EVERYDAY PRACTICAL ELECTRONICS
MARCH 1997
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£2.45

SIMPLE DUAL OUTPUT TENS UNIT

Electronic Pain Relief

VIDEO NEGATIVE VIEWER

View colour negatives with a camcorder

OIL CHECK REMINDER

Don't run out of heating oil

HOW TO USE INTELLIGENT L.C.D.s – PART 2

Driving the display with a PIC

THE No. 1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

03
9 770262 361072

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

VEGA RUSSIAN MULTIBAND World communications receiver, 9 wave bands, (5 short, 1 LW, 1FM, 1MW) internal ferrite and external telescopic aerials, mains or battery. Large, typically Russian radio! £45 ref VEGA

NEW LASER POINTERS <5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 670nm. £29 ref DEC49

MULTIBAND RADIO Compact general purpose radio receiver covering air, pb, tv, cb etc. Squelch vol and tuning £24 ref MB1

DIVINING RODS £3.99 a pair! ref EF111

MOONSHINE BIBLE 270 page book covering the production of alchohol from potatoes, rice, grains etc Drawings of simple home made stills right through to commercial systems. £12 ref MS3

NEW HIGH POWER MINI BUG With a range of 800 metres or more and up to 100 hours use from a PP3 this will be popular! Bug measures less than 1" square! £28 Ref LOT102

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

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

TRACKING TRANSMITTER range 1.5-5 miles, 5,000 hours on AA batteries, also transmits info on car direction and motion!Works with any FM radio. 1.5" square. £65 ref LOT101

ELECTRIC DOOR LOCKS Complete lock with both Yale lock and 12v operated deadlock (keys included) £10 ref LOT99

SURVEILLANCE TELESCOPE Superb Russian zoom telescope adjustable from 15x to 60x! complete with metal tripod (imposible to use without this on the higher settings) 66mm lense, leather carrying case £149 ref BAR69

WIRELESS VIDEO BUG KIT Transmits video and audio signals from a minature CCTV camera (included) to any standard television! All the components including a PP3 battery will fit into a cigarette packet with the lens requiring a hole about 3mm diameter. Supplied with telescopic aerial but a piece of wire about 4" long will still give a range of up to 100 metres. A single PP3 will probably give less than 1 hours use. **£99** REF EP79. (probably not licensable!)

GPS SATELLITE NAVIGATION SYSTEM Made by Garmin, the GPS38 is hand held, pocket sized, 255g, position, altitude, graphic compass, map builder etc £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, krypton bulb, gives out powerful infrared light! 4 D cells required. £29 ref PB1.

MONO VGA MONITORS, Perfect condition, Compaq, 14", 3 months warranty £29 ref MVGA

SUPER WIDEBAND RADAR DETECTOR Detects both radar and laser , X K and KA bands, 360 degree coverage, front and rear wave guides, may be illegal to use! 1.1"x2.7"x4.6" £149 ref RD2

9 WATT CHIEFTAN TANK LASERS

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.

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!

WIND UP FLYING PARROT! Genuine parrot that flaps its wings and flies for up to 50 meters £6 ref EF2

RADIO CONTROLLED CARS FROM £6 EACH!!!! All returns from famous manufacturer, single channel (left,right,forwards,backwards) £6 ref LOT1. Two channel with more features £12 ref LOT2.

THOUSANDS AVAILABLE RING/FAX FOR DETAILS!

MAGNETIC CARD READERS (Swipes) £9.95 Cased with flyleads, designed to read standard credit cards! they have 3 wires coming out of the head so they may write as well? complete with control elctronics PCB. just £9.95 ref BAR31

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

COIN OPERATED TIMER KIT Complete with coinslot mechanism, adjustable time delay, relay output, put a coinslot on anything you like! TV,s, videos, fridges, drinks cupboards, HIFI, takes 50p's and £1 coins. DC operated, price just £7.99 ref BAR27

ZENITH 900 X MAGNIFICATION MICROSCOPE Zoom, metal construction, built in light, shrimp farm, group viewing screen, lots of accessories. £29 ref ANAYLT.

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

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 SM2020A
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 ref TAL-1, £249

SOLAR ENERGY/GENERATOR PLANS For your home, loads of info on designing systems etc £7 ref PV1

SOLAR COOKERS Comprehensive guide to building solar powered cookers, includes plans, recipes, cooking times etc £7 ref SBC1

WOLVERHAMPTON ELECTRONICS STORE NOW OPEN IN WORCESTER ST TEL 01902 22039

CENTRAL POINT PC TOOLS Award winning software, 1,300 virus checker, memory optimiser, disc optimiser, file compression, low level formatting, backup scheduler, disk defragmenter, undelete, 4 calculators, D base, disc editor, over 40 viewers, remote computing, password protection, encryption, comprehensive manual supplied etc £8 ref lot 97 3.5" disks.

COLOUR CCTV VIDEO CAMERAS, BRAND NEW AND, CASED, £119.

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, 10 or more £99 ea

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

HANDHELD SCANNERS 10 channel, built in charger, LCD display £119 ref B110B, 100 channel model £229 ref B110E

SMOKE MACHINE 42.3 cubic metres a min from this mains operated machine £299 ref G002B, smoke fluid £25 (5 litres) gives about 2.5 hours use. ref GOO2AA

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

IBM PS2 MODEL 150Z CASE AND POWER SUPPLY Complete with fan etc and 200 watt power supply. **£9.95** ref EP67

1.44 DISC DRIVES Standard PC 3.5" drives but returns so they will need attention **SALE PRICE £4.99** ref EP68

1.2 DISC DRIVES Standard 5.25" drives but returns so they will need attention **SALE PRICE NOW ONLY £3.50** ref EP69

PP3 NICADS Unused but some storage marks. £4.99 ref EP52

GAS HOBS AND OVENS Brand new gas appliances, perfect for small flats etc. Basic 3 burner hob **£19** ref BAR316. Basic small built in oven **SALE PRICE £59** ref EP73

ENERGY BANK KIT 100 6"x6" 6v 100mA panels, 100 diodes, connection details etc. £99 ref EF112.

PASTEL ACCOUNTS SOFTWARE, does everything for all sizes of businesses, includes wordprocessor, report writer, windowing, networkable up to 10 stations, multiple cash books etc. 200 page comprehensive manual. 90 days free technical support (01342-326009 try before you buy!) **SALE PRICE** £9.95 ref SA12. SAVE £120!!!

PC PAL VGA TO TV CONVERTER 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

YUASHA SEALED LEAD ACID BATTERIES Two sizes currently available this month. 12v 15AH at £18 ref LOT8 and 6v 10AH at just £6 ref LOT7

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.

PROJECT STRIPPERS Small cased UNITS ideal for stripping, lots of useful goodies including a smart case 120X150X50mm with feet etc , and lots of components. **SALE PRICE JUST £10 FOR FIVE** REF MD1 or a pack of 20 for £19.95 ref MD2.

SOLAR POWER LAB SPECIAL You get TWO 6"x6" 6v 130mA solar cells, 4 LED's, wire, buzzer, switch plus 1 relay or motor. Superb value kit **SALE PRICE JUST £4.99** REF SA27

13.8V 1.9A PSU cased with leads. Just £9.99 REF MAG10P3

UNIVERSAL SPEED CONTROLLER KIT Designed by us for the C5 motor but ok for any 12v motor up to 30A. Complete with PCB etc. A heat sink may be required. £17.00 **REF: MAG17**

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

VIEWDATA SYSTEMS made by Phillips, complete with internal 1200/75 modem, keyboard, psu etc RGB and composite outputs, menu driven, autodialler etc. **SALE PRICE £12.99** REF SA18

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 circumfrence, 1.8m high 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.

VIDEO 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 100' range! (tune TV to a spare channel) 12v DC op. Price is £25 **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.

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. **SALE PRICE £4.99** REF SA24.

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

MIXED GOODIES BOX OF MIXED COMPONENTS WEIGHING 2 KILOS YOURS FOR JUST £5.99

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

HYPOTHERMIA SPACE BLANKET 215x150cm aluminised foil blanket, reflects more than 90% of body heat. Also suitable for the construction of two way mirrors! £3.99 each ref O/L041.

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.

LENSTATIC RANGER COMPASS Oil filled capsule, strong metal case, large luminous points. Sight line with magnifying viewer. 50mm dia, 86gm. £10.99 ref O/K604.

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.

TALKING WATCH Yes, it actually tells you the time at the press of a button. Also features a voice alarm that wakes you up and tells you what the time is! Lithium cell included. £7.99 ref EP26.

RUBBER COATED HELIOS Binoculars, 10 x 25, fully coated optics. £45 ref RP1, same spec but nitogen filled and waterproof £75 ref RP2

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 MICROSCOPES 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

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

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VOL. 26 No. 3 MARCH 1997

EVERYDAY PRACTICAL ELECTRONICS

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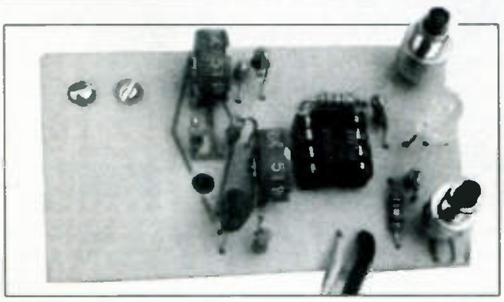
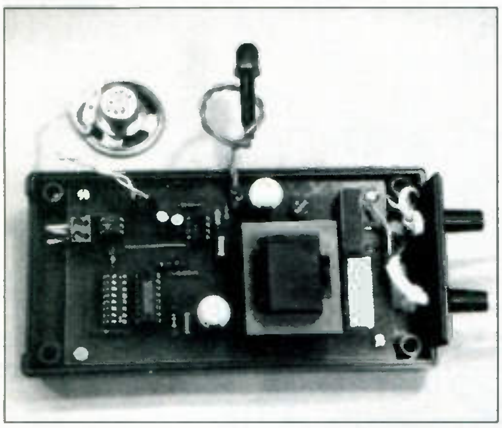
The No. 1 Magazine for Electronics, Technology and Computer Projects

Projects and Circuits

Series and Features



Regulars and Services



Our April '97 Issue will be published on Friday, 7 March 1997. See page 185 for details.

Surplus always wanted for cash!

THE *ORIGINAL* SURPLUS WONDERLAND!

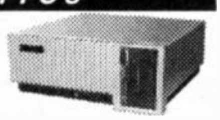
THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

Surplus always wanted for cash!

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

LOW COST 486DX-33 SYSTEM

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 avaiable - 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)
3½" **Mitsubishi** MF355C-L 1.4 Meg. Laptops only	£25.95(B)
3½" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop	£18.95(B)
5¼" **Teac** FD-55GFR 1.2 Meg (for IBM pc's) RFE	£18.95(B)
5¼" **Teac** FD-55F-03-U 720K 40/80 (for BBC's etc) RFE	£29.95(B)
5¼" **BRAND NEW Mitsubishi** MF501B 360K	£22.95(B)
Table top case with integral PSU for HH 5¼" 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)

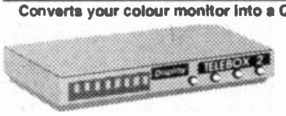
HARD DISK DRIVES

End of line purchase scoop! *Brand new* **NEC D2246** 8" 85 Mbyte drive with **industry standard SMD interface**, replaces Fujitsu equivalent model. Full manual. Only £299.00 or 2 for £525.00 (E)

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** 9754B 850 Mb SCSI RFE tested	£89.00(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)

DC POWER SUPPLIES

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

IC's -TRANSISTORS - DIODES

OBSOLETE - SHORT SUPPLY - BULK

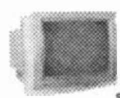
6,000,000 items EX STOCK

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

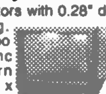
As New - Used on film set for 1 week only!! 15" 0.28 SVGA 1024 x 768 res. colour monitors. Swivel & tilt etc. Full 90 day guarantee. £145.00 (E)

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.

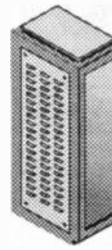
20"....£135 22"....£155 26"....£185 (F)

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 Industria 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



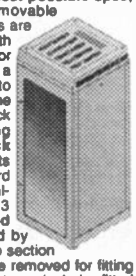
Superb quality 6 foot 40U
Virtually New, Ultra Smart
Less than Half Price!

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

OPT Rack 1 Complete with removable side panels.	£335.00 (G)
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)



Sold at LESS than a third of makers price !!

A superb buy at only £195.00 (G)

Over 1000 racks - 19" 22" & 24" wide 3 to 44 U high. Available from stock !! Call with your requirements.

TOUCH SCREEN SYSTEM

The ultimate in 'Touch Screen Technology' made by the experts - ***MicroTouch*** - **but sold at a price below cost !! System consists of** a flat translucent glass laminated panel measuring 29.5 x 23.5 cm connected to an electronic controller PCB. The controller produces a **standard serial** RS232 or TTL output **which continuously gives** simple serial data containing positional X & Y co-ordinates as to where a finger is touching the panel - as the finger moves, the data instantly changes. The X & Y information is given at an **incredible matrix resolution of 1024 x 1024 positions over the entire screen size !! A host of available translation software enables direct connection** to a PC for a myriad of applications including: control panels, pointing devices, POS systems, controllers for the disabled or computer un-trained etc etc. Imagine using your finger with 'Windows', instead of a mouse !! (a driver is indeed available !) ***The applications for this amazing product are only limited by your imagination!!*** Complete system including Controller, Power Supply and Data supplied at an incredible price of only: **£145.00** (B)
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LOW COST RAM & CPU'S

INTEL 'ABOVE' Memory Expansion Board. Full length PC-XT and PC-AT compatible card with 2 Mbytes of memory on board. Card is fully selectable for Expanded or Extended (286 processor and above) memory. **Full data and driver disks supplied.** RFE. Fully tested and guaranteed. Windows compatible. £59.95(A1)
Half length 8 bit memory upgrade cards for PC AT XT expands memory either 256k or 512k in 64k steps. May also be used to fill in RAM above 640k DOS limit. Complete with data.
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1 MB x 9 SIMM 9 chip 120ns	Only	£16.50 (A1)
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1 MB x 9 SIMM 9 chip 80 ns £21.50	or 70ns	£23.75 (A1)
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FULL RANGE OF CO-PROCESSOR'S EX STOCK - CALL FOR £££

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EPSON D0412 40x40x20 mm 12v DC	£7.95 10 / £65
PAPST TYPE 812 60x60x25 mm 12v DC	£8.95 10 / £75
MITSUBISHI MMF-D6D12DL 60x60x25 mm 12v DC	£4.95 10 / £42
MITSUBISHI MMF-08C12DM 80x80x25 mm 12v DC	£5.25 10 / £49
MITSUBISHI MMF-09B12DH 92x92x25 mm 12v DC	£5.95 10 / £53
PANCAKE 12-3.5 92x92x18 mm 12v DC	£7.95 10 / £69

EX-EQUIP AC fans. ALL TESTED 120 x 120 x 38 mm specify 110 or 240 v £6.95. 80 x 80 x 38 mm - specify 110 or 240 v £5.95
IMHOF B26 1900 rack mnt 3U x 19" Blower 110/240v NEW £79.95
Shipping on all fans (A). Blowers (B). ***50,000 Fans Ex Stock CALL***

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The latest MAGENTA DESIGN – highly stable & sensitive – with MC control of all timing functions and advanced pulse separation techniques.

- New circuit design 1994
- High stability drift cancelling
- Easy to build & use
- No ground effect, works in seawater
- Detects gold, silver, ferrous & non-ferrous metals
- Efficient quartz controlled microcontroller pulse generation.
- Full kit with headphones & all hardware

KIT 847....................£63.95

DIGITAL LCD THERMOSTAT

A versatile thermostat using a thermistor probe and having an l.c.d. display. MIN/MAX memories, −10 to 110 degrees Celsius, or can be set to read in Fahrenheit. Individually settable upper and lower switching temperatures allow close control, or alternatively allow a wide 'dead band' to be set which can result in substantial energy savings when used with domestic hot water systems. Ideal for greenhouse ventilation or heating control, aquaria, home brewing, etc. Mains powered, 10A SPCO Relay output. Punched and printed case.

KIT 841........................£29.95

PORTABLE ULTRASONIC PEsT SCARER

A powerful 23kHz ultrasound generator in a compact hand-held case. MOSFET output drives a special sealed transducer with intense pulses via a special tuned transformer. Sweeping frequency output is designed to give maximum output without any special setting up.

KIT 842........................£22.56

DIGITAL CAPACITANCE METER

A really professional looking project. Kit is supplied with a punched and printed front panel, case, p.c.b. and all components. Quartz controlled accuracy of 1%. Large clear 5-digit display and high speed operation. Ideal for beginners – as the µF, nF and pF ranges give clear unambiguous read out of marked and unmarked capacitors from a few pF up to thousands of µF.

KIT 493........................£39.95

SUPER ACOUSTIC PROBE

Our very popular project – now with ready built probe assembly and diecast box. Picks up vibrations amplifies, and drives headphones. Sounds from engines, watches, and speech through walls can be heard clearly. Useful for mechanics, instrument engineers and nosey parkers! A very useful piece of kit.

KIT 865........................£29.95

WINDICATOR

A novel wind speed indicator with LED readout. Kit comes complete with sensor cups, and weatherproof sensing head. Mainspower unit £5.99 extra.

KIT 856..£28.00

★ TENS UNIT ★

DUAL OUTPUT TENS UNIT

NEW!

As featured in this issue.

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

KIT 866.........................Phone for price

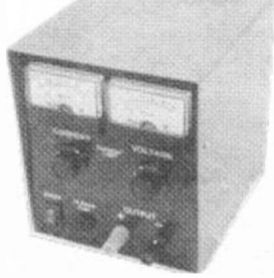
1000V & 500V INSULATION TESTER

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

KIT 848..................£32.95

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

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



KIT 845..............£64.95

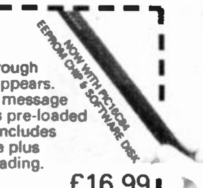
ULTRASONIC PEsT SCARER

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

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

KIT 812..£14.81

SPACEWRITER



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

KIT 849......................£16.99

12V EPROM ERASER

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

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

INSULATION TESTER

A reliable and neat electronic tester which checks insulation resistance of wiring and appliances etc., at 500 Volts. The unit is battery powered, simple and safe to operate. Leakage resistance of up to 100 Megohms can be read easily. A very popular college project.

KIT 444........................£22.37

SUPER BAT DETECTOR

NEW!

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

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

KIT 861............................£24.99

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

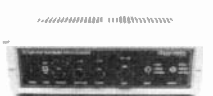
Magenta's highly developed & acclaimed design. Quartz crystal controlled circuit MOSFET coil drive. D.C. coupled amplification. Full kit includes PCB, handle, case & search coil.

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

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

DOLBY PRO-LOGIC DECODER

Experience the delight of SURROUND SOUND in your own home. This project brings full Genuine PRO-LOGIC surround sound to you at a fantastic price. The circuit meets all *Dolby specifications, with "Stereo", "3-Stereo" and "Surround Sound" selections.



For minimum cost the "Short Form Kit" is ideal. This is complete except for the case and power transformer. It includes the switches, sockets, and pots, and is ideal for building into a custom set-up with pre-amp and power-amp modules, where power is available.

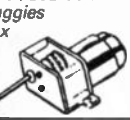
The alternative "Full Kit" gives the best value option. With a printed front panel, punched rear panel, power transformer and mains lead and black brushed aluminium knobs. This kit produces a complete stand-alone decoder that can be used with any audio.

Short Form KIT, Kit Ref: 858 £99.00
Kit with case and transformer, Kit Ref: 869 £124.99

*DOLBY and the double-D symbol are trademarks.

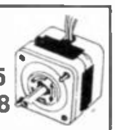
DC Motor/Gearboxes

Our Popular and Versatile DC motor/Gearbox sets. Ideal for Models, Robots, Buggies etc. 1·5 to 4·5V Multi ratio gearbox gives wide range of speeds.



LARGE TYPE – MGL £6.95
SMALL – MGS – £4.77

Stepping Motors



MD38...Mini 48 step...£8.65
MD35...Std 48 step...£12.98
MD200...200 step...£16.80
MD24...Large 200 step...£22.95

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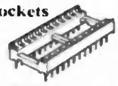
DIL Sockets



Stamped Pin

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

Turned Pin

8 Pin DIL 0.3"	£0.11
14 Pin DIL 0.3"	£0.27
16 Pin DIL 0.3"	£0.31
18 Pin DIL 0.3"	£0.35
20 Pin DIL 0.3"	£0.39
24 Pin DIL 0.6"	£0.46
28 Pin DIL 0.6"	£0.41
40 Pin DIL 0.6"	£0.78

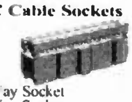
SIL Header Strip

1 x 36 Way Straight	£0.38
2 x 36 Way Straight	£0.72
1 x 36 Way 90°	£0.55
2 x 36 Way 90°	£0.78
20 Way Socket Strip	£0.54

Transistor Sockets

T018-4 Base Socket	£0.24
T05 Base Socket	£0.24

IDC Cable Sockets



10 Way Socket	£0.23
14 Way Socket	£0.34
16 Way Socket	£0.31
20 Way Socket	£0.26
26 Way Socket	£0.30
34 Way Socket	£0.42
40 Way Socket	£0.66
50 Way Socket	£0.75

PCB Box Headers

10 Way Straight	£0.27
14 Way Straight	£0.36
16 Way Straight	£0.36
20 Way Straight	£0.41
26 Way Straight	£0.49
34 Way Straight	£0.52
40 Way Straight	£0.63
50 Way Straight	£0.96
10 Way 90°	£0.36
16 Way 90°	£0.47
20 Way 90°	£0.53
26 Way 90°	£0.58
34 Way 90°	£0.72
40 Way 90°	£0.83
50 Way 90°	£0.99

PCB Latch Headers

10 Way Straight	£0.50
16 Way Straight	£0.70
20 Way Straight	£0.78
26 Way Straight	£1.00
34 Way Straight	£0.86
40 Way Straight	£1.56
50 Way Straight	£1.29
10 Way 90°	£0.58
16 Way 90°	£0.78
20 Way 90°	£0.82
26 Way 90°	£1.06
34 Way 90°	£1.14
40 Way 90°	£1.64
50 Way 90°	£1.74

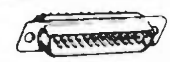
DIL Headers

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

Transistion Headers

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

D Type Connectors



Solder Bucket

9 Way Male Plug	£0.29
9 Way Female Socket	£0.30
15 Way Male Plug	£0.39
15 Way Female Socket	£0.39
15 Way H.D. Plug	£0.49
15 Way H.D. Socket	£0.78
23 Way Male Plug	£0.49
23 Way Female Socket	£0.49
25 Way Male Plug	£0.48
25 Way Female Plug	£0.50

IDC Ribbon Mounting

9 Way Male Plug	£1.20
9 Way Female Socket	£1.20
25 Way Male Plug	£1.26
25 Way Female Socket	£1.26

Right Angled PCB

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

Plastic D Covers

9 Way Cover - Grey	£0.30
9 Way Cover - Black	£0.30
15 Way Cover - Grey	£0.33
23 Way Cover - Grey	£0.36
23 Way Cover - Black	£0.36
25 Way Cover - Grey	£0.36
25 Way D Cover - Black	£0.36
9 to 9 Cover / Case	£0.96
25 to 25 Cover / Case	£0.86

Audio Connectors

2.5mm Jack Plug	£0.21
2.5mm Line Socket	£0.16
2.5mm Chassis Socket	£0.09
3.5mm Mono Plug	£0.24
3.5mm Mono Line Skt	£0.30
3.5mm Mono Chassis Sk	£0.14
3.5mm Stereo Plug	£0.33
3.5mm Stereo Line Skt	£0.37
3.5mm Stereo Chassis Sk	£0.34
¼" Mono Plug	£0.30
¼" Mono Line Socket	£0.35
¼" Mono Chassis Socket	£0.40
¼" Stereo Plug	£0.40
¼" Stereo Line Socket	£0.38
¼" Stereo Chassis Skt	£0.44

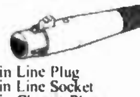
DIN Series

2 Pin Line Plug	£0.21
2 Pin Chassis Socket	£0.15
3 Pin Line Plug	£0.27
3 Pin Chassis Socket	£0.28
4 Pin Line Plug	£0.24
4 Pin Chassis Socket	£0.26
5 Pin Line Plug 180°	£0.30
5 Pin Chassis Skt 180°	£0.32
5 Pin Line Plug 240°	£0.24
5 Pin Chassis Skt 240°	£0.32
5 Pin Line Plug 360°	£0.24
5 Pin Chassis Skt 360°	£0.32
6 Pin Line Plug	£0.27
6 Pin Chassis Socket	£0.32
7 Pin Line Plug	£0.34
7 Pin Chassis Socket	£0.34
8 Pin Line Plug	£0.45
8 Pin Chassis Socket	£0.36

Phono Series

Red Line Plug	£0.20
Black Line Plug	£0.20
Yellow Line Plug	£0.20
White Line Plug	£0.20
Red Line Socket	£0.20
Black Line Socket	£0.20
Yellow Line Socket	£0.20
White Line Socket	£0.20
Red Chassis Socket	£0.20
Black Chassis Socket	£0.20
Gold Plated Plug - Red	£0.76
Gold Plated Plug - Black	£0.76

XLR Series - metal



3 Pin Line Plug	£1.50
3 Pin Line Socket	£1.82
3 Pin Chassis Plug	£1.36
3 Pin Chassis Socket	£1.70

RF Connectors

BNC Plug 50Ω Solder	£0.93
BNC Plug 50Ω Crimp	£0.56
BNC Plug 75Ω Solder	£0.96
BNC Plug 75Ω Crimp	£0.70
BNC Chassis Socket	£0.80
F Plug - Twist	£0.27
F Plug - Crimp	£0.30
TNC Plug Solder	£1.20
TNC Plug Crimp	£0.78
UHF Plug 5mm Cable	£0.72
UHF Plug 11mm Cable	£0.66
UHF Chassis Skt- Sqr	£0.45
UHF Chassis Skt- Rnd	£0.58

Terminals

All Available in - Red, Black, Green, Blue, White or Yellow

2mm Solder Plugs	£0.18
2mm Chassis Sockets	£0.20
4mm Solder Plugs	£0.30
4mm Stackable Plugs	£0.40
4mm Chassis Sockets	£0.23
4mm Binding Posts	£0.54
33mm Crocodile Clips	£0.13

Power Connectors
DC Low Voltage

DC Plug 0.7ID, 2.35OD	£0.46
DC Plug 1.3ID, 3.4OD	£0.32
DC Plug 1.7ID, 4.0OD	£0.46
DC Plug 1.7ID, 4.75OD	£0.46
DC Plug 2.1ID, 5.0OD	£0.24
DC Plug 2.5ID, 5.0OD	£0.24
DC Plug 3.1ID, 6.3OD	£0.46
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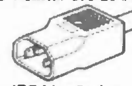
DC Chassis Skt 2.5mm	£0.46

IEC Mains 6A 250Vac



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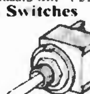

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3A 125V 1A 250V
5mm Ø Mounting Hole

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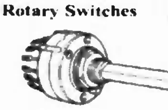

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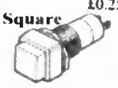

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39 x 15MM
12mm Ø Mounting Hole
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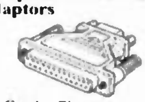

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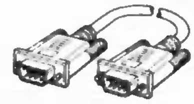

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NO PAIN – NO PROBLEM!

Electronics can be applied to almost any problem and, even where the subject is far removed from technology as we know it, electronics often comes to the rescue. An outstanding example of this is our new *Simple Dual-Output TENS Unit*.

The Victorians thought that electric shock treatment could help with some medical problems but the refinement of a unit which can be built reasonably cheaply to block pain has been a major breakthrough. Although TENS machines have been around for many years now, their acceptance in the medical profession has taken some time. Nowadays, however, many people have experienced the relief that these items can provide, without the potentially harmful side effects of drugs.

For those who want to know a little more about how to use TENS machines – the do's and don'ts plus the how and why – we are pleased to be able to make some information available. The "Home Help" box in the TENS article gives details on how you can obtain this information. Our thanks to Julia Kidson and Dr. H. Thiel of the Anglo-European College of Chiropractic for their help with this.

NEGATIVE VIEW

On a similar, but not such a spectacular, theme the *Video Negative Viewer* is also a problem solving gadget. It's a bit like reverse engineering – using electronics to solve a problem caused by older technology. Photography is rapidly becoming digitised, although we are still some way from inexpensive quality digital cameras. However, most of us have colour negatives going back many years and our simple project allows these to be put onto videotape or fed, via a video card, into a computer, etc. The unit can also provide some extra special effects for those film makers who like to experiment. Perhaps it's the versatility of modern technology that helps to make our hobby so fascinating to people from all walks of life?

Mike Kenward

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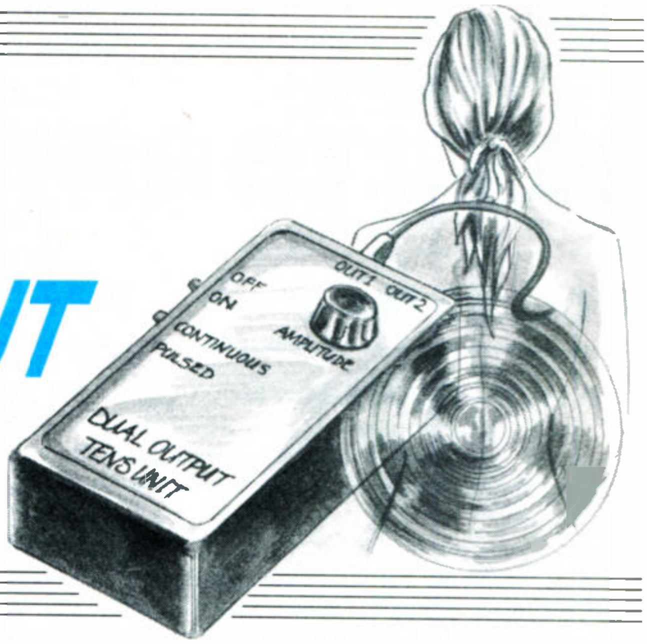
SIMPLE DUAL-OUTPUT TENS UNIT



ANDY FLIND

It is claimed that up to 70 per cent of the "millions" of "pain" victims get some relief by using a TENS Unit.

Our unit will cost you a lot less than similar units used by the NHS! It also features dual output, useful for treating larger or more deep-seated sources of pain.

A TENS device is an electronic painkiller. The name is an acronym for *Transcutaneous Electrical Neural Stimulation*, which means that it passes brief pulses of current through the skin to stimulate underlying nerves. This can *alleviate* pain, in many cases as effectively as powerful painkilling drugs but without the harmful and unpleasant side effects often associated with these.

Opinions differ as to why it works, but the generally accepted theory is that it shuts "gates" in the major pain transmitting nerve systems which block transmission of the pain signals to the brain. Another theory is that it stimulates the production of "endorphins" which are natural painkilling substances similar to opiates but again without harmful side effects.

Once considered to be "alternative" therapy, TENs is now widely used in orthodox medicine and advertisements for TENS units regularly appear in the national press. These are expensive though, so home construction is a very worthwhile proposition.

EFFECTIVE RELIEF

Two TENS projects (*Simple and Advanced TENS Unit*) featured in the May and June 1994 issues of *EPE* proved very popular and letters from constructors left no doubt about their effectiveness. These two designs were not without problems for constructors, though. A fairly high voltage is required to ensure an adequate current through the impedance of the skin and the electrodes used, so where the unit is powered by a small battery, a voltage-raising circuit is needed.

Commercially supplied TENS often have a very simple circuit with a transformer to boost the output voltage to the required level. To date the author has not found a suitable transformer available "off-the-shelf", so an alternative approach is used, generating the high voltage to begin with and using suitable high voltage output circuitry.

The generator in the two earlier designs was of the "charge pump" diode and capacitor type, using many diodes and capacitors. To accommodate these in a small case, the diodes were mounted vertically, making construction tedious.

The two designs were a "Simple" one and an "Advanced" circuit with variable output pulse frequency and width. Subsequent experience suggests these facilities are probably unnecessary, the only control really necessary is for output voltage amplitude and a "pulsed" mode, which is useful for longer treatments or where the relief obtained diminishes because the user's body becomes accustomed to continuous stimulation.

The version twice loaned out by the author to friends awaiting major back surgery was the Simple one, and in both cases excellent results were reported.

NEW DESIGN

This new design once again uses the principle of generating a high voltage to start with, but the converter is a "switch-mode" type which is much simpler to construct. The output is controlled by simple astable and monostable circuits which are easier to understand and troubleshoot than the counter and decoder circuits of the previous designs. It also lends itself more easily to modification and experiment if constructors are unable to resist this!

Another new feature is dual output, useful for treating larger or more deep-seated sources of pain. This is simply a pair of outputs in parallel from a common driver stage, made possible by the ample power available from the switch-mode converter.

> **PLEASE NOTE**
>
> **A TENS unit should NOT be used by anyone with a Heart Pacemaker, especially where the pacemaker is of the "Demand" type which might interpret pulses from the TENS as signals from the heart.**
>
> *TENS should NOT be connected in a way that would cause signals to pass across the heart, such as one on each arm. Care should be taken to avoid this when using both outputs.*
>
> **Electrodes should NOT be placed in the area of the Carotid arteries in the neck, as this may affect nerves controlling breathing and blood pressure.**
>
> *TENS current should never be allowed to flow across the head – Do NOT use TENS for Headaches!*
>
> **Medical advice should be sought for any persistent source of pain. TENS only relieves symptoms, it does NOT cure. If in any doubt YOU MUST consult YOUR doctor.**

CIRCUIT DESCRIPTION

The full circuit diagram for the Simple Dual-Output TENS Unit is shown in Fig. 1. For readers not familiar with switch-mode step-up converters, they operate by repeatedly connecting the supply voltage across an inductor (L1) so that a current builds up in it, then breaking the connection and collecting the resulting burst of high-voltage current in a capacitor.

The output is controlled by sensing when the required voltage has been reached and reducing the input current to the inductor. In Fig. 1, Schmitt NAND gates IC1c and IC1d form an astable oscillator which operates at about 65kHz. IC1a and IC1b buffer the output from the oscillator and drive the gate (g) of TR2, an *n*-channel MOSFET which switches the supply across the inductor L1.

During each "on" period of about 8µs the current builds up to a maximum of 150mA, within the limit for transistor TR2. When TR2 is turned off, the resulting current from inductor L1 passes through diode D3 into capacitor C3.

As the voltage across capacitor C3 reaches 80V the two Zener diodes D1 and D2 begin to conduct, supplying bias current to transistor TR1. This turns TR1 on and pulls the input to pin 13 of IC1d low, stopping the oscillator to limit the output to 80V.

The use of the Schmitt type gates of a 4093B i.c. ensures a clean switching action. It can be seen that as all the gates of IC1 invert, stopping the oscillator in this way results in a low output to TR2 so that it is "off".

This simple circuit can supply a couple of milliamps at 80V from a supply of just over 6V, making it suitable for operation from a PP3 battery.

PULSE GENERATION

Progressing to the pulse generator this is built with the six inverting buffers of IC2, a CMOS 40106B. Again these are Schmitt types for bounce-free switching.

The prime mover, so to speak, is the astable formed by IC2f and IC2e, which runs at about 120Hz whilst diode D5 is reverse-biased. The output from this is differentiated by capacitor C6 and resistor R12 to drive IC2d so that positive pulses

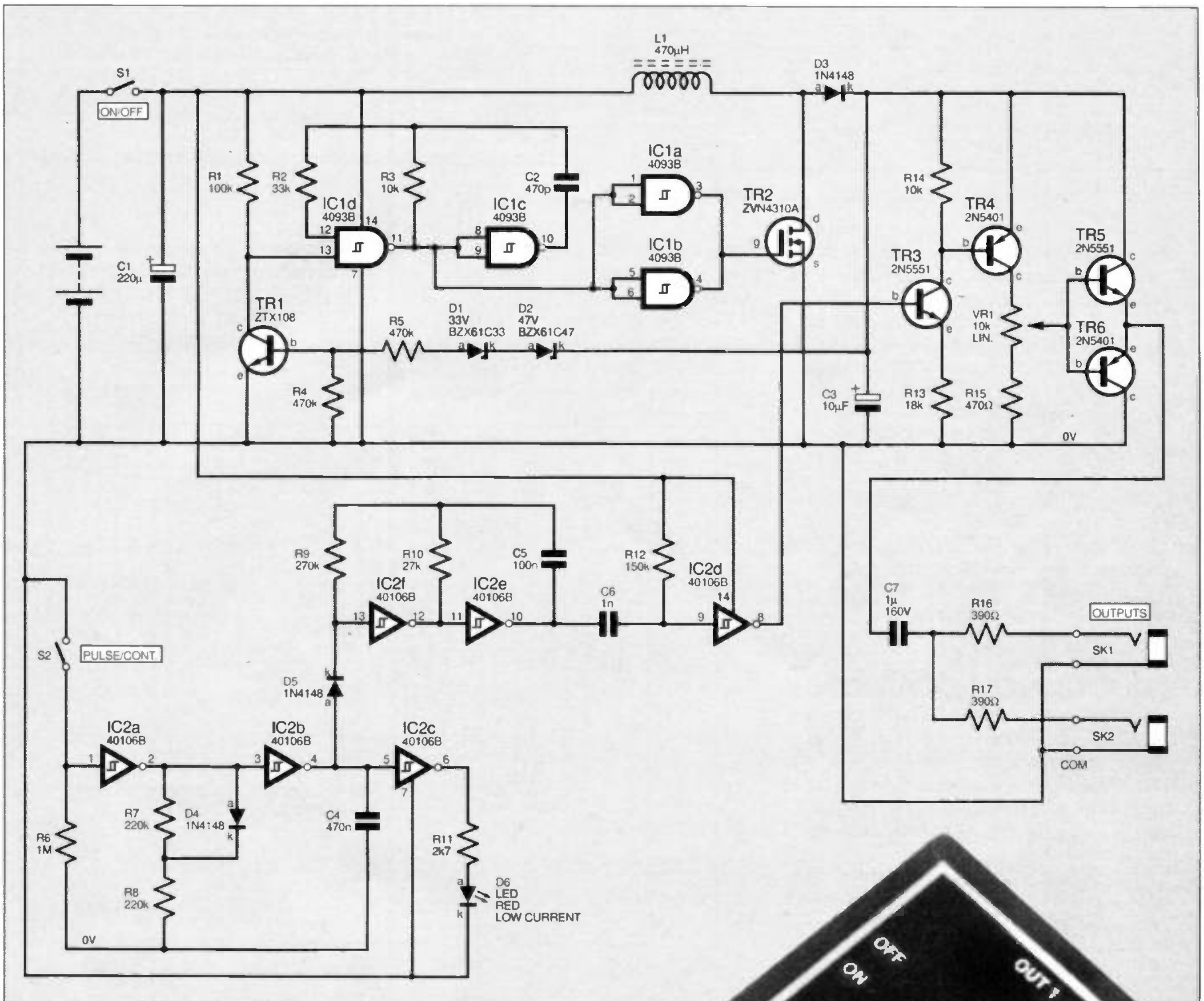


Fig. 1. Full circuit diagram for the Dual-Output TENS Unit.

