JANUARY 1998

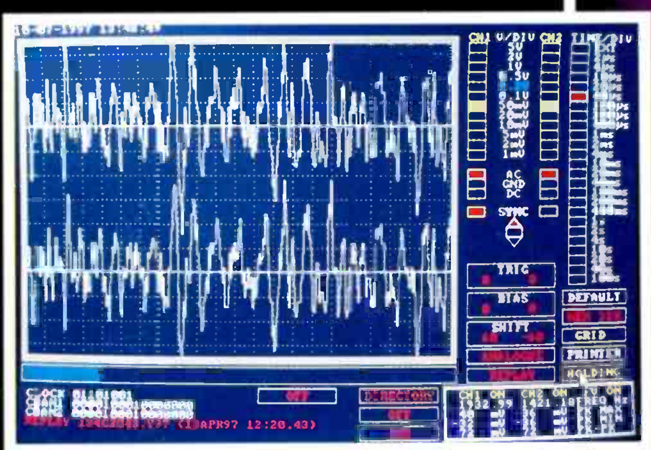
EVERYDAY PRACTICAL ELECTRONICS

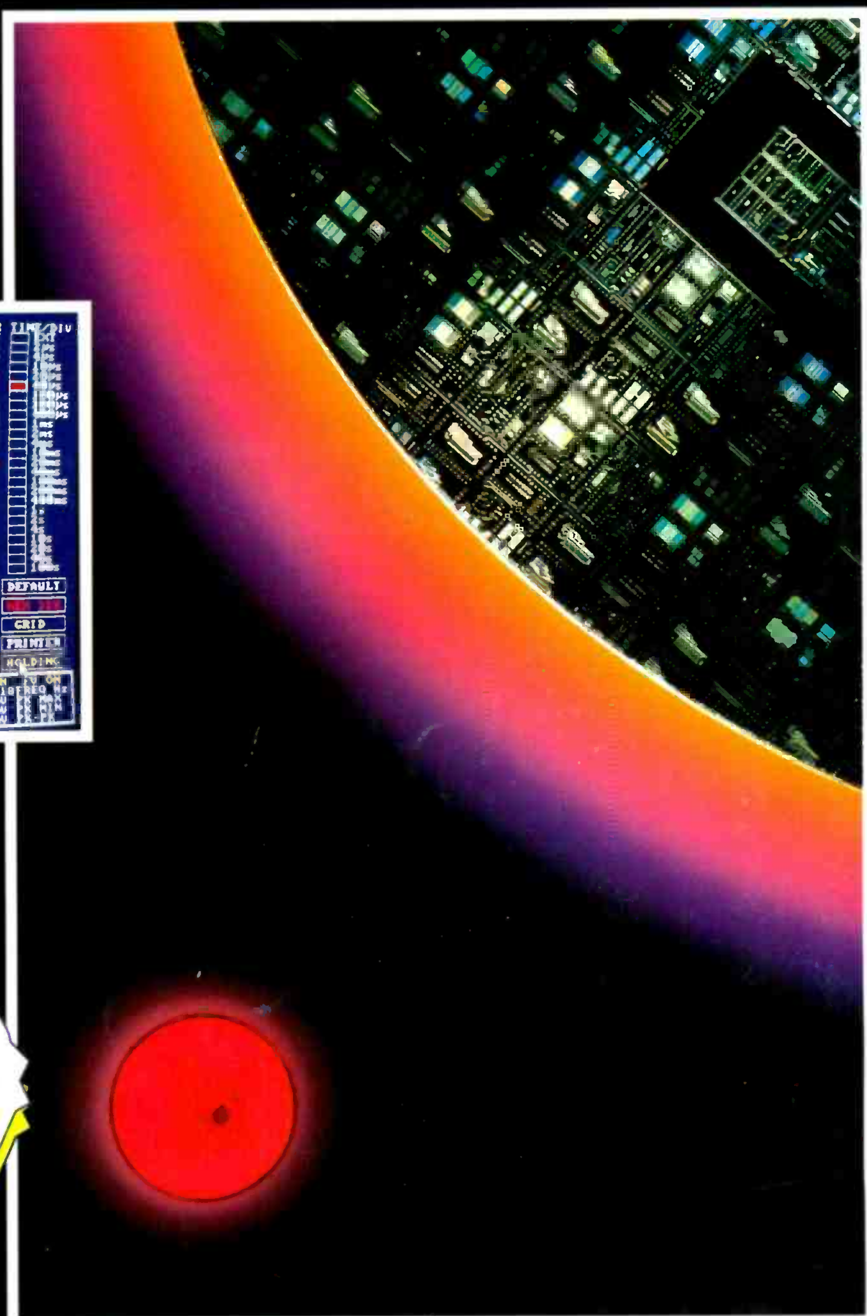
http://www.epemag.wimborne.co.uk

£2.65

EPE VIRTUAL 'SCOPE

A dual trace PC based oscilloscope with FREE SOFTWARE





With just a handful of components you can build a SIMPLE MW RADIO

FREE INSIDE! GIANT PIC DATA CHART

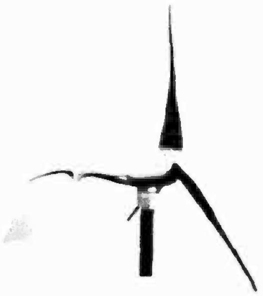
DISCO LIGHTS FLASHER

Liven up your party - an inexpensive five channel design

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

ALTERNATIVE & FUTURE TECHNOLOGIES - 2

Optical and Protein Memories, Heterojunction Transistors, Diamond Substrates, Chip-on-Chip, Conductive Adhesives, Nano Technology



WIND GENERATORS 380 WATT

1.14 metre dia blades, carbon matrix blades, 3 year warranty, 12vdc output, 24v version available, control electronics included, brushless neodymium cubic curve alternator, only two moving parts, maintenance free, simple roof top installation, start up speed 7mph, max output (30mph) 380w £499 ref AIR1

PLANS

PORTABLE X RAY MACHINE PLANS Easy to construct plans on a simple and cheap way to build a home X-ray machine! Effective device, X-ray sealed assemblies can be used for experimental purposes. Not a toy or for minors! £6/set. Ref F/XP1

TELEKINETIC ENHANCER PLANS Mystify and amaze your friends by creating motion with no known apparent means or cause. Uses no electrical or mechanical connections, no special gimmicks yet produces positive motion and effect. Excellent for science projects, magic shows, party demonstrations or serious research & development of this strange and amazing phychic phenomenon. £4/set Ref F/TKE1

ELECTRONIC HYPNOSIS PLANS & DATA This data shows several ways to put subjects under your control. Included is a full volume reference text and several construction plans that when assembled can produce highly effective stimuli. This material must be used cautiously. It is for use as entertainment at parties etc only, by those experienced in its use. £15/set. Ref F/EH2

GRAVITY GENERATOR PLANS This unique plan demonstrates a simple electrical phenomena that produces an anti-gravity effect. You can actually build a small mock spaceship out of simple materials and without any visible means- cause it to levitate. £10/set Ref F/GRA1

WORLDS SMALLEST TESLA COIL/LIGHTENING DISPLAY GLOBE PLANS Produces up to 750,000 volts of discharge, experiment with extraordinary HV effects, 'Plasma in a jar', St Elmo's fire, Corona, excellent science project or conversation piece £5/set Ref F/BTC1/LG5

COPPER VAPOUR LASER PLANS Produces 100mw of visible green light. High coherency and spectral quality similar to Argon laser but easier and less costly to build yet far more efficient. This particular design was developed at the Atomic Energy Commision of NEGEV in Israel. £10/set Ref F/CVL1

VOICE SCRAMBLER PLANS Miniature solid state system turns speech sound into indecipherable noise that cannot be understood without a second matching unit. Use on telephone to prevent third party listening and bugging. £6/set Ref F/VS9

PULSED TV JOKER PLANS Little hand held device utilises pulse techniques that will completely disrupt TV picture and sound! works on FM too! DISCRETION ADVISED. £8/set Ref F/TJ5

BODYHEAT TELESCOPE PLANS Highly directional long range device uses recent technology to detect the presence of living bodies, warm and hot spots, heat leaks etc. Intended for security, law enforcement, research and development, etc. Excellent security device or very interesting science project. £8/set Ref. F/BHT1

BURNING, CUTTING CO2 LASER PLANS Projects an invisible beam of heat capable of burning and melting materials over a considerable distance. This laser is one of the most efficient, converting 10% input power into useful output. Not only is this device a workhorse in welding, cutting and heat processing materials but it is also a likely candidate as an effective directed energy beam weapon against missiles, aircraft, ground-to-ground, etc. Particle beams may very well utilize a laser of this type to blast a channel in the atmosphere for a high energy stream of neutrons or other particles. The device is easily applicable to burning and etching wood, cutting, plastics, textiles etc £12/set Ref F/LC7

DYNAMO FLASHLIGHT Interesting concept, no batteries needed just squeeze the trigger for instant light apparently even works under water in an emergency although we haven't tried it yet! £6.99 ref SC152

ULTRASONIC BLASTER PLANS Laboratory source of sonic shock waves. Blow holes in metal, produce 'cold' steam, atomize liquides. Many cleaning uses for PC boards, jewllery, coins, small parts etc. £6/set Ref F/ULB1

ANTI DOG FORCE FIELD PLANS Highly effective circuit produces time variable pulses of accoustical energy that dogs cannot tolerate £6/set Ref F/DOG2

LASER BOUNCE LISTENER SYSTEM PLANS Allows you to hear sounds from a premises without gaining access. £12/set Ref F/LLIST1

PHASOR BLAST WAVE PISTOL SERIES PLANS Handheld, has large transducer and battery capacity with external controls. £6/set Ref F/PSP4

INFINITY TRANSMITTER PLANS Telephone line grabber/room monitor. The ultimate in home/office security and safety! simple to use! Call your home or office phone, push a secret tone on your telephone to access either: A) On premises sound and voices or B) Existing conversation with break-in capability for emergency messages £7 Ref F/TELEGRAB

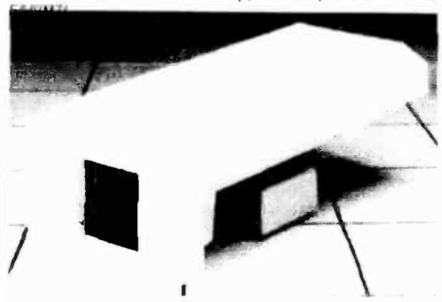
BUG DETECTOR PLANS Is that someone getting the goods on you? Easy to construct device locates any hidden source of radio energy! Sniffs out and finds bugs and other sources of bothersome interference. Detects low, high and UHF frequencies. £5/set Ref F/BD1

ELECTROMAGNETIC GUN PLANS Projects a metal object a considerable distance-requires adult supervision £5 ref F/EML2

ELECTRIC MAN PLANS, SHOCK PEOPLE WITH THE TOUCH OF YOUR HAND! £5/set Ref F/EMA1

PARABOLIC DISH MICROPHONE PLANS Listen to distant sounds and voices, open windows, sound sources in 'hard to get' or hostile premises. Uses satellite technology to gather distant sounds and focus them to our ultra sensitive electronics. Plans also show an optional wireless link system. £8/set ref F/PM5

***2 FOR 1* MULTIFUNCTIONAL HIGH FREQUENCY AND HIGH DC VOLTAGE, SOLID STATE TESLA COIL AND VARIABLE 100,000 VDC OUTPUT GENERATOR PLANS** Operates on 9-12vdc, many possible experiments. £10 Ref

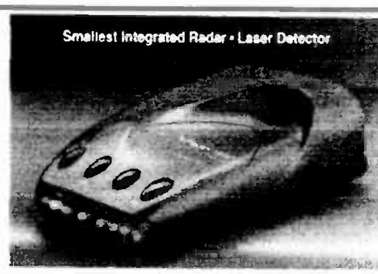


COLOUR CCTV VIDEO CAMERAS,

BRAND NEW AND CASED. FROM £99.

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

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



SUPERWIDEBAND RADAR DETECTOR 360 deg COVERAGE

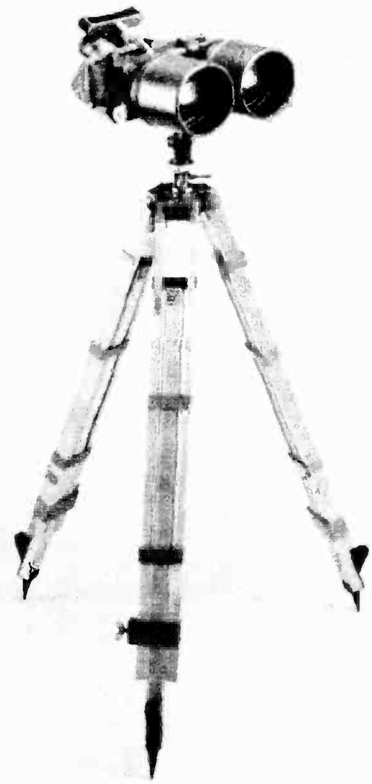
Detects both radar and laser, X, K, superwide KA bands. LED signal strength display Audio and visual alerts, Alert priority, Rear and front facing optical waveguides, Triplecheck verification, city mode, tutorial mode, dark mode, aux jack, volume control. These may be illegal to use in certain countries.
1.1"x2.7"x4.6"

Superband £149 ref RD2

PLACE YOUR ORDER VIA OUR WEBSITE AT BULL-ELECTRICAL.COM

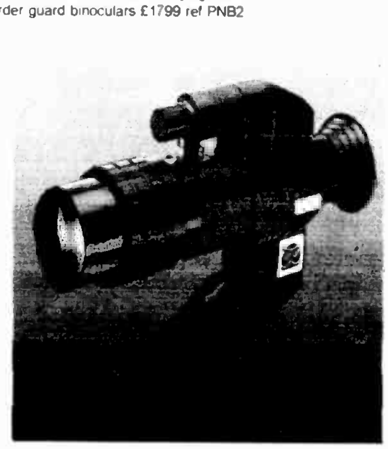
BULL ELECTRICAL

250 PORTLAND ROAD, HOVE, SUSSEX BN3 5QT. (ESTABLISHED 50 YEARS).
MAIL ORDER TERMS: CASH, PO OR CHEQUE WITH ORDER PLUS £3.50 P&P PLUS VAT.
24 HOUR SERVICE £5.00 PLUS VAT.
OVERSEAS ORDERS AT COST PLUS £3.50
(ACCESS, VISA, SWITCH, AMERICAN EXPRESS)
'phone orders: 01273 203500
FAX 01273 323077
E-mail bull@pavilion.co.uk



HELIOS PNB-2 RUSSIAN BORDER GUARD OBSERVATION BINOCULARS £1799

Intended for the medium to long range observation of air and ground targets and the determina tion of their angular co-ordinates. These giant binoculars are a tribute Russian optical ingenuity, with a performance that simply has to be seen to be believed. A large exit pupil diameter of 7.33mm provides exceptional light passing power, which when combined with its high
magnification of x15 allows the user to view over vast distances with delightfully bright, crisp, high resolution images. Robust and able in construction incorporating an uncomplicated yet thoughtfully designed mechanical layout ensuring ease of operation and quick precise targeting. These binoculars have a wide variety of applications and are suitable for use by coastguards, law enforcement organizations, customs, farmers etc.
Specifications
x15 magnification, 110mm objective, 6 deg angle of view, Field at 100m=105m, focusing 10m-inf, fully coated precision ground optics, orange and neutral filters, rubber lens caps, rapid tergetting hand grips, padded headrest, screw in silica gel cartridges, wooden tripod, operating temperatures -40 c to +50 c, weight 25kg, (15kg without tripod), supplied in wooden carrying case
Border guard binoculars £1799 ref PNB2



TZS4 INFRARED NIGHT SIGHT

One of our top most selling night sights is this Russian TZS4. This sight enable you to see in very low light levels, or with the aid of the built in Infra red illuminator- in total darkness. In 1/4 moonlight you would spot a man at 150m, in total darkness at 75m. Magnification 2.3x, 240x66x190mm, 0.9kg, focusing range 1.5m-infinity, M42 camera mount included, runs on 2xAA batteries, 100mm focal length, 8 deg illuminator divergence, 50hrs continuous (no illuminator) 10hrs with, carryingcase and strap
TZS4 Nightsight £199 ref BAR61

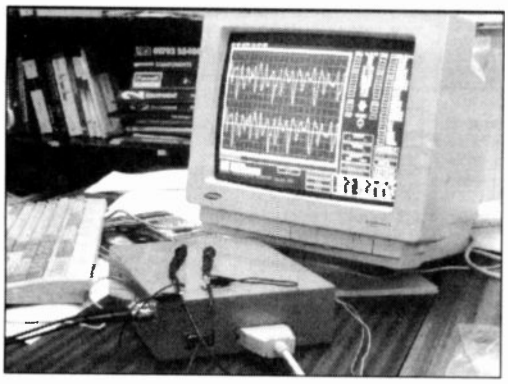
ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

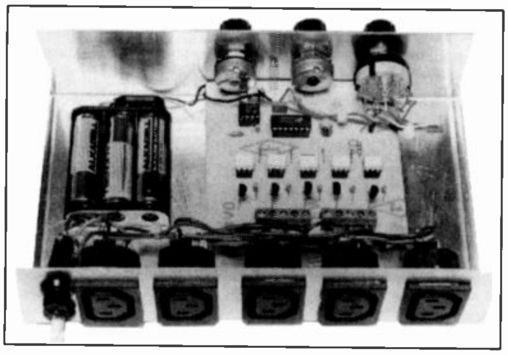
VOL. 27 No. 1 JANUARY 1998

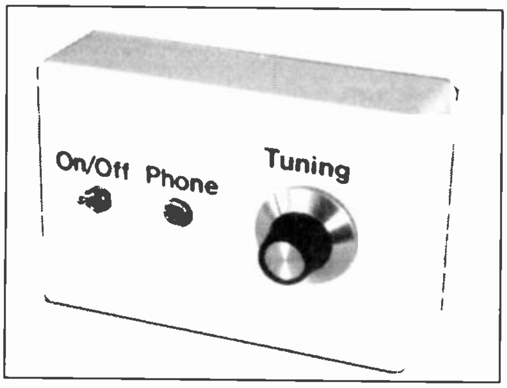
EVERYDAY PRACTICAL ELECTRONICS

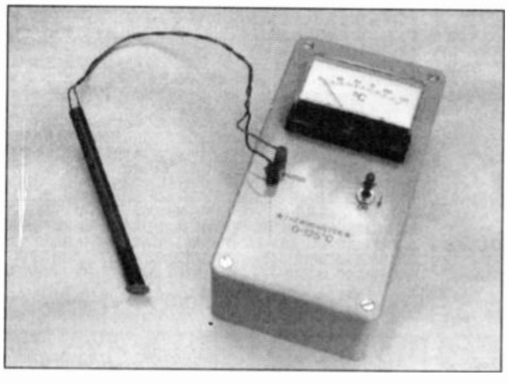
http://www.epemag.wimborne.co.uk

The No. 1 Magazine for Electronics Technology and Computer Projects









Projects and Circuits

Series and Features

Regulars and Services

Our February '98 issue will be published on Friday, 2 January 1998. See page 3 for details.

Surplus always wanted for cash!

THE *ORIGINAL* SURPLUS WONDERLAND!

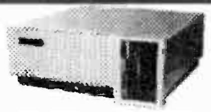
THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

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 available - call for details. Only **£399.00** (E)

FLOPPY DISK DRIVES 3½" - 8"

5¼" or 3½" from only £18.95 !

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

3½" **Panasonic** JU363/4 720K or equivalent RFE	£24.95(B)
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)

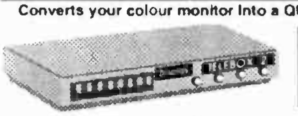
HARD DISK DRIVES

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 Teleboxe'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

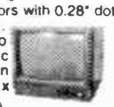
As New - Used on film set for 1 week only!! 15" 0.28 SVGA 1024 x 768 res. colour monitors. Swivel & tilt etc. Full 90 day guarantee. £145.00 (E)

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 <u>**both**</u> **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 13¾" D. 240 V AC mains powered. **Only £79.00** (D)

KME 10" 15M10009 high definition colour monitors with 0.28" dot pitch. Superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13½" x 12" x 11". Good used condition. **Only £125** (E)



20" 22" and 26" AV SPECIALS

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

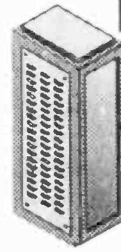
20"....£135 22"....£155 26"....£185 (F)

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 generatpr	£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 Industrila 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



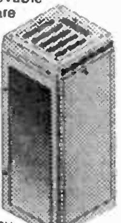
Superb quality 6 foot 40U Virtually New, Ultra Smart *Less than Half Price!*

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)
Full MICROTOUCH software support pack and manuals for IBM compatible PC's £29.95 RFE - Tested

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.
Order as: XT RAM UG. **256k. £34.95** *or* **512k £39.95** (A1)

<u>SIMM SPECIALS</u>

1 MB x 9 **SIMM** 9 chip 120ns	Only	£16.50 (A1)
1 MB x 9 **SIMM** 3 chip 80 ns **£19.50**	or 70ns	£22.95 (A1)
1 MB x 9 **SIMM** 9 chip 80 ns **£21.50**	or 70ns	£23.75 (A1)
4 MB 70 ns 72 pin SIMM *-with parity-*	Only	£95.00 (A1)
INTEL 486-DX33 CPU £55.00	**INTEL 486-DX66 CPU**	**£69.00** (A1)

FULL RANGE OF CO-PROCESSOR'S EX STOCK - CALL FOR £££

FANS & BLOWERS

EPSON D0412 40x40x20 mm 12v DC	£7.95 10 / £65
PAPST TYPE 612 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***

Issue 13 of *Display News* now available - send large SAE - PACKED with bargains!

DISPLAY -ELECTRONICS-

ALL MAIL & OFFICES
Open Mon-Fri 9.00-5:30
Dept PE. 32 Biggin Way
Upper Norwood
LONDON SE19 3XF

LONDON SHOP
Open Mon - Sat 9:00 - 5:30
215 Whitehorse Lane
South Norwood
On 68A Bus Route
Nr.Thornton Heath &
Selhurst Park SR Rail Stations

NEW **DISTEL©**
The Original
FREE On line Database
Info on 20,000 + stock items!
RETURNING SOON !

ALL ☎ ENQUIRIES
0181 679 4414
FAX 0181 679 1927

SWITCH · MasterCard · VISA · EST 25 YEARS

All prices for UK Mainland. UK customers add 17.5% VAT to TOTAL order amount. Minimum order £10. Bona Fide account orders accepted from Government, Schools, Universities and Local Authorities - minimum account order £50. Cheques over £100 are subject to 10 working days clearance. Carriage charges (A)=£3.00, (A1)=£4.00, (B)=£5.50, (C)=£8.50, (D)=£12.00, (E)=£15.00, (F)=£18.00, (G)=CALL. Allow approx 6 days for shipping - faster CALL. Scotland surcharge CALL. All goods supplied to our Standard Conditions of Sale and unless stated guaranteed for 90 days. All guarantees on a return to base basis. All rights reserved to change prices / specifications without prior notice. Orders subject to stock. Discounts for volume. Top CASH prices paid for surplus goods. All trademarks etc acknowledged. © Display Electronics 1996. E & O E. 06/6

NEXT MONTH

WATER WIZARD

This prize winning design indicates the amount of water being used. PIC based, the unit requires no controls, making it easy to waterproof and simple to use. It switches on automatically when water flows and off 30 seconds after flow ceases – storing the measured value in memory for later recall.

Useful for power showers, hosepipes or for measuring water used by washing machines etc., this project will be valuable to anyone on a water meter and those aware of the environment.

KISSOMETER

The title of this project may well suggest a rather frivolous use for discrete electronics. You could be well advised, however, to drop that stiff upper lip for a while and avoid your medication in favour of some good old fashioned fun; the fairground variety to be precise.

Place one's finger, or perhaps other bodily appendage, upon some touch pad contacts. Wait for the auditory senses to be sufficiently stimulated (or more likely at the moment onlookers ask you to kill the unearthly thing making the noise); lift your clammy finger (or whatever) – and take delight in the visual wonder that is . . . well, the means by which the Kissometer judges your kissability.

The jumping light emitting diode dot display will gradually slow down until it settles and stops so as to light only one l.e.d. The label adjacent to the lit l.e.d. now indicates your rating. From passionate to poor or ecstasy to evil – the choice is yours!

WAA-WAA EFFECTS PEDAL

The waa-waa effect has been popular with guitarist's for many years now, and one reason for this popularity is that it provides an easy means of adding great expression to your playing. It is also a relatively simple effect that can be implemented using inexpensive circuitry. A waa-waa unit is basically just a tunable filter that boosts a narrow band of frequencies. The operating frequency of the filter is moved up and down, giving the familiar "waa-waa" sound. The filtering boosts certain harmonics in the signal, and operating the pedal changes the harmonics that are affected. For good results it is essential that the processed signal contains reasonably strong harmonics, but an electric guitar is unlikely to be found lacking in this respect.

Using semi-automatic control via a footswitch this simple, easy to build, project will appeal to a wide range of musicians.

NO ONE DOES IT BETTER

PLUS ***EPE VIRTUAL SCOPE – 2***

PLUS ***ALL THE REGULAR FEATURES***

EVERYDAY PRACTICAL ELECTRONICS

DON'T MISS AN ISSUE – PLACE YOUR ORDER NOW!

FEBRUARY ISSUE ON SALE FRIDAY, JANUARY 2

MAGENTA
E L E C T R O N I C S L T D

EE185 135 Hunter Street, Burton-on-Trent, Staffs. DE14 2ST
Tel 01283 565435 Fax 546932
E-mail: Magenta_Electronics@compuserve.com
Homepage: http://ourworld.compuserve.com/homepages/Magenta_Electronics

All Prices include V.A.T. Add £3.00 per order p&p

EUROCARD MasterCard VISA SWITCH

MAIL ORDER ONLY ● CALLERS BY APPOINTMENT

EPE MICROCONTROLLER P.I. TREASURE HUNTER

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

*NEW

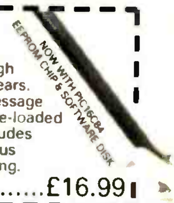
- SIMPLE TO BUILD
- SWEPT FREQUENCY
- HIGH POWER OUTPUT
- AUDIO & VISUAL MONITORING

An affordable circuit which sweeps the incoming water supply with variable frequency electromagnetic signals. May reduce scale formation, dissolve existing scale and improve lathering ability by altering the way salts in the water behave.
Kit includes case, P.C.B, coupling coil and all components.
High coil current ensures maximum effect. L.E.D. monitor

KIT 868 ....£22.95 POWER UNIT.........£3.99

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

MICRO PEsT SCARER

NEW *

Our latest design – The ultimate scarer for the garden. Uses special microchip to give random delay and pulse time. Easy to build reliable circuit. Keeps pets/pests away from newly sown areas, play areas, etc. Uses power source from 9 to 24 volts.

- RANDOM PULSES
- HIGH POWER
- DUAL OPTION

Plug-in power supply £4.99

KIT 867..............................£19.99
KIT + SLAVE UNIT.................£32.50

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 performance superheterodyne design.

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

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

WINDICATOR

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

KIT 856..£28.00

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

★ TENS UNIT ★

DUAL OUTPUT TENS UNIT

NEW!

As featured in March '97 issue.

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

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

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

KITS UNDER £10.00

Older style kits – some using P.C.B., others stripboard. All popular 'oldies'. Instructions included with each kit.

K386 Drill Speed Controller	£9.95
K561 Light Rider Lapel Badge	£9.98
K101 Electronic Dice	£7.50
K242 Two Intercom	£6.50
K455 Electronic Doorbell	£9.25
K816 Stepper Motor Interface	£8.52
K481 Soldering Iron Controller	£6.90
K512 Mains Tester/Fuse Finder	£10.00
K776 Lie Detector	£9.90
K240 Egg Timer	£7.85
K181 Soil Moisture	SOLD
K263 Buzz Off	£6.49
K569 Automatic Car Alarm	£9.95

Reprints of these special kits – send 50p stamps per kit + stamped addressed envelope

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 No. 845................£64.95

3-NOTE DOORCHIME

IDEAL BEGINNERS PROJECT

Uses SAB0600 chip to produce natural sounding 3-note chime. Adjustable pitch – so that two can be used for front and back doors.
Kit includes P.C.B., all parts and instructions.
No case or battery

KIT 869........£5.99

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

EVERYDAY PRACTICAL ELECTRONICS

VOL. 27 No. 1 JANUARY '98

Editorial Offices:
EVERYDAY PRACTICAL ELECTRONICS EDITORIAL
ALLEN HOUSE, EAST BOROUGH, WIMBORNE
DORSET BH21 1PF
Phone: Wimborne (01202) 881749
Fax: (01202) 841692. **Due to the cost we cannot reply to overseas orders or queries by Fax.**
E-mail: editorial@epemag.wimborne.co.uk
Web Site: http://www.epemag.wimborne.co.uk
See notes on **Readers' Enquiries** below – we regret lengthy technical enquiries cannot be answered over the telephone.
Advertisement Offices:
EVERYDAY PRACTICAL ELECTRONICS
ADVERTISEMENTS
MILL LODGE, MILL LANE
THORPE-LE-SOKEN, ESSEX CO16 0ED
Phone/Fax: (01255) 861161

E-RUBBISH

Great though E-mail is, it does generate its own problems, not the least of which is the unsolicited junk mail which seems impossible to get rid of! Unfortunately it also encourages readers to send in "trivia". While we are always keen to hear readers' comments and answer queries on the magazine (see below) it seems that E-mail has generated a new breed of reader – those who would rather E-mail us a query than read the magazine to find the answer:

How much is the p.c.b. for X? How do I order a back issue? Where do I buy a component for X? Etc., Etc. All of the answers are in the magazine.

What is worse is that if we are unable to answer these people the next day they then send another E-mail chasing up the first one. On one occasion recently one Italian reader asked if we had received his faxed subscription renewal; after we E-mailed him back to confirm that we had, he replied by asking if we were sure and came back again complaining when we gave him a terse "we have already told you". Needless to say we did not make a third reply.

It seems that the problem is the "play factor"; readers sit at the keyboard wondering who they can E-mail and, because the technology they use is instant, they expect an instant reply. This, of course, bogs us down with unnecessary "paperwork" (any suggestions for a more suitable term?).

Please be assured that we invariably reply to *all* correspondence within a few days and we treat E-mail with the same priority as everything else – letter, fax., etc. So, if you E-mail us on a Friday please don't 'phone, fax or E-mail again on Monday because you haven't had a reply. You might well get a reply on Monday but it could be Tuesday or Wednesday, depending on how busy we are and how much research needs to go into providing a reply. Also, please do read the magazine (including *Shoptalk*) before you ask questions about things that are clearly stated in the magazine – it will save us all a lot of time and trouble.

E-INTERESTING

Having said all of that, may I now ask you to read our *Readout* page and point out that we would like to see your *interesting* correspondence and views on all matters electronic and the magazine in general. To encourage you there is now a Best Letter prize each month, donated by Peak Electronic Design Ltd. So, next time you fancy sending an E-mail about nothing in particular, why not switch on the grey matter and send something interesting instead!

SEASONS GRETINGS

Having had a bit of a moan, may I wish all our readers the Compliments of The Season and a profitable and trouble free 1998. Thank you for reading us: as they say – may you live in interesting times.

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see below), from all UK newsagents (distributed by Seymour) and from the following UK electronic component retailers: Maplin – all stores throughout the UK (and in S. Africa); Greenweld Electronics; Cirkit Distribution; Omni Electronics. The magazine can also be purchased from many retail magazine outlets around the world.

SUBSCRIPTIONS

Annual subscriptions for delivery direct to any address in the UK: £26. Overseas: £32 standard air service, £49.50 express airmail. Cheques or bank drafts (**in £ sterling only**) payable to *Everyday Practical Electronics* and sent to EPE Subscriptions Dept., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749. Subscriptions start with the next available issue. We accept MasterCard or Visa. (For past issues see the *Back Issues* page.)

BINDERS

Binders to hold one volume (12 issues) are available from the above address. These are finished in blue p.v.c., printed with the magazine logo in gold on the spine. Price £5.95 plus £3.50 post and packing (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which cost £10.50). *Normally sent within seven days but please allow 28 days for delivery – more for overseas orders.*

Payment in £ sterling only please. Visa and Master-Card accepted, minimum credit card order £5. Send, fax or phone your card number and card expiry date with your name, address etc.

READERS' ENQUIRIES

We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply *must* be accompanied by a **stamped self-addressed envelope or a self-addressed envelope and international reply coupons. Due to the cost we cannot reply to overseas queries by Fax.**

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers (see *Shoptalk*).

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

We regret that **we cannot provide data, or answer queries, on projects that are more than five years old.**

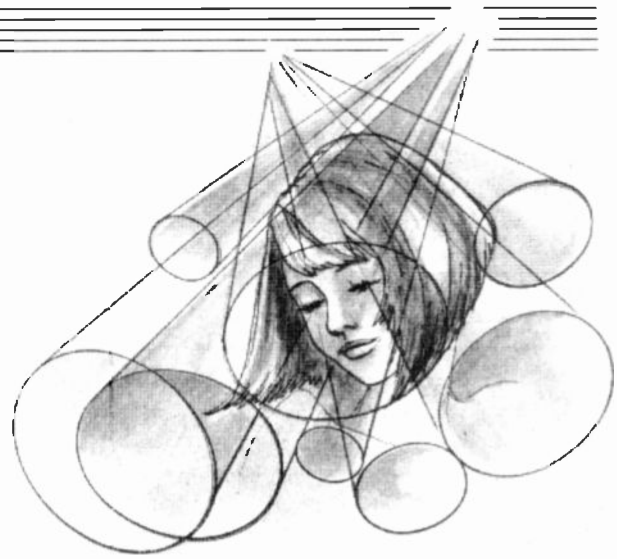
ADVERTISEMENTS

Although the proprietors and staff of EVERYDAY PRACTICAL ELECTRONICS take reasonable precautions to protect the interests of readers by ensuring as far as practicable that advertisements are *bona fide*, the magazine and its Publishers cannot give any undertakings in respect of statements or claims made by advertisers, whether these advertisements are printed as part of the magazine, or in inserts.

The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture. Legal remedies are available in respect of some of these circumstances, and readers who have complaints should first address them to the advertiser.

TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

We advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before buying any transmitting or telephone equipment as a fine, confiscation of equipment and/or imprisonment can result from illegal use or ownership. The laws vary from country to country; overseas readers should check local laws.



DISCO LIGHTS FLASHER

TERRY de VAUX-BALBIRNIE

A brilliant way to liven up the party!

No disco would be complete without at least one set of flashing lights. The commercial variety, although rich in special effects, tend to be very expensive. Even hiring them for one evening can prove prohibitively costly.

This circuit is a much cheaper and simpler alternative which will make it ideal for parties at home and similar situations.

COLOURED LAMPS

The circuit is designed to flash five mains powered lamps in various ways as set by a switch on the front panel of the unit. The first mode is Random, whereby the lamps flash in any order. The second is Sequential, where they operate in a fixed pattern. The third is Automatic and here the lamps alternate between periods of random and sequential operation.

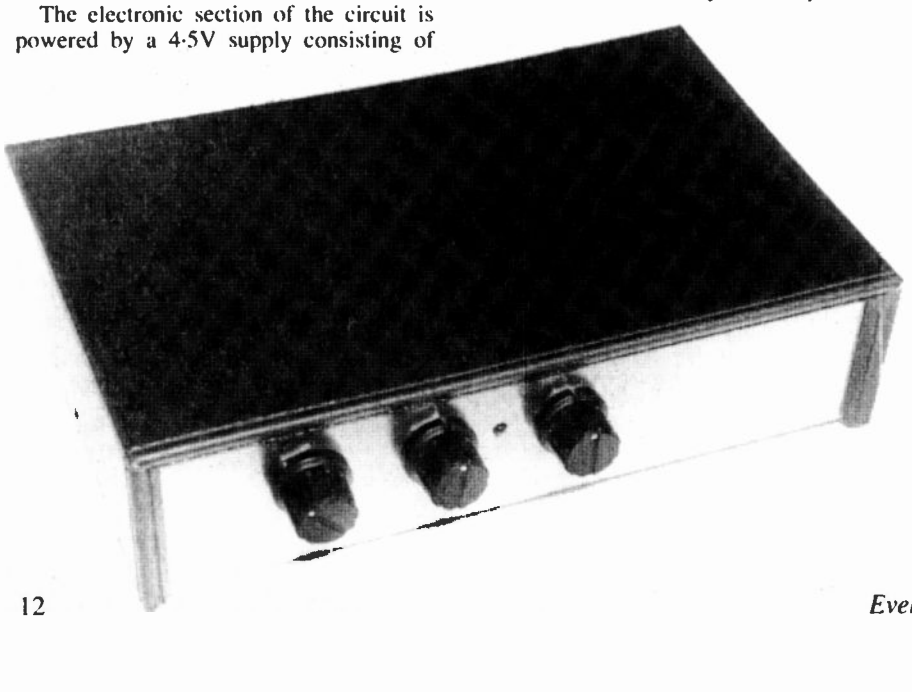
There are two further controls which set the rate at which the lamps operate and the timing of random and sequential operation when automatic control is selected.

The electronic section of the circuit is powered by a 4·5V supply consisting of three AA-size alkaline cells. Since the circuit draws on average only 10mA, approximately, these may be expected to give about 200 hours of service. Reliable operation will be provided with less than 3V. An l.e.d. (light emitting diode) indicator serves as a reminder to switch the unit off after use.

The circuit is built in a metal box with a mains input lead and five IEC (European style) sockets to which the lamps are connected. The lamps may have any rating up to 60W and, although they may be of any mains tungsten filament (not fluorescent) type, in practice they will probably be of the coloured reflector variety.

A panel-mounted fuse protects the circuit in the event of overload or the occasional current surge which sometimes occurs when a lamp fails.

An important feature of the design is the optical isolation between the mains and the low-voltage control circuit. Providing the circuit is correctly constructed and used, it will therefore be entirely safe in operation.



CIRCUIT DESCRIPTION

The Disco Lights Flasher circuit diagram is shown in Fig.1. The principal component is IC2, which is a dedicated l.e.d. flasher integrated circuit (i.c.). Of course, ordinary l.e.d.s would not be suitable for the purpose, and more will be said about this presently.

When the i.c. is connected to the supply, its five outputs – pins 9 to 13 – go low in turn. If standard l.e.d.s were connected to them, each would flash in turn with current sinking into the appropriate output.

The logic state of pin 5 determines the mode in which the device operates. If it is made high, the outputs switch sequentially, if it is low or left unconnected, they operate at random. In fact, it is not true randomness because the outputs follow a pattern. This repeats each 32 steps, but the effect appears to be random.

The rate at which the l.e.d.s flash is controlled by IC2's on-chip oscillator and the resistance connected between pin 1 and pin 2 determines its frequency. This is made adjustable using potentiometer VR2, which operates in conjunction with fixed resistor R4.

When VR2 is set to zero resistance, the rate is determined by R4 alone and will be approximately 12Hz – that is, twelve flashes per second (or less than half a second to make a complete cycle). With

WARNING

Constructing this circuit involves making numerous mains a.c. connections. No one should attempt it unless he or she is certain of being able to make a safe job. If in any doubt whatsoever, the assistance of a qualified electrician must be sought.

In particular, the unit must be built in an earthed metal case and all safety precautions referred to in the text carefully observed. Note that the unit is designed for indoor use only and under no circumstances may it be used outside, such as in the garden.

VR2 set to maximum, the frequency will be reduced and, with the component values specified, will be approximately 2Hz (about two and a half seconds to complete one cycle).

Note that each output goes low for only one-tenth of the duty cycle. In other words, it will remain low for one-tenth and high for nine-tenths of the time before the next output takes over.

OPTICAL COUPLING

As stated previously, ordinary l.e.d.s would obviously not be suitable as a light source and mains lamps are needed. This problem is overcome by making IC2 outputs operate the l.e.d.s contained within IC3 to IC7. These devices are optically-coupled triacs and each contains an infra-red l.e.d. and a mains-rated, low power, triac.

There is no electrical connection between the two sections. The l.e.d. is accessed at pin 1 (anode – a) and pin 2 (cathode – k) while the triac connections are made to pin 4 and pin 6.

This triac may be regarded as a type of electronic switch which will allow mains current to flow between its ends or main terminals (MT1, MT2) when triggered by infra-red light reaching it from the l.e.d.

Since the coupling between mains and low-voltage sections is optical rather than electrical, there is no possibility of mains current reaching the low-voltage section. Since only one l.e.d. will be illuminated at any given time, it is acceptable for them to share a single current-limiting resistor, R5.

Although the triacs built into IC3 to IC7 can handle mains voltage, their current carrying capacity is quite small, being limited to 100mA. This would not be sufficient for the lamps being used. These are operated by a set of power triacs (CSR1 to CSR5) having a higher current rating and which are triggered by the low-power triacs.

Current from the optically-triggered triacs flows from the mains Live line through one of resistors R6, R7, R8, R9 or R10 and hence to the gate (g) of the corresponding power triac. This triggers the device and allows current to flow from the mains Live line via MT2 and MT1 to the lamp. From here it returns to the mains Neutral line.

The current handling capacity of the power triacs is 1·5A, corresponding to about 300W on 230V a.c. mains. However, it is important not to load them with more than 60W (0·25A approximately on 230V mains).

The chief reason is because, at the instant of switching on a lamp, its filament is cold. It then has a much lower resistance than will be the case at normal operating temperature. There will, therefore, be a larger current than expected flowing for a short time after switching on.

Since the lamps are continuously switching on and off, the triacs are put under considerable strain and must be adequately rated.

ZERO CROSSING

Returning to the optically-coupled triacs, IC3 to IC7, the specified components contain a zero-crossing circuit. This means that when the l.e.d. section operates, triggering of the triac is delayed until the

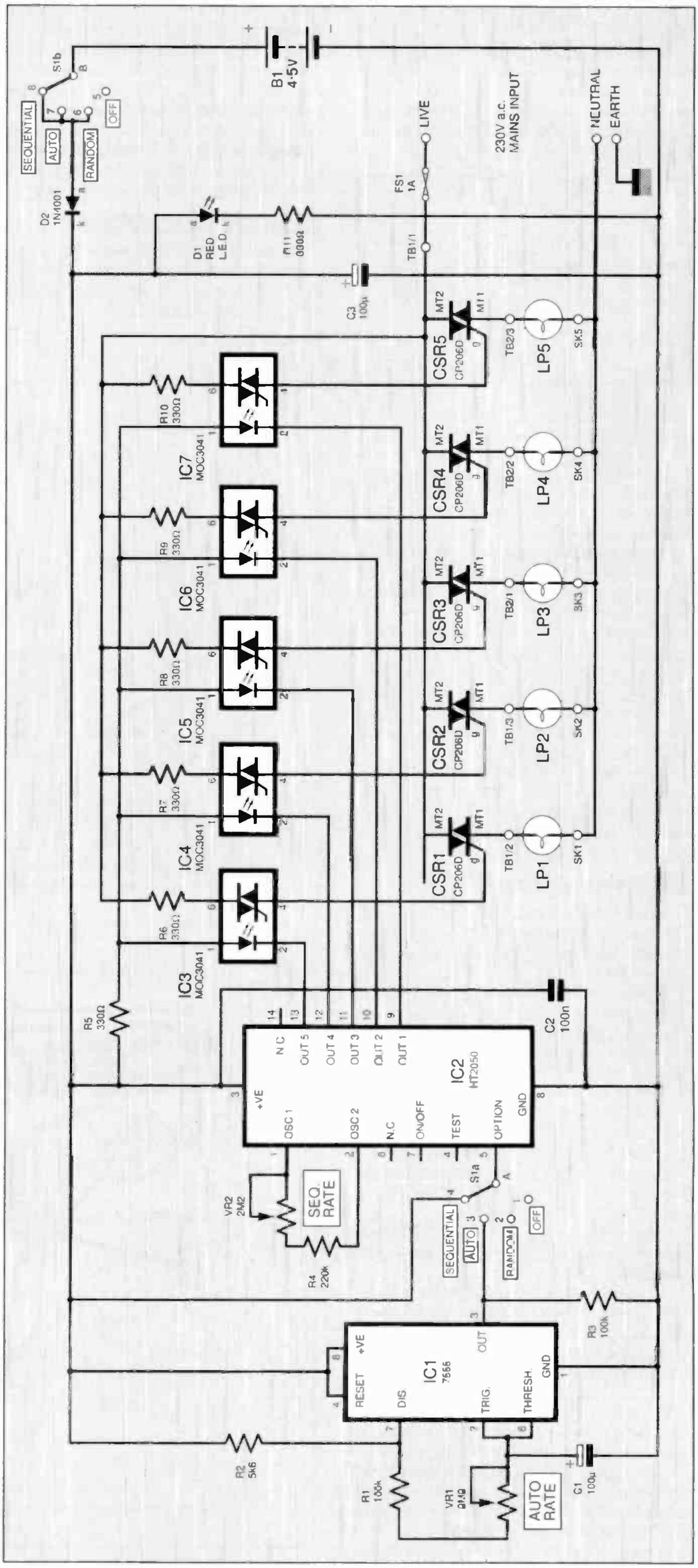


Fig.1. Complete circuit diagram for the Disco Lights Flasher.

a.c. mains cycle passes through zero (see Fig.2).

Since the mains in the UK (and in the rest of Europe) performs 50 complete cycles per second – that is, 50Hz – there are 100 zero crossings each second. Any delay, therefore, is imperceptible to the human eye.

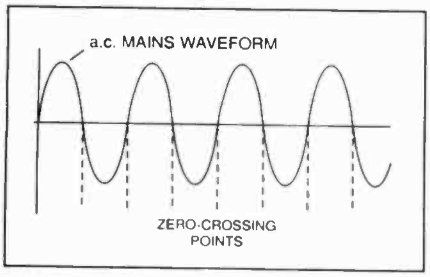


Fig.2. Zero crossing points on the a.c. mains waveform.

Furthermore, this technique eliminates the radio interference which tends to be produced by circuits which switch mains current suddenly. Since switching takes place at virtually zero voltage, there is very little current flowing at this time. The current then increases in a smooth manner as the cycle waveform rises.

Another point is that, without zero-crossing, a power triac would sometimes be triggered at the peak of the mains cycle and the current surge through a lamp filament would be very great. It is quite possible that the triacs would not survive under these circumstances.

Consequently, it is essential to use the specified devices for IC3 to IC7. Note that ordinary (non zero-crossing) optically-coupled triacs are available. These look identical and must be avoided.

POLES APART

Mode switch S1 has four positions and three poles. Although all four positions are needed, only two of the poles are used in this circuit.

Switch S1b forms the d.c. power on-off switch. When in position 5, the battery is disconnected. When it is in the other three positions, current flows from the battery through diode D2 to the rest of the circuit.

The diode provides protection to the circuit if the battery were to be connected with incorrect polarity. It would then be reverse biased and no current would flow.

Switch S1a selects the operating mode: when in position 2, IC2 pin 5 is left unconnected so the effect is Random.

With S1a position 3, IC2 pin 5 is connected to IC1 pin 3, selecting Automatic control by IC1.

In position 4, IC2 pin 5 is made high by connecting it direct to the positive supply line, selecting Sequential control.

IC1 is a timer i.c. which is configured as an astable, its output pin 3 repeatedly switching between high and low states. This makes IC2 pin 5 do likewise and, therefore, causes it to switch repeatedly between Random and Sequential modes.

The astable operating time is determined by resistors R1 and R2, capacitor C1 and potentiometer VR1. The latter provides an adjustment to the timing period.

When VR1 is set to minimum resistance, it takes some 15 seconds for the output to go through a complete cycle from high to low and back again. At maximum resistance, it will take about five minutes to go through the complete cycle.

The value of resistor R2 compared with that of R1 plus VR1 determines the mark/space ratio. With R2 much smaller in value, even with VR1 adjusted to zero, the mark/space ratio will be approximately 1:1. This means that Random times will be about the same as the Sequential ones.

CONSTRUCTION

Details of the printed circuit board component and track layouts are shown in Fig.3. This p.c.b. is available from the *EPE PCB Service*, code 178.

Begin construction by drilling the three board mounting holes to size to suit the p.c.b. supports (typically 4mm). Then enlarge the holes for the terminal blocks (TB1 and TB2) and mains triacs (CSR1 to CSR5) to about 1·3mm. Use a proper drill and drill-bit for all these holes.

Next solder the four link wires in place, and then the i.c. holders. Note that IC3 to IC7 use 6-pin sockets. These are not available from all suppliers so, if necessary, cut 8-pin units to size.

Solder all fixed resistors and capacitor C2 in place. Add C1 and C3 noting that these are electrolytic capacitors so the polarity must be observed (this is clearly

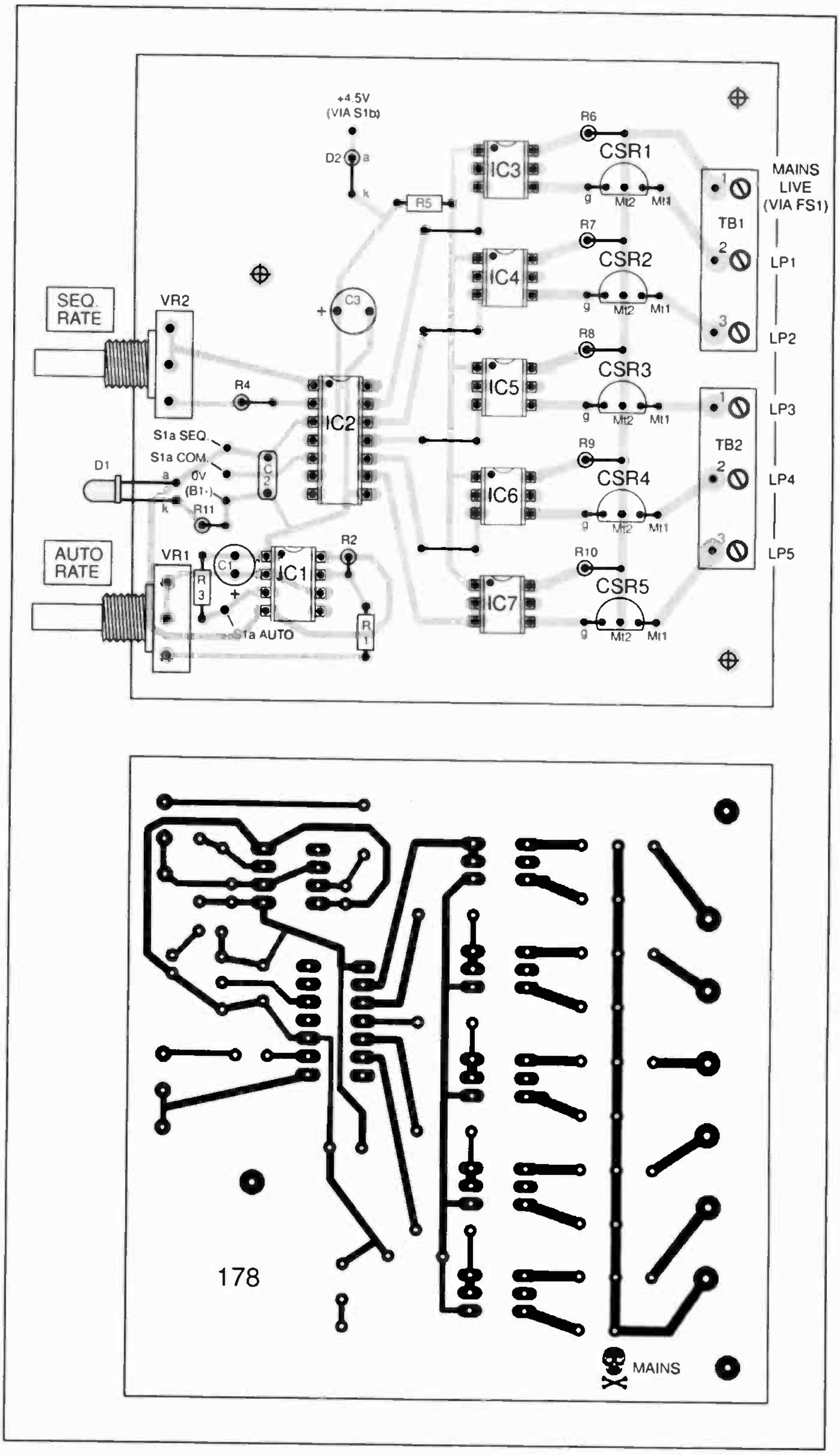
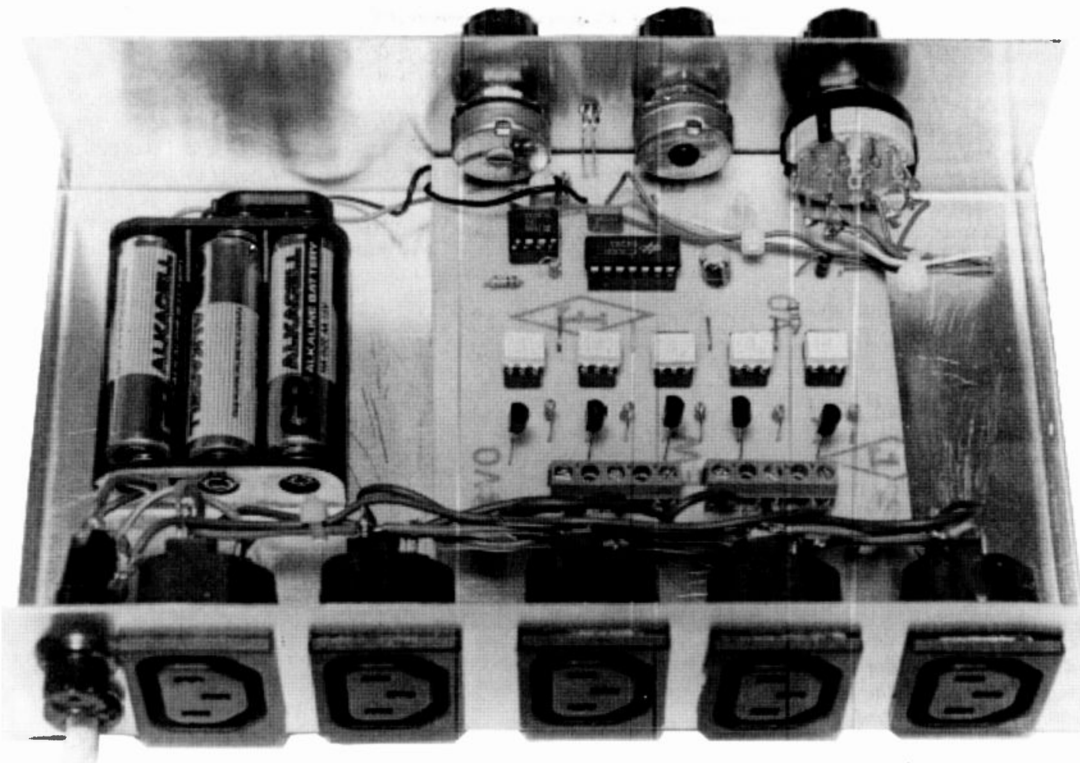


*Fig.3. Disco Lights Flasher printed circuit board component layout and full size foil master. **Be aware of mains voltages on the p.c.b.***



Layout of components inside the completed unit.

marked on the body). Mount diode D2, also taking care over its polarity – the end with the stripe is the cathode (k) end.

