "Jumbo" size digits are displayed if a large window is used, which could be useful for classroom demonstrations. For voltage measurement there are d.c. and a.c. ranges, and for a.c. voltage measurement there is the option of a decibel display. Although on the face of it the eight-bit resolution limits the dynamic range to about 46dB, the automatic ranging increases the dynamic range considerably.

Using the decibel scaling of the a.c. voltmeter, it kept accurately in step with the attenuator of my signal generator from +10 to −60dB. With a voltage readout the full scale values run from 50 millivolts to 20 volts, with manual or automatic scaling.

Although the frequency meter did not keep precisely in step with my d.f.m., it was always very close. It will certainly provide far more accurate results than can be calculated from the duration of one cycle measured from the oscilloscope display. The meter facilities are more than just afterthoughts, and are useful instruments in their own right.

"If it was a case of 'money is no object' I would certainly opt for the Picoscope"

There are the usual facilities for saving results, and printing them to any Windows compatible printer. Export facilities are limited, but screen dumps can be saved to the "clipboard", and there are some facilities for exporting data to spreadsheets, or graphs to a wordprocessor.

The external synchronisation socket can be used as the output of a simple signal generator facility. The signal is only produced during sweeps, and only a squarewave output signal is available (degrading to a triangular waveform at very high output frequencies).

Final Analysis

The Picoscope ADC200 is very capable system, providing the user with a Dual-Channel Storage Oscilloscope, Digital A.C./D.C. Voltmeter and Millivoltmeter with linear or decibel scaling, Digital Frequency Meter, and Spectrum Analyser. It may not offer the ultimate in performance in any of these guises, but its degree of precision is more than adequate for most purposes.

The lack of full printed manuals is a slight drawback, and there seem to be one or two omissions in the on-line help. However, the software is fairly simple to master provided you already understand the basics of oscilloscopes, spectrum analysis, etc. Those with a limited knowledge of test gear techniques will need to "brush up" on the subject before trying to use any system of this ilk.

I think it is fair to say that in comparison to the PCS32 the Picoscope has the superior software, however, the Picoscope is more expensive and no kit version is available. The Picoscope software is not quite as easy to use as the Velleman software with its virtual controls, but the Picoscope program gives increased screen area for the Oscilloscope and Spectrum Analyser displays.

Also, the Picoscope has proper metering facilities which work very well, and it generally seems to provide somewhat more precise results. If it was a case of "money is no object" I would certainly opt for the Picoscope.

ADC 200 Oscilloscope Specification

Minimum system requirements
Not stated

Technical Data

Digital storage	
Sampling Rate	20MHz (two channels)
Vertical Resolution	8-bits
Buffer size	2 x 8K
Vertical Deflection	
Input coupling	A.C./D.C.
Input Impedance	1M
Frequency Range	D.C. to 10MHz
Sensitivity	10mV to 4V per division
Input Voltage	20V max (D.C. or peak A.C., 5V on external trigger input)
Horizontal Deflection	
Timebase	100ns to 50s per division
Triggering	
Trigger mode	single, repeat, auto, none, delayed
Slope	positive or negative going
Level	fully adjustable
Trigger	channel A, channel B, external

PRICE

The ADC200 is available in two versions (20MHz or 50MHz), supplied with cables, power supply and Windows and MS/DOS instructions software:

ADC 200-20 **£421.82**
ADC 200-50 **£586.32**

These prices include VAT – UK post & packing charge £3·50. For export add £9 for carriage and insurance.

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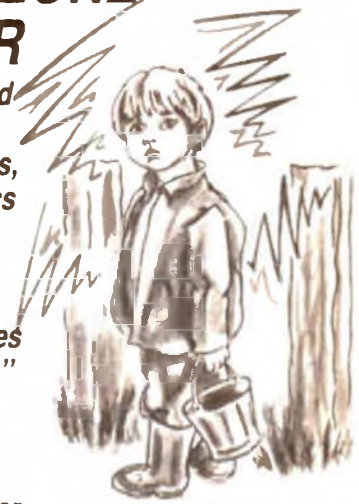

Electronics seems to be used in an ever increasing array of electronic security devices, and this sphere of electronics now covers a lot more than simple intruder alarms. The system featured is an example of what is sometimes termed an electronic "fence." This name is not a strictly accurate one, since equipment of this type does not provide any sort of barrier. It simply activates an alarm if someone, or something, goes outside the area encompassed by the notional "fence." The project consists of a transmitter and a portable receiver. The receiver produces an audio alarm if it goes outside the area covered by the transmitter.

No doubt there are many potential uses for equipment of this type, but the Electronic Zone was primarily designed to give warning if a toddler starts to wander too far away from the designated play area.