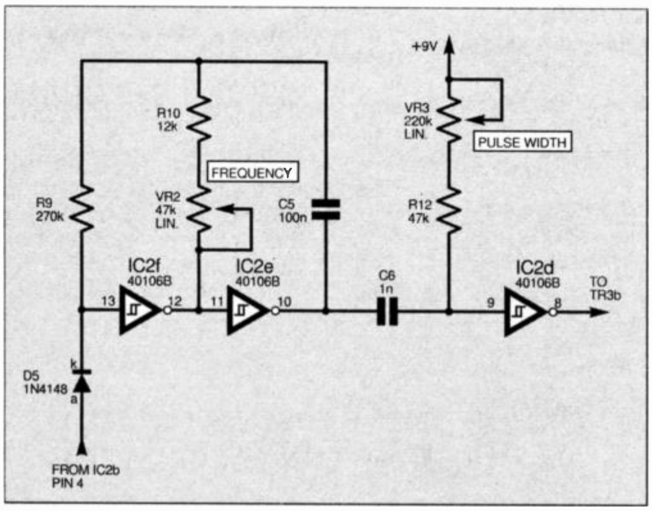


Fig. 2. Circuit modifications for pulse width and frequency experiments.

HOME HELP

Readers with *Internet* access will be interested to hear of a new *EPE* World Wide Web resource which offers more background and specific information on the correct use of TENS units, to help counter back pain and other ailments in an appropriate manner.

This material has been researched and specially written for us by Julia Kidson, a chiropractor working in association with the Anglo-European College of Chiropractic (AECC), in Bournemouth, Dorset, the largest college of its type in Europe. *Everyday Practical Electronics* is extremely grateful for the assistance and co-operation offered to *EPE* by all concerned, especially Julia and Dr. H. Thiel of AECC.

Please check our Web Site Home Page for the latest details, plus links to the new AECC Home Page and EPE TENS Page, on **http://www.epemag. wimborne.co.uk./index htm.**

A printed version is available for non-Internet users from the Editorial Offices 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 information is Free with all p.c.b. orders (see *EPE PCB Service* page).

of about 130µs appear at the output pin 8. This is the "Continuous" output mode.

If switch S2 is opened, the second astable built from IC2a and IC2b runs at about 2Hz. Whilst the output from IC2b is positive, D5 conducts and stops the first oscillator. The two resistors R7 and R8 with diode D4 give this second astable an uneven mark-space ratio, so that the output is present for about a third of the time on average – "Pulse" mode.

When S2 is closed the output from IC2b is permanently low, reverse-biasing D5 for continuous output. The gate IC2c drives l.e.d. D6, which is illuminated continuously during continuous output and flashes in the "Pulsed" mode.

PULSE WIDTH/ FREQUENCY CONTROL

The action of this part of the circuit should be much easier to follow than that of the two previous circuits. This will make it simpler for constructors who wish to experiment with pulse width and frequency using the circuit modifications as shown in Fig. 2.

Resistor R10 controls the frequency, so replacing it with a 12k component in series with a 47kilohm variable resistor (potentiometer) VR2 should give a frequency range of about 50Hz to 270Hz. R12 controls pulse width, so replacing it with 47k resistor in series with a 220k potentiometer (wired as a variable resistor) VR3 should give a pulse width of about 40µs to 230µs.

Control of the pulse width should be fairly linear but, being the reciprocal of the period, the frequency control implemented in this way will be non-linear, although still useable. These are calculated values, in practice some experiment will be needed.

OUTPUT CIRCUIT

The output stage is similar to that of the previous designs with 2N5551 and 2N5401 transistors to control current from the high voltage supply. When the output of IC2d is "high", it applies the supply voltage of 9V to the base (b) of transistor TR3. Most of this voltage appears at TR3 emitter (e), causing a current of about 0·5mA to flow through this resistor into the emitter and out through the collector (c) of TR3 into the base of TR4.

This turns on TR4 so that the 80V supply appears across Amplitude control VR1. An adjustable proportion of this is taken from VR1's wiper to drive the emitter-follower pair of transistors TR5 and TR6, which provide power for the output pulse.

Capacitor C7 ensures that the average d.c. current from the output is always zero to prevent electrode polarisation problems. It also prevents a continuous d.c. voltage appearing across the electrodes if a fault should occur.

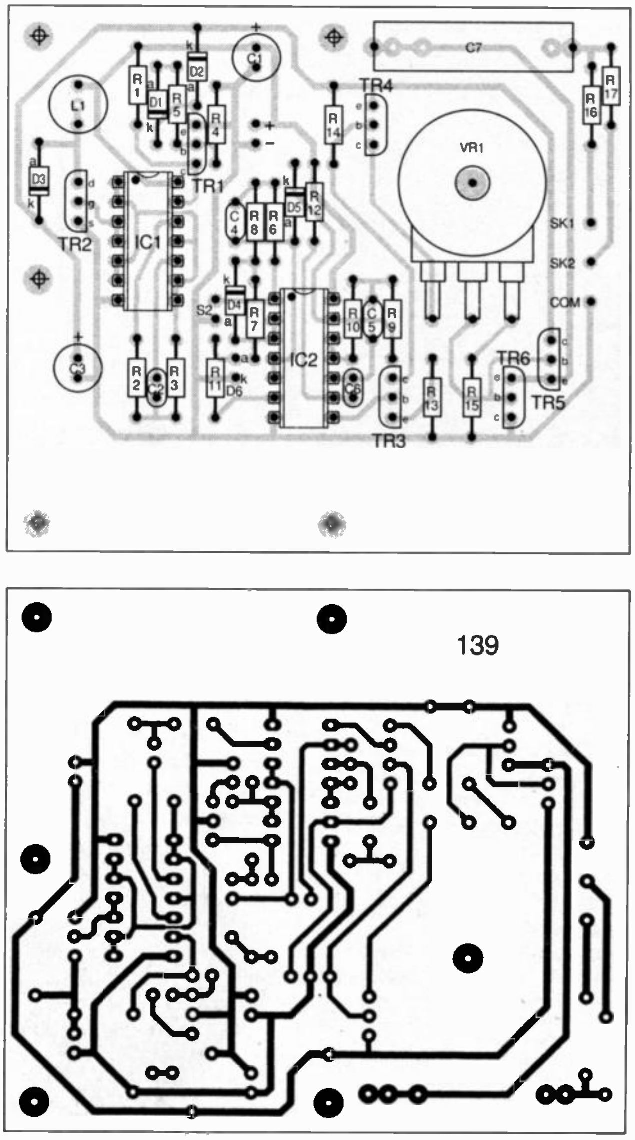


Fig. 3. Printed circuit board component layout and full size underside copper foil master pattern for the Dual-Output TENS Unit.

The output is capable of driving two pairs of electrodes simultaneously, so two sockets, SK1 and SK2, are provided, wired in parallel. The two series resistors R16 and R17 prevent damage if the electrode leads are accidentally short-circuited, and also encourage current sharing when two pairs of electrodes are in use.

COMPONENTS

Resistors

R1	100k
R2	33k
R3, R14	10k (2 off)
R4, R5	470k (2 off)
R6	1M
R7, R8	220k (2 off)
R9	270k
R10	27k
R11	2k7
R12	150k
R13	18k
R15	470Ω
R16, R17	390Ω (2 off)

All 0·6W 1% metal film

See SHOP TALK Page

Potentiometer

VR1	10k rotary carbon, linear

Capacitors

C1	220µ radial elect. 16V
C2	470p resin-dipped ceramic
C3	10µ radial elect. 100V
C4	470n resin-dipped ceramic
C5	100n resin-dipped ceramic
C6	1n resin-dipped ceramic
C7	1µ polypropylene 160V or 1µ polyester 250V

Semiconductors

D1	BZX61C33 33V Zener diode
D2	BZX61C47 47V Zener diode
D3, D4 D5	1N4148 signal diode (3 off)
D6	3mm low-current type l.e.d.
TR1	ZTX108 *npn* silicon transistor
TR2	ZVN4310A *n*-channel MOSFET transistor
TR3, TR5	2N5551 *npn* silicon transistor (2 off)
TR4, TR6	2N5401 *pnp* silicon transistor (2 off)
IC1	4093B CMOS quad 2-input Schmitt NAND gate
IC2	40106B CMOS Hex Schmitt inverting buffer

Miscellaneous

L1	470µH ferrite-cored miniature choke
S1, S2	d.p.d.t. sub-min. slide switch (2 off)
SK1, SK2	3·5mm mono jack socket (2 off)
PL1, PL2	3·5mm mono jack plug (2 off)
B1	9V battery (PP3), with connector clip

Printed circuit board available from *EPE PCB Service*, code 139; plastic ABS case, size 145mm × 80mm × 34mm with battery compartment; 14-pin d.i.l. socket (2 off); 2mm test plugs, to fit sockets on most electrodes (4 off); electrodes – see text and *Shoptalk* page; plastic, low-profile, knob; multi-strand connecting wire; solder etc.

Approx Cost Guidance Only £24.50 excl. Batt. & Electrodes

CONSTRUCTION

Assuming the recommended case is to be used, construction should start with a check to see that the printed circuit board (p.c.b.) fits on the five moulded pillars provided for mounting it. It sits on these with the copper side facing them, of course.

The hole for the shaft of VR1 can be marked on the case lid using the p.c.b. as a template before drilling. The holes for the two output sockets and the l.e.d., in the lid top edge, can be marked. The two slide switches S1 and S2, mounted in one side panel of the case lower half, can also be drilled and filed out at this time.

Although dimensions are not critical the p.c.b. has been designed to leave space for these components above and to the right, as viewed from the rear. The general layout can be seen in the photographs.

The printed circuit board component layout and full size underside copper master pattern are shown in Fig. 3. This board is available from the *EPE PCB Service*, code 139.

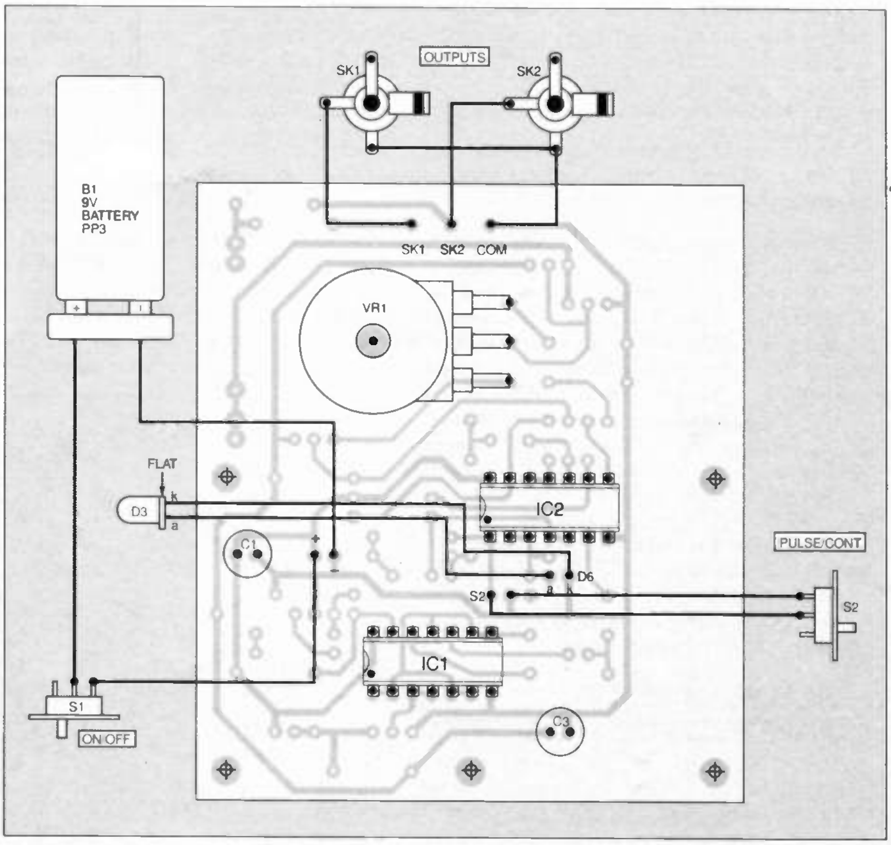
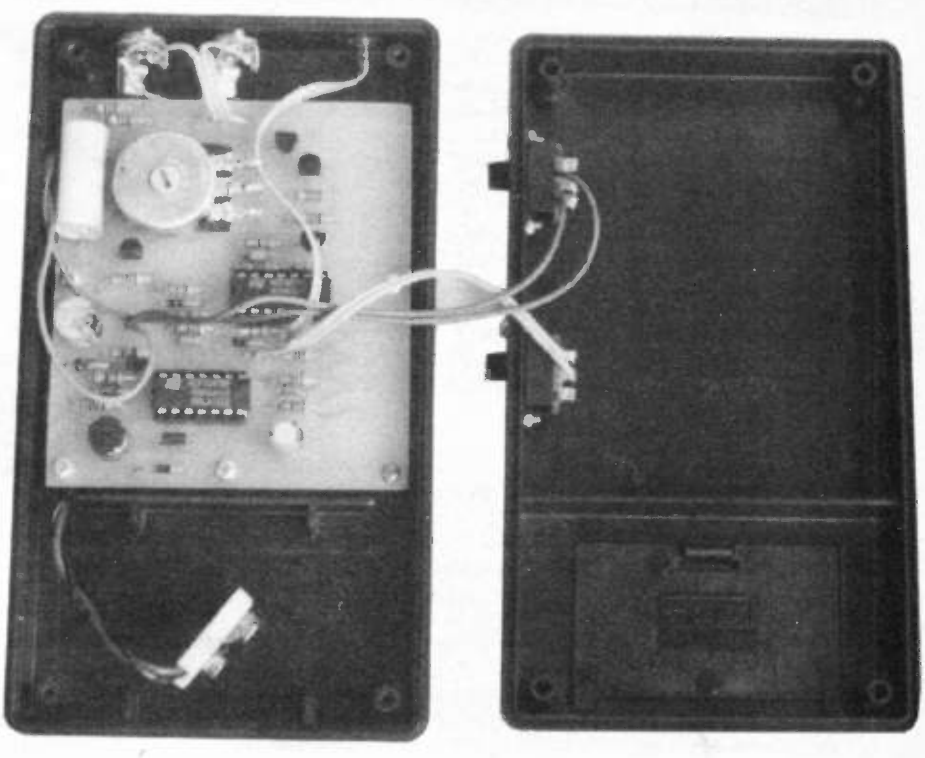
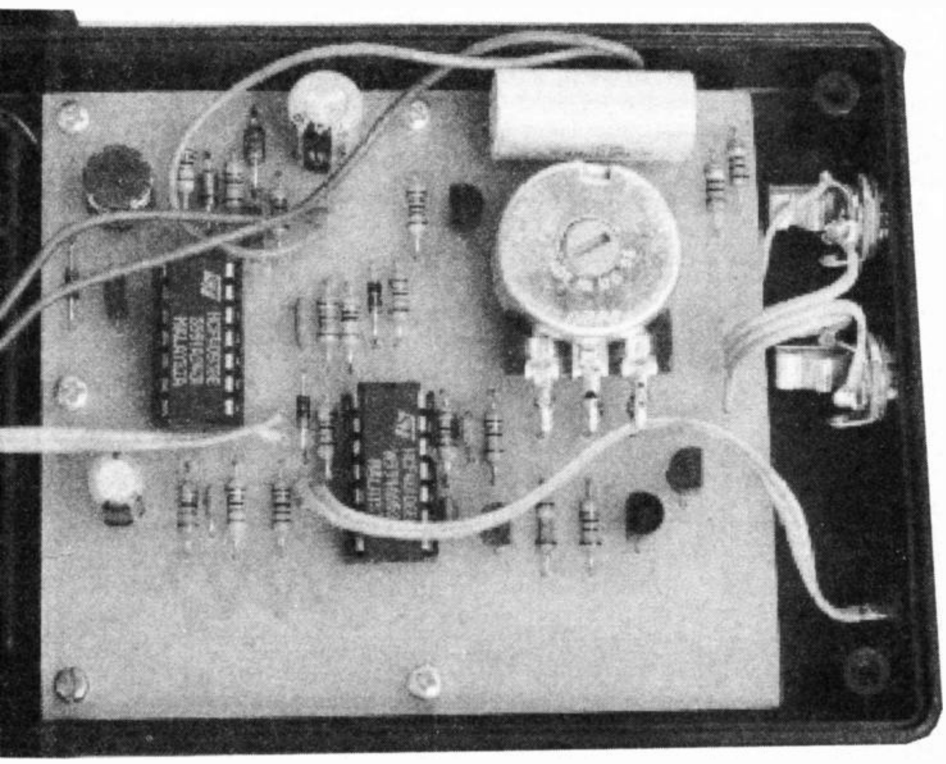


Fig. 4. Interwiring from the p.c.b. to off-board components. The general layout of components inside the case is shown below.



The components can all be fitted to the board next, with the exception of IC1, IC2 and the MOSFET TR2, as shown in Fig. 3. Assembly should be in the usual priority order of physical height, starting with the resistors and diodes, followed by the d.i.l. sockets for the two i.c.s, then the small ceramic capacitors and the remaining components.

Extra care should be taken when fitting components for the voltage converter section around IC1, ensuring that Zener diodes D1 and D2 and transistor TR1 are the correct way round etc. Switch-mode supplies have an unpleasant tendency to self-destruct if not operating correctly, which makes trouble-shooting difficult! Although this is a simple one, it is preferable by far to have it operate properly first time.



Layout of components on the completed printed circuit board.

The Amplitude control VR1 is fitted to the board with the minimum length of mounting bush projecting above the board, just sufficient for the nut and a shakeproof washer. This requires spacing washers or another nut on the other side.

It is best to solder short lengths of wire to VR1's connections before fitting it and pass these though their holes as it is fitted, soldering them to the board after the nut has been tightened. Mounting VR1 on the board in this way allows a small, low profile knob to be used as there is no nut on the outside of the case.

TAKE CARE

For safety, the output capacitor C7 should have the recommended 160V or higher rating. The prototype uses a polypropylene component readily available from a major supplier, but there are also polyester types of adequate voltage rating which could be used instead. Various pad spacings are provided to suit different lead spacings for this component.

Some constructors of the two previous designs encountered problems with transistors having different lead connections to those used in the prototypes. This applied mainly to the BC327/337 types which are not used in this project, but at least one reader reported difficulties with the 2N5401/5551 transistors.

If there is any doubt about these they should be checked before insertion. A simple test is to use a meter to see if they look like two diodes connected back-to-back, with both anodes at the base for an *npn* type and cathodes to the base for a *pnp*.

One of the specified coils should be used for L1 (see *Shoptalk*). Both types were tried in the prototype and gave virtually identical results in terms of efficiency. Copper pads are provided to suit the lead spacing of either.

Although the supply is only 9V, it should be remembered whilst testing that when the converter is operating 80V will be present. The danger of shock is not very great, it's more likely to tickle, but the charge in electrolytic capacitor C3 can easily damage other components through accidental short circuits so precautions should be taken to prevent this occurring. The usual care should be taken to prevent static damage to the CMOS components IC1 and IC2 and the MOSFET TR2.

BOARD TESTING

Following p.c.b. assembly, leads should be connected to the board for power, output, switch S2 and the l.e.d. The l.e.d. can be connected, IC2 fitted and the circuit powered. The l.e.d. should flash, indicating operation of the pulsing astable.

The supply current will pulse in time with it but should be no more than 2·5mA. If the leads for switch S2 are shorted together the l.e.d. should remain on continuously, and the current drawn from the supply should be a steady 2·5mA.

Voltages measured with a meter on IC2 pins 10 and 12 should be around half the supply in this condition, although they

Positioning of the output sockets, l.e.d. and slide switches on the finished unit.

are actually oscillating between the supply rails at about 120Hz. It may be possible to see a voltage indication from pin 8, but due to the narrow pulse width at this point it will be small, a tiny fraction of a volt.

Next, IC1 should be inserted in its socket, see Fig. 3. Without TR2, there will be insufficient voltage for current to flow through Zener diodes D1 and D2 so transistor TR1 will remain "off" and the oscillator will run. Pins 3, 4, 10 and 11 should therefore all give a measured voltage of about half the supply, although actually oscillating at 65kHz.

If this is the case, TR2 can now be fitted, taking care to place it the right way round. It has a small heatsink tab and also a "flat" which should face IC1. The p.c.b. can be powered-up again whilst monitoring the output voltage, a good place to measure this is the cathode (top) of D2, where the 80V supply should be present.

Hopefully, the warnings about this part of the circuit won't discourage potential constructors as the components used, including TR2, are actually quite robust. They took a lot of punishment during circuit development and testing and there have been no failures to date.

FINAL ASSEMBLY

Following this it remains only to fit the board into the case and connect it to the switches, output sockets and l.e.d. as shown in Fig. 4. Any suitable case can be used of course, but the one specified is quite compact and has a battery compartment to make replacement quick and easy.

With the layout used it would also be easy to fashion a belt clip from sheet metal and bolt it to the rear half. The control knob used on the prototype was chosen for the lowest possible profile, as inadvertent movement of this during use can prove rather disconcerting to the user.

ELECTRODES

Electrodes can be home-made, using cotton wool pads and a salt solution or "K-Y" gel for the contact. *Metal contact with the skin should be avoided as it can cause electrode burns, even with tiny currents.*

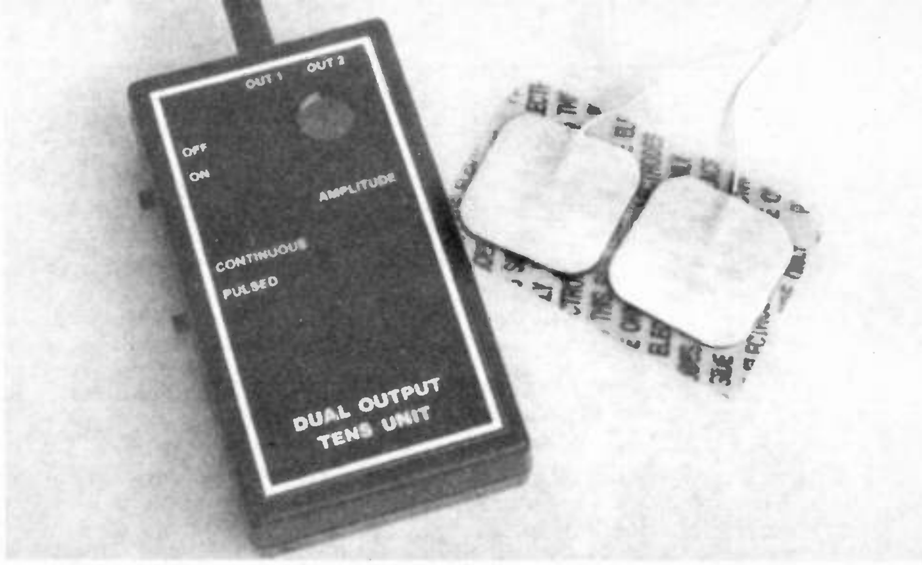
This procedure is likely to be messy however, so it is much better to obtain some self-adhesive electrodes from a commercial supplier. These are very easy to apply and are re-useable so they last for many sessions before having to be replaced. Types measuring about 45mm × 45mm square are suitable for most treatments, and they come with wires terminated with 2mm sockets ready to attach directly to the plugs specified in the Component List. See *Shoptalk* for details of a supplier.

Either or both outputs may be used, two being better for treating large areas or two areas simultaneously. Users intending to use both regularly might like to colour-code the leads for "output" and "common", to assist in positioning experiments.

The ***warnings*** about siting electrodes (see "Please Note" panel) should be read carefully before placing them. In general they are placed either side of the source of pain. For lower back pain and sciatica, one either side of the base of the spine is recommended.

Although for obvious reasons they SHOULD NOT normally be placed on the head, TENS is recommended for trigeminal neuralgia, where they are placed on the *same side* of the head, one at the back of the jaw and one just in front of the ear.

The electrodes should NOT be sited where current might pass across the heart, and as the two outputs of this project are connected in parallel this point should be remembered where two pain sites are being treated simultaneously. Users of *Pacemakers SHOULD NOT* use TENS, especially where the pacemaker is of the "demand" type as this might interpret a TENs pulse as a signal from the heart. ***Where there is any doubt a Doctor MUST be consulted.***



Completed TENS unit with commercial electrodes plugged in ready for the "patient".

TREATMENT

Treatment usually lasts for 20 to 30 minutes, though a lady of the author's acquaintance used one almost continuously whilst awaiting surgery for a very painful back condition without any apparent ill-effects.

The electrodes are set in place, and the Amplitude control turned right down before switching on. Then it is increased until a pleasant tingling is felt, which indicates the correct setting.

After a while the body usually becomes accustomed to the current so the tingling diminishes, and the amplitude should then be increased until it can be felt again. If the relief obtained lessens, or a long session is required, it may be advisable to try the Pulsed mode instead of the Continuous one.

Average current consumption during use depends on the amplitude setting, but will normally be about 10mA to 20mA. For long-term use NiCad batteries or an external battery pack could be used, but for safety ***this unit must NEVER be used with any kind of mains adapter.***

Current research states that about 70 per cent of TENS users obtain worthwhile relief, though feedback concerning the two previous designs suggests it may be even higher than this. One final important point to note is that TENS only *relieves* symptoms. It does NOT cure anything. **Anyone suffering persistent pain for no apparent reason should consult a doctor.** □

FOX REPORT

by Barry Fox

FAB INTEL PIPS APPLE

Sobering thought. If Apple had licenced the Mac Operating System, Motorola would now be where Intel is today.

Apple's refusal to licence let Microsoft make a success of DOS and Windows, which in turn made Intel the world's largest manufacturer of microprocessors; 75 per cent of the world's PCs using Intel CPUs. Last year Intel's revenue was $16·2 billion, with a profit of $3·6 billion of which $3·5 billion was invested back into research and building new chip factories or "fabs".

Intel lays claim to the world's first microprocessor, the 4004, released a quarter of a century ago on November 1st 1971. It replaced 2,300 transistors with a single silicon slice, processed 60,000 instructions a second, and came from a wafer fabrication plant that cost $1 million to build. The 4004 was designed for Japanese company Busicom to use in a calculator. Intel company founders Gordon Moore and Bob Noyce bought back all rights on the 4004, paying an ailing Busicom the $60,000 development cost.

The 4004 took two engineers nine months to develop. First they built a breadboard model and used an oscilloscope to check performance. The fab workers used tweezers to load the silicon wafers onto quartz boats, which they then pushed into red hot furnaces.

The latest Pentium Pro processor replaces 5·5 million transistors, performs 300 million instructions per second and is made in fabs which cost £1·5 billion to build.

The 4004 cost $200 (much the same as a Pentium today) and worked with 4-bit words. Then came the 8008, the first 8-bit chip; the 16-bit 8086 followed in 1981. The big break came when IBM chose the 8-bit 8088 as the heart of its first PC.

BIT OF HISTORY

In 1982 IBM used the 16-bit 286 (equivalent to 134,000 transistors) for the PC-AT. The 32-bit 386 (equivalent to 275,000 transistors) followed in 1985, with the 486 (1·2 million transistors) in 1989 and the first Pentium (3·1 million transistors) launched in 1993.

Intel now has 17 fabs round the world (numbered up to 18 because there was no fab 13). There is one in Ireland (fab 10) which makes all the Pentium processors for Europe, with another (fab 14) already under construction. A workforce of 3,500 works 24 hours a day, seven days a week in two twelve hour shifts to keep the furnaces running.

Intel is understandably reluctant to release too much inside information. But on some occasions the company's secrecy just makes it look foolish.

Like all modern microprocessors the Pentium is built by depositing layers of oxide and metal doping layers on the silicon surface. How many layers? The factory tour guide in Ireland will not say. But Intel's own publicity literature talks of 20 layers and 300 deposition and ion implant processes.

Intel uses 8-inch silicon wafers, with 0·6 micron line ruling. The wafer area is divided into a mosaic of Pentium chips, which are then diced and packaged, after the attachment of connecting pins. How many Pentiums per wafer? Again the factory guide will not say. But in the entrance hall to the factory there is a decorative plate made from a wafer of Pentium chips. It takes only a moment for a visitor to do a rough count and find that each wafer can generate 150 Pentiums.

YIELDING INFO

What is the yield? How many good chips can you get from each wafer? Just as CD pressing plants refused to talk of yields in the early days, Intel refuses even to hint at yield.

CD yield in the early days was less than 10 per cent, with nine CDs thrown away for every good one pressed. The manufacturers only admitted this when they had reversed the ratio, to 90 per cent yield. Today's CD yield is in the high 90s.

Pentium yield is likely still to be much lower than CD yield. One speck of dust can "kill" a chip. Air in the sensitive areas of the fab is purified to class 1, which means that there is only one particle of one micron size per 30 litres of air. The air flows from the ceiling down to ducts in the floor, with higher pressure inside the fabs than outside to prevent any leakage in from the dirty outside. Air flow is fast enough to create a complete change once every ten seconds. Workers must wear full protective clothing, with mouth masks to catch any moisture droplets from a cough or sneeze.

This level of air purity is a thousand times that of a hospital operating theatre. But it is still not clean enough to prevent some foreign particles falling by random on some parts of the wafer.

DUSTING OFF THE CRYSTAL

How do we know? Because of this it is still near impossible to make a large LCD screen without any faulty pixels. Sometimes they are painfully visible, especially if the fault is near the centre. Look closely at any fine pitch LCD screen and there is a good chance you will spot at least one pixel that does not switch its colour. Other faults are disguised by gang-switching neighbouring pixels.

Bear in mind that there are only 100,000 or so pixels on an LCD screen and they are large enough to be clearly visible to the naked eye. Now compare that to the five million transistors on each of the 150 Pentium chips on a single 8 inch wafer, with vital connecting parts measuring only 0·6 microns, which is around one-hundredth the width of a human hair. Now you get an idea of how difficult it is to make a perfect chip.

PRE-CHIP FAULT CHECKS

This is why chip manufacturers like Intel have now developed techniques to identify faulty chips before they are diced from the wafer. This saves the cost of attaching connecting wires and packaging a chip that will later have to be thrown away.

Reference transistors are formed between the Pentium chip areas. Applying a test probe to these transistor areas gives a broad indication of whether the overall wafer is good or bad. At the end of the wafer process further probes are used on the areas of the chips which will later be attached to connecting wires.

Texas Instruments claims that it can now work at 0·18 micron line spacing. All the manufacturers are hoping to move from 8 inch to 12 inch wafers. A smaller line spacing means more chips from a given area and a larger wafer means more chips per process.

The trade-off is that smaller line spacing means reduced yield. Larger wafers are more difficult to handle because they bow out of absolute flatness and this destroys the focus of the UV optics used to expose an image of the chip architecture on the photoresist coatings.

Intel claims that it has not yet decided what line spacing and wafer size it will use for fab 14 when it opens in two years time. By then the Pentium will be old hat. It is already scheduled for replacement by a new series of chips.

New Technology Update

Semiconductor technology has come a long way since the first transistors were invented in the late 1940s – reports Ian Poole.

DESPITE the time for which semiconductor technology has been available, there are still only three semiconductor materials which are in common use: silicon, germanium, and gallium arsenide. Of these silicon is by far the most widely used.

Although only three materials are in common use this does not mean that they are the only ones which can be employed. There are many other materials which exhibit semiconductor properties, and some are now beginning to be used.

The first of these, silicon carbide has been under investigation for some time. However, its development has been restricted by the difficulties found in manufacturing substrates with sufficient quality.

TOUGH GOING

One of the main advantages of silicon carbide as a material is its extreme toughness. It will enable semiconductors to run at much higher temperatures allowing them to operate in areas where current devices cannot.

Apart from its temperature resilience, silicon carbide has a voltage breakdown which is about ten times that of silicon as well as having a much greater thermal conductivity. It has also been shown that it has a greater theoretical power density handling capacity. These properties make it a candidate for use in a number of applications.

One area of particular interest is that of sensors. Here silicon carbide semiconductors will allow sensors to operate in environments were temperatures rise as high as 600°C, which is well in excess of that for silicon.

In another application, silicon carbide is ideal for high power devices. In particular, a number of the devices to be used in the next generation television transmitters may well be silicon carbide. Again their reliability and heat resilience means that they are ideal for these applications.

To allow silicon carbide to be used, the processing techniques have been improved. The main defects which have been encountered in the material are called micropipes. These are minute discontinuities in the crystal structure that result in very small pin holes appearing in the wafers. Now the crystal growth techniques required to produce the bulk semiconductor have been improved to a sufficient degree to enable them to be used more successfully and cut right down on the "pin hole" effect.

To prove the success of the improvements, one example of a silicon carbide device is a static induction transistor. This was demonstrated giving an output of 450W at 60MHz. Further developments of this material are likely to produce devices capable of giving higher powers at higher frequencies.

GOING ORGANIC

One of the ways in which major advances are made is to take a completely new look at the way processes are undertaken. In one new development it may be possible to print semiconductors onto either rigid or flexible substrates. To achieve this a new generation of plastic semiconductors is being developed. These are intended to be cheap, and able to be used in a very wide variety of low cost applications.

Another aspect of the technology which will bring a host of new applications is the fact that they are plastic or polymer based, and as such they can withstand bending, a feature which is totally new to semiconductors. Whilst this feature may not always be used in a direct fashion, it will add a considerable degree of reliability to any devices.

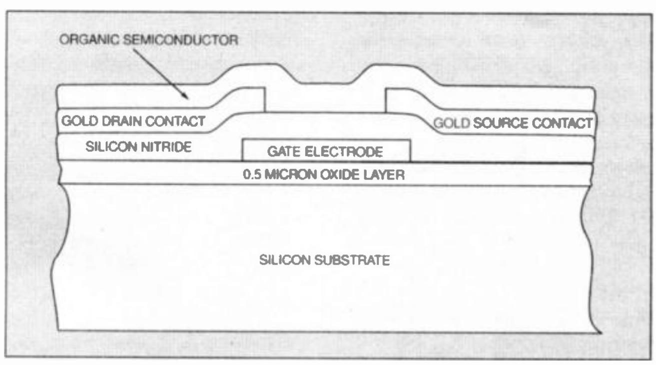


Fig. 1. A "plastic" field effect transistor.

The technology is based around some organic semiconductors. The polymers exhibit semiconducting properties, but until recently the difficulty has been that current would only flow along the polymer chains, but not from one chain to the next. Recent developments have succeeded in overcoming this by the use of molecules which allow the transfer of current more easily, thereby improving the overall electron mobility.

The fact that organic materials can exhibit semiconducting properties has been recognised since the 1980s, but they have not been able to be used until recently. Early attempts at producing plastic or polymer transistors did not give any voltage gain – a prime requirement before any circuits could be made. Now it is possible to make practical transistors which are capable of giving some gain, although their performance is such that they will not be able to compete with the performance of most silicon transistors.

Work has also been undertaken in using these transistors as part of larger integrated circuits. They have been used in simple inverters and NOR gates for logic circuits and in a ring oscillator.

EARLY TRIALS

These early circuits have been built up on a silicon substrate with a 0·5 micron oxide coating. Polysilicon gate contacts which are heavily doped with phosphorus are then deposited. This is followed by laying down a silicon nitride gate insulation layer and then depositing gold for the drain and source contacts. The final stages in the process involve depositing a 30nm film of the organic semiconductor to make the channels as shown in Fig. 1.

Although these prototype circuits have been manufactured using a silicon substrate for convenience, there is no reason why other substrates could not be used. This is just one of the areas in which progress is being made. Other development areas for the future are to improve and refine the printing techniques which can be used to deposit the organic semiconductor in the required areas. The aim is to enable very low cost circuits to be made by using techniques which do not require the high levels of technology required for normal semiconductors.

In terms of the performance of the circuits the main holding point at the moment is the fact that carrier mobility levels are still relatively low. However, it is anticipated that switching speeds of around 50kHz may soon be achievable with further increases and improvements attainable in the more distant future.

Plastic transistors represent a totally new and interesting departure from the more usual line of semiconductor developments. They are likely to find uses in a wide variety of areas, many of which have still to be conceived.

However, their low cost and variety of materials which can be used for substrates mean that they are likely to be seen in increasing numbers in the coming years. Development is still in its early stages, and this means that it will be a few years before they can gain wide acceptance, but despite this they represent a development which could have far reaching effects.

EXHIBITIONISTS

We visit two London exhibitions and report on some interesting finds

TWO exhibitions in London recently demonstrated very different faces of electronics. The Boat Show at Earls Court provided a window on the high tech world of satellite navigation, communication and management systems used on modern leisure craft. Everything from battery charge indicators to fully integrated instruments and even a hand-held global satellite communicator – almost the staff of *Star Trek*.

Magellan GSC100 anywhere to anywhere communication and navigation.

We have picked out just a handful of items – interesting for various reasons – from the hundreds of products available; we could have filled the whole magazine.

Starting with the very latest; from Magellan comes the GSC100 the world's first hand-held global satellite communicator. Using the ORBCOMM low-earth-orbit personal satellite system this unit allows you to communicate by E-mail from anywhere on earth. Almost as a sideline the GSC100 also provides an integrated GPS receiver to identify your position, chart your course or follow your progress on the track plotter etc. It's not particularly cheap at £995 but for the man who has everything it's the ultimate.

If you can't wait to buy one contact Next Destination Ltd. (we like that!) **Dept EPE, 25 The Clarendon Centre, Salisbury Business Park, Salisbury, Wilts SP1 2TJ. Tel. 01722 410800 Fax. 01722 410777.**

Also employing those useful satellites is a whole raft of safety beacons or EPIRBs – Emergency Position Indicating Radio Beacon. Small enough to wear around the neck the PLB7 from Sea-Marshall Rescue Systems costs around £100 and could automatically (it goes off when immersed in sea water) save your life. The usefulness of EPIRBs has been amply demonstrated by the recent Southern Ocean rescues.

The PLB7 EPIRB.

Sea-Marshall Rescue Systems, Dept EPE, Louis Pearlman Centre, Goulton Street, Hull HU3 4DL. Tel. 01482 586137 Fax. 01482 585161.

For shore based sailors, or those who just want to keep an eye on the weather from home, the neat Weather Wizard III gives a readout of inside and outside temperature (including high and low, with alarms), 12 or 24 hour clock with date and alarm, wind direction, wind speed (including high wind speed with alarm) plus wind chill (with low chill and alarm). You can link into a PC or Mac to record the readings with an optional interface and also add a rain-

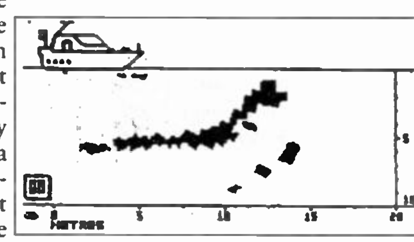
Weather Wizard III.

Weather Wizard sensors.

fall meter. Cost of the Weather Wizard III is about £200 but lower specification units are available from £150.

Made by Davis Instruments in the USA the units are available from ICS Electronics Ltd, **Dept EPE, Unit V, Rudford Industrial Estate, Ford, Arundel, W. Sussex BN18 0BD. Tel. 01903 731101 Fax 01903 731105.**

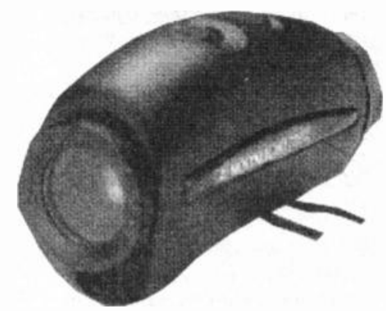
Echo sounders are pretty standard items on any craft over about 18 feet these days and one that can look up to 100 metres or more in front of the vessel has obvious advantages. The EchoPilot FLS (Forward Looking Echo Sounder) is microprocessor controlled and provides an l.c.d. display of the sea bed ahead, plus digital depth readout and shallow water alarm. It is even possible to add a log transducer to provide speed and log on the same instrument. FLS sends out a beam of ultrasound covering an area 15 degrees on either side of the boat's course and scanning from sea level to straight down. Reflected signals are processed by the unit to provide a two dimensional display of the sea bed at three to five times the depth ahead when on a flat muddy bottom. This ratio increases up to eight or nine times if the seabed shoals upwards, and items such as rocks can be seen at 100 to 150 metres.