CONTROLS

Before soldering the potentiometers in position, measure the length of spindle which needs to be removed to accommodate a control knob. To make the cut, grip the end of the spindle in a small vice. Support the body in one hand and use a sharp hacksaw in the other.

Note that the body itself should not be gripped in the vice. Repeat with the other potentiometer and the rotary switch, and then solder the two potentiometers onto the p.c.b.

Solder the l.e.d. D1, noting that the slightly shorter lead is the cathode. Use the full length of the end leads so that the body stands as high as possible above the p.c.b. Gently bend the leads through right angles close to the body so that the l.e.d. projects horizontally and at the same height as the potentiometer spindles (see photograph).

This should ensure that it will engage with the hole in the front panel when the p.c.b. is in position. Bend the leads apart slightly to make sure that they cannot touch one another.

Solder the triacs in position, noting that the flat face on each unit points downwards towards the lower edge of the p.c.b. (Fig.3 view).

Finish off by soldering 15cm pieces of light-duty stranded wire to the three points labelled for switch S1a, plus that for +4·5V. Using different colours here (such as rainbow ribbon cable) will help to avoid confusion when connecting them up later. Solder the negative (black) battery connector wire to the point labelled 0V.

Recheck all your work so far before proceeding.

CASE PREPARATION

Carefully measure the positions of the holes to be drilled in the front panel for the potentiometer bushes. This must allow the copper trackside of the p.c.b. to take up a position exactly 12·7mm (0·5 inches) from the base of the box.

Mark the position of the hole for the rotary switch. This should harmonise with those for the potentiometers – that is, the spacing and height should be the same. This will make the front panel of the unit look neat when these components are mounted (see photograph).

Mark the l.e.d. hole mid-way between those for the potentiometers. Drill all these holes and temporarily secure the potentiometers, and hence the p.c.b. As the p.c.b. is moved into position, manoeuvre the l.e.d. leads so that the body protrudes slightly through its hole.

Supporting the p.c.b. by hand, mark the base of the box directly below the mounting holes. This may be done using a thin twist drill turned by hand a few times. Remove the p.c.b. again and drill these holes.

Also drill the holes for the battery holder. Mark out the positions of the holes for the lamp output sockets on the back panel. Cutting them out is a tedious task without a suitable tool. Probably the best way is first to drill a large hole in the centre to remove most of the metal. Smaller holes may then be drilled within the outline and the rest of the metal filed away.

Check carefully as each hole is filed to size. If the specified snap-in sockets are used, the holes must be exactly the right size.

Drill holes in the rear panel for the fuseholder and for the strain relief bush which will be used on the mains input lead. Drill a hole in the base for the bolt used to secure the earthing solder tag. Mount the output sockets, the fuseholder and the Earth solder tag.

Attach the p.c.b. to the base of the box using 12·7mm (0·5-inch) plastic stand-off insulators on the bolt shanks. For safety reasons, the soldered joints on the underside of the p.c.b. *must* have a clearance of 10mm minimum with the metal base.

COMPONENTS

See SHOP TALK Page

Resistors
R1, R3 100k
R2 5k6
R4 220k
R5 to R11 330Ω (7 off)
All 0·25W 5% carbon film.

Potentiometers
VR1, VR2 2M2 rotary carbon (2 off)

Capacitors
C1, C3 100µ radial elect. 16V (2 off)
C2 100n metallised polyester, 5mm spacing

Semiconductors
D1 red l.e.d., 3mm
D2 1N4001 1A 50V rec. diode
IC1 ICM7555 CMOS timer
IC2 HT2050 5-l.e.d. driver
IC3 to IC7 MOC3041 zero-crossing optically-coupled triac (5 off)
CSR1 to CSR5 CP206D 1·5A 400V triac (5 off)

Miscellaneous
S1 3-pole 4-way rotary switch, break-before-make
SK1 to SK5 3-pin Euro chassis socket (5 off)
B1 1·5V AA cell (3 off)
TB1, TB2 3-way p.c.b. screw terminal block, mains rated, (2 off)
FS1 1A fuse, quick-blow ceramic, mains rated

Printed circuit board, available from the *EPE PCB Service*, code 178; aluminium case size, 203mm × 127mm × 51mm; 3 × AA cell holder; 20mm panel fuse-holder; 6-pin d.i.l. socket (5 off); 8-pin d.i.l. socket; 14-pin d.i.l. socket; solder tag; control knob (3 off); plastic stand-off, 12.5mm (3 off); small nuts and bolts; plastic feet (4 off); strain relief bush; 3A mains wire; light-duty stranded wire; solder, etc.

Approx Cost Guidance Only £37 excl. batts.

Tighten the nuts which secure the potentiometers. Attach the battery holder using small countersunk-headed bolts and cut off the excess bolt shank on the outside.

Refer to Fig.4 and complete the internal wiring, but do not make the connection to the solder tag yet. **Note that all the mains wiring, including the connections to the terminal blocks, TB1 and TB2, must be rated at 3A minimum.**

Secure the rotary switch in position and fit all the control knobs.

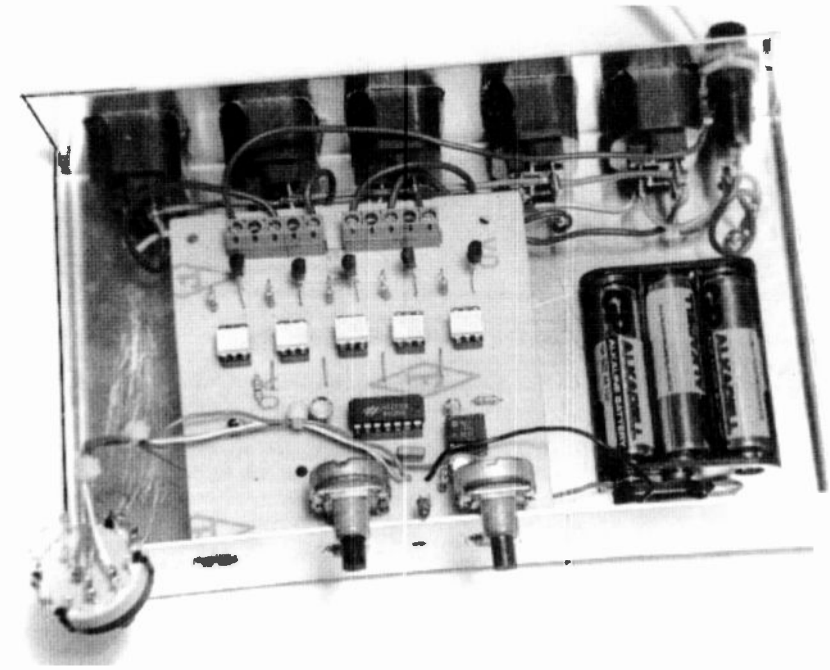
GETTING READY

Make-up the mains input lead. This must be of 3-core type having 3A rating minimum. Attach it through the strain relief bush leaving some slack on the inside. Solder the mains cable as shown in Fig.4. The Live wire is connected to the bottom tag of fuseholder FS1 and the Neutral is soldered to the common Neutral of the output sockets.

Twist together the earth wire with that from the output sockets and solder them to the solder tag. *This earths the case and is an important safety requirement so check the work carefully. Make certain that the wires cannot detach in service.*

Fit a mains plug to the other end of the mains lead. If this is of the standard UK type, fit a 3A fuse.

Adjust potentiometers VR1 and VR2 to approximately mid-track position and switch S1 off (fully anti-clockwise).



Wiring to the mains lamp output sockets SK1 to SK6. Note the "power-on" l.e.d. between the two potentiometers.

the lid of the case *must* be in position. This will avoid any possibility of touching live connections inside.

Wire up the lamps to the plugs and connect them to the sockets on the unit. Plug the unit into the mains and switch on. With switch S1 set to Random (position 2), the l.e.d. should glow and the lamps flash in any order.

Switching to Sequential (position 4), the lamps should flash in a fixed pattern. Check the effect of VR1 on both settings. Clockwise rotation increases the rate.

Now switch to Automatic (position 3). The lamps should alternate between periods of random operation followed by similar periods of sequential operation. Check the effect of VR2 on the timing. Again, clockwise rotation increases the rate.

The controls could be labelled with their functions, although this was not done with the prototype.

The lamps may be found to have a fairly short life when switched on and off repeatedly and rapidly. It is possible that when one of them blows the fuse will fail. It would, therefore, be wise to have some spare lamps and fuses available. Note that the fuses must be of the quick-blow type.

Now turn up the music! □

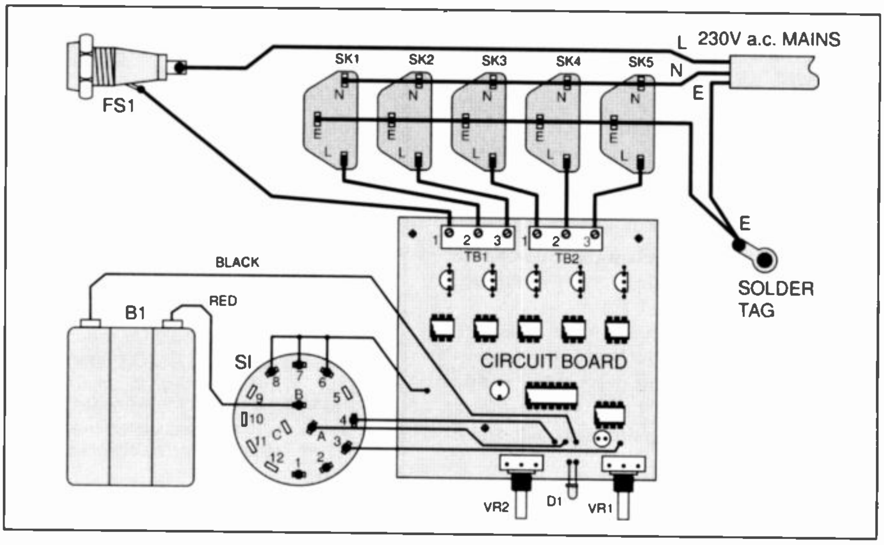


Fig.4. Interwiring details between the p.c.b. and off-board components. The thick leads are the mains carrying ones.

Insert the cells (battery) in the holder. Attach self-adhesive plastic feet onto the base of the case, making sure that these are of a greater height than the nuts which secure the battery holder.

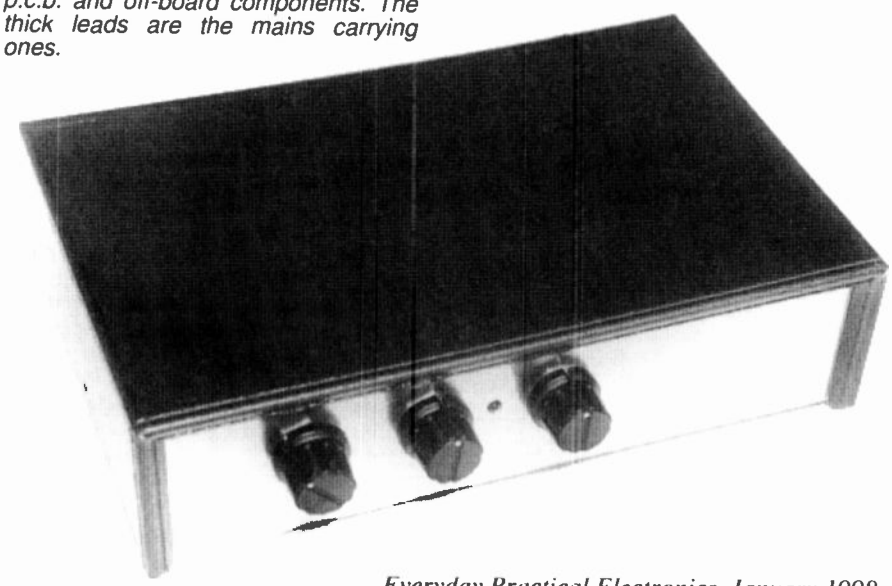
Make and fit a thick cardboard *safety* shield to cover the rear section of the case above the mains connections at the output sockets and fuse. Note that the shield has been removed for the photographs.

COMPLETION

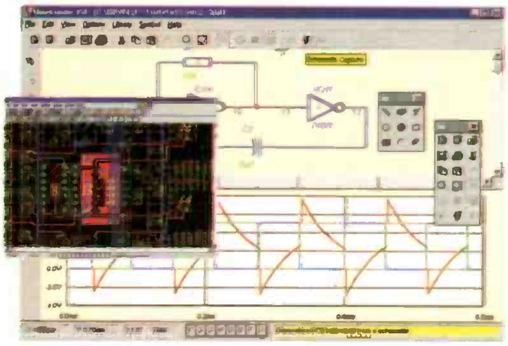
Insert the i.c.s into their sockets observing their correct orientation. These are CMOS devices and it is possible to damage them by static charge which might exist on the body. To avoid such problems, touch something which is earthed before handling the pins.

Thoroughly check that all of your connections are satisfactory.

Fit the lid of the case. Note that whenever the unit is plugged into the mains,



Looks like Quickroute 4.0 has Got the Lot!



Simulation, Schematic Capture, PCB AutoRouting & CADCAM Support for just £79**

Announcing Quickroute 4.0! Now all versions of Quickroute 4.0 have the full range of great features you've come to expect from Quickroute including a FREE integrated mixed mode simulator, plus a new modern user interface with active buttons, a fast new symbol browser, and dockable tool bars. The only difference now between the various versions of Quickroute is the size of design you can create.

CAD CAM RECOMMENDED

Best of all, you can now try Quickroute 4.0 with complete confidence because all orders are covered with our 30 day money back guarantee*. Simply fill in the coupon and fax, mail (FREEPOST address below) or FREEphone 0800 731 28 24 to place your order.

Yes, I would like to order (please tick box)

- ☐ Quickroute 4.0 (max 300 pins) at £99.88 inclusive
- ☐ Quickroute 4.0 (max 800 pins) at £182.13 inclusive
- ☐ Quickroute 4.0 (full access) at £299.63 inclusive
- ☐ Quickroute 4.0 Information Pack (free)

Inclusive price includes U.K. post & packing & V.A.T.

My payment choice (please tick box)

- ☐ I enclose a cheque payable in U.K sterling for £
- ☐ Please debit my Visa/Mastercard/American Express/Switch* card (*please delete)

Card No. Expiry

Signature

Delivery Address

- New user interface with dockable tool bars
- Multi-sheet schematic capture
- Power rail & Data bus support
- Analogue+Digital Simulation
- PCB Design with Autorouter
- Copper flood fill
- Netlist import and export
- CAD/CAM import and export
- WMF, DXF & SPICE file export
- 1000+ Library Symbols
- Engineering Change
- 30 Day Money Back Guarantee*

FREEphone **0800 731 28 24** Ref 403

Quickroute Systems Ltd FREEPOST NWW13136 Stockport SK4 1YR.
FAX 0161 476 0505 FREE Demo on WEB http:\\www.quickroute.co.uk

QR4™ QUICKROUTE

Specifications and prices are subject to change without notice. **Price quoted excludes post & packing and V.A.T
*Refunds are only issued if you contact Quickroute Systems Ltd within 30 days of receiving your copy of Quickroute 4.0.

Innovations

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

FREE DIRECTORY ENQUIRIES

Why should BT have sole rights to our telephone numbers? Oftel intends to change that, so we can all do our own on-line directory searching. Barry Fox has the details

OFTEL, the UK's telecoms regulator, will now force BT to relax its grip on subscribers' telephone numbers. Anyone with a PC will then be able to make a low cost electronic search using the Internet or a CD-ROM, instead of paying BT 25p for operator assistance. BT has so far stopped any third party publishing its subscriber lists by claiming artistic copyright in the layout of the list. Oftel will pull the rug from under this legal ploy, by changing the wording of the government licence which allows BT to provide a phone service and collect subscribers' numbers.

Said Oftel's Director General, Don Cruickshank, "We shall oblige BT to make its database of numbers available to anyone, on fair and reasonable terms. It will be Oftel who decides what is fair and reasonable."

Historical Monopoly

The current situation stems from the monopoly which the Post Office used to have on providing a telephone service and delivering mail. Although there are now rival telephone companies, BT still controls the UK's database of telephone numbers. The telcos are obliged to give BT their numbers, and pay BT to store them in its database. BT then charges subscribers to phone Directory Enquiries, and for paper directories covering numbers outside the subscriber's area. In 1990 BT put all its numbers on a CD-ROM, but charged £2585 (£2200 + VAT) for a disc that stopped working after a year. The owner then had to pay another £2585.

The price of BT's Phone Disc ROM has now fallen to £234 (£199 + VAT), but the disc still only works for a year. Although BT will now licence third parties to make ROMs, they can include only business numbers. BT will not release its residential lists.

Online service Tel-Me sells a directory service, but can do so only by providing a gateway into BT's own database.

Oftel says third parties have complained about BT's high prices and restrictions. BT refuses to say how much it earns each year from its database.

Last year German software company Topware used optical scanning equipment to copy 16 million numbers, names and addresses from paper directories onto a CD-ROM which sold for around £20. BT sued for breach of copyright and sales ceased.

Oftel Turns it Round

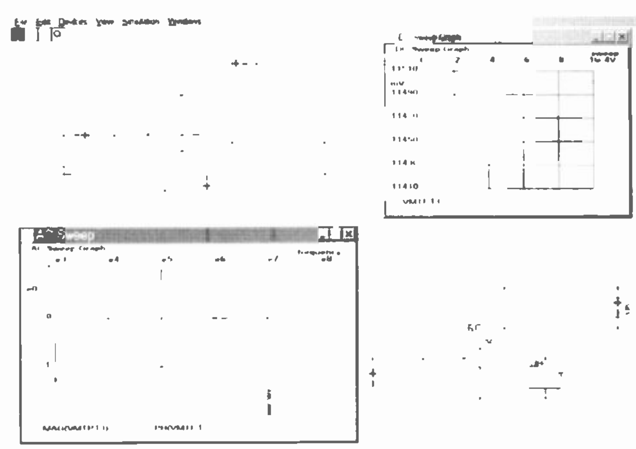
"We want to turn things round", said Cruickshank. "We think BT should be paying the other telcos for their numbers, and then make the complete database available, not just to the telcos, but to anyone who wants to provide a rival directory service. Getting at BT under competition law is tough. It is easier to use an amendment to BT's licence under the Telecommunications Act".

Oftel will impose only one technical constraint. Any electronic directory must not provide reverse searching, as offered by Topware's CD-ROM and the wide variety of ROMs which list all North American numbers. A user should not be able to enter a phone number and search out the owner's name and address. "People do not want someone turning up on the doorstep after they have put their phone number in a small ad", said Cruickshank.

Oftel has now published a discussion document on the *Provision of Directory Information*, and invites comments by the end of the year. BT's licence will then be changed early in 1998. But Oftel expects BT to relax its grip well before it is forced to. Commented Cruickshank, "History tells that when BT sees something is going to change, BT's own policy will begin to change. Electronic searching may become the usual way of finding a number".

The Consultation document also looks at ways of persuading people not to be ex-Directory. In London, 56 per cent of subscribers now keep their numbers secret. Most do so to stop nuisance calls from telesales staff. Oftel wants to use the Telecommunications Act and Data Protection Laws to let people list their numbers on condition that no-one then phones to try and sell them double glazing.

MAPLIN GETS SPICEY



LAST month we reviewed RD Research's BSpice computer-based electronics circuit design package. Maplin have announced that they are now stocking the B² Spice Lite version.

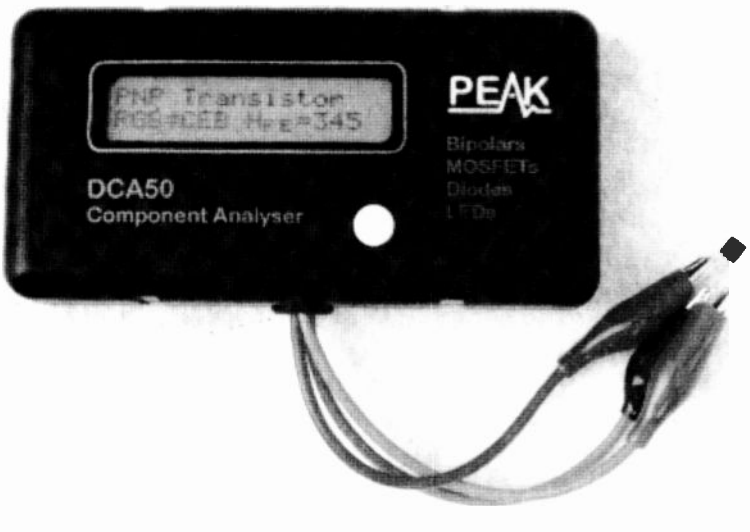
This latest version allows engineers, designers, enthusiasts and students alike to design and simulate complex circuits in a fraction of the time it would take to build them – all for just £49·99.

Available in PC and MAC formats, this software package allows you build "virtual" circuits on screen and run simulations by choosing options from the easy to use menus and dialogue boxes. Results can be displayed in graphs or tables, or directly onto voltmeters and ammeters.

B² Spice Lite (order code NR75) is available by mail order from MPS or through the 40 Maplin and three Mondo Maplin superstores nationwide.

For further information on store locations, trade counter opening times and mail order call 01702 554002.

PEAK ANALYSIS



MANY of you will recall that we published a *Components Analyser* in our Aug. '96 issue. It was designed by Jeremy Francis Siddons and was based on his project submitted for the *Young Engineer For Britain Competition 1987*.

By August '96, through his company Peak Electronic Design, Jeremy was already marketing a microcontrolled version of his *EPE* project, calling it the DTA30. Since then, he has introduced three other analysers to his range:

The DCA50 Component Analyser (illustrated here) is the latest introduction. It is an incredibly versatile analyser that will identify almost any transistor, MOSFET, diode or l.e.d., as well as identify pinouts and measure transistor gain.

MOSFET analysing is also the purpose of the HMA20. It identifies the three leads of en' ement mode MOSFETs and the device type as well.

iode testing, the DCH10 is the ideal tool. It tests and identifies the leads of diodes, Ze. l.e.d.s and other semiconductor junctions. It will even illuminate an l.e.d. under test, rdless of its connected orientation.

Just remind you, the original DTA30 will verify bipolar transistor operation and identify ll three leads, as well as the transistor type – *npn/pnp*. Importantly, this unit is being given away by Peak Electronic Design to the author of the best *Readout* letter published each month. A generous gesture indeed – and an instrument well worth owning.

Prices of Peak's range start at £19 for the DCH10 rising to £59 for the DCA50. There is no VAT or P&P to be added to UK orders (overseas readers should add £5).

For more information, contact Peak Electronic Design Ltd., Dept. EPE, 70 Nunsfield Road, Buxton, Derbys SK17 7BW. Tel: 01298 70012. Fax: 01298 70046.

E-mail: sales@peakelec.co.uk. Web: www.peakelec.co.uk.

Where's the Fair?

FINDING computer fairs, auctions, shows, amateur radio rallies and so on, is likely to be far easier now that NetXtra has launched its latest search tool.

A comprehensive database of such events is being compiled by the company. Visitors to the website can select events by date, type and location. The system has been designed for quick and easy use and incorporates a map so that there is no need to enter specific towns or countries.

The new search engine is at **http://www.computerfairs.co.uk** and details of newly booked events can be easily passed to the company via **info@computerfairs.co.uk**.

For more information, contact NetXtra Ltd., Dept. EPE, Maynard House, Bradfield St Clare, Bury St Edmunds, Suffolk IP30 0DX.

Tel: 01284 386112. Fax: 01284 386163.

E-mail: info@netxtra.co.uk.

Web: http://www.netxtra.co.uk.

Scanap Pilots the Way

CIVIL aviation enthusiasts who enjoy listening in to conversations between pilots and air traffic control will shortly have to change their equipment.

New channel spacing, to be phased in throughout Europe in January 1999, dictates that the receiver band for civil aircraft changes from the current 25kHz spacing (which has been in place since the 1970s) to 8.33kHz.

One answer for enthusiasts is offered by the Scanap AP-1000 receiver from AYP Electronics. The new receiver, say AYP, fills a unique and now vital gap in the market by being the only receiver to allow users to listen in to both steps from the same unit.

Scanap AP-1000 can receive either VHF or UHF bands with an A.M. coverage of 118-137MHz and 225-400MHz, essentially catering for both the present and the future. Other features include 100 memory channels, back-lit l.c.d., backlit keypad, pre-programmed frequency with limit key, memory backup and fully shrouded antenna.

For more information contact Dept. EPE, AYP Electronics Ltd., 34 St Margarets Road, Great Barr, Birmingham B43 6LD.

Tel: 0121 358 6299. Fax: 0121 358 1793.

Sherwood Catalogue

Nearly 100 A5 pages are in Sherwood Electronics' 1998 catalogue just received. Detailed on them is a wide variety of full specification components and equipment. The components range from passive devices such as resistors and capacitors to a selection of digital and linear i.c.s. Also featured are such essential hardware items as batteries, connectors, knobs, heatsinks and switches. A choice of tools is available as well.

Sherwood also say that they will quote for items not listed in the catalogue, provided you enclose an s.a.e. with your request.

All catalogue items have been allocated code numbers to simplify ordering, and customers are given personal account numbers for a similar reason. There is no minimum order value expected, and Sherwood are happy to accept UK cheques and postal orders. No VAT is charged on purchases.

For your copy of this useful catalogue, contact Sherwood Electronics, Dept. EPE, 7 Williamson Street, Mansfield, Notts NG19 6TD.

VIDEO INDEXING

PHILIPS in Eindhoven is working on a system for "VHS indexing", reports Barry Fox. The idea is to help VHS users sort out what is on their tapes, without having to play through them all. Anyone who has a pile of unlabeled, half-used tapes will jump at the idea.

As the tape runs, the recorder detects scene changes, and extracts literally thousands of key images for every hour of running time. An intelligent computer circuit then filters out frames that are similar, and stores only the most obviously different shots.

The system then arranges them in an index order, and stores a chess board mosaic of low resolution postage stamp pictures on the first thirty seconds of the tape.

Each shot is numbered with an index point which the VCR can then search out. Apart from the obvious use as an aid to home taping, the system will be ideal for surveillance tapes, and video editing.

WHAT'S ON IN ESSEX

THERE'S a radio and computer rally happening at Canvey Island in Essex on 1 February 1998. Run by the 13th South Essex Amateur Radio Society, the venue is at the Paddocks (end of the A130), Long Road, Canvey Island; doors open at 10.30am. Featured will be amateur radio, computer and electronic component exhibitors, bring and buy, RSGB Morse testing on demand (two passport photos required), refreshments and free car parking. Admission is £1.

For more details contact David Speechley G4UVJ, telephone 01268 697978 (mentioning *EPE*, of course).

Special Feature

ALTERNATIVE AND FUTURE TECHNOLOGIES

CLIVE (call me "Max") MAXFIELD Part 2

A smorgasborg of technologies which may or may not influence the future of electronics. (Reproduced from Chapter 21 of the book Bebop To The Boolean Boogie *with kind permission of the publishers and Max - see the* EPE Direct Book Service *pages for ordering details).*

IT has been estimated that the total sum of human knowledge is doubling approximately every ten years. Coupled with this, the amount of information that is being generated, stored and accessed is increasing at an exponential rate. This is driving the demand for fast, cheap memories that can store gigabits, or even terabits, of data.

Optical Memories

One medium with the potential to cope with this level of data density is optical storage. Among many other techniques, evaluations are being performed on extremely thin layers of glass-based materials[17], which are doped with organic dyes or rare-earth elements. Using a technique known as *photochemical hole-burning (PHB)*, a laser in the visible waveband is directed at a microscopic point on the surface of the glass.

If the laser is weak, its light will pass through the glass without affecting it and reappear at the other side. If the laser is stronger (but not intense enough to physically damage the glass), electrons in the glass will be excited by the light. The electrons can be excited such that they change the absorption characteristics of that area of the glass and leave a band, or hole, in the absorption spectrum. To put this another way, if the weak laser beam is redirected at the same point on the glass surface, its light would now be absorbed and would *not* reappear at the other side of the glass.

Thus, depending on whether or not the light from the weaker beam passes through the glass, it can be determined whether or not that point has been exposed to the strong laser. This means that each point can be used to represent a binary 0 or 1. Because the point affected by the laser is so small, this process can be replicated millions upon millions of times across the surface of the glass.

If a point occurs at one micron (one millionth of a meter) intervals, then it is possible to store 100 megabits per square centimetre, but this still does not come close to the terabit storage that will be required. However, it turns out that each point can be "multiplexed" and used to store many bits of information. A small change in the wavelength of the laser can be used to create another hole in a different part of the spectrum. In fact, 100× multiplexing has been achieved, where each point on the glass was used to store 100 bits of data at different wavelengths. Using 100× multiplexing offers a data density of 10 gigabits per square centimetre, and even higher levels of multiplexing may be achieved in the future!

Protein Switches and Memories

Another area receiving a lot of interest is that of switches and memories based on proteins[18]. Organic molecules have a number of useful properties, not the least that their structures are intrinsically "*self-healing*" and reject contamination. Also, in addition to being extremely small, many organic molecules have excellent electronic properties. Unlike metallic conductors, they transfer energy by moving electron excitations from place to place rather than relocating entire electrons. This can result in switching speeds that are orders of magnitude faster than their semiconductor equivalents.

Some proteins react to electric fields, while others respond to light. For example, there is a lot of current interest in the protein Rhodopsin, which is used by certain photosynthetic bacteria to convert light into energy. The bacteria that contain Rhodopsin are the ones that cause ponds to turn red, and their saltwater cousins are responsible for the purple tint which is sometimes seen in San Francisco Bay.

In certain cases, light from a laser can be used to cause such optically responsive proteins to switch from one state to another (which they do by changing colour) and back again. Additionally, some varieties of proteins are only responsive to the influence of two discrete frequencies. This feature is extremely attractive, because it offers the possibility of three-dimensional optical protein memories.

Experiments have been performed, in which 3-D cubes have been formed as ordered arrays of such bi-frequency proteins suspended in transparent polymers. If the protein were affected by a single laser, then firing a beam into the cube would result in a line of proteins changing state. But in the case of bi-frequency proteins, two lasers mounted at 90° to each other can be used to address individual points in the 3-D space (Figure 21.16).

By only slightly enhancing the technology available today, it may be possible to store as much as 20 gigabits in a 1cm × 1cm × 1cm cube of such material, where even one gigabit would be equivalent to 1,250 of today's 16 megabit RAM devices!

Electromagnetic Transistor Fabrication

For some time it has been known that the application of strong electromagnetic fields to special compound semiconductors can create structures that behave like transistors. The original technique was to coat the surface of a semiconductor substrate with a

17 One such material, boric-acid glass, is also widely used in heat-resistant kitchen ware!

18 A complex organic molecule formed from chains of amino acids, which are themselves formed from combinations of certain atoms, namely: carbon, hydrogen, nitrogen, oxygen, usually sulphur, and occasionally phosphorus or iron. Additionally, the chain of amino acids "folds in on itself forming an extremely complex 3-D shape.

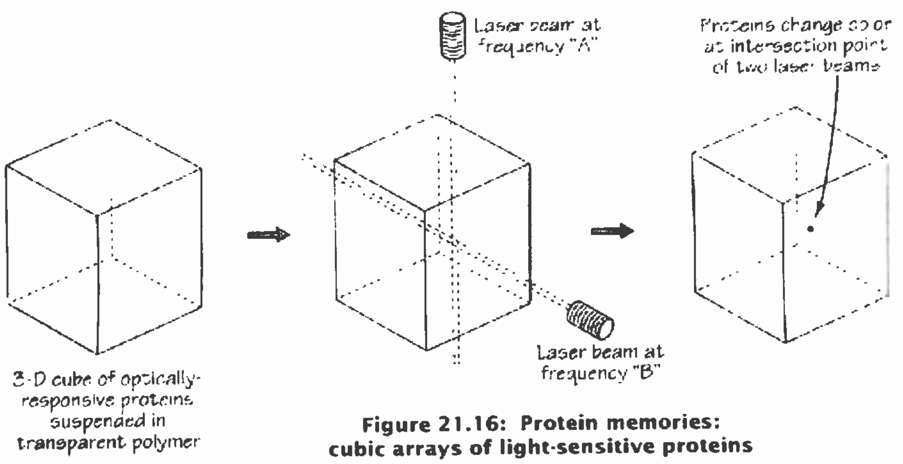


Figure 21.16: Protein memories: cubic arrays of light-sensitive proteins

layer of dopant material, and then to bring an extremely strong, concentrated electromagnetic field in close proximity.

The theory behind this original technique was that the intense field caused the electromigration of the dopant into the substrate. However, much to everyone's surprise, it was later found that this process remained effective even without the presence of the dopant!

Strange as it may seem, nobody actually understands the mechanism that causes this phenomenon. Physicists currently suspect that the strong electromagnetic fields cause microscopic native defects in the crystals to migrate through the crystal lattice and cluster together.

Heterojunction Transistors

If there is one truism in electronics, it is that "*faster is better*," and a large proportion of research and development funds are invested in increasing the speed of electronic devices.

Ultimately there are only two ways to increase the speed of semiconductor devices. The first is to reduce the size of the structures on the semiconductor, thereby obtaining smaller transistors that are closer together. The second is to use alternative materials that inherently switch faster. However, although there are a variety of semiconductors, such as gallium arsenide, that offer advantages over silicon for one reason or another, silicon is cheap, readily available, and relatively easy to work with. Additionally, the electronics industry has billions of dollars invested in silicon-based processes.

For these reasons, speed improvements have traditionally been achieved by making transistors smaller. However, it is becoming apparent that we are reaching the end of this route using conventional technologies. At one time, the limiting factors appeared to be simple process limitations: the quality of the resist, the ability to manufacture accurate masks, and the features that could be achieved with the wavelength of ultraviolet light. Around 1990, when structures with dimensions of 1·0 microns first became available, it was believed that structures of 0·5 microns would be the effective limit that could be achieved with opto-lithographic processes, and that the next stage would be a move to X-ray lithography. However, there have been constant improvements in the techniques associated with mask fabrication, optical systems and lenses, servo motors and positioning systems, and advances in chemical engineering such as chemically-amplified resists[19]. The combination of all these factors means that it is now considered feasible to achieve structures as small as 0·1 microns by continuing to refine existing processes.

However, there are other considerations. The speed of a transistor is strongly related to its size, which affects the distance electrons have to travel. Thus, to enable transistors to switch faster, technologists have concentrated on reducing size, a strategy which is commonly referred to as scaling. However, while scaling reduces the size of structures, it is necessary to maintain certain levels of dopants to achieve the desired effect. This means that, as the size of the structures is reduced, it is necessary to increase the concentration of dopant atoms.

Increasing the concentration beyond a certain level causes leakage, resulting in the transistor being permanently ON and therefore useless. Thus, technologists are increasingly considering alternative materials and structures.

An interface between two regions of semiconductor having the same basic composition but opposing types of doping is called a *homojunction*. By comparison, the interface between two regions of dissimilar semiconductor materials is called a *heterojunction*. Homojunctions dominate current processes because they are easier to fabricate. However, the interface of a heterojunction has naturally occurring electric fields which can be used to accelerate electrons, and transistors created using heterojunctions can switch much faster than their homojunction counterparts of the same size.

One form of heterojunction that is attracting a lot of interest is found at the interface between silicon and germanium. Silicon and germanium are in the same family of elements and have similar crystalline structures which, in theory, should make it easy to combine them but, in practice, is a little more difficult. A process currently being evaluated is to create a standard silicon wafer with doped regions, and then to grow extremely thin layers of a silicon-germanium alloy where required.

The two most popular methods of depositing these layers are *chemical vapour deposition* (CVD) and *molecular beam epitaxy (MBE)*. In the case of chemical vapour deposition, a gas containing the required molecules is converted into a *plasma*[20] by heating it to extremely high temperatures using microwaves. The plasma carries atoms to the surface of the wafer where they are attracted to the crystalline structure of the substrate. This underlying structure acts as a template. The new atoms continue to develop the structure to build up a layer on the substrate's surface:

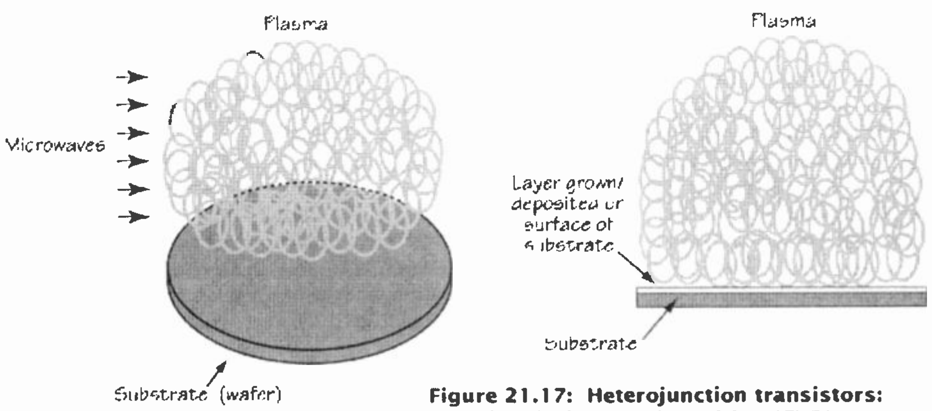


Figure 21.17: Heterojunction transistors: chemical vapor deposition (CVD)

By comparison, in the case of molecular beam epitaxy, the wafer is placed in a high vacuum, and a guided beam of ionized molecules is fired at it, effectively allowing molecular-thin layers to be "painted" onto the substrate where required[21].

Ideally, such a heterojunction would be formed between a pure silicon substrate and a pure layer of germanium. Unfortunately, germanium atoms are approximately 4% larger than silicon atoms, the resulting crystal lattice cannot tolerate the strains that develop, and the result is defects in the structure. In fact, millions of minute inclusions occur in every square millimeter, preventing the chip

19 In the case of a chemically-amplified resist, the application of a relatively small quantity of ultraviolet light stimulates the formation of chemicals in the resist which accelerates the degrading process. This reduces the amount of ultraviolet light which is required to degrade the resist and allows the creation of finer features with improved accuracy.

20 A gaseous state in which the atoms or molecules are dissociated to form ions.

21 Molecular beam epitaxy is similar to electron beam epitaxy (EBE), in which the wafer is first coated with a layer of dopant material before being placed in a high vacuum. A guided beam of electrons is fired at the wafer causing the dopant to be driven into it.

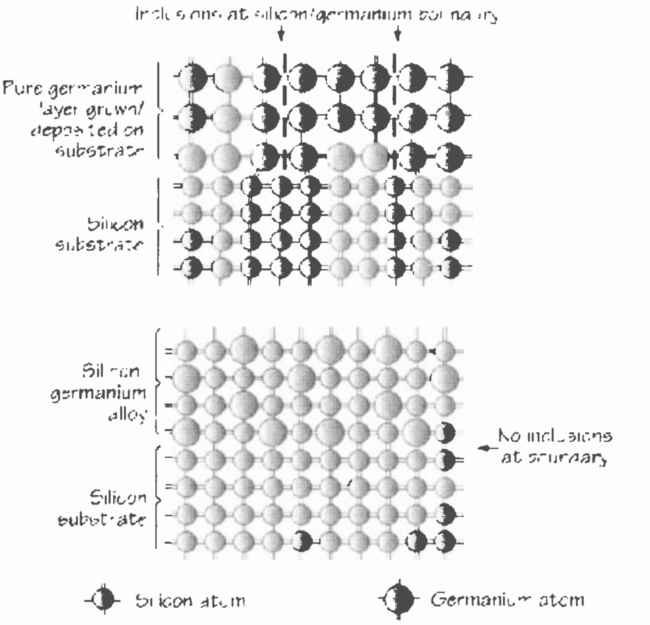


Figure 21.18: Heterojunction transistors: silicon-germanium alloy

from working. Hence, the solution of growing a layer of silicon-germanium alloy, which relieves the stresses in the crystalline structure, thereby preventing the formation of inclusions (Figure 21.18).

Heterojunctions offer the potential to create transistors that switch as fast, or faster, than those on gallium arsenide, but use significantly less power. Additionally, they have the advantage of being able to be produced on existing fabrication lines, thereby preserving the investment and leveraging current expertise in silicon-based manufacturing processes.

Diamond Substrates

As was noted in the previous section, there is a constant drive towards smaller, more densely packed transistors switching at higher speeds. Unfortunately, packing the little devils closer together and cracking the whip to make them work faster substantially increases the amount of heat that they generate. Similarly, the increasing utilization of optical interconnections relies on the use of laser diodes, but today's most efficient laser diodes only convert 30% to 40% of the incoming electrical power into an optical output, while the rest emerges in the form of heat. Although each laser diode is relatively small (perhaps as small as only 500 atoms in diameter), their heating effect becomes highly significant when tens of thousands of them are performing their version of Star Wars.

And so we come to diamond, which derives its name from the Greek *adamas*, meaning "invincible." Diamond is famous as the hardest substance known, but it also has a number of other interesting characteristics: it is a better conductor of heat at room temperatures than any other material[22], in its pure form it is a good electrical insulator, it is one of the most transparent materials available, and it is extremely strong and non-corrosive. For all of these reasons, diamond would form an ideal substrate material for multichip modules[23].

In addition to multichip modules, diamond has potential for a variety of other electronics applications. Because diamond is in the same family of elements as silicon and germanium, it can function as a semiconductor and could be used as a substrate for integrated circuits. In fact, in many ways, diamond would be far superior to silicon: it is stronger, it is capable of withstanding high temperatures, and it is relatively immune to the effects of radiation (the bane of components intended for nuclear and space applications). Additionally, due to diamond's high thermal conductivity, each die would act as its own heatsink and would rapidly conduct heat away. It is believed that diamond-based devices could switch up to 50 times faster than silicon and operate at temperatures over 500°C.

Unfortunately, natural diamond is extremely expensive and, if you should happen to find one of the little beauties, the last thing that would come to mind would be to chop it up into thin slices for electronics applications! However, there are a number of methods for depositing or growing diamond crystals, one of the most successful being chemical vapour deposition (CVD), which was introduced in the previous discussions. In this CVD process, microwaves are used to heat mixtures of hydrogen and hydrocarbons into a plasma, out of which diamond films nucleate and form on suitable substrates. Although the plasma chemistry underlying this phenomena is not fully understood, polycrystalline diamond films can be nucleated on a wide variety of materials, including metals such as titanium, molybdenum, and tungsten, ceramics, and other hard materials such as quartz, silicon, and sapphire.

CVD processes work by growing layers of diamond directly onto a substrate. A similar, more recent, technique, known as *chemical vapour infiltration (CVI)*[24], commences by placing diamond powder in a mold. Additionally, thin posts, or columns, can be preformed in the mold, and the diamond powder can be deposited around them. When exposed to the same plasma as used in the CVD technique, the diamond powder coalesces into a polycrystalline mass. After the CVI process has been performed, the posts can be dissolved leaving holes through the diamond for use in creating vias. CVI processes can produce diamond layers twice the thickness of those obtained using CVD techniques at a fraction of the cost.

An alternative, relatively new technique for creating diamond films involves heating carbon with laser beams in a vacuum. Focusing the lasers on a very small area generates extremely high temperatures, which rip atoms away from the carbon and also strip away some of their electrons. The resulting ions fly off and stick to a substrate placed in close proximity. Because the lasers are tightly focused, the high temperatures they generate are localised on the carbon, permitting the substrate to remain close to room temperature. Thus, this process can be used to create diamond films on almost any substrate, including semiconductors, metals, and plastics.

The number of electrons stripped from the carbon atoms varies, allowing their ions to reform in *nanophase* diamond structures which have never been seen before. Nanophase materials are a new form of matter which was only recently discovered, in which small clusters of atoms form the building blocks of a larger structure. These structures differ from those of naturally occurring crystals, in which individual atoms arrange themselves into a lattice. In fact, it is believed that it may be possible to create more than thirty previously unknown forms of diamond using these techniques.

Last, but not least, in the late 1980s, a maverick inventor called Ernest Nagy[25] invented a simple, cheap, and elegant technique for creating thin diamond films. Nagy's process involves treating a soft pad with diamond powder, spinning the pad at approximately 30,000 revolutions per minute, and maintaining the pad in close contact with a substrate. Although the physics underlying the process is not fully understood, diamond is transferred from the pad to form a smooth and continuous film on the substrate. The diamond appears to undergo some kind of phase transformation, changing from a cubic arrangement into a hexagonal form with an unusual structure. Interestingly enough, Nagy's technique appears to work with almost any material on almost any substrate!

All of the techniques described above result in films that come respectfully close, if not equal, to the properties of natural diamond in such terms as heat conduction. Thus, these films are highly attractive for use as substrates in multichip modules. However, the unusual diamond structures that are created fall short of the perfection required for them to be used as a substrate suitable for the fabrication of transistors.

Substrates for integrated circuits require the single, large crystalline structures found only in natural diamond. Unfortunately, there are currently no known materials onto which a single-crystal diamond layer will grow, with the exception of single-crystal diamond itself (which sort of defeats the point of doing it in the first place). The only answer appears to be to modify the surface of the

---

22 Diamond can conduct five times as much heat as copper, which is the second most thermally-conductive material known.

23 Actually, other exotic substrates are also of interest to electronic engineers, including sapphire, which is of particular use in microwave applications.

24 Thanks go to Crystallume, Menlo Park, CA, USA, for the information on their CVD and CVI processes.

25 Nagy, whose full name is Ernest Nagy de Nagybaczon, was born in 1942 in Hungary. He left as a refugee in the 1956 uprising and now lives in England.

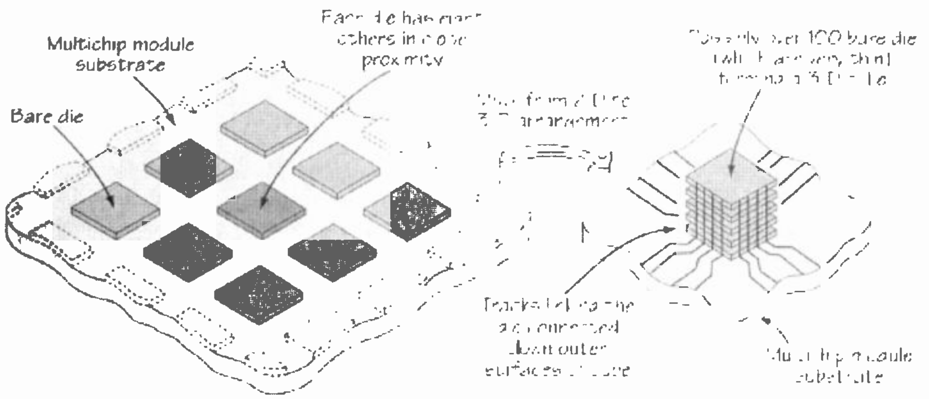


Figure 21.19: Chip-on-chip: die organized as 3-D cubes

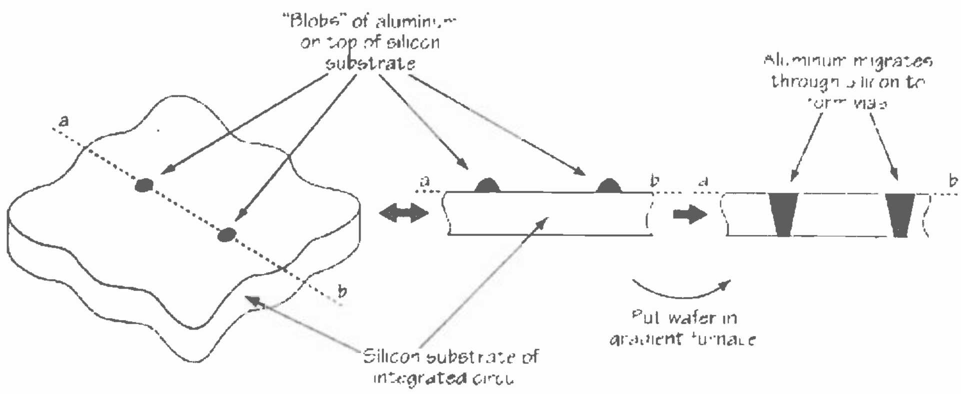


Figure 21.20: Chip-on-chip: creating vias through silicon

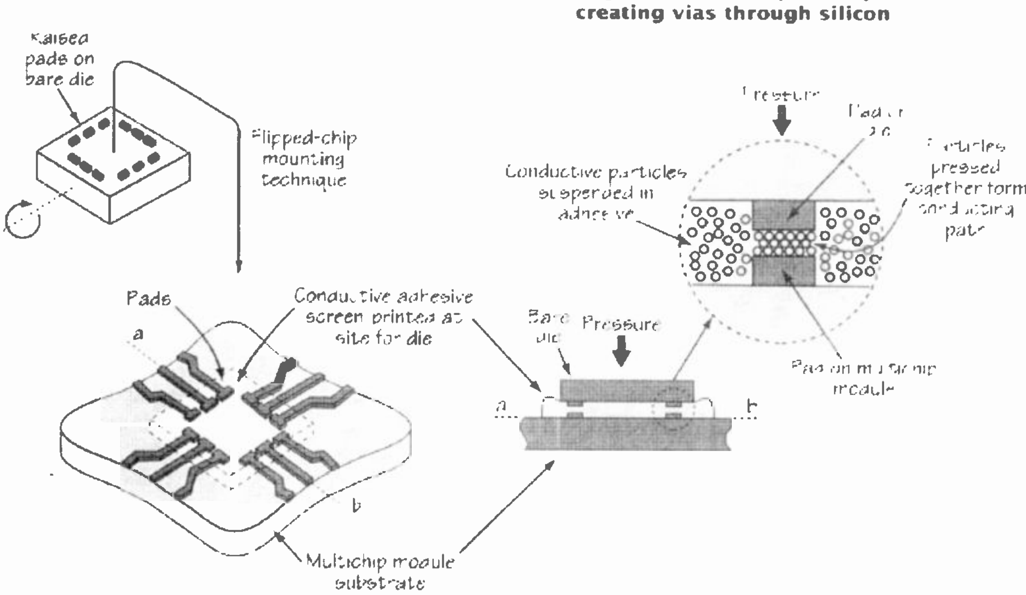


Figure 21.21: Conductive adhesives

substrate onto which the diamond layer is grown, and many observers believe that this technology may be developed in the near future. If it does prove possible to create consistent, single-crystal diamond films then, in addition to being *"a girl's best friend"*, diamonds would also become *"an engineer's biggest buddy"*.

