EVERYDAY
PRACTICAL
ELECTRONICS

FEBRUARY 1998

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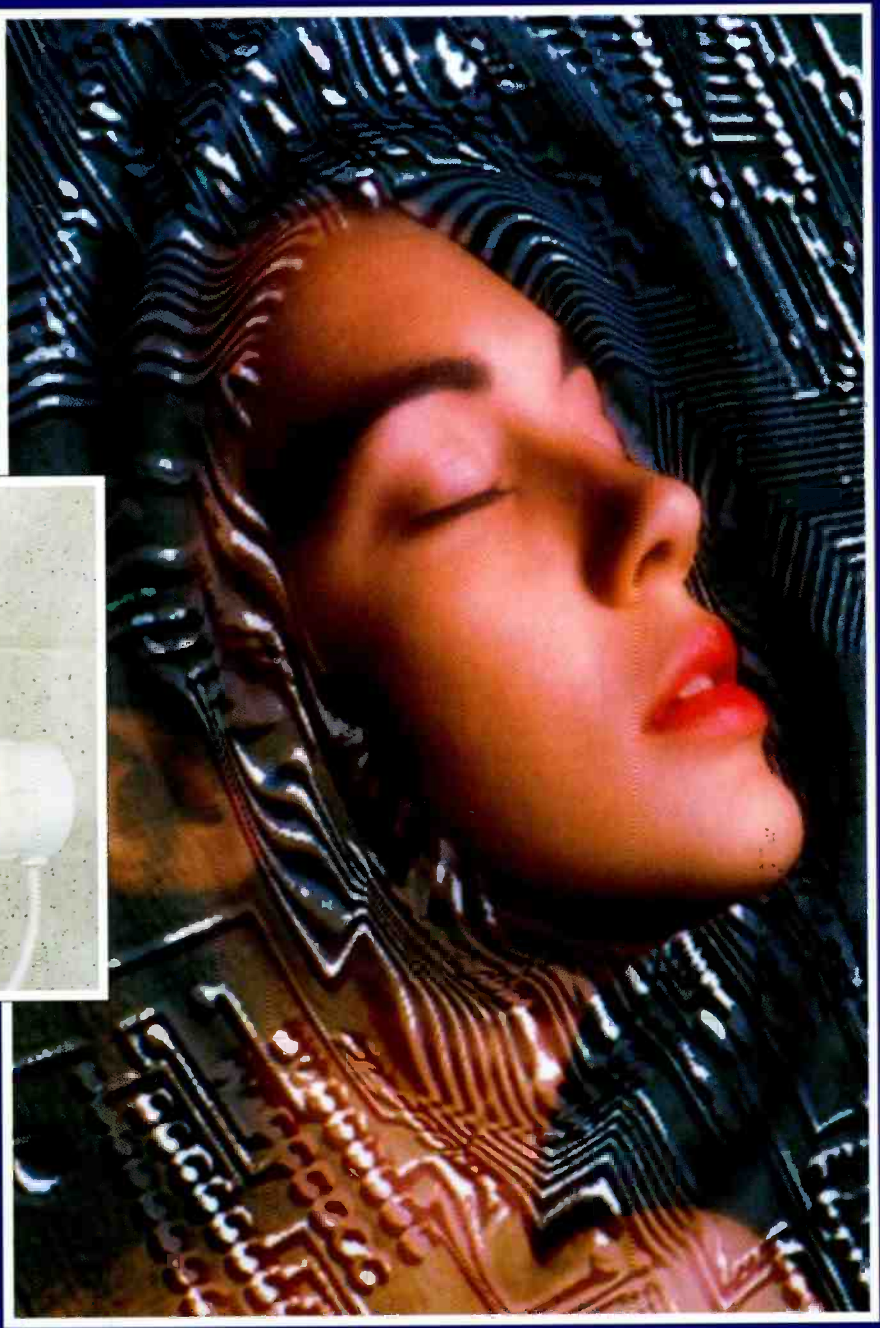