EchoPilot FLS display showing rocks ahead. Digital depth reading is in the bottom left corner.

Echopilot Ltd are at **Dept EPE, 75/77 Christchurch Road, Ringwood, Hants BH24 1DH. Tel. 01425 476211/2 Fax. 01425 474300.**

This years "must have" gadget is undoubtedly the palm size monocular type night viewer. Development of these "see in the dark" miracles from complex armed forces equipment to neat, easy to use viewers has been spectacular. There were plenty of different types on display for £250 to £350 but we spotted one in the latest Bull Electrical catalogue (see opposite), it's the Moonlight Mini Night Sight and costs £249.



Moonlight Night Sight.

GOOD BETT

The BETT '97 exhibition at Olympia – it overlapped with the Boat Show in early January – proved fascinating for those from outside of the world of education. BETT stands for British Education Training Technology. Those readers who left school more than a few years ago, or who never received any education in what is now called technology, would be fascinated by the hundreds of products available to educationalists to help train students for virtually any engineering discipline. Again we have picked just a few items from the hundreds on display.

If you thought LEGO was just for fun and building toy houses, think again, the LEGO Dacta range, sold directly to schools and colleges, is an eye-opener with a complete Control Lab linked to PC, Mac or Acorn with mouse controlled software and full project material. There is an Intelligent House for the 9 to 13 age group where a computer can be used to control a satellite dish, room fan, security lights or garage door. The house has a fire alarm and intruder detector.

The Dacta Control Lab.

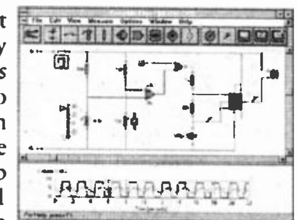
Dacta Pneumatics packs introduce air power and can be used to simulate real-world industrial equipment under computer control. The introductory pack costs about £20 and the range goes up to the Air Power Total Solution Class Pack at nearly £800.

The Dacta range covers a whole lot more besides – contact LEGO Dacta (UK), Dept EPE, Ruthin Road, Wrexham LL13 7TQ. Tel 01978 296293. E-mail LEGODACTUK@AOL.COM.

Talking Technologies can supply the answer to the one finger typists dream – VoicePad Pro turns a PC with Soundblaster 16 into a voice operated system. Once the microphone is plugged in and the CD software is installed your 486/75 can recognise speech. It looks just like the word processor with Windows 95 but you can forget the keyboard or the mouse, everything is voice operated, all you do is talk – or so the sales pitch goes. At only £79 plus VAT it's got to be worth a try. You can also have Kurzweil VOICE for £299 plus VAT. VOICE prioritises 30,000 words you want to use from its list of 200,000 and listens to the way you say them to recognize them easier as you use it – I wonder if the EPE editorial staff know 30,000 words?

Talking Technologies Ltd are at Dept EPE, 34A Glazbury Road, London W14 9AS. Tel 0171 602 4107 Fax. 0171 603 2109. E-mail talk@easynet.co.uk. Web site www.talk-systems.com.

Finally some more software that caught our eye – there was plenty of it at BETT '97. Crocodile *clips* looks like a simple package to teach electronics, you can draw on screen circuits and test them. The sales blurb says "Drag and drop components from any of the 11 toolbars. Connect them up with the Reel-of-Wire. See your circuits spring into life as you draw them!"



Crocodile Clips screen display.

The Windows version is available in English, French and German (it is also available for Mac) and, from the basic information we have, it looks capable of fairly complex circuit simulation, up to a few basic ICs at least.

Free demonstration software can be downloaded from www.crocodile-clips.com/education/ or contact Crocodile Clips, Dept EPE, 11 Randolph Place, Edinburgh EH3 7TA, Scotland. Tel. 0131 226 1511 Fax. 0131 226 1522. E-mail sales@crocodile-clips.com.

DUAL THERMOSTAT

NO DOUBT many of you will be familiar with the much-loved LM35 series of temperature sensor i.c.s. They have come to be the standard heart of many temperature orientated projects.

Warmly received, then, could be the newest member of National Semiconductor's growing family of integrated temperature sensors, the LM56.

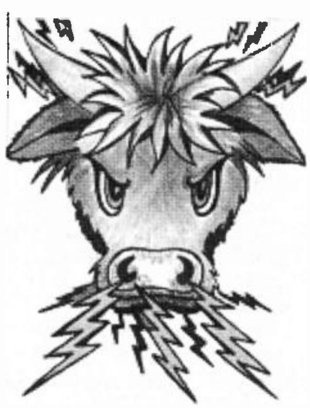
This device is a low-power dual thermostat with digital outputs. The LM56 combines an integrated temperature sensor, two comparators and a voltage reference in the same i.c. With the addition of three external resistors, you can set up a thermostat-type function that is fully programmable over the operating temperature range (−40°C to +125°C). An additional analogue temperature output offers 6.25mA/°C with excellent voltage linearity.

Capable of operating from a 2·7V power supply, the LM56CIM requires 230mA (max) quiescent current. A slight drawback for home constructors is that it appears to be available only in the SO package, which is the surface mount style.

For data sheets and user information, please call National Semiconductor European Customer Support Centre on 00 49 180 5327 832, or visit their World Web Site at http://www.national.com.

Cat and Bull Story

BULL Electricals' catalogue may look slender, but it's packed with fascinating products, such as bugs and kits, nightlights and nightsights, magnets and microscopes, telescopes and torches, magic balloons, hot-air balloons, satellite navigation and much



more as well – there's even a Moonshine Bible for sale – how to distill alcohol from vegetables etc!

Established for more than 50 years, Bull obviously know what's what when finding things that will interest all sorts of tastes, as this 32-page booklet proves. Get a copy, don't just take our word for it!

Ring or write Bull Electrical, 250 Portland Road, Hove, Sussex, BN3 5QT. Tel: 01273 203500. *Or you can "net" them via* http://www.pavilion.co.uk./bull-electrical.

Patent It!

THERE'S a new book that will be of great interest to all you budding and practising inventors – Laurence Shaw's *Practical Guide to Patents, Trademarks, Copyright and Designs*, ISBN 0 9508556 2 8.

This matter-of-fact revised third edition of Shaw's easy-to-read work guides the uninitiated through the legal minefield of patent and copyright law. In simple language, it explains how to go about exploiting a new idea and how to put the necessary steps in place to get it protected. Browsing through, it appears to be written in a most readable style and seems highly informative.

Recommended by the Patent Office, the book is a loose-leaf reference work, with 224 pages and 28 tables. Supplements to update the information are to be published twice a year. It is available by mail order only from Bilgrey Samson Ltd., 5th Floor, Metropolitan House, 1 Hagley Road, Edgbaston, Birmingham B16 8TG and is priced at £19.95 plus £2.00 p&p per copy, which will include the two 1996 supplements.

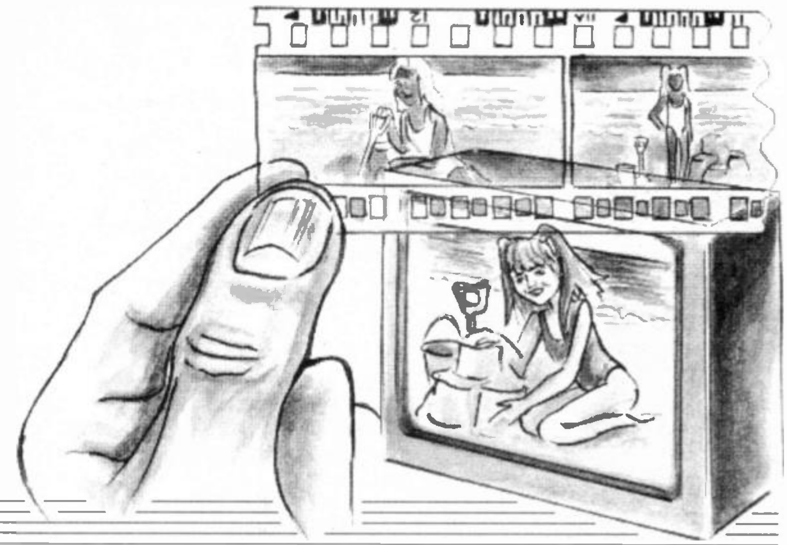
DIGITAL TV REGS

COINCIDENT to our look at Digital TV, both in this issue and in next month's, the DTI have announced new safeguards to prevent anti-competitive behaviour in the digital TV market. The regulations came into force on 7th January 1997.

Says Science and Technology Minister Ian Taylor, "The new provision requires information and co-operation to be provided to broadcasters before services are offered by any entrant to the digital conditional access market, so that those broadcasters can take up this service as soon as it is available".

National Heritage Secretary Virginia Bottomley went on to comment: "The way is now clear for broadcasters to put together imaginative and diverse proposals for digital service to the benefit of viewers".

But is the "gatekeeper" problem yet resolved? (See Barry Fox's *Digital TV*, elsewhere in these pages.) Perhaps the answer will be revealed when copies of the Regulations are made available from HMSO, which will be "in due course".



VIDEO NEGATIVE VIEWER

ROBERT PENFOLD

View those negatives in a new light with this video inverter. Create your own simple "Sci-Fi" special effects.

VIRTUALLY all modern camcorders seem to have a macro facility which enables them to focus down to just a few millimetres in front of the lens. Indeed, with some models it is actually possible to focus on any dust on the front of the lens!

This close focusing ability makes it possible to view slides via a camcorder, a television set, and a simple adaptor that fits onto the front of the camcorder. It is also possible to record "stills" using a VCR, editing them into your home videos if desired.

The adaptor is basically just a diffusor and a holder to carry the slide, although a few include some optics. Any reasonably bright light source can be used to illuminate the slide, with the diffusor helping to eliminate any light or dark patches caused by unevenness in the light source.

Most of these adaptors can also take 35 millimetre film strips, including negatives. The vast majority of amateur photographs are now taken on negative film, and it would obviously be very useful if negatives could be viewed on a television screen via a camcorder.

POSITIVE EFFECTS

However, there is an obvious problem in that the image on the screen would be a negative one, with light areas produced as dark areas, and vice versa. Also, the colours would be the complements of the correct ones (red instead of green, etc.).

The purpose of this unit is to provide an inversion of the video signal, so that negatives can be viewed as positive images having the correct colours. Apart from its intended use of viewing negatives, it could probably be used as a simple special effects unit by those who are into do-it-yourself sci-fi videos.

The Video Negative Viewer is intended for connection between the standard composite PAL output of the camcorder, and the composite video input of a television set or monitor. It will also work properly with the u.h.f. input of a television set via a suitable modulator unit (as supplied with most camcorders).

The unit *cannot* be used directly with a u.h.f. television signal, and it will not work with any form of RGB video signal, or a type which has a separate synchronisation signal.

SYSTEM OPERATION

After experimenting with various systems, the one outlined in the block diagram of Fig. 1 proved to be the simplest that worked well. The waveform diagram of Fig. 2 helps to explain the way in which the unit functions.

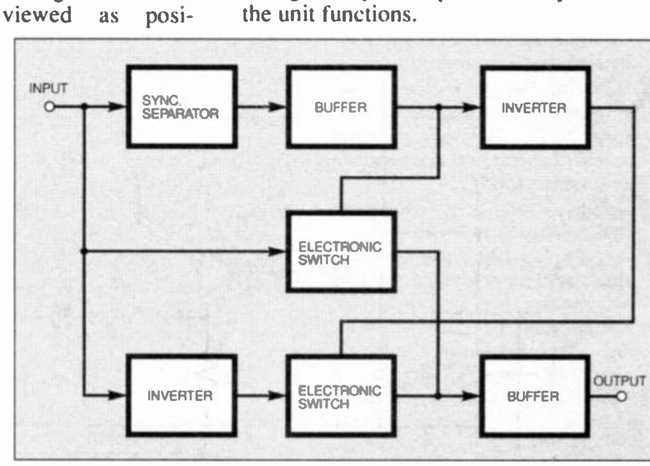


Fig. 1. Block diagram for the Video Negative Viewer.

The top waveform (a) represents two and a bit lines of a video frame. Each line consists of a negative synchronisation pulse first, followed by the high frequency colour burst signal. Then comes the picture signal, which is a positive type with the UK PAL system. In other words, the more positive the voltage, the brighter the corresponding part of the line is made.

Simply inverting the whole signal will not give the desired effect, because the synchronisation signals will also be inverted. The television set or monitor would not be able to lock onto the inverted pulses, and there would be severe break-up of the picture. Satisfactory results are

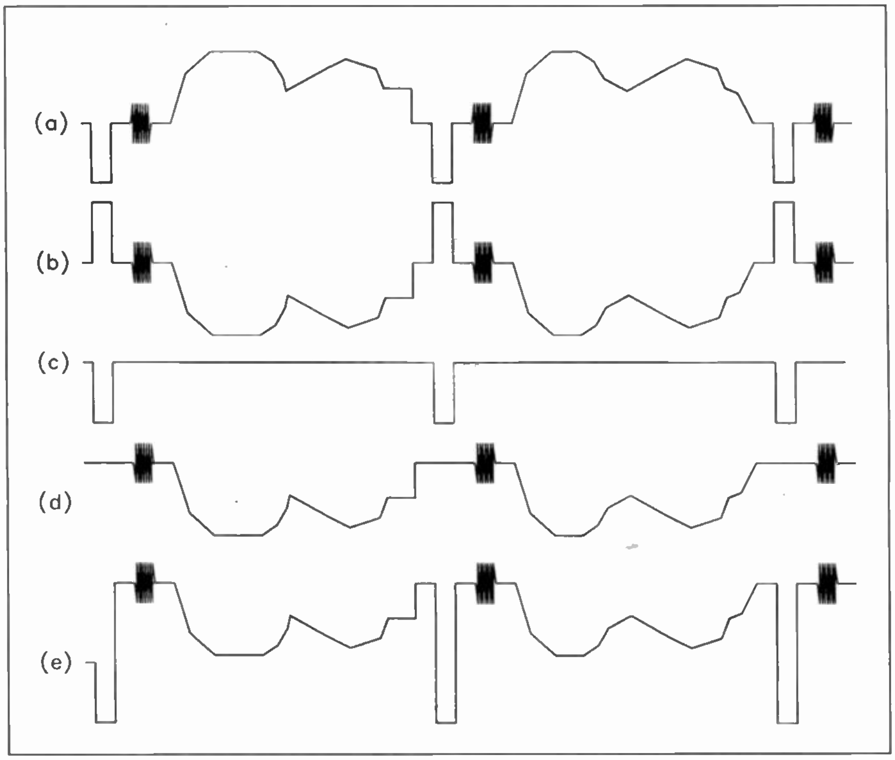


Fig. 2. Typical waveforms at various points in the circuit.

obtained if the synchronisation pulses are left intact, but the rest of the signal, including the burst signal, is inverted.

There are two electronic switches at the heart of the unit. One of these is fed with the unprocessed input signal, and the other is fed with an inverted version of the input signal, see Fig. 2b. This gives the waveform of Fig. 2c from the upper switch, and the waveform of Fig. 2d from the lower switch.

The output signals from the electronic switches are simply mixed together and fed to the output via a buffer amplifier. The latter ensures that the unit has a suitably low output impedance. This gives the output waveform of Fig. 2e, with negative synchronisation pulses and an inverted picture signal.

In order to obtain the required output signal it is necessary to have the upper switch activated during the synchronisation pulses, so that non-inverted pulses are fed through to the output. For the rest of the time the lower switch must be turned on, so that an inverted version of the picture modulation is fed through to the output.

The control signal for the electronic switches is generated using a synchronisation separator. This is basically just a high gain clipping amplifier which removes the picture and colour burst signals, and gives strong output pulses during the synchronisation pulse periods.

A buffer amplifier at the output of the separator stage ensures that the pulses switch cleanly at levels which are suitable to drive the upper switch. The lower switch is driven via an inverter which gives the required anti-phase operation of the switches.

CIRCUIT DESCRIPTION

The full circuit diagram for the Video Negative Viewer is shown in Fig. 3. The synchronisation separator uses transistors TR1 and TR2 as two common emitter amplifiers. The biasing of TR1, and the lack of it for TR2, gives the required clipping action, with the positive picture and colour burst signals being stripped off.

Only two gates, IC1a and IC1b, of a 4001 CMOS quad 2-input NOR gate are used in this circuit. The two gates have their inputs (pins 1/2 and pins 5/6) wired together so that they act as simple inverters. The two unused gates have their inputs connected to the positive supply rail so that spurious operations are avoided.

Signals from the synchronisation separator are processed by IC1a to give pulses that provide "clean" switching from IC2a, which is one section of a

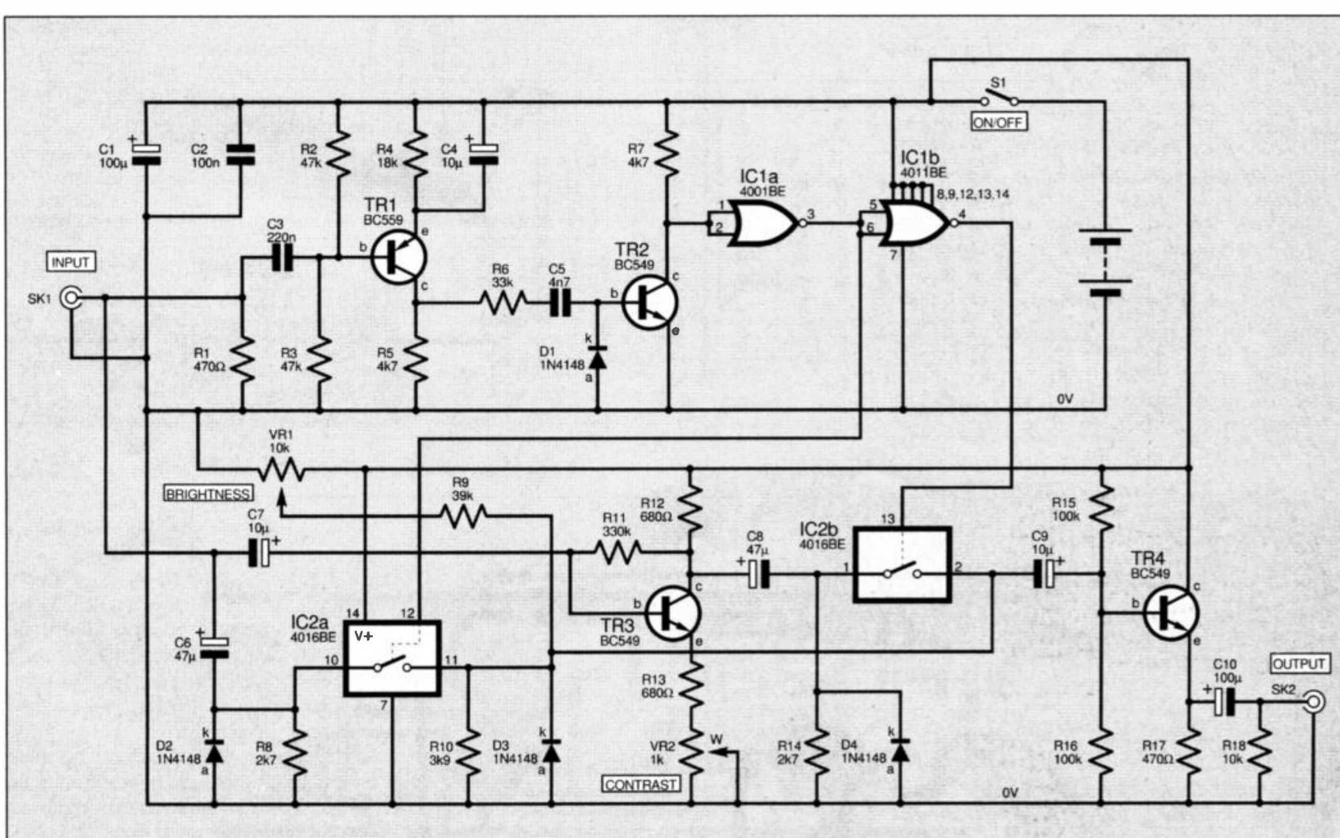


Fig. 3. Circuit diagram for the Video Negative Viewer.

CMOS quad analogue switch. IC1a also provides an inversion which gives the required positive pulses to IC2a.

The anti-phase signal is provided by IC1b for the second electronic switch, which is IC2b. The other two switches in IC2 are not used in this circuit, and no connections are made to them.

Transistor TR3 operates as a common emitter amplifier, and normally a stage of this type provides a high level of voltage gain together with a phase inversion. In this instance it is only the phase inversion through the amplifier that is needed, as it is this stage that inverts the picture modulation.

No voltage gain at all is required. Resistor R13 and potentiometer VR2 are therefore used to provide a large amount of negative feedback which reduces the gain of TR3 to a suitable level. VR2 provides some control over the gain of TR3, and acts as a simple Contrast control.

There is no need for a mixer stage to combine the outputs of the electronic switches, IC2a and IC2b, as they effectively provide their own mixing action. The two outputs, pin 11 and pin 2, are simply wired together.

Diode D2 and resistor R8 form a simple d.c. restoration circuit at the input of IC2a, and similar components are used at the input of IC2b and the outputs of the electronic switches. Their purpose is to prevent unwanted d.c. shifts occurring, which would affect the picture brightness.

Control potentiometer VR1 can be used to deliberately introduce a positive offset to the picture signal, and therefore acts as a Brightness control.

Transistor TR4 is used as an emitter follower, and it acts as the output buffer stage. Electrolytic capacitor C10 provides d.c. blocking at the output.

The current consumption of the circuit is approximately 15 milliamps, and this is provided by eight HP7 size cells in a plastic holder.

CONSTRUCTION

Most of the components for the Video Negative Viewer are mounted on a small printed circuit board (p.c.b.). The topside component overlay for the p.c.b. and the actual size copper pattern are shown in Fig. 4. This board is available from the *EPE PCB Service*, code 135.

Both the integrated circuits are CMOS types, and as such they are vulnerable to damage from high static voltages. Accordingly, both devices should be fitted in holders, but they should not be plugged into place until the unit is otherwise complete. Until then, leave both components in their anti-static packing, and handle them as little as possible when they are being fitted into their holders.

In theory there is some advantage in using a 4066BE for IC2, as this is a faster version of the 4016BE. The 4066BE also has a lower "on" resistance. In practice results seem to be much the same whichever of these two devices is used, so it is a matter of using whichever you can obtain the cheapest.

The order in which the other components are fitted is not too important, but it is advisable to fit the resistors and capacitors first, and then the semiconductors. Make sure that the diodes and electrolytic capacitors are fitted the right way round. Fit single-sided solder pins at the points where connections to the controls and sockets will be made.

CASE AND ASSEMBLY

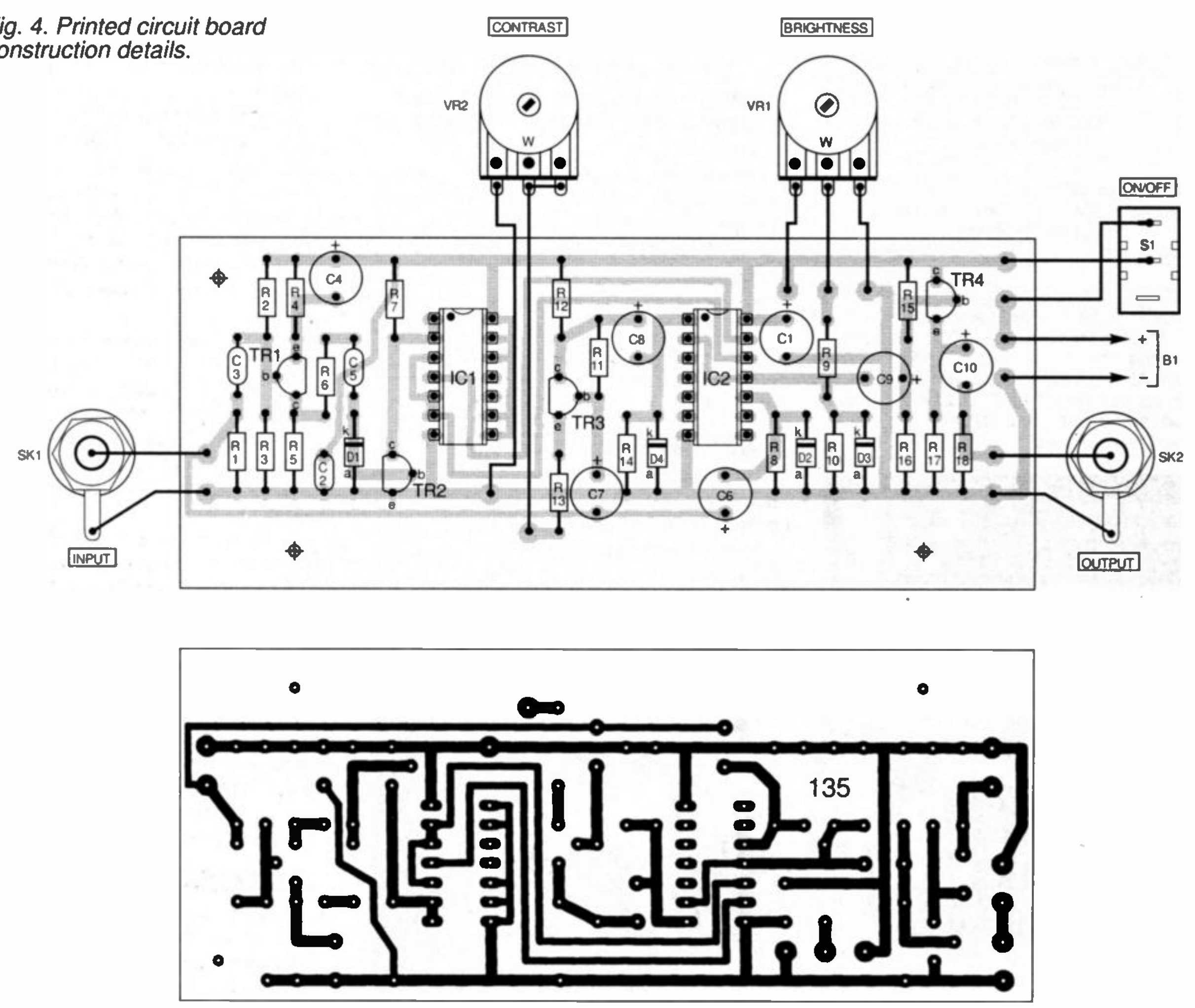
Practically any medium size plastic or metal box should accommodate this project. However, the battery pack is quite large, and this precludes the use of the more "low-profile" cases.

Sockets SK1 and SK2 are fitted on the front panel of the prototype, but they can obviously be fitted on the rear panel if you would rather keep the input and output leads tucked away out of sight at the back of the unit. Both sockets are of the phono variety, which is the standard type of connector for amateur video gear.

The printed circuit board is mounted using 6BA screws or plastic stand-offs. If you use screws, include spacers about six to 12 millimetres long to keep the underside of the board well clear of the base panel.

The hard wiring is quite straightforward, and is also illustrated in Fig. 4. Ordinary

Fig. 4. Printed circuit board construction details.



multistrand connecting wire or bits of the appropriate type of ribbon cable are used for this wiring. It is not necessary to use any screened leads, but try to keep all the wiring reasonably short.

COMPONENTS

See SHOP TALK Page

Resistors

R1, R17	470Ω (2 off)
R2, R3	47k (2 off)
R4	18k
R5, R7	4k7 (2 off)
R6	33k
R8, R14	2k7 (2 off)
R9	39k
R10	3k9
R11	330k
R12, R13	680Ω (2 off)
R15, R16	100k (2 off)
R18	10k

All 0·25W 5% carbon film

Potentiometers

VR1	10k rotary carbon, lin.
VR2	1k rotary carbon, lin.

Capacitors

C1, C10	100µ radial elect. 16V (2 off)
C2	100n disc ceramic
C3	220n polyester layer
C4, C7, C9	10µ radial elect. 25V (3 off)
C5	4n7 metallised polyester
C6, C8	47µ radial elect. 16V (2 off)

Semiconductors

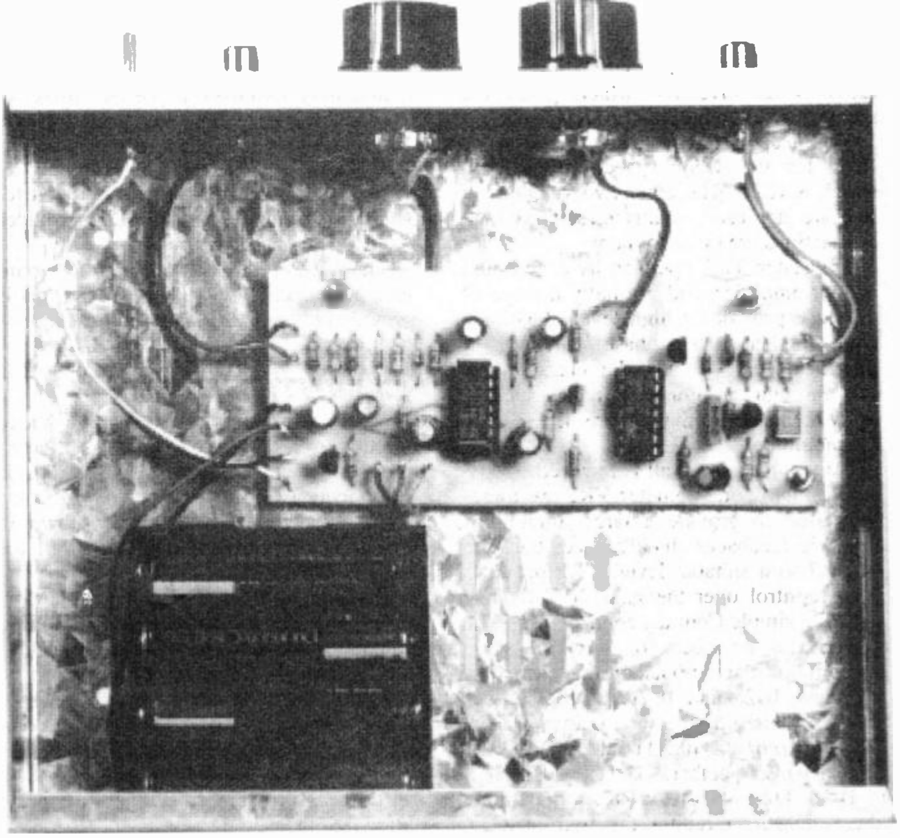
D1, D2, D3, D4	1N4148 signal diode (4 off)
TR1	BC559 *pnp* silicon transistor
TR2, TR3, TR4	BC549 *npn* silicon transistor (3 off)
IC1	4001BE CMOS quad 2-input NOR gate
IC2	4016BE CMOS quad analogue switch

Miscellaneous

B1	12V (8 x HP7 size cells in plastic holder)
S1	s.p.s.t. min. toggle switch
SK1, SK2	phono socket (2 off)

Printed circuit board available from *EPE PCB Service*, code 135; medium size metal or plastic case; 14-pin d.i.l. socket (2 off); battery connector (PP3 type); control knob (2 off); 6BA fixings or plastic stand-offs; multistrand connecting wire; solder, etc.

Approx Cost Guidance Only £16 excluding case & batts.



IN USE

Connect the video output of the camcorder to the video input of the Video Negative Viewer using an ordinary screened video lead. A lead of the same type is used to connect the output of the Viewer to the video input of the television set, monitor, or u.h.f. modulator. Obviously the audio output of the camcorder serves no useful purpose in this case, and it should be left unconnected.

Switch on the camcorder and set it to effectively operate as a closed-circuit television camera. The effect of the unit should be very obvious, with both a light/dark inversion, and a colour inversion apparent on the reproduced picture. Apart from this, results should be much as normal, with a sharp and stable picture being displayed on the television or monitor.

NEGATIVE VIEWING

In order to view negatives properly it is necessary to fit the camcorder with the appropriate attachment. These usually screw into the filter thread around the front of the lens. It may be necessary to use a stepping ring in order to fit an adaptor onto your recorder, as there are several standard sizes for this thread.

Check the instruction book for your camcorder to determine the size of its filter thread. The size of the filter thread is sometimes marked around the front of the lens, but this seems to be rare with video equipment.

It is possible to improvise a home-made negative holder and diffusor, and it is potentially a lot cheaper than using ready-made adaptors. However, great care must be exercised if you adopt the do-it-yourself approach. It would be very easy to come up with something that gives good results, but which also damages all your precious negatives!

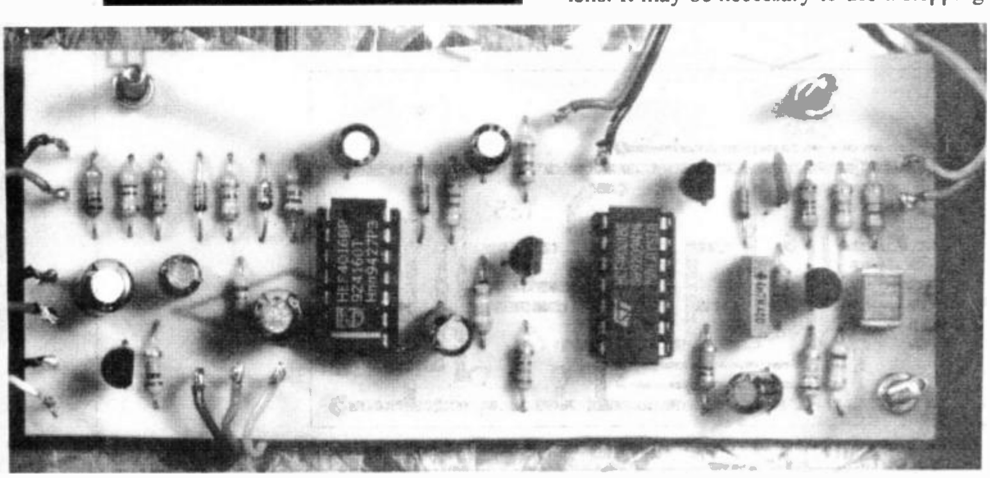
Even when using a ready-made adaptor it is essential to handle the negatives with great care, as the emulsion is easily scratched. Most of the ready-made adaptors are only intended for use with mounted slides, but provided due care is taken they seem to be usable with strips of negative.

In most cases the camcorder will have to be set to its macro mode in order to get it to focus close enough, but this depends on the type of adaptor used. With most camcorders the focusing must be carried out manually.

If you are going to use a simple adaptor that has no built-in optics it is clearly essential to check that you can focus close enough to give a reasonably large image, and to only proceed with the construction of this project if your camcorder will give worthwhile results.

STRONG COLOURS

Results seem to vary substantially from one set of negatives to another. Some negatives give quite good colours with reasonably strong colour saturation, but with most negatives there seems to be a problem with rather weak colours.

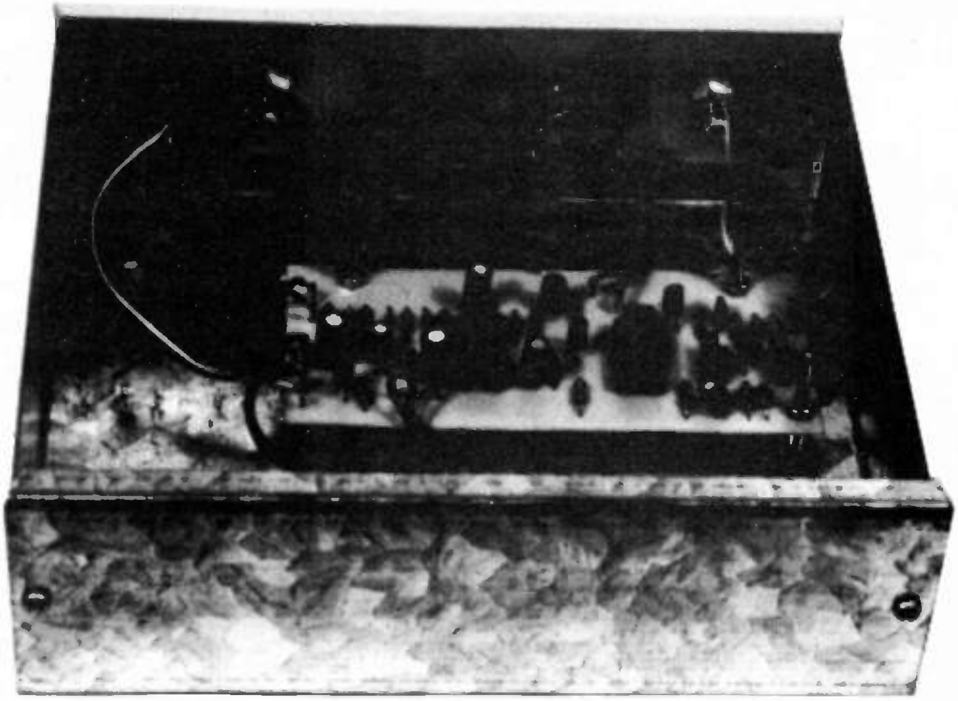


Adjustment of the Contrast and Brightness controls can help, and it seems to be best if really strong light sources are avoided. With the majority of films though, it is necessary to set either the camcorder or the television/monitor for stronger colours. Of course, the system can be used to display black and white negatives if desired, and it gives excellent results when used in this way.

When making recordings of slides or negatives it is better if the camcorder is used as a camera to make the recording via the VCR, rather than making a recording using the camcorder, and then copying it to the VCR. Most camcorders can be used in this way when switched on but not set to record. Recording direct to the VCR avoids an extra copying stage, and the loss of quality that this would inevitably involve.

Bear in mind that this system can only give good results if it is used with negatives that have reasonably accurate exposures. With most modern print films it is possible to obtain satisfactory prints from negatives that are under or over exposed by up to about two stops or so.

This system will also give reasonable results with negatives that are within this exposure range. Very "thin" or dark negatives simply lack the information needed to give good results, and will not give satisfactory pictures with this, or any other system.



A simple adaptor and stepping rings can be obtained from SRB Film Services, 286 Leagrave Road, Luton, Beds., LU3 1RB (Tel. 0582 572471, Fax 0582 572535). More advanced copying devices and adaptor rings can be obtained from the chain of Jessop stores, or by mail order from The Jessop Group Ltd., Jessop House, 98 Scudamore Road, Leicester, LE3 1TZ (Tel. 0116 232 0432, Fax 0116 232 0060).

BUILD YOUR OWN PROJECTS

Alan Winstanley — Part 5

IN THIS short series of articles we have been discussing modern methods for constructing your electronic projects. We have also suggested the tools and equipment needed and how to use them, described how to fabricate your own printed circuit boards, how to solder, and talked about various ways of preparing various types of instrument cases in the workshop.

Now, in this final part of the series, we check out methods of interconnecting your circuits, wire types and ratings, hardware and other aspects of completing the assembly of your project – in other words, finally putting it all together!

TO KICK-OFF our concluding part, let's look at the fixing of panel or chassis-mounted parts first. *Light-emitting diodes* (l.e.d.s) can be fitted into place using a moulded clip, though I prefer to use "lens clips" for a more attractive finish. If you want to do something a little different, you can, incidentally, file l.e.d.s to shape easily.

Perhaps experiment by filing a standard-size l.e.d. to form a wedge or a "flat" on the end, rather than the usual dome-shape. Simply ensure you don't damage the l.e.d. chip itself, embedded within the resin, and use metal polish to produce a smooth finish on the plastic, if desired.