Chip-On-Chip (COC)

The intrachip connections linking bare die on a multichip module are a source of fairly significant delays. One obvious solution is to mount the die as closely together as possible, thereby reducing the lengths of the tracks and the delays associated with them. However, each die can only have eight others mounted in close proximity on a 2-D substrate. The solution is to proceed into three dimensions. Each die is very thin and, if they are mounted on top of each other, it is possible to have over a hundred die forming a 3-D cube (Figure 21.19).

One problem with this chip-on-chip (COC) technique is the amount of heat that is generated, which drastically affects the inner layers forming the cube. This problem could be eased by constructing the earlier die out of diamond as discussed earlier. Another problem with traditional techniques is that any tracks linking the die must be connected down the outer surfaces of the cube. The result is that the chip-on-chip technique has typically been restricted to applications utilising identical die with regular structures. For example, the most common application to date has been large memory devices constructed by stacking SRAM or DRAM die on top of each other.

A new technique which may serve to alleviate the problem of chip-on-chip interconnect is a process for creating vias through silicon substrates. Experiments are being performed in which aluminium "blobs" are placed on the surface of a silicon substrate and, by means of a gradient furnace, the aluminium migrates through the silicon providing vias from one side to the other (Figure 21.20).

Another technique more in keeping with the times is to create the vias by punching the aluminium through the silicon by means of a laser. These developments pave the way for double-sided silicon substrates with chips and interconnections on both sides. Additionally, they offer strong potential for interconnecting the die used in chip-on-chip structures.

Conductive Adhesives

Many electronics fabrication processes are exhibiting a trend towards mechanical simplicity with underlying sophistication in materials technology. A good example of this trend is illustrated by conductive, or *anisotropic*, adhesives which contain minute particles of conductive material.

These adhesives find particular application with the "flipped-chip" techniques used to mount bare die on the substrates of hybrids, multichip modules, or circuit boards. The adhesive is screen-printed onto the substrate at the site where the die is to be located, the die is pressed into the adhesive, and the adhesive is cured using a combination of temperature and pressure (Figure 21.21).

The beauty of this scheme is that the masks used to screen-print the adhesive do not need to be too complex and the application of the adhesive does not need to be excessively precise, because it can be spread across all of the component pads. The conducting particles are only brought in contact with each other at the sites where the raised pads on the die meet their corresponding pads on the substrate, thereby forming good electrical connections.

The original conductive adhesives were based on particles such as silver. But, in addition to being expensive, metals like silver can cause electron migration problems at the points where they meet the silicon substrates. Modern equivalents are based on organic metallic particles, thereby reducing these problems.

In addition to being simpler and requiring fewer process steps than traditional methods, the conductive adhesive technique removes the need for solder, whose lead content is beginning to raise environmental concerns.

Superconductors

One of the "Holy Grails" of the electronics industry is to have access to conductors with zero resistance to the flow of electrons, and for such conductors, known as *superconductors*, to operate at room temperatures. As a concept, superconductivity is relatively easy to understand: consider two sloping ramps into which a number of pegs are driven. In the case of the first ramp, the pegs are arranged randomly across the surface, while in the second the pegs are arranged in orderly lines. Now consider what happens when balls are released at the top of each surface:

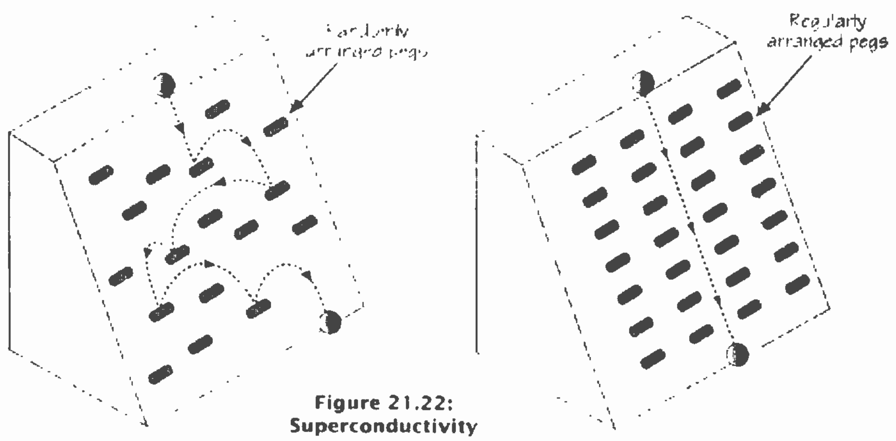


Figure 21.22: Superconductivity

In the case of the randomly arranged pegs, the ball's progress is repeatedly interrupted, while in the case of the pegs arranged in orderly lines, the ball slips through like "*water off a duck's back*". Although analogies are always suspect (and this one doubly so), the ramps may be considered to represent conducting materials, the gravity accelerating the balls takes on the role of voltage differentials applied across the ends of the conductors, the balls play the part of electrons, and the pegs portray atoms.

The atoms in materials vibrate due to the thermal energy contained in the material: the higher the temperature, the more the atoms vibrate. An ordinary conductor's electrical resistance is caused by these atomic vibrations, which obstruct the movement of the electrons forming the current. Using the Kelvin[26], or absolute, scale of temperature, 0K (corresponding to −273°C) is the coldest possible temperature and is known as absolute zero. If an ordinary conductor were cooled to a temperature of absolute zero, atomic vibrations would cease, electrons could flow without obstruction, and electrical resistance would fall to zero. A temperature of absolute zero cannot be achieved in practice, but some materials exhibit superconducting characteristics at higher temperatures[27].

In 1911, the Dutch physicist Heike Kamerlingh Onnes discovered superconductivity in mercury at a temperature of approximately 4K (−269°C). Many other superconducting metals and alloys were subsequently discovered but, until 1986, the highest temperature at which superconducting properties were achieved was around 23K (−250°C) with the niobium-germanium alloy (Nb_3Ge).

In 1986, Georg Bednorz and Alex Müller discovered a metal oxide that exhibited superconductivity at the relatively high temperature of 30K(−243°C). This led to the discovery of ceramic oxides that super-conduct at even higher temperatures. In 1988, an oxide of thallium, calcium, barium and copper ($Tl_2Ca_2Ba_2Cu_3O_{10}$) displayed superconductivity at 125K (−148°C), and, in 1993, a family based on copper oxide and mercury attained superconductivity at 160K (−113°C). These "*high-temperature*" superconductors are all the more noteworthy because ceramics are usually extremely good insulators.

Like ceramics, most organic compounds are strong insulators; however, some organic materials known as organic synthetic metals do display both conductivity and superconductivity. In the early 1990s, one such compound was shown to superconduct at approximately 33K (−24°C). Although this is well below the temperatures achieved for ceramic oxides, organic superconductors are considered to have great potential for the future.

New ceramic and organic superconducting materials are being discovered on a regular basis, and the search is on for room temperature superconductors which, if discovered, are expected to revolutionize electronics as we know it.

Nano-technology

Nano-technology is an elusive term that is used by different research-and-development teams to refer to whatever it is that they're working on at the time. However, regardless of their particular area of interest, nano-technology always refers to something extremely small; for example, motors and pumps the size of a pinhead, which are created using similar processes to those used to fabricate integrated circuits. In fact, around the beginning of 1994, one such team unveiled a miniature model car, which was smaller than a grain of short-grain rice. This model contained a micro-miniature electric motor, battery, and gear train, and was capable of traversing a fair-sized room (though presumably not on a shag-pile carpet).

One of the more outrageous branches of nano-technology that has been suggested as having potential in the future is that of micro-miniature electronic products that assemble themselves! The theory is based on the way in which biological systems operate. Specifically, the way in which *enzymes*[28] act as biological catalysts[29] to assemble large, complex molecules from smaller molecular building blocks.

Before commencing this discussion, it is necessary to return to the humble water molecule[30]. As you may recall, water molecules are formed from two hydrogen atoms and one oxygen atom, all of which share electrons between themselves. However, the electrons are not distributed equally, because the oxygen atom is a bigger, more robust fellow which grabs more than its fair share (Figure 21.23).

The angle formed between the two hydrogen atoms is 105°. This is because, of the six electrons that the oxygen atom owns, two are shared with the hydrogen atoms and four remain the exclusive property of the oxygen. These four huddle together on one side of

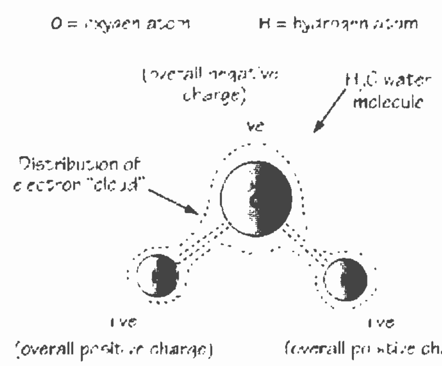


Figure 21.23: Nano-technology: distribution of electrons in a water molecule

the oxygen atom and put "pressure", on the bond angle. The bond angle settles on 105° because this is the point where the pressure from the four electrons is balanced by the natural repulsion of the two positively charged hydrogen atoms (similar charges repel each other).

The end result is that the oxygen atom has an overall negative charge, while the two hydrogen atoms are left feeling somewhat on the positive side. This unequal distribution of charge means that the

26 *Invented by the British mathematician and physicist William Thomson, first Baron of Kelvin.*
27 *If the author were an expert in superconductivity, this is the point where he might be tempted to start muttering about "Correlated electron movements in conducting planes separated by insulating layers of mesoscopic thickness, under which conditions the wave properties of electrons assert themselves and electrons behave like waves rather than particles". But he's not, so he won't.*
28 *Complex proteins which are produced by living cells and catalyze biochemical reactions at body temperatures.*
29 *A substance that initiates a chemical reaction under different conditions (such as lower temperatures) than would otherwise be possible. The catalyst itself remains unchanged at the end of the reaction.*
30 *Water molecules were introduced in Chapter 2.*

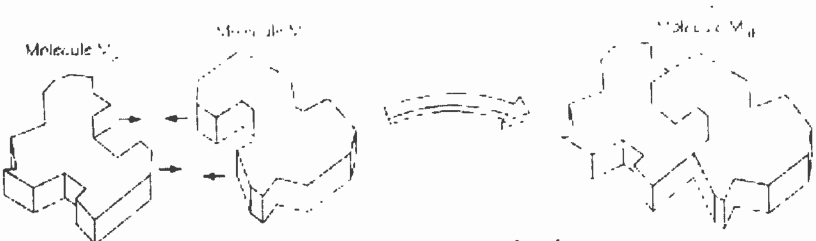


Figure 21.24: Nano-technology: combining molecules M_a and M_b to form M_{ab}

hydrogen atoms are attracted to anything with a negative bias – for example, the oxygen atom of another water molecule. Although the strength of the resulting bond, known as a hydrogen bond, is weaker than the bond between the hydrogen atom and its "parent" oxygen atom, it is still quite respectable.

When water is cooled until it freezes, its resulting crystalline structure is based on these hydrogen bonds. Even in its liquid state, the promiscuous, randomly wandering water molecules are constantly forming hydrogen bonds with each other. These bonds persist for a short time until another water molecule clumsily barges into them and knocks them apart. From this perspective, a glass of water actually contains billions of tiny ice crystals that are constantly forming and being broken apart again.

However, we digress. Larger molecules can form similar electrostatic bonds with each other. Imagine a "soup" consisting of large quantities of many different types of molecules, two of which, M_a and M_b, may be combined to form larger molecules of type M_{ab} (Figure 21.24).

This is similar in concept to two pieces of a jigsaw, which will only fit together if they are in the correct orientation to each other. Similarly, M_a and M_b will only bond to form M_{ab} if they are formally presented to each other in precisely the right orientation. However, the surfaces of the molecules are extremely complex three-dimensional shapes, and achieving the correct orientation is a tricky affair. Once the molecules have been brought together their resulting bonds are surprisingly strong, but the chances of the two molecules randomly achieving exactly the correct orientation to form the bonds are extremely small.

It is at this point of the story that enzymes re-enter the plot. There are numerous enzymes, each dedicated to the task of "matchmaking" for two of their favourite molecules. The surface of an enzyme is also an extremely complex three-dimensional shape, but it is much larger than its target molecules and has a better chance of gathering them up. The enzyme floats around until it bumps into a molecule of type M_a to which it bonds. The enzyme then continues on its trek until it locates a molecule of type M_b. When the enzyme bonds to molecule M_b, it orientates it in exactly the right way to complete the puzzle with molecule M_a (Figure 21.25).

The bonds between M_a and M_b are far stronger than their bonds to the enzyme. In fact, as soon a these bonds are formed, the enzyme is actually repelled by the two little lovebirds and promptly thrusts M_{ab} away. However, the enzyme immediately forgets its pique, and commences to search for two more molecules (some enzymes can catalyze their reactions at the rate of half a million molecules per minute).

The saga continues, because another, larger enzyme may see its task in life as bringing M_{ab} together with yet another molecule M_{cd}. And so it continues, onwards and upwards, until the final result, whatever that may be, is achieved.

As our ability to create "*designer molecules*" increases, it becomes increasingly probable that we will one day be able to create "designer enzymes." This would enable us to mass-produce "*designer proteins*" that could act as alternatives to semiconductors (see also the "*Protein Switches and Memories*" section). As one of the first steps along this path, a process could be developed to manufacture various proteins that could then be bonded to a substrate or formed into three-dimensional blocks for optical memory applications. At a more sophisticated level, it may be possible for such a process to directly create the requisite combinations of proteins as self-replicating structures across the face of a substrate.

However, the possibilities extend far beyond the mass-production of proteins. It is conceivable that similar techniques could be used to assemble non-organic structures such as microscopic electromechanical artifacts. All that would be required (he said casually) would be for the individual components to be shaped in such a way that naturally occurring electrostatic fields would cause them to form bonds when they were brought together with their soul mates. In fact, this is one step along the path towards molecular-sized robots known as *Nanobots*.

Taken to extremes, the discipline of electronics in the future may not involve the extreme temperatures, pressures and noxious chemicals that are in vogue today. Instead, electronics may simply involve "cookbook" style recipes; for example, the notes accompanying an electronics course in 2050 AD may well read as follows:

Intermediate Electronics (Ages 12 to 14) **Super Computers 101**

Instructions for creating a micro-miniature massively parallel super-computer.*

a) Obtain a large barrel.
b) In your barrel, mix two parts water and one part each of chemicals A, B, C . . .
c) Add a pinch of nanobot-mix (which you previously created in Nanobots 101).
d) Stir briskly for one hour with a large wooden spoon.

Congratulations, you will find your new super-computers in the sediment at the bottom of the barrel. Please keep one teaspoon of these super computers for your next lesson.

***These instructions were reproduced from "*Bebop to the Boolean Boogie*," 50th Edition, "The most successful electronics book in the history of the universe" – over 300,000,000 copies sold, by kind permission of HighText Publications Inc.**

Of course, some of this is a little far-fetched (with the hopeful exception of the references to *Bebop to the Boolean Boogie*). However, for what it's worth, the author would bet his wife's life savings that this type of technology will occur one day, and also that it will be here sooner than you think!

Summary

The potpourri of technologies introduced above have been offered for your delectation and delight. Some of these concepts may appear to be a little on the wild side, and you certainly should not believe everything that you read or hear. On the other hand, you should also be careful not to close your mind, even to seemingly wild and wacky ideas, in case something sneaks up behind you and bites you on the ****.[31] As the Prize said in *Where is Earth* by Robert Sheckley: "*Be admiring but avoid the fulsome, take exception to what you don't like, but don't be stubbornly critical; in short, exercise moderation except where a more extreme attitude is clearly called for.*"

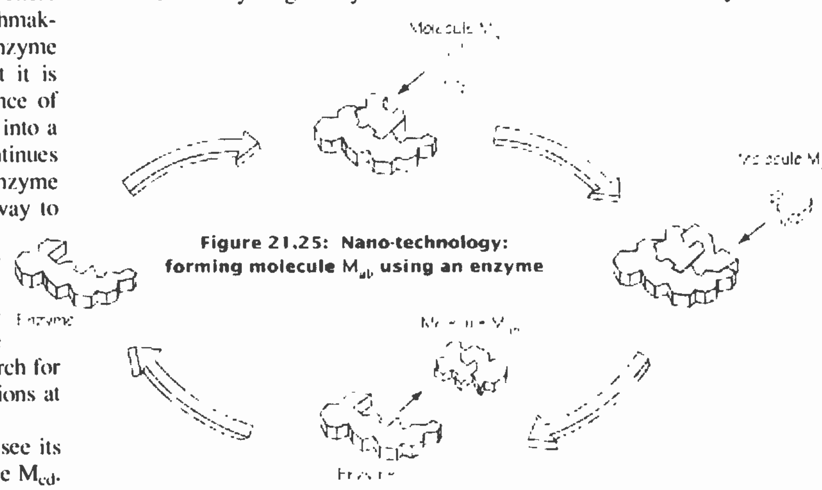


Figure 21.25: Nano-technology: forming molecule M_{ab} using an enzyme

And so, with our lower lips quivering and little tears rolling down our cheeks, we come to the close of this, the final chapter. As that great British Prime Minister Winston Spencer Churchill (1874-1965) would have said: "*Now this is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning.*"[32]

IF YOU WANT MORE BUY THE BOOK – SEE PAGE 73

31 Arsek no questions!
32 Speech at the Lord Mayor's Day Luncheon, London (November 10, 1942).

EVERYDAY PRACTICAL ELECTRONICS

BACK ISSUES

We can supply back issues of *EPE* by post, many issues from the past five years are available. An index for the last five years 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.

DID YOU MISS THESE?

JULY '96 Photostats Only (see below)

PROJECTS ● Advanced NiCad Chargers ● Single-Station Radio 4 Tuner ● Games Compendium ● Twin-Beam Infra-Red Alarm ● Ultra-Fast Frequency Generator and Counter – 2.
FEATURES ● Teach-In '96 Part 9 ● More Scope for Good Measurements Part 2 ● Circuit Surgery ● The Internet ● Ingenuity Unlimited.

AUG '96 Photostats Only (see below)

PROJECTS ● Component Analyser ● Garden Mole-Ester ● Mono "Cordless" Headphones ● Bike-Speedo ● Mobile Miser.
FEATURES ● Teach-In '96 Part 10 ● Circuit Surgery ● Ingenuity Unlimited ● Spies, Lies and Electronics ● EPT 3.0 Review.

SEPT '96

PROJECTS ● Analogue Delay and Flanger ● Simple Exposure Timer ● PIC-Tock Pendulum Clock ● Draught Detector ● Power Check.
FEATURES ● Circuit Surgery ● Ingenuity Unlimited ● Net Work – The Internet ● MAX038 Waveform Generator.

OCT '96

PROJECTS ● Video Fade-To-White ● Direct Conversion Topband and 80m Receiver ● Vehicle Alert ● 10MHz Function Generator.
FEATURES ● Introduction to Satellite Television ● Ingenuity Unlimited ● Circuit Surgery ● Net Work – The Internet.

NOV '96

PROJECTS ● D.C.-to-D.C. Converters ● Central Heating Controller ● EPE Elysian Theremin, Part 1 ● Tuneable Scratch Filter.
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

PROJECTS ● Pacific Waves ● How To Use Intelligent L.C.D.s, Part 1 ● PsiCom Experimental Controller ● Earth Resistivity Meter, Part 2 ● Theremin MIDI/CV Interface, Part 2.
FEATURES ● Ingenuity Unlimited ● Build Your Own Projects, Part 4 ● Circuit Surgery ● Interface ● Net Work – Internet News.

MARCH '97

PROJECTS ● Simple Dual-Output TENS Unit ● Video Negative Viewer ● Tri-Colour NiCad Checker ● How To Use Intelligent L.C.D.s – 2 ● Oil Check Reminder.
FEATURES ● Interface ● Ingenuity Unlimited ● Build Your Own Projects, Part 5 ● Digital TV – The Reality ● Circuit Surgery ● Net Work.

APRIL '97

PROJECTS ● 418MHz Remote Control System ● Midi Matrix ● Puppy Puddle Probe ● PIC-Agoras Wheelie Meter – 1.
FEATURES ● Interface ● Ingenuity Unlimited ● Digital TV and MPEG2 ● EDWin NC Software Review ● Circuit Surgery ● Net Work.

MAY '97

PROJECTS ● 2 Metre F.M. Receiver ● EPE PIC-A-Tuner ● Alarm Operated Car Window Winder ● Quasi-Bell Door Alert ● PIC-Agoras – 2.
FEATURES ● Ingenuity Unlimited ● Circuit Surgery ● Techniques – Actually Doing It ● Great Experimenters – 1 ● Type 7660 Voltage Converters ● ADC200 Storage Oscilloscope Interface Review ● Net Work.

JUNE '97

PROJECTS ● PIC Digilogue Clock ● Child Minder Protection Zone ● Pyrotechnic Controller ● Narrow Range Thermometer.
FEATURES ● Great Experimenters – 2 ● Circuit Surgery ● Interface ● Reactobot and Virtual Reality ● Ingenuity Unlimited ● Net Work.

JULY '97

PROJECTS ● Micro PEsT Scarer ● Karaoke Echo Unit ● Infra-Red Remote Repeater ● Computer Dual User Interface ● Micropower PIR Detector – 1.
FEATURES ● Ingenuity Unlimited ● Techniques – Actually Doing It ● Circuit Surgery ● Great Experimenters – 3 ● Electronics Workbench V5.0 Review ● Net Work.

AUG. '97

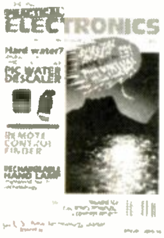
PROJECTS ● Variable Bench Power Supply ● PIC-olo Music Maker ● Universal Input Amplifier ● Micropower PIR Detector – 2.
FEATURES ● Interface ● Ingenuity Unlimited ● Colossus Recreated ● Circuit Surgery ● MExpress – Basic for Engineers Review ● Great Experimenters – 4 ● Net Work.

SEPT '97

PROJECTS ● PIC-Noughts & Crosses Game ● Ironing Safety Device ● Active Receiving Antenna ● Soldering Iron Controller ● Micropower PIR Detector – 3.
FEATURES ● Ingenuity Unlimited ● Raising the Pressure – RC4190 Switch-Mode I.C. ● Circuit Surgery ● Techniques – Actually Doing It ● Great Experimenters – 5 ● Net Work.

OCT '97

PROJECTS ●PIC Water Descaler ● Remote Control Finder ● Multi-Station Quiz Monitor ● Rechargeable Handlamp.
FEATURES ● Ingenuity Unlimited ● It's Probably Murphy's Law ● Interface ● Circuit Surgery ● Kanda PIC Explorer Review ● Network ● Special Offer – Pico Virtual 'Scopes.



NOV '97

PROJECTS ●Portable 12V PSU/Charger ● Case Alarm ● Auto-Dim Bedlight ● *EPE* Time Machine.
FEATURES ● Satellite Celebration ● Ingenuity Unlimited ● TEACH-IN '98 – An Introduction to Digital Electronics–1 ● New Technology Update ● Techniques – Actually Doing It ● Circuit Surgery ● Net Work ● Special Offer – Pico Virtual Scopes ● Free Greenweld Catalogue.

DEC '97

PROJECTS ● Safe and Sound – Security Bleeper ● Active Microphone ● Car Immobiliser ● Mini Organ.
FEATURES ● TEACH-IN '98 – An Introduction to Digital Electronics–2 ● Circuit Surgery ● Interface ● B² Spice Review ● Ingenuity Unlimited ● Alternative and Future Technologies–1 ● Net Work – The Internet ● *Free* Giant Data Chart – Formulae.

BACK ISSUES ONLY £2.75 each inc. UK p&p.
Overseas prices £3.35 each surface mail, £4.35 each airmail.

We can also supply issues from earlier years: 1990 (**except** Jan., March, Oct. and Dec.), 1991 (**except** May, June, Aug., Sept. and Nov.), 1992 (**except** April and Dec.), 1993 (**except** Jan., Feb., March, April and May), 1994 (**except** April, May, June and Nov.), 1995 (**except** Jan., March, May, June, Aug., Sept., Nov. and Dec.), 1996 (**except** Feb., July, Aug.). Please note we are not able to supply copies (or 'stats of articles) of *Practical Electronics* prior to the merger of the two magazines in November 1992.
Where we do not have an issue a photostat of any *one article* or *one part* of a series can be provided at the same price.

ORDER FORM – BACK ISSUES – PHOTOSTATS – INDEXES

☐ Send back issues dated ....

☐ Send photostats of (article title and issue date) ....

☐ Send copies of last five years indexes (£2.75 for five inc. p&p – Overseas £3.35 surface, £4.35 airmail)

Name ....

Address ....

....

☐ I enclose cheque/P.O./bank draft to the value of £..

☐ Please charge my Visa/Mastercard £..

Card No. .... Card Expiry Date ....

Note: Minimum order for credit cards £5. Please supply name and address of cardholder if different from that shown above.
SEND TO: **Everyday Practical Electronics, Allen House, East Borough, Wimborne, Dorset BH21 1PF.**
Tel: 01202 881749. Fax: 01202 841692. (Due to the cost we cannot reply to overseas queries or orders by Fax.)
E-mail:editorial@epemag.wimborne.co.uk
Payments must be in £ sterling – cheque or bank draft drawn on a UK bank. Normally supplied within seven days of receipt of order.
Send a copy of this form, or order by letter if you do not wish to cut your issue.

M1/98

Constructional Project

SIMPLE M.W. RADIO

ROBERT PENFOLD

Most beginners to electronics build a radio. Here's your chance to achieve that magical result – sound out of nowhere!

THE COST of ready-made radio sets is so low these days that at first there seems to be little point in building your own. On the other hand, a simple broadcast receiver has traditionally been a popular starting point for the electronics hobbyist, and it remains an interesting and useful project for beginners.

This very simple design provides reception of the medium waveband (m.w.), and drives a pair of medium impedance stereo headphones at good volume. Of course, the output to the headphones is only monophonic as this is an a.m. (amplitude modulated) receiver.

Power is obtained from a single 1·5V HP7 size battery (strictly speaking, it should be called a cell). As the current consumption of the circuit is very low, the running costs are negligible. In fact the running costs are unlikely to be more than about 0·1 pence per hour!

The circuit is a tuned radio frequency (t.r.f.) type which is based on a single integrated circuit that is designed specifically for this function. Although only a handful of components are used, the level of performance is quite good, and a number of stations can be received at good volume.

AMPLITUDE MODULATION

The form of modulation used on the low frequency broadcast bands is amplitude modulation (a.m.), and Fig.1 helps to explain how this system operates.

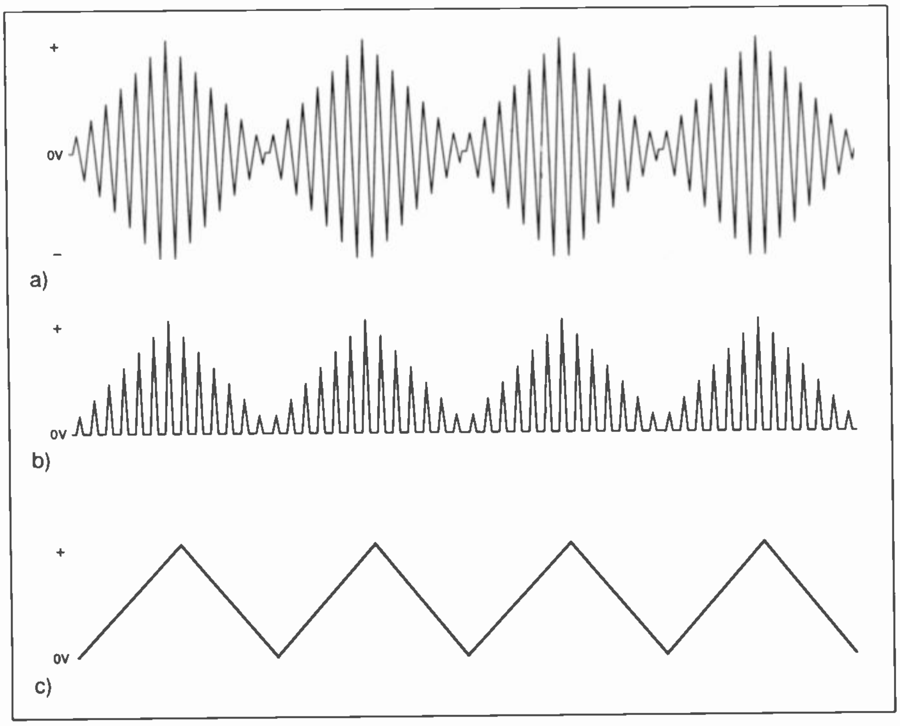


Fig.1. The a.m. signal (a) is half-wave rectified (b) and then filtered to recover the audio signal (c).

A high frequency carrier wave must be modulated with the low frequency audio signal in such a way that the audio signal can be recovered at the receiver. With amplitude modulation, the strength of the radio frequency carrier signal is varied in sympathy with the audio input voltage. The strength of the carrier wave is increased on positive input half cycles, and decreased on negative half cycles.

In the example waveform of Fig.1a, the audio input signal is a triangular signal and it is providing 100 per cent modulation. The carrier wave, therefore, reaches double its normal amplitude on positive audio peaks, and goes right down to zero on negative audio peaks.

There is more than one way of demodulating an a.m. signal, but the most simple and common method is to first rectify the signal as in Fig.1b. The average amplitude of the carrier wave is always zero because the negative half cycles are equal in strength to the positive half cycles, and the two sets of half cycles therefore cancel out each other.

By removing one set of half cycles, the average amplitude of the signal varies in sympathy with the audio modulation. In order to recover the audio signal (Fig.1c) it is merely necessary to use some simple lowpass filtering to smooth the signal.

SYSTEM OPERATION

The block diagram of Fig.2 shows the general scheme of things used in this receiver. A ferrite aerial is the standard choice for a medium wave radio as it offers a reasonably strong output signal and is very compact. This type of aerial is just a coil of wire on a rod of ferrite, which is an iron based material.

The coil of wire forms a simple inductor which is wired in parallel with a variable capacitor. Together, these two components form a parallel tuned circuit, and the important characteristic of this type of circuit is that it has a very high impedance at its resonant frequency.

At this frequency, the aerial offers high efficiency, but at other frequencies its low impedance results in signals effectively being short-circuited to earth. The variable capacitor enables the resonant frequency of the tuned circuit to be set anywhere within the medium waveband, which extends from 550kHz to 1·6MHz.

Most radio receivers are of the superhet variety, and convert the incoming radio signal to a certain frequency. This is known as the intermediate frequency (i.f.), and it is at this frequency that much of the receiver's gain is provided.

SELECTIVITY

It is at this frequency that most of the receiver's selectivity is obtained. This is the ability of the receiver to pick out just one transmission when several stations are operating close together. By converting the incoming signals to an intermediate frequency, it is easy to obtain good selectivity as there is no difficulty in producing high quality filters that operate at a fixed frequency.

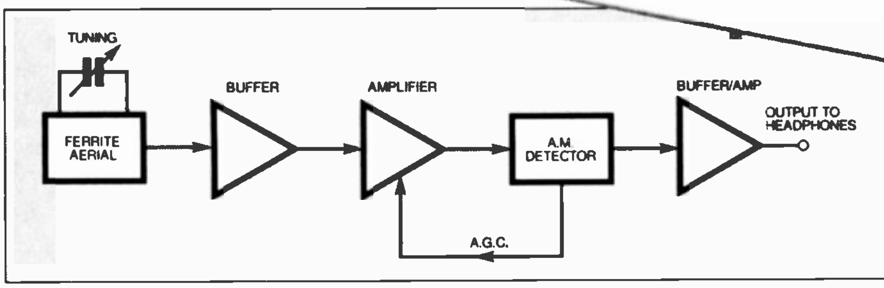


Fig.2. System block diagram for the Simple M.W. Radio.

A t.r.f. receiver such as this is much simpler than a superhet design as it provides all the radio frequency gain and selectivity at the reception frequency. Obtaining adequate gain without using intermediate frequency stages is not too difficult with a medium wave radio as it is not operating over a very high frequency range.

Good selectivity is more difficult to obtain as it requires a number of tuneable filters. Most practical t.r.f. designs, including this one, only have a single filter to provide the selectivity. In this case, the ferrite aerial is the only r.f. filter, and it cannot provide selectivity to rival a superhet design. The receiver's selectivity is perfectly adequate, though.

The signal from the aerial is coupled to a high input impedance buffer stage which ensures that there is minimal loading on the aerial. High loading would tend to broaden the response of the aerial and give inadequate selectivity.

UNDER CONTROL

Next, the signal is amplified by what is shown as a single amplifier in Fig.2, but this is actually a three stage capacitor coupled amplifier. The amplified r.f. signal is then fed to a conventional a.m. detector stage, which also provides automatic gain control (a.g.c.).

Signal strengths vary considerably from one station to another, and the purpose of the automatic gain control circuit is to provide a virtually constant volume level despite these variations. It also prevents the receiver from being overloaded by strong local stations.

The automatic gain control circuit operates by taking some of the rectified carrier signal and applying lowpass filtering with a very low cutoff frequency. This removes the audio modulation and gives a d.c. output signal that is proportional to the strength of the received transmission.

The a.g.c. bias signal is used to reduce the supply voltage to the amplifier stages, and this reduces their gain. The stronger the received signal, the greater the reduction in the gain of the amplifier stages.

While the automatic gain control circuit is not perfect, and strong signals do produce higher volume than weak ones, the difference in volume is greatly reduced.

Finally, the audio output signal from the detector stage is fed to an amplifier which provides a small amount of voltage gain. The main purpose of this stage is to provide a high enough output current to drive the relatively low load impedance provided by the headphones.

CIRCUIT DESCRIPTION

Refer to Fig.3 for the circuit diagram of the Simple M.W. Radio. IC1 is a Ferranti ZN416E, which is basically the same as that old favourite the ZN414Z, but with an added output stage that gives sufficient output power to directly drive a pair of headphones.

Inductor L1 is the ferrite aerial, and the tuning capacitor is VC1. Capacitor C1 provides decoupling in the bias circuit of IC1, and C2 is the smoothing capacitor in the detector stage of the circuit. Capacitor C3 couples the demodulated audio signal to the buffer amplifier at the output of the circuit.

The headphones are directly coupled to the output of IC1 and, therefore, a small d.c. current passes through them while the receiver is switched on. Having a d.c. component in the signal applied to high quality headphones is definitely not advisable, but it is not likely to be of any significance with inexpensive headphones of the type that will be used with this receiver.

The circuit is powered from a single 1·5V battery, but powering the circuit directly from the battery is likely to give rather lively results. A simple voltage regulator based on transistor TR1 is used, therefore, to drop the supply voltage slightly, and ensure good stability.

The regulator circuit is a simple shunt type which uses TR1 in the so-called amplified diode arrangement. VR1 can be adjusted to provide any output voltage

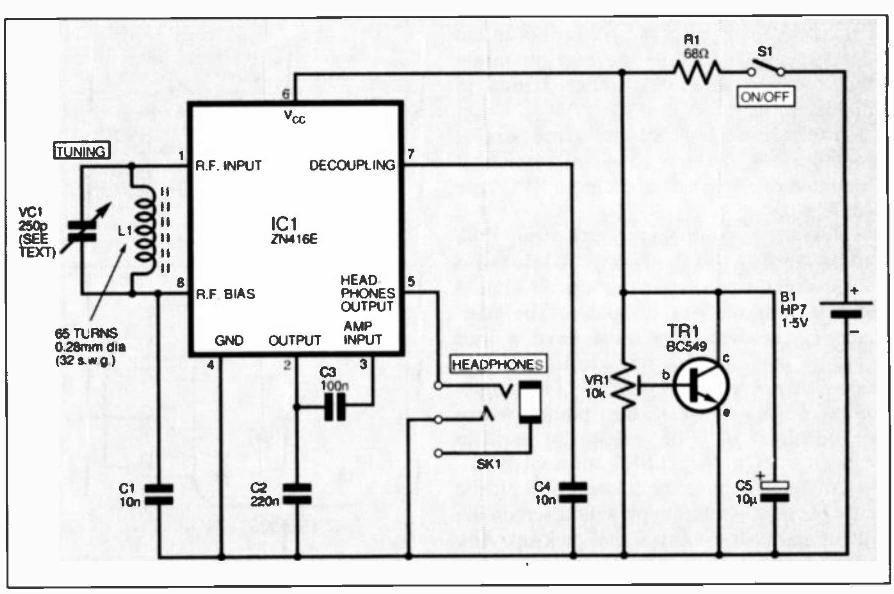


Fig.3. Complete circuit diagram for the Simple M.W. Radio.

from about 0·6V to the input potential, and in practice it is adjusted for the highest output voltage that provides stable results. The current consumption of the circuit is only about six milliamps.

AERIAL

The first task is to make the ferrite aerial, which takes the general form shown in Fig.4. The circuit should work properly using a ready made ferrite aerial, but most of these have a small coupling winding which is not required in this case and should be ignored.

It is not difficult to make your own aerial using a piece of ferrite rod about 9·5mm in diameter and 100mm long. You may only be able to obtain the rod in longer lengths, but it is perfectly acceptable to use a longer rod. However, using a long aerial precludes the use of a small pocket-sized case.

The ferrite rod is easily trimmed to length, but as ferrite is extremely hard it is virtually impossible to cut right through it using a hacksaw. Instead, it is best to cut a deep groove around the rod at the point where the cut is required, and then snap it at this point. Ferrite is very brittle and there should be no difficulty in snapping the rod.

The winding is made from 0·28mm (32s.w.g.) diameter enamelled copper wire. Start by taping the wire in place at one end of the rod using 19mm wide insulation tape, leaving a leadout wire about 60mm long.

Then wind 65 turns of wire around the rod in a *single layer*, keeping the turns closely spaced, and all going in the same direction. Tape the wire to the rod so that the coil cannot spring apart, and then trim the wire to leave a second leadout wire about 60mm long.

Finally, scrape away the insulation at the ends of the leadouts using a penknife or a small file, and "tin" the exposed copper with solder.

CONSTRUCTION

The stripboard component layout, together with hard wiring and underside view of the board, is shown in Fig.5.

The board is a non-standard size, so start by cutting it down to the required size of 32 holes by 21 copper strips using a hacksaw. Then make the six breaks in the copper strips and drill the two mounting holes, which should be about 3·3mm in diameter.

A mounting hole of the same size is required for the ferrite aerial, which is mounted on the board via a large "P" type cable grip.

Next, the components and four link wires are fitted to the board. IC1 is not a static-sensitive component, but it should still be mounted in a holder. The non-electrolytic capacitors must have a lead spacing of 5·0mm if they are to fit easily into this component layout. Fit single-sided solder pins at the points where connections will be made to variable capacitor VC1, socket SK1 and switch S1.

This project *must* be housed in a plastic case because a metal type would screen the aerial and prevent any signal pick-up. Any plastic case that is able to accommodate the ferrite aerial should be suitable. The removable lid of the case becomes the

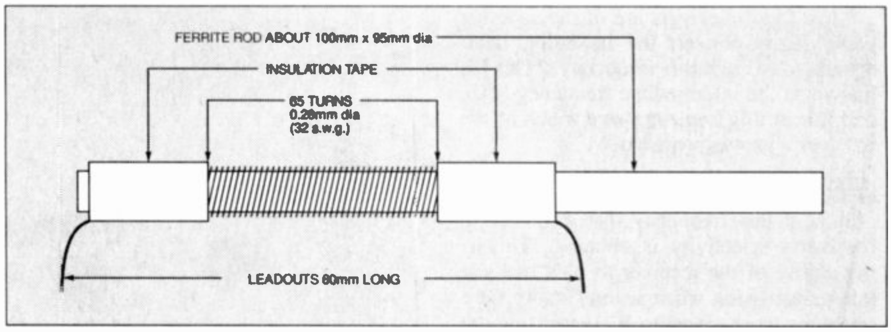


Fig.4. Details of the ferrite rod aerial. The coil is made from 0·28mm (32s.w.g.) enamelled copper wire.

rear panel, and the component board is mounted here. Components VC1, SK1, and S1 are mounted on the front panel.

Any variable capacitor having a maximum value of about 200pF to 300pF is suitable for VC1, but many of the available components are very expensive. Some are also quite large. The most practical choice is one of the inexpensive miniature solid dielectric types that are available from some component retailers.

The tuning capacitor used in the prototype is the type which has two gangs of 141pF and 159pF. These are wired in parallel to provide a maximum capacitance of 300pF. This component has provision

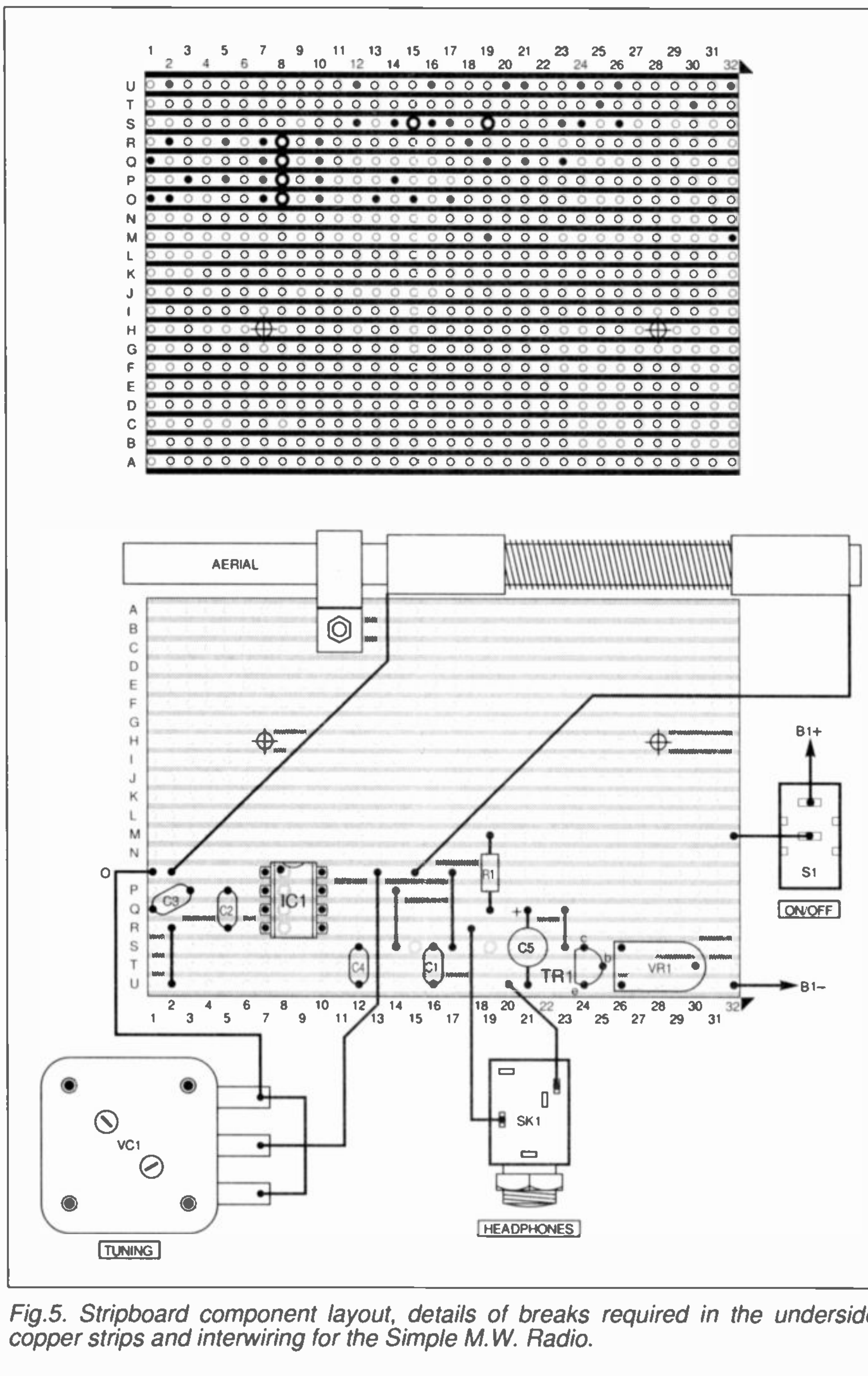
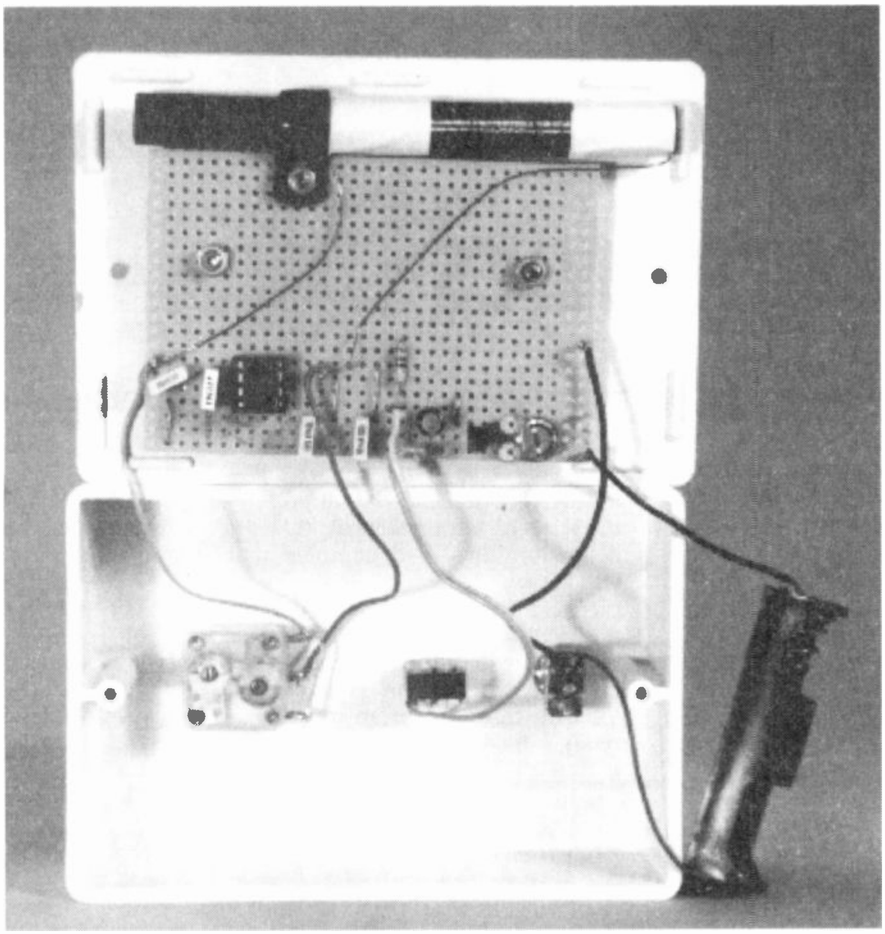


Fig.5. Stripboard component layout, details of breaks required in the underside copper strips and interwiring for the Simple M.W. Radio.



Layout of components inside the small plastic case.

COMPONENTS

See SHOP TALK Page

Resistor

R1	68Ω 0·25W 5% carbon film

Potentiometer

VR1	10k min. preset horizontal

Capacitors

C1, C4	10n polyester, 5mm lead spacing (2 off)
C2	220n polyester, 5mm lead spacing
C3	100n polyester, 5mm lead spacing
C5	10µ radial elect. 25V
VC1	250p variable (see text)

Semiconductors

TR1	BC549 silicon *npn* transistor
IC1	ZN416E t.r.f. radio receiver

Miscellaneous

B1	1·5V battery (HP7 size cell in holder)
L1	medium wave ferrite rod aerial (see text)
SK1	3·5mm stereo jack socket
S1	s.p.s.t. min. toggle switch

Plastic case about 114mm × 76mm × 38mm; 0·1 inch pitch stripboard, 32 holes × 21 copper strips; 8-pin d.i.l. holder, 100mm × 9·5mm diameter ferrite rod (see text); insulation tape, 19mm; 32s.w.g. enamelled copper wire for aerial; control knob; 9·5mm "P" clip; connecting wire; solder, etc.

Approx Cost Guidance Only £14 excl. Batt.

for two mounting screws, but it is easier to glue it in place using a high quality adhesive such as "Superglue".

Miniature variable capacitors often have non-standard spindles which are not compatible with normal control knobs. The one in the model has a flattened 6mm diameter spindle which will take standard control knobs quite well. The spindle is very short, but the component is supplied with a small extension piece which can be glued in place or fixed in position using a short M2·5 bolt.

Audio output is via SK1, a stereo 3·5mm jack socket, but in this application connections are made to only two of its three tags as no connection is required to the earth tag.

Some 3·5mm stereo jack sockets have a built-in switch, but any switch contacts are not needed in this case and are ignored.

The battery is fitted in a plastic holder, and this has solder tags which permit it to be hard wired to the component board and switch S1. Do not position the battery very close to the aerial as this could impair performance.

The unit is designed for use with medium impedance headphones (about 35 ohms), which is the type sold as replacements for personal stereo units. Both the in-ear and the headband varieties are suitable, but in-ear headphones are generally better if you require high volume levels.

IN USE

With the wiper of preset VR1 at a roughly central setting, the radio will probably work quite well, but some tweaking of VR1 will probably produce improved results. It should be adjusted in a clockwise direction if the receiver is unstable at any setting of the tuning control, or in a counter-clockwise direction if it is not.

Optimum results are normally obtained with VR1 given the most clockwise setting that does not cause instability. Instability will be heard as a higher than normal background noise level, and a tone of varying pitch as the radio is tuned across a station.

The tuning capacitor is fitted with two trimmer capacitors that are largely irrelevant in the current context. Results will probably be satisfactory if they are set for minimum capacitance (with the two sets of metal plates fully unmeshed). They can be set for higher capacitance if the receiver's coverage is inadequate at the low frequency end of the band.

Remember that a ferrite aerial is directional, and that the set can be rotated to find the orientation that produces maximum signal pickup. The directional properties of the aerial can also be used to null a station that is causing interference. □

TEACH-IN '98

An Introduction to
DIGITAL ELECTRONICS

Ian Bell, Rob Miles, Dr. Tony Wilkinson, Alan Winstanley

TEACH-IN is a ten part series designed to support candidates following City and Guilds (C&G) 726 Information Technology, with reference to the following specific syllabuses: ***7261/301 Introductory Digital Electronics, *726/321 Elementary Digital Electronics, *726/341 Intermediate Digital Electronics.**

Even if you are not undertaking the City and Guilds syllabus, there is much to be learned from following *Teach-In*, whether you are a GCSE or "A" level student, apprentice technician or you simply want to discover the exciting world of Digital Electronics.

Lab Work

Throughout *Teach-In*, attempts are made to involve the student with practical "Lab Work" experiments and demonstrations, and complex mathematics and physics will be avoided unless really necessary – and even then, plenty of help is to hand! We make a point of identifying practical components in special sections of *Teach-In*, so that you will learn to recognise parts, even if you don't necessarily use them yourself just yet. We also take a light-hearted view from time to time, because electronics really is *fun* to learn.

Part Three: DIODES AND ALTERNATING CURRENT; THE MOSFET TRANSISTOR

IN THE previous section of *Teach-In*, we introduced the most fundamental semiconductor component – the *diode*. In this part, we will be outlining further applications for the diode before progressing on to describe the basic semiconductor element which resides at the heart of all digital circuitry – the **transistor.**

We will then be perfectly equipped to investigate digital logic circuitry for the remainder of *Teach-In: An introduction to* ***Digital Electronics.***

Building Bridges

The fact that a diode passes current in one direction only, is something which can be used to convert alternating current (a.c.) into direct current (d.c.). The process of converting an a.c. waveform into a d.c. one is called ***rectification***. Placing a single diode in series with an a.c. supply will cause one half of the a.c. cycle to be cut off or "chopped" because the diode will not allow conduction in the reverse direction. Fig. 3.1 shows this process which is called ***half-wave rectification.***

However, it is wasteful to simply lose one half of the sine wave this way, so by using an arrangement of diodes in a "diode bridge" formation we can achieve ***full wave rectification***, see Fig. 3.2 where instead of chopping one half of the sine wave, it's actually added back in! This is far more efficient in the field of power supplies.