KISSOMETER
Fun Passion Presenter

WATER WIZARD
Automatically measures water flow

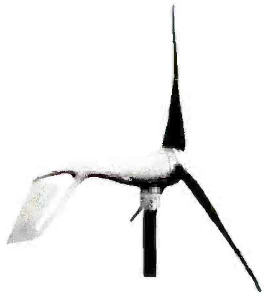
WAA WAA
Semi-automatic guitar gizmo

EPE VIRTUAL SCOPE
Dual trace PC based oscilloscope
Part 2 - Construction Details

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

02
9 770262 361089

PLUS Ingenuity Unlimited - New Technology Update
Circuit Surgery - Net Work - Techniques



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 Minature 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.

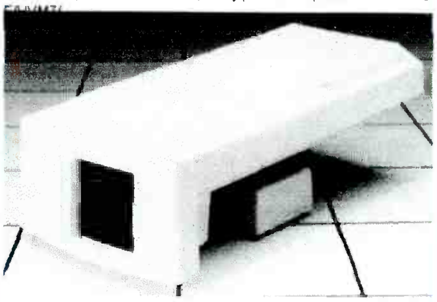
BUG DETECTOR PLANS Is that someone getting the goods on you? Easy to construct device locates any hidden source of radio energy! Sniffs out and finds bugs and other sources of bothersome interference. Detects low, high and UHF frequencies. £5/set Ref F/BD1.

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

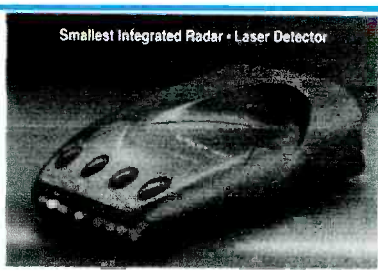


COLOUR CCTV VIDEO CAMERAS,

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

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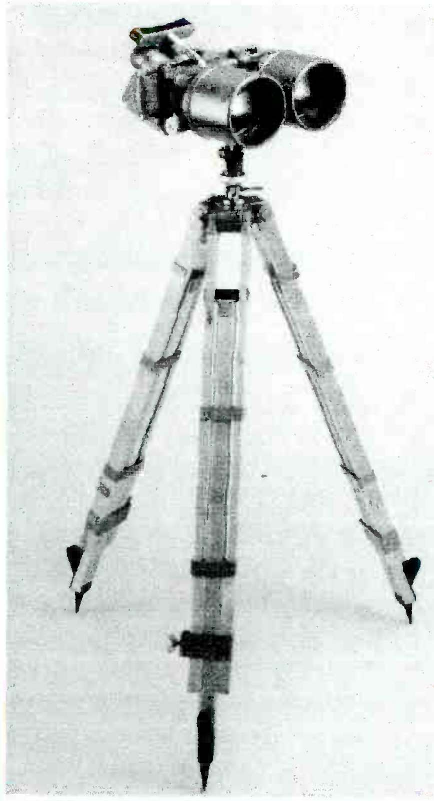
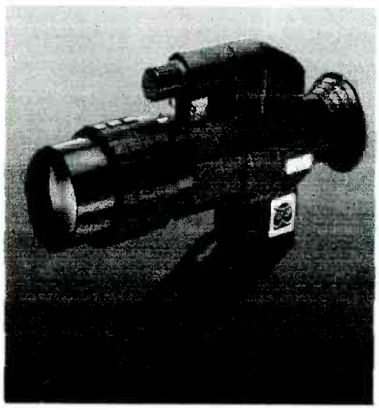


HELIOS PNB-2 RUSSIAN BORDER GUARD OBSERVATION BINOCULARS £1799

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, cus toms, 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 . . .