PYROTECHNIC CONTROLLER

The use of stage flashes for effect has increased in recent years. Once, it was strictly the domain of professional theatre companies. Now, it is not unusual for stage pyrotechnics to be used in the local pantomime, or even by the group performing at the local youth club.

Commercial flash cartridges are readily available, as are the controllers required to initiate them. The controllers are expensive and are often designed to give a large amount of flexibility. This article describes a relatively simple pyrotechnic controller that can be built for approximately £35.

PIC DIGILOGUE CLOCK

In this updated design a PIC is used to replace several CMOS counters, plus many other components, in a clock where hours are shown in analogue fashion and minutes digitally. The resulting timepiece is easy to read, unusual and easy to build in virtually any size case.

REACTOBOT AND VIRTUAL REALITY

How the work of the Department of Electronic Engineering at the University of Hull is making Virtual Worlds more realistic using a "reacting robot".

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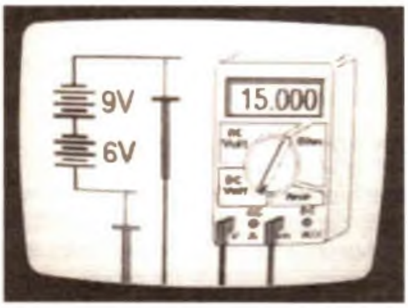

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PIC-AGORAS WHEELIE METER

JOHN BECKER

Part 2

Keep a check on your speed and distance. From child's tricycle to heavy-haulage vehicle.

LAST month we introduced the megnetic field sensor and dealt with the circuits and construction of the frequency-to-logic interface, display and processing stages. The system software demands were also discussed.

We conclude this month with the first display run and possible downloading failures. Also, details of setting the wheel size and possible alternative sensing are covered.

FIRST DISPLAY RUN

Switching off S3 (Reset), the program inside the PIC should now start running, though preset VR2 will probably need adjusting before anything is seen on the l.c.d. screen. What you should see is Line 1 showing the time counting upwards in seconds, from a zero starting position which you may have missed while adjusting VR2. Line 2 should show "KD000.00".

Rotate switch S4 through all eight Mode positions, observing that the display shows what appears to be sensible information (see Part 1 for typical Mode displays), and that the buzzer sounds when in Mode 7.

It is just possible, particularly if the PIC has been used before, that non-zero results may appear in some lines for which the data should at present be zero. This situation can be resolved later by initiating the Full Reset option.

DOWNLOADING FAILURE

This section will be of particular interest to anyone who has had problems programming PICs.

Apart from errors in assembly (or the unlikely event of a faulty component), there are two reasons why the program may not behave as expected, probably resulting in no screen display or one that is unexpected.

Sometimes, if the leads to the computer are a bit long, the data being transferred may become corrupted. Re-send (download) the data and try again. Shorten the leads if necessary.

The other possibility is that the computer has been configured to output information to the printer port via a different register than the downloading software has been set for. The TASM Send software is set to output via the "normal" register &H378.

To check the printer port operation, run the following test program from QBasic or GWBasic:

```
10 FOR A = 0 TO 255
20 OUT &H378, A
30 NEXT A
40 GOTO 10
```

This toggles the printer register &H378, and thus the printer port lines if this register is the one the computer has been configured to use. An oscilloscope can be used to monitor connector PL2 pins 2 and 3 (port lines DA0 and DA1) to check that they are toggling between high and low. Line DA1 should toggle at half the rate of DA0.

A multimeter (preferably analogue) can be used if a scope is not available. Set it to a suitable range for +5V d.c. and observe the meter display. It will probably be necessary to insert a delay loop in the above program so that the meter readings can be seen more slowly. The following is a good starting point (inserting it between lines 20 and 30) :

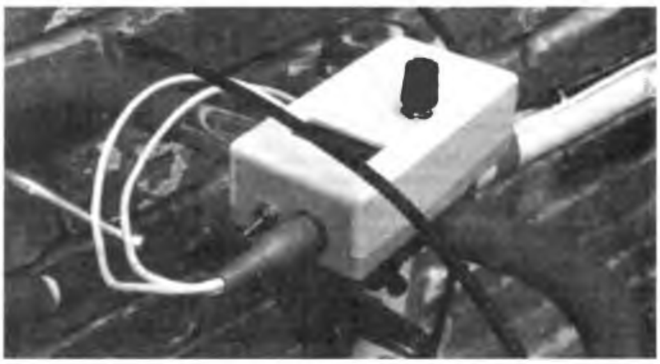
```
25 FOR B = 1 TO 10000: NEXT B
```

The value of 10000 can be increased if the delay is still not long enough.

If it is found that the port register is not &H378, the computer must have its printer configuration changed. You should consult your computer manual to find out how this is done. The TASM Send program cannot be modified except by programmers experienced in C and having the necessary compilers.