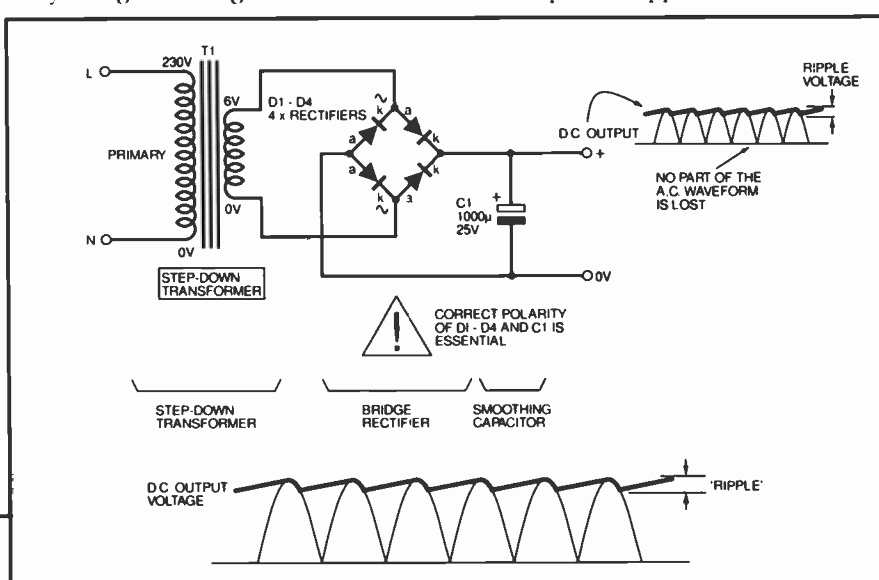


Fig.3.2. A standard full-wave d.c. power supply with bridge rectifier (D1 to D4) and smoothing electrolytic capacitor C1. Here, instead of chopping one half of the sine wave, it's actually added back in!

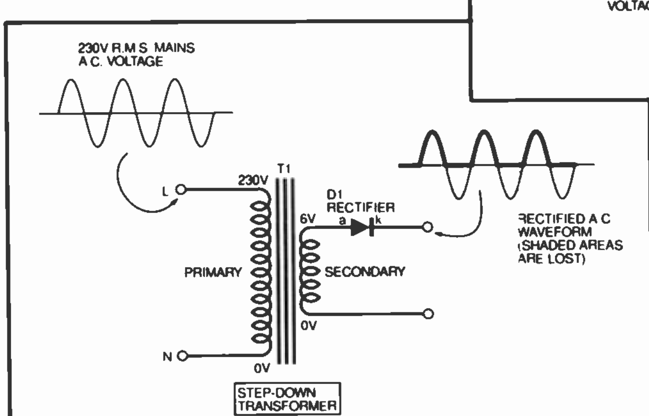
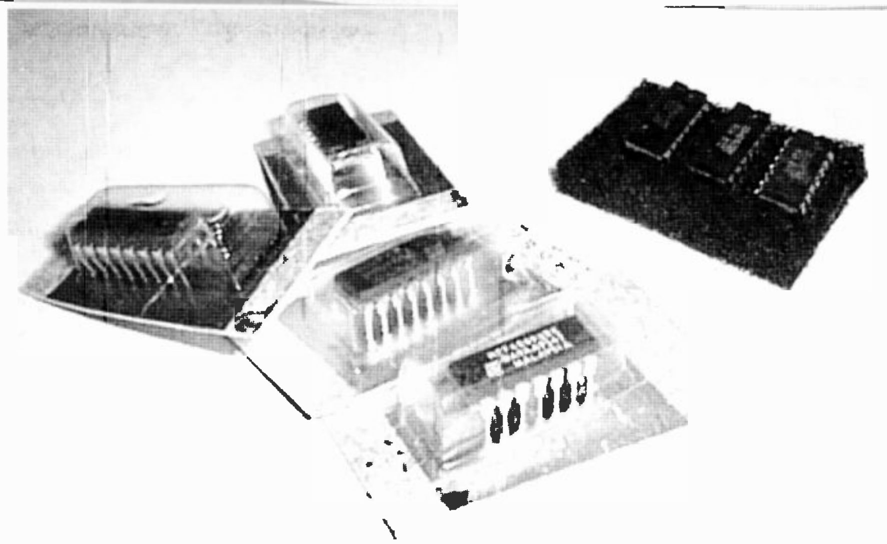


Fig.3.1. Half-wave rectification causes one half of the sine wave to be "chopped".

THE AUTHORS

Teach-In has been co-written for *Everyday Practical Electronics* by Ian Bell, Rob Miles and Dr. Tony Wilkinson who are lecturers in the Department of Electronic Engineering at the *University of Hull*, England. Regular readers will know Alan Winstanley, of course, as the author of several columns in *EPE*. Alan has co-ordinated the series.



A sample collection of CMOS integrated circuits sealed in anti-static packages or special foam pads.

Notice that although the voltage always moves in the same direction, it also goes up and down at double the original input frequency – 100Hz. At least the result is a more efficient use of the direct current, but the resultant signal requires "smoothing out" before it can be used.

It is more common to call a diode a **rectifier**, when used in heavier-duty power supply roles. A **bridge rectifier** contains four such rectifiers moulded into one package, specially designed for power supply rectification. They have four pins – two for the a.c. input, and two for the d.c. output.

To form the basis of a usable power supply, a bridge rectifier is used together with a very large smoothing or reservoir capacitor (typically 1,000µF or more, C1 in Fig. 3.2) which stores charge and "fills up the voltage gaps" The result is a d.c. voltage which can be used to power many circuits, and it is the basis of a simple but effective power supply – one which converts mains a.c. voltage to a low d.c. voltage, as required by many types of electronic equipment.

After the transformer secondary voltage has been rectified, the "peaks" of the rectified voltage will charge the capacitor, which then discharges into the load during the period between the peaks. Hence the smoothing capacitor helps to keep the load supplied with a reasonably steady voltage.

The thick line in Fig. 3.2 shows the sort of signal which would be witnessed if you used an oscilloscope to check the output. It is not quite the straight line of a d.c. voltage but is adequate for many simple applications.

The peaks become more pronounced when the load current increases, which introduces ripple into the supply. You'll sometimes hear this on a radio loudspeaker, for example, as "mains hum".

Getting Regulated

A major drawback with this simple circuit is that the output voltage will be **unregulated** (or *unstabilised*). If you draw more current, the voltage will gradually fall. Many circuits using digital logic or microprocessors need a good quality regulated supply which will stay *at the same voltage* even if more current is drawn.

An **integrated circuit *voltage regulator*** is excellent for this – they're easy to use and have several features not available with a Zener diode (see Part Two), including short-circuit protection and temperature overload shutdown. They ensure that no matter what the input voltage is, within reason, and no matter how much ripple there may be on the incoming supply, their output will always be a steady **regulated** voltage, regardless of the load current drawn.

How a typical three-terminal voltage regulator is used is shown in Fig.3.3. The suggested plug-in mains adaptor we are using in the practical lab demonstrations contains a transformer, four rectifiers and an electrolytic smoothing capacitor to smooth the resultant voltage. It also uses a *variable voltage* integrated circuit voltage regulator – the highly popular LM317 – to provide a range of stabilised voltages, see Fig. 3.4. Such devices usually need a ***heatsink*** to dissipate heat, but if they become too hot, they will electronically shut down.

In the accompanying **Lab Work** section for Part Three, we describe how you can make an easy-to-build 5V Add-on Regulator for use with your mains adaptor. This will, in fact, make your adaptor more versatile because you will then have both a +5V and +12V supply available at the same time.

Transistors

Transistors are semiconductor devices which provide control of voltages or currents using other (often

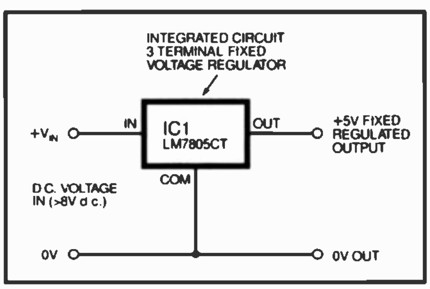


Fig.3.3. A standard 3-terminal voltage regulator provides a fixed d.c. output voltage independent of the current drawn by the load.

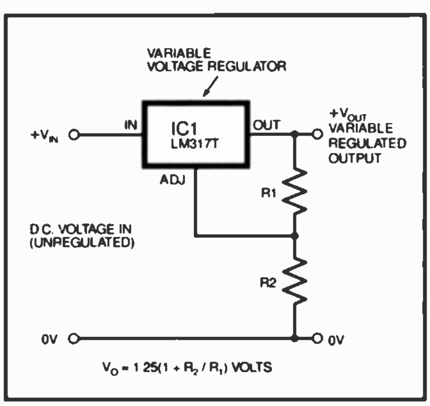


Fig.3.4. An LM317T 3-pin voltage regulator offers an output voltage which is determined by the values of resistors R1 and R2. (As used in the suggested mains adaptor.)

smaller) voltages or currents. This control can be between fully on and off states, like a mechanical switch, or proportionally so that, for example, a small variation in voltage can set the value of a large current.

Thus transistors can be used as **switches** in logic circuits, to switch higher-power loads on and off under the control of a much smaller signal, or to control routing of signals through circuits. They can also be used as amplifiers, for example in audio or video circuits.

There are a number of different families of transistors including the Bipolar Junction Transistor (BJT), the Junction Field Effect Transistor (JFET) and the Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET). Most electronics hobbyists are probably more familiar with the common-or-garden BJT than other types of transistor as these appear very frequently in our constructional projects.

Each of these transistor types is available in two basic forms: *n* and *p* versions which operate with opposite (negative and positive) voltages applied. Within each transistor family, a large number of devices with different individual characteristics, such as gain and power handling capability (see later), is available. Scan the pages of a supplier's catalogue to get an idea of the variety of devices on sale.

Crowd Control

Back to our January Sales! In previous sections of *Teach-In*, we have considered the flow of charge carriers within a conductor, in terms of an analogy:

Each "particle" of electric current – a charge carrier – has been likened to a shopper at the January Sales, driven by a desire to reach bargains (electrical potential) and forcing its way through corridors and paths of different "*resistance*" to get to them. In the same way, we could regard a *transistor* as a door into our store, operated by a hapless doorman whose job it is to hold back the thronging crowd!

Under telephone instructions from the management, the doorman can be told to close the door, so that no shoppers are allowed in (transistor *off*), or the door can be opened to permit them to pass (transistor *on*). It is even possible for the door to be set half way open, so that a restricted number of shoppers can go through.

If the door was held as wide open as possible then many people could pass through quickly (a *high* current flows), if it was held narrowly open then it would only allow people through at a slower rate (hence a *low* current flows). *A transistor works in the same way!*

Bipolar Transistors

How an "*npn*" transistor can be used to amplify a small current is depicted in Fig.3.5. The transistor has three connections, called the *Base* (b), the *Emitter* (e) and the *Collector* (c). A small signal (*base current*) at the input (base terminal) of a transistor can be used to make the transistor conduct a larger current on the output (through the emitter and the collector).

In this way the small base current can be ***amplified*** in the form of a larger collector current. When we use a transistor to amplify a signal in a radio or an audio system it is amplifying all the different levels which the analogue audio signal will contain.

These so-called "bipolar" (i.e. made with *p*-type and *n*-type semiconductor material) transistors are current-sensitive. The more current which we allow to flow into the base (b) terminal, the larger the current which will flow in the emitter (e) and collector (c) circuit. By making the small base current "wiggle", a larger collector current can be made to "wiggle" in sympathy.

There eventually comes a point where the base terminal is drawing so much current that the transistor cannot really conduct any more current; it is as though the door is held open as wide as possible to those shoppers! This state is called "*saturation*" which is encountered when the transistor is used as a switch, so it will either be on or off.

Biased for the Job

With an *npn* transistor, the base (b) terminal must be *biased* by about 0·6V or so more positive than the emitter (e), before the transistor will conduct. It is no coincidence that this is the same figure we saw in the previous part of *Teach-In*, as the *forward voltage* of a (silicon) diode.

Individual transistors are designed by manufacturers to perform a particular type of job. A "small signal" transistor is only really useful for dealing with exactly that – e.g. audio waveforms, such as those produced by a microphone. At the opposite end of the spectrum, a "power" transistor is a high power device which is capable of handling many amperes of current, and might appear as the final stage of an audio amplifier, say, driving the loudspeakers directly.

There are several characteristics relating to a transistor which you will find specified in manufacturers' data. It is beyond the scope of *Teach-In* to delve deeply into these ratings, but probably the most common ones quoted are *current gain* (given the symbol h_{FE}), *collector current* (I_c) and *power dissipation* (P_{tot}).

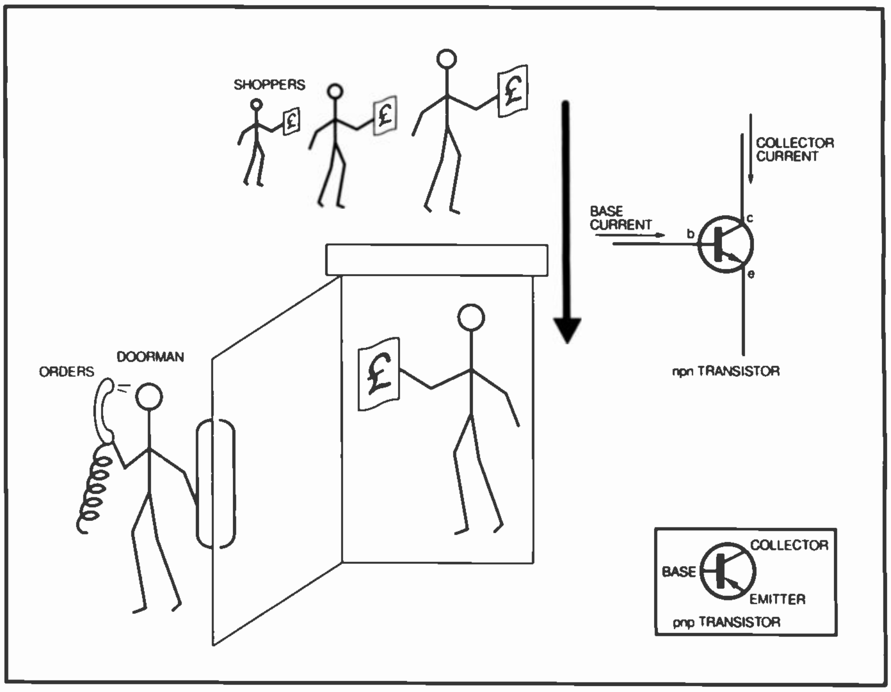


Fig.3.5. Shoppers behave as a current, which is controlled by a doorman obeying orders to open or close the door.

The **gain** indicates the "amplification factor" of a transistor, and implies how much current can be made to flow through the emitter-collector circuit in relation to how much base current is needed. The formula is $h_{FE} = I_c/I_b$. A gain of 250 indicates that under the right conditions, 250mA will flow in the collector if 1mA flows into the base.

The **collector current** I_c determines the absolute maximum current permitted – anything from 100mA for a small signal device to many amperes for a power transistor. As a rule of thumb, the collector current is roughly the same as the emitter current.

Power Game

We saw in Part One that **power dissipation** is the product of *voltage × current*, and it is just the same with transistors. If we know the voltage "across" the transistor (between emitter and collector), together with the collector current, then we can work out the transistor's power dissipation in *watts* (W), using $P = I \times V$. This figure *must not* exceed the rating P_{tot} quoted in the manufacturers' data or the device may overheat and be damaged.

Power transistors often need extra help to dissipate the heat, in the form of a ***heatsink*** – a bolt-on radiator which is very efficient at radiating heat away from the transistor. It is worth noting that if a bipolar transistor is in "saturation", switched hard on by lots of base current, then the voltage across the transistor's emitter/collector is very low, typically 0·2V or so. Hence, a transistor switch doesn't dissipate a great deal of power, even if it is conducting lots of current, but an amplifying transistor might well do, if it has a larger voltage across it.

The alternative flavour of bipolar transistor is a *pnp* type, which operates in the same way as the *npn* variety, only with reversed voltages and current flow. The base of a *pnp* type has to be 0·6V **more negative** than the emitter for the transistor to conduct.

This is useful in certain circuits where we might want to switch on a transistor with a "low" signal rather than a "high" signal. Current then flows **into** the emitter, and **out of** the collector.

When we use a transistor in a purely digital circuit (which, as you will discover, deals only with the values "0" or "1") then the transistor will be either **on** or **off**. In this latter respect we are using the transistor as a switch, or perhaps more accurately, a form of ***relay***.

It would theoretically be possible to make a computer entirely out of relays, using electromechanical switches instead of transistors. (This is how the first digital computers were actually constructed). We reckon that a relay-based equivalent of a Pentium microprocessor would cover an area equal to a good portion of Hull, and require quite a large power station to supply it (and unfortunately it would not quite be as fast as a Pentium. Nor could you play games on it.)

MOS Transistors

Probably the most common electronic component in the world is the **MOSFET** (Metal Oxide Semiconductor Field Effect Transistor). Some large digital devices such an Intel Pentium microprocessor contain millions of them on a single silicon chip (integrated circuit). The individual transistors can be extremely small, much less than one micron (one millionth of a metre) across.

Check Out: Transistors

The main *Teach-In* Tutorial describes the principle of operation of the bipolar junction transistor (BJT) and the Metal-Oxide Semiconductor Field Effect Transistor (MOSFET). You can supplement the text material by flicking through component catalogues to see what's on offer; you'll soon see that MOSFETs are everywhere these days. *Check Out: Transistors* looks at typical packages used to house transistors. What do they look like?

Transistors have three terminals – a BJT will have a base (**b**), emitter (**e**) and collector (**c**) whilst a Field-Effect Transistor (f.e.t.) possesses a gate (**g**), drain (**d**) and source (**s**). A *small signal* transistor is physically quite small and will usually have a plastic package, whilst a *power transistor* is a lot meatier in construction and is designed for high power applications in amplifiers, for example.

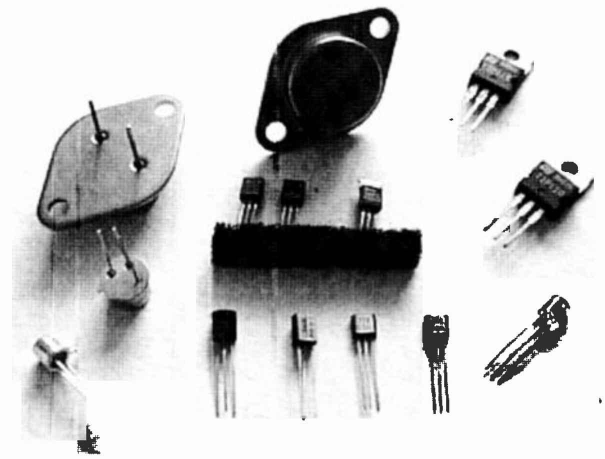
With experience, you will soon start to recognise common transistor names in circuits. As examples, the BC548 and 2N3704 are popular general purpose bipolar types for low power use. The 2N3055 is a large TO-3 type bipolar for high power circuitry.

The VN10KM is a popular low power general purpose MOSFET whilst the BUK456-60A is a TO-220 power MOSFET which will carry 52 Amps continuously! (Some of the latest MOSFETs include thermal overload circuitry making them almost indestructible.)

In Outline

The shapes of transistors are standardised, and they have peculiar-sounding names for their "transistor outlines". Common small-signal types include TO-18 and TO-5 metal cans, with a small "tag" identifying the emitter (**e**), and small plastic TO-92 cases.

Larger power types such as the TO-220 have a metal tab which is intended to enable the transistor to be bolted to a large *heatsink* – a radiator which dissipates heat and prevents the transistor from overheating. The larger metal TO-3 package only has two pins (emitter and base) – the collector is connected to the case. *Insulating kits* might sometimes be needed to ensure that devices such as these are electrically insulated from the heatsink or the chassis.



Although many transistors *look* the same, a big problem is that transistor *pinouts* (their connection diagram) can be completely different! This is especially so with similar-looking small-signal plastic types. The only sure way of fathoming this out is to check the manufacturer's or supplier's data. **Transistor pinouts are usually shown from the underside, looking up at the pins.** Incorrect connections are probably the commonest reason why transistor projects don't always work first time!

MOSFET transistors require extra handling precautions to ensure they are not damaged by static discharge – see the section *ESD – It's Shocking Stuff!* for more guidance. All transistors are semiconductors, and it is possible to damage them by heating them excessively during soldering iron operations. Read our separate section: *Check Out: Soldering.*

Although transistors are usually designed with one type of application in mind, very often it is possible to perform a substitution, since one particular transistor might have pretty similar characteristics to another. Often you can swap one sort for another – useful if you live in the United States and are trying to build a European circuit (or vice versa)!

Check Out: Soldering and First Aid

Soldering is the system used to form permanent electrical joints connecting the individual parts of a circuit together. There is no substitute for practising with a soldering iron, but like riding a bicycle, the skill once learned is never forgotten!

An electric soldering iron is used to conduct heat to all the parts of the joint, and then a short length of solder is dabbed onto the heated area. To make the successful joint, just follow these guidelines!

- An electric iron rated 15W to 25W is perfect for most general applications. Temperature-controlled irons are more expensive and are for dedicated enthusiasts and professionals, as are sophisticated "soldering stations".
- Ensure all parts being soldered are completely clean and free from dirt and grease. Old components may have oxidised, and this must be removed with, say, an abrasive rubber block specially made for the job. Solder will not "take" to dirty components, often forming an unreliable *dry joint* instead.
- Use 60%-40% tin-lead electronics solder for general use, 20 to 22s.w.g. (0·71mm to 0·91mm dia.). Do not apply a separate flux paste (e.g. as used by plumbers). Electronics solder already contains a flux (it's the brown bubbly liquid).
- Clean the hot soldering iron tip ("bit") on a damp sponge and "tin" it with a small amount of solder – do this immediately you use a new bit for the first time.
- Heat all the parts with the bit for a few seconds, then apply a few millimetres of solder to the heated parts, allowing it to flow over all the joint area.
- Remove the iron and allow the joint to cool. The perfect joint will be quite shiny, not dull or grainy-looking.

It should take no more than three or four seconds to make the average solder joint but semiconductors (diodes, transistors and integrated circuits) are thermally sensitive and should be soldered into place as quickly as possible to avoid damage. Remember to take anti-static discharge precautions before handling CMOS semiconductors (e.g. MOSFETs) – see *ESD – It's Shocking Stuff.*

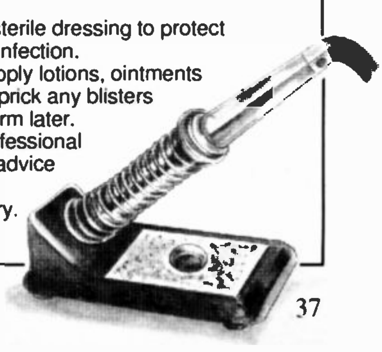
You might find either a solder sucker or a small reel of desoldering braid useful for the times when you may need to remove any excess solder, or when removing a component from a board. An excellent resource is available on-line, for Internet users. See the popular *EPE Basic Soldering Guide* on our web site at **http://www.epemag.wimborne.co.uk/solderfaq.htm.** Additionally, a series of close-up colour pictures is available on-line showing the process step by step.

Heat conducts through copper wires extremely efficiently, so use fine-pointed pliers for holding any parts, or hold the work piece in a hobby vice or similar. A soldering iron stand is a must for storing the hot iron in between use. **Never hang an iron on the bench, with the exposed hot tip pointing upwards.**

First Aid

Which brings us to FIRST AID: accidents never happen, they are caused! In the unlikely event of receiving a burn from a hot iron (or component) which requires treatment, then:

- **Immediately** cool the affected area with cold running water, ice, or even frozen peas, for at least ten minutes.
- Remove any rings etc. before swelling starts.
- Apply a sterile dressing to protect against infection.
- Do not apply lotions, ointments etc. nor prick any blisters which form later.
- Seek professional medical advice where necessary.



The name **MOSFET** comes from the structure of the transistor which consists of three layers, namely *metal*, *oxide* and *semiconductor*. In fact, on silicon-based integrated circuits ("silicon chips") the metal is replaced with polycrystalline silicon containing impurities to make it highly conductive, but the name has stuck. High conductivity polycrystalline silicon is used to form the gates of MOSFET transistors, as well as some transistor interconnections (interwiring).

A simplified structure of a MOSFET is shown in Fig. 3.6 (see the panel *How The MOSFET Works*). The basic operation of the MOSFET involves the control of current flow between the source (s) and **drain (d)** terminals, by applying a voltage to the gate (g) to form an electric field. Note that the oxide is an insulator and so the gate, oxide and channel terminals form a **capacitor** with the oxide acting as a dielectric.

The transistor shown is an *n-channel* MOS (NMOS) transistor which will be switched on by a *positive* gate. We can also make *p-channel* transistors (PMOS) which are switched on by a *negative* gate voltage.

Circuits which utilise both of these types of MOS transistor are called CMOS (Complementary MOS). There is a large range of CMOS digital integrated circuits available, as some readers will know.

It is also possible to make MOS transistors which are "normally on", because the conducting channel is created during manufacture, and can be switched off by the application of a gate voltage. These are known as *depletion mode* MOSFETs, whereas the "normally off" device described in Fig. 3.6 is an *enhancement mode* MOSFET. Both *n* and *p* type (NMOS and PMOS) depletion mode devices are available.

For each type, a large number of discrete devices with different individual characteristics, such as gain and power handling capability, are available. Scan the Semiconductors – "Discrete devices" pages of a supplier's catalogue to get an idea of the variety of MOSFET transistors available. (A discrete device is a *single* component – the opposite of *integrated* circuits, which contain lots of individual devices connected together.) MOSFETs now occupy an increasing proportion of catalogues, indicating that they are fast catching on as the standard switching and amplifying component.

The insulating gate oxide of a MOS transistor is very thin, typically within the range 100Å to 1000Å (an Angstrom is one ten-thousandth of a micrometer), and is therefore very susceptible to damage by *electrostatic discharge*. This is why CMOS digital chips and individual MOS transistors are supplied in conductive foam or conductive bags, and why technicians repairing equipment such as PCs wear earthing straps.

You will read that static electricity is a major cause of damage to MOS circuits, and special precautions are needed to ensure that MOS devices (transistors and integrated circuits) are not accidentally destroyed by electrostatic discharges (ESD). Check the panel *ESD – It's Shocking Stuff!*

JFETs are field-effect transistors (f.e.t.s.) which utilise *n*-type and *p*-type semiconductor materials, of the type used in junction *npn* and *pnp* transistors (BJTs). JFETs are becoming increasingly obsolete as MOS technology with its many advantages, has taken over from bipolar construction.

How the MOSFET Works

Looking at the cross-sectional diagram of the MOSFET transistor we see that the **drain (d)** and **source (s)** are labelled *n* while bulk silicon, or **substrate**, in which the transistor is fabricated is labelled *p*. These refer to different types of added chemical impurities which change the electrical behaviour of the silicon. It is beyond the scope of this series to go into great depth about the semiconductor physics behind the operation of transistors, but we think it's important to cover a few basic concepts to give you some idea of how the MOSFET works.

The *n* and *p* type regions are so called because the *charge carriers* within them are negatively-charged and positively-charged respectively. In a metal, the charge carries are all electrons (akin to those shoppers we introduced in Part One) which are negatively charged, but in semiconductors we can have both negative and positive charge carriers – electrons and "holes" (a space in the structure waiting to be filled by a moving electron), respectively.

What's the Attraction

At the risk of being politically incorrect, we could extend the shopper analogy to liken women to negative charge carriers attracted to bargains, whereas their husbands were positively charged and therefore repelled by any possibility of spending money on shopping, causing them to move in the opposite direction! Charges of opposite polarity are attracted to each other and similar charges repel each other, like the poles of an ordinary magnet.

In Part Two we discovered that a diode only conducted in one direction. An ordinary diode is actually a semiconductor device formed by adjacent *n* and *p* regions of semiconductor (forming a *p-n* junction).

Knowing this and looking at Fig.3.6, we see that between the source and drain we have two *p-n* junctions in opposite directions (trace a path from source to drain: you go from the *n* source into the *p* substrate, and then from the *p* substrate to the *n* drain). This resembles two "back-to-back" diodes which will therefore not conduct in either direction. This is the situation when the transistor is switched **off**.

Now if we apply a positive voltage on the **gate (g)** of the transistor, electrons (being negatively charged) will be attracted to the region labelled **channel** on the diagram, which is the region directly underneath the gate. Note that the gate, oxide (dielectric) and channel together form a

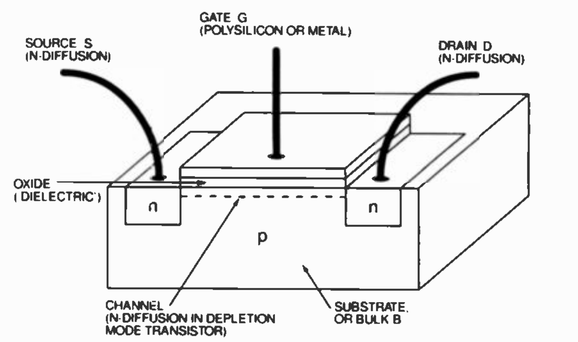


Fig.3.6. Cross section of a MOSFET transistor. Showing the oxide layer which acts as a capacitor dielectric between the channel and gate.

capacitor, so what we now have is basically the formation of an equal and opposite charge on the other plate of the capacitor, in the channel.

If you're with us thus far, you're perhaps thinking where did these negatively-charged electrons come from, since the channel is in the region labelled as *p* and should contain positive charge carriers? The answer is that *both* types of charge carrier are present in all semiconductors, but the *p* and *n* labels actually indicate which type is dominant. So negative electrons *are* available in *p*-type material and will move into the channel, attracted by the positive voltage we have applied to the gate.

If we apply a large enough voltage (typically a volt or so) to the gate then we will attract sufficient negative electrons under the gate so that they are more numerous than the positive "holes" already there, creating an *n*-type region. This *n*-type region then links the *n*-type source and drain, and provides a conducting *n*-type channel (hence the back to back diodes (*np*, *pn*) are bypassed). Thus, the application of the gate voltage creates a conducting channel allowing *current* to flow either way between the source **(s)** and the drain **(d)**.

In this state the transistor is switched **on**. The voltage required between the gate and channel to switch the transistor on is called the *threshold voltage* and is denoted V_T or $V_G(th)$ on the data sheets. For discrete devices typical values range from about 1·5V to 4V (positive or negative for *n*- and *p*-channel).

F.E.T. Symbology

The schematic symbols for the commonest JFETs and MOSFETs are shown in Fig. 3.7. Note that simplified forms of these symbols are quite commonly used, particularly for logic circuits, and you may come across further variations of these symbols.

In particular, note the directions of the arrowheads used in some symbols. In the case of *n*-channel enhancement MOSFETs (the commonest ones you will probably deal with), the arrow on the *simplified* symbol points *outwards* on the *source* (s) terminal. In the *full* symbol, though, the arrowhead shown represents the *substrate diode*, and points in the opposite direction, being the equivalent of a reverse biased diode.

How NMOS and PMOS transistors can be used to switch current on an off through a load is shown in Fig.3.8. A flying lead is connected to the gate (g), and a load (e.g. a lamp or solenoid) is wired to the drain (d). Note that because the MOS transistor gate is a *capacitor*, then unlike an ordinary BJT, it does *not* need a continuous current to the gate to hold the transistor on or off.

If the flying lead is removed, then the transistor would remain either on or off as it had been prior to the removal of the lead, as least for a short while, due to the voltage stored on its gate capacitance. This ability of the MOS transistor to "remember" its state is the principle behind dynamic RAM and other types of "dynamic data storage" in advanced digital circuits.

In Fig. 3.8, the MOSFET can be thought of as being equivalent to a mechanical switch (but under the control of the gate voltage, rather than a human finger!). This analogy is not completely accurate because transistors have a relatively high "*on*" resistance (called $R_{DS(ON)}$ in data sheets) and often cannot be regarded as anything near a perfect short-circuit when on.

The on resistance of low power MOS transistors varies from about 1 to 50 ohms. The MOS transistors used on digital integrated circuits are usually much smaller devices with much higher on resistances (100s or 1000s of ohms or more).

On the other hand, "power MOSFETs" are available which are able to switch high current loads and can have on resistances as low as 0·03Ω (30 milliohms). The MOS transistor is not a perfect open-circuit (it does not have an infinitely high resistance) when switched off either, but the resistance is still very high and results in only a very small *leakage current* through the device.

Another important parameter is the f.e.t.'s drain current rating I_D which is the maximum current allowed to flow without damage. They will also have a maximum power dissipation value, P_{TOT} in watts.

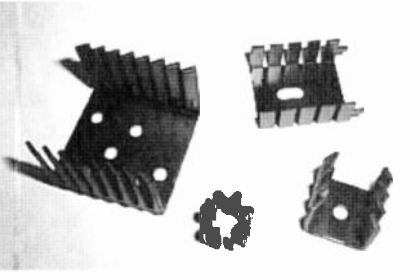
Complementary Switching

It is worth considering a few further points about the circuits in Fig. 3.8. Firstly a couple of practical things; if you actually attempted to build them, then the load *must not take more* current that the transistor is able to handle (I_D), and the flying lead may put the transistors at risk from static damage: see the separate topic *ESD: It's Shocking Stuff!*. A high value resistor between the gate and ground (0V) would help.

Secondly, note the difference between the *n*-type and *p*-type transistors: the *n*-type is ON when $+V_{SUPPLY}$ is connected to its gate and off when 0V is applied, whereas the *p*-type transistor is ON when its gate is at 0V and OFF when $+V_{SUPPLY}$ is connected. The transistors are ON and OFF under *opposite* conditions on their gates and it is this *complementary* switching action which is the basis of CMOS – Complementary Metal Oxide Semiconductor – digital circuits.

CMOS Inverter

The circuit shown in Fig. 3.9 uses two complementary MOSFETs to form a **CMOS inverter**. This circuit produces



Heatsinks help to protect semiconductor devices from "overheating" and come in all different forms and sizes.

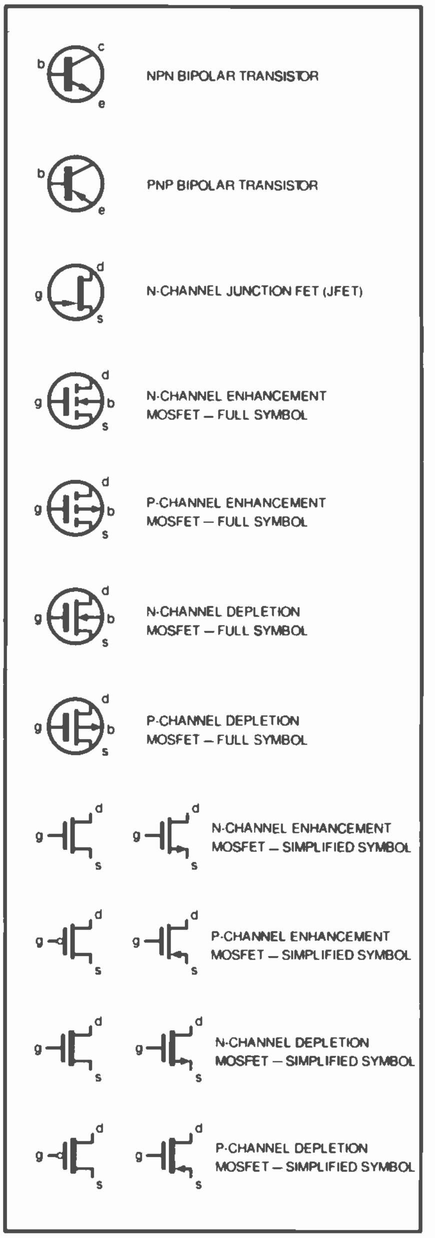


Fig.3.7a. Bipolar npn *and* pnp *transistors, JFET and MOSFET symbols, and variations commonly encountered.*

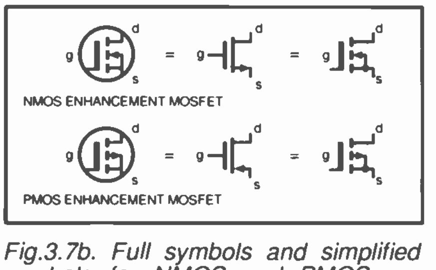


Fig.3.7b. Full symbols and simplified symbols for NMOS and PMOS enhancement MOSFETS.

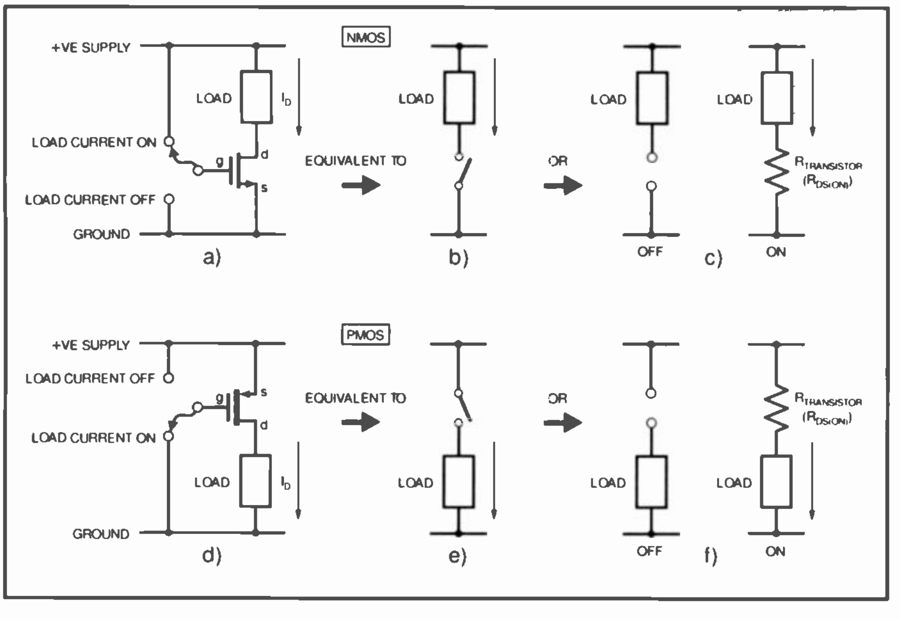


Fig.3.8. MOSFETs can be thought of as switches. (a) to (c) n-MOS *types require a high gate voltage to operate the load. (d) to (f)* p-MOS *require a low gate voltage.*

an *output* voltage which is the opposite of its *input* voltage (i.e. *inverted*). That is, an input of 0V gives an output of $+V_{SUPPLY}$ and an input of $+V_{SUPPLY}$ gives an output of 0V.

This can be explained as follows. If the input is connected to $+V_{SUPPLY}$ then the *p*-type transistor is OFF and the *n*-type transistor is ON. This effectively connects the output to 0V via the *n*-type transistor.

If the input is changed to 0V, the *p*-type transistor is ON and the *n*-type transistor is OFF, thus connecting the output to the positive supply via the *p*-type transistor. Hence, the output is the opposite voltage to the input.

You have actually just encountered your first *digital logic function*! We will see in the next part that the inverter, or "NOT function", is just one of several types of basic *logic gate* which are used to build digital circuits.

ESD – It's Shocking Stuff!

Ever had a nasty electric shock from a metal-framed plastic chair, or a filing cabinet, or when touching your car door handle? *Static electricity!*

A major problem concerning the handling of MOS devices is that of *electrostatic discharge* – ESD for short. The human body can quickly accumulate a static charge of several tens of thousands of volts, simply by walking across a nylon carpet. This is then discharged to "earth" when you touch an earthed object, hence the nasty tingling shock.

ESD can play havoc with modern electronic circuits. Whilst CMOS digital devices usually incorporate some protection (internal diodes which short away any static charges before they can do any damage) it is always wise to take special care so that you ensure you are not storing a static charge on your body (or any tools or equipment you are holding), prior to handling sensitive electronic components. Otherwise, this static charge is often enough to destroy CMOS components.

You can do this by grasping an earthed part before you handle a CMOS device, in order to sink any accumulated static charge to earth. Alternatively, you can buy special earthing wrist-straps. These connect directly to the mains earth via a high value resistor (say 1M). Special anti-static bench mats can be used which are made of conductive rubber compounds which are also connected to the mains earth via a resistor, and they dissipate static electricity away before it can do any harm.

A modestly-priced wrist-strap will be of help and reassurance, but otherwise, *don't forget* to touch an earthed object before handling CMOS devices.

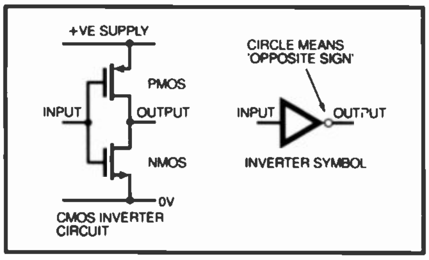


Fig.3.9. Two complementary (NMOS/PMOS) MOSFETS together form an inverter. The output is the opposite of the input. A logic symbol of an inverter (a "NOT" gate) is also shown.

The *logic symbol* which is used to represent an *inverter* is also shown. In particular, note the *circle symbol* placed at the output. This is shorthand for "inversion takes place" and this symbol is something you will see repeatedly when we discuss logic functions, starting with the next part of *Teach-In*.

Delayed Action

If we connect *two* inverters in series, as shown in Fig. 3.10, then the output of the first inverter will cause the second to switch. Thus with an input of 0V, the output of the first inverter (the "mid point") will be at +V (the positive supply rail) causing the output of the second inverter to be at 0V. With an input of +V, the mid-point will be at 0V and the output at +V (as shown); the input has therefore been "double inverted".

Now consider what happens during the very brief time when the input is *changing*. For example, assume the input changes from +V to 0V. This will switch the first inverter's *p*-transistor ON and its *n*-transistor OFF. At the moment of switching, the mid point will be at 0V due to the previous input of +V.

The mid-point is also connected to the gates of the two MOSFET transistors of the second inverter, which we recall are in fact capacitances. Thus at the moment of switching we effectively have a capacitor with 0V on it, connected to the mid-point.

The first inverter's *n*-transistor has just switched OFF, so we can now ignore it, but its *p*-transistor is ON and is therefore acting like a resistor (with resistance equal to the transistor's on-resistance) connected from the supply to the mid point. *Therefore, during the period just after the input switches states, the gate capacitance of the second inverter charge up from 0V towards +V, through the on resistance of the first inverter.*

The second inverter will not switch immediately after the input changes but will have to wait for its *gate capacitance* to charge to a sufficiently high voltage to make it switch. This will result in a **propagation delay** between the input changing state, and the output responding.

Note that the resistor-capacitor (*RC*) charging curve (Fig.3.10) which we met in the previous part of *Teach-In*, and appears at first sight to be an "analogue electronics" thing, is of fundamental importance in digital circuits. At the most fundamental level, all circuits are analogue in nature, dealing with signals which vary, but digital design uses simplifications and abstractions to enable designers to mainly ignore the detailed behaviour of individual transistors.

Delays occur in all digital circuits and great efforts are made by chip designers and manufacturers to get them as small as possible. The smaller the switching delays, the faster the circuit can work.

In the next part of *Teach-In*, we will start to investigate digital functions, commencing with logic gates. Now go to the **Lab Work** section for constructional details of the simple 5V Add-on Regulator which will equip your Mains Adaptor for powering a variety of logic demonstration circuits in the following parts of *Teach- In*.

The *Teach-In* writers are delighted to receive your comments, feedback and queries. You can write to us at *Teach-In* c/o the Editorial address, or E-mail **Teach_In98@epemag.demon.co.uk.**

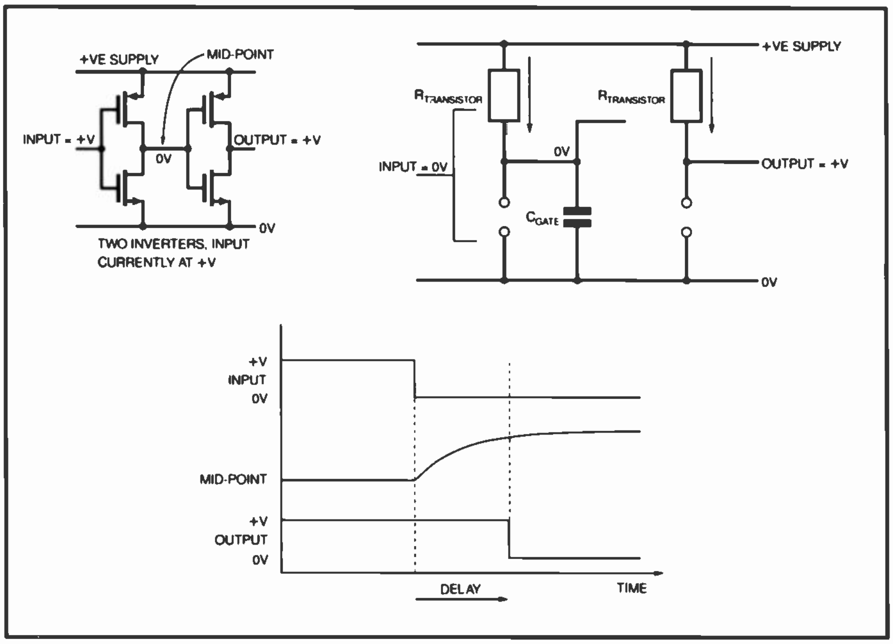


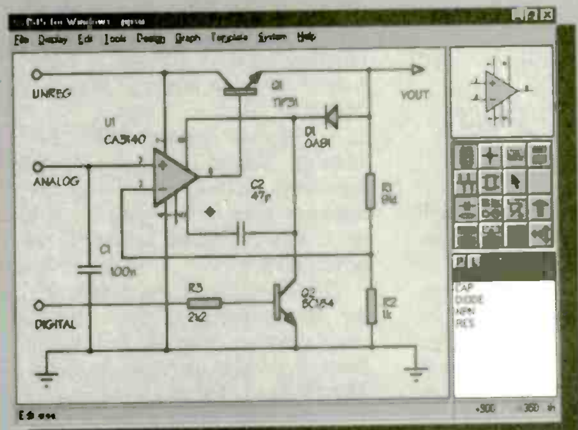
Fig.3.10. Two CMOS inverters exhibit "propagation delay" caused by the time needed for the gate capacitance on the second inverter to charge via the ON-resistance of the first inverter.

PROTEUS

The IVth Generation

Schematic Capture

NEW Version IV



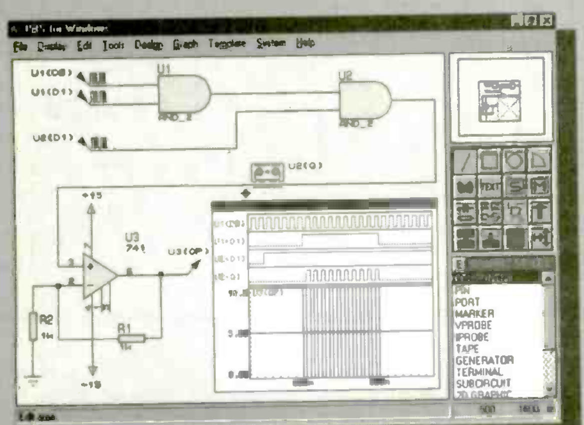
●Produces attractive schematics like you see in the magazines. ●Netlist, Parts List & ERC reports. ●Hierarchical Design. ●Full support for buses including bus pins. ●Extensive component/model libraries. ●Advanced Property Management. ●Seamless integration with simulation and PCB design.

New Features

Component Auto-Placer
Pinswap/Gateswap Optimizer
Background Regeneration of Power Planes
Enhanced Autorouting with Tidy Pass
Full Control of Schematic Appearance
Extensive New Component Libraries

Available in 5 levels - prices from £295 to £1625 + VAT.
Call now for further information & upgrade prices.

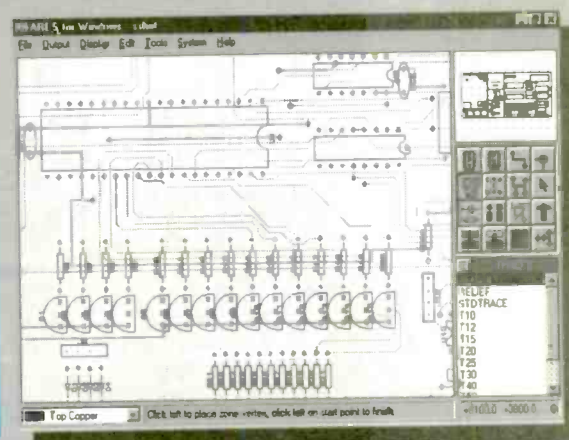
Simulation



●Non-Linear & Linear Analogue Simulation. ●Event driven Digital Simulation with modelling language. ●Partitioned simulation of large designs with multiple analogue & digital sections. ●Graphs displayed directly on the schematic.

PCB Design

NEW Version IV



●Automatic Component Placement. ●Rip-Up & Retry Autorouter with tidy pass. ●Pinswap/Gateswap Optimizer & Backannotation. ●32 bit high resolution database. ●Full DRC and Connectivity Checking. ●Shape based gridless power planes. ●Gerber and DXF Import capability.

"PROTEUS is particularly good with its rip-up-and-retry autorouter"

EWW January 1997

labcenter Electronics

Write, phone or fax for your free demo disk, or ask about our full evaluation kit.
Tel: 01756 753440. Fax: 01756 752857. EMAIL: info@labcenter.co.uk
53-55 Main St, Grassington. BD23 5AA. WWW: http://www.labcenter.co.uk

Fully interactive demo versions available for download from our WWW site.
Call for educational, multi-user and dealer pricing - new dealers always wanted.
Prices exclude VAT and delivery. All manufacturer's trademarks acknowledged.

TEACH-IN '98

LAB WORK 3

Objective: Construct a Simple 5V Add-on Regulator power unit suitable for use with "digital logic" circuits. This will be necessary for future Lab Work demos.

PRACTICAL work for this month's Lab Work describes the construction of a simple 5V Add-on Regulator accessory for use with any typical mains adaptor capable of supplying 12V at 500mA or so. The idea is that this additional regulator will generate a stable 5V supply, which is suitable for the majority of logic circuits. This will be necessary for future demonstrations of digital logic in *Teach-In*.

The design is very simple to construct and will be an ideal challenge for novices and beginners; it combines a little bit of mechanical handiwork, plus a limited amount of soldering.

Circuit Details

The circuit diagram of the 5V Add-on Regulator accessory is shown in Fig. 3.11. The design is essentially based around an ordinary 3-terminal fixed voltage 5V regulator, IC1. (See *Teach-In* Part 3 for details of their operation.) The input voltage is derived from your mains adaptor, and should be anything from 9V d.c. upwards.

The voltage regulator device IC1 is an LM7805CT which is a 5V 1A type. However, it will allow *considerably* higher currents to pass initially, say up to 1·5A or more, but like all devices of this type it is short-circuit proof and thermal overload proof. It will automatically limit the current under overload conditions, to prevent the chip fusing internally; it will also shut itself down if its temperature rises excessively.

Indeed, virtually the only way to destroy IC1 is to connect it incorrectly! But be aware that IC1 can deliver well over one amp before current-limiting, so caution is needed to ensure that the mains adaptor is not unduly overloaded in use. Otherwise the chip is surprisingly tolerant of abuse.

The 12V input supply is connected via SK1, which is a d.c. power socket (see parts list and *Shoptalk* page) to match a corresponding d.c. plug (2·1mm size) of the mains adaptor. Hence, your mains adaptor can be plugged directly into the 5V regulator, and there is no need to cut off the mains adaptor's wire or make up an adaptor lead.

You will probably want to use your mains adaptor for other jobs around the house or workshop later on, so you will probably opt for the option of using a socket (SK1) into which you can plug your mains adaptor directly. You can substitute SK1 for anything else available.

The rectifier D1 only conducts one way round (see Part Two of *Teach-In*), and is included as a reverse-voltage protection device to safeguard the regulator if you reverse the input voltage accidentally. (D1 introduces a 0·6V forward voltage drop as a side effect, but this isn't important in this design.)

A polyester capacitor C1 helps with stability. You will often see "decoupling" capacitors dotted around circuits for no apparent reason, but they help to counteract any noise and localised dips in the power rails.

The 5V voltage is taken from IC1 output pin. Being stabilised, this voltage will not change value even if the current drawn from the chip increases (within limits). The 5V rail is fed to an output socket SK3 via one half of a d.p.d.t. (double-pole double-throw) switch S1b; the light-emitting diode (l.e.d.) D2 glows to show that the 5V rail is switched on. R1 is its limiting resistor.