An unusual finish can be achieved by using *flat-top* light-emitting diodes (e.g. 3mm diameter types), and inserting them through a precise 3mm hole in the panel for a tight push-fit (an "interference fit") – this produces an invisible fixing which is appealing to look at. A dab of hot-melt glue behind the l.e.d., will secure it in place if needed.

Toggle switches and *potentiometers* should readily fit into place, especially if you used a Q-Max chassis cutter where appropriate (see last month). For years I have used nothing more sophisticated than a bicycle dumb-bell spanner (or "box spanner"), for dealing with most panel mounting parts! The spanners have ten different socket sizes and are very convenient for this work, given that not a tremendous amount of leverage is needed in this application.

KEEPING UP APPEARANCES

It would be a pity to scratch a newly-prepared panel accidentally, especially if it's a handsome anodised type which has been freshly lettered and lacquered, so due care should be taken to avoid this. Small toggle switches usually have a spare lock nut and washer which should be twirled up the shaft of the switch to a suitable point, to act as a "back stop" before tightening the front nut using a spanner. Personally, I throw away the anti-rotation washer which may be supplied with some switches, and with certain types (e.g. single-pole on-off toggles) you may need to remember not to install the switch upside down!

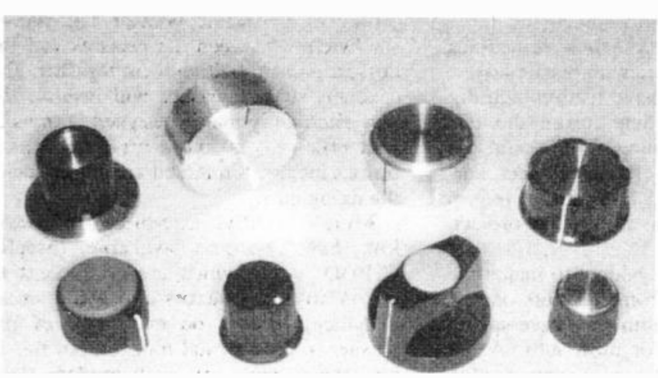
Rotary controls will require an instrument knob: catalogues have a selection of attractive plastic and aluminium types, and it's worth gradually building up a small stock of common sizes. The cheapest types simply push onto the shaft, in which case you may have to align the switch body properly to enable the knob to "point" at any markings on the panel.

Other alternative styles have a grub screw fixing for a more secure fixing. More expensive still, "collet" instrument knobs are often seen on professional equipment; they push over the shaft and are then tightened using a spanner (or large screwdriver, for some types) located into the end of the knob. This forces the brass collet within the knob to close up – like the jaws of a vice – around the shaft.

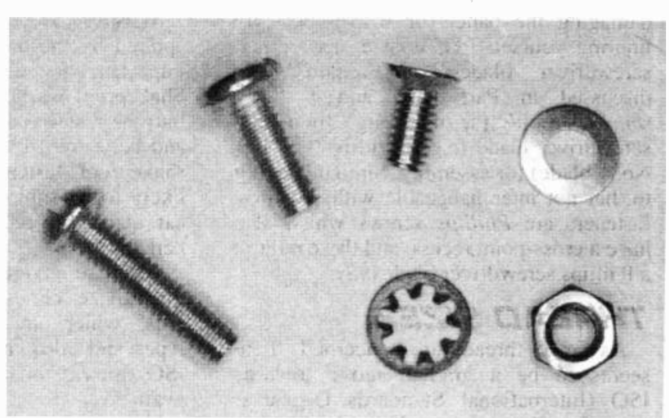
COLOUR-CODED

A coloured plastic cap is fitted over the end, which is extremely useful for complex equipment (e.g. mixer desks), since they allow the controls to be colour-coded in a logical manner. Other accessories are available for collet knobs, including skirts which fit around the base, pointers and numbered dials. Thus they offer a "hidden" fixing along with very secure and precise control.

Many instrument knobs have a recessed base to cover the ugly mounting nut of the component itself. The shafts of potentiometers (and rotary switches) will usually need to be hacksawed to length beforehand. Quite how *short* you cut the shaft will depend on the design of instrument knob you've decided to use. Consider cutting the shaft gradually until a desired fit is achieved, and take your time! Finally, ensure that the pointer



Assortment of control knobs enhance the final appearance and function of your project.



Typical fasteners – roundhead, panhead and countersunk machine screws, shakeproof and plain washers, full nut.

aligns properly with any panel marking, if relevant, prior to fitting the knob onto the switch or potentiometer shaft.

FASTENERS

Assembly of your project could continue by fitting any other peripheral parts – sockets, terminals etc. into their allotted places. Certain items, perhaps mains transformers, may be bulky and will need to be bolted down securely into place (but they may need an earth connection, see later).

A variety of fasteners – nuts, screws, washers, spacers, etc. – is available and most catalogues carry a representative range. It's worth building up a stock of fastener hardware, one good way being to just order one or two different sizes or types of fastener every time you write out an order for parts. You can gradually build a comprehensive range this way, and they can be stored in convenient selector boxes (e.g. Raaco Assorter Boxes, available from several DIY super stores).

It may be the case that you're not fussy about using precisely the right fastener, since you may have plenty of nuts and screws in the junk box, but here's the low-down on handy hardware for those just arriving:

Bolts have a hexagonal head which requires a spanner, and are seldom used in routine electronics assembly work. *Screws* (or more correctly, "machine screws") are used almost universally, and are categorised by their **head**, **thread** and **length**.

HEAD FIRST

The **head** will be one of several shapes: *countersink*, which lies flush with the panel; *round-head*, having a dome-shaped head; *cheese-head*, ugly-looking things which resemble a large round "cheese"; *pan-head*, which seems to be the type favoured for general work. One may also see *raised countersunk* heads – countersunk screws with a slightly raised surface – which I sometimes use for a neat finish.

You may read of "BZP" (bright zinc plate) finish, a sort of blue-silver industrial coating which prevents the fasteners from corroding, or alternatively a nickel-plated finish, which is a bright and chrome-shiny finish which looks attractive on panels. It depends how fussy you are!

You have a further choice of *slotted* screw heads which accept a traditional flat screwdriver blade, or much better, *Pozidriv*™ screws which greatly reduce the risk of the blade slipping out and damaging the panel (or worse, possibly injuring yourself). Of course, appropriate screwdriver blades are required, as discussed in Part One, and Pozidriv screws require the matching "number" screwdriver blade (e.g. Pozidriv No. 0 or No. 1 blade) for assembly. Similar-looking to, but not interchangeable with, Pozidriv fasteners are *Phillips* screws which also have a cross-point recess, and these require a Phillips screwdriver blade *only*.

THREAD SIZES

As far as threads are concerned, there seems to be a gradual move towards ISO (International Standards Organisation) thread types, and ISO Metric sizes are increasingly used rather than traditional Imperial types of fastener. You'll see metric threads expressed in terms of M3 or M4, for instance, to indicate that they are metric screws of 3mm and 4mm thread *diameter*, respectively. Generally speaking, M3 or possibly M4 sizes are used for most regular assembly work, perhaps M2·5 for small-scale work, and M6 (6mm dia.) for larger, heavier items including, perhaps, mains transformers and similar parts.

As an alternative to metric dimensions, the older BA (British Association) sizes are still very common: I appear to own a lifetime's stock of them! BA fasteners merely have a BA number, such as 2BA, 4BA or 8BA to identify their size – the larger the BA number, the *smaller* the bolt's diameter. Sizes 4BA and 6BA are those used for most constructional tasks, with 2BA for larger parts, and very occasionally, 8BA as the smallest size.

You may also occasionally see BSW (British Standard Whitworth) or UNC/UNF (Unified National Coarse/Fine thread) standards mentioned from time to time: you'll see that power semiconductor devices such as stud-mounted diodes or triacs will have either a UNF or metric thread, if you check the data closely.

The final aspect of a screw size is its **length**. This catches out many constructors, for the simple reason that if a machine screw length is specified, this does *not* mean the total length of the fastener! The "length" starts from the *underside of the head*. This is worth remembering, especially when buying short fasteners of just a few millimetres: the head is not included in the length (or at least, if it is, then the catalogue is wrong).

Hence a machine screw might typically be specified as "M4 × 25" – 4mm diameter thread, having a thread length of 25mm. Incidentally, after measuring a few which I had in stock, it appears, however, that the specified length of a *countersunk* screw does indeed include the head!

MISCELLANY

Washers are used to spread the force applied by the head, which is sometimes important when dealing with plastic boxes. Shakeproof washers have teeth which dig into the material and help prevent the nuts and bolts from loosening. You would use shakeproof fasteners if the project was likely to be subjected to vibration (e.g. a car alarm project, or a portable project, perhaps).

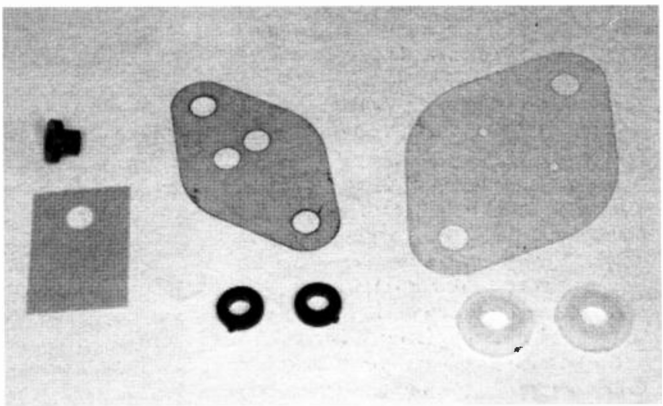
Nuts are obviously bought to match the thread size: choose from full nuts or half nuts, which are slimmer, space-saving types and adequate for most jobs. Again ISO metric or BA sizes are readily available.

To mention a few alternatives briefly, a small range of fasteners is available which is moulded in *nylon*, which you may need to use if electrical insulation is important, providing the parts concerned don't become excessively hot. It's useful to keep just a small range in stock for such occasions, but they are not particularly strong and should not be over-tightened. For particularly demanding applications, you might select *stainless steel* fasteners for longevity and total weather-resistance.

Self-tapping screws cut their own thread when screwed into place. They're used mostly for screwing sheet metal together or for grounding wires to a chassis (look at any car) or for securing items into a "blind" hole (a hole drilled into a material, rather than all the way through it). Generally, though, prototypes tend to be assembled using good old machine screws and nuts!

HEATSINKS

Some projects will require the use of a heatsink – a heat-dissipating radiator usually made of aluminium onto which a semiconductor power device is bolted. A connection is sometimes made via one of the component's mounting bolts (usually for the collector of a power transistor, or the output of a regulator) using a solder tag placed either under the screw head, or under the *nut* if the device is mounted on the outside of the project housing. This means that the case of the semiconductor device is "live".



Transistor mounting kits – TO-126, TO-66 and TO-3, with insulating bushes.

It might often be necessary to insulate the semiconductor entirely from the heatsink, and special "mounting kits" are available which contain all the necessary insulating components. A specially-shaped washer is used, which matches the profile of the semiconductor can, and is sandwiched between the heatsink and the device, prior to bolting them together. The specially-shaped washer will insulate the part electrically, but is designed to transfer heat efficiently at the same time. Plastic bushes included in the kit are placed under the fixing nuts.

More recently, one-piece insulating kits have become available (Maplin CH03D *et al*) which are convenient to use. Many constructors also add a smear of silicon grease on each side of the washer to aid thermal transfer, but this is no longer necessary with modern thermally-conducting materials. It's a good idea to keep one or two insulating kits in stock to accommodate various semiconductor outlines.

P.C.B. STAND-OFFS

By this stage, your project will hopefully be taking on its final form. The printed circuit board now requires fitting into place after which the interwiring can be carried out to complete the project. It's best to ensure that the board (usually a glass-fibre printed circuit board) is secured solidly into place and can't move, especially if it's operating at mains voltages. This can be accomplished effectively using a variety of "mounting hardware" so that the board is stood off a short distance from the chassis floor or panel.

Moulded one-piece nylon "stand-offs" (or pillars) are convenient and are readily available in different lengths by mail-order, and these simply push-fit into place. Because they have a finger-tip release latch, they enable the p.c.b. to be removed without the need for tools – useful if you intend to remove the board to modify it during prototyping. You simply need to ensure that you follow the drilling dimensions specified in the supplier's data. Such nylon stand-offs have the added benefit of ensuring that the p.c.b. is completely insulated from the chassis, which is reassuring (and important, if the board is operating at mains voltages).

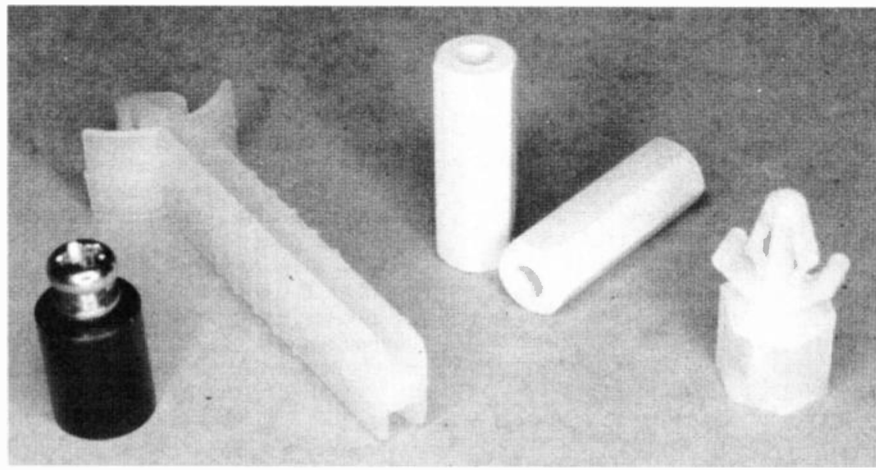
Alternatives to moulded pillars include hollow plastic or metal spacers which are used in conjunction with a machine screw of appropriate length, plus nuts and washers. I prefer to use these as they hold the board very solidly in place, but they are fiddly compared with one-piece moulded parts. Usually, M3 fittings are used. Once again, if mains voltages are present then it is wise to ensure that *fully insulating* fittings are utilised so that the fixing screws cannot possibly become live and cause a shock hazard, in the event of an internal wiring failure.

FLYING LEADS

If there are any flying leads to be soldered to the board then you might decide to leave the board loosely in position so that you can still access the solder-side of the board. Alternatively, if you have used "solder pin" connections on the p.c.b., then these will be prominent on the component side, so the board can now be fixed into place and conveniently interwired *in-situ*, because you don't need access to the copper-foil side of the board.

It is customary to employ multi-stranded-core p.v.c. insulated wire for most interwiring tasks. The multiple strands give the wire a flexibility which also helps ensure that the wire won't fracture internally through vibration. Solid-core single strand wire can be used in assemblies where such damage isn't likely to be a problem, and this type of wire has the added bonus of being able to be bent to shape with pliers, to form the wire into neat looms ("plate wiring").

Multi-stranded wire is normally specified by the number of copper strands together with their diameter. This determines the total cross-sectional area (CSA) of the wire and therefore the current-carrying capacity of the wire – the larger the CSA, the lower its electrical resistance will be, and so the greater the current it may carry safely. (The current value also depends on the wire's temperature.) Table 1 shows a listing of common cable current ratings and specifications.



Selection of p.c.b. mounting pillars, both screw and clip-on fixing.

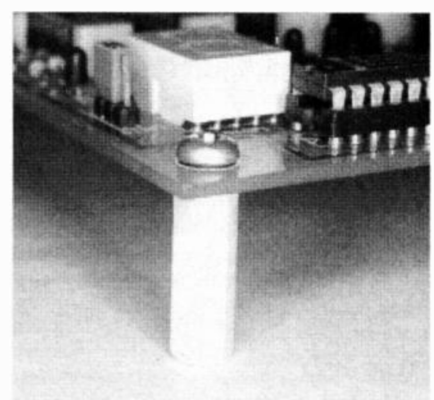
Ordinary "hook-up" wire is 7/0·2mm (seven strands, each 0·2mm diameter). A quick calculation using *Area of a circle* = Πr^2 where r is the radius, produces a CSA of 0·03mm^2 per strand. Hence the overall CSA of the wire is seven times this, i.e. 0·22mm^2 in total. It's best to buy a quantity of 7/0·2 hook-up wire of a few different colours, to help identify the interwiring and aid tracing and fault-finding. A modest 10 metre pack, e.g. as retailed by Maplin, will easily get you off the ground with minimal cost. Rapid Electronics (Tel. 01206-751166) sell a kit of 11 reels, each 100m, in differenct colours, for heavier users.

From experience, a flying lead which is soldered to, say, the tag of a switch, is likely to be a weak point in the future, especially if the project is subject to vibration. The wire flexes at the solder joint, and due to metal fatigue in the solder, it may ultimately break off in extreme instances. A dab of hot-melt glue to cover the joint, will help prevent this by acting as a strain relief.

HEAVY-DUTY

For heavier-duty connections, notably those at mains or EHT (extra high tension) voltages, then you must take especial care to ensure that the wire used is of an adequate voltage and current capacity: observe the specifications carefully. Although 7/0·2mm wire is rated at up to 1·4A, 1kV (at 70°C), personally, I would seldom use it to connect anything at mains voltages except perhaps mains neon indicators. Otherwise I reserve it purely for most low voltage general-purpose connections.

The mains input side (where applicable) of a project will usually require 3-core mains flex or cord, (live, neutral and earth/ground). Regardless of how low the current consumption of a project may be, it is best to use 6A mains flex at a minimum, since this is physically a stronger cable which will withstand more rough treatment than, say, a 3A cable, and the overall difference in cost is negligible.



Insulated mounting pillar holding the p.c.b. clear of the case floor.

Table 1: Ratings for hook-up wire. Typical values only are shown, and suppliers' specifications should be consulted where necessary.

No. of Cores/Dia. (mm)	Total CSA (mm^2)	Maximum Current	Maximum Voltage (RMS)	Overall Diameter (mm)	Suggested uses
1/0·25	0.049	0·4A	300V	0·5	specialist wire wrapping
10/0·1	0.078	0·5A	1kV	0·9	miniature, signal, low power
1/0·6	0.28	1·8A	1kV	1·2	rigid interwiring
7/0·2	0.22	1·4A	1kV	1·2	general low-duty hook-up
16/0·2	0.5	3A	1kV	1·6	general hook up, mains
24/0·2	0.75	4·5-6A	1kV	2·3	general hook up, mains
32/0·2	1.00	6A	1·5kV	2·6	general hook up, heavy duty
30/0·1	0.23	1·5A	500V a.c.	2·0	miniature test leads
55/0·1	0.43	2·5A	500V a.c.	2·8	extra flexible test leads
260/0·07	1.00	20A	1kV	3·6	high quality test leads

STRIP JOINTS

If you're like me, you'll think that stripping the insulation from any form of cable is a chore, and so I always use a "Toggle" mains cable stripper, a small disposable tool which bares multi-core mains cable ends deftly, and with almost surgical precision, and my trusty and indispensable Ideal Tools "Stripmaster" makes short work of all other wire-stripping (see Part One).

To form mains connections actually within a prototype, 16/0·2 is suitable for lighter-duty usage up to 3A, whilst a heavier-grade 24/0·2mm is good for 6A. You may sometimes find it very difficult to solder 6A wire to the small tags of toggle switches or other sub-miniature parts, though, and one work-around is to use 6A mains flex for the mains supply input, and take this to a terminal block from which a narrower-gauge (e.g. 16/0·2) cable can be hooked to the mains switches, neon indicators and similar parts. Certain projects (e.g. a mains-operated heater thermostat) may require a fully-rated 13A cable connection (40/0·2mm).

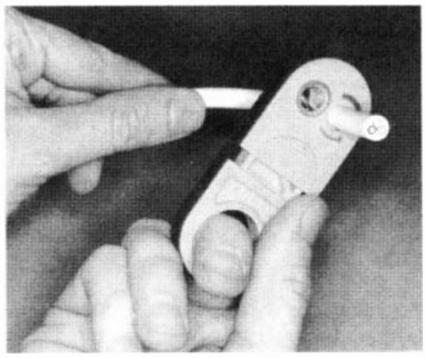
It is critical that the mains cord is secured into place using a cable-retention device. It is potentially very dangerous to overlook this since, in the event of an accident, if the cable is pulled out then the miscreant will be left holding a **live mains cable**. It is very bad practice to simply knot the cable, something you do at your peril, given that there are plenty of cheap ready-made solutions available which ensure that the flex will be held firmly and safely in place. A humble nylon "P" clip of the correct size will provide a very strong grip, for example.

Furthermore, the cable must be protected from chafing at the point of entry – especially when using metal panels – so use a PVC grommet at the very least to cushion the cable. Alternatively, select a "cable gland" which acts as a grommet and cable grip, all in one. Possibly keep a few cable retention clips for 6A and 13A cable – noting the diameters of the cable so that you select the right size of clip (Table 2 may help).

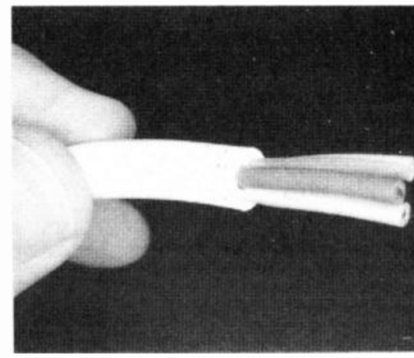
BLOCKS AND FERRULES

Screw-terminal blocks can be a source of potential disaster if the cables themselves are inadequately prepared. It's not uncommon, when stripping the insulation off a wire, to cut into the copper strands, thereby weakening that part of the cable. The use of correctly-adjusted wirestrippers will help avoid this. Also, any errant strands which are *not* trapped under the terminal screw can protrude outwards and short to adjacent terminals, or, worse, to the chassis itself.

An excellent means of tidying up any multi-stranded cable connections prior to inserting them into a terminal block is to use a "ferrule", which will appeal to more discerning constructors and will provide probably the most reliable connection possible. Constructors sometimes tin the bared end with solder before inserting it into a terminal block, but the screw can actually create a weak spot in the wire, and also the wire can ultimately fracture through vibration. Hence, it's arguably better not to tin the wire end at all.



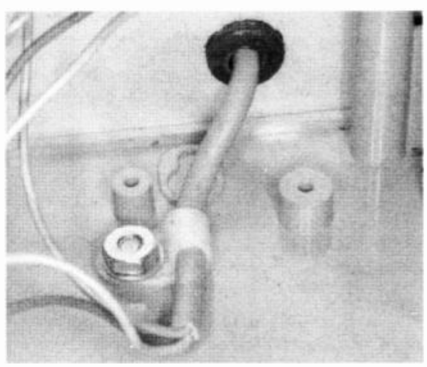
Using a Toggle wire stripper makes a neat job of mains cable.



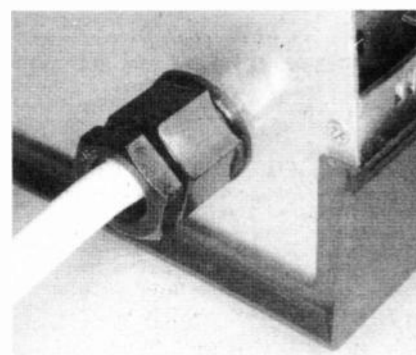
Results of using wire stripper to remove the outer covering of mains cable.

Table 2 Ratings and dimensions for multi-core mains cable. The nominal diameter shown, will help when choosing grommets and cable retention clips.

Multicore Mains Cable	CSA per core (mm^2)	Maximum Current	Maximum Voltage	Nominal Diameter (mm)	Notes
3 × 16/0·2	0.5	3A	300V	5·6	low load equipment
3 × 24/0·2	0.75	6A	300V	6·9	mains power leads
3 × 40/0·2	1.25	13A	300V	8·5	H.D. mains leads



Using a P-clip as a strain relief for mains cable.



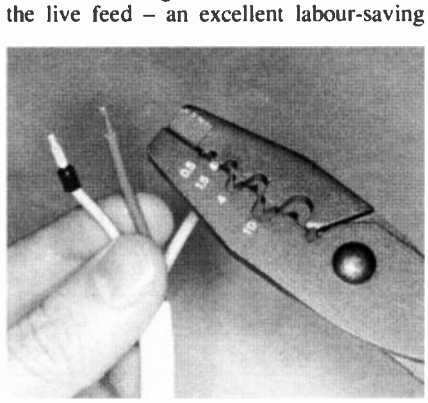
Using a "cable gland" provides protection from chafing.

Ferrules avoid all of these problems and they ensure that all copper strands are held together neatly. Either a special crimping tool can be used to crimp them tightly onto the cable end, or to save money, simply slide a ferrule over the bared cable end, then insert it fully into the terminal block and tighten down the screw. The terminal block screw will crimp the ferrule onto the cable, and helps to guarantee that all of the copper wire is fully caught underneath the screw.

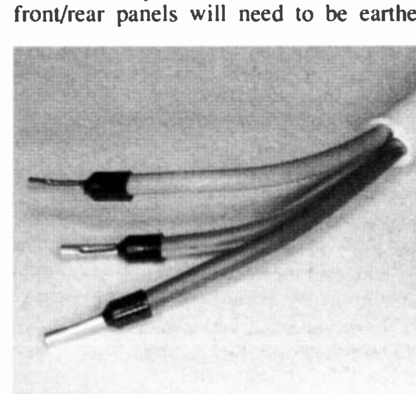
Still on the subject of mains interwiring, a fuseholder is usually compulsory and one particular type of mains terminal block has a built-in cartridge fuseholder in series with the live feed – an excellent labour-saving idea (stocked by Maplin, RS, Premier Farnell Components). Otherwise choose from a range of chassis-mounting or panel-mounting 20mm or 1¼" types.

EARTHING IT

Unless a mains-powered project has been designed to be "double insulated" – which is rarely possible in the home-construction market – then the designer will give instructions concerning the *earthing* of the prototype. Usually, this means that the mains earth will be brought in and electrically connected to the box, if it is made entirely of metal. Otherwise, the front/rear panels will need to be earthed



A metal ferrule being crimped onto a bare cable.



Using ferrules on the ends of mains leads prevents stray strands.

individually if the box is of the combination type which has metal panels retained within a plastic moulding.

Earthing can be effected by soldering the earth wire (green/yellow) to a solder tag, which is then held captive under a transformer mounting screw, for example, or use a large 10mm diameter crimp tag which can be placed under a rotary switch nut or similar, behind the control panel. Usually, the transformer mounting frame is earthed via one of its mounting bolts, and you can use further solder tags placed under the same bolt, to take earth connections to other areas of the project if needed (e.g. a mains outlet socket).

Whilst all earth connections can generally remain uninsulated, it's of considerable importance that any **mains-voltage** joints are adequately insulated, to protect both yourself or anyone else who might use or work on the project, both now or in the future. *PVC insulation* tape is crude and unreliable, but is better than nothing (just) for insulating awkwardly-shaped joints. Try to do as neat and thorough an insulation job as possible: if you can afford it, you might think about using *heat-shrinkable tubing* which is probably the most effective way of insulating many types of joint.

HEAT-SHRINK TUBING

Various diameters and colours (including transparent) of heat-shrink sleeving are available, which shrink to half of their original diameter when heated and form a good-quality insulated joint. Ordinary DIY-type hot-air guns aren't really suitable for this application, as they are far too imprecise (or just plain too hot!).

It is difficult to produce consistent results unless a hot-air gun is used which has specially-shaped heat reducer adaptors made for this type of delicate work. In my view, the best type is the lightweight, precision USA-made model by Ungar, as sold by RS and Maplin, but unfortunately at some £120 this gun is now very expensive indeed, and will only be of interest to serious constructors. It is worth considering an economically-priced gas-powered pencil torch for heat-shrinking. Antex produce a compact gas-catalyst torch kit (about £36), but other models are available under the "Flame Master" brand, including a pencil gas torch and hot air blower head. Maybe buy the torch and hot air tip as separate items, to save money.

Large-diameter heat-shrinkable tubing is also useful for insulating entire components such as fuseholders or small battery stacks. *Heat-resistant sleeving* made with Teflon or fibre-glass has occasional uses too (e.g. the piezo spark ignitor of my barbecue!), and a short length may be handy in the spares box.

Ordinary (non-shrinking) PVC sleeving could be used if you don't wish to utilise heat-shrinkable tubing; simply cut a piece to length, slide it over the wire, then solder the joint before sliding the sleeving back over to insulate the joint. A dab of hot melt glue may help secure the tubing in place if necessary.

WIRE ROUTING

You will also enhance your project by keeping all wiring neat and tidy, and nylon cable ties can be used to form bundles of wires into looms, remembering to colour-code individual wires to help with tracing and checking.

You may need to ensure that sensitive signal wires (e.g. audio leads) are routed away from mains supplies, transformers or other potential sources of "noise". Certain classes of project, notably audio amplifiers and heavy-duty power supplies, may have special requirements for connecting power rails or earths at *one point* only. This is generally to avoid introducing an unnecessary electrical resistance into a circuit which could cause a voltage drop which would introduce hum and noise.

You will also improve the access to the circuit boards and components themselves by wiring neatly, and wires should be routed away from any parts which may require ventilation – power devices which run hot, for example. Catalogues are full of cable accessories, and wire looms can be secured by using a nylon tie, fitted to a self-adhesive tie-wrap base, which can be stuck down onto the chassis. (The same technique can be used for securing other components, including larger can-type electrolytic capacitors.)

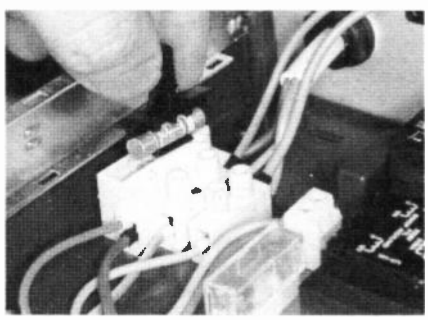
FOOT NOTE

By this stage, the constructional aspects of your project will be completed. Only a few finishing touches remain – perhaps use self-adhesive cabinet feet to protect surfaces from scratching, and ensure that all fasteners are tight. Blow out any residual metal swarf (if any) which might be lurking within the box, and perform any final double-checks. Then power up the project and proceed to ensure that it operates in accordance with expectations.

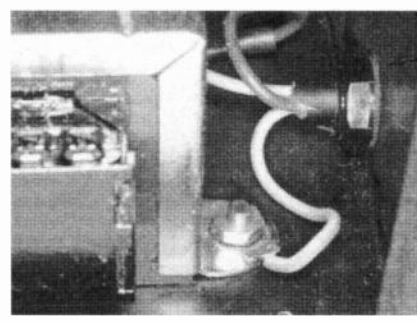
What if your project doesn't quite function properly? The black art of trouble-shooting and fault-finding is beyond the scope of this *Build Your Own Projects* series, unfortunately, but you can check some obvious aspects first: completely incorrect components (especially colour-coded parts), reverse-connected parts (diodes and transistors), missing or incorrect wiring, even a missing fuse!

Remember that many *EPE* contributors will be willing to lend a hand if you experience a problem with one of their projects. You can write to them (*no models*) via the Editorial address, explaining any symptoms fully, and including any test readings if available.

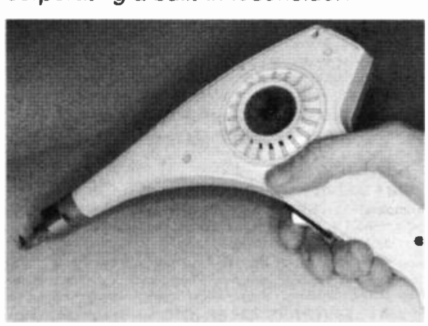
Having come all this way, assembling your prototype from scratch using your own skills, and then witnessing the finished product for the first time is a tremendously rewarding experience. Working with modern micro-electronics and mastering it in your own home or workshop, takes some beating. We wish you many a successful project. □



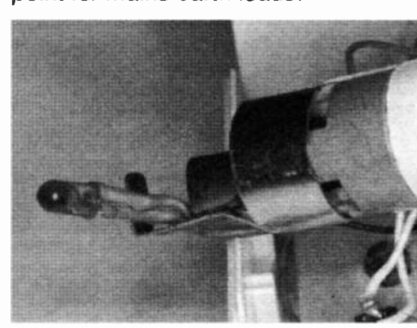
Mains cable, with ferrule terminations, inserted into a screw-terminal block incorporating a built-in fuseholder.



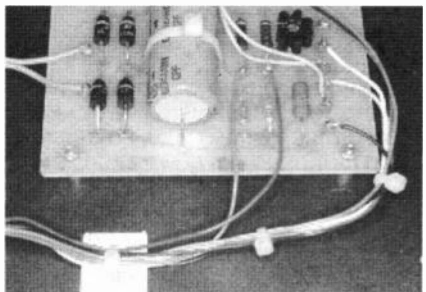
Using a solder tag underneath a transformer mounting bolt – a good "Earth" point for mains earth leads.



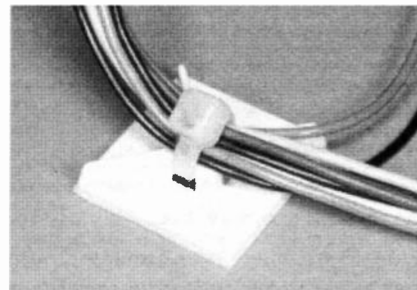
Hot air gun for heat-shrinking sleeving over bare solder joints.



Applying heat-shrink to an off-board l.e.d. (light-emitting diode).

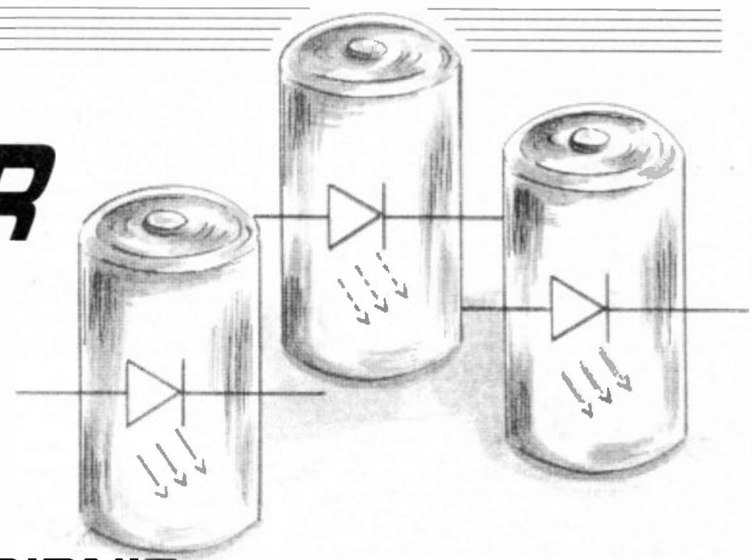


Using nylon tie-wraps forms wires into neat looms.



A self-adhesive tie-wrap, together with a nylon tie.

Constructional Project



TRI-COLOUR NiCad CHECKER

TERRY de VAUX-BALBIRNIE

A quick and easy method of checking-out the condition of your NiCads.

THIS device will determine the approximate charge state of most nickel-cadmium batteries found around the house. The display is in the form of a tri-colour light-emitting diode (l.e.d.) which will light up Red for *Recharge*, Yellow for *Serviceable* and Green for *Good*.

This provides a simple way of finding the amount of use a battery is likely to give before the need to recharge. The simplicity of testing will make the circuit popular with non-technically minded people, the elderly and children.

MAKING CONTACT

The tester is housed in a small plastic box which contains the circuit panel and a long-life battery (see photographs). There is a probe on a short lead which is held on the top (positive) contact of the cell to be checked. The bottom of the cell (negative contact) is then touched on a metal stud – this is a one-handed operation. A push-button switch is operated and the l.e.d. observed.

Note that the circuit is *only* suitable for checking *nickel-cadmium* (rechargeable) cells – not throw-away types. Also, it will only test *single cells* – not a battery pack containing more than one cell such as the 9V PP3 variety. Examples of single cells are the "AA", "C" and "D" type but, in practice, it is the "AA" size which is most commonly found in the home.

LET DOWN

It is important to keep a careful eye on the state of charge of nickel-cadmium cells. The chief reason is because the amount of energy contained in them is much less than in the alkaline (throw-away) variety.

A NiCad cell therefore gives much less service from one charge and can let you down unexpectedly. Also, the performance of a throw-away cell falls off gradually and gives ample warning that it needs to be replaced. By contrast, a NiCad cell maintains a fairly steady output until near the end whereupon it fails suddenly.

The Tri-Colour NiCad Checker works by responding to the voltage of the cell being checked. This falls slightly as energy is drawn from it. When freshly-charged, the on-load voltage of a NiCad cell (that is, the voltage measured while current is being drawn) approaches 1·5V.

However, this quickly falls and any voltage above 1·4V may be regarded as indicating "fully charged". When about one-half of the charge remains, the voltage will have fallen to around 1·28V and when one-quarter is left it will be some 1·2V. The useful end-point voltage is about 1V.

The Checker applies a suitable load during the test and this may be increased by operating a pushbutton boost switch. This could be appropriate for a larger cell or for a smaller one in a high-current application. For simplicity, this latter part could be omitted.

CIRCUIT DESCRIPTION

The full circuit diagram for the Tri-Colour NiCad Checker is shown in Fig. 1. The key components are the 2·5V voltage reference device, D1, and dual operational amplifier IC1. The op.amp is an inexpensive bipolar type. This is robust and will not be harmed if the cell under test were to be connected the wrong way round.

This is likely to happen every now and again – especially where children are involved. When this is done, the display goes off – i.e. no colour shows.

Battery B1 provides a nominal 6V supply for the circuit. Current is only drawn while Test switch S2 is operated so it will have a very long life – probably several years. It is important, therefore, that it has a long shelf life to match. The battery used in this circuit consists of *two* 3V lithium "coin" cells connected in series and these serve the purpose well.

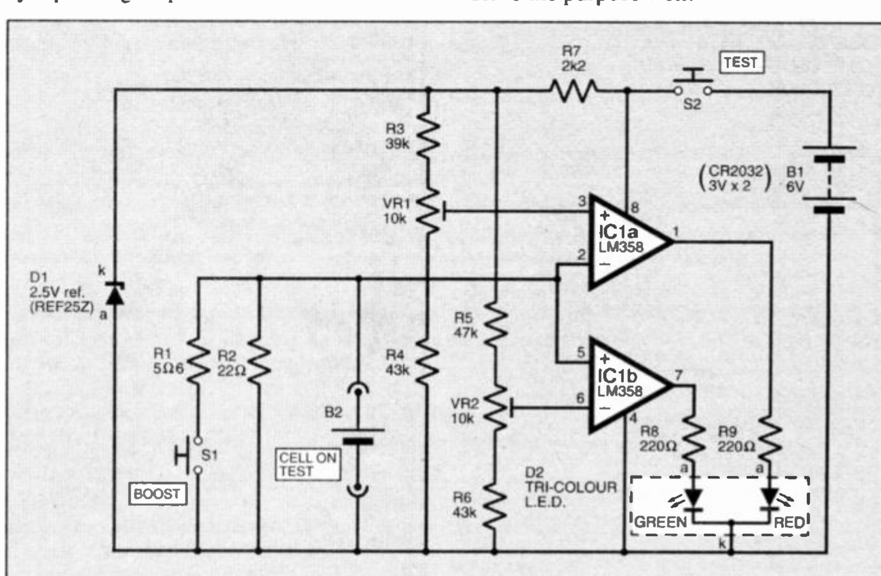


Fig. 1. Complete circuit diagram for the Tri-Colour NiCad Checker.