A related problem may be that attempts are made to assemble/download the data which is in the wrong format for the downloading program. TASM files need TASM downloading software, for example.

The magnetic field sensor taped to the bike fork and the magnet glued and taped to a plastic reflective plate attached to the wheel spokes.



The display/control unit clamped to the bike handlebars. The two leads from the DIN plug go to the sensor and battery (located in rear saddle-bag).

SETTING WHEEL SIZE

Readers who will be doing their own programming of the PIC16C84 may prefer to set the wheel diameter size directly into the software, using the modified program referred to earlier. Those of you who are using pre-programmed chips, or unmodified software, should still read the calculation aspects of this section as you still need to know how to establish the parameters to suit your wheel.

For the *internally preset* method, wheel diameter details are held in two sub-routine calls whose details need to be entered before the PIC is programmed (if preferred, they can be changed later and the PIC re-programmed).

About 270 lines into the ASCII source code text file are the two statements:

```
SIZE1: retlw 45 ;lsb wheel size 27.5
   inches
SIZE2: retlw 56 ;msb wheel size 27.5
   inches
```

When these routines are called, the software returns to the calling point with the stated value (45 or 56) held in its accumulator register.

The values shown are those calculated for the author's wheel size of 27·5 inches diameter. Other values can be calculated through the following QBasic/GWBasic program, which uses the diameter of 27·5 inches as the example:

```
10 DIA = 27.5: PI = 3.1416: MM =
   25.4
20 REM MM = 25.4 only for wheel
   diameter in inches
30 REM if wheel diameter is in mil-
   limetres, set MM = 1
40 CIRCUM = DIA * PI * MM
50 X = INT(65536 * CIRCUM / 10000)
60 MSB = INT(X / 256)
70 LSB = X - (MSB * 256)
80 CLS: LOCATE 10, 1
90 PRINT "MSB ="; MSB; "LSB =";
   LSB
```

(Those who wish to use a hand calculator should note that **INT** means *integer*, i.e. ignore the fraction.)

The screen – displayed answer in this case is:

MSB = 56 LSB = 45

From this answer, 56 is the SIZE2 value, and 45 is the SIZE1 value.

If the wheel size is in millimetres, change the value of MM in Line 10 to a value of 1.

The statements following the semicolon (;) in the SIZE1 and SIZE2 sub-routine lines do not need to be changed, except for your own information; the software ignores anything following a semicolon.

Theoretically, the smallest diameter wheel that can be used in calculation is 0·002 inches (0·0508mm) (m.s.b. = 0, l.s.b. = 1), though you might have problems mounting the magnet! The maximum wheel diameter that can be monitored is about 125·317 inches (3183·052mm) (m.s.b. = 255, l.s.b. = 255).

When considering the diameter of a wheel having pneumatic tyres, calculated answers may never really be borne out in practice since the tyres of a bicycle, for example, will flatten slightly when the rider mounts the bike, so changing the actual distance covered per wheel revolution. Different rider weights will have different flattening effects! This situation applies to any distance/rotation calculator used with flexible tyres.

The maximum speed that can be detected for any wheel depends on its size. As previous stated, the maximum wheel rotation rate that can be used is 25Hz. Therefore, for a 27·5 inch diameter wheel, the maximum speed is:

diameter in inches × Π × 25Hz × seconds per hour / inches per mile

Thus: 27·5 × 3·1416 × 25 × 3600 / 63360 = 120·49 m.p.h. (192·78 k.p.h.).

The 25Hz limit is dictated by three factors, the rate at which data can be processed, the number of memory bits allocated to calculations, and the *RC* time constant of resistor R4 and capacitor C2 on the output of IC1.

If the maximum pulse rate is exceeded, the velocity line in Mode 1 and Mode 4 will have the word MAX substituted for the speed value. In Mode 6, the TA value will show 255.

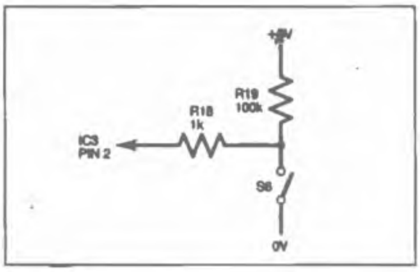


Fig. 5. Circuit for triggering wheel diameter parameters into PIC16C84 EEPROM Data Memory.

EXTERNAL SETTING

With the unmodified software and pre-programmed chips, wheel size data is entered by using a signal generator. Three components also need to be temporarily added, as shown in Fig. 5. Disconnect the wires of the buzzer, WD1. Switch off the additional switch, S6. Calculate the values of the m.s.b. and l.s.b. for your wheel diameter.

Connect the signal generator to test point TP1. Switch on PIC-Agoras and the signal generator, set to a 5V square wave output at between 0·1Hz and 25Hz. Switch to Mode 6, and observe line 2 (display 'TA xxx').