- Given an output voltage of 5V, and assuming a forward voltage of 1·8V for the l.e.d., 3·2V will appear across the series limiting resistor R1. The current flowing through both the resistor and l.e.d. will therefore be 3·2V/330 ohms = 9·7mA. (Also refer to **Lab 2.6.**)

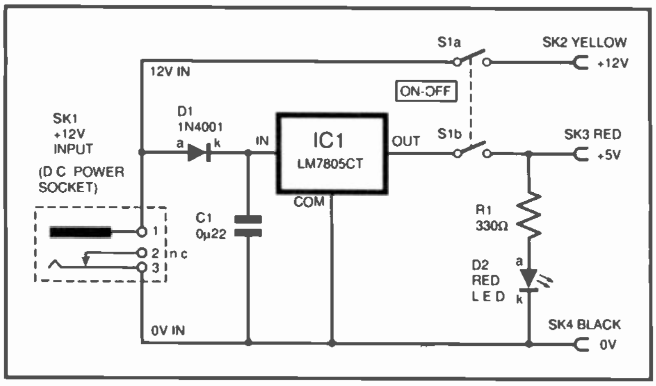


Fig.3.11. Circuit diagram for the 5V Add-on Regulator.

Dual Voltage

As an extra feature, the unit's input voltage is also fed through to an output socket (SK2) via switch S1a contacts.

You Will Need

Resistor
R1 330 ohm 0·25W 5% carbon film

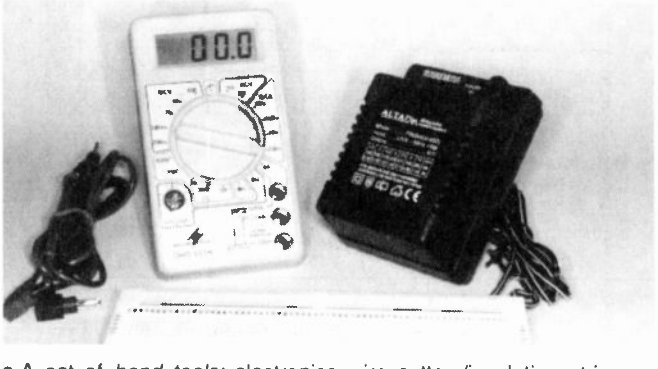
Capacitor
C1 220n polyester capacitor

Semiconductors
IC1 LM7805CT 5V 1A regulator i.c. or equivalent type
D1 1N4001 rectifier
D2 5mm red l.e.d.

Miscellaneous
SK1 2·1mm chassis fixing d.c. power inlet socket
SK2 to SK4 4mm terminal (binding post) yellow, black, red (3 off)
S1 d.p.d.t. rocker switch

Mounting clip for D2; aluminium box 140mm × 70mm × 40mm approx.; TO-220 insulating kit; adhesive rubber feet (4 off); hook-up wire, solder, M3 fixing bolt for IC1, etc.

- A *mains adaptor power supply* capable of producing 6V, 9V and 12V d.c., and around half an amp (0·5A) of current.
- A modest *digital multimeter* (DMM) capable of measuring d.c. voltages, d.c. current (perhaps with a 10 amp socket), and resistance up to 2MΩ or more, will be fine.



- A set of *hand tools:* electronics wire cutters/insulation strippers, pointed-nose pliers, flat-blade screwdriver to get you started. Plus, of course, a *soldering iron*.

When considering your lab work, it is worth bearing a few things in mind. You'll discover that many components are fussy about their polarity (i.e. which connection is *positive* and which is *negative*). Incorrect connection can therefore have potentially messy (and expensive) results. Do NOT adjust your circuit with the power *switched on*; assemble everything first, check it and then apply the power.

Thus, there is now available a +5V and +12V supply for your experiments. The 0V rail is fed directly through to SK4, and note that it also connects to the "common" terminal of the regulator IC1. The total current drawn from *both* outputs ***must not*** exceed the maximum your adaptor is capable of providing, though.

It is important that the design is built into a **metal** box. This is to help "heat-sink" IC1 under maximum output conditions. Assuming a 12V input to IC1, then with a 5V output, 7V will appear across the regulator. The maximum current provided by the suggested adaptor is roughly 600mA (0·6A). This means that IC1 could be forced to dissipate $P = I \times V = 4{\cdot}2W$ (watts) at maximum current conditions.

- If the 5V output was accidentally shorted out to 0V, IC1 will *not* be damaged but it will ***current limit*** at anywhere between 1A to 1·5A.

However the full 12V is then placed across the regulator i.c., which will dissipate up to $12 \times 1{\cdot}5 = 18W$ maximum! (But only until it thermally shuts down to protect itself, which could take several minutes.)

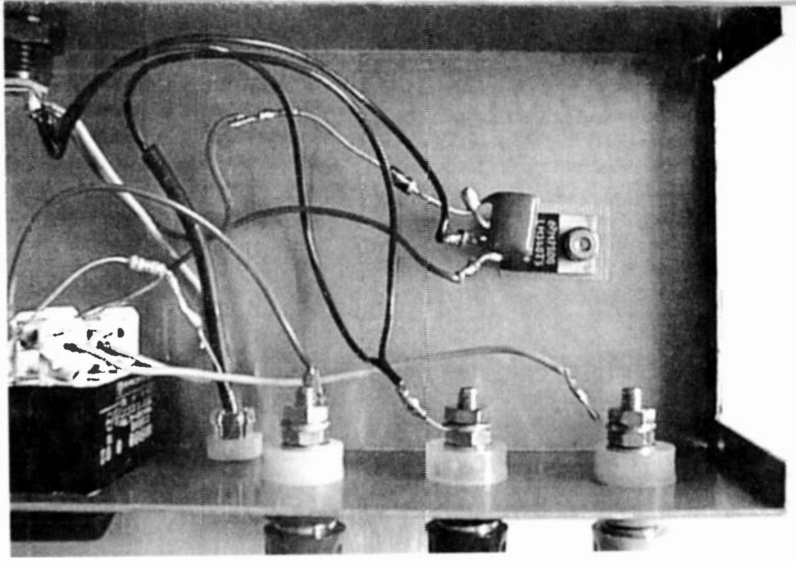
- Incidentally if the 12V rail SK2 was shorted to 0V we now depend upon the mains adaptor limiting the current, instead.

Construction Starts Here . . .

The unit is best assembled in an aluminium box for ease of working. The prototype measured 140mm × 70mm × 40mm. Fig 3.12 is the interwiring diagram. Everything is wired "point-to-point" because there are very few parts to assemble, and the rigidity of the wiring will be sufficient to ensure that nothing will short together.

The metal case should be drilled to accept the four sockets, light-emitting diode and switch. Switch S1 was a rocker type in our prototypes, requiring a rectangular cut-out: use a fretsaw or drill a series of holes then file to shape. A 3mm hole is needed in the base for IC1, and usually a 6·35mm (¼in.) diameter hole suffices for most l.e.d. mounting clips.

The metal mounting tab of IC1 is also internally connected to its "common" terminal. It is best (though not strictly necessary in this design) to insulate the device from the case using a TO-220 insulating kit:



a plastic bush insulates the mounting tab from the screw and a specially-shaped washer isolates the face of the metal tab from the case. Assemble the insulating kit loosely, align everything then tighten the mounting nut and screw to secure IC1 firmly into place on the bottom of the case.

Diode D1 and capacitor C1 can be soldered directly to the lead outs of IC1 as shown, observing the correct polarity of D1. Take care not to overheat these solder joints – three or four seconds should be adequate. The l.e.d. D2 is fitted with a plastic mounting clip (we used a transparent "lens" clip), and the flat detent on the l.e.d. body denotes the *cathode* (*k*) when viewed from the underside. Solder resistor R1 directly as shown.

The three 4mm terminals (binding posts) SK2 to SK4 MUST be insulated from the metal case, using the mounting hardware provided. Connections are made to them using a solder tag supplied, and all wiring can be completed using standard general purpose insulated hook-up wire. (You might want to confirm the switch solder tag layout with your ohmmeter (multimeter) – see **Lab 1.2.**)

Finish off by adding four self-adhesive cabinet feet underneath, and you can embellish the case with rub-down lettering (e.g. Letraset) as desired.

Testing

Prior to powering up, check the wiring carefully, looking closely to ensure there are no short circuits on IC1 or l.e.d. D2. Set your mains adaptor to 12V at the appropriate polarity (the inner core of a d.c. power plug is *positive* in this design) and switch on at S1.

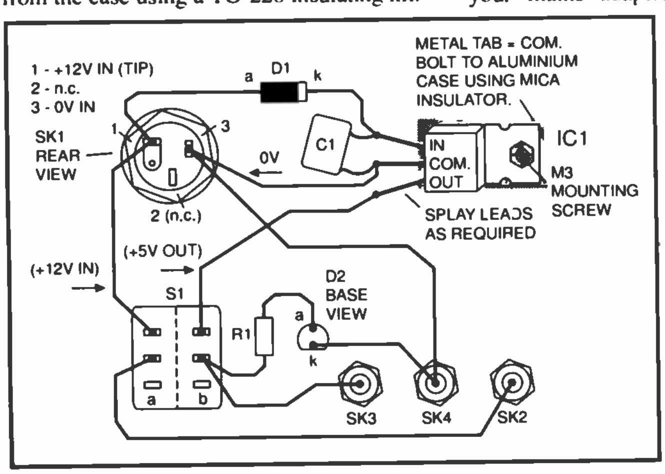


Fig.3.12. Interwiring details. IC1 is bolted to the metal case base using a mica washer and plastic bush to provide electrical insulation. See also photograph above.

The l.e.d. should illuminate and you should measure 5V across terminals SK3 and SK4 with a multimeter. If not (and you'd have to be very unlucky for it not to work first time) check diode D1 polarity and ensure that 12V is present at the input to IC1, and check the wiring to the regulator; ensure that the 4mm terminals are all *insulated* from the metal case.

- D2, when illuminated, indicates normal operation. If it should suddenly extinguish in use, it may be because there is a short circuit somewhere across the 5V supply, perhaps a fault with the load (e.g. a digital circuit being tested). Switch off and check your test circuit.
- You should restrict the total current drawn to the maximum which your mains adaptor can sustain (595mA for the type recommended).

End of Lab 3 Tasks

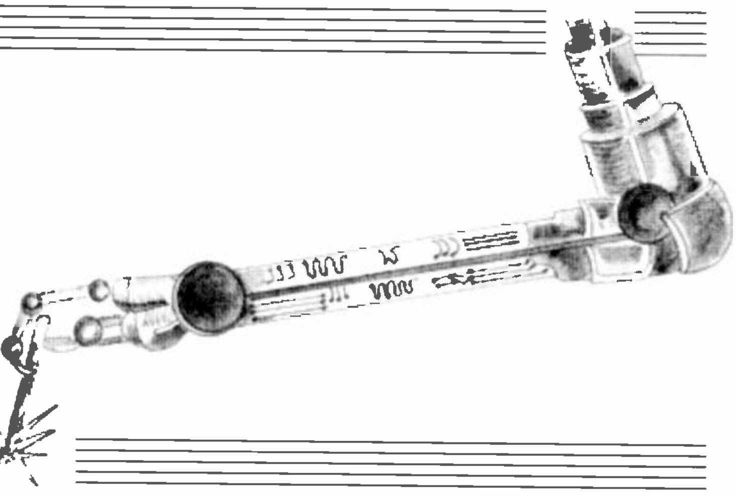
At the end of **Lab 3**, you have successfully constructed a handy 5V Add-on Regulator unit. Well done! You are now ready for the next part of *Teach-In*, when we start to check out digital logic integrated circuits.

In Lab Work 4: We start to investigate digital logic chips and functions, demonstrating logic types and i.c. families, then progressing into more advanced logic systems.

Your solderless breadboard will be used for assembling the simplest of circuits, but in due course you will find it very useful to have a second breadboard available. As an alternative, we will introduce *wirewrapping*, a way of prototyping more complex systems, so you can use whichever system works for you.

Regular Clinic

CIRCUIT SURGERY



ALAN WINSTANLEY

Our monthly Surgeon gets audibly quizzical, then takes the lid off Zener diodes and thyristors, looking at various application circuits for these modestly priced but useful discrete devices. Plus, a look at "crowbarring" of power supplies.

Quick Quiz

The Surgery, as busy as ever, starts with a project query from ***Eamonn Fitzpatrick*** who E-mailed a quick question concerning the *Multi-Station Quiz Monitor* project (October 1997 issue). He asks:

I am interested to know whether it is possible to add an audio dimension to the Quiz Monitor *project. Even a single tone to indicate that a button had been pressed would do, rather than the more complicated option of having different tones related to different teams. Many thanks!*

Robert Penfold's design is a straightforward battery-operated circuit which uses four thyristors (silicon controlled rectifiers) to provide a "who pressed first" latching system for quizzes and competitions. Being built on stripboard, it's a great project for beginners and old hands alike.

When a thyristor is triggered into conduction by applying a suitable signal to its gate terminal, it then remains in this conductive state even if the triggering signal is removed. In the *Quiz Monitor* design, when an individual channel (there are four) is triggered by the contestant who presses their button first, this triggers their respective thyristor. This not only illuminates the contestant's l.e.d. signifying the winner, but it also causes the triggering current for the other three channels to be shunted away from their gate terminals, locking them out of the race!

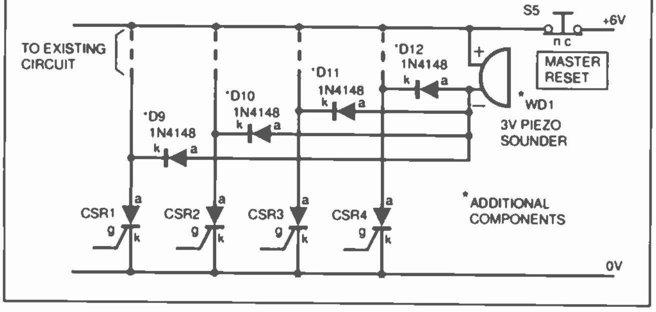


Fig. 1. Adding an audible warning device to the Multi-Station Quiz Monitor.

The circuit does this with a series of diodes (D1, D3, D5 and D7, see page 693, October 1997) which will direct the main trigger supply into the anode of the single conducting thyristor. The same kind of technique could be used to add an audible warning device to the circuit, and the bleeper would sound as soon as one of the thyristors triggered. Fig. 1 shows one idea for experimenters.

Four more diodes are used, except this time they will allow current to flow through a buzzer (WD1) into the anode of the conducting thyristor. The buzzer will sound when any thyristor conducts. The diodes are needed to isolate each channel from all the others.

The only way to silence the buzzer will be to press the Master Reset button, a normally closed switch (S5). Incidentally, there are alternative ways in which a conducting thyristor can be reset:

- allow the current flowing through the thyristor to drop below the thyristor's "holding current" (typically just a few milliamps);
- reduce the voltage between anode and cathode, to less than the forward voltage (e.g. by shorting anode to cathode with a switch). This is also a good way of incorporating a combined "test/reset" switch, because closing such a switch will reset a conducting thyristor and also power up any load in the anode circuit.

Because 0·6V is lost across the extra diode, and typically 1V is lost across the thyristor as "forward voltage", a 3V or 4·5V buzzer would be adequate. Fortunately the design is constructed on stripboard so it is possible to modify the circuit quite easily, as there is some spare room available on the circuit board to add the extra diodes.

Zener Diodes

Meantime, ***Chris Friskey*** of Stamford in Lincolnshire asks:

I always enjoy the magazine and Circuit Surgery *is brilliant and very useful!* (Flattery gets you everywhere, Chris! More!) *My question concerns "Zener" diodes – can you tell me what they are and what are their applications?*

We introduced the Zener diode in *Teach-In '98 Part 2* (December '97 issue). They are used to provide a stable voltage for circuits which require a regulated supply – one that won't change regardless of the current drawn. In *Teach-In*, we decided not to demonstrate their use in *Lab Work 2*, and we preferred to skip straight onto three-terminal voltage regulators as these have many benefits, including thermal overload protection and current limiting. *Lab Work 3* (this month) utilises a 5V fixed voltage regulator at the centre of a mini-project. The prototype's right here on my bench as I write.

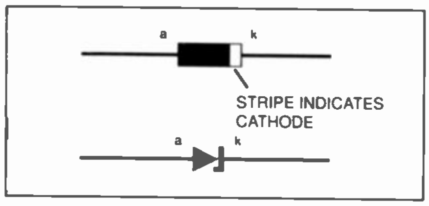


Fig.2. Physical identification and symbol for a Zener diode.

There are still many applications where a Zener diode circuit would be adequate, however. Fig. 2 shows typical physical connections. If you consider an ordinary diode, they are always specified as having a PIV – Peak Inverse Voltage, being the maximum reverse voltage that they could withstand before an internal avalanche breakdown takes place, when a large current will then flow (perhaps damaging the device). The ubiquitous 1N4001 has a PIV of 50V and a forward current rating of 1 amp, for instance.

The basic idea of a Zener diode is shown in Fig. 3. Notice that Zener diodes

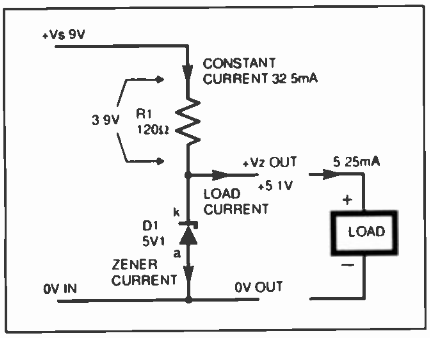


Fig.3. Basic arrangement for using a Zener diode.

are connected so that they are reverse biased (compare with the four diodes in Fig. 1, which are forward biased). The effect is that Zener breakdown occurs at a designated voltage. A steady reference voltage is produced across the diode D1.

The Zener works like this: in Fig. 3, imagine that D1 is, say, a 5·1V Zener diode. In order to operate properly, a small Zener current needs to flow through the diode, say, 5mA. The Zener voltage will then develop across the device and this can be used to power a load or provide a reference voltage for other circuitry.

The resistor R1 is a compulsory series limiting resistor whose purpose is to drop the rest of the voltage in the circuit (Vs – Vz), and it also determines the current flowing through the Zener diode.

There is a subtle trap here. The load is placed across the Zener as shown, and it enjoys a steady voltage supply of 5·1V. However, if the load current varies, then the Zener diode will draw more or less current to compensate, because the current flowing through the resistor R1 is always a constant value. If the load suddenly draws no current at all, then the entire current will flow through the Zener.

This isn't a problem provided that you choose a Zener with a suitable power dissipation figure which allows for peak currents.

Worked Example

Assume the supply voltage Vs is, say, 9 volts. The load requires a 5·1V supply, and it draws anything from 5mA to 25mA maximum. We will allow a further Zener current of 5mA minimum to flow. This means that the current which will flow through the resistor should be 30mA (5mA + 25mA).

Using Ohm's Law, we can calculate the series resistor now as $(9 - 5{\cdot}1) \div (30 \times 10^{-3}) = 130$ ohms. In practice, we would use a "preferred value", say 120 ohms, implying that a total current of 3·9V/120 = 32.5mA would flow through the resistor, a minimum of 7·5mA passed by the Zener.

That's the total current flow dealt with. Now, if the load draws its minimum stated value of 5mA, then the rest of the resistor current will be passed by the Zener diode to compensate. Hence the Zener will dissipate (P = IV) 140mW maximum, in these "worst case" conditions. A standard 500mW type can easily cope with this.

The resistor will dissipate (I^2R) about 126mW, regardless of what the load is doing.

There are some other practical problems, though. Zener diodes have a typical tolerance of 5 per cent, so they are not ultra-accurate (which might not be a problem in many circuits). The amount of power a Zener can dissipate becomes important especially when the load varies, so bear in mind these worst case conditions.

In another worst case scene, if the load is shorted out altogether, then the resistor is connected across the supply and dissipates (V^2/R) 0·675W, quite hefty! It's up to you to decide whether to up-spec. the resistor's power rating just in case; you would probably risk it instead.

Common Zener diodes are available in a range of fixed values and any good catalogue will have a representative range on sale. They are graded by power rating and Zener voltage.

Originally produced by Mullard, now Philips Semiconductors, the standard 400mW type is the BZX79C range; a suffix indicates the voltage, e.g. BZX79C5V1 is a 5·1V device. I see that Maplin and Farnell both market BZX55C range of 500mW Zeners, and if you need a higher power device, choose the BZX85C range, rated at 1·3W.

All these devices are manufactured in standard glass packages (e.g. "DO35" diode outline glass package). Identifying them amongst a bagload of parts can be really confusing, especially given their tiny size, but at least some of the part number will be printed on the diode body, from which you should be able to see the voltage rating. (I had to use a magnifying glass to read "4V7" when I inspected some, just now!)

I have a whole bunch of diodes marked solely as "88C6V2", and it's only my experience which tells me that they're 6·2V Zener diodes from the BZY88C range! Tricky!

Higher power Zeners are available, if you really feel the need – the 1N53xx range is good for 5 watts and is fabricated in a bolt-down stud case. Semitron's BZY91C range is rated at a mammoth 75 watts! So clearly there is still scope and demand for the good old Zener diode.

Beefy Zeners

If you need a higher power rating, then Fig. 4 shows how external *npn* "pass" power transistors can be added. (This is a circuit from an old bench power supply design I produced way back in 1981, hence the transistors may seem a bit outdated.) The transistors are wired in "Darlington" configuration to provide a high overall gain.

Two Zener diodes in series provide a stable 32V ±5% and the Darlington draws minimal base current from the Zener

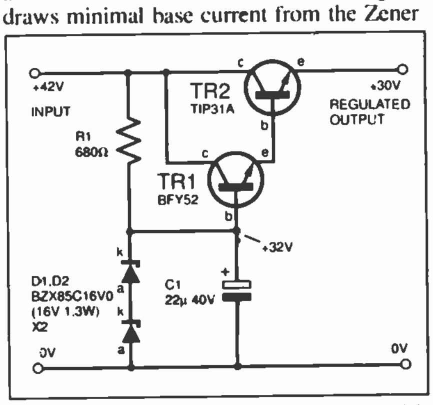


Fig.4. Higher voltage regulator providing 30V d.c.

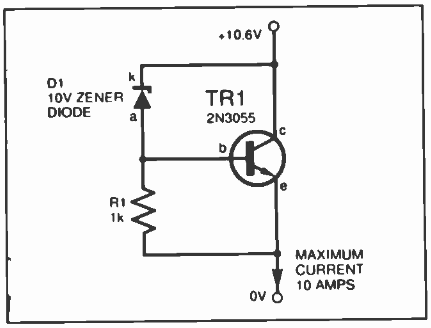


Fig.5. A power transistor-assisted Zener diode.

network. The electrolytic capacitor added across the Zeners will help remove noise, which effect is amplified by the transistors. There are two V_{be} voltage drops involved, so the output is just over 30V or so, depending on the real-life values of the Zeners. I used this as a simple form of "pre-regulator" to control the input voltage to the rest of the bench power supply (which resulted in *Everyday Electronics'* first ever use of the LM317, incidentally).

Horowitz & Hill in the *Art of Electronics*[1] suggest a simple circuit as depicted in Fig. 5, namely an "active power Zener". The *npn* pass transistor is a 2N3055, everybody's favourite 115W bipolar transistor, which is biased by the 10V Zener diode, plus, it mixes in a V_{be} diode voltage drop. Thus this active Zener circuit is equivalent to a virtually unburstable 10·6V Zener diode, plus Zener tolerances. Their circuit would provide some ten amps before the transistor complains (10 amps with 10·6V across it generating 106 watts). Consider the heat-sinking arrangements of a device dissipating well over 100 watts, though!

As the Crow Bars

Since we're talking about Zener diodes and thyristors this month, a circuit which combines both devices to offer a simple form of over-voltage protection is the circuit of Fig. 6, a "crowbar" protection circuit.

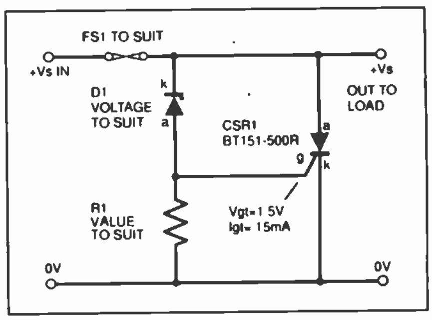


Fig.6. A "crowbar" over-voltage protection circuit.

Basically, the circuit is constantly looking for the voltage rail to increase beyond a certain value, after which the Zener will start to conduct to allow gate current to flow. The thyristor CSR1 triggers when the rail rises to that of the Zener voltage plus the gate trigger voltage.

This does unspeakable things to the power supply – namely, it shorts it out altogether! This "crowbarring" effect causes fuse FS1 to melt, which disconnects the supply from the rest of the circuit. The thyristor can conduct a considerable surge

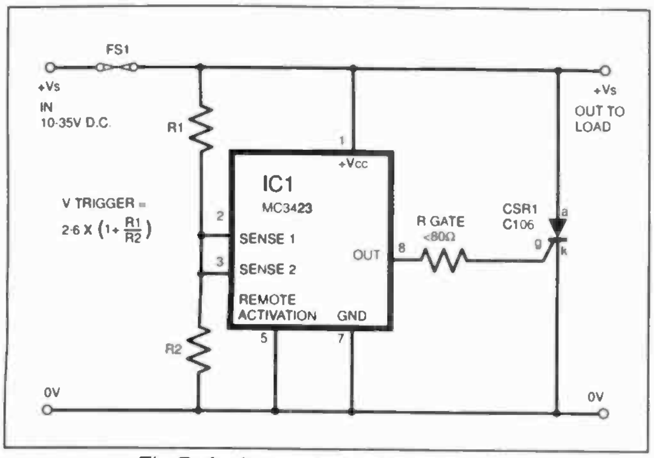
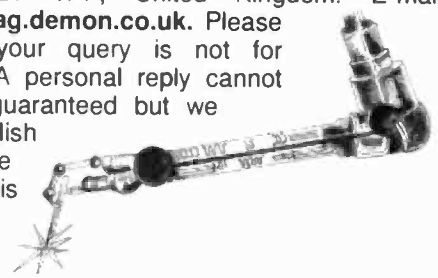


Fig. 7. An integrated crowbar circuit.

CIRCUIT THERAPY

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



current, but unless you have current limiting further upstream, you must incorporate the fuse FS1 (or a circuit breaker) to disconnect the supply – a standard form of overvoltage protection.

If you don't like the idea of a fuse racing the power supply to destruction, you could insert a power resistor further upstream to limit the maximum current which could flow (e.g. on the input side of the circuit in Fig. 6). In the crowbar circuit, D1 and R1 should be selected to suit, allowing a generous level of Zener current to flow.

Intelligent Crowbar

This month's column concludes by mentioning a chip which has more "intelligence" than the discrete crowbar circuit. The MC3423 8-pin d.i.l. i.c. (Texas, Motorola) protects sensitive circuitry against overvoltage, and the circuit can be programmed with the minimum propagation period before the thyristor is triggered. Fig. 7 shows an application circuit where both internal sensing amplifiers have been tied together (pins 2 and 3).

Two external resistors R1 and R2 then set the point at which the thyristor will be triggered relative to an internal 2·6V reference voltage, and the formula is:

$$V_{trig} = 2{\cdot}6 \times (1 + (R1/R2)) \text{ approx.}$$

This circuit operates up to 36V rail voltage, but if you used a Zener diode to create a power rail for the chip (at pin 1) you could then apply it to much higher rail voltages. Incidentally, the MC3425 is a combined over/undervoltage protection chip; both chips can be sourced from Farnell Components, for example, or you could order it via your local parts store.

● Also check out earlier *Circuit Surgery* features which may be of interest – *The TL431 Reference Diode* (page 114, February 1997) and *Low Drop-out Regulators* (page 473, July 1997).

Circuit Surgery is your column! Don't forget that myself, together with Ian Bell of the Department of Electronic Engineering at the University of Hull, will attempt to address readers' queries and questions in the fields of educational, light industrial and hobby electronics, so don't forget to write or E-mail us with your comments and feedback.

Reference

1 Page 319, *The Art of Electronics 2nd Edition*, by Paul Horowitz & Winfield Hill, Cambridge University Press, ISBN 0-521-37095-7

New Technology Update

The accuracy of impurity diffusion into semiconductors is being increased by using high velocity techniques – Ian Poole reports.

IN RECENT years the use of a process known as ion implantation has become far more widespread in the semiconductor industry. The more traditional approach of using a diffusion process still retains many advantages, but it cannot be used, or it has significant limitations, for some of the new technologies arriving on the market.

In view of this, much work is being put into new ideas related to ion implantation, making its use far more widespread than it was a few years ago.

What is Diffusion?

Before looking any further at ion implantation, it is worth taking a brief look at how the diffusion process takes place in semiconductor manufacture. In order to create the different areas of *p*-type and *n*-type material, it is necessary to place new ions into the structure so that holes or electrons are created.

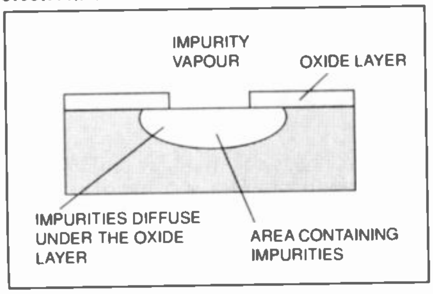


Fig.1. Basic diffusion process.

The easiest method of achieving this is to diffuse them in via the surface. To do so a layer of oxide is first grown on the surface of the semiconductor. After which a thin layer of photo-resist is added to cover the whole surface. When this is complete the new surface is exposed to ultraviolet light through a mask, defining the shapes which are required in the diffusion process.

Once this stage is complete the photo-resist is removed in areas where it is not exposed and the oxide layer etched where it is not protected by the photo-resist. This exposes the base semiconductor, which can in turn be exposed to the impurity to be added. The diffusion process is undertaken at high temperature, and the impurity vapour passed into the diffusion chamber so that it enters the crystal structure.

The problem with this process is that it is difficult to control the process to any degree of accuracy. The process is not very repeatable and diffusion will take place laterally as well as directly down into the structure, see Fig.1.

Ion Implantation

The ion implantation process overcomes some of the problems encountered with diffusion. It is far more repeatable and can be controlled to a much higher degree. However, it is more costly and this is one of the reasons why it has not been as widely used.

The process involves inserting the ions into the semiconductor by accelerating the atoms to a high velocity. When they reach the semiconductor they are implanted into the crystal as a result of their kinetic energy, rather than their thermal energy as in the case of diffusion. To ensure that no damage occurs to the crystal itself, the substrate is annealed, i.e. heated to ensure than any damage repairs itself. Normally, temperatures around 600°C are used.

To achieve the required results, the atoms are extracted from the donor material and then passed through a collimator to generate a very fine stream of atoms. These are then focused and passed through plates which control their position in the X and Y planes. This is very similar in concept to a cathode ray tube, although the realisation of it is naturally somewhat different. The way in which the ion implantation equipment is organised is shown in Fig.2.

As with a cathode ray tube, the stream of atoms is scanned across the target material. The depth is controlled by the speed at which the ions travel, allowing control of the positioning of the impurities in all three dimensions.

However, for fabricating complex device structures, like those used in many i.c.s which require repeated implantations, selective area doping is achieved by the use of masks in a similar manner to that used for diffusion. It is also possible to use photo-resist under many circumstances. This simplifies the process and reduces costs.

Ion implantation has a number of advantages, especially when working with sub-micron structures. The sideways scatter around the mask is very much reduced when compared to diffusion. This enables devices with much smaller geometries to be manufactured more reliably and repeatably.

Opto-devices

The process has been used for many years, but now it is being used more widely. Previously, it was only used for very specialised applications. Nowadays, reduced costs of the system and exacting requirements for new i.c.s mean that its use is becoming more common.

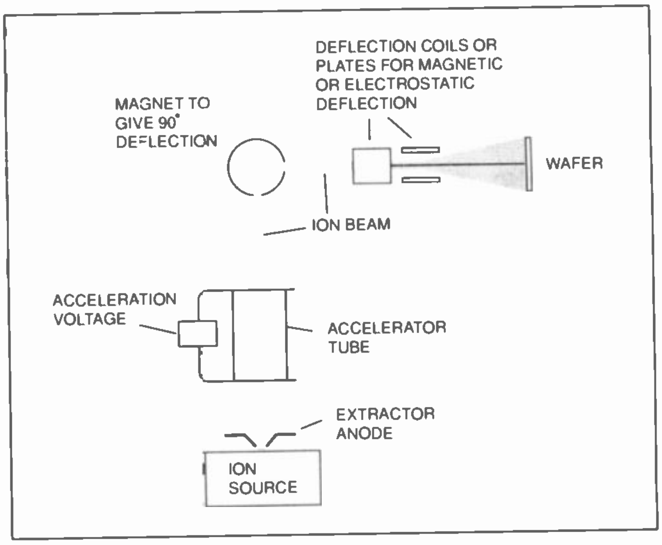


Fig.2. Ion implantation.

In one new development taking place at SGS in Italy, ion implantation has been used to generate some new opto-electronic diodes. They use a rare earth called erbium implanted into the structure (see Fig.3).

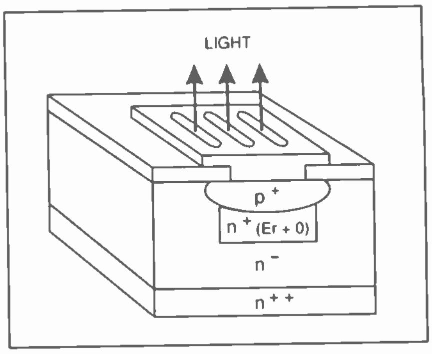


Fig.3. Erbium doped diode.

It has been established for many years that erbium-doped optical fibres can be stimulated to emit light when a flash light is used. This principle is employed in optical repeaters where the fibres are used to amplify the signals.

Now this principle has been transferred to semiconductor technology. To make the new junction, it is necessary to use ion implantation because the traditional techniques do not work properly with erbium.

In order for the technique to work, the implantation must create tiny clusters of atomic level erbium in the diode. Oxygen is also implanted and this combination enables a diode with a modulation performance in excess of 100MHz to be generated. This allows the new diodes to be used in optical fibre data transmission applications.

For the future, there are some exciting possibilities which are on the horizon. Investigations are pursuing the idea that it may be possible to generate buried light pipes into the structure. A buried oxide layer would act as a light pipe from one of the new diodes and this could be used to distribute the clock and data around a chip. As electrical interfaces are fast becoming too slow for the next generations of processor chips, this may help produce the answers to the computers of tomorrow.

Low Energy Implantation

With semiconductor technology itself advancing apace, it is also necessary for the manufacturing equipment to be developed by the same degree. In order to manufacture the new ranges of i.c.s with feature sizes of less than 0·25 microns, very shallow junction depths are required, typically of the order of 150Å. Previous generations of ion implanters were not able to achieve these because high currents and low energy levels are required.

A further requirement is that implanters now need to be able to cover a wider area. This results from the fact that larger wafers are being used now, to achieve this increased levels of control are required so that the ion beam can be targeted over wider angles.

A new ion implantation unit has been designed by researchers at Eaton Corp in the USA. To achieve these new levels of performance, the focusing element or beamline employs new beam shapers utilising magnetic dipole/quadrupole steering. This enables it to deliver currents which are two to three times higher than was previously possible whilst keeping ion energies low. By doing this, throughputs can be increased and in turn this reduces the cost of the implantation process for each wafer.

The new beam focuser also allows for much greater degrees of control. This enables much larger wafers to be processed. The maximum for previous systems was around 80mm, whereas this new system can process wafers up to 140mm, with systems in the pipeline due to be able to process the new series up to 300mm.

SHOP TALK
with David Barrington

Disco Lights Flasher

Apart from the dire warnings concerning the presence of mains voltages on the p.c.b., it is **most essential** that 3A minimum mains cable be used to interwire between the lamp sockets and the *Disco Lights Flasher* printed circuit board screw terminal blocks. The lamp IEC, mains outlet, chassis mounting sockets and matching plugs should be available from most of our component advertisers. These are sometimes found listed in catalogues as Bulgin Euro types.

Some difficulty may be encountered finding a local source for the l.e.d. driver chip and the low-power zero-crossing triacs. The five l.e.d. flasher/driver type HT2050 is currently listed by Maplin, code AZ26D. The MOC3041 optically-coupled, zero-crossing triac is also available from the above source, code RA56L. This is a 6-pin d.i.l. device and if you don't have a 6-pin socket you can cut down an 8-pin i.c. socket to size.

You **must** use an aluminium/metal case for this project and make sure it is securely "earthed" as outlined. Most of our component advertisers carry stocks of the popular vinyl-effect, two-piece, aluminium case similar to the one in the model.

The printed circuit board is available from our *PCB Service*, code 178 (see page 75).

Simple M.W. Radio

Some small savings in cost can be had by shopping around for some parts needed to make the *Simple M.W. Radio*. This applies particularly to the ferrite aerial and tuning capacitor.

The radio should work using a ready-made ferrite aerial, but these can work out at about £3 to £4 and usually have an L.W. winding included which needs to be discarded. However, glancing down the **J&N Factors** (☎ ***01444 881965***) advertisement they are listing a pack of two in their £1 bargain list (5). These will need to be cut down if the small case is used.

Quite a few of our advertisers, such as **Cirkit** and **Maplin**, stock ferrite rods without coils, but these usually come in longer lengths. Ferrite is very brittle, so be extra careful when cutting/snapping it to size.

Variable capacitors come in many shapes and sizes and prices vary quite considerably. The type used in the model is one listed for "transistor radios" and came from **Maplin**, code FT78K.

The Ferranti ZN416E radio chip is basically the same as the old favourite ZN414Z, with an added output stage and should be generally available.

Surface Thermometer

The only problem likely to arise when purchasing components for the *Surface Thermometer* project will be in selecting a suitable meter.

The only reference to type MU and type T panel meters we have come across in our catalogues is from **ElectroValue** (☎ ***01784 433604***). Most of our component advertisers should be able to offer a suitable 500μA type, the coil resistance being around 350 to 450 ohms.

The printed circuit board is available from the *EPE PCB Service*, code 174.

Teach-In '98 Part 3

Just a couple of additions to requirements for this month's *Lab Work 3* section of *Teach-In '98* Part 3. You will needan electric soldering iron and one rated between 15W to 25W is about ideal for general purpose work. Also, the investment in a stand for storing the hot iron (preferably weighted), between use, is a ***must***.

Alan informs us that he chose to use the **Farnell** (☎ ***0113 263 6311***) 2·1mm d.c. power inlet socket (code 299-972) for the *5V Add-on Regulator* mainly because it is known to be fully insulated, plastic-bodied and single-hole fixing. Unfortunately, they are only sold in packs of ten; perhaps your kindly distributor will be willing to split a pack.

Provided you *definitely* use an insulating kit for the regulator chip, you can use the Maplin (single-hole mounting – preferred) or HH85G (chassis mounting) sockets.

Greenweld are putting together a pack of all the recommended items including the multimeter and p.s.u. These will be offered at a special price, post free if you spend over £10. Contact them on ☎ ***01703 236363*** Fax ***01703 236307*** or by writing to them at 27D Park Road, Southampton, SO15 3UQ.

Maplin can also supply all the items. Their order code for these is HB99 and they will include a *free* copy of their new catalogue. Hobbyists will find the catalogue an invaluable source of components, tools, test gear, etc., as well as information.

Squires have told us that they can supply a set of tools for those following *Teach-In*, they are at The Old Corn Store, Chessels Farm, Hoe Lane, Bognor Regis, West Sussex, PO22 8NW. ***Tel/Fax 01243 587009***.

EPE Virtual Scope

Practically all the "special" parts called up for the *EPE Virtual Scope* project are RS components and will need to be purchased through your local *bona-fide* RS distributor or through their mail order outlet, namely **Electromail** (☎ ***01536 204555***).

Starting with the semiconductor devices first: the SRAMs type TC55257DPL-85L (12MHz) and CXK58257AP-70LL (14MHz) are carried as 298-190 and 193-6310; and the 10MHz crystal module, code 267-922. The rest of the semiconductors should be readily available, once again RS types have been used in the prototype model.

Moving on to the connectors, these should now be stocked by most of our components advertisers, such as **ESR Electronic Components** (☎ ***0191 251 4363***). The RS codes are as follows: right-angle 36-pin Centronics, 470-639; 14-pin, 473-802; BNC 75Ω panel socket, 405-039.

The large plastic case is ordered as 503-650. The 24s.w.g. tinned annealed copper wire should be ordered as 355-085.

Finally, the large Digital and Analogue printed circuit boards are available from the *EPE PCB Service*, codes 176 (Digital) and 177 (Analogue) – See page 75.

The software for this design is available on a 3·5 inch PC-compatible disk from the *EPE PCB Service*, see page 75. Alternatively, the files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk/Vscope**.

It is recommended that readers run the software to check to see if their computer will run the *EPE Virtual Scope* before they buy anything. Also, an additional file is on the disk. It is MOUSE01.BAS and is not discussed in the text. It allows you to check your mouse response from Basic without loading the full VSCOPE.BAS. program.

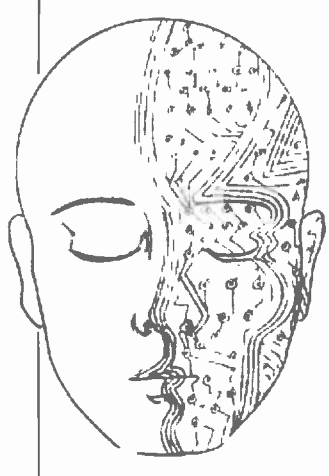
PLEASE TAKE NOTE

EPE Time Machine *Nov '97*

Regarding the 2-line 16 character Hitachi display module, we understand that **Magenta** gave us the wrong code for this device and it should be quoted as LM016L. They are aware of this and have been supplying the correct module.

Universal Input Amplifier *Aug '97*

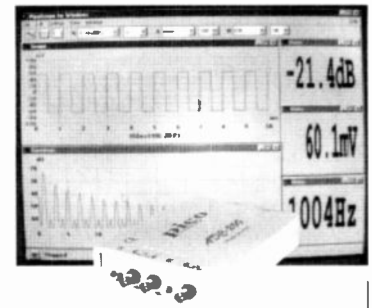
Page 550 Fig.5. Readers should note that the +15V and −15V designations on the component layout have been transposed. The circuit diagram is correct.



INGENUITY UNLIMITED

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

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



WIN A PICO PC BASED OSCILLOSCOPE

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

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours.

Every six months, Pico Technology will be awarding an ADC200-50 digital storage oscilloscope for the best IU submission. In addition, two single channel ADC-40s will be presented to the runners up.

12V Lamp Dimmer – Let there be light (and wind)

THE CIRCUIT of Fig. 1 was originally devised for someone whose sole electricity supply was provided by lead/acid batteries coupled to a home-made wind-powered charger. It may be of interest to boat and caravan owners and campers and is intended to control a 12V incandescent lamp efficiently. A 10W tungsten halogen lamp gives a light output comparable to a 60W domestic bulb, and the circuit has been tested at up to 100W of 12 volt lighting without problems.

The circuit is based around two ICM7555 timers, low power CMOS versions of the bipolar 555. IC1 is wired as an astable which sets the basic running frequency of the dimmer to approximately 40kHz. (It was found that the high frequency was necessary to prevent the bulb filament from "singing" at low light levels.)

This square wave is used to trigger the second timer, IC2 which is a monostable. It drives TR1, a 30A *n*-channel BUZ11 power MOSFET, and this powers the lamp.

Potentiometer VR1 is included to allow the mark-space ratio of IC2 to be adjusted. This determines the on-off time of TR1 which therefore controls the brilliance of the lamp(s). The brightness range can be adjusted by altering the value of C3 slightly. Most of the circuit was constructed on stripboard, with heavy-gauge wire being used to connect the lamp to the MOSFET via a terminal block (not shown). For convenience, S1 and VR1 were ganged together using a combined potentiometer/switch. D1 protects against reverse polarity connection of the battery.

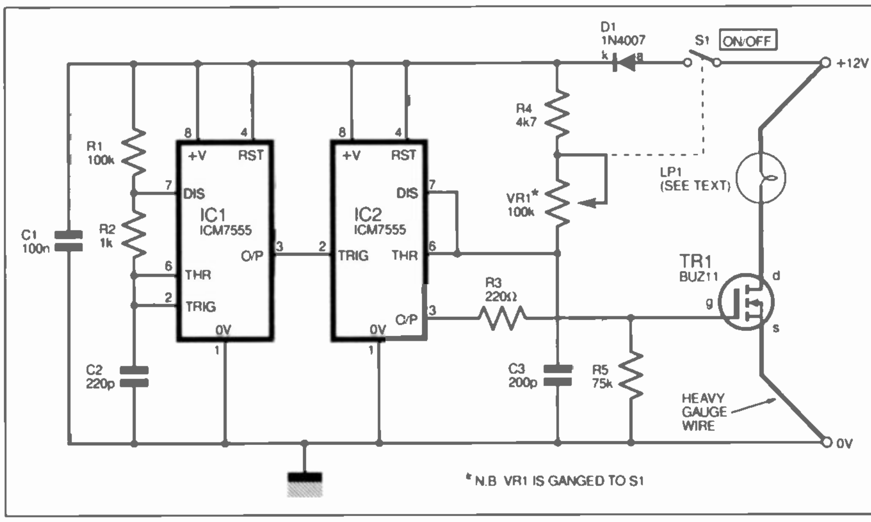


Fig. 1. Circuit diagram for a 12V Lamp Dimmer.

David Allen, Cheltenham, Glocs.

V.C.O. Continuity Tester – Bleeps High or Low

SOME types of continuity tester are unable to distinguish between a low and a high resistance value, e.g. the difference between a short circuit (low resistance) or a dry joint (high resistance). The Continuity Tester of Fig. 2 is extremely easy to build as a beginner's project and utilises the voltage-controlled oscillator (v.c.o.) section contained within a 4046B phase-locked loop chip.

In Fig. 2, IC1 drives a piezoelectric sounder X1 directly from the v.c.o. output (pin 4), but the frequency of output is directly proportional to the resistance being applied across the test leads at SK1 and SK2. A low resistance (e.g. an intact fuse) results in a low frequency tone whilst a higher resistance will generate a higher pitch.

The circuit uses very little current and will operate from a 9V battery, perhaps one which has been nearly exhausted in another application.

Mark McGuinness, Clondalkin, Dublin 22.

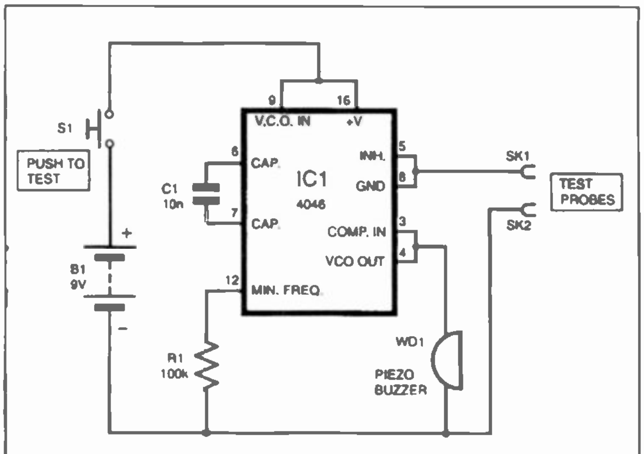


Fig.2. V.C.O. Continuity Tester circuit

Simple NAND Circuits – Cheap and Cheerful

I HAVE never seen the point of using 64 components when four would do! Innovation should apply not only in, say, making a light-emitting diode flash at 0·8V, but also in doing so with the minimum component count and price!

Also, in many circuits a 555, for instance, is used as an oscillator when in fact one Schmitt gate plus two components would suffice, leaving spare gates on the chip available for other functions. To illustrate my point, here are a handful of simple but effective circuits based around CMOS Schmitt NAND gates.

Touch-Operated Single-Bit Latch

A single gate memory circuit is shown in Fig.3a. At power up, point "A" rises to half the rail, due to the capacitor C1, and is approximately midway between the two Schmitt threshold levels. This causes "B" to go high and remain at that level. Closing switch S1 passes current from "B" back into the input so that "A" will slowly rise to the upper threshold, when the output will go low.

If S1 is then released, the output will remain low. Closing S1 again, discharges C1 towards the lower threshold (logic 0), so the output will go high again. Thus, a simple bistable or one-bit memory is formed.

The switch could be replaced with a transistor for signal control. By adding a pair of touch contacts at points "A" and "B", and using 1M resistors for R1 and R2, and making C1 100nF capacitor instead, a simple touch-operated latch is created.

Normally-Closed Loop Alarm

A simple "Loop Alarm" based on a single Schmitt NAND gate is shown in Fig.3b. The inputs rise to mid rail as before and the gate output "B" goes high. The protection wire loop is fed through any property to be protected. Resistor R2 and capacitor C1 act as a low-pass filter which counters any noise from CB, taxis, mobile phones etc. to prevent false triggering. When the normally closed loop is broken, "A" goes high and "B" latches low, which is the alarm condition.

Closing the loop again does not reset the alarm. This can only be effected by interrupting the power and restoring the loop. Fig. 3c shows how spare Schmitt NAND gates can form a piezo sounder which connects directly to the loop alarm at "B".

Static and Live Wire Detector

A simple Static Electricity and Live Wire Detector is shown in Fig.3d. When the diode D1 is connected as shown, the resistance exhibited by its leakage current approaches some 1000M which biases the already high-impedance gate to logic 1, so the output is low. (No need for an on-off switch.)

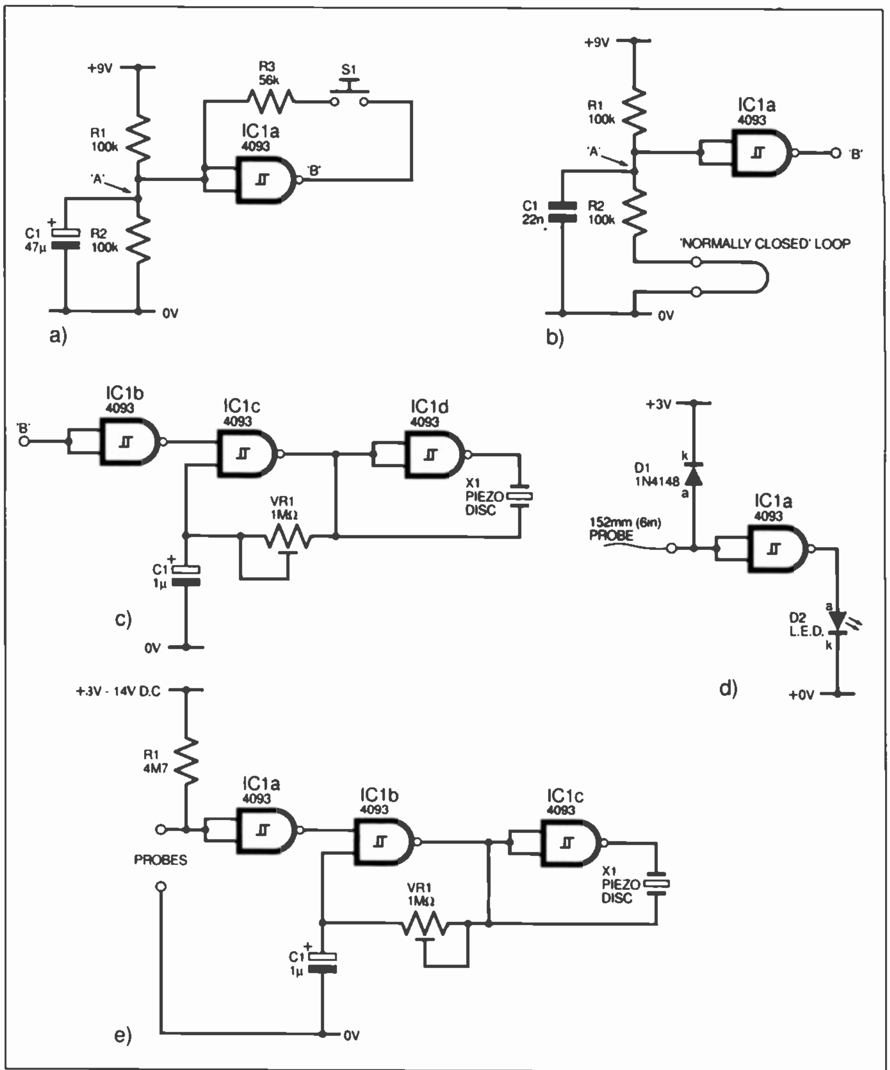


Fig.3. Simple CMOS Schmitt circuits. (a) Single-bit latch. (b) Normally-closed loop alarm. (c) Piezoelectric sounder. (d) Static and live wire detector. (e) Fluid level sensor.

When the probe (a 6in. length of wire) is approached by a charged comb (for example), or when placed within a few inches of a live wire, the l.e.d. will light! (No series resistor needed.) For best results, ensure that your hand holds the battery or ground rail of the circuit to provide an earth to which the static may flow. Experimenters can try it for remotely monitor the firing of spark plugs in an engine, or checking for stray electric fields.