REFERENCE VOLTAGE

When switch S2 is pressed, a supply is established to the op.amp, IC1. Current also flows through resistor R7 and voltage reference device, D1. This is shown as a Zener diode but, although it serves the same purpose, it is a much more precise device. Whatever the voltage of the supply (subject to a minimum of about 3·5V), exactly 2·5V will exist across D1.

The reference voltage is connected across two potential dividers – R3, VR1 and R4 on one hand and R5, VR2 and R6 on the other. The fixed resistor values have been chosen to narrow the range of adjustment of the preset potentiometers to about 0·2V. In the case of VR1 this is 1·2V to 1·4V and for VR2, 1·1V to 1·3V approximately. Narrowing the range in this way allows for more accurate adjustment than would otherwise be possible.

Dual op.amp IC1 contains two identical units, IC1a and IC1b in the same package. Both sections are connected as voltage comparators.

The principle is this: If the non-inverting (+) input voltage exceeds the corresponding inverting (–) one, the output will be *high*. In other cases it will be *low*. With the particular device used, high is actually some 2V lower than positive supply voltage (nominally 4V).

The positive terminal of the cell under test, B2, is applied to the inverting input of IC1a (pin 2) and the non-inverting input (pin 5) of IC1b. Resistor R2 imposes a load of about 60mA on the cell (although this varies somewhat with the voltage). This is appropriate for a small cell ("AA" or "AAA" size). When Boost switch S1 is pressed, the load is increased to 300mA approximately by allowing additional current to flow through resistor R1.

GOOD BEHAVIOUR

To illustrate the behaviour of the circuit, suppose presets VR1 and VR2 are adjusted so that 1·35V and 1·25V respectively appear at their sliding contacts. This will result in 1·35V appearing at IC1a non-inverting input, pin 3, and 1·25V at IC1b inverting input, pin 6.

Suppose also that battery B2 under test has a terminal voltage of 1·4V (that is, it is well charged). Considering the comparator action of IC1a, the voltage at pin 2 exceeds that at pin 3 so it is *off* with the output, pin 1, *low*. The Red l.e.d. (D2) will therefore be off. In the case of IC1b, the voltage at pin 5 exceeds that at pin 6 so it is on with the output, pin 7 ***high***. This will result in the Green l.e.d. (D2) being on.

COMPONENTS

Resistors

R1	5Ω6 (if needed, see text)	
R2	22Ω	See
R3	39k	SHOP
R4, R6	43k (2 off)	TALK
R5	47k	Page
R7	2k2	
R8, R9	220Ω (2 off)	

All fixed resistors 0·6W 1% metal film.

Potentiometers

VR1, VR2 10k min enclosed carbon preset, vertical

Semiconductors

D1	REF25Z 2·5V precision voltage reference
D2	5mm tri-colour l.e.d.
IC1	LM358N dual op.amp.

Miscellaneous

B1	CR2032 3V lithium coin cell, 20mm diameter 3·2mm thick (2 off – see text).
S1, S2	Sub min. push-to-make switch (2 off) – possibly only one needed see text.

Printed circuit board available from *EPE PCB Service*, code 138; 8-pin d.i.l. socket; plastic box, size 75mm × 50mm × 25mm; plastic stand-off insulator; small plug for test probe; solder tag; material for bracket; small fixings; M3 nylon nut and bolt, solder, etc.

Approx Cost Guidance Only £12 excluding lithium cells

Suppose B2 has a voltage of 1·1V (i.e. it is practically "flat"). The conditions for the two comparators are now reversed. With IC1a, the voltage at pin 3 now exceeds that at pin 2 so the Red l.e.d. will be on. With IC1b, the voltage at pin 6 exceeds that at pin 5 so the Green one will be off.

TWO-IN-ONE

Now, consider the cell "on test" to have some intermediate voltage – say, 1·3V (medium charge). The voltage at pin 3 exceeds that at pin 2 so the Red l.e.d. is on. The voltage at pin 5 is greater than that at pin 6 so the Green one is also on. The l.e.d.s are not separate units but share the same package. When either Red or Green colours show, the appearance will be similar to that of a *single*-colour device.

However, when both red and green are on, the display will be *Yellow*. This is because the primary colours, red and green, mix in the milky white translucent plastic to produce the secondary colour, *yellow*.

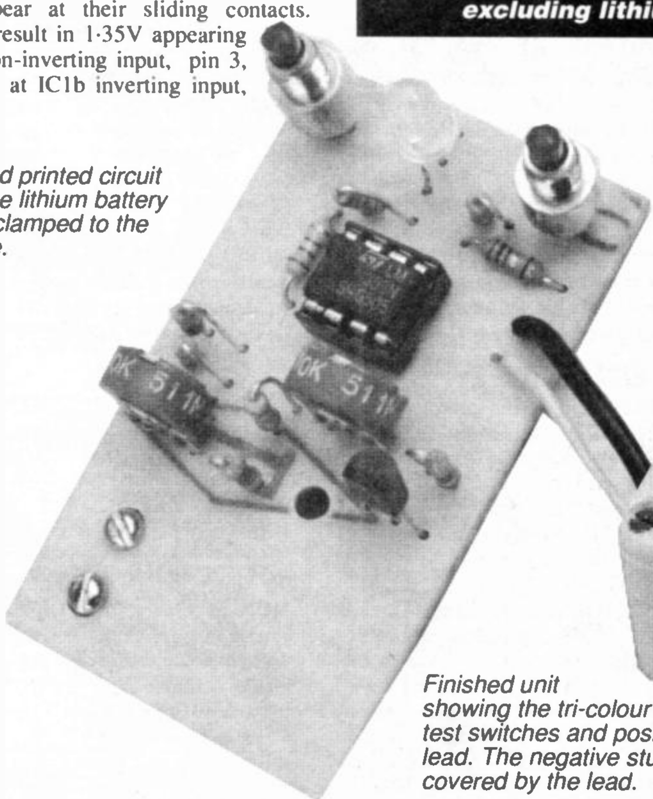
Both l.e.d. sections share a common cathode (k) connection but the two anode (a) leads are separate and need their own current-limiting resistor. These are R8 for the Green section and R9 for the Red one.

Taking account of the 2V approximately which exists across an operating l.e.d., and the fact that a ***high*** output from an op.amp output is actually about 4V, there will be about 2V available to drive current though it. The specified values of R8 and R9, will allow about 10mA to flow and this provides sufficient brightness without there being an excessive drain on the supply battery.

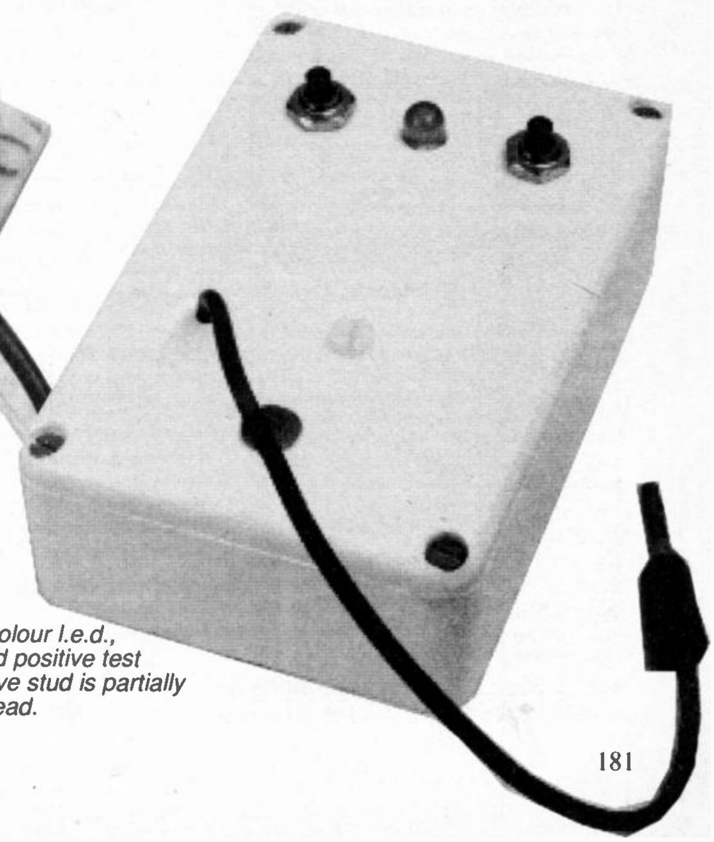
CONSTRUCTION

Details of the printed circuit board (p.c.b.) are shown in Fig. 2. This shows the topside component layout and underside (copper track) view. This board is available from the *EPE PCB Service*, code 138.

Construction is very straightforward because all the components, including supply



Completed printed circuit board. The lithium battery cells are clamped to the underside.



Finished unit showing the tri-colour l.e.d., test switches and positive test lead. The negative stud is partially covered by the lead.

battery, B1, are mounted on the p.c.b. If the Boost facility is not needed, resistor R1 and switch S1 are simply omitted.

Drill the single fixing hole and two small ones for battery B1 bracket in the positions indicated. "Solder-tin" (that is, apply a thin layer of solder) the large copper pad which will form the negative battery connection.

Solder the 8-pin d.i.l. socket in place and follow with all fixed resistors. Press the preset potentiometers firmly into their holes before soldering so that they occupy *minimum* height.

Mount the pushbutton switches with the *minimum* pin length needed to provide good soldered joints. This will allow the switches to stand above the panel by the greatest amount and will help when the p.c.b. is attached in position later.

Solder a 5cm piece of stranded connecting wire to the point labelled "B2−" and a 20cm piece to the point labelled "B2+". It will be best if the positive test wire is of a thin extra flexible type but any multistrand wire will give good service.

TRI-COLOUR L.E.D.

Solder the l.e.d. (D2) in position so that its top stands 15mm above the p.c.b. The centre lead is the common cathode (k). The two outer ones are bent differently near the body to signify the red and green sections – the right-angled bend denotes the red one. The pinout details are shown in Fig. 2.

Add the voltage reference device, D1, taking care over its orientation. Note that although this has three leads soldered to the p.c.b. only two of them are connected underneath – see Fig. 2. Adjust both presets fully clockwise (as viewed from IC1 position).

CELL DETAILS

Prepare the lithium cells which together form battery B1. These should be handled using a paper tissue to prevent grease from the fingers remaining on the surface. If they are touched, any fingermarks should be polished off using a paper tissue. The larger face of each cell is the *positive* (+) one and is so marked.

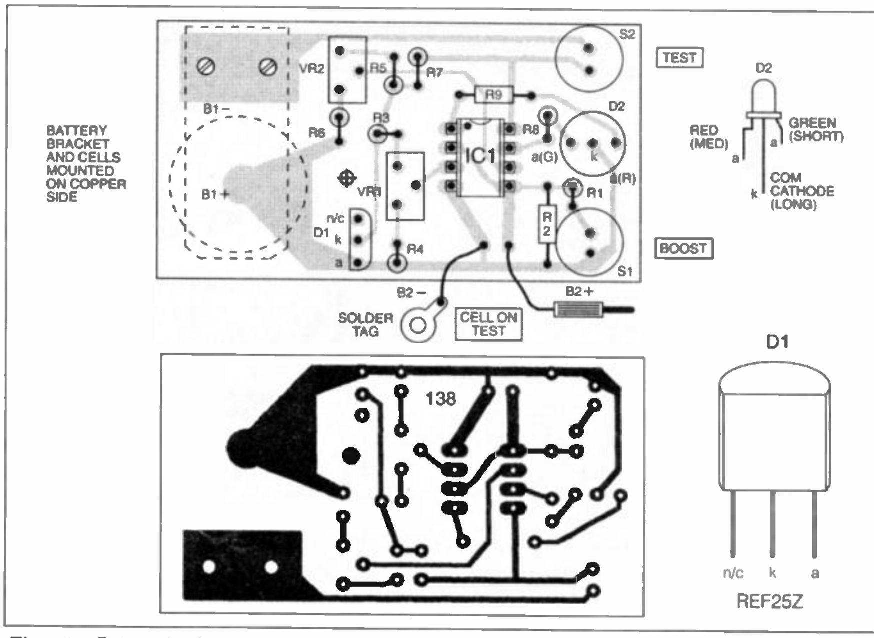
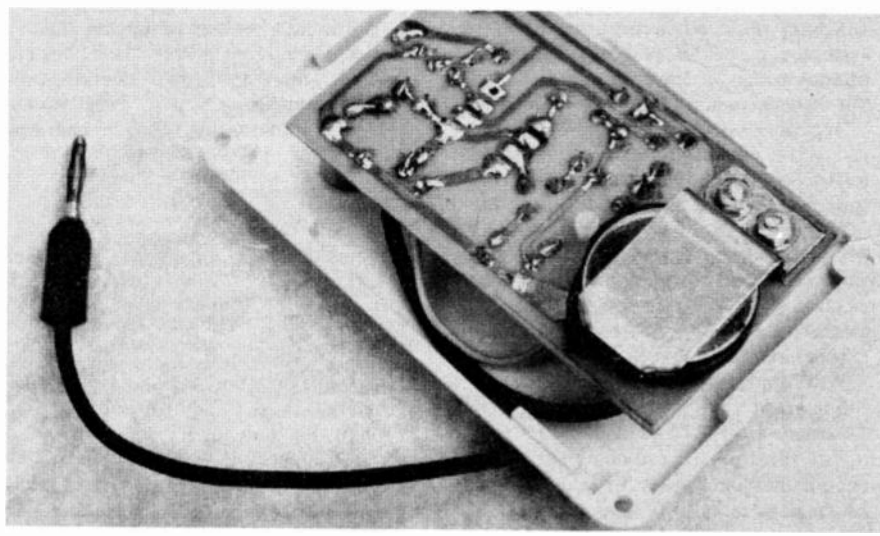


Fig. 2. Printed circuit board component layout, full size underside copper foil master and pinout details for the voltage reference "diode" and tri-colour l.e.d.



The "button" cells clamped in position on the copper side of the p.c.b.

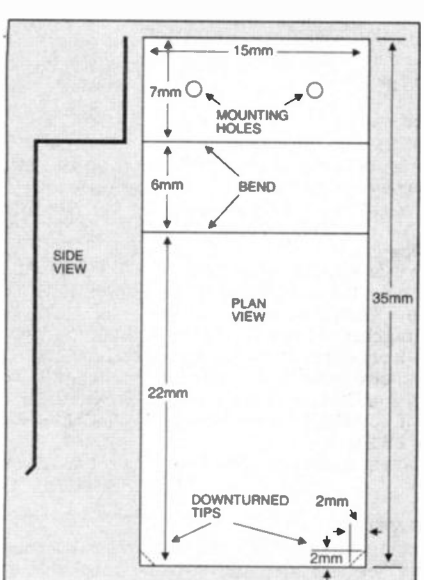


Fig. 3. Battery bracket dimensions and bending details.

Stack the cells with the positive face of each *upwards*. This will connect them is series. Press them together tightly and apply some p.v.c. insulating tape tightly around the rim. Trim off any excess so that the top and bottom faces are almost fully exposed. Apart from securing the cells as a unit, this also serves as insulation to prevent possible short-circuits being caused with the bracket which will form the positive connection.

CELL BRACKET

The bracket used in the prototype was made to the pattern shown in Fig. 3. A strip of brass size 35mm × 15mm was cut from a mains earthing strap. This material is easily cut and bent yet is springy and rigid enough for the purpose. However, other materials would probably be equally suitable.

Make the bends cleanly using a small vice or pliers. Measure the positions of the holes on the p.c.b. and drill those in the bracket to correspond. Make the downturned tips using a pair of pliers. These will help to locate the cell pack. Note that they must be small so that they only hold the top cell.

Place the cells in position, negative face down, and secure the bracket over them. Make any adjustments, as necessary, so that the cells are held securely and the lower one makes good contact with the tinned pad on the p.c.b. Check that the bracket makes a good connection with the positive face. Insert IC1 into its socket observing the orientation.

Measure the position of the switches, l.e.d. and fixing hole in the p.c.b. Mark these on the lid of the case and drill holes to correspond. Make the hole for the test stud in the position shown in the photographs and a small one for the positive test lead to pass through.

TEST STUD

Make the test stud by filing down the head of a small cheese-headed bolt until the slot is removed. Although this is not really necessary, it will improve the final appearance. Secure the stud in position with a solder tag under the nut on the inside. Solder the "B2−" wire leading from the p.c.b. to it.

Tie a knot in the "B2+" wire leaving some slack and pass it through the hole from the inside of the lid. Check that the knot provides strain relief so that the wire cannot be pulled from the p.c.b. pad in use. Attach the 2mm plug (or similar small plug) to the free end of the lead to act as the test probe.

Pass the threaded switch barrels through the holes drilled in the lid. The l.e.d. should locate in its hole and protrude by a small amount. Attach the nuts to the switches so that the p.c.b. is secured. The presets VR1 and VR2 may prevent it taking up a horizontal position but if it tilts slightly this does not matter.

Measure the length of plastic stand-off insulator needed for the nylon bolt which will be used through the single p.c.b. fixing hole. Cut it to size. Remove the p.c.b. again since it will be much more convenient to test and adjust it this way.

TESTING

It will be convenient to use a rubber band or adhesive tape to hold pushbutton switch S2 down while making adjustments. With no cell connected, the red l.e.d. should be on.

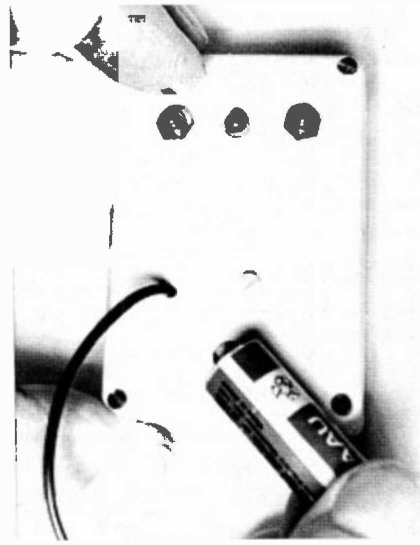
It is possible to set up the NiCad Checker using a digital voltmeter only. However, some adjustment may still be needed over a trial period to make the unit respond exactly as required.

If the voltmeter method is used, hold its negative probe on the stud. Touch the positive one on the sliding contact connection of VR1 and adjust it so that the meter reads 1·28V.

Note that the front of the preset will probably have a metal ring and the plastic body will have a small cut-out at the top. The ring is connected to the centre (sliding contact) pin and the cut-out gives a convenient place on which to touch the meter probe.

Next, apply the positive probe to VR2 sliding contact in the same way and adjust it so that the meter reads 1·20V. These figures correspond to about one-half and one-quarter charge respectively.

Close-up of the negative lead terminating at the solder tag beneath the "negative" test stud mounted in the lid of the case.



In use the Checker probe lead is held on the positive connection and the negative end of the "test cell" is then placed on the test stud.

A BIT DIM

An alternative setting-up method involves discharging a cell in a controlled manner. The best way is to connect it to a 1·25V 250mA torch bulb in a suitable holder. Start with a fully-charged battery and measure the time taken for the bulb to go dim. For example, a standard (500mAh) "AA" cell would provide about two hours of service.

Now decide on the boundary times between *good/serviceable* and *serviceable/recharge*. It is suggested that up to half the total time be regarded as *good*, between half and three-quarters, *serviceable* and more than that, *recharge*.

Charge the cell again and discharge it through the bulb to the end of the *good* period. Connect it to the Checker – the green l.e.d. should be on. Adjust preset VR1 so that the red l.e.d. just begins to operate giving a *yellow* effect. Now run the cell down until the *satisfactory* time has elapsed. Adjust preset VR2 until the green l.e.d. goes off leaving a red display.

With these adjustments now complete, re-attach the circuit panel using the stand-off insulator on the bolt shank. Assemble the two sections of the case and put the unit into service.

Note that this NiCad Checker circuit is not effective at indicating the state of a cell when it has just been taken off charge. It works best when the cell has stood for a while or has just been removed from a piece of equipment.

Experience will soon help the user to decide whether to press the Boost switch S1. For ordinary small cells this will probably not be necessary. □

SHOP TALK
with David Barrington

Dual-Output TENS Unit

A couple of devices for the *Dual-Output TENS Unit* have been found to be special and not generally available. The *n*-channel MOSFET transistor type ZVN4310A appears to be only available from **Electromail** (☎ *01536 204555*), code 814-306.

For safety, the output capacitor C7 *MUST* be rated for at least 160V working or higher. The prototype used a polypropylene type (**Maplin** JY78K), but there are also polyester types with adequate voltage rating. The p.c.b. has pads to suit different lead spacing.

Two miniature 470µH chokes have been successfully tried for the inductor L1. These came from **Electromail** (228-539) and **Maplin** (AH36P). It is also likely that **Cirkit** (☎ *01992 448899*) can supply one from their large range of inductors.

Other cases can be used here, but the p.c.b. has been specially designed to screw directly onto the internal mounting bosses. The case is the Maplin ZB16S, with battery compartment.

Two sources of commercial electrodes have been found: **Spembley Medical Ltd** (☎ *01264 365741*) pack of four £8·53 inclusive; and **N.H. Eastwood** (☎ *0181 4419641*) ring for prices.

The TENS printed circuit board is available, together with some information about TENS Units, from the *EPE PCB Service*, code 139 (see page 211).

Finally, we understand that **Magenta Electronics** (☎ *01283 565435*) are putting together a complete kit of parts for this project – give them a ring for details.

Tri-Colour NiCad Checker

Key components for the *Tri-Colour NiCad Checker* are the 2·5V precision voltage reference type REF25Z and the LM358N dual op.amp. As far as the op.amp goes, this should be stocked by most of our component advertisers and should not be a problem to find. The same situation should apply to the 5mm tri-colour l.e.d.

However, the 2·5V REF25Z voltage reference may not be so readily available through readers' usual channels and could be difficult to track down. The one in the model came from **Maplin**, code DB58N.

We are not quite sure of the general availability of the 3V lithium "button" cells, type CR2032, that make up the supply source. They are certainly listed by the above company as code ZB74R.

The small printed circuit board is available from the *EPE PCB Service*, code 138 (see page 211).

Oil Check Reminder

One or two items called for in the *Oil Check Reminder* project will have to be selected with care if they are to fit accurately on the circuit board. This applies particularly to the mains transformer.

The 6VA transformer, with two 500mA secondaries, came from **Maplin**, code YJ52G. Other similarly rated transformers can be used provided they will fit on the p.c.b.

A similar situation exists regarding the remotely mounted Reset switch. This can be any type, but it *MUST* be a "waterproof" type. The one used in the model is a "splashproof" pushswitch, with waterproof cap and bezel, and was purchased from Maplin, code RD20W.

The following components were all ordered from the above supplier (other advertisers may offer the same or similar parts): 10mm Super-bright l.e.d., code UK53H; 4N25 opto-isolator, code AY44X; 8Ω 38mm dia. speaker, code WB04E; µA2240CN timer/counter, code CP99H; and main case (D-009), code ZB02C.

The printed circuit board is available from the *EPE PCB Service*, code 125 (see page 211).

Video Negative Viewer

Apart from the possible requirement of a stepping ring and negative holder accessory, all the "electronic" parts needed to construct the *Video Negative Viewer* are standard "off-the-shelf" devices that most component advertisers should be able to supply. Detail of suppliers for the camcorder adaptors are contained at the end of the article.

The p.c.b. is available from the *EPE PCB Service*, code 135.

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We can supply back issues of *EPE* by post, many issues from the past five years are available. An index for each year is also available – see order form. Alternatively, indexes are published in the December issue for that year. Where we are unable to provide a back issue a photostat of any *one article* (or *one part* of a series) can be purchased for the same price.

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FEATURES ● Build Your Own Projects, Part 1 ● Ingenuity Unlimited ● Circuit Surgery ● Net Work ● Interface.

DEC '96

PROJECTS ● Vari-Colour Christmas Tree Lights ● PIC Digital/Analogue Tachometer ● Stereo Cassette Recorder ● EPE Elysian Theremin, Part 2.
FEATURES ● Build Your Own Projects, Part 2 ● Interface ● Circuit Surgery ● Ingenuity Unlimited ● Net Work – Internet News.

JAN '97

PROJECTS ● Earth Resistivity Meter, Part 1 ● Psycho Rat ● Theremin MIDI/CV Interface, Part 1 ● Mains-Failure Warning.
FEATURES ● Ingenuity Unlimited ● Build Your Own Projects, Part 3 ● Circuit Surgery ● Interface ● Net Work – Internet News ● PCS32 Storage 'Scope Interface Review.

FEB '97

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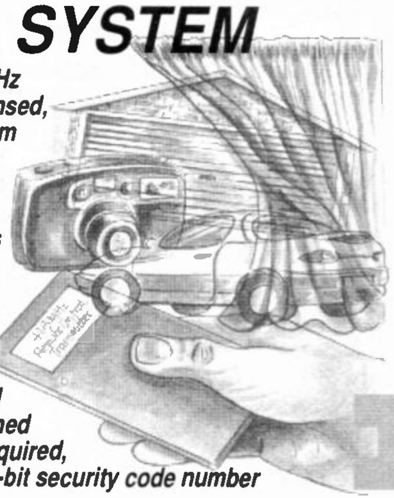
418MHz REMOTE CONTROL SYSTEM



Transmissions on the 418MHz Band do not need to be licensed, so this remote control system can be used by anyone who has the need to control the world from a simple source. There are many applications for this easy-to-build coded transmission and reception system, though its main use is probably radio-linked control and monitoring of intruder alarms. Designed around commercial pre-aligned modules, no setting-up is required, except for selecting which 8-bit security code number you want to use.

PIC-AGORAS

Who do think of when geometry-angles, dangles, triangles, diameters and circumferences – is mentioned? Pythagoras, probably. What chip do you think of when microcontrollers – data inputting, data calculating, data outputting – are mentioned? PICs, probably. Combine the two thoughts and what do you get? PIC-agoras, of course!

So what does a PIC-agoras do? Quite naturally, it monitors the angular rotations of wheels, almost any conceivable wheel (as long as it's round), calculates the circumferential distance travelled over periods of time, and shows the results alphanumerically on a 16-character intelligent liquid crystal display screen – of course!

And how do you use a PIC-agoras? Well, the author mounted his on his push-bike, and now pedals off in the satisfying knowledge that he can keep track of the miles and kilometres travelled, the time taken to cover them, the average speed that he's done them, and so on; AND PIC-agoras has a non-volatile memory that doesn't get lost on switch-off (unlike the author's), so it remembers various totals for the next time.

But, PIC-agoras can be used on other vehicles as well, irrespective of wheel-size (within reason!): golf carts, shopping trolleys, penny-farthings, indeed probably most wheelies that can travel at up to about 100 m.p.h.! Enough of the teaser intro – read all about PIC-agoras next month

MIDI MATRIX

If you've got a MIDI set-up, we'll lay odds that you're probably fed up with messing around constantly changing and re-changing all those cables that connect up the variety of instruments in the system. Breath a sigh of relief, now it's MIDI Matrix to the rescue!

Using the 'telephone exchange' principle, MIDI Matrix allows lots of signals to come in but uses few switches to select their output routing. Any electronic musician, amateur or professional, can reap benefits from this superbly designed tool.

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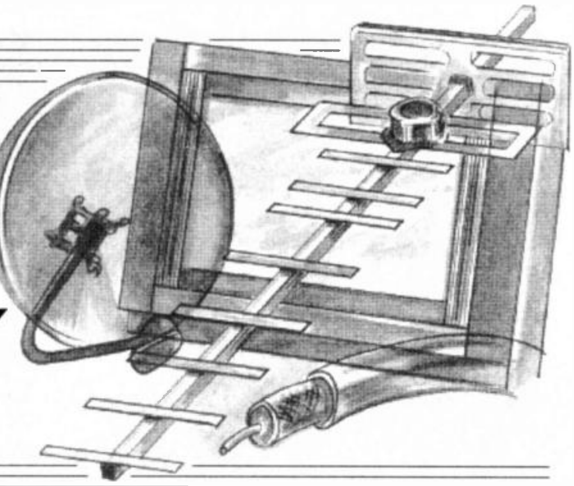


DIGITAL TV - THE REALITY

BARRY FOX

Power, politics and market forces are controlling Digital TV's future as much as the technicalities.

EVERYONE is talking about digital TV, and warning that Rupert Murdoch is poised to become the technology gatekeeper for the new age. Often the media reports are long on opinion and short on technical fact. So we look at the underlying questions. What is digital TV, why do we need it, do we want it, when will we get it and who can call the shots?

Digital transmission technology already exists and is used by broadcasters to relay their programmes between studios and transmitters. Digital signals are more robust and take up less space in the airwaves than their analogue equivalents. The electronics industry is now working to drive down the cost so that viewers can have their own digital receivers.

The target for the UK is a launch in late 1997, or more likely some time in 1998, with services arriving from satellites in space and from the same terrestrial transmitters that currently deliver analogue TV. The first receivers will be set-top decoder boxes that plug into an existing TV set. But unless subsidised they will cost at least £500.

On top of that, viewers will have to pay to view most programmes. Also, to get the full benefits from digital TV, viewers will have to invest in a new TV set, with large 16:9 widescreen CRT (cathode ray tube) and built-in decoder. This pushes the startup cost up towards £2000.

AERIAL CONVERSION

Although it is not yet widely recognised, satellite viewers will need to modify or replace their dish aerials to receive the new signals.

So there will be no overnight conversion to digital TV. The broadcasters will have to find ways of enticing viewers, with subsidies, special offers and irresistible programmes. If anyone yet has any clear game plans they are not letting on.

The more honest broadcasters and manufacturers admit they do not yet have a clue what they are going to do to make us spend whatever it costs to convert from analogue to digital TV. Rupert Murdoch's BSkyB has consistently ducked the issue of who will pay for the labour-intensive job of modifying the four million or more dish aerials currently in analogue use.

PROMOTING DIGITAL

Britain is not alone in promoting the digital transition. The US already has a direct-to-home digital satellite TV service. Aerospace giant Hughes launched DirecTV two years ago, as part of a push to replace income previously earned from the military. The US government is now close to setting a standard for digital terrestrial TV, but commercialisation has been bogged down because the national plan was to use digital technology to carry high definition TV (HDTV) programmes, not a wider choice of conventional quality TV. Few viewers want high definition pictures and even fewer will pay the high price of the new screens needed to do them justice. The Federal Communications Commission is now rethinking its strategy.

Japan is handicapped because state broadcaster NHK made an early pioneering commitment to Hi Vision, an analogue HDTV system. The Japanese government dares not repay viewers' support for Hi Vision by telling them that their receivers are now obsolete. So digital TV is coming to Japan from commercial satellite services.

On the mainland of Europe, there is a bewildering tangle of alliances and competition between French pay-TV service Canal+, German media giants Bertlesmann and Kirch, and BSkyB. The situation changes almost daily, from country to country.

The most vigorous and coordinated digital push is coming from the UK, thanks to a race which is developing between satellite and terrestrial broadcasters. It is not yet clear whether the race will become a commercial battle or an uneasy commercial alliance. But pieces of the jigsaw are now starting to fall into place.

Rupert Murdoch's News International empire won control of key digital transmission technology when he bought the digital research laboratories and patent folio which were originally state-owned by the Independent Broadcasting Authority, then privatised as NTL and now renamed Digi-Media Vision (DMV).

Murdoch's BSkyB satellite service has run out of analogue space on the transmitters which it currently leases from Luxembourg company Astra. So BSkyB has leased 14 transmitters on the new, second, series of satellites which Astra will start launching in August 1997. These 14 transmitters will carry several hundred digital TV programme channels. BSkyB has let its investors know – or encouraged them to believe – that transmissions will begin soon after the satellite is operational in Autumn 1997.

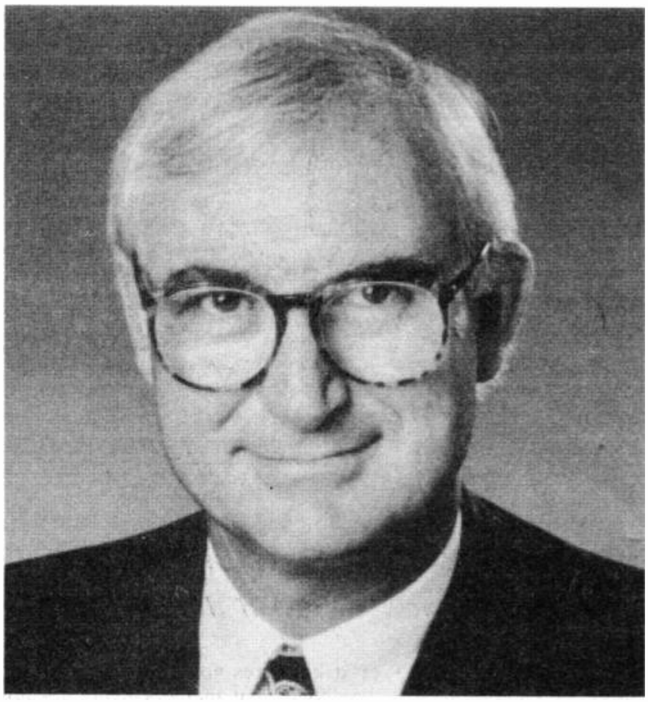
BBC'S ROLE

The British government has now awarded the BBC a new ten year charter as state broadcaster. This guarantees the BBC an annual income of £1·8bn from viewers' licence fees. Immediately the charter was secure, Director General John Birt announced his plans for the Digital Dividend. The BBC wanted to start digital TV broadcasting in late 1997.

Although the BBC needs no special licence to start a digital service, its commercial rivals do. So the Independent Television Commission has now opened the bidding for licences to be granted in 1997 for services to begin no later than July 1998.

John Birt predicts that the next ten years will see the BBC sending programmes into homes by whatever means is appropriate; digital satellite, terrestrial, cable and telephone wires. This opens the door to interactivity, with viewers sending digital commands back to the broadcaster by telephone line or cable link. Astra has now announced that within two years its new satellites will have the facility to receive control signals beamed back by the viewer from a home dish. Interaction lets viewers vote in a quiz or referendum, gamble on a games show or select from a choice of programmes.

The BBC's push on digital broadcasting parallels the situation in 1936 when the young Corporation made the UK a world leader with the inauguration of a highly ambitious all-electronic TV service from Alexandra Palace in North London. The BBC



"Either we make the digital transition or we just let our beards grow and do nothing", comments John Birt, Director General of the BBC.

worked with Marconi-EMI to deliver 405 line pictures, which were then regarded as "high definition" in comparison with the much coarser images delivered by John Logie Baird's neo-mechanical technology.

Says John Birt: "Either we make the digital transition or we just let our beards grow and do nothing. That's not a sustainable option".

The analogue option is not sustainable because analogue technology is very inefficient at delivering TV programmes. Each station needs around 8MHz of frequency space. Two terrestrial transmitters cannot use the same frequency within several hundred kilometres of each other because even weak signals from one will interfere with strong signals from the other, causing "herringbone" patterns on the screen. So the frequency bands allocated for analogue terrestrial broadcasting can support only a few TV programmes in each country.

A satellite can transmit more programmes, but its transmitters cover a wide geographical area. So the satellite usually delivers a handful of channels in different languages to several adjacent countries.

Converting a transmission system from analogue to digital, multiplies the number of programme channels it can deliver by a factor of up to ten. The exact number varies with the system, and the wishes of the operator. Satellite channels are wider than terrestrial; in each case the bitstream can be used to carry a few programmes with higher picture quality or a lot of programmes which either match the picture quality of today's analogue programmes, or make compromises, for instance on news footage.

EXISTING AERIALS

The ITC's strategy is to license digital frequencies which viewers can receive with existing TV aerials. In many homes, set-top wire aerials will work as well as a rooftop array. So, as long as they are content with 4:3 pictures, viewers will only need a set-top box which converts the new digital transmissions into analogue signals which a conventional TV set can display.

The UK government has told the ITC to licence six multiplexes (each 8MHz wide) and capable of carrying between three and eight programmes depending on picture quality. The BBC, ITV, Channel 4, C5 and Welsh C4 will take space equivalent to two multiplexes. The other four, with capacity for up to 30 programmes, will be awarded to commercial bidders.

The digital multiplexes will slot into today's "taboo" channels, the UHF frequencies which are spare in an area but cannot be used for analogue broadcasting because the signals may interfere with programmes in other areas. Digital TV needs only one hundredth the transmission power of analogue TV, so digits in taboos cause no interference to existing services.

SIMULCASTING

The BBC has promised to "simulcast" its existing analogue programmes, "free to air". So, for no extra fee, viewers with new equipment will be able to watch BBC1 and BBC2 digitally in high quality 16:9 widescreen aspect ratio, while viewers with analogue sets continue to see conventional 4:3 aspect ratio pictures. In practice, the BBC will use a widescreen aspect ratio of 14:9, so that by slightly trimming the picture sides, 4:3 sets will show only a slight letterboxing effect.

In addition to simulcasting, the BBC and the commercial stations will broadcast digital bouquets of new programmes, available only with new receivers and on payment of subscription fees.

NTL, the privatised company which currently provides the transmitters for Britain's analogue commercial stations, is hoping soon to buy the BBC's transmitter network and win multiplex licences. NTL recently used a spare channel on London's TV transmitters to demonstrate what Jeremy Thorp, the company's director for digital and interactive services, claims is "the first fully operational end-to-end digital terrestrial system".

GATEKEEPER THREAT

NTL took the opportunity to warn that BSkyB may launch a satellite service which uses proprietary encryption technology developed by DMV, the company which Rupert Murdoch bought last year from NTL. If BSkyB's set-top box only works with satellite signals, viewers will not want to buy a second box for terrestrial viewing. If terrestrial broadcasters have to ask BSkyB for a licence to make a dual-purpose box, Rupert Murdoch becomes a digital "gatekeeper", effectively controlling the BBC.

The gatekeeper issues arise despite the fact that there is an agreed and open standard for digital TV in Europe. This standard emerged at lightning speed. The impetus came from the failure of an analogue project and the lessons learned from the mistakes made.

In the '80s manufacturers and broadcasters got together under an official European research project, *Eureka 95*, to develop native European high definition TV technology. HD-MAC (High Definition Multiplexed Analogue Components) was a hybrid system; the transmitted pictures were analogue but they travelled with digitally coded "helper" signals which a suitable TV set could use to make the images much wider and clearer than for conventional TV. MAC was heavily patented to try and protect the European electronics industry from low cost competition from the Far East.

The European Commission in Brussels tried to force European satellite and cable broadcasters to use MAC, but they rebelled and used conventional PAL instead. Even the major European manufactures, Philips of the Netherlands, Thomson of France and Nokia of Finland hedged their bets by secretly developing digital TV systems. So the Far Eastern manufacturers had no interest in making MAC sets anyway.

NTL hope to buy the BBC's transmitter network to provide, according to their Director Jeremy Thorp, "the first fully operational end-to-end digital terrestrial system."

SENSIBLE STANDARDS

In September 1993, with MAC dead, the manufacturers and broadcasters got together again and created the voluntary Digital Video Broadcasting group. Their object was to set standards for a system driven by commercial market need, not political whimsy. The DVB group was fiercely independent. It got no EC funding, and its members quickly voted to reject a grant which Brussels offered. The DVB group agrees standards which it passes to ETSI, the European Telecommunications Standards Institute, for rubber-stamping.

There are three main standards, for cable, satellite and terrestrial broadcasting. All are based on MPEG2 coding, the digital compression standard set by the Motion Picture Experts Group of the IEC, International Electrotechnical Commission and ISO, International Standards Organisation. The prime differences are in the way the compressed signal is packaged for transmission.

The satellite and cable systems build on the techniques used to send the digital pulses which convey electronic mail by ordinary analogue telephone line. The shape of an analogue wave is rapidly switched to convey a rapid series of pulses. This quite simple system only works if the waves can travel freely, without interference or distortion. TV cables act like an electronic pipe which shields the signals from ill effects. Satellite signals arrive at a dish aerial direct from space, in a narrow, unobstructed beam, that behaves like a pipe.