Adjust the signal generator until line 2 displays the m.s.b. value. Since the display shows an average of the pulse count received over 10 seconds, allow at least that time to elapse between slight adjustments to the signal frequency.

When the correctly displayed m.s.b. value has stabilised, switch to Mode 0 (showing time and kilometres distance), then switch on the new switch S6, leave it on for a couple of seconds, and then switch it off. The m.s.b. value is now programmed into the PIC's EEPROM data memory.

Switch back to Mode 6 and adjust the signal frequency so that line 2 now displays the wheel's l.s.b. value. Allow it to stabilise, then switch to Mode 1 (showing kilometres speed and average). Again switch on the new switch S6, leave it on for a couple of seconds, and then switch it off. The l.s.b. value is now programmed into the PIC.

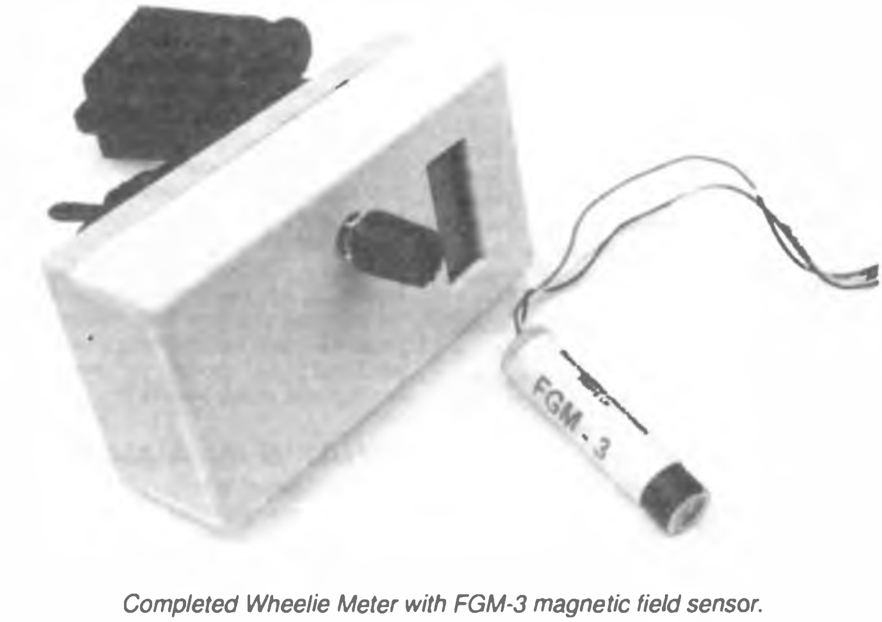
Programming space available (three bytes left!) has not allowed room for a routine to provide a visual check of the EEPROM's new contents, but you could verify them indirectly by setting the signal generator to different frequencies for which you have calculated the equivalent factors for speed and distance, as if the pulses were being generated by the wheel itself.

When satisfied, disconnect the three temporary components and the signal generator, and reconnect the buzzer. That's all there is to the external programming. The same technique can be used as many times as you want to change the wheel diameter factors.

SIGNAL GENERATOR

Most electronics enthusiasts should have a signal generator, but if you don't, you can construct a suitable one on a breadboard using the circuit in Fig. 6. No assembly details are offered, but stripboard is the suggested constructional base.

Potentiometers VR3 and VR4 provide Coarse and Fine adjustment respectively.



Completed Wheelie Meter with FGM-3 magnetic field sensor.

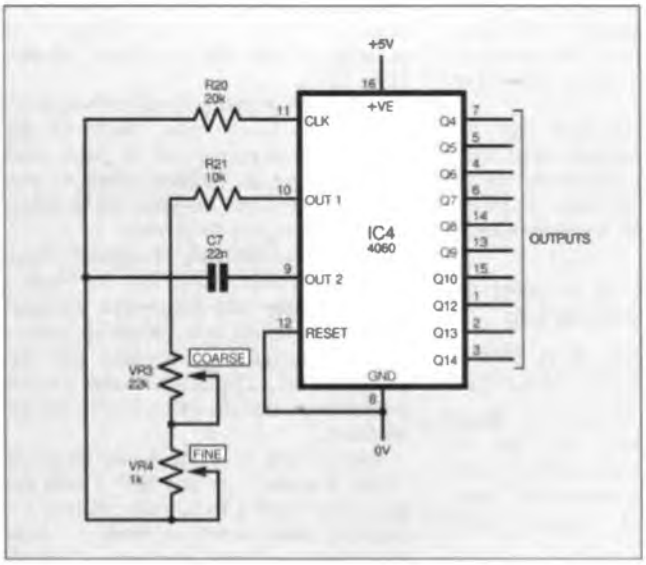
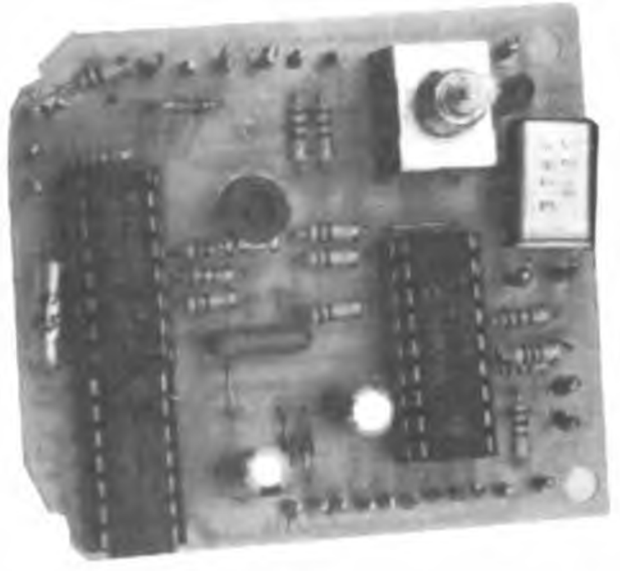