Fluid Level Detector

A Fluid Level Detector circuit, again using CMOS NAND gates, is shown in Fig.3e. When fluid presents a resistance of less than 2M across the probes, the oscillator will be enabled and the piezo sounder will operate. VR1 is adjusted for pitch.

John Hyland,
Strood, Kent.

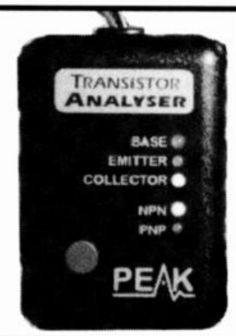
READOUT

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

Win a Peak DTA30 Transistor Analyser

The DTA30 will test and identify the type (*npn/pnp*) and the leads of any bipolar transistor connected to it.

Every month Peak Electronic Design Ltd will be giving a DTA30 to the author of the best *Readout* letter published.



FARNELL'S CATALOGUE

Several readers have asked the following question:

Referring to *Circuit Surgery* Oct '97, is it true that Farnell's catalogue is only available to *bona fide* trade sources and that a £10 minimum order applies to credit card payments?

No and no! As I have just checked by phone, Farnell's catalogue is available to anyone, whether or not you have an account with them, and it is FREE!

Farnell's relevant payment terms as stated in their latest catalogue (Oct '97 to March '98) are: "Payment either by cheque made payable to Farnell Electronic Components Limited, credit transfer, BACS or credit card (Mastercard, Visa or American Express)".

Whereas a £10 minimum order used to be required for credit card payment (as stated in their Apr-Sep '96 cat, for example), this statement is not made in the current issue. Furthermore, it states that: "Please note that we do not impose any minimum order conditions."

Farnell's catalogue has around 2100 pages of high quality electronic components and information. It is essential to the serious constructor's workshop, so get a copy – phone 0113 263 6311.

JAPANESE CHIPS

Dear EPE,

The letter from Jack Treeby intrigues me (*Out Bespoken, Readout*, Oct '97). Your reply implies that he is talking about computer or VHF/UHF gear. Well, Jack, all I can say is "good luck"! I look at such boards with total admiration, and get someone else to fix it. The trouble is that if you want compact gear, then it's going to use SMDs and be truly "no user-serviceable parts inside".

However, if he means boards that I once saw described as "looking as if components had been fired at the board by a blunderbuss", I couldn't agree more. Even expensive audio gear can have electrolytics laying anything but vertical, overheated under-rated resistors, tracks cut or ground away and, worst of all, wire jumpers on the trackside inserted to save a redesign of a board.

As to "bespoke" i.c.s, if Jack is talking about Japanese TV and audio gear, then Toshiba and Panasonic i.c.s are fairly easy to get. Check out Cricklewood Electronics, or firms advertising in *Television* magazine.

Barry J. Taylor, Rickmansworth, Herts

Thanks for the comments Barry – your contributions to Readout *as well as* Ingenuity Unlimited *are appreciated. Congratulations on winning the valuable Pico PC-based Oscilloscope with your* 19kHz Reference Source *in* Ingenuity Unlimited *of Sept. '97.*

★ LETTER OF THE MONTH ★

TRIPAD

Dear EPE,

I have read Robert Penfold's article on using stripboard (*Techniques*, Nov. '97). I agree with many of the points you have made, but you have not mentioned *Tripad*, the variation of the standard stripboard which is, I think, the best for prototyping and one off projects.

This type of stripboard can be adapted to accommodate most circuits (except when using i.c.s having large numbers of tightly spaced pins) and can maintain a good components density. If the layout is planned first, it is usually possible to keep the number of links across the board to quite a low level. The best way to use this material, I find, is to surface mount the components; and put the links underneath.

Once upon a time there was a similar product called *Blob-Board*, which was intended to be used for surface soldering, but I don't think you can get it now.

I "rescue" some of my components from scrap boards, and I find it is much easier to cut the i.c.s off close to the board, without desoldering, and then remount them on the copper side of Tripad. Although 14-pin and 16-pin i.c.s are only supposed to straddle four holes, they *will* cover five holes.

One can also use Tripad for proper surface mount components – resistors, capacitors and other 2-pin items, and also 3-pin and 4-pin semiconductors (but no more pins than that).

Surface mount is an exciting field for the small constructor (that's me!) but the p.c.b.s involved are a nightmare!. I don't want to mess about with chemicals indoors, and in any case I normally only want one example of each so the trouble involved in producing a real p.c.b. is too much. To be able to use Tripad with little or no extra cutting is a considerable advantage.

It is believed that this pre-cut board is obtainable in "quadpad" form (four holes per section) but I do not know where to get it. Tandy have a number of circuit boards with strips and/or single pads and these can be useful as well.

Please do not think this letter is intended to be critical of Robert's article – I just thought you would be interested in my own experiences.

John Smith, Penrith, Cumbria.

Indeed we are, John, and have forwarded a copy of your letter to Robert. I expect he's familiar with the product (as he seems to be with most matters electronic) and perhaps he might care to offer observations on it (Robert, would you care to in your column some time?).

Personally, I am a p.c.b.s-only man and enjoy producing them. But I have to admit that I have the computer software and other necessary facilities in order to simply do a board, even a one-off that is not intended for publication. Stripboard tends to tax the brain too much – all that flipping from side to side and having to mentally invert images!

However, Ambyr's new product Stripboard Magic, *highlighted in December's* Innovations, *may change that for many people: it's a computer aided design package intended for simplifying stripboard layouts.*

EOCS

Dear EPE,

I am happy to say that membership of the Electronic Organ Constructors Society (EOCS) is stable, and even increasing, despite losses due to *anno domini*. The final figures for 1997 are not in yet but I am full of hope. This happy situation must be, at least in part, due to the editorial "honourable mentions" you published for us.

We are working hard at this end to live up to the reputation you have given us. The EOCS magazine is four pages bigger this quarter and there are more photographs than before. We hope that the next step will be to have our own web site. I will keep you informed if it all works out.

I take this opportunity to wish you and your staff the compliments of the forthcoming season.

Don Bray, Hon. Sec. and Editor Pro. Tem., EOCS, 34 Etherton Way, Seaford, Sussex BN25 3QB. Tel: 01323 894909. Fax: 01323 492234.

We reciprocate the compliments Don, and trust that this additional exposure will help add to your membership.

THE PARTS GALLERY
+
ELECTRONIC CIRCUITS AND COMPONENTS

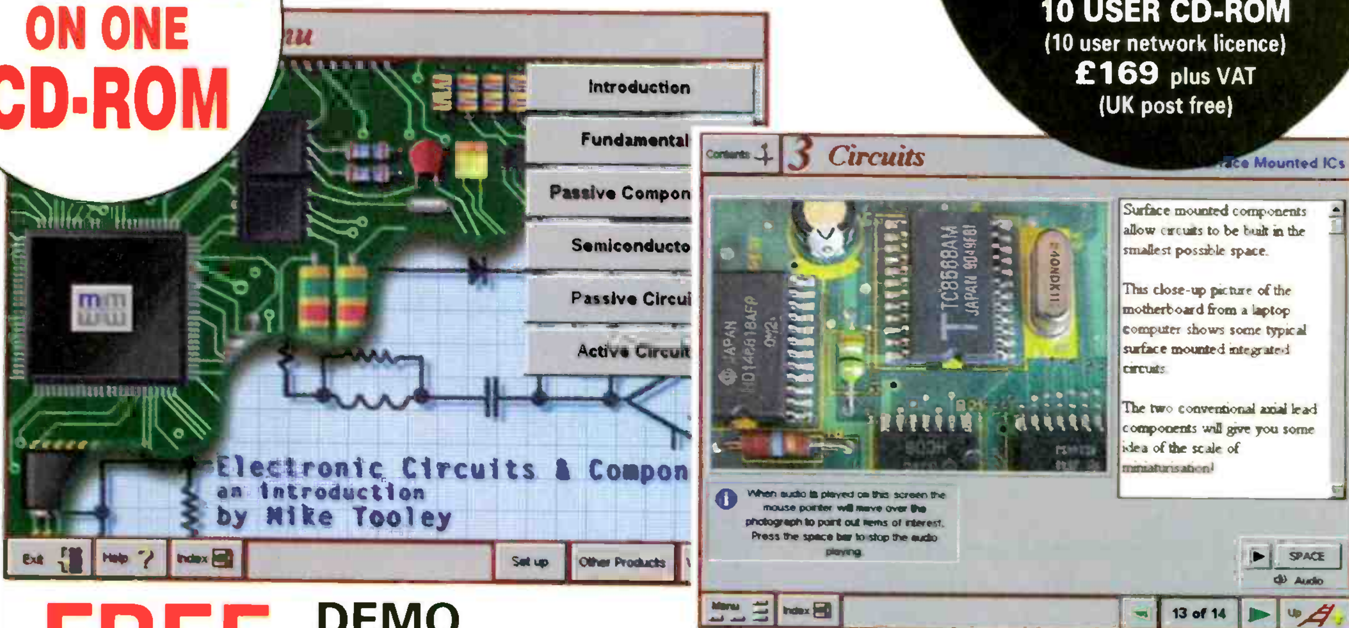
by MIKE TOOLEY Brooklands College of Further and Higher Education

TWO APPLICATIONS ON ONE CD-ROM

HOBBYIST/STUDENT CD-ROM
£34 including VAT
(UK post free)

INSTITUTIONAL LICENCE CD-ROM
(Schools/HE/FE/Industry)
£89 plus VAT
(UK post free)

INSTITUTIONAL 10 USER CD-ROM
(10 user network licence)
£169 plus VAT
(UK post free)



FREE DEMO
from Web site – http://www.MatrixMultimedia.co.uk

Many students have a good understanding of electronic theory, but still have difficulty in recognising the vast number of different types and makes of electronic components. **The Parts Gallery** has been designed to help overcome this problem; it will enable students to recognise common electronic components and their corresponding symbols in circuit diagrams.

This CD-ROM also incorporates component and symbol quizzes so that students can test their knowledge.

★ Over 150 component and circuit photographs
★ 100's of electronic symbols
★ Self-test component and symbol quizzes

Electronic Circuits and Components provides a sound introduction to the principles and application of the most common types of electronic components and how they are used to form complete circuits. Sections on the disc include: fundamental electronic theory, active components, passive components, analogue circuits and digital circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding of each section on the CD-ROM.

★ Virtual laboratories ★ Full audio commentary
★ Over 20 links to pre-designed Electronics Workbench circuits

All text shown on each page is also spoken. Suitable for hobbyists, trainees and students. Covers Design and Technology: Key Stage 4 Electronics GCSE, Key Stage 3 Science. GNVQ Electronics Key Stage 4. Intermediate BTEC Electronics.

Minimum system requirements: PC with 486/25MHz, VGA + 256 colours, CD-ROM drive, 8MB RAM, 8MB hard disk space. Windows 3.1, DOS 3.1, mouse, sound card.

CD-ROM ORDER FORM

Please send me **The Parts Gallery + Electronic Circuits and Components** on CD-ROM

Full name: ....

Address: ....

....

.... Post code: .... Tel. No: ....

Signature: ....

☐ I enclose cheque/PO in £ sterling payable to WIMBORNE PUBLISHING LTD for £..................

☐ Please charge my Visa/Mastercard: £ .... Card expiry date: ....

Card No: ....

ORDERING: Student Version – price includes postage to most countries in the world
EU residents outside the UK add £5 for airmail postage per order

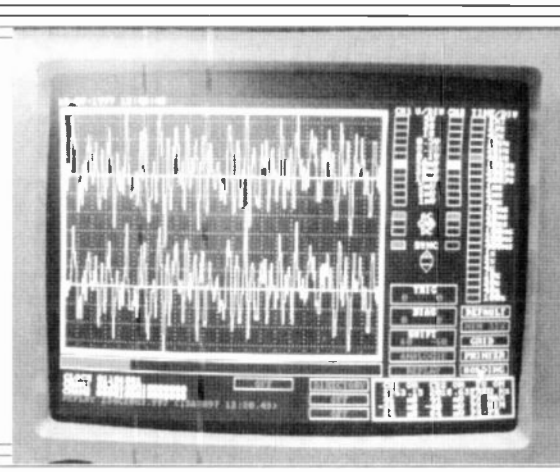
OVERSEAS ORDERS: Institutional Licence Versions – overseas readers add £5 to the basic price of each CD-ROM for airmail postage (**do not add VAT** unless you live in an EU country, then add 17½% VAT or provide your official VAT registration number).

Send your order to: Direct Book Service, 33 Gravel Hill, Merley, Wimborne, Dorset BH21 1RW
(Mail Order Only)
Direct Book Service is a division of Wimborne Publishing Ltd. To order by phone ring 01202 881749. Fax: 01202 841692
We cannot reply to overseas orders by Fax.
CD-ROMs are normally sent within seven days

EE11

Constructional Project

EPE VIRTUAL SCOPE Part 1



JOHN BECKER

Dramatically improve your workshop facilities with this flexible computer-controlled dual-trace oscilloscope simulator.

ANY computer with a screen display can be used as an oscilloscope, provided that the right interfaces are used with it. Even in the days before the term *PC-compatible* meant anything to most people, the author designed a rudimentary computer-based scope complete with frequency counter and automatic assessment of the range in use.

That was in about 1980 and was designed for the Commodore PET, a state-of-the-(then)-art machine having a 32 kilobyte memory and running at 1MHz. The screen resolution was basically 40×25, although the use of the PET graphics characters enhanced it somewhat. The interface used switches and potentiometers to set the different parameters.

Since 1980, many improvements to computer speed, memory capacity and screen resolution have come about and modern PC-compatible computers bear little resemblance to such early pioneering machines as the PET and its immediate relatives. This Virtual Scope interface takes advantage of the facilities that are now regarded as commonplace.

However, the interface does not *need* the latest generation of computer in order to run it successfully. Whilst computer clock speeds of 100MHz or more are beneficial, the circuit has been designed in such a way that even a computer running at 8MHz, or so, can be used with it.

Basically, there are five requirements: that the computer is PC-compatible, has MS-DOS 3.1 or later, has a medium-to high-resolution colour screen (e.g. EGA, VGA or better), a PS/2 2-button mouse driver, and that QuickBASIC (or QBasic) is installed. So far as is known, it will run with any version of either dated 1985 or later. Throughout this article both will be referred to jointly as QBasic.

The software runs entirely under DOS (i.e. Windows facilities are not used). It requires less than 100 kilobytes of memory.

It will be explained later how you can use our software to check if your machine has the necessary requirements before you buy any components for the interface.

It should be noted that this design is complex and that if trouble-shooting should become necessary, the skills of an experienced constructor will be required. Consequently, it is not a project suited to construction by those who do not know much about electronics.

FACILITIES

The full interface has two analogue channels, two 8-bit digital channels, runs at 10MHz and uses the mouse as the principal source of option selection and control – there are no controls on the interface itself. Everything is controlled via the screen.

Data transfer between the computer and the interface is via the computer's parallel printer port, using a standard printer cable (Centronics).

The full line-up of options is detailed in the Specification panel below.

Specification . . .

ANALOGUE CHANNELS

Quantity: 2 – each processed individually
Frequency range: d.c. to 1MHz
Maximum input amplitude: ±50V peak-to-peak
Gain ranges: 12
Gain choices: 1/20 to ×200 (2, 5, 10 progression)
Input coupling: a.c., d.c., off
ADC sampling resolution: 8-bit
Sync mode: positive, negative, off, Chan 1 or Chan 2
Sync level trigger: 8-bit shift
Bias level: 8-bit shift
Display shift: vertical full-screen
Selectable display of channel gain or volts/div factors
Frequency calculation and peak-to-peak voltage calculation
Maximum/minimum voltage calculation
Grid: 20-pixel (bit) steps horizontal and vertical, off

DIGITAL CHANNELS

Quantity: 2×8-bit (16 inputs)
Frequency range: d.c. to 10MHz
Amplitude range: 0V/+5V logic
Sync selection: byte value dependent, off
Grid: vertically, logic 0/logic 1 for each of 16 waveforms
horizontally, 40-pixel (bit) steps

OTHER OPTIONS

Sampling memory size: controllable 2K, 32K, nil
Sampling ranges: 25
Sampling rates: 0·2Hz to 10MHz (2, 5, 10 progression)
Selectable display of sampling frequency or period factors
Screen dump to dot-matrix printer (Epson ESC/P2 compatible, 24-pin, e.g. LQ550)
Waveform data output to disk
Disk file names uniquely date and time related
Disk storage modes: automatic, user select, off
Directory of waveforms filed on disk
Waveform data input from disk
Loaded file name display
Mouse selection of all options
Coloured highlight of options selected
Real-time clock/date display
Selectable display modes: analogue, digital, Lissajous
Channel display modes: Chan 1 + Chan 2, Chan 1 only, Chan 2 only
Software operation: QuickBASIC (or QBasic)/machine code
Sync/shift/bias control: single-step/repeat key variation
Continuous run/hold option
Simulation mode for software/screen display test
Waveform display area: 440×256 pixels

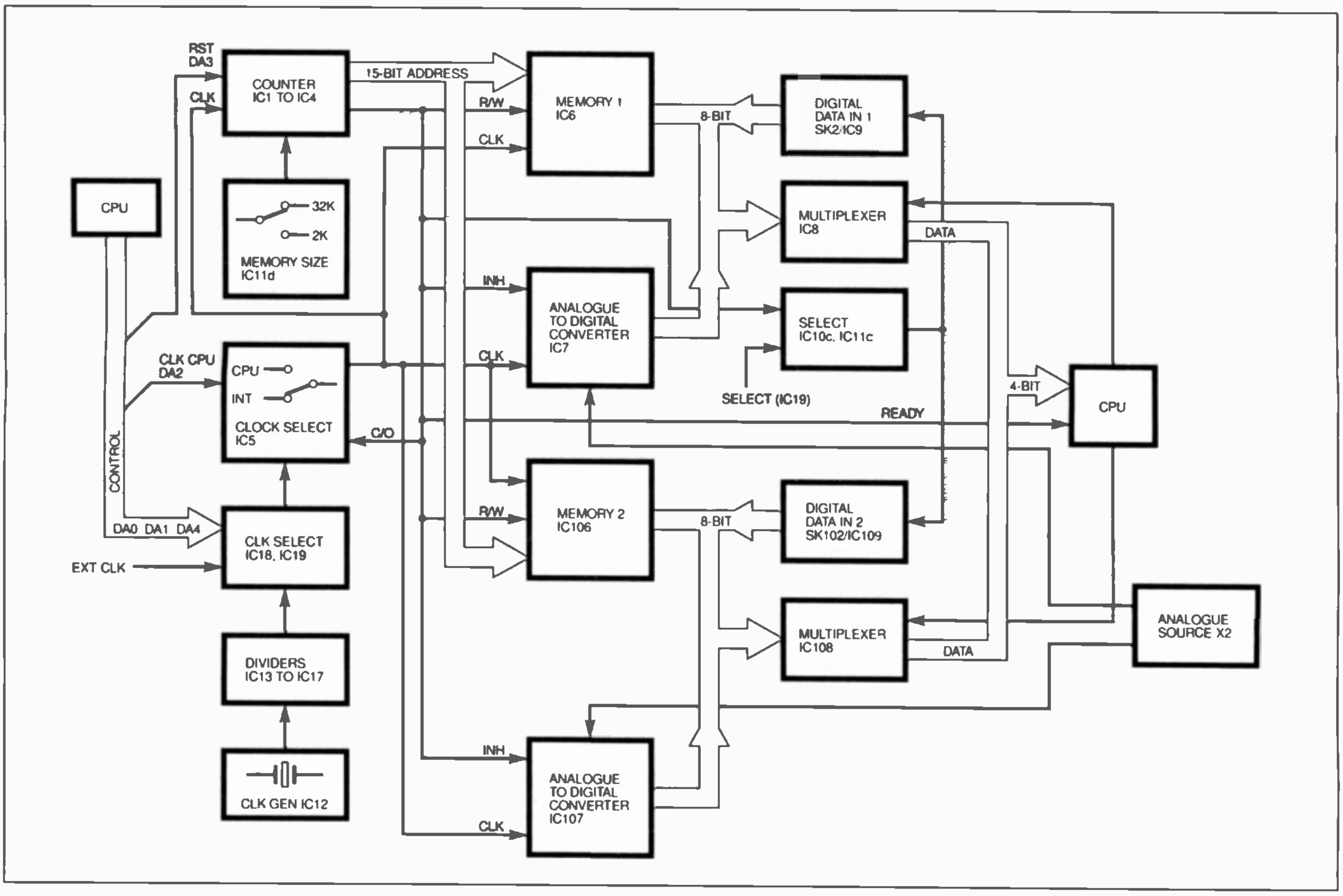


Fig.1. Block diagram for the Digital Control Board of the EPE *Virtual Scope.*

DIGITAL CONTROL

Whilst it is obvious that the circuits and the program for the *EPE* Virtual Scope are complex, the underlying concept is simplicity itself: record the input signals as fast as possible, and then play back at leisure.

The block diagram for the digital control aspect of the *EPE* Virtual Scope is shown in Fig.1. A bit more digital circuitry is used in the analogue section covered later, but as far as understanding the control circuit is concerned, Fig.1 shows the essential details.

The computer sends a Reset signal to a bank of counters whose outputs control the memory byte into which each signal sample is stored. At the end of the Reset pulse, the counters are incremented at a clock rate previously selected via the computer. The rate is a sub-division of a master crystal controlled frequency.

Each clock pulse jointly increments the memory address and (when Analogue mode is selected – which includes Lissajous) triggers the analogue-to-digital converter (ADC) into which the analogue signal is sent. Both memories and ADCs are clocked in parallel so that both signals are sampled at identical points in time.

When the counters reach a predetermined value (2048 or 32768 as selected via the computer), conversion and recording cease, the system automatically switches over to play-back mode and a "ready" signal is sent to the computer. Now the counter clock signals are supplied by the computer which sends them at a rate determined by its own clock frequency and the rate at which it can process the commands involved.

On each pulse, the counters are incremented from the first address onwards and the computer reads the data present in each memory byte, alternating between channel memories on each step. Multiplexers and software jointly control which of the two memories is read each time. The 8-bit data from each memory is handled as two 4-bit nibbles to suit the requirements of the computer's printer port.

DATA DISPLAY

During the sampling of the memories, the computer uses high speed Machine Code routines which automatically plot the data on the screen, vertically according to value and horizontally with time.

Simultaneously, it assesses peak sample (voltage) values and the periods between the values crossing user-set thresholds, for subsequent frequency calculation. The software also examines the data in relation to sync control requirements.

The screen is set to display 256 pixels vertically, thus the full 8-bit range of the sample value can be displayed, though in practice, a narrower range would normally be selected – the choice is yours via the screen control options available.

Horizontally, the active display width is 440 pixels. When the final pixel has been plotted, the display recommences from the first pixel, progressively blanking out the previously plotted pixels as it once more crosses the screen. Fresh data is input from the memories for each screen block.

When each 440-byte block has been processed, the software drops out from machine code and reverts to Basic. Here such procedures as frequency and voltage calculation and display are performed.

Also, the position of the mouse cursor and the status of the mouse buttons are determined. This is done jointly through a separate machine code routine, the results then being processed through Basic.

From the resulting information, the software determines if you have used the mouse and its buttons to change one of the many options available via the screen control boxes, taking action accordingly.

After a multiple number of 440-byte data blocks have been processed (relative to the active memory size in use at that time and whether or not sync control is active), the computer again sends a Reset signal to the interface, and the process begins again.

In Digital mode, the sampling routine is similar, except that the ADC circuits are not used (inhibited) and digital input data is fed directly to the memories without pre-processing.

In both Analogue and Digital modes, an external clock signal (which you supply to suit your own needs) can be used in place of the internal clock source. This facility is of principal benefit when digital sampling needs to have its relative phases recorded synchronously with the clock phase.

Referring back to Fig.1, the main integrated circuits associated with each function block are notated by number. These numbers relate directly to the circuit diagram for the Digital Controller as detailed in Fig.2.

DIGITAL CIRCUIT

An in-depth discussion of each item in the digital circuit diagram of Fig.2 would take up more space than is reasonably available. Frankly, it would also add little to the overall understanding of the circuit as outlined in Fig.1. Those who are specifically interested in digital design, however, will find the circuit diagram of value when read in conjunction with the block diagram.

The main section of Fig.2 details all the components required for sampling analogue and digital data for one channel. Only three additional chips are required to expand the design for dual analogue/digital sampling. These are shown in the inset diagram (IC107 to IC109, which are the

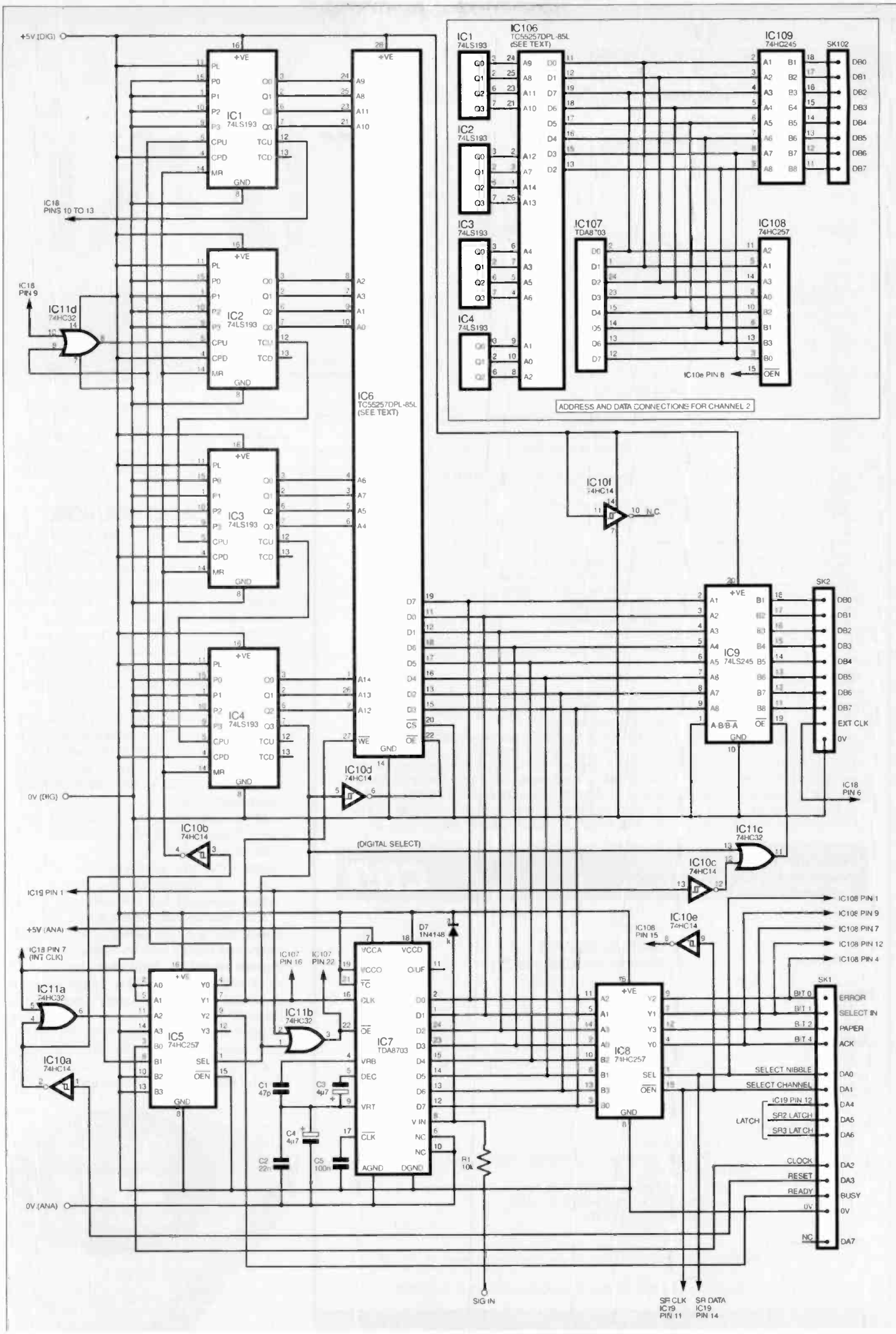


Fig.2. Circuit diagram for the main Digital Control stages of the EPE *Virtual Scope. Additional components inset (top right) enable dual analogue/digital sampling to be undertaken.*

COMPONENTS

DIGITAL BOARD
(Main Components)

See SHOP TALK Page

Resistors

R1 to R3	10k (3 off)

All 0.25W 5% carbon film

Capacitors

C1	47p polystyrene
C2	22n polyester, 10mm pitch
C3, C4	4µ7 radial elect. 16V (2 off)
C5 to C21, C23 to C25, C28	100n polyester, 10mm pitch (21 off)
C22	2200µ min. axial or radial elect. 25V
C26, C27	22µ radial elect. 16V (2 off)

Semiconductors

D6	1N4001 rectifier diode
D7	1N4148 signal diode
IC1 TO IC4	74LS193 BCD/decade up/down synchronous counter (4 off)
IC5, IC8	74HC257 quad 2-input multiplexer, tri-state (2 off)
IC6	TC55257DPL-85L (12MHz) or CXK58257AP-70LL (14MHz), SRAM (see text)
IC7	TDA8703 8-bit analogue-to-digital converter, 40MHz
IC9	74HC245 octal bus transceiver
IC10	74HC14 hex Schmitt trigger inverter
IC11	74HC32 quad 2-input OR gate
IC12	10MHz crystal module
IC13 to IC16	74HC390 dual 4-stage binary counter (4 off)
IC17	74HC251 8-input multiplexer, tri-state
IC18	74HC253 dual 4-input multiplexer, tri-state
IC19	74HC595 8-bit SIPO shift register, tri-state
IC27	7805 +5V 1A voltage regulator
IC28	78L05 +5V 100mA voltage regulator
IC29	ICL7660 voltage converter
IC30	79L05 −5V 100mA voltage regulator

Miscellaneous

SK1	36-pin Centronics socket, right-angle, p.c.b. mounting
SK2	14-pin Centronics socket, right angle, p.c.b. mounting
SK4	3.5mm jack socket or power connector

Printed circuit board, available from the *EPE PCB Service*, code 176; 8-pin d.i.l. socket (2 off); 14-pin d.i.l. socket (2 off); 16-pin d.i.l. socket (13 off); 20-pin d.i.l. socket; 24-pin d.i.l. socket; 28-pin d.i.l. socket; stacking p.c.b. supports (4 off); short self-adhesive p.c.b. supports (4 off); plastic case, 250mm × 200mm × 65mm; aluminium/copper-clad sheet, 195mm × 180mm; M3 × 12mm bolts (4 off); M3 nuts (4 off); cable ties; 1mm terminal pins; stranded connecting wire; 10-way colour-code ribbon cable (2 metres); 24 s.w.g. tinned annealed copper wire; solder, etc.

Approx Cost Guidance Only £69

DIGITAL BOARD
(Components for Channel 2)

Resistors

R101	10k 0.25W 5% carbon film

Capacitors

C101	47p polystyrene
C102	22n polyester, 10mm pitch
C103, C104	4µ7 radial elect. 16V (2 off)
C105	100n polyester, 10mm pitch

Semiconductors

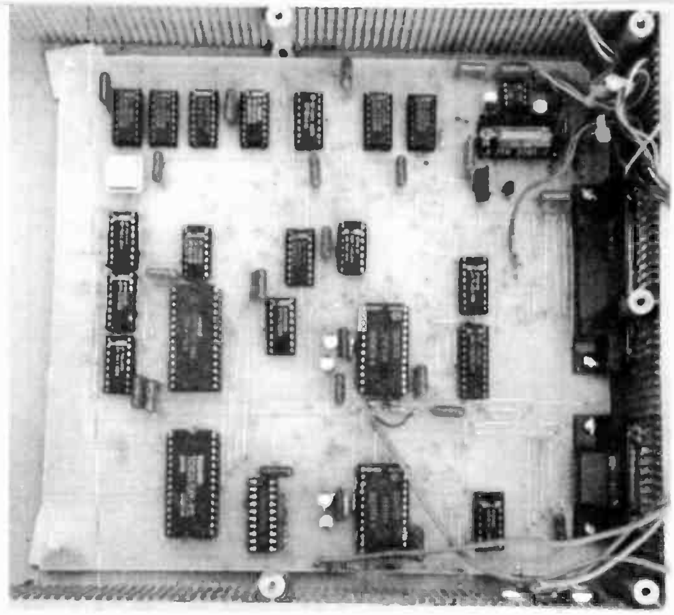
D107	1N4148 signal diode
IC106	TC55257DPL-85L (12MHz) or CXK58257AP-70LL (14MHz), SRAM (see text)
IC107	TDA8703 8-bit analogue-to-digital converter, 40MHz
IC108	74HC257 quad 2-input mutiplexer, tri-state
IC109	74HC245 octal bus transceiver

Miscellaneous

SK102	14-pin Centronics socket, right angle, p.c.b. mounting (R 473-802)

16-pin d.i.l. socket; 20-pin d.i.l. socket; 24-pin d.i.l. socket; 28-pin d.i.l. socket

Approx Cost Guidance Only £23



Digital Control printed circuit board.

equivalents of IC7 to IC9). The remaining detail in the inset shows the principal connections between these devices and the main circuit in Fig.2.

FIXED ADC RANGE

A point worth highlighting is that the ADC chip, IC7, is a fixed range device, unlike many ADCs with which you may be familiar. In other words, you cannot adjust its response relative to the analogue input signal amplitude.

Additionally, its minimum analogue input voltage level is not 0V, as might be expected (and even hoped for). Rather, a typical minimum bias level of 1·55V is required for a digital conversion value of zero to result. The maximum digital conversion value (255) is produced when the analogue input voltage is typically 3·26V. Compensation for any diversion from typical values is made in the earlier analogue processing stages.

If you consider using this ADC (Philips type TDA8703, 40MHz capability) in other applications, it is strongly recommended that you obtain its data sheet so that its requirements are understood – it is not the easiest of ADCs to use.

Note that two sets of 5V power lines are shown in Fig.2. One powers the digital circuitry (+5V DIG and 0V DIG), the other powers the ADC's analogue section (+5V ANA and 0V ANA). This supply splitting is crucial to the satisfactory operation of the ADC chip.

Incidentally, although IC6 and IC106 are stated as type TC55257DPL-85L (12MHz) devices, the CXK58257AP-70LL (14MHz) may be used instead.

CLOCK DIVISION

Circuit diagram details for the clock Oscillator and Dividers are shown in Fig.3. The 10MHz master frequency is generated by the crystal oscillator module IC12. This is a completely self-contained oscillator requiring no further components. Its output is sub-divided by a chain of dual BCD (binary coded decimal) counter chips, IC13 to IC15 plus one half of IC16 (its section A).

Each of the seven counters in the chain divides its input frequency by 10. The output from each stage, plus the direct output from IC12, is fed into the 8-way multiplexer IC17. In turn, the selected output from IC17 is fed into the second counter within IC16 (its section B) and to one half of a second multiplexer, IC18. IC16b divides the frequency by two and by five, feeding the results into IC18. Additionally, IC18 is used to switch between the internal and external clock sources.

Controlled by latch IC19, the required clock rate division is output from IC18 pin 7. Data which sets the latch output value is sourced from the computer. The latch output value is also responsible for controlling the input source, analogue or digital.

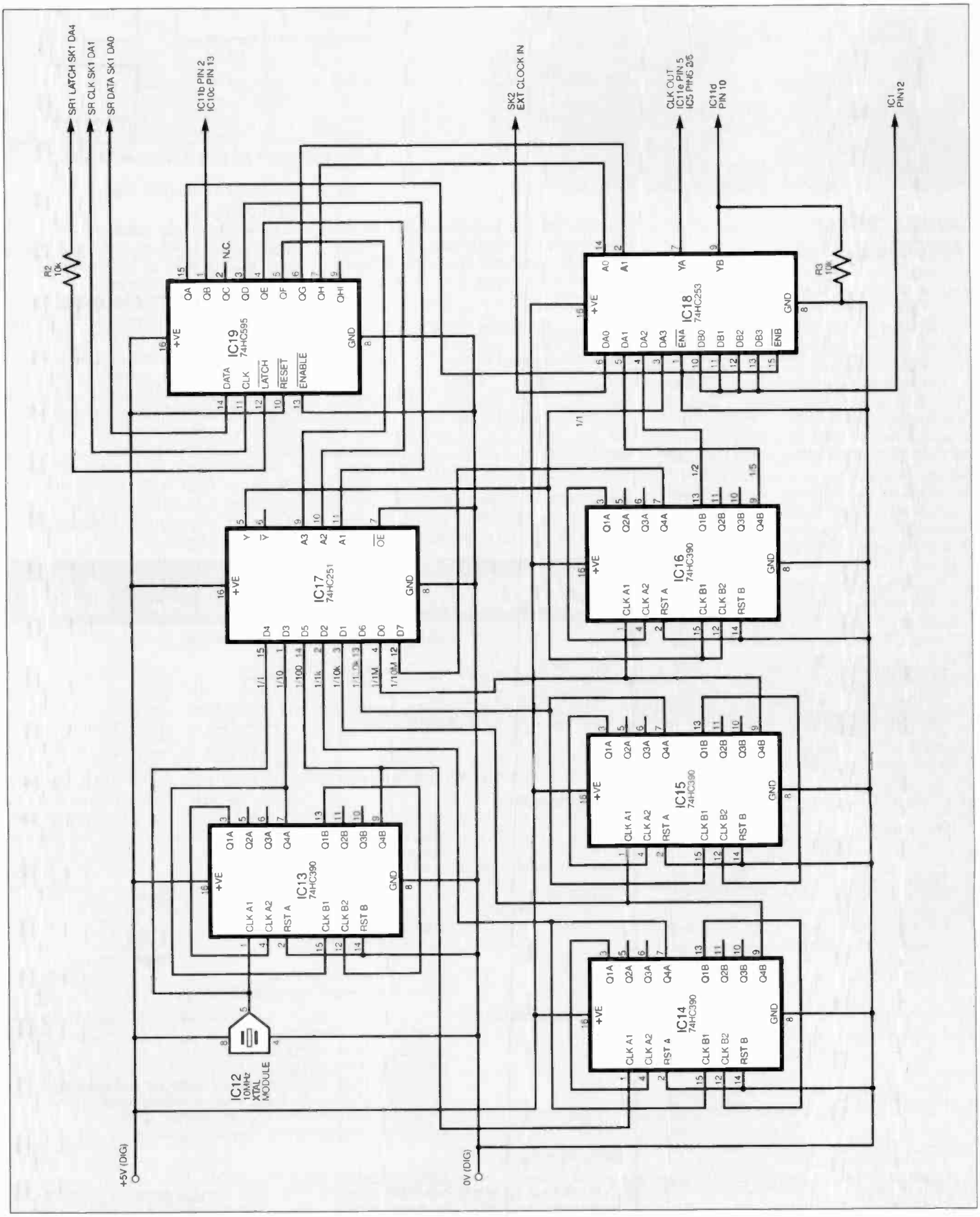
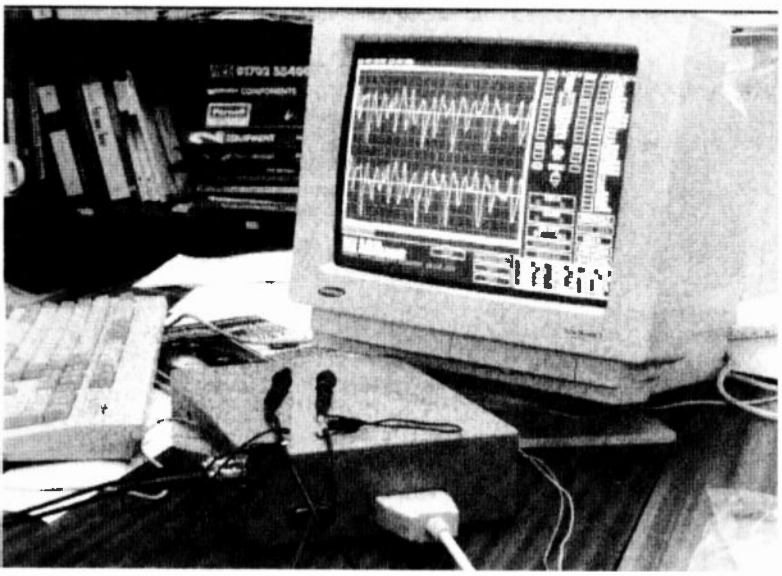


Fig.3. Circuit diagram for the Clock Dividers and Rate selection.



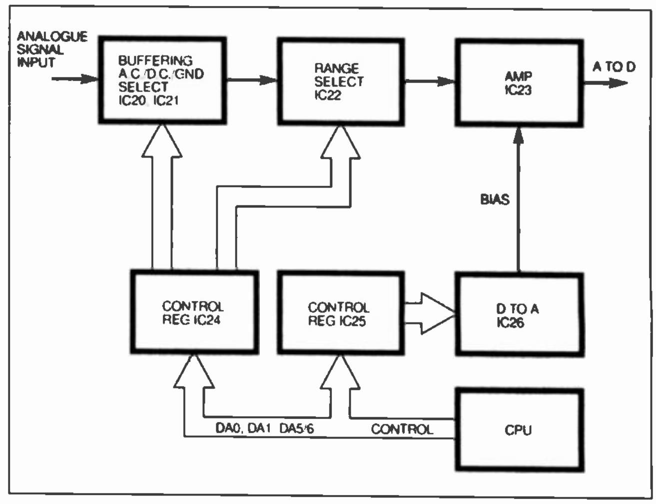


Fig.4. Block diagram for one Analogue Channel.

ANALOGUE PROCESSING

Block diagram details of the Analogue Processor for one channel are shown in Fig.4 (the second channel is identical). These need to be related to the actual circuit diagram, as shown in Fig.5, for them to be meaningful.

The input signal is brought in via socket SK3. It is split in two directions, both of which provide a degree of passive frequency compensation to benefit linearity of the amplification stages when handling square wave signals, adjustment being provided by variable capacitors VC1 and VC2. Diodes D1 to D4 limit the maximum signal amplitude that can be seen by the following switch stage (IC21) to about ±5·5V

The signal path through R4 to IC21 pin 12 (X0) essentially leaves the signal level unattenuated, i.e. at ×1. The path through R7 to IC21 pin 13 (X1) uses VR4 to attenuate the signal to one tenth (1/10) of the input value.

IC21 is a triple 2-pole analogue changeover switch (multiplexer). Each switch is individually controlled by the data from latch IC24. The selected ×1 or 1/10 signal path is routed through IC21 pin 14 (X) to the twin current amplifiers TR1 and TR2. These are followed by buffer op.amp IC20.

Preset potentiometer VR1 is used to compensate for ADC conversion range variation. Preset VR2 adjusts the op.amp offset for a null d.c. output level when the d.c. input level is grounded (0V).

The output from IC20 is a.c. coupled by capacitor C30 to the second changeover switch within IC21 (at pin 2 – Y0), and directly to the gain controlling resistors, R11 to R21. The d.c. output from IC20 is fed into IC21 pin 1 (Y1). Thus, the Y-path allows for IC21 to control selection of a.c. or d.c. signal coupling to the gain stage.

The third changeover stage within IC21, the Z-path, allows a grounded (0V) signal to be passed to TR1 and the subsequent stages, allowing for a null screen trace position to be established prior to taking measurements, and when the channel is not required on screen.

Op.amp IC23 provides amplification to the analogue signal. Its gain is set by the feedback resistor R22 in relation to the input resistance. Multiplexer IC22 selects the input resistance from the network provided by resistors R11 to R21. The gains selectable are:

Path	Resistor(s)	Value	Gain
X0	R11	100k	×1
X1	R12//R13	50k	×2
X2	R14	20k	×5
X3	R15	10k	×10
X4	R16//R17	5k	×20
X5	R18	2k	×50
X6	R19	1k	×100
X7	R20//R21	500Ω	×200

One tenth of these gains is, of course, available by selecting the 1/10 path through IC21. It is recommended that resistors R11 to R22 should be one per cent devices.

Selection of the gain values routed through IC22 is determined by data from latch IC24 which, as previously said, is controlled from the computer.

Data from IC24 also allows IC22 to be put into high impedance state (i.e. no signal passing through) when the channel is not required to be displayed on screen, or when setting of a specific screen trace position is needed. Originally intended to be treated separately from the zero-setting via IC21, the two controls are combined in the final software version.

Diode D5 limits the negative-going output swing from IC22 to approximately −0·5V, in order to avoid possible distress to the ADC chip into which the signal then feeds (IC7 in Fig.2).

COMPONENTS

Approx Cost Guidance Only £26

ANALOGUE BOARD (one channel)

Resistors

R4, R6, R7, R15 to R17, R26, R28, R34	10k (9 off)	R14	20k
R5, R8, R31	1M (3 off)	R18	2k
R9, R10 to R13, R22, R23, R30	100k (8 off)	R19 to R21	1k (3 off)
		R24, R29	47k (2 off)
		R25, R27	4k7 (2 off)
		R32, R33	10Ω (2 off)

All 0.25W 5% carbon film or better (see text)

Potentiometers

VR1, VR4	100k preset (3 off)
VR2	50k preset
VR3	10k preset

All min. cermet round or multiturn top-adjustment (see text)

Capacitors

C29, C31 to C34, C38, C40 to C45	100n polyester, 10mm pitch (12 off)
C30	4μ7 radial elect. 16V
C35 to C37, C39	22μ radial elect. 16V (4 off)
VC1, VC2	5p5 to 65p variable capacitor (2 off)

See SHOP TALK Page

Semiconductors

D1 to D5	1N4148 signal diode (5 off)
TR1, TR2	BC559 *pnp* signal transistor (2 off)
IC20, IC23	LM6361 high-speed op.amp (2 off)
IC21	74HC4053 triple single-pole 2-way analogue multiplexer
IC22	74HC4051 single-pole 8 way analogue multiplexer
IC24, IC25	74HC595 8-bit SIPO shift register, tri-state (2 off)
IC26	DAC08 or DAC0800 digital-to-analogue converter

Miscellaneous

SK3 — BNC 75Ω socket, panel mounting

Printed circuit board, available from the *EPE PCB Service*, code 177; standard switchable ×1/×10 oscilloscope probe with BNC connector; 8-pin d.i.l. socket (2 off); 16-pin d.i.l. socket (5 off); short self-adhesive p.c.b. supports (4 off)

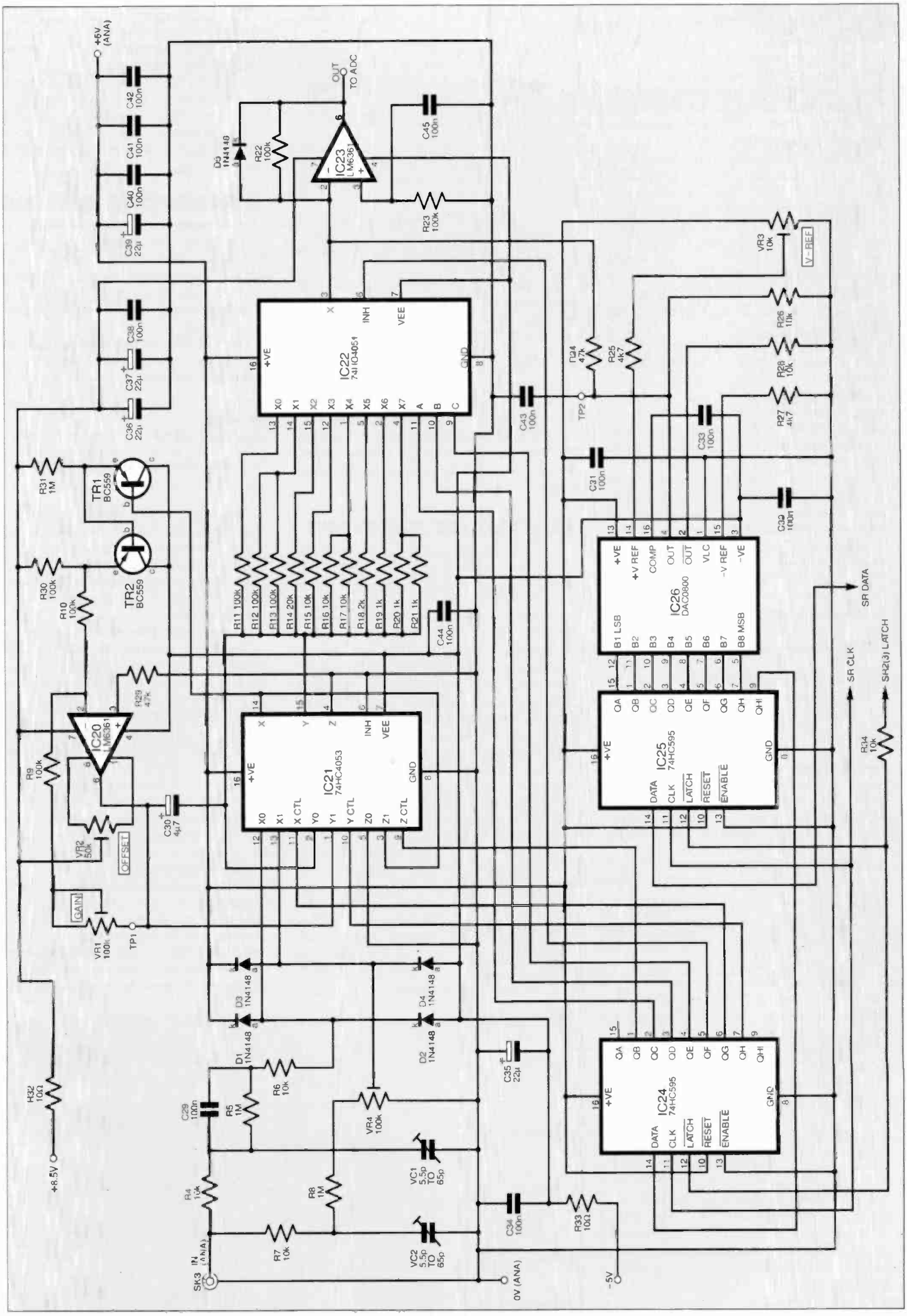


Fig.5. Circuit diagram for one Analogue Channel.

OUTPUT BIAS CONTROL

As with an ordinary oscilloscope, the ability to shift the bias voltage of the signal output from the gain stage is provided. This facility is computer controlled via latch IC25 and digital-to-analogue converter (DAC) IC26.

The joint combination of IC25 and IC26 allows 256 discrete voltage levels to bias op.amp IC23. The range of voltage is fixed, but the initial reference bias is presettable by VR3. The voltage increment per binary step is not related to any specific value, but is simply a level which allows reasonable movement of the display trace on the screen. An additional screen trace shift facility is also provided via software.

The bias shift provided by the DAC allows voltage levels to be shifted for relative d.c. voltage measurement, and for synchronisation purposes. Additional sync trigger point selection can be made via the software. There is also a direct screen shift facility which allows display traces to be moved to convenient positions on screen.

The latches, IC24, IC25 and IC19 (in Fig.3) are fed with common data and clock lines from the computer. Each, though, is fed by a different latching control line so that they only accept data specifically intended for them.

Op.amps IC20 and IC23 are powered at +8·5V and −5V, allowing adequate signal headroom before clipping. The remaining chips in Fig.5 are all powered at +5V/0V (analogue supply).

POWER SUPPLY

The principal power supply components are mounted on the Digital Control board. Their circuit diagram is shown in Fig.6.

It is intended that the entire system is powered from an existing 9V d.c. power supply (as is done by the author), or from a mains powered 9V d.c. adaptor (battery eliminator) connected via socket SK4. The current consumption is about 300mA average, so the power source should be rated at 500mA minimum.

Diode D6 prevents circuit damage should the power supply be connected with the wrong polarity. The diode reduces the supply to about +8·5V, which provides positive power to the op.amps, IC20 and IC23.

Negative power for the op.amps is generated by voltage converter IC29. Its output, of nominally −8·5V, is regulated down to −5V by IC30.

The analogue +5V supply is regulated down from the +8·5V line by IC28. Similarly, the digital supply is regulated down to +5V by IC27.

The separate analogue and digital 0V lines originate from the same 0V source, but each uses different connecting wires from that source, which is at the power input point on the digital board. This technique minimises sharp digital switching transients from unduly affecting the supply lines feeding to the analogue circuits.

There are numerous power line smoothing capacitors generously scattered around the physical layout on the printed circuit boards to assist in keeping power lines quiet.

SOFTWARE FACTORS

The software for this design is available on 3·5-inch disk or *free* via the Internet, as stated in the *Shop Talk* column and on the *EPE PCB Service* page.

There are three operational programs supplied and which are used together. One is in QBasic and the other two are in machine code. The latter were written using a registered copy of the shareware program A86/D86 (which originated from the Public Domain Shareware Library – PDSL).