Terrestrial TV signals have a much more difficult journey from the broadcaster's transmitter to the viewer's aerial. They are blocked by buildings and hills and reflect off them so that the same signal arrives several times over at the receiver, with varying delays. On an analogue TV set this causes snow and ghost images spread across the screen. On a digital system the echoes so confuse the decoder that it stops working altogether, and the set displays no pictures at all.

COFDM SOLUTION

The solution is to use a system called COFDM (Coded Orthogonal Frequency Division Multiplex), previously developed for digital radio. Instead of transmitting one wide radio channel, the broadcaster puts out several thousand narrow channels, packed tightly together like the teeth of a comb. The digital code is split into a similar number of streams and one stream sent on each channel. So each channel carries fewer bits of code each second, and the bits in each channel are widely spaced apart in time. Unwanted reflections arrive in the wide gaps and the receiver rejects them.

The BBC believed that 8000 channels would be needed to make digital terrestrial signals robust in cities and valleys. Electronics companies argued that 2000 channels would be enough and that the microchips needed for "8k" reception would be as complex as a Pentium computer, cost far too much and not be ready until the year 2000. NTL argued that 8k transmission was "doomed to failure".

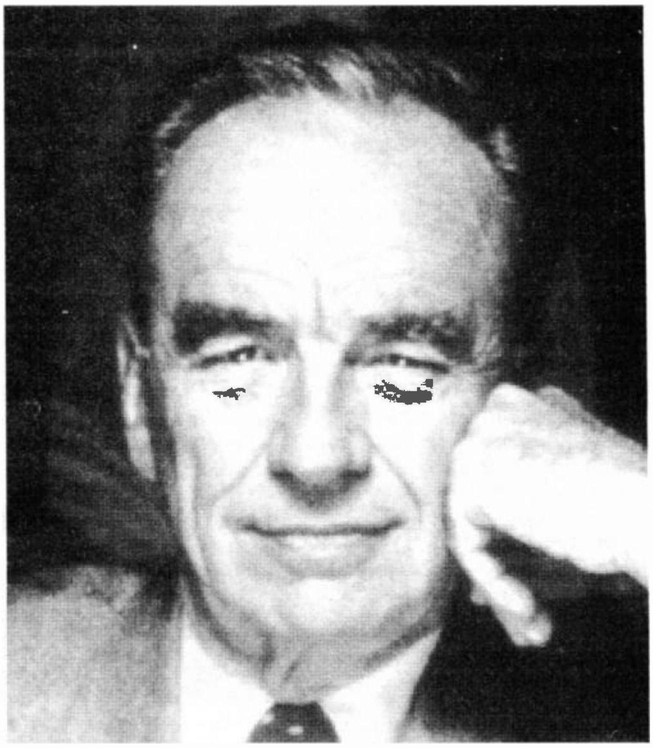
The DVB group finally compromised by leaving the choice up to individual countries. To avoid delays to its service launch plans, the BBC has agreed to use a 2k system. Some other countries, such as Spain and Sweden, may delay their service launch plans until 8k chips are a cost-effective option.

The UK's decision is far-reaching. Although 8k chips will be able to receive 2k transmissions, 2k receivers will never be able to pick up 8k transmissions. So once the UK starts digital broadcasting with a 2k system, the die is cast and there will be no turning back. The BBC, however, now seems confident that it can make 2k work.

The DVB group also set a standard for encrypting or scrambling the MPEG2 signal, so that programmes can only be seen by viewers who have paid to view. But there was no agreed standard for a "conditional access" system which accepts the payments made and instructs the receiver to unscramble the signals. No-one wanted any one company to become the gatekeeper for conditional access technology because it would give them too much power and revenue.

Instead, the DVB group recommended a "common interface" which will work like a plug and socket on the receiver to connect the DVB standard unscrambler with a module which contains whatever non-standard electronics are needed for the access system chosen by the broadcaster.

In practice, the module will probably be a second generation "fat" smart card which plugs into a slot in the receiver. A receiver with several slots can be used to unscramble a wide range of programmes broadcast with completely different conditional access requirements. If an encryption system is compromised by piracy, the broadcaster can simply provide all subscribers with new modules which incorporate new codes.



If BSkyB wins a "critical mass" of digital satellite viewers, Rupert Murdoch would become the "Digital Gatekeeper", effectively controlling the BBC.

CRITICAL MASS

The fear that Rupert Murdoch becomes the digital gatekeeper flows from this scenario. If BSkyB starts its digital satellite service ahead of the terrestrials, and wins a critical mass of viewers, the company can use a proprietary conditional access system and make it a *de facto* standard for all digital broadcasting – just as Sky has made VideoCrypt the *de facto* standard for analogue encryption and access.

But this only happens if BSkyB does get in first and here things are not quite as they seem, or as BSkyB's publicity machine would like them to seem. In reality, BSkyB faces significant technical and commercial problems.

All existing dishes in the UK are sighted on Astra's analogue satellites at 19 degrees East. The dishes each have an electronic system, called a low noise block (LNB), which is tuned to receive the relatively low frequencies used by analogue satellites and convert them to an even lower frequency which can survive the cable run to the TV set.

Despite Astra's recommendations, only a few dish makers and aerial installers yet fit the Universal LNBs needed to receive the higher frequencies used for digital TV. This is not surprising. Universal LNBs are more expensive and the public expects to get a satellite system for under £50, or now even for free, in return for paying BSkyB a subscription to view.

Also, Astra's new digital satellite will be at 28 degrees East, not 19 East. So if viewers want to pay to receive the new digital programmes they will first have to pay an engineer to re-sight their dish, and fit a new LNB at the same time. This is in addition to paying several hundred pounds for the set-top box needed to decode any digital TV service.

BSkyB will not say how it hopes to persuade viewers to pay up. "It's all speculation at the moment", says a spokeswoman.

This is why it is so significant that the ITC is licensing frequencies for digital terrestrial transmission which will allow viewers to use existing, or even set-top, aerials.

DUAL PURPOSE DECODERS

Consumers certainly will not want two boxes, one for satellite and one for terrestrial reception. The difficulty and cost of changing satellite viewers' dish aerials makes it impractical, and probably impossible, for BSkyB to win its critical mass ahead of the terrestrial launch. So the market screams for a dual-purpose set-top box which uses standard MPEG decoder chips along with front ends for either satellite or terrestrial reception.

Because of the high price of even 2k COFDM circuitry, it costs only an extra £5 to make a terrestrial receiver receive satellite programmes, but it costs an extra £50 to make a satellite box receive terrestrial programmes. Leading manufacturer Pace puts the real (unsubsidised) selling price of a dual standard box at between £500 and £600 at the end of 1997 or early 1998, falling to £150 or £200 by the year 2000.

In practice, consumers look most likely to buy into digital TV if the terrestrial and satellite broadcasters cooperate rather than compete.

In mid June 1996 John Birt called on the UK government to compel manufacturers to sell only equipment which will receive both terrestrial and satellite broadcasts. The government's DTI, along with Oftel, the UK's telecommunications watchdog, have pledged to prevent any one broadcaster obstructing the manufacture of dual standard boxes. Whatever conditional access technology becomes the *de facto* standard, it must be available for licence, to all manufacturers, at reasonable rates. Oftel has now published a consultation document on this.

There is another good reason why a dual standard box and policy of cooperation makes sense. The British broadcasters cover 90 per cent of the population with 50 main analogue transmitters. Another 1000 are needed to serve the remaining 10 per cent. Of these, 500 are very small stations which transmit to just 2 per cent of the population.

This leads logically to a digital TV launch which sees the digital terrestrial broadcasters simulcasting by satellite, with viewers in the more densely populated areas using a dual standard box for terrestrial reception, and those in more remote areas using the same boxes to pull in the same programmes direct from satellite. Nine out of ten homes will be able to install or modify dishes to receive a wider choice of digital TV from satellite as well as from terrestrial transmitters.

TACTICAL ALLIANCE

But this scenario leads logically to an alliance of necessity between Rupert Murdoch, News International, John Birt and the BBC.

The alternative is a straight fight between the BBC and BSkyB, with the terrestrial broadcaster offering less programme choice but the obvious convenience of using existing or set-top aerials. In such a fight, BSkyB would be forced to subsidise the mass modification of aerials, at a cost to its shareholders of many hundreds of millions of pounds.

As 1997 rolls by we shall get a better idea of whether the terrestrials will work together or try and fight it out. Only one thing is certain. With an election looming, the British government will remain at arm's length and do nothing to obstruct BSkyB and risk the wrath of the Murdoch press.

NEWS FLASH

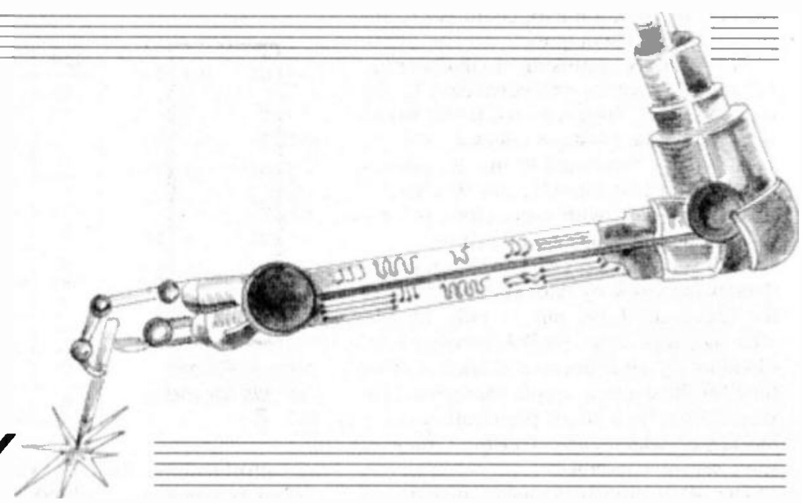
The BBC has been characteristically cagey about its DTTV launch schedule. But a letter written to employees by John Birt now reveals the BBC's plans. Says John Birt, after welcoming the government's decision to increase licence fees, "We are now in a confident position to launch our new digital services in October".

This is earlier than expected and only a couple of months after the launch promised by BSkyB.

DIGITAL TV AND MPEG2

Next month, in a separate feature, Mike Rutherford unravels the technicalities of digital TV and the digital compression standard MPEG2 which has been internationally adopted for cable, satellite and terrestrial broadcasting.

CIRCUIT SURGERY



ALAN WINSTANLEY

A selection of readers' letters and queries this month deals with a puzzling Darlington pinout, binary and decade counters, and environmental issues concerning NiCad batteries.

MUCH of the *Surgery's* work never makes it to print in this column, but a lot of background support is given to readers during the month, both by mail and E-mail. For example, sometimes I'm asked to help identify a particular chip or other semiconductor device, and I have been known to scan and send pinouts of elusive chips by E-mail – not something I can always guarantee to do but, time permitting, I try to help readers to fathom out any puzzling pinouts when possible.

Dubious Darlingtons

Mr David Jones of Llanelli, Wales posed a problem which had me rustling through my Data Library for quite some time! David writes:

I was recently given some very "meaty" transistors, type ESM 6045DV. They're listed as npn *Darlingtons but I cannot find out why, as a normal bipolar transistor, they should have* two *base terminals!*

None of the terminals correspond to the resistance measurements that I would expect from a normal npn *transistor. Maybe you could point me in the right direction?*

Well, this device took quite some tracking down, but eventually this information was found in the SGS Thomson *Microelectronics Data Book.* They describe it as a bipolar power module in an *"isotop"* casing.

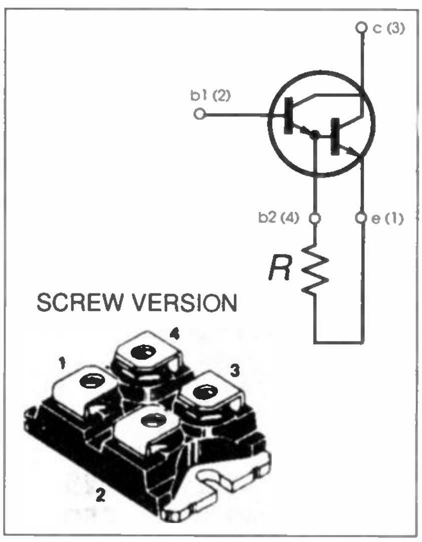


Fig. 1. Darlington transistor circuit symbol, plus "isotop" transistor graphic.

Its specification is pretty scary – a collector current (I_c) of 84 amps and a total power dissipation (P_{tot}) of 250 watts! The pinout drawing is shown in Fig. 1. It appears to have two base terminals, all right, but why?

All connections are made via screw terminals, and the base/emitter terminals of *both* internal transistors are brought out to their own pins. As things stand, you could ignore pin 4 if you wanted to, but it's not uncommon to add a small resistor (*R*) as shown. Sometimes this is already built into the Darlington and may be shown in manufacturer's Data Sheets.

The resistor speeds up the turn-off time, and prevents any leakage current which will flow through TR1, from driving TR2 and sending it into conduction. Instead, the resistor shunts this leakage current away and is selected such that the current leaked through TR1 produces a voltage drop of only a few hundred millivolts across resistor *R*: not enough to turn on TR2. It would have a value in the region of under one kilohm, say. In the case of the ESM 6045DV you can access the individual transistors within the Darlington, via the extra pin provided by the manufacturer.

Counter Intelligence

By E-mail came the following query from ***Simon N. Atkin*** who asks:

I just need a little help choosing a CMOS ripple counter. I'm wanting an output whereby each bit goes high in sequence, one after the other.

The counters type 4060 or 4020 could be suitable, I think, but not having used ripple counters for a long time, I'd appreciate any help.

The CMOS counters which you mention are actually *binary* counters, what you appear to need is a *decimal* counter. What's the difference? Whilst it's true that most logic devices are either *on* or *off* (Logic 1 or Logic 0), and are therefore working in *binary* in this respect, you need to check the *output sequence* to determine whether you actually want a true binary counter or a *decimal* (or decade) counter. Hence

Table 1. A 4-bit binary sequence, counting from decimal 0 to 9.

8	4	2	1	
Q4	**Q3**	**Q2**	**Q1**	**Decimal**
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9

we dip our toes into *sequential logic*, because the logic operation depends on what happened earlier in the sequence.

A binary counting sequence is shown in Table 1 - and because I've only drawn the first four **binary** digits **(bits)** labelled Q1 to Q4, this is a *4-bit binary counter*. The decimal equivalent of the binary count is shown alongside. The full 4-bit binary count, of course, actually runs from decimal 0 to 15. (Incidentally you might see the stages labelled as Q0 to Q3, sometimes.)

Pinouts for both the 4020 and 4060 ripple counters are shown in Fig. 2. The output pins change state in a binary sequence with each successive clock pulse received. Because one bit is used to clock

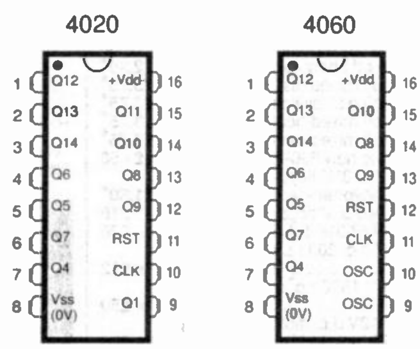


Fig. 2. Pinout details for the 4020 and 4060 counters.

the next register, a binary count is seen to *ripple* through the outputs.

The 4020 is confusing in that neither Q2 nor Q3 outputs are connected to the outside world! None-the-less, it still works internally as a 14-stage counter, with 12 of the stages connected to the i.c. pins as shown. The first bit (Q1, pin 9) changes state (or *toggles*) with every clock pulse – so it divides the clock signal by two.

Each successive register in the chip also divides the clock by two, so the last bit in the sequence (Q14, pin 3) only toggles after no less than 16,384 clock cycles (dividing by 2^{14}). Because it takes a finite time for the count to ripple through all the stages, there is a slight propagation delay introduced which can affect the timing of some sensitive circuits.

The 4020 obviously needs an external clock pulse connected to pin 10, to advance the 14-bit count sequence. The 4060 (and the faster 74HC4060) is also a 14-stage binary ripple counter, but it includes an *internal* clock oscillator which only needs an external *RC* (resistor-capacitor) network to operate. This time, the Q1, Q2, Q3 and Q11 outputs are not brought out to the pins. Otherwise, the counter ripples through the 14 internal registers as before.

What I think you actually want is a *decade* counter. This produces an output sequence as shown in Table 2. The 4017 (or 74HC4017) would be suitable. Looking at the internal circuit diagram for the chip, the 4017 is a five-stage counter, and each stage has complementary outputs which are decoded to produce a decimal count which is strobed across the output pins with each successive clock pulse. The 4017 pinout is shown in Fig. 3.

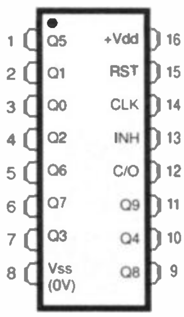


Fig. 3. Pinout details for the 4017.

Table 2. A decimal counting sequence.

Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0
0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	1	0	0	0	0
0	0	0	0	1	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0

Heavy Metal (Batteries)

An interesting comment from ***Mr Alan Bradley*** of Belfast concerns the disposal of spent batteries. Alan comments:

As Nickel Cadmium rechargeable cells contain cadmium – a Class 1 poisonous heavy metal – and no-one seems to want to recycle them or provide safe disposal facilities, I thought EPE *should perhaps only allow projects which use Nickel Hydride or gel lead acid cells. Also, if a proper method of disposal exists, I'd appreciate any information.*

Unfortunately, the UK waste disposal scene is some way behind that of, say, Holland or Scandinavia where there are far more extensive waste disposal/recycling facilities. The crux is that NiCad cells are cheap and readily available. Nickel-Metal Hydride (NiMH) cells are considerably more expensive and to many, an unfamiliar technology. They're appearing in laptop computers and mobile phones, more for performance reasons (higher capacity and lack of *memory effect*) rather than environmental ones, I think.

Until NiMH ranges develop and their prices drop, the guess is that NiCad consumption will continue unabated in the UK and elsewhere, and it's probably unrealistic to expect otherwise. We would feel more comfortable if there was indeed a safe, convenient and reliable way to recycle them after use.

Some local authority waste disposal sites do actually accept batteries, although the facility seems to be intended mainly for car batteries – note that a large proportion of lead which is in use in the UK has been recycled by the scrap metal industry from spent car batteries. At least some battery manufacturers have started on the right road by selling *mercury*-free cells.

In future years, you will increasingly see a peculiar *wheelie-bin* symbol, as depicted in Fig.4, appearing on the packaging of batteries and other products which pose a potential waste-disposal hazard. It's called the *KCA* logo – the German *Small Chemical Waste* symbol, and is currently the bane of my life in industry.

Spot it on car batteries (my Audi-supplied battery is labelled with one), fluorescent tubes (because of the phosphors), nail varnish and adhesives (because of the volatile solvents), too! This symbol is currently meaningless in the UK, but is statutory in Holland, and my spies in Brussels tell me that it's heading our way.

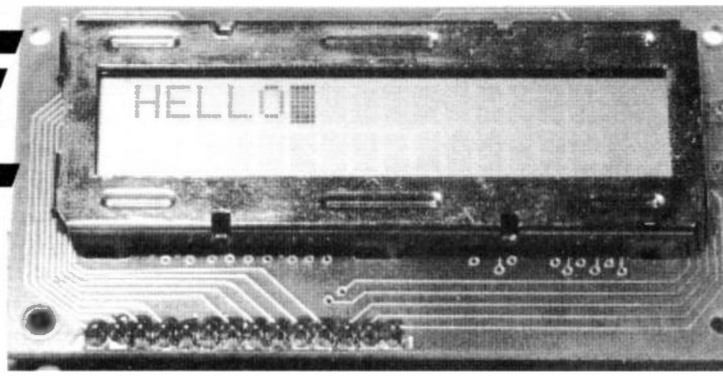
Fig. 4. The KCA "wheelie-bin" waste hazard logo, with caution in Dutch.

It indicates that such products should receive special recycling attention as chemically-active scrap, and not simply be thrown in the household dustbin: once again, the UK lags far behind. You have made a good point, Mr Bradley, and I would welcome readers' comments.

If you have any queries or comments to make, 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.

In coming months: look forward to the low-down on choosing resistor types; also, piezo sounders and alarm generators, and more!

HOW TO USE INTELLIGENT L.C.D.s



JULYAN ILETT

Part Two

An utterly "practical" guide to interfacing and programming intelligent liquid crystal display modules.

In the first part of this article, the capabilities of character-based liquid crystal display (l.c.d.) modules were examined, using a few simple, practical experiments. A series of switches was all that was needed to evaluate the command set in its most fundamental form, in binary (or hexadecimal).

However, in almost all instances where an l.c.d. is to be used in a design, a microprocessor, or more probably a microcontroller, will be needed to drive it. This is the subject we examine now.

GOOD TIMES

The timing requirements of the HD44780 chip, the controlling device used in most character-based l.c.d. modules, are illustrated in Fig. 6. The diagram provides the information for both read and write cycles, although some data sheets may show the two separately. Table 4 details the timing parameters referred to in Fig. 6.

In the experiments last month, commands were sent to the display by pressing switches on an experimental test rig. Nothing much went wrong there, so why is it necessary to have such a complex timing diagram?

Well, we human beings leave plenty of time between pressing one switch and the next, so the l.c.d. controller can easily keep up with us. Microcontrollers are faster than we are, though; they can toggle a control line several million times a second, and at such speeds the l.c.d. controller might not keep pace with the commands.

The timing diagram and its tabulated figures simply tell us how quickly the l.c.d. chip can respond so that we can program the microcontroller accordingly.

Let's take a typical microcontroller, one of the PIC devices which have become so popular, and see how we program it to control an l.c.d. from the quoted timing details.

First, though, it must be pointed out that the discussions from now assume that you have a rudimentary understanding of programming PIC microcontrollers, and that you have suitable software and equipment for doing so. It is not the intention of this article to teach PIC programming.

(We have published several PIC-based projects in recent month's which are well worth studying, along with their software listings. See the Back Issues *and* EPE PCB Service *pages. Ed.)*

The PIC microcontroller would be programmed to start by first setting the l.c.d.'s RS line to its correct logic level. This is the line that determines whether the l.c.d. should regard data as control instructions or character information. In cases where data needs to be read back from the l.c.d., the microcontroller must also have control over the R/W line (read/write), otherwise it should be connected to ground, as on the test rig.

The microcontroller can set up these two signals at the same time, or it may do one before the other, it doesn't really matter. What is important, is that they are both "valid" or "stable" for a minimum period of time before the level on the "E" (Enable) line is raised to a logic 1. On the diagram in Fig. 6, this period is shown as "tAS" (time – address setup), and in the table this is specified as 140ns minimum. It can be more than 140ns, but it must not be any less.

Once line E is high, it must not be brought low again until at least 450ns has elapsed, as is indicated by the "tEH" (time – enable high). Also, all eight data lines must be set to their appropriate logic levels and allowed to stabilise for at least the "tDS" (time – data setup) period of 200ns before bringing line E low again.

Note that the l.c.d. allows the data lines to be set up after line E is taken high. In the experiments last month, data was established well before the E switch was pressed, but either condition is allowed.

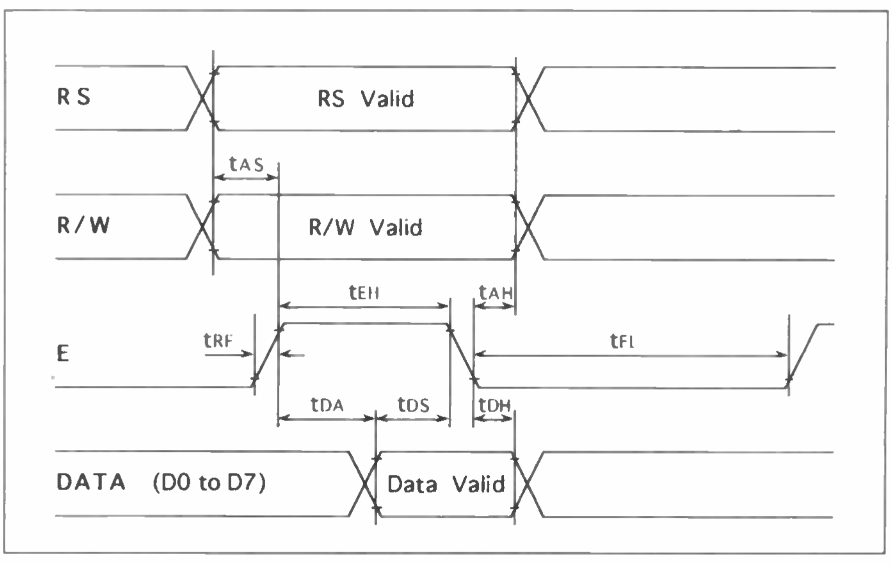


Fig. 6. HD44780 timing diagram.

Table 4. HD44780 Timing Parameters.

Parameter	Description	Time
tAS	Address set up time	140ns min
tAH	Address hold time	10ns min
tDS	Data set up time	200ns min
tDH	Data hold time	20ns min
tDA	Data access time	320ns max
tEH	Enable high time	450ns min
tEL	Enable low time	500ns min
tRF	Rise/Fall time	25ns max

Table 5. HD44780 Command Execution Times.

Instruction	Time (Max)
Clear Display	82µs to 1·64ms
Display & Cursor Home	40µs to 1·64ms
Character Entry Mode	40µs
Display On/Off & Cursor	40µs
Display/Cursor Shift	40µs
Function Set	40µs
Set CGRAM Address	40µs
Set Display Address	40µs
Write Data	40µs
Read Data	40µs
Read Status	1µs

When line E is returned to a low level, there are also two hold times that must be taken into account. The "tAH" (time – address hold) parameter indicates that the RS and R/W lines must not be altered for at least 10ns, and "tDH" (time – data hold) shows that none of the data lines must change for at least 20ns.

One further restriction exists. The E line must not be taken high again (for the next command, that is) for another 500ns (tEL: time – enable low). This means that the total cycle time of the E line is 450ns plus 500ns. Allowing for the rise and fall times, indicated by "tRF", which should be no longer than 25ns each, an approximate value of 1µs can be calculated. This means that no more than one million commands (or one million characters) per second should be sent to the display, not a restriction that would normally present many problems!

BUSY

The timing diagram doesn't tell the whole story, however. Much longer delays are required to enable the l.c.d. to process commands and data. Most commands tie-up the l.c.d. for 40µs, during which time it is said to be "busy". The Clear Display and Cursor Home commands, though, can take a lot longer.

Execution times for all the instructions are shown in Table 5. This includes all the commands, writing data to the display, and reading both data and status. The two Read instructions have not yet been experimented with, but reading the status of the l.c.d. is the method used to determine whether or not it is busy.

The practical implication of these instruction times is just a case of having to insert a delay between one instruction and the next. The first two commands, Clear Display and Cursor Home, have variable execution times that depend upon several factors. Not much is said about this variation in the data sheets, but it does involve returning the cursor to address 10000000 ($80), unshifting the display and, in the case of Clear Display, putting a space character into each display address.

There is one other important situation when the l.c.d. will be busy. This is immediately after it has been powered up. It takes some 10 to 15 milliseconds for the full initialisation sequence to be completed, during which time no instructions can be executed.

This has important implications for a circuit using a microcontroller. A suitable delay must be added to the beginning of the program, otherwise the l.c.d. won't be ready when the first few instructions are sent to it and could become locked up in a non-correctable condition, requiring the power to be switched off again for a while.

NEW CIRCUIT

Time now to re-wire last month's experimental test rig to incorporate the PIC microcontroller. The circuit diagram of the modified arrangement is shown in Fig. 7. There's no longer any need for the debounce circuit, the microcontroller provides very clean output signals. It is not essential to use the PIC16C84 type specified in the diagram, the 54, 56, 61 and 71 types can all be used, but some minor changes may need to be made to one or two of the pin connections.

However, it is best to experiment with the PIC16C84 since it is the EEPROM (Electrically Erasable Programmable Read Only Memory) version of the microcontroller.

The use of this version is desirable because several different versions of software will need to be programmed and erased during the course of experimentation. Other versions of the microcontroller cannot be erased so easily, indeed some cannot be erased at all (those referred to as OTP, One-Time Programmable devices, for example).

The microcontroller's Clock Option can be set for RC (resistor/capacitor) or any one of the XT (crystal) options, but the RC option is cheaper, and precise timing accuracy is not important in this instance. The values of the resistor R1 and capacitor C1 connected to the OSC1 input in Fig. 7, will give a clock frequency of very approximately 2MHz. For the time-being, lower values of resistance or capacitance

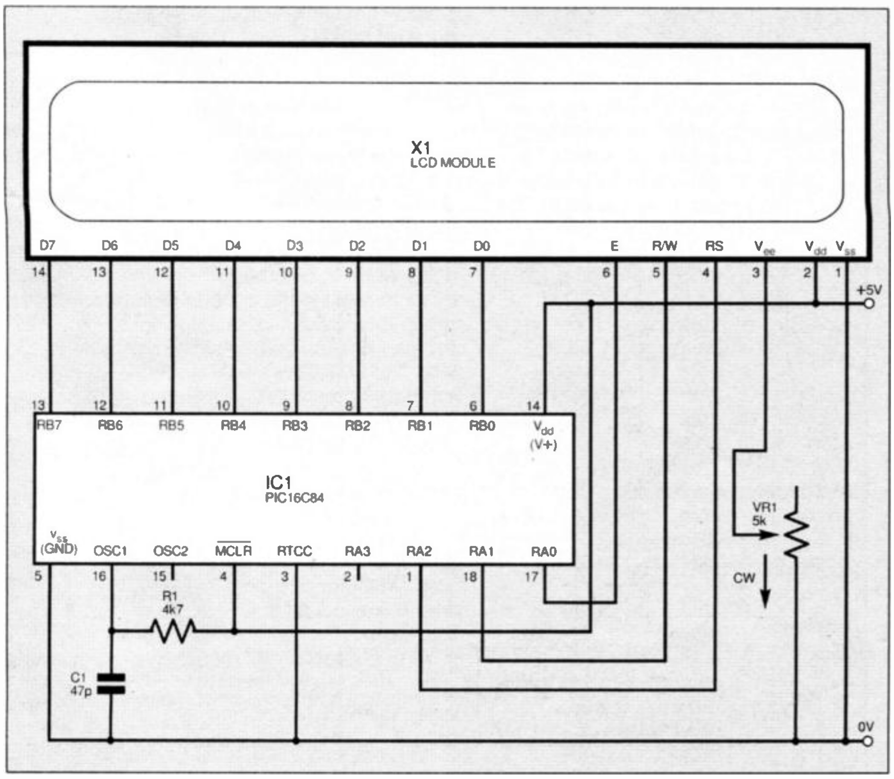


Fig. 7. Circuit diagram for interfacing a PIC16C84 microcontroller to an l.c.d. module.

(for faster speeds) should be avoided, to ensure the software delays are sufficiently long.

EXPERIMENT 8

PIC Program

Compile and program the contents of Listing 1 into the PIC microcontroller. It has been written for use with MPALC assembler software, although it can be readily translated to suit MPASM or TASM assembly.

Once the PIC has been programmed, re-power up the circuit. The word HELLO will appear on the display. There may seem to be a lot of source code required to do such a simple job, but the program performs all the setting up that the display needs, and can form the basis of a more complex system.

Precisely what all these instructions do is important and will be described in some detail.

The first routine, "initialise", comprises five Clear File (clrf) instructions which set the contents of five registers to zero. Two of these registers, 05 and 06, relate to output Ports A and B.

When the microcontroller is powered up, all port pins are automatically set up as inputs, so that no damage is done to external circuitry. The "setports" routine uses "tris" instructions to redefine each bit of Ports A and B as either an input or an output.

(Be aware that Microchip, manufacturers of the PIC family, now discourage the use of "TRIS", a command becoming incompatable with their newer devices. There are alternative ways of achieving the same result, as discussed in the PIC data books. Ed.)

The "longdelay" routine keeps the microcontroller occupied while the l.c.d. is initialising. This delay must be no less than 15ms, but can be more, of course. The routines "functionset" and "displayon" are very similar and issue hexadecimal commands $38 and $0F (00111000 and 00001111) to the l.c.d. These numbers should be familiar from the experiments carried out in Part 1.

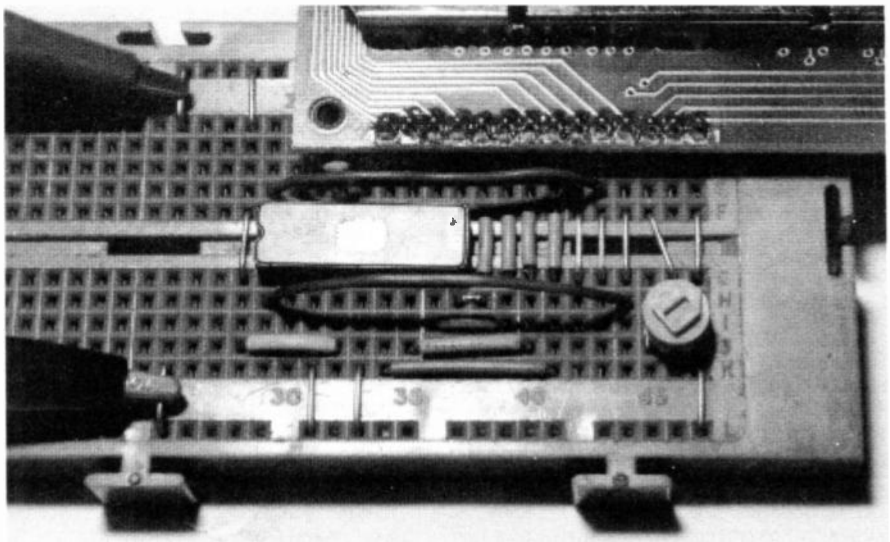
Both routines contain "call" instructions to two subroutines, "pulse_e' and "shortdelay", which can be seen towards the end of the listing. The "message" routine incorporates a program loop which is executed five times to output the five characters in the text table ("text") to the l.c.d. The PIC uses an unusual type of subroutine, comprising a list of "retlw" (return with literal) instructions which can be used to form tables of data.

Register $0D is used as a counter which is initially set to zero by the "clrf" instruction in the "initialise" routine. This value is then used as a pointer to the text table which contains the ASCII characters which spell HELLO.

The "stop" routine locks up the microcontroller to stop it doing anything else. Finally, the "end" directive is not a program command, but an instruction to tell the assembler to stop assembling.

A GOOD READ

The program in Listing 1 only *writes* to the display. In many applications this is quite satisfactory, and it has the advantage of allowing the R/W line on the l.c.d. to



The prototype test rig showing the microcontroller in position (it's actually a PIC16C54, although a PIC16C84 is recommended.

LISTING 1

```
list          p=16C84                    ;tells assembler to generate code for this device
initialise    clrf      0D               ;clear register 0D, counter register
              clrf      0E               ;clear register 0E, short delay register
              clrf      0F               ;clear register 0F, long delay register
              clrf      05               ;Port A (register 05) outputs all set to logic 0
              clrf      06               ;Port B (register 06) outputs all set to logic 0
setports      movlw     0F8              ;Port A bits 0, 1, 2 as outputs (E, RS, R/W)
              tris      05
              movlw     00               ;Port B all bits as outputs (D0 to D7)
              tris      06
longdelay     call      shortdelay       ;long delay while lcd initialises
              decfsz    0F,f
              goto      longdelay
functionset   bcf       05,02            ;RS line to 0 (Port A, bit 2)
              bcf       05,01            ;R/W line to 0 (Port A, bit 1)
              movlw     38               ;Function Set command
              movwf     06               ;put it on the data lines (Port B)
              call      pulse_e          ;pulse the E line high (Port A, bit 0)
              call      shortdelay
displayon     bcf       05,02            ;RS line to 0 (Port A, bit 2)
              bcf       05,01            ;R/W line to 0 (Port A, bit 1)
              movlw     0F               ;Display On/Off & Cursor command
              movwf     06               ;put it on the data lines (Port B)
              call      pulse_e          ;pulse the E line high (Port A, bit 0)
              call      shortdelay
              clrf      0D               ;set counter register to zero
message       movf      0D,w             ;put counter value in W
              call      text             ;get a character from the text table
              bsf       05,02            ;set RS line to 1 (Port A, bit 2)
              bcf       05,01            ;set R/W line to 0 (Port A, bit 1)
              movwf     06               ;put character on the data lines (Port B)
              call      pulse_e          ;pulse the E line high (Port A, bit 0)
              call      shortdelay       ;delay while l.c.d. is busy
              incf      0D,w             ;try incrementing the counter register
              xorlw     05               ;would that make it increase to 5?
              btfsc     03,02            ;set the zero flag in the status register
              goto      stop             ;stop if all characters displayed
              incf      0D,f             ;increment the counter register
              goto      message          ;go back and do the next character
stop          goto      stop             ;stop the program running
;Subroutines and text table
shortdelay    decfsz    0E,f             ;delay while l.c.d. is busy
              goto      shortdelay
              retlw     0
pulse_e       bsf       05,00            ;take E line high
              nop                        ;hold it high for one clock cycle
              bcf       05,00            ;take E line low again
              retlw     0
text          addwf     02,f             ;table of characters for message
              retlw     'H'
              retlw     'E'
              retlw     'L'
              retlw     'L'
              retlw     'O'
end
```

Table 6. HD44780 Read Instructions

Instruction	RS	Binary							
		D7	D6	D5	D4	D3	D2	D1	D0
Read data	High	D	D	D	D	D	D	D	D
Read Status	Low	BF	A	A	A	A	A	A	A
D: Character data at current cursor address									
A: Current cursor address ($00 to $7f)									
BF: Busy Flag (0 = Ready, 1 = Busy)									

be connected to ground, which in turn saves an I/O (input/output) pin on the microcontroller.

It is possible (and sometimes necessary) to read data and status information from the l.c.d., but of course the R/W line must be actively connected in order to do this. Reading the display differs from writing to it in some fundamental ways, so a re-examination of the timing diagram is now required, as the sequence of events is described.

Lines RS and R/W must be set up first, with R/W being set to a logic 1 this time. If RS is set high, data is returned indicating the character that is at the current cursor address. If RS is set low, a status byte is sent back, containing two separate items, bits 0 to 6 holding the current cursor address, and bit 7 containing the Busy flag.

The two Read instruction formats are shown in Table 6. After the necessary "address setup time" (tAS), the E line can be taken high. This is the point at which the read cycle differs from the write cycle, as the l.c.d.'s data lines will switch over to being outputs.

Clearly, before the microcontroller starts this read cycle, it must change its data lines to inputs, otherwise outputs would be connected to outputs and a fight (known as *bus contention*) would ensue. In any case, if the microcontroller's data lines were not inputs at this time, it would not be able to read the data.

It takes a while for the l.c.d. to change its data lines to outputs, and stabilise the data on them, but it guarantees to do this within 320ns, the "data access time" (tDA). The microcontroller can then read this data in through its inputs, and as soon as it's happy that it's got it, the E line can go back down.

Most of the information that can be read back from the display must have been written there by the microcontroller in the first place, which explains why many designs can get away without having the R/W line connected up.

The Busy flag, though, can be useful to the microcontroller, to avoid using all those delay routines. For applications which need to put a lot of information on the display in a very short time, checking the Busy flag is the most efficient way of knowing when the display is ready.

EXPERIMENT 9

Status Reading

In this experiment, the program in Listing 1 will be altered to incorporate checking of the Busy flag. The plan here is to replace the subroutine "shortdelay", which has a fixed delay time, with another routine which will constantly check the Busy flag until it isn't busy any more.