Fig. 6. Circuit for a simple Squarewave Signal Generator.



Completed prototype control board for the distance/speed monitor.

The signal can be taken from any of the output pins. The value of capacitor C7 may be changed if you want to alter the frequency range for another application.

A breadboarded version of this generator produced a basic range of 750Hz to 2000Hz (at pin 9). The output range at Q6 was thus 11·72Hz to 31·25Hz, and at Q14 it was 0·05Hz to 0·12Hz.

MOUNTING - UP

On the author's bike, the unit's case is bolted to the top of the bracket normally used for the bike's battery-powered front lamp (from Halford's). A suitable bolt already exists in the bracket. The battery is held in the pocket of a rear saddle-bag, the wires being run along the frame and secured with cable ties and insulating tape at convenient intervals.

The magnetic sensor X1 is secured to a front fork with insulating tape. Its wires are lengthened, using insulating tape to cover the connections (a 3-way connector block could be used), and then terminated by plug PL1.

The magnet is fixed to one of the clear plastic reflective plates which most bike's have on their wheels. Again, insulating tape can be used, or a strong glue.

It must be remembered, though, that fast wheel rotation rates will put a strain on the magnet fixing and unless really secure, it could fly off, causing injury.

Recalling the results of the bench tests with the magnet and sensor, position them relative to each other for the maximum change when the wheel is rotated. Then adjust preset VR1 until the best output response at IC2b pin 10 occurs. During this time, Mode switch S4 can be set to Mode 6 and the l.c.d.'s changing rotation count observed.

Note that PIC-Agoras does not know whether the bike is going forwards or backwards, or if you are stationary and just idly moving the wheel back and forth with the sensor and magnet at the fringe of high/low response.

ALTERNATIVE SENSING

Other types of sensor which produce individual pulses per wheel revolution could be used instead of the FGM-3. In this situation, IC1, the p.l.l., is not required and should be omitted, as should resistors R1 to R4, capacitors C1 and C2, and preset VR1.

The pulses from the alternative sensor can be brought in at test point TP1, using IC2a and IC2b as buffers. The pulses must have normal 5V logic levels.

For test purpose, signal generator pulses can also be brought into TP1, without removing IC1 or other components, should you want to trigger the microcontroller without using the sensor.

As a suggestion for experimentation, a wind speed sensor or even a water flow sensor could have its output fed into TP1, making appropriate changes to the programmed wheel size value to suit.

Perhaps even a speed indicator for boat or sail-board use could be evolved from this suggestion, as long as adequate waterproofing is ensured!

SOFTWARE SOURCES

Copies of the author's PIC program for this unit are available on 3·5-inch disk from the Editorial Office for the sum of £2·50 UK, £3·10 overseas surface mail or £4·10 airmail. This is to cover admin costs and postage. The disk itself is *free*.

The program can also be downloaded *free* from our FTP site: **ftp://ftp.epemag.wimborne.co.uk**, in the sub-directory: **pub/PICS/PICagoras**.

The source code is written for the TASM assembler, which is included on the same disk and also available from our FTP site. Experienced programmers can translate the code to suit other assemblers, such as MPASM, for example.

Magenta Electronics have offered to supply PIC16C84s pre-programmed with the software, see *Shop Talk*. The author is grateful to them for supplying him with an intelligent l.c.d. module for use in the development of this project.

WHAT'S IN A NAME?

PIC – Agoras? Why?

It was one of those days at the office when euphoria rolled through the atmosphere and banter exchange reached nearly warp speed. Queries Tech-Ed to Ed: "What can we call it? It's more than a bike computer, less than the infinite answer to wheeled life as we know it."