The source code for the machine code is also supplied on the same disk. This is included purely for the interest of those who know about writing in assembler; it is not used by the circuit/computer.

The machine code is upwardly compatible with any microprocessor of the '86 family, from the 8086 to the Pentium (including '286, '386 and '486 processors). Note, though, that part of it is written to control a type PS/2 mouse.

The implication of this is that although (for example) the Amstrad 1640 uses an 8086 microprocessor, the author's Amstrad does not have a PS/2 mouse. The *EPE* Virtual Scope runs on this machine as far as waveform input is concerned, but the mouse does not respond. Since the mouse is essential to the design, a non-PS/2 mouse will prevent the Virtual Scope from working.

TRY BEFORE BUYING

It is strongly recommended that you check out the software with your computer before you buy anything for the Virtual Scope. All you need to do is obtain our free software and run it. It can be run without anything else being connected to the computer.

From DOS, copy the software into your QBasic directory by typing the following commands (pressing Enter after each):

c:
cd\ qbasic
copy a:vscope*.*

Now load QBasic with this command:

qb/l

The /l part of the command tells QBasic that it is to also load its own sub-program which allows machine code to be run from Basic. The normal QB command does not allow this to happen and will generate error messages if you attempt to run the main program.

(Experienced programmers might care to consider amending the relevant .BAT program – or other system-routing program – to include the /l in its commands, so allowing the usual QB command to be given from the keyboard.)

Once in QBasic, load VSCOPE.BAS. Look at line 5 where it says that **setupsim = 0**; change the 0 to 1 and run the program. *(Do not resave the program.)*

First of all, the screen is formatted for all the command boxes and the display area (see front cover). Some boxes should be seen to be coloured yellow and the overall background to be dark blue.

Next, an initialisation routine is entered. Depending on your computer speed, this can take anywhere between about six seconds and 25 minutes (yes, that wide a variation!). Fortunately, it only takes that long the first time you run VSCOPE. The author experienced the stated delays with a

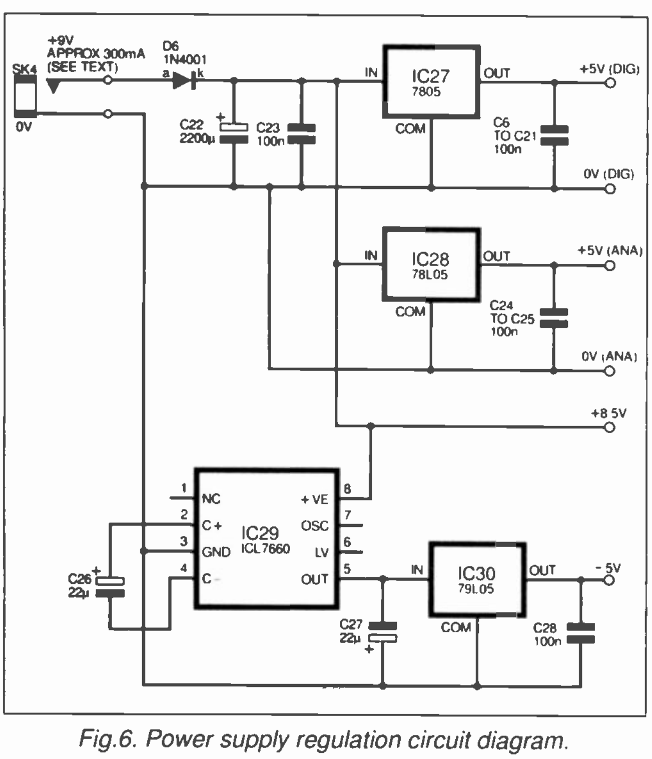
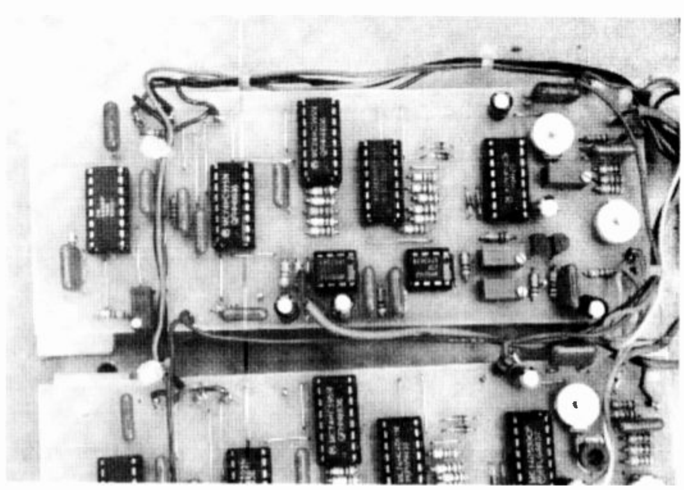


Fig.6. Power supply regulation circuit diagram.



Component layout on Analogue board (one channel).

120MHz Pentium Dell (six seconds) and a 4MHz Compaq (25 minutes).

On the first run, a lot more files are generated, setting up data which can be called in as various sine wave simulations. This information is written to the disk with a .SJM extension. Having been set up, the files can be called in on demand. Grid data files are also generated, having a .GRD extension.

On subsequent runs of VSCOPE, the files already exist and so do not need to be created. Hence, in future, loading and running VSCOPE only takes a few seconds.

MOUSE CHECK

Once the initialisation is complete, check out the mouse control. Move the mouse and see if the cursor (an arrow near the bottom right of the screen, pointing into the LIVE box) shifts accordingly.

If it does, re-position the cursor on the LIVE box and click the mouse left-hand button. The box should change to state SIMULATE. Having done so, one of the simulation files will be loaded and two waveforms will be drawn in the display area. Moving the mouse cursor to the right hand column of the frequency-setting boxes, clicking the left hand mouse button on any of them will load other simulation files.

Click the mouse (trying both left and right buttons) on any of the other function boxes, except for SIMULATE, DIRECTORY and PRINTER. Note the different responses which result, in particular those from gain setting changes. Read on next month to find out more about the functions.

First, though, note a bit of terminology as used in the rest of this article. Some functions are sensitive to which mouse button is pressed, others are not. If the statement is made to "left-click" then click the mouse left hand button with the cursor on the box required: similarly for "right-click". The simple statement "click" (without left or right designation) means that either mouse button can be used to achieve the same result.

In the (seemingly) unlikely event that the mouse cursor and buttons do not respond to the above tests then, regrettably, your computer cannot use the *EPE* Virtual Scope. In this case, exit back to DOS and delete all its files, using the three (separate) commands:

del vscop*.*

del simul*.sjm

del *.grd

(It is assumed that no other files of similar names already exist in the QBasic directory.)

The author has successfully used the *EPE* Virtual Scope with four computers and their mice: Dell Pentium, Dell '486, Compaq '386 and a custom-built '386. We would be interested to know what computer system you have if it cannot successfully run the above tests. *We cannot offer help on your problem, but we would still like to hear from you.*

PRINTER PORT CHECKING

If the mouse is working and the screen shows waveform displays, you should have no problem with running the *EPE* Virtual Scope. However, it is important that your computer is set up to use the printer port via the registers at &H378 – LPT1 and &H379 (the normal setting).

If it is not set in this way (other registers may be used) you will need to reconfigure the computer accordingly. You should consult your computer manual (or supplier) for information on how to do this; neither the author nor *EPE* can advise on it.

You can check your computer's printer port output control from the VSCOPE.BAS program. Stop the program by pressing the CTRL and BREAK keys together (but pressing CTRL first – if BREAK is pressed first, the PAUSE function occurs. If it does, press any other key).

Look at the start of the program. Delete the word REM in front of the line numbered 1234. *Do not resave the program.* Re-run the program by using shift-F5 (instead of the more usual F5 on its own).

Now use a multimeter on a suitable range for 5V d.c. monitoring to check the response at printer port pins DA0 to DA7, with the common lead on the 0V pin (see Fig.7). ***Be very careful not to cause a short between the pins.***

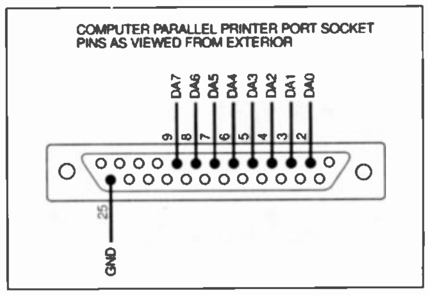


Fig.7. Pin connections for a PC-compatible parallel printer port.

The test program line constantly increments a number from 0 to 255 and outputs it to the printer port and to the screen. Your meter should show that pin DA7 changes state at a very much slower rate than DA0 (1:256)

To change the rate at which the increments occur, change the delay value used in the FOR B loop.

If all is well, read the *Shop Talk* column, get out your catalogues and order all the components!

Now exit QBasic, *without re-saving the program.*

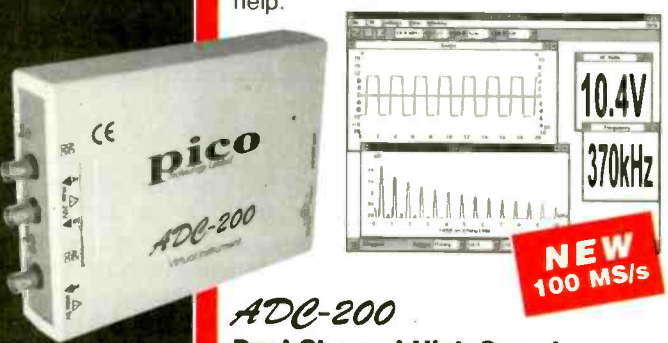
Next Month: Full constructional details, setting-up and use.

Data Acquisition
Virtual Instrumentation
Environmental Monitoring

Pico Technology

'Pico's Virtual Instrument is the most powerful, flexible test equipment in my lab.'

Pico's virtual instruments emulate the functions of traditional instruments such as **Oscilloscopes, Spectrum Analysers and Multimeters.** Controlled using the standard Windows interface, the software is easy to use with full on line help.



NEW 100 MS/s

ADC-200

Dual Channel High Speed

- 100, 50 or 20 MS/s sampling.
- 50, 25 or 10 MHz spectrum analysis.
- Advanced trigger modes - capture intermittent one-off events.
- Less than half the cost of a comparable benchtop scope.

ADC 200-100	£499.00
ADC 200-50	£399.00
ADC 200-20	£299.00

Supplied with cables and power supply.

ADC-100

Dual Channel 12 bit resolution

The ADC-100 offers both a high sampling rate 100kS/s and a high resolution. Flexible input ranges (±50mV to ±20V) make the unit ideal for audio, automotive and education use.

ADC-100
with PicoScope software £199.00
with PicoScope & PicoLog software £219.00

ADC-40/42

Single Channel - low cost

- 20 kS/s sampling.
- 10 kHz spectrum analysis.
- ± 5V input range.

ADC-40 8 bit resolution £59.00
ADC-42 12 bit resolution £85.00

Call for free demo disk or download our web site: http://www.picotech.com

All prices exclusive of VAT.

Broadway House, 149-151 St Neots Rd, Hardwick, Cambridge. CB3 7QJ UK
Tel: (0)1954 211716 Fax: (0)1954 211880
E-mail: post@picotech.co.uk

pico Technology Limited

Program your PIC12C508/9s

Visible Sound's Pentium Friendly PIC programmer will program the PIC12C508/9, PIC16C71/84. The programmer includes a ZIF socket to easily mount the device to be programmed. (H137A).
All this for only £25 inc. P&P (UK Only) and VAT.
25 way M/M cable £6 (A057A). **Power Supply £5** (A061A).

Christmas Special PIC Programmers Starter Kit

This value for money Special Offer consists of our PIC programmer (H137A), parallel connection cable (A057A) and Power supply (A061A) and 10 x PIC12C508-04/P.
Incredible value at £49.99 inc. VAT and (UK) P&P

PIC12C508-04/P 1x£2.30, 10x£2.00, 50x£1.88 and 100x£1.76(C504A).
PIC12C508/JW 1x£13.50 (C503A). PIC16C84 1x£6.00 (C500A).

Voice Command Module

£60 H138A

Based on the Sensory Devices RSC neural network speech recognition processor. 20 individual digital word ID outputs on IDC header. Each output with an 'on' word and 'off' word giving you up to 99% speaker dependent recognition. Simply train the module with up to 40 words.

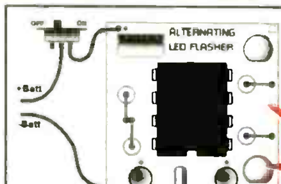
VCM low cost microphone (A060A) £6.50, VCM low cost Speaker (A062) £5.00, VCM serial cable (A059A) £9.00.

Voice Command module Christmas Value Pack £67.49 inc. VAT and (UK) P&P.

This pack contains VCM (H138A), VCM microphone (A060A), VCM speaker (A062A) and Power supply (A061A).

ALL Prices INCLUSIVE of vat and delivery (UK) Only) Same day despatch.

Visible Sound Ltd., 151, The Exchange Building, Mount Stuart Square, Cardiff. CF1 6EB. Tel (01222) 458417. Fax (01222) 480326. email Info@vsltec.demon.co.uk. WWW http:\www.vsltec.demon.co.uk.



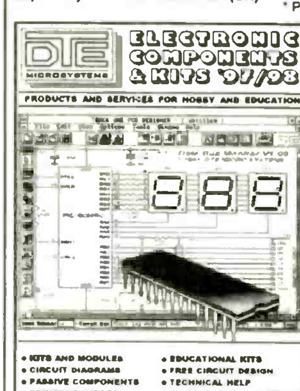
DTE K131

Alternately flashes two bright red LED's, but is capable of flashing a bank of up to 30 LED's - ideal for use in novel Christmas decorations. Supplied with all components, PCB, battery clip, switch, full instructions and details of other boards available. Can be purchased separately for £3.82 + £2.50 P&P (UK)

Special Offer Free Kit Worth £6.32*

With every order over £15 (goods value) placed before 31st December 1997

* Price including UK P&P when purchased separately



FREE 1997/98 MAIL ORDER CATALOGUE

- FM Transmitters and Bugs
- PIC Microcontroller Kits
- Greetings Cards Modules
- Remote Control
- Test Equipment
- Power Supplies
- Radio Receivers
- Sound Effect Modules
- Amplifiers
- Security Devices
- Motor Controllers
- Novelties and Games
- PC Data Acquisition

... PLUS MANY MORE

PHONE / FAX ORDERLINE
+44 (0) 1283 542229
Most major credit cards accepted

To receive your copy, just send your name and address, and include four 1st class stamps (to cover handling costs)

For the most up to date information check our web site at;
http://www.btinternet.com/~dtemicrosystems/

DTE MICROSYSTEMS
112 Shobnall Road. Burton on Trent. Staffs. DE14 2BB. UK

VIDEOS ON ELECTRONICS

A range of videos (selected by EPE editorial staff) 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. 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 originate from VCR Educational Products Co, an American supplier.
(All videos are to the UK PAL standard on VHS tapes.)

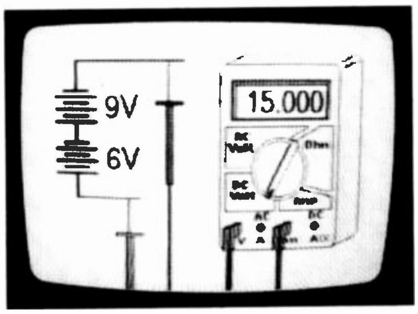
BASICS

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

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

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

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



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

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

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

£34·95 each
inc. VAT & postage
Order 8 or more get one extra FREE
Order 16 get two extra FREE

VCR MAINTENANCE

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

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

DIGITAL

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

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

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

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

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

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

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

RADIO

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

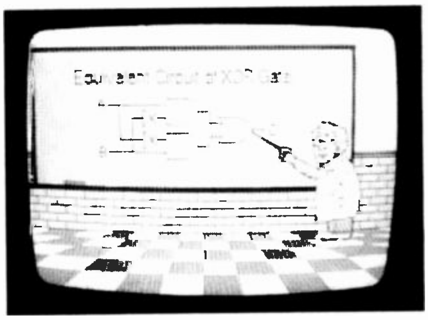
VT402 58 minutes. **F.M. Radio Part 1**. F.M. basics including the functional blocks of a receiver. Plus r.f. amplifier, mixer oscillator, i.f. amplifier, limiter and f.m. decoder stages of a typical f.m. receiver. **Order Code VT402**

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

MISCELLANEOUS

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

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



VIDEO ORDER FORM

Full name: ....

Address: ....

....

.... Post code: ....Telephone No. ....

Signature: ....

☐ I enclose cheque/PO payable to WIMBORNE PUBLISHING LTD

☐ Please charge my Visa/Mastercard: Card expiry date ....

Card No: ....

Please send video order codes: ....

....

Please continue on a separate sheet of paper if necessary.

ORDERING: Price includes postage to anywhere in the world.

OVERSEAS ORDERS: We use the VAT portion of the price to pay for *airmail* postage and packing, wherever you live in the world. Just send £34.95 per tape. All payments in £ sterling only (send cheque or money order drawn on a UK bank).

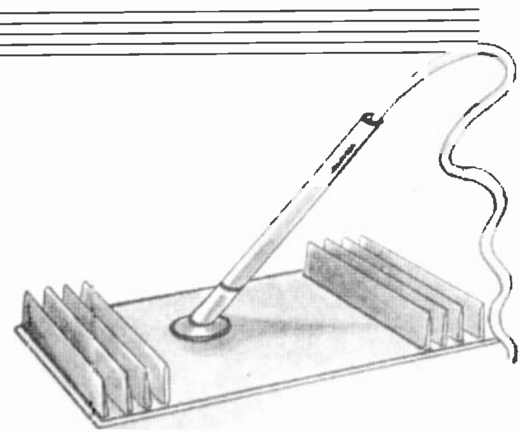
Send your order to:
Direct Book Service, 33 Gravel Hill, Merley, Wimborne, Dorset BH21 1RW
(Mail Order Only)

Direct Book Service is a division of Wimborne Publishing Ltd.
Tel: 01202 881749 Fax: 01202 841692

Videos are normally sent within seven days of receipt of order.

E22

SURFACE THERMOMETER



STEVE KNIGHT

Using a single silicon diode as a sensor, constructing an electronic thermometer is amazingly easy!

This relatively simple design describes a thermometer which was originally made up for the measurement of heatsink temperatures when the author was working on high current power supply units, some of which have appeared in past issues of *EPE*.

For surface temperature measurements on heatsinks and similar applications, the highest temperature reading should be at least 125°C, but extreme accuracy is not called for. This project, however, despite its basic simplicity, will read to ±2 per cent at worst and over the lower ranges of the scale may well be better than this. A circuit arrangement also makes it possible to go down to temperatures below 0°C if desired.

SENSOR CHOICE

As was noted in the *Narrow Range Thermometer* which appeared in *EPE* June '97, there are a number of heat sensors available: thermocouples, thermistors and diodes, to name only three of them.

At first, a thermistor sensor was considered, similar to that used in the previous design, but over an extended temperature range as was required here, problems arose over the need for a linear scale readout, which was not easily obtained at the higher end of the scale without a linearised bridge design and some associated complex circuitry.

After a lot of experimentation with various sensors, the humble silicon diode was finally selected as providing the best (and easiest) solution to the problem.

The principle involved here works on the fact that the variation in the forward voltage drop across the diode at a given current when the temperature of the diode is changed, remains linear; this means that the temperature coefficient of a diode does not vary with temperature over a reasonably wide range.

This linear relationship between the forward drop and the temperature of the diode for a given forward bias, makes the device a good and inexpensive temperature sensor.

SELECTING THE DIODE

In most silicon diodes, as you can easily find out by using the "diode test" position found on digital meters, the forward drop lies between about 550mV and 700mV. This is not necessarily measured at a specific forward bias, of course, but it does give an indication of the spread in the forward drop of a number of test pieces.

After trying a few of the most common diodes available, the ubiquitous 1N4148 turned out to be a suitable candidate. Using a range of water temperatures between ambient (about 20°C) and 100°C at a constant diode current of 1mA, it was found that the spread on forward voltage for 25 samples was between 580mV and 630mV, with one odd specimen showing 690mV.

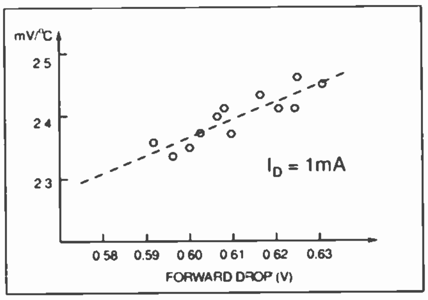


Fig.1. Temperature coefficient versus forward voltage drop for a sample of the 1N4148 diode.

The temperature coefficient for each of these samples was calculated over the same range. There was, as might be expected, a variation in the coefficient with variations in the forward drop, but this averaged out to about 2·35mV/°C for the 25 diodes concerned. This means that for every degree Celsius rise, the voltage drop across a diode decreases by about 2·35mV.

For simplification, the graph of Fig.1 shows the relationship between the temperature coefficient and the forward drop for a dozen of the 1N4148s used in the investigation, the diode current being 1mA.

From these results, it was reasonable to accept that for a given diode at a constant current within the forward drop limits of 580mV and 630mV, the temperature coefficient was stable over the range 20°C and 100°C and hence, with a suitable setting-up procedure, a linear scale could be achieved between the design temperature limits of 0°C and 125°C.

BASIC CIRCUIT

A bridge circuit comes to mind when a means of measuring the voltage drop across a diode is first considered, but although this method was tried (and worked!), a problem emerged in that one or two of the component values were critical and the system might not necessarily have been easily repeatable by individual constructors.

So the method was abandoned and recourse was made to the basic arrangement shown in Fig.2, which is suggested in several application notes; and this, with the right associated circuitry, proved very successful.

If a constant voltage is applied to the non-inverting input of an op.amp, the current flowing through resistor R and diode D, which is in the feedback path, will also be maintained at a constant level, about 1mA in this design.

This ensures that any voltage changes across the diode will be the direct result of temperature, and variations in the voltage output of the op.amp can occur *only* as the result of such voltage changes. The output voltage is consequently proportional to the diode temperature.

Even in a simple design, however, there are three stringent requirements about the final circuit: (a) the diode current must be

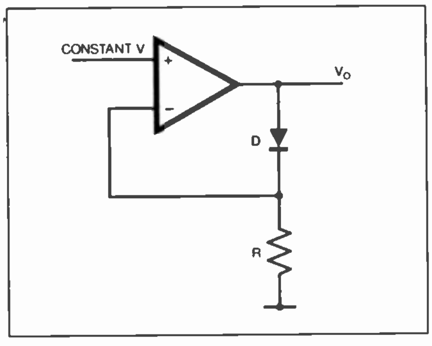


Fig.2. Method of measuring forward voltage drop of a diode for temperature changes.

set to the level desired and held constant, (b) it consequently follows that the supply voltage must be stable, and (c) the resistances used must be highly stable and of low temperature coefficient. If you can, use metal film resistors.

But enough of such interesting design theory – the time has come to get down to the building of the project!

CIRCUIT DESCRIPTION

The complete circuit diagram of the Surface Thermometer is shown in Fig.3. Three op.amps are used, and although these could have been in individual packages, it is neater to use three sections of a quad chip, such as the TL074, or any similar op.amp with JFET inputs.

A 9V battery supplies the d.c. power for the op.amp package directly at pins 4 and 11. The supply is reduced to a stabilized 5V for the rest of the circuit by the use of IC1, a +5V 100mA voltage regulator chip.

Further to this, op.amp IC2a is used to supply power to the system in the form of a symmetrical positive and negative line, so enabling the instrument to give temperature readings below 0°C if required.

A single supply could not do this; it is therefore necessary to provide what might be called an "operational" earth line which is not at the negative pole of the battery, what we might call the "real" earth.

With the non-inverting input at IC2a pin 12 held at 2·5V by the potential divider formed by resistors R1 and R2, and with the op.amp wired as a voltage follower, this voltage appears at the output, pin 14, so providing the operational earth line at +2·5V relative to the real earth line.

Pin 11 of the op.amp is, therefore, effectually at −2·5V and pin 4 is consequently at +6·5V with respect to this operational earth and a split supply is achieved.

This might seem an elaborate way of doing things – why not use the battery directly with a simple divider? But this would be a risky method if we are looking for a stable supply; here IC1 provides the stable supply and IC2 does the dividing from the R1 and R2 combination across the stabilized line.

Pin 10 of IC2b is held at a constant voltage by the setting of preset potentiometer VR1; this is set during calibration so that the output at IC2b pin 8 is zero for the diode forward voltage corresponding to the lowest temperature reading.

This may be 0°C but can be adjusted to any other level, such as a starting point of −10°C or +25°C, for example. The output of IC2b will then be a function of the diode voltage at low or elevated temperatures.

The output voltage from IC2b pin 8 is amplified and buffered by IC2c. Pin 5 of IC2c is also maintained at a constant level by the potential divider formed by resistors R7 and R8, this level being chosen so that zero volts will correspond to 0°C.

The output of IC2c at pin 7 is monitored by meter ME1 which, in the prototype, is scaled to 500μA, but other full scale deflections (f.s.d.) may be used. With the series resistances R11 and VR2, the 500μA scaling is effectively the equivalent of a 1·5V voltmeter, hence the setting of VR2 determines the upper temperature limit and constitutes a Span control.

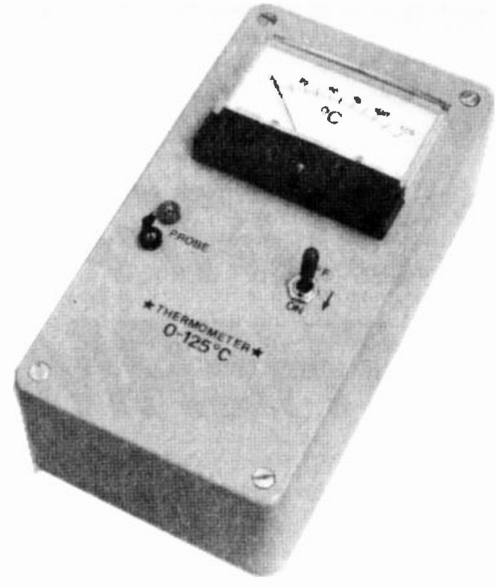
METER SCALING

As said, the meter used is a 500μA f.s.d. model, but the basic temperature range required for this project is 0° to 125°C. This means that a change is required to the scale markings so that the temperature can be read directly. Fig.4 shows the original meter scale and the modified scaling needed; each division on the scale is then 2·5°C.

To do this, the scale must be removed from the meter and, for the types suggested in the components list, this requires the removal of two screws, after which the scale can be carefully slid away from the meter body. A clean, dust-free environment is called for here; certainly a dirty bench top where there may be metal filings, hairs and the like about must be avoided.

Using a razor blade, carefully scrape away the "μA" marking and the scale figures, trying to avoid digging into the white surface of the scale. This can be done fairly easily but care is called for.

A final rub over with an ordinary eraser will help to prepare the surface for the new



figuring, which should follow that shown in Fig.4b, using 6- or 8-point figure size from rub-off lettering.

You may wish to make the scaling of the thermometer range from 0° to 100°C; in that case the meter may be replaced with a 100μA f.s.d. type and then no alteration need be made to the scaling. However, preset VR2 should then be replaced by a 10kΩ type.

CIRCUIT BOARD

The full size copper foil master pattern and the component overlay details for the printed circuit board (p.c.b.) are given in Fig.5. This board is available from the *EPE PCB Service*, code 174.

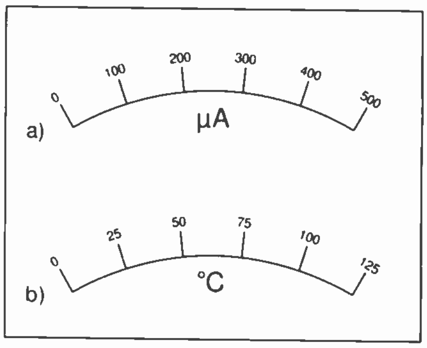


Fig.4. Scaling before (a) and after (b) modification. Intermediate markings not shown.

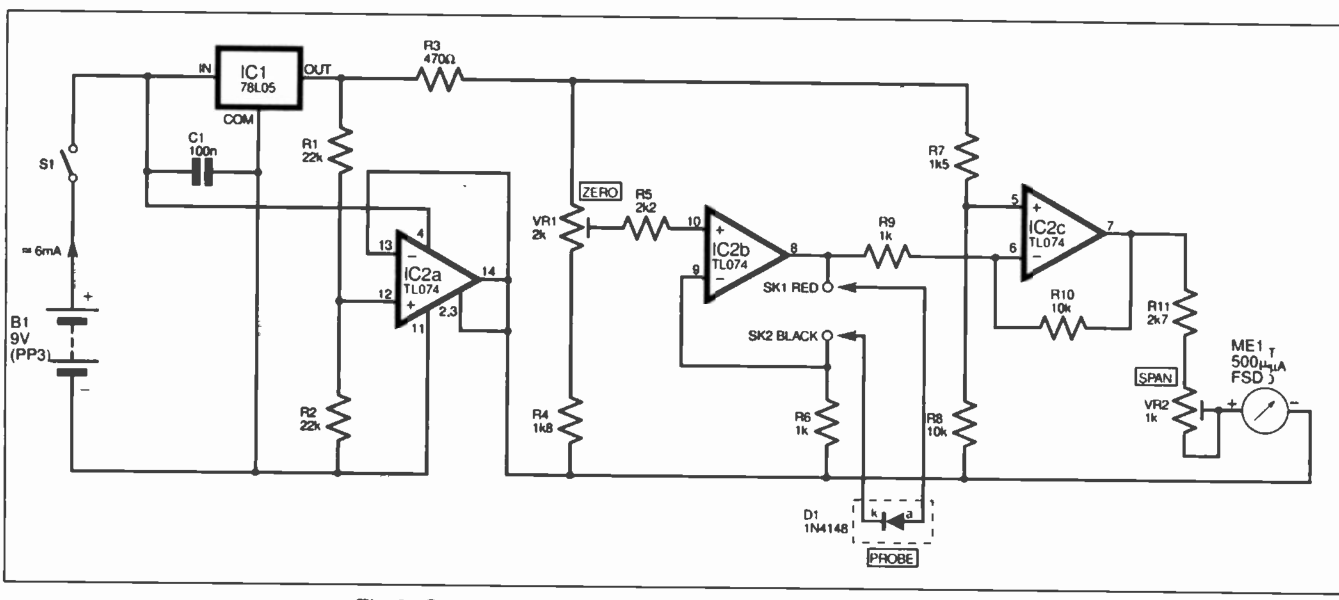


Fig.3. Complete circuit diagram for the Surface Thermometer.

All parts are mounted on this board, with the exception of battery B1, switch S1, meter ME1 and sensor diode D1. There should be no problems in assembling the components on the p.c.b. as there are no electrolytic capacitor or diode orientations to worry about, but make sure that IC1 is positioned as shown in the overlay. Use a socket for IC2.

Using 1mm terminal pins on the board eases connection to the battery, meter and sensor pads, although the wires may be soldered directly. Cut the stranded wires to about 300mm (12in.) lengths for the time being.

MAKING THE PROBE

The trickiest piece of this design has been left towards the end. The author agrees that the fabrication of the sensor probe, particularly the metal tip piece, is a bit fiddly and really calls for a small model-maker's lathe for the best result; there are one or two simpler alternatives which will be discussed in due course.

What is wanted is a means of bringing the diode sensor into contact with the surface whose temperature needs to be measured. This has to be accomplished by mounting the diode in a metal headpiece which can then be fitted to a length of tubing, providing the handheld part of the assembly.

The metal piece can be made from copper, hard aluminium or brass; aluminium is probably the easiest to work, but copper has the best heat conductivity of the three (unless you have won the lottery and prefer silver!) with aluminium and brass following in that order.

We also want a short length of tubing, non-metallic in material but no more than 9·5mm (3/8in.) in diameter. For the prototype, the author obtained an old plastic pen casing of 9·5mm diameter

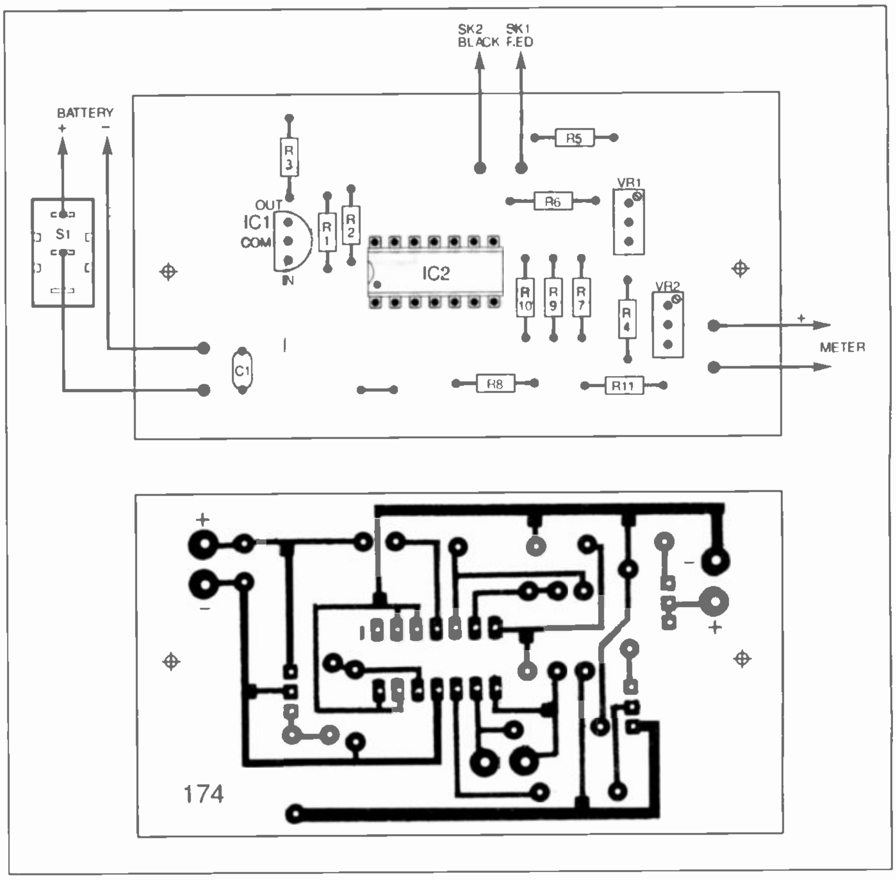


Fig.5. Printed circuit board component layout, off-board wiring details and full size underside copper foil master pattern.

which served successfully, but any plastic which softens at above 100°C must be avoided. However, a 6·5mm (¼in.) s.r.b.p. tube, which had once served as a coil former, was used in the final design.

There is plenty of scope for individual ingenuity to come into play over the making of the sensor head, the problem being that of holding the diode in close contact with the face piece. The general idea of the probe assembly is shown in Fig.6.

If you have access to a lathe, the tip should be made to the dimensions shown in Fig.7.

There are two other possibilities which the author has tried; the first of these is shown in Fig.8a.

The base plate is a piece of 22 s.w.g. brass or tinplate on which the diode is strapped with a narrow strip of very thin tinplate which can be cut conveniently from most old bean cans and the like.

This strap is bent to the shape shown and neatly soldered to the base piece so that the diode is kept in contact with this plate. The bent up "ears" are not strictly necessary; in the prototype these were bent to fit to the internal diameter of the probe tube, but the base plate can be neatly glued to the tube without the need for such. The

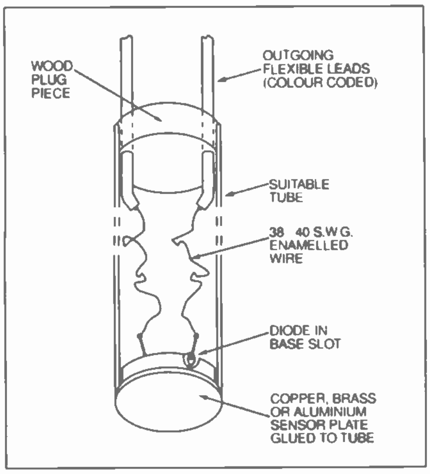


Fig.6. General probe assembly details. The tube can be an old plastic pen barrel or a piece of paxolin tubing.

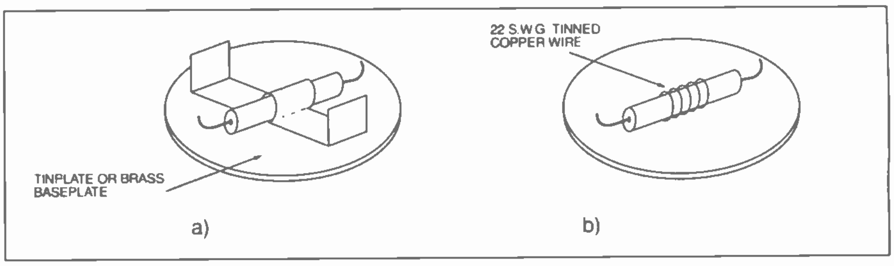


Fig.8. Alternative probe end plates. (a) Using a piece of tinplate to strap the diode to the baseplate. (b) Using a 22 s.w.g. "coil", soldered to the baseplate, to form a thermal contact with the sensor plate.

rest of the assembly then follows that shown in Fig.6.

Another method is shown in Fig.8b. Here a short length of 22 s.w.g. tinned wire is wrapped for three turns about the shank of a 2mm drill bit, the ends being neatly snipped off to form a short "tube" into which the diode will fit snugly.

Using very little solder, fix this tube to the face plate, then insert the diode with a smear of glue. Allow this to set, and then complete the assembly as per Fig.6.

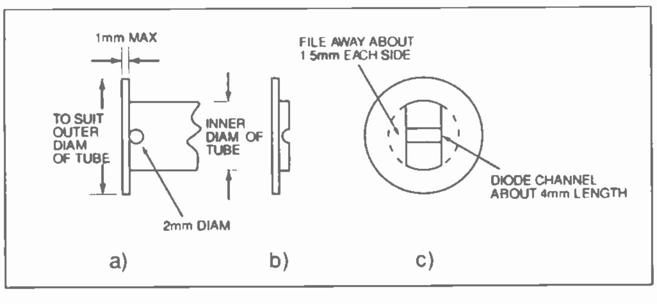
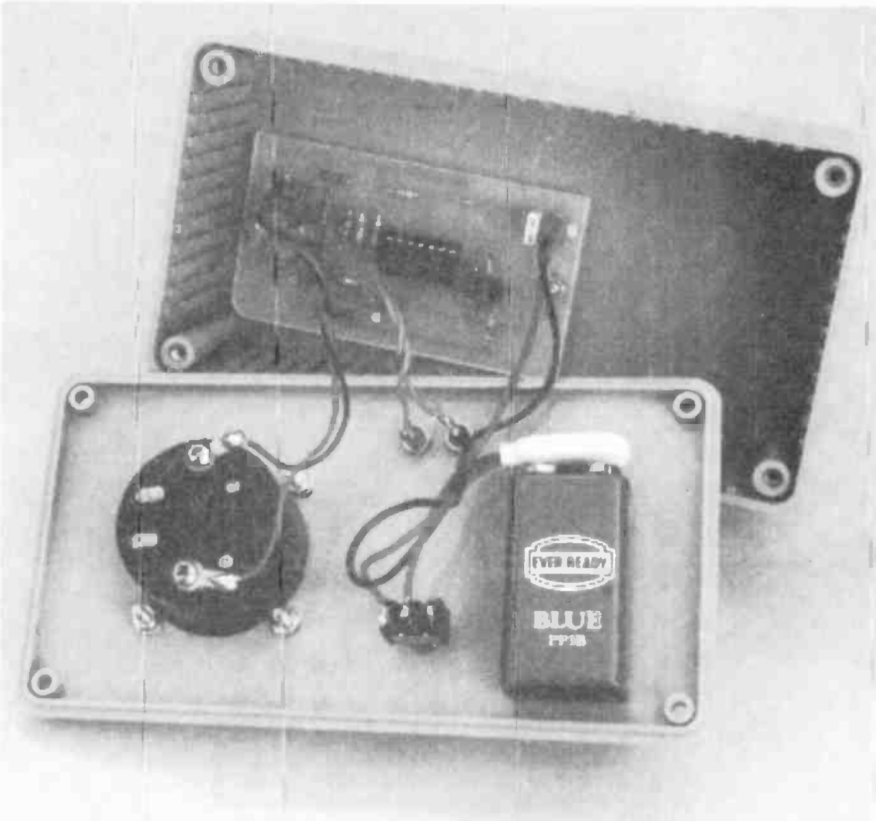


Fig.7 (left). Probe end piece details.



For these two alternatives, it may be an advantage to set the tip at a slight angle to the tube, but this is entirely a personal choice. Whatever method you come up with, keep in mind that the conductivity of the path to the diode should not be impaired by air gaps or excessive use of glue.

BOXING UP

Any small metal or plastic box will do for this project. An ABS two-piece case measuring 150mm × 80mm × 50mm deep was used for the prototype; anything round about these dimensions will do.

The only panel components are the meter, on-off switch and a couple of 1mm sockets for the probe connection, the photographs show the general arrangement of things. There is nothing critical about any of the positions (but make sure that if you use a shallow case, the meter will not foul any of the board components), so you can fit things together to your own particular fancy.

However, do not connect the meter until some initial calibration has been done.

CALIBRATION

Turn both potentiometers to their mid-positions; this can be done by turning the adjusting screws one way or the other until a clicking sound indicates that the end of the track has been reached. Since the specified pots are 25-turn types, screw back by about 12 turns to reach the mid-position of each of them.

When you commence the calibration process, it is advisable to use a multimeter on a 5V d.c. range (or thereabouts) connected between IC2 pin 7 and the 0V line (battery negative).

Adjust preset VR1 until the meter reads zero. Once this is done you can replace the multimeter with the 500μA meter connected to its proper terminal pads. Check by adjustment of VR1 that the meter needle can be moved on either side of the zero point.

For a calibration range of 0°C to 125°C you can start off in one of two ways: (a) for a 0°C reference, use an ice-water mix in about equal amounts and kept well stirred; (b) use the ambient temperature as the reference.

In both cases, check the temperature against a mercury-in-glass thermometer and set VR1 so that the meter shows the same value. This for the moment sets the lower temperature end of the scale.

Now hold the probe just above the surface of some boiling water for about half a minute, then immerse it fully. This action avoids giving the diode (just out of the ice mixture) a thermal shock.

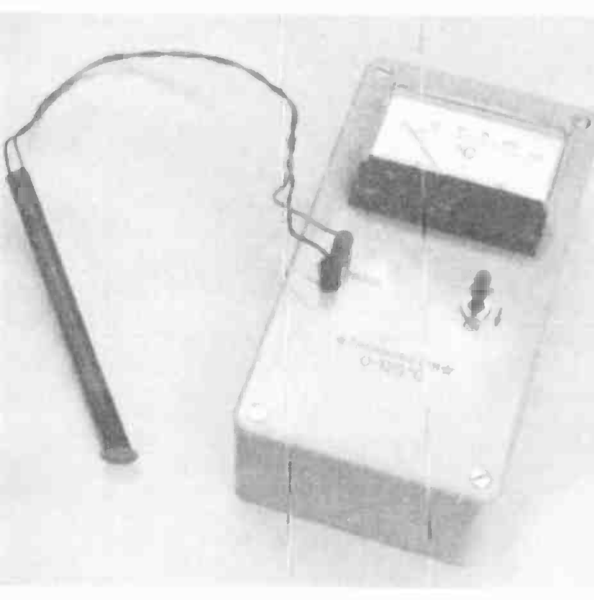
Adjust the Span control VR2 to set the meter reading to 100°C. The actual temperature of boiling water does depend upon the air pressure and if you have a mercury-in-glass thermometer you might use this to check on the actual boiling point.

However, at worst, the true temperature will almost certainly lie within a degree or so of the accepted 100°C so, unless you live on the top of Mont Blanc, the error in taking the boiling point to be exactly 100°C can be neglected.

Return now to the ice-water bath and check that the meter reads 0°C. In theory it should be the same, but in practice it may be found to have shifted slightly; if it has, readjust VR1 to restore it to zero.

The same procedure will apply if you are working on the ambient level, but check that this itself has not changed in the interval. Check between the temperature extremes in this way until no variation is evident, and this completes the calibration.

If you want to use an alternative scaling, say from −10°C to 50°C, the calibration points can be selected at 0°C as above, and a water bath of 50°C checked against a mercury-in-glass thermometer. Do not try to go lower than −20°C or higher than 140°C with the diode sensor or the linearity will be affected.



COMPONENTS

Resistors

R1, R2	22k (2 off)	See SHOP TALK Page
R3	470Ω	
R4	1k8	
R5	2k2	
R6, R9	1k (2 off)	
R7	1k5	
R8, R10	10k (2 off)	
R11	2k7	

All 0·25W 5% metal film or better.

Potentiometers

VR1	2k 25-turn preset, top adjust
VR2	1k 25-turn preset, top adjust (see text)

Capacitor

C1	100n polyester

Semiconductors

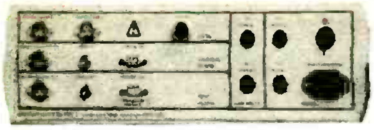
D1	1N4148 silicon signal diode (probe)
IC1	78L05 +5V voltage regulator
IC2	TL074 quad JFET op.amp

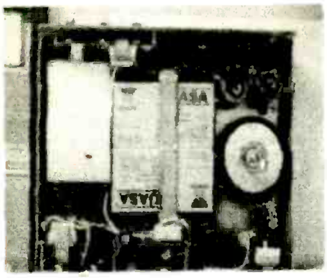
Miscellaneous

S1	s.p.s.t. min. toggle switch
ME1	500μA f.s.d. meter, MU or T-type
SK1	1mm socket, red
SK2	1mm socket, black
B1	9V battery, PP3

Printed circuit board, available from the *EPE PCB Service*, code 174; ABS plastic case, 150mm × 80mm × 50mm (see text); materials for probe (see text) 1mm plug (1 red, 1 black); 16-pin d.i.l. socket; 1mm terminal pins; connecting wire; solder, etc.

Approx Cost Guidance Only £15
Excluding batt. & meter



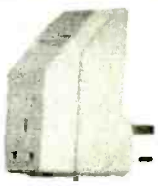


SALE PRICE £9.95

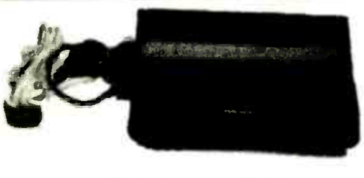
VIDEO PROCESSOR UNITS?/6v 10AH BATTS/24V 8A TX Not too sure what the function of these units is but they certainly make good strippers! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear. Inside 2 x 6v 10AH sealed lead acid batts, pcb's and a 8A? 24v torroidial transformer (mains in). sold as seen, may have one or two broken knobs etc due to poor storage. £9.95 ref VP2X

Dell switched mode psu 12v 15amp £9.95

140x 150 x 90mm, fully cased with built in fan, +12 @ 13A, +5 @ 15A IEC power inlet, flylead output. £9.95 ref DEL2



UK made energy saving device that can give you a 15% saving on the running costs of fridges etc.
Suitable for mains appliances fitted with a motor of up to 2A rating. We have tried the device on other things like soldering irons, conventional bulbs and still achieved a saving.
One off price is £9 ref LOT71
Pack of 10 is £89 ref LOT72
Pack of 20 is £119 ref LOT73



SALE PRICE £10

These units must be cleared at the absurd price of just £10!! you get loads of leads, an infra red remote keyboard and receiver, a standard uhf modulator, a standard bt approved modem 1200/75 and loads of chips, resistors, capacitors etc etc
all for just £10 ref bar33

Switched mode psu special offer £2.99

Brand new psu's giving 5v at 4.4Amps. Originally made for the Archimedes but obviously have many other uses. Fitted on/off switch and fly lead. 150 x 100 x 42mm. £2.99 ref ARCH1X

SALE PRICE £2.50

Customer returns, domestic telephone coin boxes, used to convert ordinary phones in to pay phones. ref CBT1X

The ultimate enclosure for your projects must be one of these!

Well made ABS screw together beige case measuring 120 x 150 x 50mm. Already fitted with rubber feet and front mounted LED. Inside is a pcb fitted with other bits and pieces you may find useful. Sold either as a pack of five for £10 ref MD1 Or as a pack of 20 for £19.95 ref MD2

Order via our web site at www.bull-electrical.com

SOLAR PANELS

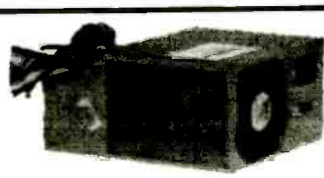
3' x 1' Amorphous silicon, 7 watt 12-14v output. Unframed. Ref SOLX

SALE PRICE 4 for £59

PC KEYBOARDS

sale price just £2.99

Standard ps2 type connector, 104 keys. ref PCX



Compaq 244 watt pc power supplies buy 2 for £16

Ex equipment but in full working order direct from one of the top manufacturers. 145 x 175 x 85mm, fitted fan and IEC inlet, switch on flylead. Outputs are 3.3vdc, +5vdc, -5vdc, +12vdc, -12vdc. You may need to change the mother board connector so we have included another one with the power supply to help. £16 for 2 ref COM2

BULL ELECTRICAL

250 PORTLAND ROAD, HOVE, SUSSEX BN3 5QT. (ESTABLISHED 50 YEARS).
MAIL ORDER TERMS: CASH, PO OR CHEQUE WITH ORDER PLUS £3.50 P&P PLUS VAT.
24 HOUR SERVICE £5.00 PLUS VAT.
OVERSEAS ORDERS AT COST PLUS £3.50
(ACCESS, VISA, SWITCH, AMERICAN EXPRESS)
'phone orders: 01273 203500
FAX 01273 323077
E-mail bull@pavilion.co.uk

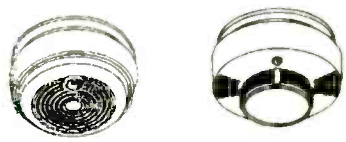
12V FANS, EX EQUIPMENT COMPLETE WITH METAL CASES
PACK OF 10 FOR £9.95

RCB UNITS £2.99

This in line miniature earth leakage unit instantly shut off the mains supply in the event of any current flowing between live and earth thus preventing a potentially lethal shock. IEC plug one end, socket the other, fitted in seconds, reset button. The ultimate safety aid when working on electronic equipment, computers etc.
As these units are fitted with an in-line IEC plug on one end and socket on the other than could even be used to extend standard IEC computer leads.

Complete accounts system for your PC for just £9.95

Unlimited companies, general ledger, multiple cash books, debtors and creditors, stock, invoicing, purchasing, budgets, report writer, caculator, wordprocessor, automated backups, on line help, windowing, networkable up to 10 workstations. **Free telephone support for 30 days from MAP computer products 01616788413** all for the bargain price of just £9.95! worth it for the 200 page Pastel manual alone! ref SA12 3.5" disk version only. £9.95 ref PAS2

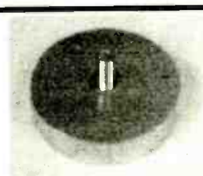


MAINS SMOKE ALARMS (GENT) NEW AND BOXED £4.99 ref SMKX

BBC selector videocrypt 's' tvtuner with smart card

sale price £9.95

Interesting new item in this week is this Selector. Originally made for the BBC to send encrypted video films to your VCR at night time. The project seems to have failed.
Very complex units consisting of a smart card slot in the front plus several switches and an IR receiver. Fully cased and measuring 230 x 430 x 50mm, new and boxed.
On the back of the unit is a scart socket plus a UHF input and output. A channel tuning control numbered 28 to 40 and an IR socket.
Inside is a comprehensive tuner section, smart card reader mechanism and control electronics plus a power supply section.
These units are sold as strippers but we imagine you could use one to convert a monitor into a TV or maybe use the videocrypt side of things for something else. Supplied complete with manual and mains lead.
Clearance price just £9.95 ref BBC1X



Introducing our mega magnet that lifts 33 kilo's!