Listing 2 shows the new subroutine, called "busywait". All occurrences of the "call shortdelay" instruction in Listing 1 should be replaced by "call busywait", including the three line section headed "longdelay". The program will put the message onto the display much more quickly than before, as unnecessary delays are eliminated.

The first two lines of "busywait" change the assignment of Port B, so that all of its I/O lines become inputs. Following this, the RS and R/W lines are set up ready for the status read. For short delays, the "nop" (no operation) instruction can be used, it is ideal for the small delay times required by the l.c.d. interface.

The E line is then sent high and, after a short delay to allow for the data access time (tDA), the state of the Busy flag is read into the microcontroller. A "rotate left" (rlf) instruction is used here, to transfer the Busy flag on data line D7, into the PIC's Carry flag, where it can be stored prior to testing.

Line E is then taken low, after which a test is performed on the Carry flag using the "btfss" instruction. If the Carry flag is set, then the l.c.d. was busy at the moment the reading was taken, and the program branches back to perform another status read.

If the l.c.d. is found to be no longer busy, Port B is switched back for all bits to be outputs and the subroutine returns to the main program. The program uses more code, but saves time by avoiding unnecessary delays.

LISTING 2

```
busywait   movlw   0FF        ;Port B all inputs (D0 to D7)
           tris    06
           bcf     05,02      ;RS line to 0 (Port A, bit 2)
           bsf     05,01      ;R/W line to 1 (Port A, bit 1)
           nop                ;wait for tAS
busyread   bsf     05,00      ;raise E line (Port A, bit 0)
           nop                ;wait for tDA
           rlf     06,w       ;rotate BF into Carry flag
           bcf     05,00      ;lower E line (Port A, bit 0)
           nop                ;wait for tEL
           nop                ;wait for tEL
           btfsc   03,00      ;test Carry flag
           goto    busyread   ;if busy, go round again
           movlw   00         ;Port B all outputs (D0 to D7)
           tris    06
           retlw   0          ;return to main program
```

LISTING 3

```
functionset  bcf     05,02       ;RS line to 0 (Port A, bit 2)
             bcf     05,01       ;R/W line to 0 (Port A, bit 1)
             movlw   20          ;1st Function Set command
             movwf   06          ;put it on the data lines (Port B)
             call    pulse_e     ;pulse the E line high (Port A, bit 0)
             call    busywait
functionset2 bcf     05,02       ;RS line to 0 (Port A, bit 2)
             bcf     05,01       ;R/W line to 0 (Port A, bit 1)
             movlw   28          ;2nd Function Set command
             movwf   0C          ;store command temporarily in 0C
             call    portnibble
             call    pulse_e     ;pulse E line high (Port A, bit 0)
             swapf   0C,w        ;swap nibbles of 0C, put result in W
             call    portnibble
             call    pulse_e     ;pulse E line high (Port A, bit 0)
             call    busywait
;Additional subroutine for nibble mode
portnibble   andlw   0F0         ;clear lower 4 bits of W
             iorwf   06,f        ;OR this with Port B
             iorlw   0F          ;set lower 4 bits of W
             andwf   06,f        ;AND this with Port B
             retlw   0
```

EXPERIMENT 10

Nibble Mode

The final experiment is to implement 4-bit data transfer mode between the l.c.d. and the microcontroller. This was examined in Experiment 7 in Part 1, so the technique should be reasonably well understood.

However, several changes need to be made, both to the circuit and to the program, details of which will be left to you to fully implement, but the principles involved are as follows:

Listing 3 shows some of the changes. Data lines D0 to D3 on the l.c.d. should be disconnected from the microcontroller (see Part 1 for how to deal with these unused l.c.d. lines). Data lines D0 to D3 on the microcontroller are now free to be used for other purposes, but for the time being can be left open circuit.

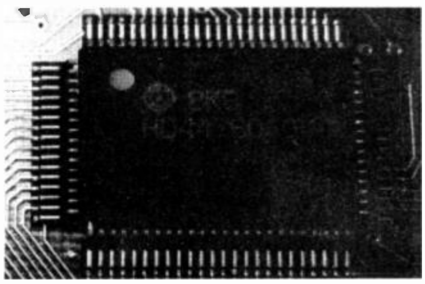
As we saw in Part 1, two separate Function Set commands are needed to set up the l.c.d. First. binary code 00100000 (hexadecimal \$20) is sent while the l.c.d. is still in 8-bit mode, the mode which it automatically adopts when first switched on. This first code is followed by 00101000 (\$28) sent as two separate nibbles, i.e. 0010 and 1000, both sent on lines D4 to D7. (Don't forget that lines RS and E must be dealt with appropriately when sending data.)

In Listing 3, the "functionset" routine of Listing 1 has been modified to send \$20 instead of \$38, and then a new routine, "functionset2", has been added, between "functionset" and "displayon", to send \$2, and then \$8. In the new routine, splitting a command byte into two nibbles is achieved by using the PIC's "swapf" instruction, which exchanges the upper and lower halves of any register.

The purpose of using 4-bit mode is that the other four bits of Port B (bits 0 to 3) can be used for something else, so writing data out on the upper half of Port B, must be done in such a way that it does not affect the lower half. In practice, *any* of the microcontroller's data lines can be used to send control the l.c.d., programming the software accordingly.

Individual "bit set" (bsf) or "bit clear" (bcf) instructions could be used to alter each bit in turn, but there is a simpler, more logical way, literally! A sequence of AND and OR instructions can be used to handle all eight bits of Port B, masking out those which must not be changed.

Listing 3 shows a subroutine called "portnibble" which contains a sequence of four instructions that do the job. The upper four bits of the W register are transferred to the upper four bits of Port B, without affecting the lower four bits. A separate "pulse_e" call must be made for each of the two nibbles transferred, after which a single "busywait" call is added.



The "intelligent" heart of the l.c.d. modules discussed.

The "portnibble" routine is added to Listing 1 between the end of the "text" table and the "end" statement.

It is also necessary to alter the "displayon" routine of Listing 1 to operate in 4-bit mode, in the same way as is done in the "functionset2" routine. You can do the conversion for yourself to prove that you have understood so far!

More challenging, perhaps, are the modifications that have to be made to the "message" routine of the program. The procedure is the same, however, two 4-bit transfers being required instead of one 8-bit transfer. The use of 4-bit data transfer mode does add to the complexity of the software, but is well worth the effort as four extra I/O pins are released.

DIGITAL ALTERNATIVES

So many electronic devices, these days, have a small keyboard and a liquid crystal display. For example, many of the better portable radio systems have dispensed with the potentiometer as a volume control, and the variable capacitor as a tuning control, and opted for a digital data entry and display alternative.

The advantages that such digital systems offer are undeniable, and even for the amateur constructor are readily achievable using low-cost but powerful microcontrollers, and inexpensive but versatile displays and keyboards, as the experiments in this two-part series have hopefully suggested to you.

(We have more PIC-controlled l.c.d. orientated projects in the pipeline. Ed.)

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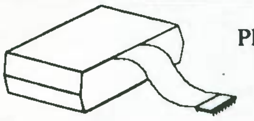

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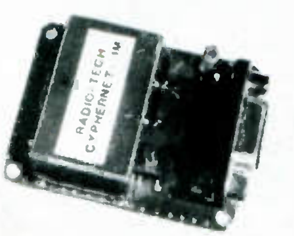

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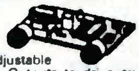

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Constructional Project

OIL CHECK REMINDER

DAVID SMITH

Winter's Here! So don't delay, guard against running out of central heating oil now! It could save you pounds!

FOR those of us who have central heating systems at home, they usually fall into three main categories i.e. gas, oil, or solid fuel. For those on gas, the supply is never in question, it is always there "on tap" so to speak – unless one forgets to pay the bill!

For those who use solid fuel; well, there never is a time when you can forget. Every day means stoking up the boiler, cleaning out the ashes, plus a lot of other dirty jobs that solid fuel advertisement campaigns always seem to leave out of their television commercials.

However, when it comes to those of us who run an oil-fired central heating system, then there are opportunities for us to become forgetful. Heating oil is usually ordered on average every three months and in the interim period, the central heating system generally runs itself. We can become so complacent with it operating day in and day out, that we can forget to do a very important job, which is to check the level of the outside oil tank from time to time to see when to order the next delivery of fuel.

TIME CHECK

Forgetting to do this simple task can incur an expensive call out fee from a heating engineer. This is because, if the tank is allowed to completely empty and the boiler's pump is calling for more fuel, then air locks could form in the supply pipe leading from the tank to the house. Not only this, but sediment, situated in the bottom of the oil tank, could be sucked into the filter system.

What is required is some kind of periodic reminder to prompt us to check the oil level in the tank. The Oil Check Reminder featured here does just that, and one day could perhaps pay for itself by saving an expensive call out fee.

It consists of a box, in which is housed a programmable timer, which can be set for timing periods of up to one month. At the end of a timing cycle, an l.e.d. situated on the front of the main timing box, flashes a warning, and a quiet but persistent clicking noise emanates from an in-built loudspeaker. It was decided at the outset that the audio warning signal should be a click rather than a continuous tone, owing to the fact that the device may trigger during the night.

Resetting the timer simply requires the pressing of a button. This is housed separately in a small remote waterproof plastic box and mounted under the oil tank outside. Of course, whilst you are stood by the oil tank resetting the timer, you may as well check the level of the oil at the same time. *Mission accomplished!*

CIRCUIT DESCRIPTION

The full circuit diagram for the Oil Check Reminder is shown in Fig. 2.

Because of the necessity to generate timing periods of up to a month, the ubiquitous 555 timer chip, so often used in timing circuits, cannot be used as the central timing device in this instance. This is because the values of both the timing capacitor and resistor would have to be so large that the microscopic amount of charging current passing through the resistor would quickly leak away through the capacitor without ever allowing it to charge up.

Instead, at the heart of our oil check circuit, we have used a μA2240 timer/counter (IC2). The internal functions and pinout are given in Fig. 1. This CMOS chip is capable of producing accurate time delays ranging from microseconds to many days duration. It does this in the following way.

Referring to the circuit diagram in Fig. 2, an *RC* timing network consisting of resistor R4 and capacitor C1 is connected to IC2's internal oscillator via pin 13. The maximum *RC* values suggested by the manufacturers of the chip are 10 megohms (10MΩ) and 1000 microfarads (1000μF), and these values have been used in the circuit to give the maximum amount of timing capability possible.

PROGRAM TIME

The output from the timebase is fed internally to an 8-bit counter, which can be externally programmed to provide an output ranging from 1 RC to 255 RC. This is accomplished by using an 8-way d.i.l. (dual-in-line) switch (S2 to S9) connected to pins 1 through to 8 of IC2. By closing one or more of these d.i.l. switches, various combinations of timings can be achieved.

The outputs from IC2 pins 1 to 8, represent values of 0, 2, 4, 8, 16, 32, 64, and 128 respectively. So, for example, if only pin 6 is connected to the output and the rest left open, the total duration of the timing cycle would be 32 T. Similarly, if only pins 1, 5, and 6 are shorted to the output, then the total time delay can be calculated as $T = (1 + 16 + 32) = 49T$. Therefore, by the appropriate combination of d.i.l. switches being closed, any timing period from 1 RC to 255 RC in 1T steps can be achieved.

Put another way, if the internal oscillator was running at one cycle per second, then closing all the switches would give an

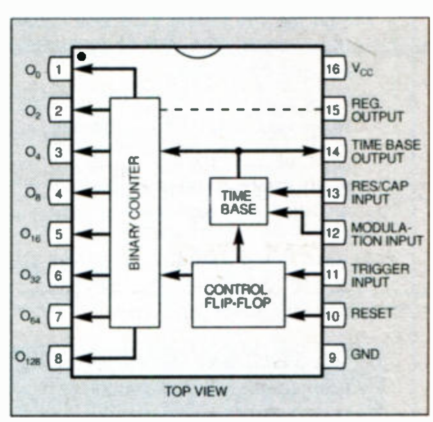


Fig. 1. Pinout details for the μA2240 programmable timer/counter.

output every 255 secs (4·25 minutes). Of course, with *RC* values of 10MΩ and 1000μF, the time delay will be considerably longer than this, and with the chip having a quoted accuracy of 0·5 per cent, very long and accurate time delays can be accomplished.

The μA2240 timer/counter i.c. can be operated in either a monostable or astable mode. For our purposes, it has been wired to provide a monostable output. This is achieved by permanently connecting the output bus to the reset input (pin 10) via resistor R5.

It was felt necessary to include an opto-isolator in the circuit owing to the potentially long cable run required to the oil tank and the likelihood of the cable picking up all sorts of electrical interference. An electrical spike, perhaps erroneously introduced into the cable after a couple of weeks, would reset the circuit prematurely and one would be unaware anything was wrong for a further month!

However, with the cable only carrying current to switch on the internal l.e.d. of IC1, then the circuitry is immune to such problems. Not only that, the transistor, also encased within the opto-isolator, provides a nice smooth transitional voltage with which to reset IC2.

Powering of the circuit is straight forward with a mains transformer T1, bridge rectifier REC1 and a smoothing capacitor (C5). The circuit for the Power Supply stage is also shown in Fig. 2 and it is incorporated on the printed circuit board (p.c.b.).

Note, the "mains earthing" is continued all the way to the external remote Reset switch S1, so it is vital to use "double-insulated" cable to connect it to the indoor main control unit. The Reset box *must* be plastic and sealed against the ingress of moisture.

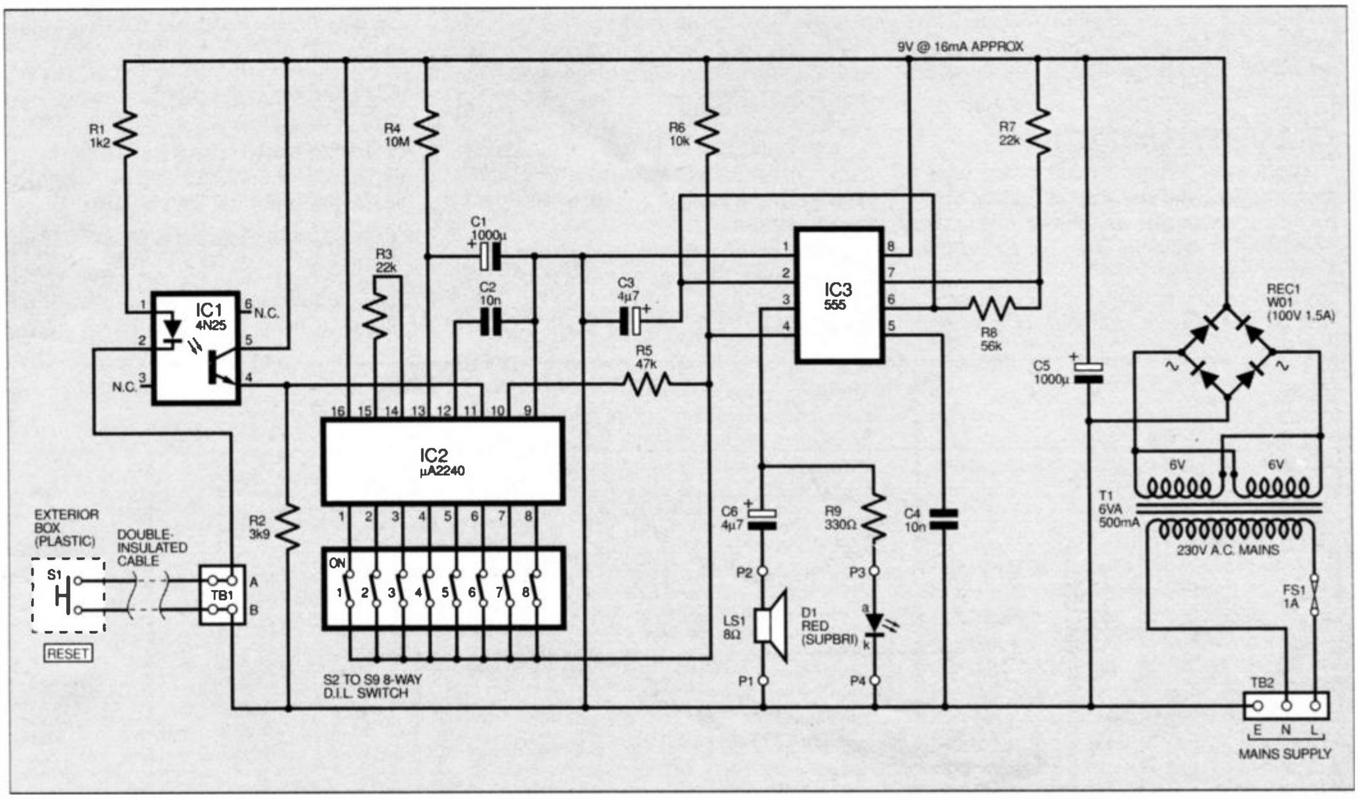


Fig. 2. Complete circuit diagram for the Oil Check Reminder. Note the use of a "double-insulated" cable run for the remote Reset-switch. The completed alarm unit is shown below.

When the first timing period is complete the output from the μA2240 goes high. This is fed to pin 4 of IC3 (a 555 timer) which allows it to oscillate at a low frequency, set by resistor R8 and capacitor C3.

The output from IC3, pin 3, is then fed to an l.e.d. D1 via current limiting resistor R9 and to a small loudspeaker LS1, whose volume is preset by capacitor C6. A value of 4·7μF was chosen for C6 to give a click, easily audible whilst in the vicinity of the box, but not so loud as to become an annoyance should it trigger during the night. Alternative values of capacitor may be tried here if it is felt the volume is not to ones liking.

Because we are not using the modulation input of IC2 (pin 12), capacitor C2, is used to connect this pin to the 0V or "earth" line.

ALARM TIME

Once the alarm has been triggered, the only way to stop it, is to press the remote Reset button (S1) situated "outdoors", alongside the oil tank. This resetting of the circuit is accomplished by sending a positive going control pulse to pin 11 of IC2. The pulse is provided by IC1, an opto-isolator type device.

PROJECT SAFETY

At one end of the circuitry lies *MAINS* voltages, whereas at the other end, there is a pushbutton switch situated outside in the garden and "fixed" to a *metal* tank, which will sometimes be wet because of rain. ***It is vital therefore, that the utmost care be taken with this project.***

When finally installing the Reset unit outside, it is imperative to bear in mind the safety aspects of cabling. The remote location of the Reset switch extends the mains Earth outside the building. Therefore, under exceptional mains fault conditions, it could become "live" up to 230V a.c. relative to any nearby surfaces at ground potential (e.g. metal railings, metal greenhouse frames or any other metal structure) and may present a serious shock risk.

Readers MUST ensure that the cable to the remote Reset box is double insulated and that there is no possibility of external contact being made with the electrical connections to the switch tags within the box. Ordinary twin-cored mains cable is suitable; each core is separately insulated, with both jointly wrapped by an external

outer insulating sheath. **If in any doubt, consult a qualified electrician.**

The circuit design includes a mains fuse situated on the p.c.b. which also has a safety cover over it. Also note that once the mains cable has been connected to terminal block TB2, the top of the block should have a small piece of p.v.c. tape stuck over it to prevent any possibility of the "live (L)" screw from being accidentally touched.

Furthermore, a carefully routed p.c.b. track has been included to take an Earth line between the mains area and the low voltage area of the circuit board. The external "splashproof" Reset switch S1 *MUST* be housed inside a moisture free, plastic box.

CONSTRUCTION

The topside printed circuit board component layout and full size underside copper foil track master are shown in Fig. 3. This board is available from the *EPE PCB Service*, code 125.

Construction is quite straightforward, with the majority of components mounted on the printed circuit board (p.c.b.). The only items not on the board are the lid-mounted loudspeaker LS1, l.e.d. D1 and the remotely sited Reset switch S1.

Commence construction by soldering in place the single link wire and the d.i.l. sockets. Do not insert the i.c.s. at this stage, wait until the board has been completed and double-checked for any errors. You may already have many of the components yourself, but be aware that the lead pitch of capacitors etc., may not be the same and it may be necessary to do some lead bending to make your components fit on the p.c.b.

Pay special attention when soldering the mains transformer T1 into place, as the transformer pins are the only means of retaining it on the p.c.b. and must therefore be sound mechanically as well as electrically. Also, be particularly careful with the polarity of the bridge rectifier when soldering it in position.

Solder pins have been used on the p.c.b. to allow connections to be made to both the l.e.d. D1 and speaker LS1. For the incoming mains supply cable and the leads from the external Reset switch S1, use p.c.b. mounting terminal blocks (TB1 and TB2).

When connecting the speaker and l.e.d. wires to the pins on the p.c.b. it is a good idea to use some small pieces of sleeving or heat-shrink tubing to cover the solder connections. Have you remembered to fit the wire link which connects the d.i.l. switches S2 to S9 to IC3?

Once all the components have been mounted on the p.c.b., check for any "dry" solder joints or solder bridges between i.c. pins or copper tracks. If everything seems to be in order the i.c.s can now be inserted in their sockets, check against Fig. 3.

CARD-BOARD

In the interest of total safety, a piece of thick plastic card approximately the size of the p.c.b., should be situated under the board just prior to final assembly in the case. This can be held in place with either some double-sided adhesive tape or small blobs of glue, see Fig. 5. This cover is important, because it prevents the possibility of the p.c.b. copper tracks shorting

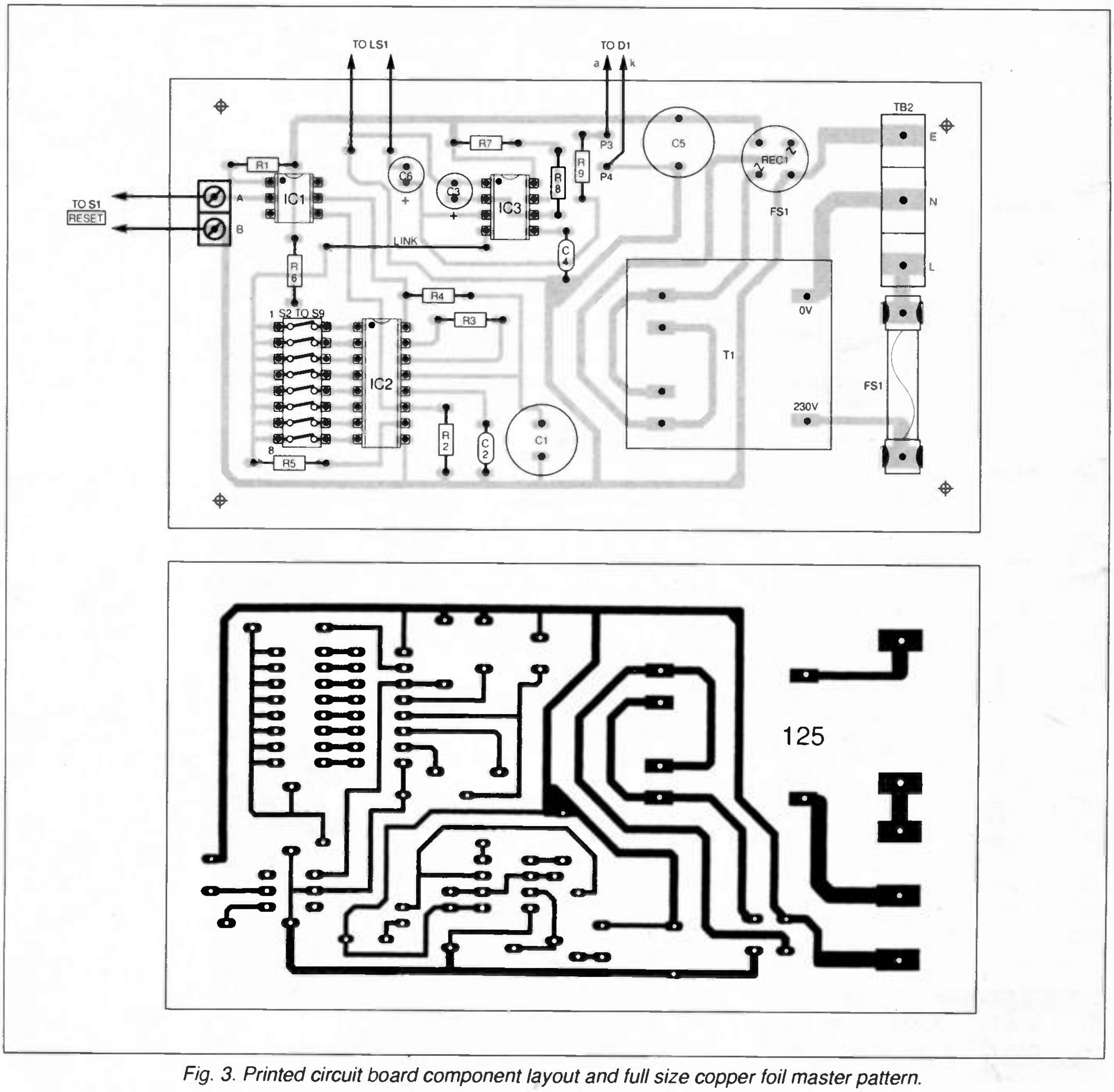


Fig. 3. Printed circuit board component layout and full size copper foil master pattern.

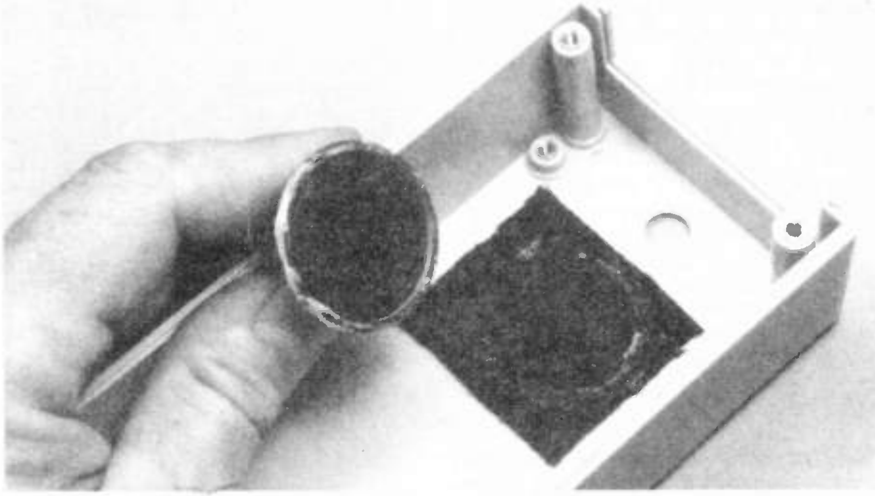
to anything either during the testing period or later.

In addition, the remote switch cable, which runs under the p.c.b., should have an additional length of plastic tubing shrouding it. This will safeguard it from being punctured by any sharp solder points or components wires, as the p.c.b. is screwed down over the top of it later.

At this point the circuit can be tested, taking care to observe all the electrical safeguards mentioned earlier. Once happy that the circuit is functioning correctly, the board can be fitted into its case.

FINAL ASSEMBLY

Make sure that the four corner fixing holes on the p.c.b. have been drilled accurately to line up with the four brass bushes fitted in the base of the case. You will find that the brass bushes in the specified case are not symmetrical, and that two of the "studs" at one end are closer together than those at the other end. The distance between the bushes at one end is 58mm, whilst at the other it is 63mm.



After smearing the loudspeaker rim with glue dab it on the grille cloth. This will mark where additional glue has to be applied.

COMPONENTS

Resistors

R1	1k2
R2	3k9
R3	22k
R4	10M
R5	47k
R6	10k
R7	22k
R8	56k
R9	330Ω

All 0·6W 1% metal film

See SHOP TALK Page

Capacitors

C1, C5	1000µ radial elect. 35V (2 off)
C2, C4	10n polyester layer (2 off)
C3, C6	4µ7 radial elect. 63V (2 off)

Semiconductors

D1	10mm red Superbright l.e.d., with clip
IC1	4N25 opto-isolator
IC2	µA2240CN programmable timer/counter
IC3	NE555 timer
REC1	WO1 100V 1·5A bridge rec.

Miscellaneous

S1	pushbutton, plastic-bodied, splashproof (waterproof cap) switch
S2 to S9	8-way d.i.l. switch
FS1	1A 20mm fuse, with holder and cover
TB1	2-way 5mm p.c.b. mounting terminal block
TB2	3-way 10mm p.c.b. mounting terminal block
LS1	8ohm 38mm dia. loudspeaker
T1	6VA p.c.b. mounting mains transformer, with two 6V 500mA secondaries

Printed circuit board available from the *EPE PCB Service*, code 125; main plastic case, size 160mm x 80mm x 60mm; remote reset switch box, size 75mm x 50mm x 25mm; 6-pin d.i.l. socket; 8-pin d.i.l. socket; 16-pin d.i.l. socket (2 off); 3-core mains cable; double-insulated cable (i.e. mains) for remote switch; sleeved rubber grommet (2 off); small rubber grommet; piece of speaker cloth; rubber feet (4 off); multi-strand connecting wire; fixing screws; solder pins, solder etc.

Approx Cost Guidance Only £30 excluding cases

Drill all necessary holes in the case, making sure to fit sleeved entry grommets for both the mains cable and the leads leading to the remote Reset switch S1. Connections to the l.e.d. should be covered with heat-shrink sleeving after soldering.

Carefully check the polarity of the l.e.d. when wiring up. Although a 10mm l.e.d. fixing clip is called for to fasten the l.e.d. to the case lid, it was found to fit snugly within the 10mm hole drilled for it.

LOUDSPEAKER

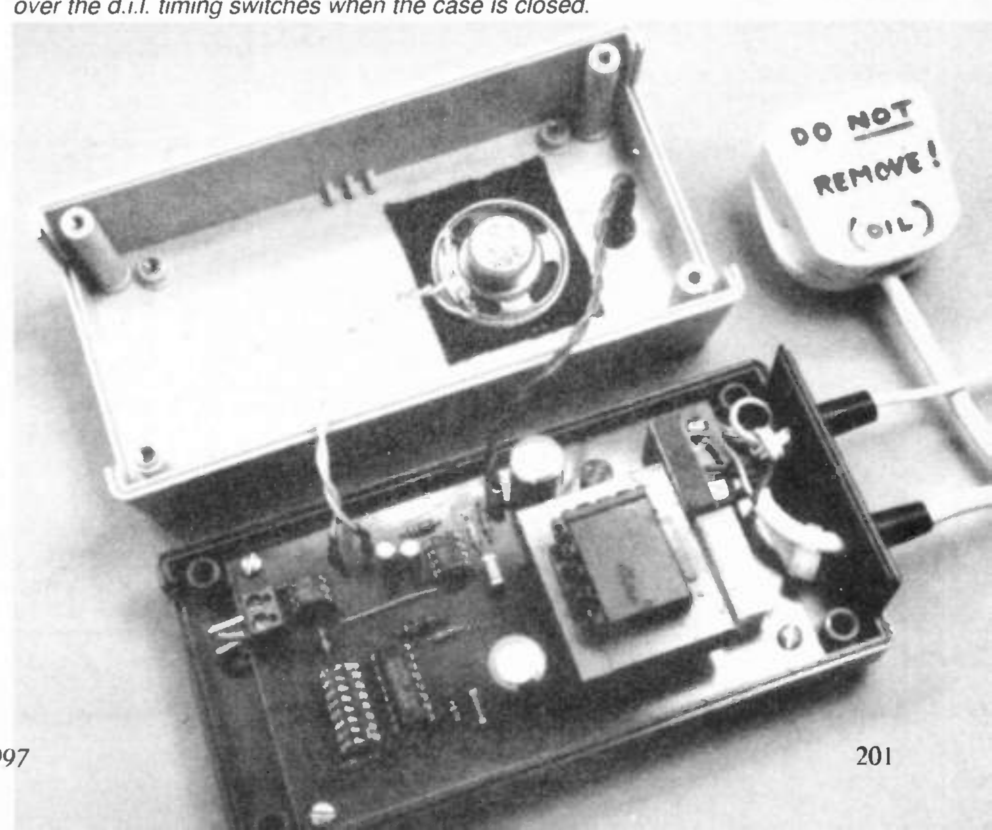
The "sound" hole for the loudspeaker was made using a 25mm chassis cutter which gives a very neat and clean hole. If a chassis cutter is not available, then a series of smaller holes can be drilled in a circular pattern and the central piece of plastic punched out. The jagged hole which remains, can then be smoothed using either a modelling knife or a file.

For best results, mark the area to be cut out, by using a pair of compasses and carefully file or cut very accurately to the circular pencil mark. As an alternative to one large hole, you may prefer to drill a series of smaller holes in a decorative pattern.

Before mounting the loudspeaker, a small piece of gauze should be glued over the area of the hole(s) to protect the speaker cone from damage. Once the glue has dried, you will be able to fix the loudspeaker to the case using a small amount of contact adhesive.

The glue should be carefully smeared around the extreme circumference of the speaker, taking care not to allow any of it to encroach onto the cone area. Whilst the glue is still wet, dab the loudspeaker briefly onto its final resting position. This will mark the speaker fabric with a ring of glue. Add a little more glue to both the speaker and the fabric if necessary and allow both surfaces to become tacky before permanently fixing the loudspeaker onto the fabric.

Layout of components on the two halves of the alarm unit. The speaker is sited over the d.i.l. timing swithes when the case is closed.



Four rubber feet should be fixed to the underside of the case, and should there be a requirement to fasten the case onto a wall, two sets of holes should be cut in the bottom of the case using two differently sized small drills (4mm and 9mm). After drilling, cut a slot between the two holes using a modelling knife to form a "keyhole". Details are shown in Fig. 4.

Of course, the reason why holes of this shape are needed, is because the box can only be fitted to the wall *after* the p.c.b. and top cover have been fitted. Similarly shaped holes can be found on a lot of domestic equipment.

For those not familiar with this type of fixing, proceed as follows. After deciding where the box is to be situated, *it MUST be a dry indoor location*, carefully drill two holes into the wall and fit Rawlplugs. Next, using flat-headed screws, partly screw them into the wall. Allow the screws to protrude just enough to permit the box to fit over them and for it to slide slightly downwards into its final position.

The use of round-headed screws are not recommended, as they may touch the underside of the p.c.b. inside the case and cause a short. This is another good reason why a thick piece of plastic card is placed between the p.c.b. and the bottom of the case.

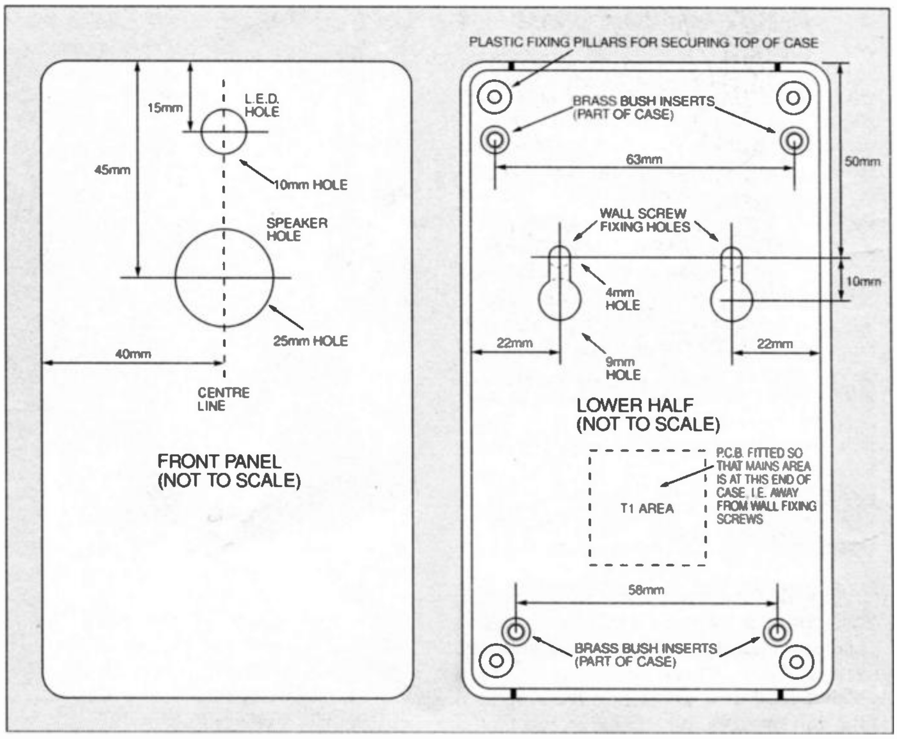


Fig. 4. Drilling details for the two halves of the main case.

EXTERNAL BOX

The Reset switch S1 is housed in a small plastic box. At one end of the box, find and mark the centre then, using a chassis punch, cut a 16·5mm hole in it. The pushbutton switch will now snap into the hole.

Although the specified switch used in this project is described as being "splashproof", British weather can be very harsh, and it is suggested that the box be mounted a little underneath the oil tank to give further protection from the elements, see Fig. 6. Also, smear a little waterproof sealant or contact adhesive around the hole where the cable enters the box and around the lid join. This will prevent the ingress of moisture and insects.

Fixing the box to the tank can be achieved using a contact adhesive or some double-sided adhesive tape. A dry day is needed when fixing, making absolutely sure that the tank area where the box is to be fixed is entirely free from moisture and rust particles.

TESTING

Testing has to be done with the circuit connected to the mains supply. It is assumed that all safety precautions have been taken and that all connections or soldered joints at mains potential have been suitably insulated.

Always, always, unplug the mains supply before attempting any adjustments to the circuit. Mains voltage is lethal and a moments inattentiveness can be fatal. ***DON'T TAKE SHORT CUTS!***

If in any doubt you should consult a qualified electrician.

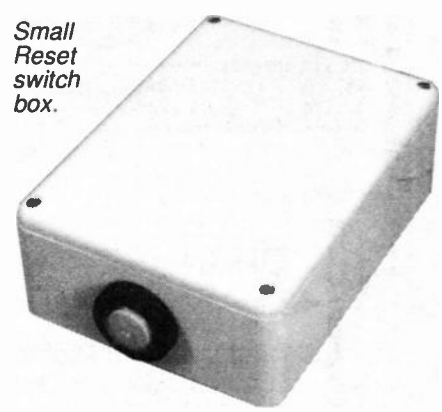
Once satisfied that the circuit is electrically safe, testing can begin.

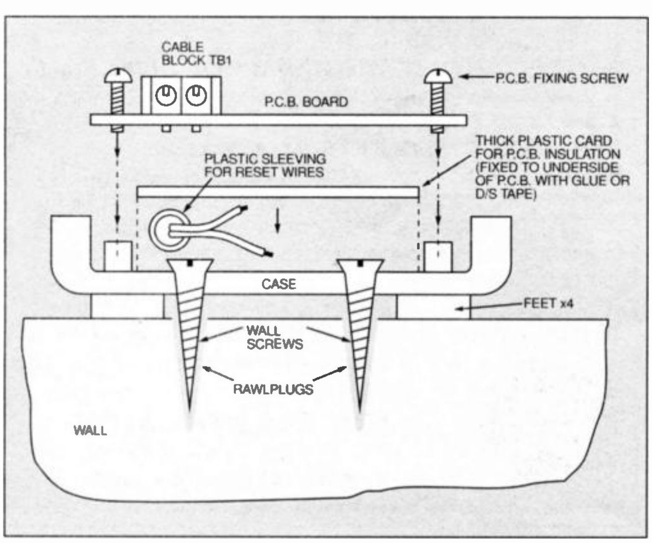
Obviously, waiting for one month to see if the circuit works or not is a bit of a problem, so to speed things up, we need to increase the frequency of the internal timebase of IC2, the µA2240. To do this, temporarily replace C1 (1000µF) with a 4·7µF capacitor, and R4 (10MΩ) with a 2·7kΩ resistor. The timebase will now oscillate at about 1Hz. Also, connect the Reset button temporarily, using a short length of twin cable.