It's nearly *The Ultimate PIC-uppable Revolutionary Versatile Wheeled Distance Computer for Anyone Who's Going Places*. Bit long, perhaps", cogitates Ed. "Any Greek gods of the Wheel?"

"Helios and his chariot, that's got wheels; *HelioPIC?*"

"Would need to be solar powered."

"There's the mythical Cyclops; *CycloPIC*?"

"Just says *bikes for the optically impoverished.*"

"Greek mathematicians?"

"Euclid; Archimedes; Aristotle; Aristweed; Pythagoras ..."

"Modern Greeks seem to call him *Pit – a – gor – rass*. His birth village still exists – on Samos, named after him – Πυθαγορειον. They've got a statue."

"PIC – Agoras! That's it – angles of the dangles; arc-eology; diametrics; distance round a wheel!"

And so the World revolves . . .

Homage to Pythagoras (Πυθαγορας) on the Greek island of Samos.

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EPE SOFTWARE

Software programs for the *EPE* projects marked above with an asterisk (*) are available altogether on a *single* 3.5 inch PC-compatible disk, or as needed via our Internet site. The same disk also contains the following additional software: Simple PIC16C84 Programmer (Feb '96), PIC Disassembler (unpublished).

The disk (order as "PIC-disk") is available from the *EPE PCB Service* at £2.50 (UK) to cover our admin costs (the software itself is *free*). Overseas £3.10 surface mail, £4.10 airmail. Alternatively, the files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk.**

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SURFING THE INTERNET

NET WORK

ALAN WINSTANLEY

REGULAR readers of this column will be aware of the EPE World Wide Web Site, the URL (Uniform Resource Locator) of which is **http://www.epemag.wimborne.co.uk.** Interestingly, we hear that our overseas readers eagerly look forward to the new site update, which features the latest issue's cover in colour plus basic details of the projects and features. This is especially welcomed, you tell us, because as it can take a week or two for overseas copies to be delivered by airmail, you can now get a preview on the Internet!

Also it is possible to subscribe to *EPE* on-line, check the availability of Back Issues, and purchase these on-line, too. Unfortunately we haven't been able to make the Secure Electronic Transaction (SET) system available yet, due to reasons which are out of our hands.

FTP Layout

Don't forget our FTP site, too, (**ftp://ftp.epemag.wimborne.co.uk**) from where you may download the codes for most of our PIC projects. Without any doubt, this is a unique service that *EPE* provides which has made us a "smash hit" with Internet users. Usually, the source codes are available from the date of publication, and the Web Site is updated on the date of publication of the new issue, or shortly thereafter. So you can have the PIC codes in a matter of seconds.

Some readers seem a little confused about the layout of the FTP site: we try to arrange the files in a logical way. However, it seems that some users attempt to download a "folder" rather than the files within! It is always necessary to navigate to the correct folder (sub-directory) first of all, and then, you need to open that folder to access the file(s) it contains.

For example, if you are interested in the *PIC-A-Tuner* project (May '97 issue), you would need to go to **ftp://ftp.epemag.wimborne.co.uk/pub/PICS/PICatuner** and then, open that folder and fetch the file TUNER213.ASM within. Some other PIC folders have several files and you would need to fetch them all. Also note that since the server uses Unix, filenames and folders are usually case-sensitive.

How you actually effect the transfer, depends very much on your software. In my view, it is usually preferable to use proper FTP software (an FTP client) rather than, say, Netscape Navigator for FTP transfers (where you type the FTP URL into the browser, instead of a web address). Some packages will recognise a crash or time-out during a transfer, and will enable you to re-start the transfer where you left off, rather than being forced to transfer the entire file all over again.

However, the FTP process is usually quite reliable, as witnessed by the fact that I recently downloaded a software upgrade – all 9Mb of it – in somewhat over an hour, at a cost of well under £1, without missing a beat. Problems usually only occur due to heavy traffic; this may be when a new PIC project is launched or when the planet is generally busy, thereby limiting available bandwidth. Or you might simply have got a noisy connection. If you have any persistent problems using the FTP site, we'd like to know straight away so that we can check with our sysadmin. E-mail please to **webmaster@epemag.demon.co.uk.**

A Question of Service

London-based Demon Internet Services are reputedly the UK's largest Internet Service Providers. They offer the quirky "Turnpike" Windows package as the "Demon Internet Suite" of software. Call me old-fashioned, but I like old-fashioned levels of personal service. Or even, *any* level of personal service. Even the maligned CompuServe manages to handle customer relations reasonably effectively, in my experience, so much so that I forgave them for losing my web pages several months ago. However, if you send Demon a support query by E-mail, you automatically get a "bot" reply from a machine, a bit like an answerphone telling you that you are in a queue, please hold; only the wait can be for several weeks or more.