Just in this week are these incredible Neodymium magnets that will lift an incredible 33 kilo's! Each magnet has a threaded bolt protruding from the rear for easy fixing. 32mm diameter. £15 ref MAG33

Everyday Practical Electronics Books

ELECTRONIC PROJECTS – BOOK 1
Published by *Everyday Practical Electronics* in association with Magenta Electronics.
Contains twenty of the best projects from previous issues of EE each backed with a kit of components. The projects are: Seashell Sea Synthesiser, EE Treasure Hunter, Mini Strobe, Digital Capacitance Meter, Three Channel Sound to Light, BBC 16K Sideways Ram, Simple Short Wave Radio, Insulation Tester, Stepper Motor Interface, Eprom Eraser, 200MHz Digital Frequency Meter, Infra Red Alarm, EE Equaliser Ioniser, Bat Detector, Acoustic Probe, Mains Tester and Fuse Finder, Light Rider – (Lapel Badge, Disco Lights, Chaser Light), Musical Doorbell, Function Generator, Tilt Alarm, 10W Audio Amplifier, EE Buccaneer Induction Balance Metal Detector, BBC Midi Interface, Variable Bench Power Supply, Pet Scarer, Audio Signal Generator.
128 pages (A4 size) **Order code EP1** £2.45

ELECTRONICS TEACH-IN 88/89 – INTRODUCING MICROPROCESSORS
Mike Tooley BA (published by *Everyday Practical Electronics*)
A complete course that can lead successful readers to the award of a City and Guilds Certificate in Introductory Microprocessors (726/303). The book contains everything you need to know including full details on registering for assessment, etc. Starting with basic terminology, integrated circuits, logic families and numbering systems the text builds in stages, with revision and assessments built in, up to programming, languages, flow charts, etc. The course is ideal for the newcomer to the subject.
80 pages (A4 size) **Order code TI-88/89** £2.45

TEACH-IN No. 7 plus FREE Software
ANALOGUE AND DIGITAL ELECTRONIC COURSE
(Published by *Everyday Practical Electronics*)
Alan Winstanley and Keith Dye B.Eng(Tech)AMIEE
The highly acclaimed *Teach-In* series, which included the construction and use of the *Mini Lab* and *Micro Lab* test and development units, has been put together in book form. Additionally EPT Educational Software have developed a GCSE Electronics software program to compliment the course and a FREE DISC covering the first two parts of the course is included with the book.
An interesting and thorough tutorial series aimed specifically at the novice or complete beginner in electronics. The series is designed to support those undertaking either GCSE Electronics or GCE Advanced Levels, and starts with fundamental principles.
If you are taking electronics or technology at school or college, this book is for you. If you just want to learn the basics of electronics then this is for you. If you are teaching electronics or technology you must make sure you see it. *Teach-In No. 7* will be invaluable if you are considering a career in electronics or even if you are already training in one. The Mini Lab and software enable the construction and testing of both demonstration and development circuits. These learning aids bring electronics to life in an enjoyable and interesting way: you will both see and hear the electron in action! The Micro Lab microprocessor add-on system will appeal to higher level students and those developing microprocessor projects.
152 pages (A4 size) **Order code T17** £3.95

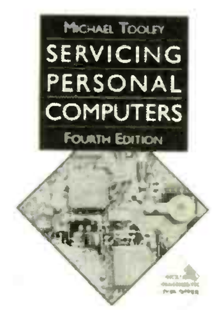
DIRECT BOOK SERVICE

The books listed have been selected by Everyday Practical Electronics *editorial staff as being of special interest to everyone involved in electronics and computing. Books are supplied by mail order direct to your door. Full ordering details are given on the last book page. For another selection of books see the next two issues of* EPE.

Testing and Test Gear

HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT
R. A. Penfold
This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers, and crystal calibrators.
104 pages **Order code BP267** £3.50

SERVICING PERSONAL COMPUTERS – 4th EDITION
Mike Tooley BA



The revised and enlarged forth edition has been completely re-written to cover the latest technology, such as 32-bit microprocessors and serial communications servicing. It includes a diagnostic disk offer. Essential for anyone concerned with the maintenance of personal computer equipment or peripherals, whether professional service technician, student or enthusiast.
387 pages Hardback **Order code NE15** £30

Computers and Computing

MULTIMEDIA ON THE PC
Ian R. Sinclair
In this book, you'll find out what a CD ROM is, how it works, and why it is such a perfect add-on for a PC, allowing you to buy programmes, text, graphics and sound on a CD. It also describes the installation of a CD ROM drive and a sound card, pointing out the common problems that arise, and then shows how to use them to create a complete multimedia presentation that contains text, photos, a soundtrack with your own voice recorded as a commentary, even animation and edited video footage.
184 pages **Order code PC112** £11.95

A CONCISE INTRODUCTION TO MS-DOS
N. Kantaris
(Revised Edition Covers Version 6.2)
This guide is written with the non-expert, busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nevertheless, the guide is also designed to be circular, which means that you don't have to start at the beginning and go to the end. The more experienced user can start from any section.
176 pages **Order code BP232** £4.99

UNDERSTANDING PC SPECIFICATIONS
R. A. Penfold (Revised Edition)
If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.
This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!
128 pages **Order code BP282** £4.95

Radio, TV, Satellite

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold
This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.
The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.
Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.
92 pages **Order code BP304** £3.95

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole
Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century.
This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.
150 pages **Order code BP257** £4.99

SIMPLE SHORT WAVE RECEIVER CONSTRUCTION
R. A. Penfold
Short wave radio is a fascinating hobby, but one that seems to be regarded by many as an expensive pastime these days. In fact it is possible to pursue this hobby for a minimal monetary outlay if you are prepared to undertake a bit of d.i.y., and the receivers described in this book can all be built at low cost. All the sets are easy to costruct, full wiring diagrams etc. are provided, and they are suitable for complete beginners. The receivers only require simple aerials, and do not need any complex alignment or other difficult setting up procedures.
The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.
Contains everything you need to know in order to get started in this absorbing hobby.
88 pages **Order code BP275** £3.95

Our postage is the same no matter how many books you buy – just £1.50 in the UK.

TWO EXCITING NEW BOOKS

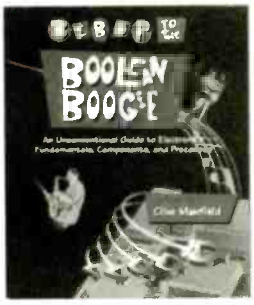
Specially imported by *EPE*

Bebop To The Boolean Boogie

By Clive (call me Max) Maxfield

ORDER CODE BEB1

£24.95



An Unconventional Guide to Electronics Fundamentals, Components and Processes

The Foreword by Pete Waddell, Editor, *Printed Circuit Design*, reads:

My first exposure to the unique writing style of Clive (call me Max) Maxfield was a magazine article that he co-wrote with an associate. The article was technically brilliant (he paid me to say that) and very informative, but it was the short biography at the end of the piece that I enjoyed the most. I say enjoyed the most because, as you will soon learn, Max does not necessarily follow the herd or dance to the same drummer as the masses. Trade journals have a reputation for being informative and educational but also as dry as West Texas real estate.

Anyway, Max's personally submitted biography not only included a message from his mom, but also made mention of the fact that he (Max) is taller than his co-author, who just happened to be his boss at the time. Now to some people this may seem irrelevant, but to our readers (and Max's boss), these kind of things – trivial as they may seem to the uninitiated – are what helps us to maintain our off-grid sense of the world. Max has become, for better or worse, a part of that alternate life experience.

So now it's a couple of years later, and Max has asked me to write a few words by way of introduction. Personally, I think that the title of this tome alone (hmmm, a movie?) should provide some input as to what you can expect. But, for those who require a bit more: be forewarned, dear reader, you will probably learn far more than you could hope to expect from *Bebop to the Boolean Boogie*, just because of the unique approach Max has to technical material. The author will guide you from the basics through a minefield of potentially boring theoretical mish-mash, to a Nirvana of understanding. You will not suffer that fate familiar to every reader: re-reading paragraphs over and over wondering what in the world the author was trying to say. For a limey, Max shoots amazingly well and from the hip, but in a way that will keep you interested and amused. If you are not vigilant, you may not only learn something, but you may even enjoy the process. The only further advice I can give is to "expect the unexpected."

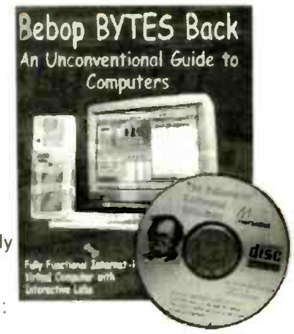
By importing these books ourselves we have managed to make them available in the UK at an exceptional price.

Bebop Bytes Back

By Clive "Max" Maxfield and Alvin Brown

ORDER CODE BEB2

£29.95



An Unconventional Guide To Computers

Plus **FREE CD-ROM** which includes: Fully Functional Internet-Ready Virtual Computer with Interactive Labs

The Foreword by Lee Felsenstein reads:

This book is not for everyone.

It's for people who want to make a dinosaur dance . . . to exactly the tune that suits them at the moment. Who want to take the most complex, precision-built machines available and make them do something bizarre, inexplicable, or totally unexpected.

It's for people who keep looking for what's underneath the surface, who never stop wondering "how does this work?" And when they find what's underneath, they want to know how that works.

It's for young people, or more exactly, people who haven't grown old. People who don't believe that they've already done everything remarkable they're ever going to do. It's for people with a future.

If you're the right person for this book, you need to know a few facts:

1. The more time you spend with this book and its accompanying CD-ROM, the more you'll get out of it. Skimming through it won't take you where you want to go. Paying serious attention, on the other hand, will teach you more about computers than you can imagine. (You might also see a few beautiful sunrises.)

2. The labs work on two levels: on and under the surface. When you're performing the labs you'll need to look for patterns that build up from individual events.

3. When you're done, you won't look any different. You won't get a trophy or a certificate to hang on your wall. You'll have some knowledge, and some skill, and you'll be ready to find more knowledge and develop more skill. Much of this will be recognisable only to someone who has the same knowledge and skill.

This book will admit you to the company of people who have deep knowlege of computer technology. It is only a beginning (there is no end), and there are many possible directions for you to go.

And this book makes it fun. Written by a couple of wise-cracking English computer engineers with overactive imaginations, it is rich in jokes, trivial information, and overblown vocabulary (with a lexicon). Maxfield and Brown have masterfully made the task of learning computer technology engaging.

Good luck, enjoy your voyage of discovery, and I expect to see some of you in the near future.

Audio and Music

PRACTICAL MIDI HANDBOOK
R. A. Penfold

The Musical Instrument Digital Interfaced (MIDI) is surrounded by a great deal of misunderstanding, and many of the user manuals that accompany MIDI equipment are quite incomprehensible to the reader.

The Practical MIDI Handbook is aimed primarily at musicians, enthusiasts and technicians who want to exploit the vast capabilities of MIDI, but who have no previous knowledge of electronics or computing. The majority of the book is devoted to an explanation of what MIDI can do and how to exploit it to the full, with practical advice on connecting up a MIDI system and getting it to work, as well as deciphering the technical information in those manuals.

128 pages **Order code PC101** **£6.95**

AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN
V. Capel

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him – or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.

148 pages **Order code BP256** **£3.99**

ACOUSTIC FEEDBACK – HOW TO AVOID IT
V. Capel

Feedback is the bane of all public address systems. While feedback cannot be completely eliminated, many things can be done to reduce it to a level at which it is no longer a problem.

Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving acoustics. Some microphones are prone to feedback while others are not. Certain loudspeaker systems are much better than others, and the way the units are positioned can produce a reduced feedback. All these matters are fully explored as well as electronic aids such as equalizers, frequency-shifters and notch filters.

The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

Also included is the circuit and layout of an inexpensive but highly successful twin-notch filter, and how to operate it.

92 pages **Order code BP310** **£4.99**

PREAMPLIFIER AND FILTER CIRCUITS
R. A. Penfold

This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases). The preamplifier circuits featured include: Microphone preamplifiers (low impedance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A. equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier (for use with compact cassette systems).

Other circuits include: Audio limiter to prevent overloading of power amplifiers. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Audio mixers. Volume and balance controls.

92 pages **Order code BP309** **£4.99**

COMPUTERS AND MUSIC – AN INTRODUCTION
R. A. Penfold

Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.

174 pages **Order code PC107** **£8.95**

ELECTRONIC PROJECTS FOR GUITAR
R. A. Penfold

This book contains a collection of guitar effects and some general purpose effects units, many of which are suitable for beginners to project building. An introductory chapter gives guidance on construction.

Each project has an introduction, an explanation of how it works, a circuit diagram, complete instructions on stripboard layout and assembly, as well as notes on setting up and using the units. Contents include: Guitar tuner; Guitar preamplifier; Guitar headphone amplifier; Soft distortion unit; Compressor; Envelope waa waa; Phaser; Dual tracking effects unit; Noise gate/expander; Treble booster; Dynamic treble booster; Envelope modifier; Tremelo unit; DI box.

110 pages **Order code PC110** **£8.95**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold

Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.

96 pages **Order code BP277** **£3.95**

Circuits, Data and Design

PRACTICAL ELECTRONIC FILTERS
Owen Bishop
This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.
The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.
Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.
88 pages **Order code BP299** £4.99

ELECTRONIC ALARM CIRCUITS MANUAL
R. M. Marston
One hundred and forty useful alarm circuits, of a variety of types, are shown in this volume. The operating principle of each one is explained in concise but comprehensive terms, and brief construction notes are given where necessary.
Aimed at the practical design engineer, technician and experimenter, as well as the electronics student and amateur.
124 pages **Order code NE11** £13.95

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair
This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.
Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.
No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.
200 pages **Order code PC106** £8.95

ELECTRONIC HOBBYISTS DATA BOOK
R. A. Penfold
This book should tell you everything you are ever likely to want to know about hobby electronics, but did not know where to ask or refer. Comprehensive contents pages makes it easy to quickly locate the data you require.
The subjects covered include: Common circuits, and related data (including helpful graphs and tables of values); Colour codes for resistors, capacitors and inductors; Pinout details for a wide range of CMOS and TTL devices, plus basic data on the various logic families; Pinout details and basic data for a wide range of operational amplifiers; Data and leadout information for a wide range of transistors, FETs, power FETs, triacs, thyristors, diodes, etc; General data including MIDI message coding, radio data, ASCII/Baudot coding, decibel ratios, etc.
242 pages **Order code BP396** £5.95

50 SIMPLE LED CIRCUITS
R. N. Soar
Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components – the light-emitting diode (LED). Also includes circuits for the 707 common anode display.
64 pages **Order code BP42** £2.99

BOOK 2 50 more l.e.d. circuits.
50 pages **Order code BP87** £2.99

CIRCUIT SOURCE BOOK 1
A. Penfold
Written to help you create and experiment with your own electronic designs by combining and using the various standard "building block" circuits provided. Where applicable, advice on how to alter the circuit parameters is given.
The circuits covered in this book are mainly concerned with analogue signal processing and include: Audio amplifiers (op.amp and bipolar transistors); audio power amplifiers; d.c. amplifiers; highpass, lowpass, bandpass and notch filters; tone controls; voltage controlled amplifiers and filters; triggers and voltage comparators; gates and electronic switching; bargraphs; mixers; phase shifters, current mirrors, hold circuits, etc.
Over 150 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
182 pages **Order code BP321** £4.99

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold
This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".
142 pages **Order code BP332** £4.95

CIRCUIT SOURCE BOOK 2
R. A. Penfold
This book will help you to create and experiment with your own electronic designs by combining and using the various standard "building blocks" circuits provided. Where applicable, advice on how to alter the circuit parameters is provided.
The circuits covered are mainly concerned with signal generation, power supplies, and digital electronics.
The topics covered in this book include: 555 oscillators; sinewave oscillators; function generators; CMOS oscillators; voltage controlled oscillators; radio frequency oscillators; 555 monostables; CMOS monostables; TTL monostables; precision long timers; power supply and regulator circuits; negative supply generators and voltage boosters; digital dividers; decoders, etc; counters and display drivers; D/A and A/D converters; opto-isolators, flip/flops, noise generators, tone decoders, etc.
Over 170 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
192 pages **Order code BP322** £4.99

HOW TO USE OP.AMPS
E. A. Parr
This book has been written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.
160 pages **Order code BP88** £3.99

Project Building

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold
Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.
The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.
138 pages **Order code BP371** £4.95

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold
While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.
The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.
All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.
132 pages **Order code BP374** £4.95

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold
This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:
Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.
In fact everything you need to know in order to get started in this absorbing and creative hobby.
135 pages **Order code BP392** £4.95

A BEGINNER'S GUIDE TO MODERN ELECTRONIC COMPONENTS
R. A. Penfold
The purpose of this book is to provide practical information to help the reader sort out the bewildering array of components currently on offer. An advanced knowledge of the theory of electronics is not needed, and this book is not intended to be a course in electronic theory. The main aim is to explain the differences between components of the same basic type (e.g. carbon, carbon film, metal film, and wire-wound resistors) so that the right component for a given application can be selected. A wide range of components are included, with the emphasis firmly on those components that are used a great deal in projects for the home constructor.
166 pages **Order code BP285** £4.99

BOOK ORDERING DETAILS

Our postage price is the same no matter how many books you order, just add **£1.50** to your *total* order for postage and packing (overseas readers **add £3** for countries in the EEC, or **add £6** for all countries outside the EEC, surface mail postage) and send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or credit card details, Visa or Mastercard – minimum credit card order is £5 – to: **DIRECT BOOK SERVICE, 33 GRAVEL HILL, MERLEY, WIMBORNE, DORSET BH21 1RW** *(mail order only).*
Books are normally sent within seven days of receipt of order. *Please check price and availability (see latest issue of* Everyday Practical Electronics) *before ordering from old lists.*
For a further selection of books see the next two issues of EPE.

DIRECT BOOK SERVICE IS A DIVISION OF WIMBORNE PUBLISHING LTD. Tel 01202 881749
Fax 01202 841692. Due to the cost we cannot reply to overseas orders or queries by Fax.
E-mail:editorial@epemag.wimborne.co.uk

BOOK ORDER FORM

Full name: ....

Address: ....

....

.... Post code: .... Telephone No: ....

Signature: ....

☐ I enclose cheque/PO payable to WIMBORNE PUBLISHING LTD for £ ....

☐ Please charge my Visa/Mastercard £ .... Card expiry date ....

Card Number ....

Please send book order codes: ....

....

Please continue on separate sheet of paper if necessary

2a

PCB SERVICE

Printed circuit boards for certain EPE constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749; Fax 01202 841692 (NOTE, we cannot reply to orders or queries by Fax); E-mail: editorial@epemag.wimborne.co.uk**. Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**

NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photostats of articles are available if required – see the *Back Issues* page for details.

Please check price and availability in the latest issue.
Boards can only be supplied on a payment with order basis.

PROJECT TITLE		Order Code	Cost
Mind Machine Mk III – Programmer	APR'96	983	£7.36
Bat Band Converter/B.F.O.		984a/b	£5.80
Hearing Tester		985	£6.87
Event Counter (Teach-In '96)		986	£8.39
B.F.O. and Bat Band Converter	MAY'96	984a/b	£5.80
Versatile PIR Detector Alarm		988	£6.76
Mind machine Mk III – Tape Controller		989	£6.70
Midi Analyser		992	£6.74
Countdown Timer (Teach-In '96)		993	£9.44
Sarah's Light	JUNE'96	996	£7.17
Home Telephone Link		997 (pr)	£10.72
∗PulStar		998	£6.60
VU Display and Alarm		999	£7.02
Ultra-Fast Frequency Generator and Counter – Oscillator/L.C.D. Driver	JULY'96	994/995 (pr)	£12.72
Timed NiCad Charger		100	£6.99
Single-Station Radio 4 Tuner		101	£7.02
Twin-Beam Infra-Red Alarm – Transmitter/Receiver		102/103 (pr)	£10.50
∗Games Compendium		104	£6.09
Mono "Cordless" Headphones – Transmitter/Receiver	AUG'96	990/991 (pr)	£10.16
Component Analyser (double-sided p.t.h.)		105	£12.18
Garden Mole-Ester		106	£6.07
Mobile Miser		107	£6.36
Bike Speedo		108	£6.61
∗PIC-Tock Pendulum Clock	SEPT'96	109	£6.31
Power Check		110	£6.42
Analogue Delay/Flanger		111	£7.95
Draught Detector		112	£6.22
Simple Exposure Timer		113	£6.63
Video Fade-to-White	OCT'96	114	£6.98
Direct Conversion 80m Receiver		116	£7.52
Vehicle Alert		117	£6.55
10MHz Function Generator – Main Board		118	£7.33
– PSU		119	£5.39
Tuneable Scratch Filter	NOV'96	115	£7.83
∗Central Heating Controller		120	£7.85
D.C. to D.C. Converters – Negative Supply Generator		122	£5.96
– Step-Down Regulator		123	£6.01
– Step-Up Regulator		124	£6.12
EPE Elysian Theremin (double-sided p.t.h.)	DEC'96	121	£22.00
∗PIC Digital/Analogue Tachometer		127	£7.23
Stereo Cassette Recorder Playback/PSU		128	£7.94
Record/Erase		129	£9.04
∗Earth Resistivity Meter Current Gen. – Amp/Rect.	JAN'97	131/132 (pr)	£12.70
Theremin MIDI/CV Interface (double-sided p.t.h.)		130 (set)	£40.00
Mains Failure Warning		126	£6.77
Pacific Waves	FEB'97	136	£9.00
PsiCom Experimental Controller		137	£6.78
Oil Check Reminder	MAR'97	125	£7.16
Video Negative Viewer		135	£6.75
Tri-Colour NiCad Checker		138	£6.45
Dual-Output TENS Unit (plus Free TENS info.)		139	£7.20
∗PIC-Agoras – Wheelie Meter	APRIL'97	141	£6.90
418MHz Remote Control – Transmitter		142	£5.36
– Receiver		143	£6.04
Puppy Puddle Probe		145	£6.10
MIDI Matrix – PSU		147	£5.42
– Interface		148	£5.91
Quasi-Bell Door Alert	MAY'97	133	£6.59
2M F.M. Receiver		144	£7.69
∗PIC-A-Tuner		149	£7.83
Window Closer – Trigger		150	£4.91
– Closer		151	£4.47

PROJECT TITLE		Order Code	Cost
Child Minder Protection Zone	JUN'97		
– Transmitter		153	£6.58
– Receiver		154	£6.42
Pyrotechnic Controller		155	£6.93
∗PIC Digilogue Clock		156	£7.39
Narrow Range Thermometer		158	£6.37
Micropower PIR Detector – 1	JULY'97	152	£6.69
Infra-Red Remote Control Repeater (Multi-project P.C.B.)		932	£3.00
Karaoke Echo Unit – Echo Board		159	£6.40
– Mixer Board		160	£6.75
Computer Dual User Interface		161	£6.70
∗PEsT Scarer		162	£6.60
Variable Bench Power Supply	AUG'97	932	£3.00
Universal Input Amplifier		146	£6.55
Micropower PIR Detector – 2 Controller		163	£6.72
∗PIC-OLO		164	£7.02
Active Receiving Antenna	SEPT'97	140	£6.59
Soldering Iron Controller		157	£6.63
∗PIC Noughts & Crosses Game		165	£7.82
Micropower PIR Detector – 3 Alarm Disarm/Reset Switch		166	£5.72
Ironing Safety Device		167	£5.12
Remote Control Finder	OCT'97	168	£6.32
Rechargeable Handlamp		169	£6.23
∗PIC Water Descaler		170	£6.90
∗EPE Time Machine	NOV'97	171	£8.34
Auto-Dim Bedlight		172	£6.63
Portable 12V PSU/Charger		173	£6.61
Car Immobiliser	DEC'97	175	£7.00
Safe and Sound (Security Bleeper)		179	£7.32
Surface Thermometer	JAN'98	174	£7.64
Virtual Scope Digital Board		176	£14.49
Analogue Board (per board)		177	£7.34
Disco Lights Flasher		178	£8.30

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). The disk (order as "PIC-disk") is available from the *EPE PCB Service* at £2.75 (UK) to cover our admin costs (the software itself is *free*). Overseas £3.35 surface mail, £4.35 airmail. Alternatively, the files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk.**

EPE PRINTED CIRCUIT BOARD SERVICE

Order Code **Project** **Quantity** **Price**

....

Name..

Address...

....

....

I enclose payment of £.......... ....(cheque/PO in **£ sterling only**) to:

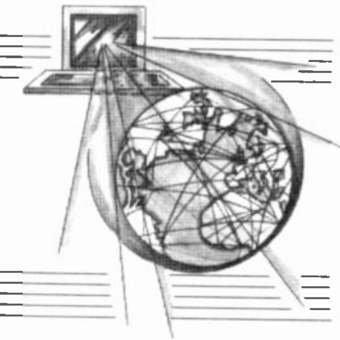
Everyday Practical Electronics
Access (MasterCard) or Visa No.
Minimum order for credit cards £5

Signature..Card Exp. Date...........................

Please supply name and address of cardholder if different from the address shown

NOTE: You can order p.c.b.s via our Internet site on a *secure* server: **http://www.epemag.wimborne.co.uk**

SURFING THE INTERNET
NET WORK



ALAN WINSTANLEY

OUR web site **http://www.epemag.wimborne.co.uk** is gradually taking on a new look, don't forget to check it out – you can subscribe or renew on-line via our secure server and there is a wealth of other information too. Also check the "What's Ahead" page for the latest developments.

Becoming Indispensable

If you have a more serious interest in personal computing, then Internet connectivity is now the best way of ensuring that your current suite of software is kept up to scratch. Programs aren't always quite as "fresh out the box" as they may seem, and one of the first things I do after installing new software is to check the vendor's web site and see if any upgrades or patches are available. (The first thing my *Cleansweep 3.0* did was to check on the 'net for the latest version of itself.)

Other examples include *JASC Paint Shop Pro* (where some essential updates are published on their web site at **www.jasc.com**, and scores of free plug-in filters are also available) and Nico Mak's indispensable file utility *WinZip* (**www.winzip.com**) which has recently published a free add-on for unzipping compressed files with one click, via your browser.

It is worth keeping copies of the patches and upgrades on disks, because in the event of re-installation being necessary you may need to build up the software from scratch again. Also, newsgroups are handy for tuning in to what's happening with software and hardware, e.g. **comp.graphics.apps.paint-shop-pro** or **alt.iomega.zip.jazz**.

Incidentally it is also best to note any registration numbers, or unlock codes which are sent to you, or passwords you submit, if you register on-line. You may well need these codes again if you need to re-install the software in the future. (I find 3M's *Post-It Notes for Windows* software – demo, and the history of the Post-It Note, from **http://www.mmm.com/psnotes** – ideal for quickly scribbling virtual sticky notes when on-line, so I can deal with them later.) Invariably, some software will have upgrades installed over earlier upgrades (e.g. *WinZip*) and it is easy to forget that one day, you may want to re-install from scratch.

In medieval days, say three years ago, the only on-line support available to software users in the UK was either via a clunky bulletin board or in a closed-shop CompuServe forum. CompuServe was the first to blitz the UK with offers of on-line connectivity to their service, before the world-wide web was even born. Otherwise if you were stuck with your software, you queued in a stack of callers at premium rates, waiting to get through to a telephone help desk: little use outside of working hours, and expensive. Hence the drive towards making users more self-sufficient, by letting them find the answers for themselves on a web site.

Web Support

In all fairness, I have been mightily impressed by Microsoft's efforts to support its customers via its web presence (**www.microsoft.com**). I have had some pretty obscure problems with software at times but answers to these maddening headaches have been found on Microsoft's site. Similarly, web sites for other vendors has generally turned up trumps and after a short local rate phone call, I have left the web site duly satisfied.

There are exceptions though. My visit to the Iomega web site (**www.iomega.com**), whose popular Zip 100MB drives are promoted heavily in the backup media markets, left me frustrated and pretty unimpressed. My experiences brought back memories of what typical Internet access was like three years ago, when we struggled with 14·4K modems (some still do) and played a lottery just to get a connection with our ISP; it made me realise how far we have come since! A desired upgrade of Iomega drivers eventually found me trying to fetch the relevant 1·6MB file via their web site. After three increasingly nerve-wracking attempts, and in spite of there being five FTP servers to choose from, I failed dismally to fetch the upgrade as the transfer ground to a halt and timed out each time. This is lack of bandwidth at its worst, and I could well believe Iomega's on-line advice that fetching the files from their site on AOL, might be quicker.

I then tried via a CompuServe connection, hoping for better transatlantic bandwidth. It took over an hour to download a mere 600kB, after which my connection stalled, CompuServe apparently timed out, my Netscape browser locked up and I lost the lot. I gave up. 7.30 a.m. the following morning saw me trying to beat the Internet traffic jams when America wakes up, by accessing the Iomega site several more times before I finally fetched the file, preying that it wouldn't crash after passing the 99% mark. The whole process took far longer than necessary, frustrated me to hell and I was subsequently very late for work.

The Way Things are Going

Apparently 40 per cent of you now use *Microsoft Internet Explorer*, and I hope those of you who upgraded are enjoying your experience with *Explorer Version 4.0*. Personally, I am still happy with *Version 3.02*, as I have temporarily drawn the line at the way that *Explorer 4.0* may optionally attempt to take over my desktop and henceforth show me a better way to work. I don't think I'm ready for such a leap just yet; it has taken me all this time to discover the wonder of *Shortcuts* in *Windows 95*.

Microsoft Internet Explorer 4.0 is not just a browser upgrade but is ultimately about Microsoft paving the way for the shape of things to come – URLs with everything, and discretely training us to deal with a planet-load of information – and hopefully having to do less work to sniff it out. Instead, stuff can be delivered straight to the desktop (via Channel push technology) and software will recognise a URL and make the Internet connection for you, look no hands.

Thus, you and your desktop computer are now starting to be interfaced inextricably with "cyberspace", bringing with it a new immediacy of access to on-line information. A year ago, in the November 1996 issue of *Net Work* I described the move towards browser-style screens, away from the familiar desktops you currently see today. This has arrived with *MSIE 4.0*, and once you've got used to it (and sooner or later, you will), your desktop will never be quite the same again. Don't forget to check the Microsoft web site to fetch the first *Explorer* patch, in the meantime.

Latest Links and MicroLab News

Let me know about your site or any favourites! The following are ready-made on our *Net Work* web page; bookmark any which work for you. First, news of the *MicroLab* – the microprocessor trainer we designed for *Teach-In '93* and which still has a very keen following. Fellow *Teach-In* co-writer Geoff MacDonald who designed the *MicroLab* software routines has just opened a special web page with *Microlab* software, so try **www.pan1c.demon.co.uk/Microlab** (that's **pan-one-c**).

PC upgraders might try *Tom's Hardware Guide* on **sysdoc.pair.com/** which contains vast amounts of PC-related material, as does **www.fmfraga.com**, a brilliant collection of sites related to personal computing and software. Author John Adams has an electronics/Internet site at **pobox.com/~electronics** with lots of basic American-based information useful to beginners. The following site contains a variety of resources: **www.trip.net/~jimpy/tronics.html** whilst **http://engr-www.unl.edu/ee/eeshop/netsites.html** is an old favourite, with hundreds of links. Finally, as a bit of fun may I recommend **pw2.netcom.com/~sleight/interactivemagic.html** which will entertain and amaze.

Have a very Happy Christmas!

EVERYDAY PRACTICAL ELECTRONICS CLASSIFIED

Everyday Practical Electronics reaches nearly twice as many UK readers as any other independent monthly hobby electronics magazine, our audited sales figures prove it. We have been the leading independent monthly magazine in this market for the last thirteen years.

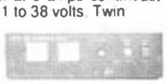
If you want your advertisements to be seen by the largest readership at the most economical price our classified and semi-display pages offer the best value. The prepaid rate for semi-display space is £8 (+VAT) per single column centimetre (minimum 2·5cm). The prepaid rate for classified adverts is 30p (+VAT) per word (minimum 12 words).

All cheques, postal orders, etc., to be made payable to Everyday Practical Electronics. **VAT must be added.** Advertisements, together with remittance, should be sent to Everyday Practical Electronics Advertisements, Mill Lodge, Mill Lane, Thorpe-le-Soken, Essex CO16 0ED. Phone/Fax (01255) 861161.

For rates and information on display and classified advertising please contact our Advertisement Manager, Peter Mew as above.

RCS VARIABLE VOLTAGE D.C. BENCH POWER SUPPLY

Up to 38 volts d.c. at 6 amps continous, 10 amps peak, fully variable from 1 to 38 volts. Twin Voltage and Current meters for easy read out. 240 volt a.c. input. Fully smoothed, size 14½ x 11 x 4½ inches. 20 volt 1 amp model £44, post £4



£76 inc. VAT carriage £6

RADIO COMPONENT SPECIALISTS

337 WHITEHORSE ROAD, CROYDON SURREY, CR0 2HS. Tel: 0181-684 1665

Lots of transformers, high volt caps, valves, speakers, in stock. Phone or send your wants list for quote.

LIGHT ENGINEERING SERVICES (PRECISION)

Machining, sheet metalwork, instrument/toolmaking etc – most engineering processes in most materials. One offs, parts, prototypes, panels, mods, jigs, repairs, anything – no job too small – trade or private – for quick friendly service contact Richard:

Tel/Fax: 01954 260804

BTEC ELECTRONICS TECHNICIAN TRAINING

GNVQ ADVANCED ENGINEERING (ELECTRONIC) – PART-TIME

HND ELECTRONICS – FULL-TIME

B.Eng FOUNDATION – FULL-TIME

Next course commences

Monday 2nd February 1998

FULL PROSPECTUS FROM

LONDON ELECTRONICS COLLEGE (Dept EPE) 20 PENYWERN ROAD EARLS COURT, LONDON SW5 9SU TEL: 0171-373 8721

Z88

BRAND NEW SINCLAIR SPECTRUM & QL PARTS

ZX MICRODRIVES £15, INTERFACE ONE £20, CARTRIDGES 10 FOR £15, 50 FOR £50.

QL BOARDS 5, 6 &7, POPULATED WITH JS ROMS, £30; UNPOPULATED, £12; MICRODRIVES £10 EACH. TOP & BOTTOM CASES £15, MEMBRANES £15.

THE P.C., MAC and QL's "Little Friend" MAC LINK £10 - P.C. LINK £25 - QL LINK £12

CAMBRIDGE Z88 A4 NOTEBOOK COMPUTER AVAILABLE AGAIN £99, RECONDITIONED £60

ONLY 1" THICK, 4xAA BATTS, 20 HOURS WORK, LCD SCREEN, 72 Crs, 6 LINES, 32K RAM, EXTRA RAMS & EPROMS, 9 pin D SERIAL PORT, ROM HAS BBC BASIC, W/PROCESSOR, SPREADSHEET, DATA BASE, IMP/EXPORT TO PC etc, V52 TERMINAL.

W.N. RICHARDSON & CO.

PHONE/FAX 01494 871319

6 RAVENSMEAD, CHALFONT ST PETER, BUCKS. SL9 0NB

POST £5, ACCESS, VISA, ETC. SAE

THE BRITISH AMATEUR ELECTRONICS CLUB

exists to help electronics enthusiasts by personal contact and through a quarterly Newsletter.

For membership details, write to the Secretary:

Mr. J. F. Davies, 70 Ash Road, Cuddington, Northwich, Cheshire CW8 2PB.

Space donated by Everyday Practical Electronics

Miscellaneous

PRINTED CIRCUIT BOARDS – QUICK SERVICE. Prototype and Production. Artwork raised from magazines or draft designs at low cost. PCBs also designed from schematics. Production assembly also undertaken. For details send to P. Agar, Unit 5, East Belfast Enterprise Park, 308 Albertbridge Road, Belfast, BT5 4GX, or phone/fax 01232 738897.

ANYONE REPAIRING TOYOTA/other engine management control units, car spares marketing/distribution company seeks supplier. Malcolm Jackson, Phone/Fax 0181 467 6671.

DESIGNERS OF DOMESTIC ROBOT demo'd on Tomorrow's World, seek microelectronics enthusiast for promising venture. If interested, contact Ashley, 01483 776104 evenings.

DIGITAL I/O CARD

For further details see **http://indigo.ie/~jamed**

CCTV BOARD CAMERAS

32mm x 32mm, auto iris, low lux, with 3·6mm wide angle lens or pinhole for covert surveillance

£39.80 + VAT (P&P FREE) with free audio – value £10!

LONG RANGE LASER POINTERS

Deluxe brushed stainless steel, keyfob type MRRP £29.50 – **NOW £15**

Luxury Pen Type MRRP £39.50 – **NOW £18** incl. VAT + P&P

Not sold to minors – For professionals only

A GREAT XMAS GIFT! – NEXT DAY DELIVERY

STORM CPS 01642 824938

OSCILLOSCOPES FOR SALE: Hewlett Packard 1740A, 100MHz, dual beam and delay, £149; Philips PM3215, 50MHz, dual beam, £95; Tektronix 2335, 100MHz, dual beam and delay, portable, £140. Tel. 0860 825933.

L.C.D. TEMPERATURE GAUGE, 80mm × 40mm × 10mm, reads 0-199°C, high/low temp., display alarm, low battery, sleep, requires battery, thermistor, case. Full instructions supplied. £23.50 inc. VAT and P&P. Phone or Fax for details: 015395 34503.

HUNDREDS OF UNUSUAL ITEMS CHEAP! Send £1 coin for interesting samples and list. Grimsby Electronics, Lambert Road, Grimsby.

PROTOTYPE PRINTED CIRCUIT BOARDS one offs and quantities, for details send s.a.e. to B. M. Ansbro, 38 Poynings Drive, Hove, Sussex BN3 8GR, or phone Brighton 883871, fax 01273 706670.

VALVE ENTHUSIASTS: Capacitors and other parts in stock. For free advice/lists please ring, Geoff Davies (Radio), Tel. 01788 574774.

G.C.S.E. ELECTRONIC KITS, at pocket money prices. S.A.E. for FREE catalogue. SIR-KIT Electronics, 52 Severn Road, Clacton, CO15 3RB.

CAN YOU HELP ME

?

Electronics baffle me! I have a small Amusement Machine which I want to modify to take a l.c.d. screen and run graphics. I have several of the current model on bars in pubs and clubs etc., but the new game would sell well. If you would like to meet or phone to discuss possibilities, please call Peter on:

REDDITCH (01527) 542544

and ideally live less than 20 miles away!

BUGS, KITS and more . . .

- 88-108MHz FM transmitters **under £5**
- Other educational and hobby electronic kits covering all technical abilities, from beginners' circuits to MCU/MPU designs
- Low cost PCB services and equipment
- **FREE** price list available on request

DTE MICROSYSTEMS, 112 SHOBNALL ROAD, BURTON-ON-TRENT, STAFFS DE14 2BB PHONE or FAX: 01283 542229 http://www.btinternet.com/~dtemicrosystems

REACH MORE READERS

ADVERTISE IN *EPE*

For full details contact our Advertisement Manager Peter Mew on 01255 861161

Cooke International

SUPPLIER OF QUALITY USED TEST INSTRUMENTS

ANALYSERS, BRIDGES, CALIBRATORS, VOLTMETERS, GENERATORS, OSCILLOSCOPES, POWER METERS, ETC. ALWAYS AVAILABLE

ORIGINAL SERVICE MANUALS FOR SALE
COPY SERVICE ALSO AVAILABLE

EXPORT, TRADE AND U.K. ENQUIRIES WELCOME
SEND FOR LISTS OF EQUIPMENT & MANUALS
ALL PRICES EXCLUDE VAT AND CARRIAGE
DISCOUNT FOR BULK ORDERS — SHIPPING ARRANGED

OPEN MONDAY TO FRIDAY 9AM-5PM

Unit Four, Fordingbridge Site, Main Road, Barnham, Bognor Regis, West Sussex, PO22 0HD. U.K.
Tel (+ 44) 01243 545111/2 Fax (+ 44) 01243 542457

EQUIPMENT & ACCESSORIES PURCHASED

SERVICE MANUALS
& Technical Books

Available for most equipment, any make, age or model.
Technical Book and Manual Compilations now on CD-ROM
Return the coupon for your FREE catalogue on Floppy Discs.

PRICE CRASH ON ALL OUR CD-ROM's

MAURITRON TECHNICAL SERVICES (EPE)
8 Cherry Tree Road, Chinnor, Oxon, OX9 4QY.
Tel:- 01844-351694. Fax:- 01844 352554.
Email:- sales@mauritron.co.uk Web site at:- http://dialspace.dial.pipex.com/mauritron/

Please forward your latest Disc catalogue for which I enclose 4 x 1st Class Stamps, or £5.00 for the complete Service Manuals Index on PC Disc plus catalogue.

NAME ______________________
ADDRESS ______________________
____
____
______________________ POSTCODE ______________________

Photocopy this coupon if you do not wish to cut the magazine

Veronica KITS — 88-108MHz FM TRANSMITTERS

Professional PLL transmitter, Stereo Coder, and Compressor/Limiter kits licensable in the UK.
Also very stable VFO transmitter kits.
Prices from under £10 and a 'Ready Built' service is available.
Contact us for a free brochure including prices and more detailed information.

18 Victoria St., Queensbury, BRADFORD, BD13 1AR
Tel 01274 816200 Email veronica@legend.co.uk
Website: http://www.legend.co.uk/~veronica/

MEL BASIC Compiler for PICs

Takes the hassle out of working with PICs!

With MEL PicBasic just write your code in Basic, and then instantly compile it to produce the hex or binary files needed to program your standard 18, 28 or 40 pin PIC chip. English-like instructions make programming a joy instead of a struggle – serial comms, if/then, pulse measurement, time delays, etc., etc., each takes just one command!

Comprehensive user manual.

Mail order only from
Pineapple Presentations
30 Breckhill Road
Nottingham NG5 4GP
Tel. 0115 903 1851
Fax 0115 903 2172
£69.95
plus £2.50 p&p per order

More info on the web at http://www.melabs.com/mel/pbc.htm

TECHNICAL INFORMATION SERVICES

76 Church St, Larkhall, Lanarks, ML9 1HE
Tel: 01698 883334/884585 Fax: 01698 884825

PHONE NOW FOR YOUR FREE QUOTE

We have the World's Largest Collection of

SERVICE MANUALS

Why not join Europe's fastest growing "Information Library Service"

Buy *ANY* Service Manual for £10.00 and return any manual no longer needed for a £5.00 credit

CALL/WRITE NOW FOR FURTHER DETAILS

Initial joining fee of £65 : Thereafter £20 Yearly
Join Now: Get your first Manual FREE!

N. R. BARDWELL LTD (EPE)

100	Signal diodes 1N4148	£1.00
75	Rectifier Diodes 1N4001	£1.00
50	Rectifier Diodes 1N4007	£1.00
10	W01 Bridge Rectifiers	£1.00
5	NE555 Timer I.C.s	£1.00
4	741 Op Amps	£1.00
50	Assorted Zener Diodes 400mW	£1.00
12	Assorted 7-segment Displays	£1.00
25	5mm l.e.d.s, red, green or yellow	£1.00
25	3mm l.e.d.s, red, green or yellow	£1.00
50	Axial l.e.d.s, 2mcd red Diode Package	£1.00
25	Asstd. High Brightness l.e.d.s, var cols	£1.00
20	BC182L Transistors	£1.00
25	BC212L Transistors	£1.00
30	BC237 Transistors	£1.00
20	BC327 Transistors	£1.00
30	BC328 Transistors	£1.00
30	BC547 Transistors	£1.00
30	BC548 Transistors	£1.00
30	BC549 Transistors	£1.00
25	BC557 Transistors	£1.00
30	BC558 Transistors	£1.00
30	BC559 Transistors	£1.00
20	2N3904 Transistors	£1.00
100	50v wkg Axial Capacitors 1nf	£1.00
100	50v wkg Axial Capacitors 4N7	£1.00
100	50v wkg sub-miniature Capacitors 33nf	£1.00
100	Radial Film Capacitor 22nf	£1.00
12	luf 250v encapsulated radial plastic cased capacitors	£1.00
80	Asstd capacitors electrolytic	£1.00
80	Asstd. capacitors 1nF to 1µF	£1.00
200	Asstd. disc ceramic capacitors	£1.00
50	Asstd. Skel Presets (sm, stand, cermet)	£1.00
50	Asstd. RF chokes (inductors)	£1.00
50	Asstd. grommets	£1.00
80	Asstd. solder tags, p/conns, terminals	£1.00
10	Asstd. crystals – plug in	£1.00
24	Asstd. coil formers	£1.00
8	Asstd. dil switches	£1.00
20	Miniature slide switches sp/co	£1.00
10	Standard slide switches dp/dt	£1.00
30	Asstd. If transformers	£1.00
100	Asstd. beads (ceramic, teflon, fish spine)	£1.00
80	Asstd. small stand offs, I/throughs etc	£1.00
30	Asstd. dil sockets up to 40 way	£1.00
10	TV coax plugs, plastic	£1.00
20	Small spring loaded terminals	£1.00
40	metres very thin connecting wire, red	£1.00
20	1in. glass reed switches	£1.00
20	Magnetic ear pips with lead and plug	£1.00
100	Any one value ¼W 5% cf resistors range 1R to 10M	£0.45

Prices include VAT. postage £1.25. 31p stamp for Lists
288 Abbeydale Road. Sheffield S7 1FL
Phone (0114) 2552886 Fax (0114) 2500689
E-mail Bardwells@compuserve.com
Web site: http://ourworld.Compuserve.com/homepages/BARDWELLS

COVERT VIDEO CAMERAS

Black and White Pin Hole Board Cameras with Audio. Cameras in P.I.R., Radios, Clocks, Briefcases etc. Transmitting Cameras with Receivers (Wireless).
Cameras as above with colour.
Audio Surveillance Kits and Ready Built Units, Bug Detector etc.

A.L. ELECTRONICS

Please phone **0181 203 0161** for free catalogue.
Fax **0181 201 5359**

New DTI approved Video Transmitters and Receivers (Wireless)

TRAIN TODAY FOR A BETTER FUTURE

Now you can get the skills and qualifications you need for career success with an ICS Home Study Course. Learn in the comfort of your own home at the pace and times that suit you. ICS is the world's largest, most experienced home study school. Over the past 100 years ICS have helped nearly 10 million people to improve their job prospects. Find out how we can help YOU. Post or phone today for **FREE INFORMATION** on the course of your

Electrical Contracting & Installation
Electrical Engineering
C&G Basic Electronic Engineering
C&G Basic Mechanical Engineering
TV and Video Servicing
Radio and Hi-Fi Servicing
Refrigeration Heating & Air Conditioning
Motorcycle Maintenance

FREEPHONE 0500 581 557

Or write to: International Correspondence Schools, FREEPOST 882, 8 Elliot Place, Clydeway Skypark, Glasgow, G3 8BR. Tel. 0500 581 557 or Tel/Fax: Ireland 01 285 2533.

Please send me my Free Information on your Electronics Courses.

Mr/Mrs/Ms/Miss
(BLOCK CAPITALS PLEASE) Date of Birth / /
Address
Postcode
Occupation Tel. No.

From time to time, we permit other carefully screened organisations to write to you about products and services. If you would prefer not to hear from such organisations please tick box ☐ Dept. ZEEE051297

ADVERTISERS INDEX

ADVERTISEMENT MANAGER: PETER J. MEW
ADVERTISEMENT OFFICES:
EVERYDAY PRACTICAL ELECTRONICS, ADVERTISEMENTS, MILL LODGE, MILL LANE, THORPE-LE-SOKEN, ESSEX CO16 0ED.
Phone/Fax: (01255) 861161

For Editorial address and phone numbers see page 11.

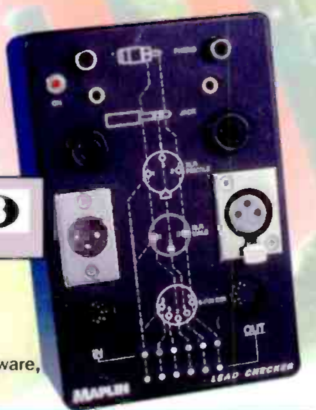
Published on approximately the first Friday of each month by Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Printed in England by Wiltshire (Bristol) Printers Ltd., Bristol, BS20 9XP. Distributed by Seymour, Windsor House, 1270 London Road, Norbury, London SW16 4DH. Subscriptions INLAND £26 and OVERSEAS £32 standard air service (£49.50 express airmail) payable to "Everyday Practical Electronics", Subs Dept, Allen House, East Borough, Wimborne, Dorset BH21 1PF. EVERYDAY PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

projects

New Project Kits from Maplin

AUDIO LEAD CHECKER KIT

– No home or professional studio should be without one!



PROJECT RATING 3 Average

FEATURES:

- Rapidly and clearly identifies connections on most audio cables
- Will test very long cables
- Clear led readout
- Robust design

IDEAL FOR:

- PA/Sound engineers
- Gigging bands
- Fault diagnosis

Kit includes all components, PCB, fixing hardware, case, front panel label and full instructions.

AUDIO LEAD CHECKER KIT LU26D £19.99
Construction details: Audio Lead Checker Leaflet XZ20W 80p
Issue 114 / June 1997 Electronics & Beyond XD14Q £2.25

NATIONAL LOTTERY PREDICTOR KIT

PROJECT RATING 1 Simple

FEATURES

- Ideal beginners project
- Simple to use – one switch operation
- Automatic switch off saves batteries
- Full source code available

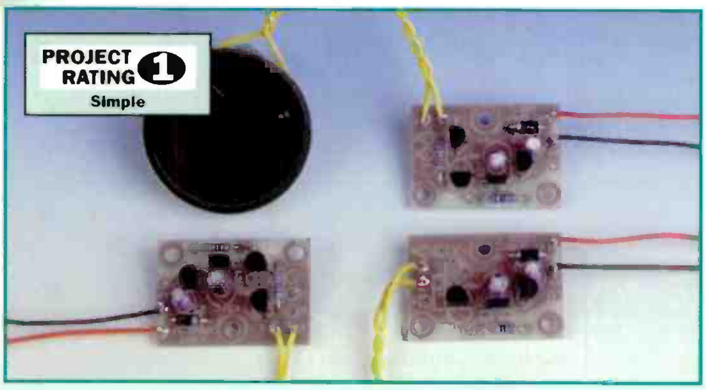
APPLICATIONS

- Use to choose your lottery numbers!
- Excellent introduction to microcontrollers
- Use in other games

Kit includes all components, PCB, fixing hardware and full instructions. Two AAA batteries are required (not supplied).

NATIONAL LOTTERY PREDICTOR KIT LU61R £9.99
Construction details: National Lottery Predictor Leaflet XZ46A 50p
Issue 120 / December 1997 Electronics & beyond XD20W £2.65

MELODY GENERATOR KIT



FEATURES

- Ideal beginners project
- Safe, low voltage operation
- Low current giving long battery life
- Directly drives speakers (included) or piezo sounders
- Large range of melodies supported (15 available)

APPLICATIONS

- Children's toys
- Teaching nursery rhymes
- Turn ordinary cards and gifts into novel presents

Kit includes all components, PCB, speaker, connecting wire and full instructions. One or two 1.5V batteries are required (not supplied).

MELODY GENERATOR KIT:

LU64U Happy Birthday	LU66W London Bridge	LU67 Old McDonald
LU68 Greensleeves	LU69 Love Me Tender	LU70 Jingle Bells
LU75 Merry Christmas	LU76 12 Days of Christmas	LU77 You Are My Sunshine
LU80 I Just Called	LU81 Twinkle Twinkle	LU84 I'd Like To Teach
LU90 White Christmas	LU91 Warning Tone	LU92 Wedding March

All at £4.99

Construction details: Melody Generator Leaflet XZ47B 50p
Issue 120 / December 1997 Electronics & beyond XD20W £2.65

PAL COLOUR ENCODER KIT

FEATURES

- PAL and NTSC compatible
- TTL compatible inputs
- 64 colour palette
- Composite video and UHF outputs
- Analogue or digital RGB inputs
- Optional S-video output

APPLICATIONS

- Colour bar generation
- RGB to composite and UHF conversion
- Computer displays

Kit includes all components, PCB, Modulator, hardware to connect the Maplin Colour Bar Generator LT50E and full instructions. A +12V DC @ 300mA, regulated supply is required (not supplied).

PAL COLOUR ENCODER KIT LU74R £24.99
Construction details: PAL Colour Encoder Leaflet XZ41U 80p
Issue 115 / July 1997 Electronics & beyond XD15R

These kits are:

- Supplied with high-quality fibre-glass PCBs – pre-tinned, with printed legend and solder resist
- Supplied with comprehensive instructions and a constructors' guide
- Covered by the Maplin Get-You-Working Service and 12-month warranty

Kits do not include tools or test equipment. Kits may require additional components or products, depending on application, please refer to construction details or contact the Maplin Technical Support Helpline (Tel: 01702 556001) if in doubt.

ORDER NOW!

Tel: 01702 554000, Fax: 01702 554001, E-mail: Sales@maplin.co.uk
Or write to Maplin Electronics, P.O. Box 777, Rayleigh, Essex, SS6 8LU
Or Tel: 01702 554002 for details of your nearest Maplin or Mondo store.
Please quote **Priority Reference Code MA043** When ordering.

MasterCard VISA AMERICAN EXPRESS SWITCH CONNECT

For orders over £30.00 inc VAT goods are dispatched free of handling charges. A small order charge of £2.95 inc VAT is applied to orders less than £30.00 inc VAT. All items subject to availability. All prices are inclusive of VAT and are subject to change. E&OE.

MAPLIN

Internet Web Site:
http://www.maplin.co.uk