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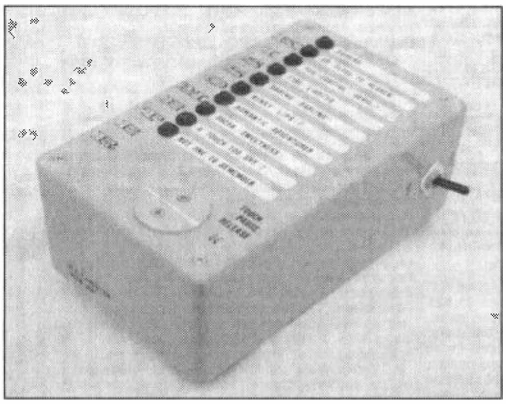
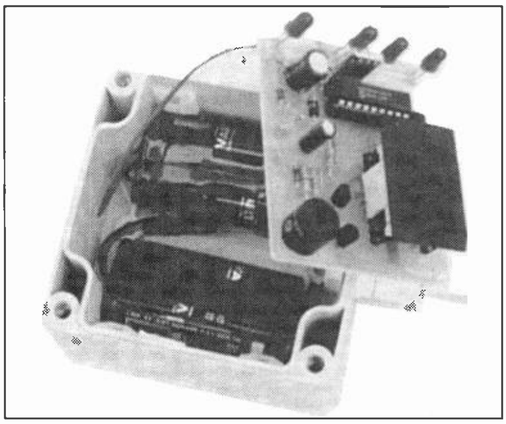
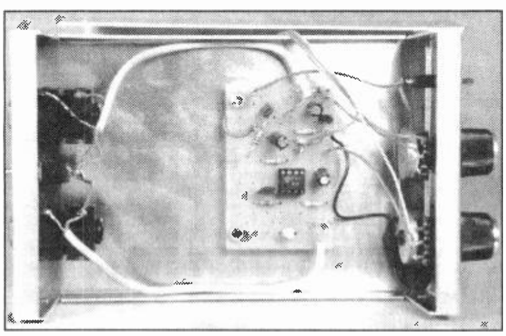
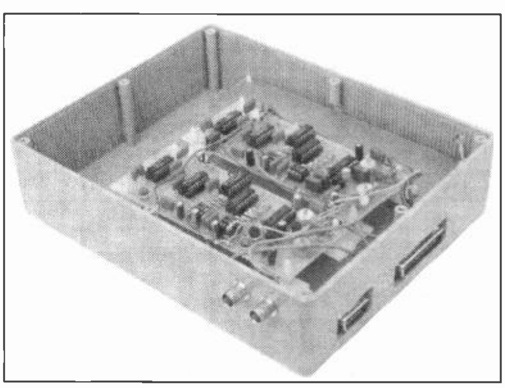
The No. 1 Magazine for Electronics Technology and Computer Projects









Our March '98 issue will be published on Friday, 6 February 1998. See page 83 for details.

Projects and Circuits

Series and Features

Regulars and Services

Surplus always wanted for cash!

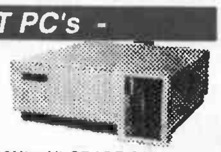
THE *ORIGINAL* SURPLUS WONDERLAND!

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, superb 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)

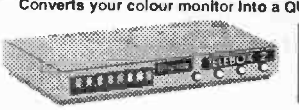
HARD DISK DRIVES

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 Telebox's is (B)

DC POWER SUPPLIES

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

IC's -TRANSISTORS - DIODES

OBSOLETE - SHORT SUPPLY - BULK

6,000,000 items EX STOCK

For *MAJOR* SAVINGS - CALL FOR SEMICONDUCTOR HOTLIST

VIDEO MONITOR SPECIALS

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

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

Tilt & Swivel Base £4.75
VGA cable for IBM PC included. **Only £119** (E) Order as MITS-SVGA
External cables for other types of computers CALL

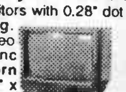
As New - Used on film set for 1 week only!!
15" 0.28 SVGA 1024 x 768 res. colour monitors.
Swivel & tilt etc. Full 90 day guarantee. £145.00 (E)

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

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

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

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



20" 22" and 26" AV SPECIALS

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

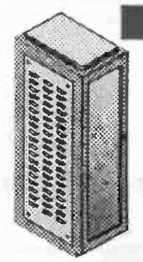
20"....£135 22"....£155 26"....£185 (F)