In the case of Demon Internet Services, I very rarely need to contact their Support but when I do, I see that little has changed. In one bewildering example of disarray, I sent a specific Turnpike software query by E-mail to Turnpike Ltd. themselves, who replied that I would now have to address it to Demon Support where all Turnpike queries are dealt with. So I obediently copied Demon in on the game, received the autoresponder reply, then nothing. Several weeks later, still nothing. For a Company founded on communications, this is terrible.

Sending a terse chaser together with another detailed explanation of the problem to Demon Support produced an equally terse one line reply: that I must address my query to Turnpike instead! After several weeks, full circle! There seems to be more help on offer (if you call blunt, one-line replies "help") in the form of **demon.internet.support.turnpike,** a Usenet newsgroup where at least Turnpike users can cry on each others' shoulders, with the odd brusque interjection by a *Demonpike* guru.

Meantime, Demon's marketing guys gush about their expansion plans – including setting up an office in New York. Perhaps the higher expectations of Americans, rather than the customary acceptance in England of indifferent and impersonal service, will give Demon the jolt I think it deserves.

Pick of the Web

Onwards to this month's pick of electronics-related web links. Remember, if you know of any sites which would appeal to your fellow readers, let me know and I'll check them out for possible inclusion. As always, the following links are made for you on the Net Work page of our Web site.

First, Microsoft Internet Explorer 3.0 running in Windows 95 or NT4.0 has an apparent security flaw whereby, when you follow a link on a web page, this can cause a program to be executed on your PC without your permission. Details of a fix can be found on **http://www.microsoft.com/ie/security/update.htm.**

If you'd like the low-down on the latest MMX (multimedia extensions for the Pentium processor) technology from Intel, try **http://www.mmx.com.** Two sites worth checking, if you are involved with electronics education, include the Doctronics Educational Publishing for Design & Technology at **http://www.users.dircon.co.uk/~doctron/index.htm,** (with a nice example of flashing l.e.d.s!) and **http://www.crocodile-clips.com/education/index.htm,** the latter being a simulation program for demonstrating electronic circuits for, say, GCSE and Advanced Level pupils.

Thanks to Jaap van Ganswijk in Holland for updating us on the famous "ChipDir" IC Directory. Jaap says that a UK mirror is finally coming on-line at **http://www.shellnet.co.uk/chipdir/.** It's an invaluable resource for sussing out tricky chips. Simon Davis at Lancaster University recommends **http://www.crhc.uiuc.edu/~dburke/databookshelf.html** as a very comprehensive data source. A fast UK mirror is given too.

A well presented WWW tutorial on basic d.c. circuits (resistors in series, parallel, Thevenin, etc.) is listed at **http://www.infinet.com/~sweeethvn/tech03.html.** The Unusual Diode FAQ is sponsored as a commercial site but has some very interesting snippets, at **http://www.avtechpulse.com/faq.html.** See what a brick-built diode looks like!

Next month I'll be describing web by E-mail – see you next month for more *Net Work.* My E-mail address is **alan@epemag.demon.co.uk.** My own Home Page is at **http://ourworld.compuserve.com/homepages/alan_winstanley.**

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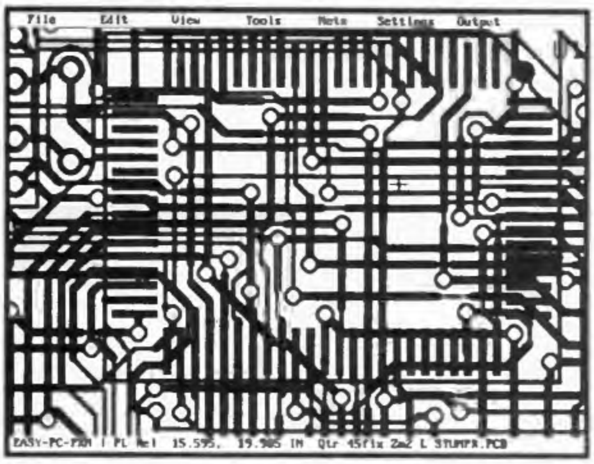

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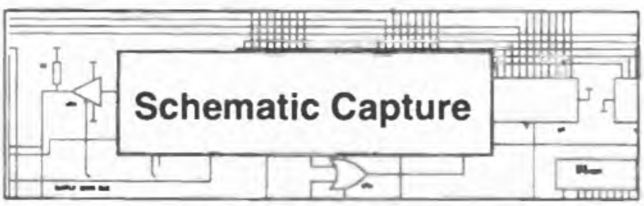

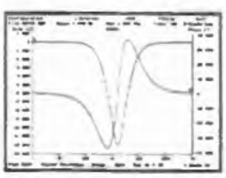

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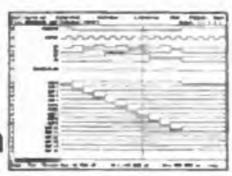