When the device is initially powered up, the alarm will sound. Set the first d.i.l. switch (S2) to the "ON" position. Press the Reset button to cancel the alarm and reset the timer.

With the other seven d.i.l. switches set to the "off" position, the timer will sound approximately once every second. Setting all eight d.i.l. switches to their "on" position, the timer will sound approximately once every 255 seconds.

Small Reset switch box.





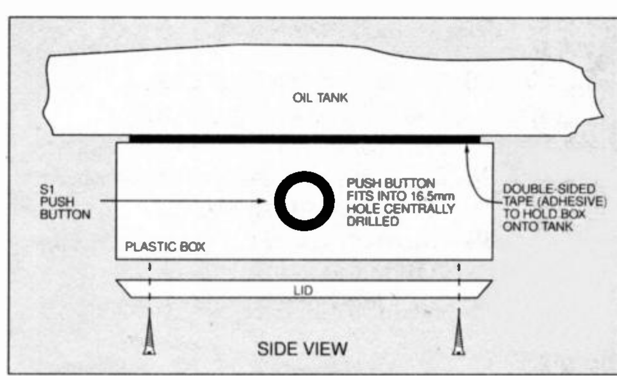
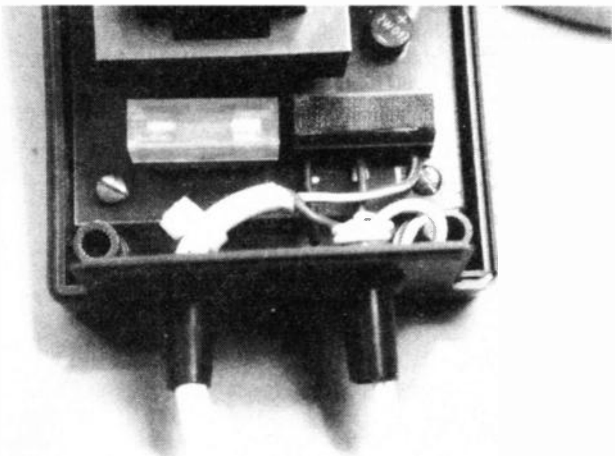
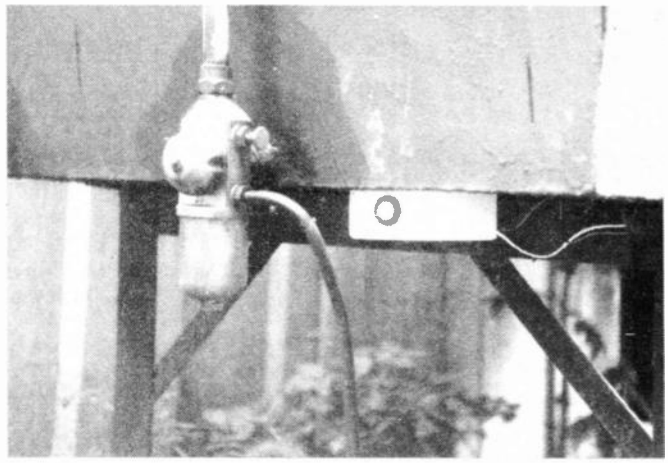


Fig. 6 (above). Suggested method of mounting the external Reset box beneath the oil tank.

Fig. 5 (left). End view of warning unit showing order of assembling the p.c.b. in case and mounting on wall. This unit must be located indoors.



Interior close-up of the alarm case showing the fuse protective cover and a piece of p.v.c. tape stuck across the mains input terminal block.



Close-up view of the oil tank showing the Reset button and associated case mounted slightly under the tank to protect it from the weather.

Try all the combinations of d.i.l. switch positions in between these extremes to check that all the switches work and to get a feel of how the circuit operates. This is also a good time to listen to the volume of the loudspeaker and to judge whether or not you would like to alter it by changing the value of capacitor C6.

Now, replace the original timing capacitor and resistor and set all the d.i.l. switches, apart from S2(1), to their "off" positions. Power up the circuit, making a careful note of the time. Now wait for the alarm to sound. When this happens note the time interval between power-up and the onset of the alarm.

This interval represents one clock cycle using the values of 1000µF and 10MΩ. It is now a simple mathematical task to work out the time interval you personally require between each alarm going off. Set the d.i.l. switches accordingly.

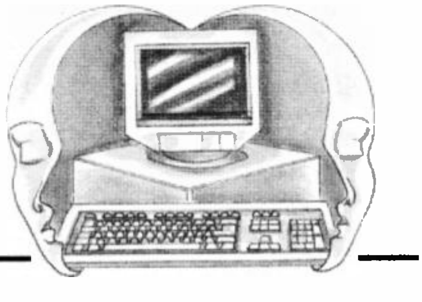
On the prototype, a single clock cycle was timed at three hours. Multiplying three hours by 255 (the maximum count of the µA2240) gives us a total of 765 hours. Dividing 765 by 24 (hours in a day), works out to approximately 31 days (one month) between alarm cycles.

If you want to work out the timing more accurately, ignore the first clock cycle after power up. This is always slightly different owing to the initial settle down time, respecting capacitor charging current etc.

Any artwork you may feel like putting on the box can be accomplished by using rub down lettering. This is best done after all drilling has taken place but before mounting the loudspeaker and l.e.d.

The project is now complete and the only thing left to do, is to mount the project on a suitable wall and plug it into a mains socket that is unlikely to be needed at any other time. It may be worth using a black felt tip pen to mark the 13A plug top with the words *"Oil Alarm – Do Not Remove"* in case someone forgets what the plug is being used for after many weeks. □

INTERFACE



Robert Penfold

A recent *Interface* article covered the subject of computer controlled signal generation. The method used was to control a v.c.o. (voltage controlled oscillator) via a digital-to-analogue converter (DAC).

This method is reasonably simple, and is well suited to some applications, but it does not offer the ultimate in frequency accuracy. Any non-linearity in the control characteristic of the v.c.o. causes frequency errors.

There are purely digital methods of frequency generation which produce output frequencies that are as accurate as the clock signal. The latter is usually crystal controlled, and has a very high degree of frequency accuracy.

Resolution

The most simple form of digital frequency generator consists of a clock oscillator followed by a divide by "N" counter. The division rate of the counter is controlled by the computer, and division by any integer value is possible.

A drawback of this simple system is that the resolution tends to be bad at high frequencies, and good at low frequencies. For example, suppose that a 1MHz clock signal is fed to a circuit that can divide by any integer value from two to 1000.

Divisions by two, three, and four provide output frequencies of 500kHz, 333kHz, and 250kHz. This gives quite a large jump from one frequency to the next. In contrast, divisions by 901 to 1000 provide one hundred frequencies from about 1kHz to about 1·11kHz, giving superb resolution. There is an increment of only about 1Hz from one frequency to the next.

Linear scaling would be preferable for many applications, and it is possible to achieve this if the divide by "N" circuit is used in a frequency synthesiser based on a p.l.l. (phase-locked loop). This effectively inverts things, so that the output frequency is a multiple of a low clock frequency, rather than a division of a high clock frequency.

This type of frequency synthesis is relatively complex, but it can be achieved using inexpensive "off-the-shelf" components. It is a subject we will consider in more detail at a later date.

Few Options

Although one might expect to find numerous divide by "N" logic devices in component catalogues, there seem to be relatively few options. Most of the divide by "N" counters that are listed are not easily programmable, and do not appear to be intended for computer control.

There seems to be one exception, and this is the 74HC161 4-bit binary counter. The 74HC161 has the pinout configuration shown in Fig. 1, and it can be used as a simple programmable divide by "N" counter.

It has the usual clock input and four outputs (Q0 to Q3), but it additionally has four data inputs (D0 to D3). Together with other inputs and outputs, these can be used to set any integer division rate from two to 16.

The circuit resets itself once a certain binary value is reached, so that it can provide less than the full divide by 16 action associated with 4-bit binary division. The circuit diagram for a Simple Frequency Generator, which uses a divide by "N" counter based on a single 74HC161, is shown in Fig. 2.

Although IC1a and IC1b are NOR gates, in this circuit they are used as inverters in a crystal clock generator. This provides an accurate 2MHz output signal that is fed to the input of the divide by "N" circuit based on IC2 and IC1c. An inversion is needed between the comparator output and the negative active preset enable input, and this inversion is provided by IC1c.

Unfortunately, setting the division rate is more convoluted than simply writing the required value for "N" to the data inputs (D0 to D3). Table 1 shows the division rates and output frequencies for the sixteen input codes to IC2.

Table 1. Division Rates and Output Frequencies

D0	D1	D2	D3	Div.	Frequency (kHz)
L	L	L	L	16	125
H	L	L	L	15	133·333
L	H	L	L	14	142·857
H	H	L	L	13	153·846
L	L	H	L	12	166·55
H	L	H	L	11	181·181
L	H	H	L	10	200
H	H	H	L	9	222·222
L	L	L	H	8	250
H	L	L	H	7	285·714
L	H	L	H	6	333·333
H	H	L	H	5	400
L	L	H	H	4	500
H	L	H	H	3	666·666
L	H	H	H	2	1000 (1MHz)
H	H	H	H	-	-

If the data inputs, of IC2 are controlled via inverters, the division rate is one more than the value written to the port. Without a hardware inversion, a software inversion is required.

This is actually quite easy, and it is just a matter of deducting the required division rate from 16 (e.g. for a division rate of 4 a value of 12 is written to IC2). Note that the minimum division rate is 2, and that writing a value of 15 to IC2 will not give a division by one.

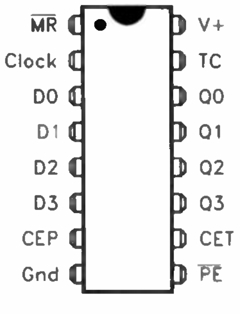


Fig. 1. Pinout details for the 74HC161 binary counter.

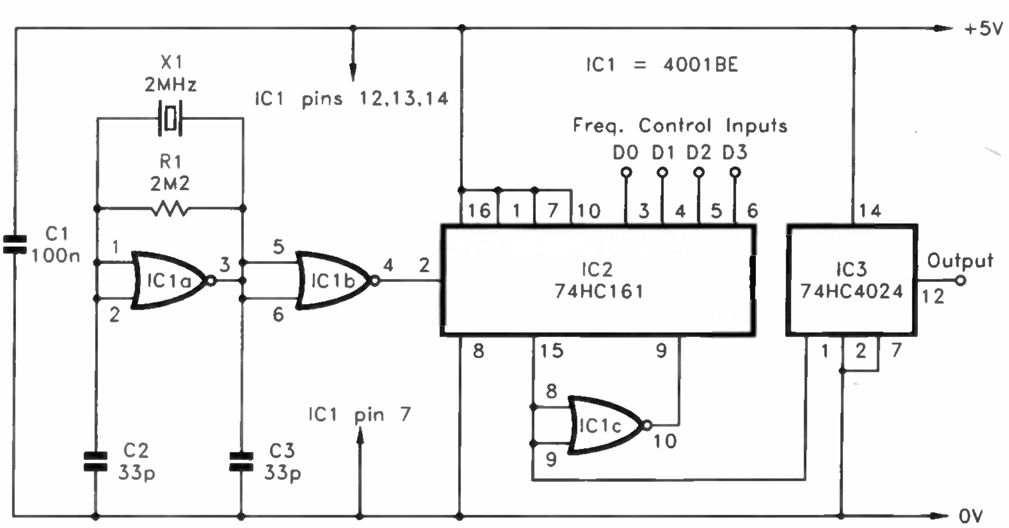


Fig. 2. Circuit diagram for a Simple Frequency Generator using the 74HC161.

Setting all four data inputs high switches off the output signal. This is potentially useful, as it provides an easy way of switching the output signal on and off under software control.

Waveforms

The mark-space ratio of the output signal depends on the division rate. The waveforms of Fig. 3 help to explain the way in which the output waveform varies. The waveform in (a) represents the clock signal, while (b) shows the output signal with a division by two. This gives a squarewave output having a 1-to-1 mark-space ratio.

The waveform of (c) is the output signal with a division rate of four. The output signal is positive for one clock cycle, and is always positive for one clock cycle regardless of the division rate. This gives a 1-to-3 mark-space ratio with a division by four, and a 1-to-15 ratio with a division by 16.

This changing mark-space ratio is not of importance in all applications, but it can make the circuit unsuitable in some instances. In particular, some phase-locked loops will not work properly with an input signal that is well removed from a squarewave.

The easy solution is to feed the output signal into a divide-by-two circuit. This is the purpose of IC3 in Fig.2. The output of IC3 is toggled by each pulse from IC2, and has an accurate 1-to-1 mark-space ratio regardless of the division rate through IC2. Of course, including IC3 doubles the division rates and halves the output frequencies.

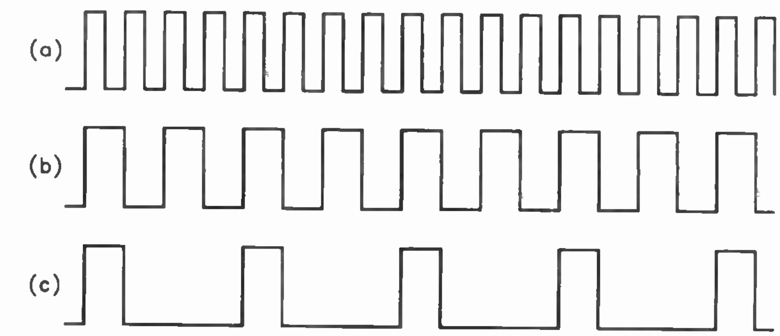


Fig. 3. Output waveforms for the 74HC161. Waveform (a) represents the clock signal, (b) division rate by two and (c) division rate by four.

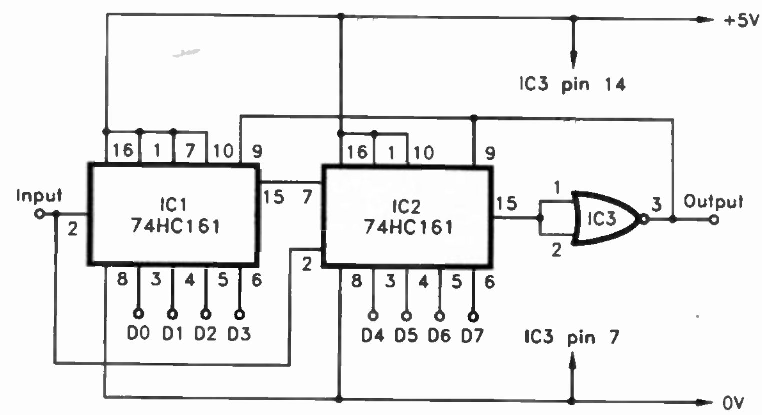


Fig. 4. Circuit diagram for an (almost) 8-bit programmable divider using two 74HC161s.

Bigger Divisions

Unfortunately, adding two 74HC161 circuits in series does not produce a true 8-bit divide by "N" counter. This is due to the fact that the minimum division is by two and not by one.

It is possible to produce an 8-bit divide by "N" counter of sorts by using two 74HC161s in the circuit arrangement shown in Fig. 4. This is not quite a true 8-bit counter as its division range is from two to 241, rather than one to 255. With this circuit it is acceptable to have all four inputs of IC1 high, and this will not block the output signal.

However, it is not acceptable to have all four inputs of IC2 high, because this will block the output signal. In binary the highest acceptable input value is therefore 11101111 (239 decimal, EF in hexadecimal). This gives a divide by two action.

The division rate is equal to 256, minus an offset of 15, minus the value written to the eight inputs. This can obviously be simplified to 241 minus the value written to the circuit's control inputs. Thus, a control value of 239 gives the minimum division rate of two (241 − 239 = 2), and a control value of 0 gives the maximum division rate of 241 (241 − 0 = 241).

To find the value required to produce a given division rate, simply deduct the required division rate from 241. For example, a division by 100 would require a value of 141 to be written to the port (241 − 100 = 141).

The obvious next step is to add a third stage using the same basic configuration of Fig. 4. Unfortunately, this does not seem to give the desired result, but a two stage circuit covering a division range of over 100 to 1 is adequate for many purposes.

Of course, these divider circuits are not restricted to computer control, and they are useful for applications that require unusual division rates. It is just a matter of hard wiring the control inputs with the appropriate binary code for the required division rate.

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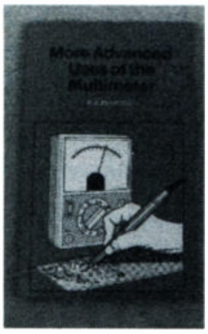
R. A. Penfold



This book is primarily intended as a follow-up to BP239, (see below), and should also be of value to anyone who already understands the basics of voltage testing and simple component testing. By using the techniques described in Chapter 1 you can test and analyse the performance of a range of components with just a multimeter (plus a very few inexpensive components in some cases). Some useful quick check methods are also covered.

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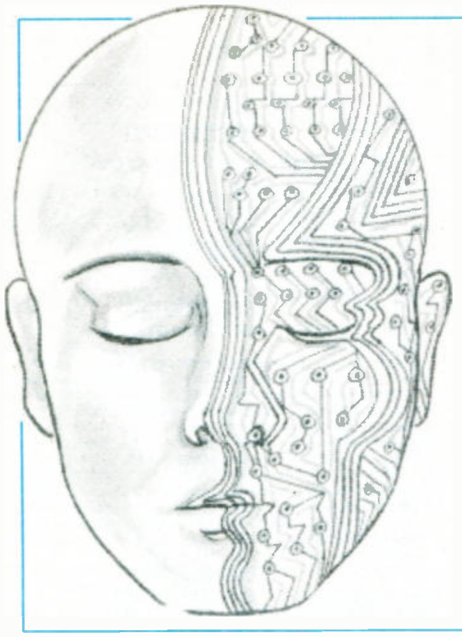

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CMOS Audio Selector Circuit – Switched-On Sounds

The circuit of Fig. 1 imitates the functions of a mechanically-interlocked switch bank, also allowing some unintentional functions such as pressing two or more switches on simultaneously, or cancelling a switch by "half pressing" another. It could be used to drive further logic control circuitry, including the 3-Input Stereo Selector switch shown in Fig. 2, for virtually noiseless selection of audio sources.

Each "switch" requires the circuit shown within the dotted line, and two switches can be formed from each pair of i.c.s. Pin numbers in brackets refer to the second half of each i.c. (not shown). The rest of the circuitry is common to all switches.

One half of IC2 forms a 22ms monostable which is triggered by closing switch S1. Resistors R3, R4 and capacitor C2 remove any noise and clean up the switch signal.

The positive-going edge of the pulse at pin4(10) clocks the D-type flip-flop IC3a; since the D input pin 5(9) is connected to the $\overline{Q}$ output pin 2(12), then without the reset circuitry of IC1, the Q output would toggle high/low on successive operations of S1. D1 and all the other D1 diodes in the other switch modules, form a diode-resistor OR gate which is commoned to the bus labelled "Reset Bus A".

However, IC3a is reset by the remaining circuitry via its reset pin 4(10). When any pushbutton is operated, a positive pulse from IC2a output is fed via D1 to IC1a. A propagation delay is introduced by IC1a/b before IC1c and IC1d – an 84µs monostable – triggers. This ensures that the leading edge of the positive pulse at IC1d pin 3 occurs after the leading edge of the negative pulse at IC2b output.

Ignoring S2, this 84µs pulse is fed to "Reset Bus B". The reset pin of IC3a is fed by a diode-resistor AND gate (D2, D3, R6). Normally the reset pin is held low since the input via D2 is high, and that via D3 is low, hence the output of the AND gate is low.

When any push-switch is closed, every other switch receives a reset pulse (D2 input

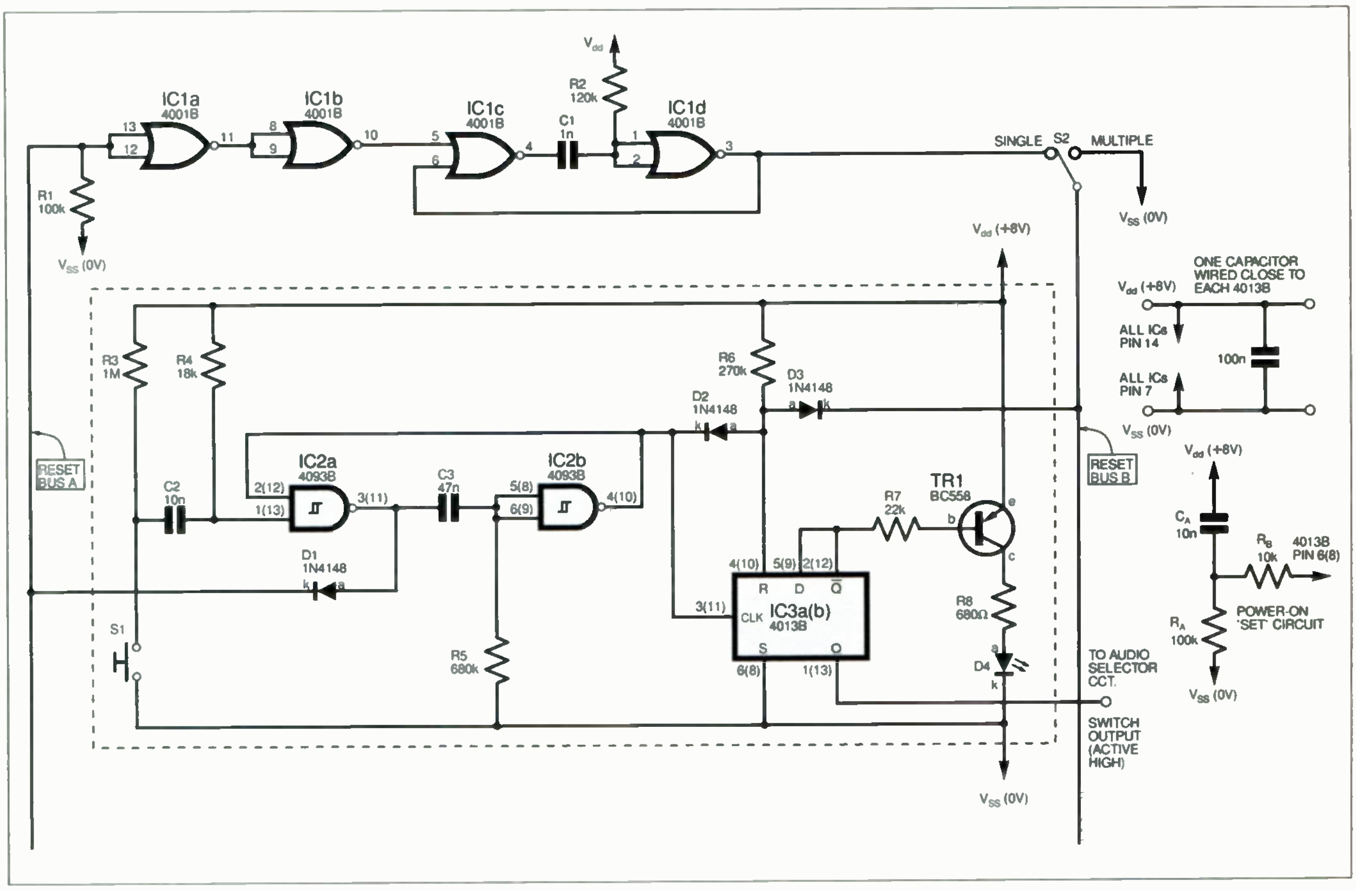


Fig. 1. Circuit diagram for the CMOS Audio Selector. Figures in brackets are pin numbers for the second identical circuit, see text.

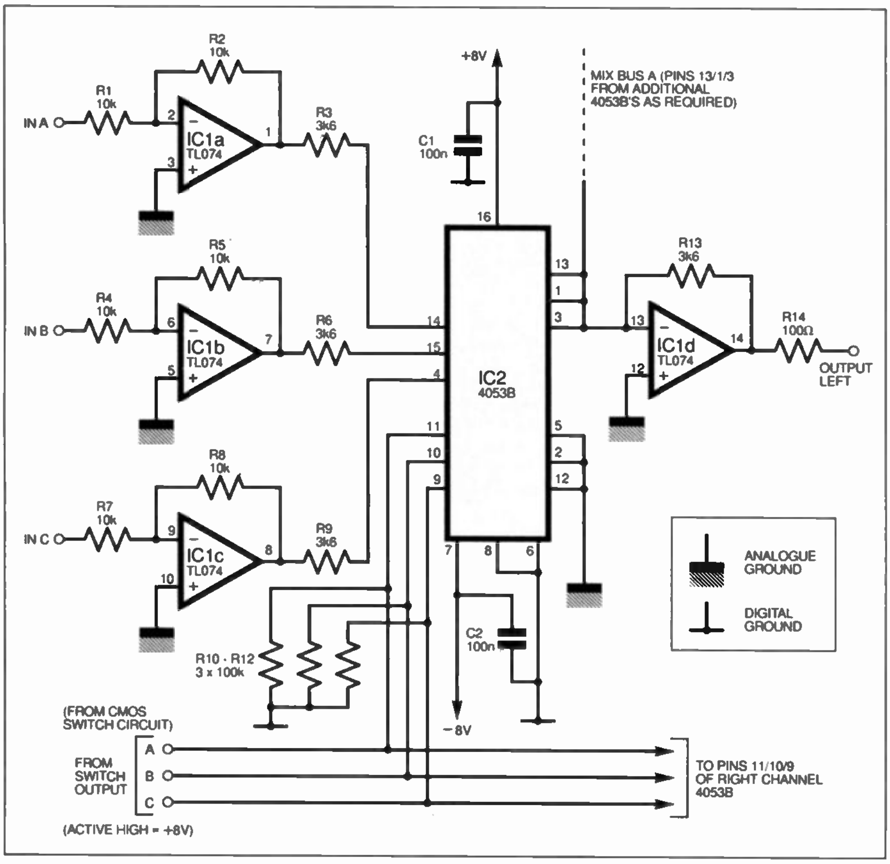


Fig. 2. Circuit diagram for the 3-Input-Stereo Selector. Only the left-channel is shown, the right channel is identical.

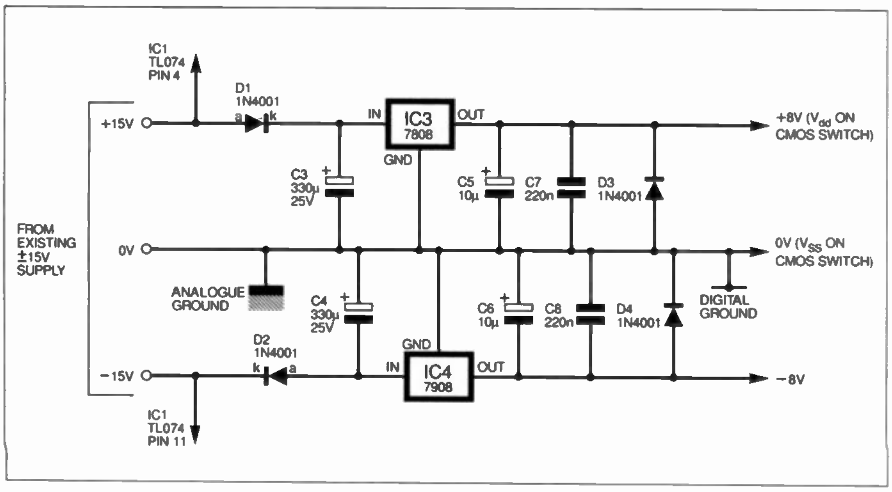
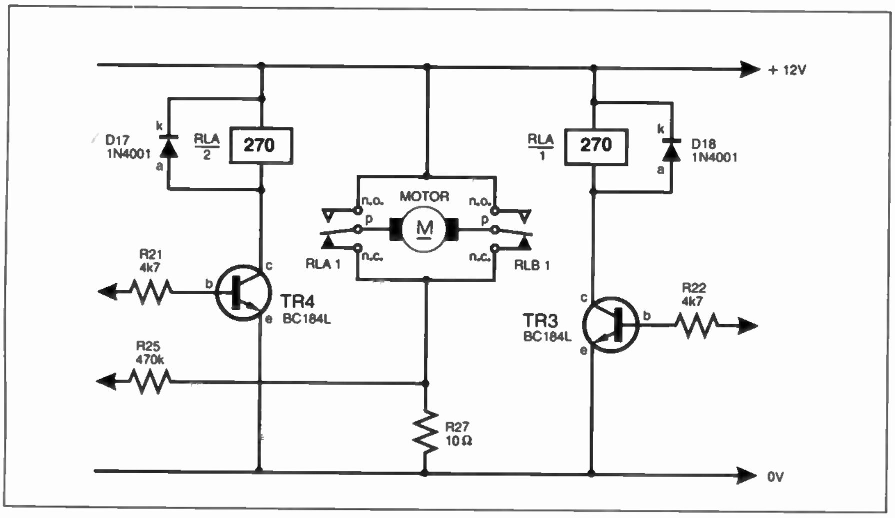


Fig. 3. The power supply circuit is designed to run from a 15V d.c. input and produces a stabilised +8V d.c. output.



high, D3 input low). On the switch pressed, the reset pulse is over-ridden since it occurs while the input to D2 is low, and thus the reset pin 4(10) stays low. This allows a switch to be toggled on/off. In theory it is possible to have at least 16 push-switches banked together.

Diode D4 is driven via transistor TR1 and in effect illuminates when the Q output is high. Switch S2 can be set to allow either one switch on, or multiple switches on, thereby allowing switched mixing of audio sources. The inset diagram shows how one switch can be hardwired with an *RC* network to be on at power up. The supply rail ($+V_{dd}$) can be anything from +5V to +16V d.c.

3-Input Stereo Selector

An extension to allow solid state selection of three audio sources is shown in Fig. 2. Each source is buffered by a TL074 op.amp (IC1a to IC1c). These have unity gain with the resistor values shown, but can be amended to suit. It is a good idea to raise all sources to CD player output levels which are usually 2V r.m.s. peak or just over +8dBu.

The respective outputs are fed to IC2, a 4053B triple 2-channel digital switch i.c., whose outputs are paralleled into IC1d. Wired as a unity-gain virtual earth mixer, the selected audio signal is seen at pin 14.

The control buses connected to pins 9 to 11 of IC2 are connected to the outputs derived from the CMOS switch circuit of Fig. 1, to provide an electronic and almost clickless means of selecting audio sources remotely (the pushbutton switches may be several metres away from the logic section).

Additional selector inputs can be wired via the "mix" bus shown. Note the digital and analogue ground buses which are shown in the power supply circuit illustrated separately (Fig. 3) which is designed to run from a 15V supply.

B.J. Taylor, Rickmansworth, Herts.

Motor Output Stage - Curtains For Transistors

THE *Automatic Curtain Winder* project (*EPE*, July 1995) uses four output transistors in a classic "H-bridge" configuration, to control a d.c. motor. Whilst this has the advantages of being quiet, reliable and very fast, I considered this to be outweighed by the fact that transistors introduce *two* collector-emitter voltage drops, which can be considerable in the case of, say, a TIP41A.

My alternative circuit, see Fig. 4, is to use two perfectly ordinary relays RLA and RLB with changeover contacts, in place of the four power transistors used in the original design. These are driven by the two BC184L transistors of the original circuit. Resistor R27 has been modified in value as shown.

The use of relay contacts ensure that the voltage drop is negligible: I have built this circuit and it has now been operating flawlessly for three months.

B. Clothier, Oadby, Leics.

Fig. 4 (left). Circuit diagram for using relays to switch the Automatic Curtain Winder *motor.*

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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 will be aware that we publish our own World Wide Web Site, the URL of which is **http://www.epemag.wimborne.co.uk.** Here you can check on current issue details, also up to date Back Issue availability, and there is a nifty and very easy to use On-Line Back Issue Order Form too, which has met with considerable enthusiasm from Internet users.

What's New on the EPE Web Site

A new EPE web resource for TENS users has been on my drawing board for the past six months, and this material has been specially written for us by Julia Kidson, a chiropractor working in association with the Anglo-European College of Chiropractic, Bournemouth, the largest College of its type in Europe. We are sure that the extra background information it contains will help users of Andy Flind's latest TENS unit (see this issue) and back pain sufferers world-wide. Check the web site for the latest news.

Work progresses with an On-line Five Year Index, together with the Soldering FAQ – condensed from the series *Build Your Own Projects* (Nov '96 to Mar '97) – nearing their on-line debuts. Remember that you can obtain the very latest news of developments by checking our web page *What's Ahead on the EPE Web Site* **(./whatsahd.htm).**

Also, of course, remember that all our available PIC source codes and more, are available by anonymous FTP from **ftp://ftp.epemag.wimborne.co.uk/pub/PICS.**

Internet Strangulation

Recently I took the plunge in my worklab and upgraded my modem to a 33·6Kbps (Kilobits per second) internal type, something I've been promising myself for months. In the true traditions of the computer industry, modem prices are starting to fall off a cliff and it's now possible to purchase a BT-approved 33·6Kbps fax modem in the UK for £65 + VAT, half the price of its 14·4Kbps predecessor I purchased two years ago.

At times, due to the worldwide bandwidth famine, I could be forgiven for thinking that I still had my former 14·4Kbps modem smouldering away in its expansion slot. (See *Net Work*, August 1996 for advice on choosing a modem to suit your PC.)

Be warned – there is simply nothing like the Internet for delivering the world's knowledge base to your doorstep, but the service delivered from around the planet is far from perfect, though it is improving all the time. Some major service providers including London's *Demon Internet Services* and *CompuServe* have clearly been embarrassed by demand in the past and to some extent are still playing catch-up, several years after popularising themselves in the UK.

With more than 200 Internet Service Providers now operating in the UK alone, there is much talk in the trade of an ISP shakedown, with smaller operators possibly being forced out or snapped up by larger players who will pay several hundred pounds per address for an ISP's customer base. The emerging Internet access market is still therefore very unstable.

My guess is that in coming years, smaller ISP's will earn their living by working on a more regionalised basis, helping local firms to establish a net presence of their own, maybe offering training and consultancy along with Internet installation and access, whilst the largest operators will live on their bulk connectivity and nationwide access networks, servicing both consumers and commerce.

To counter total strangulation of bandwidth, it is possible that "usage-based" rates could replace popular standard flat-rate fee pricing structures as a method of deterring bandwidth-hogging by casual users. One economic model speculates that this would probably be the most efficient way of improving slow download times suffered by WWW users.

Access speeds have risen dramatically over the past two years, with most UK service providers offering 28·8Kbps or 33·6Kbps access for dial-up users. Indeed, there is a danger of the imperfect Internet becoming almost routinely *usable*. Data transfer speeds are fast approaching the theoretical maximum which an ordinary copper telephone line can reliably handle, though the very latest "K56 Plus" 56Kbps modem technology is now emerging. (See **http://www.rockwell.com.**) In the meantime, I'm afraid we're all stuck with a variable state of the art in this still developing market.

Looking Ahead

Looking ahead to future *Net Work* features, I'll be concentrating on using the World Wide Web – what is it and how to use it. Regular readers might be interested to learn that the feature article "*The Internet*" (*EPE*, July 1996) was researched entirely using the Internet medium, nearly all of it in web form. Hence, I'll be describing "search engines" – how to get the best out of these web-based resources offering pointers to sites suited to a particular interest. Also, I'll describe "webmail" – if resources or your Internet access is limited, you can use ordinary E-mail to surf the net and have web pages delivered to you!

Latest Links

Tell me your favourite electronics links! This month's round up starts with another on-line bookshop, this one declaring that they sell "US books at US prices": **http://www.bookstore.co.uk.** A range of books related to MIDI music for the PC, Mac, Atari and more is now described on-line by PC Publishing, on **http://www.pc-pubs.demon.co.uk.** Three out of four schools surf the net using Energis networks, they say, and Demon users too may be interested in **http://www.energis.co.uk** which describes the technology purchased by the UK's largest ISP.

Psion Organiser users could try the **PSION FAQ** *(Frequently Asked Questions)* which is mirrored in the UK at: **http://info.bris.ac.uk/~lwmdcg/Psion/FAQ/.** The PSION User's Club resides at **http://www.nicolas.com/psion/index.htm** whilst **http://www.the-wire.com/ce/psion/info.html** offers a plethora of general information.

Another source of interest to OEMs and consumers alike will be Rayovac's web site **http://www.rayovac.com/business.** This lists many .zip files covering battery data and usage, which unzip into Microsoft Word .doc files, so make sure you can read these before downloading.

Finally, a special thanks to David Tait who has adapted the *Simple PIC Programmer* project software (*EPE*, Feb '96) in an attempt to use MPASM hex files rather than the TASM object file. This is available as freeware from **ftp://ftp.epemag.wimborne.co.uk/pub/PICS/PIC.Programmer/sendhex/sendhex.zip.** David also provides a pointer to his Home Page which is at **http://www.man.ac.uk/~mbhstdj.**

Remember that all links are made for you on the *Net Work* page of the *EPE* Web Site. TENS users note – we're also reciprocating with the nearby *Anglo-European College of Chiropractic*, which *Net Work* encouraged to open a web site of their own. Watch this space for its URL. See you next month for more *Net Work*.

My E-mail address is **alan@epemag.demon.co.uk.** My Web Home Page is **http://ourworld.compuserve.com/homepages/alan_winstanley.**

VIDEOS ON ELECTRONICS

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

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

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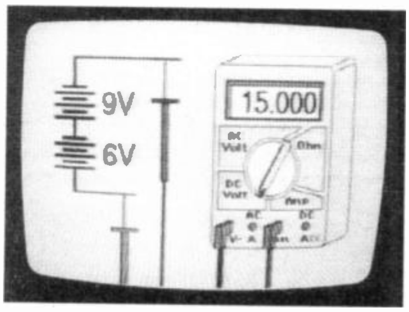

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VT205 57 minutes. Part Five; Amplifiers. Shows you how amplifiers work as you have never seen them before. Class A, class B, class C, op.amps. etc. **Order Code VT205**

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

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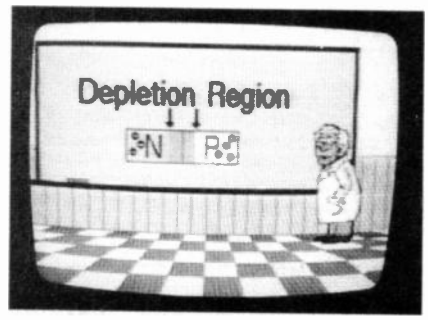
VT306 56 minutes. Digital Six; The CPU gives you a thorough understanding in the basics of the central processing unit and the input/output circuits used to make the system work. **Order Code VT306**

RADIO

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

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



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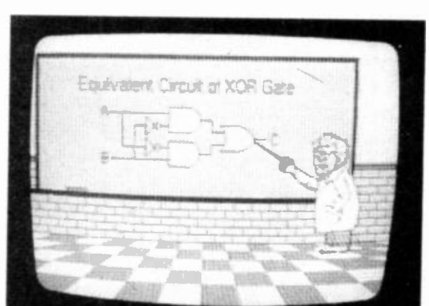
MISCELLANEOUS

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

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



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

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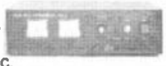

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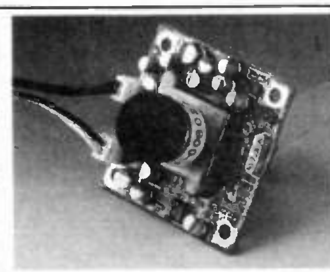

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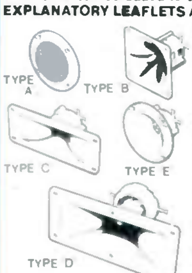

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