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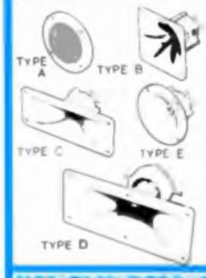

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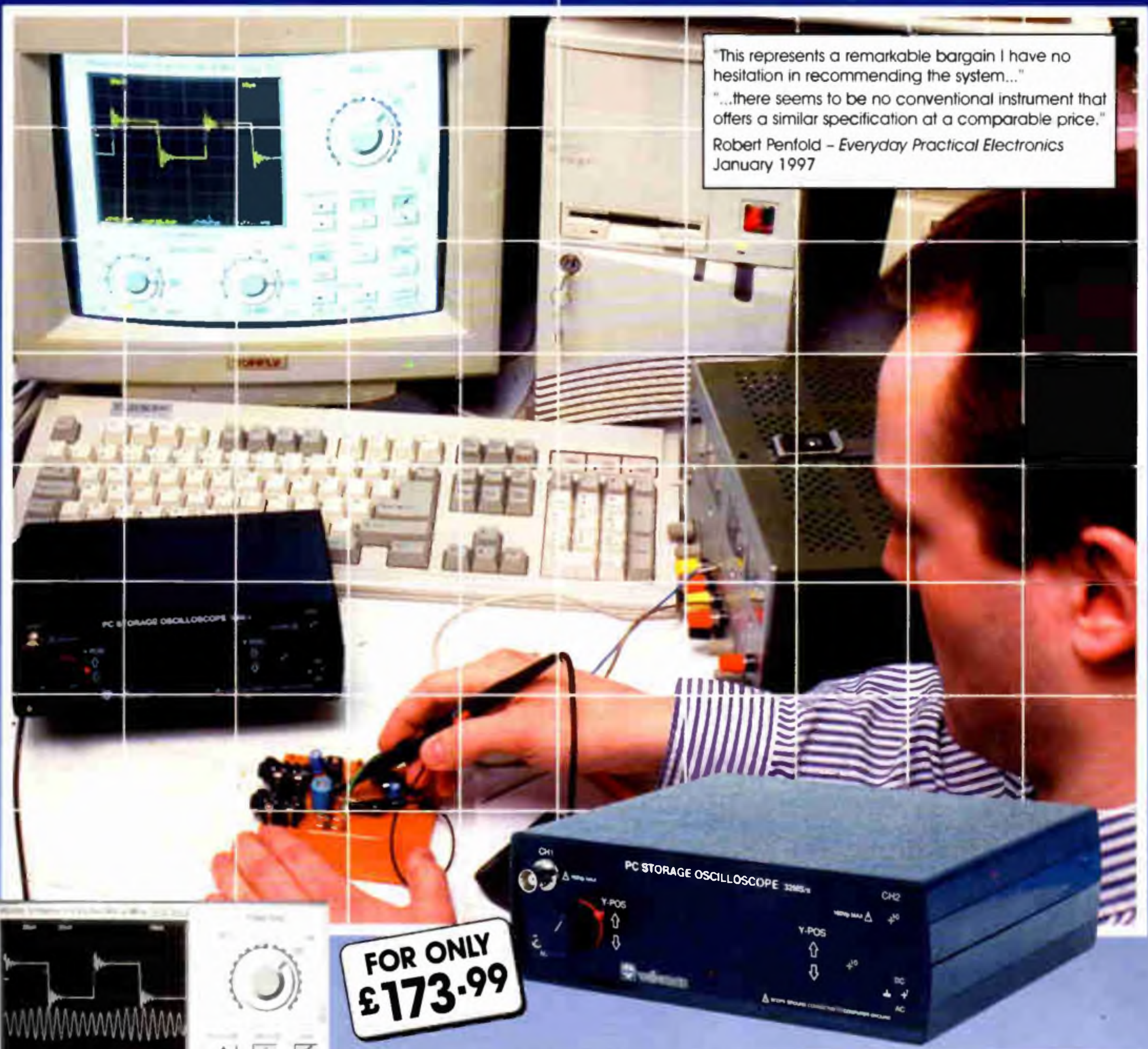

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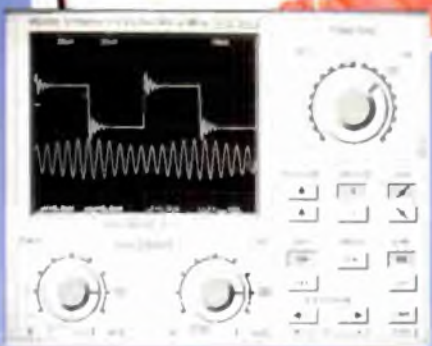

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