SPECIAL INTEREST ITEMS

MITS. FA3445ETKL 14" Industrial spec SVGA monitors	£245
2kW to 400 kW - 400 Hz 3 phase power sources - ex stock	£POA
IBM 8230 Type 1, Token ring base unit driver	£950
IBM 53F5501 Token Ring ICS 20 port lobe modules	£750
IBM MAU Token ring distribution panel 8228-23-5050N	£95
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE	£550
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
Marconi 6310 Programmable 2 to 22 GHz sweep generator	£6500
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & **HP3782A** Error Detector	£POA
HP APOLLO RX700 system units	£950
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP3081A 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

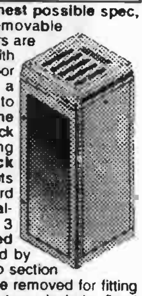


Superb quality 6 foot 40U
Virtually New, Ultra Smart
Less than Half Price!

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 !!
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The best introduction to using PIC microcontrollers ever written! Based around the PIC16C84, this tutorial series takes you by the hand and leads you down the adventurous path of getting to know about PICs.

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At each stage of the thirty-odd tutorials, we encourage you to change various bits of the simple programs we supply you with on disk, loading them into the PIC and getting it to do other tasks related to each discussion. In this way you build up your experience and knowledge about PICs. At the end of the series, you should be perfectly capable of writing your own programs for PICs – and getting them to fulfil that task you've always wished you could put under microcontroller control!

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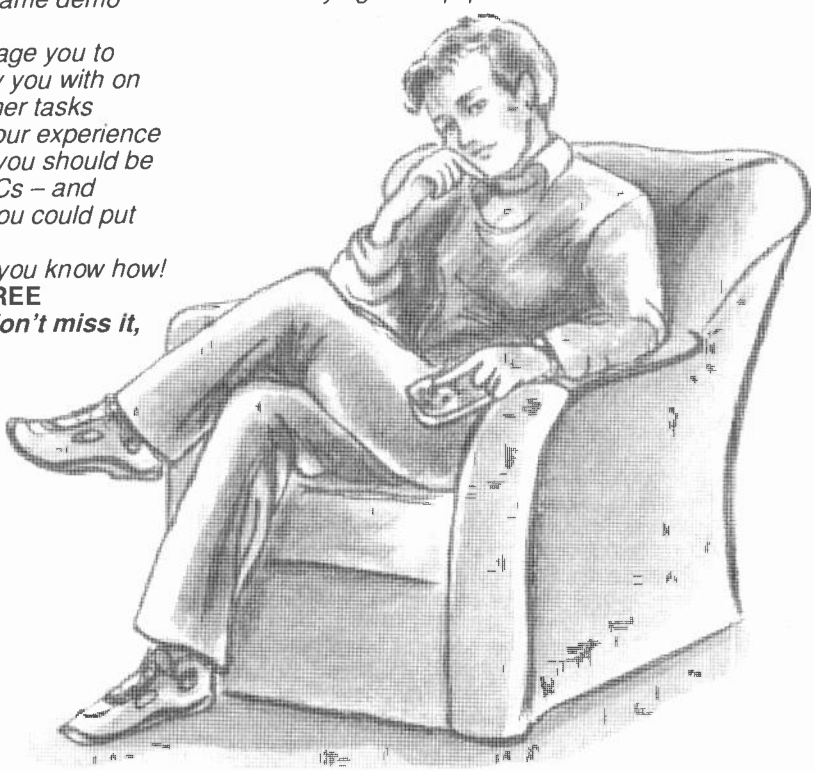

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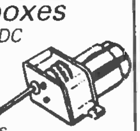

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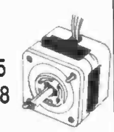

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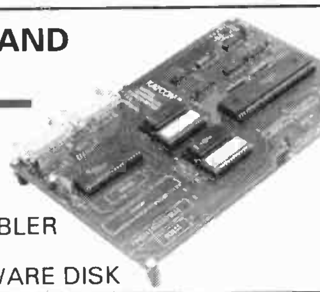

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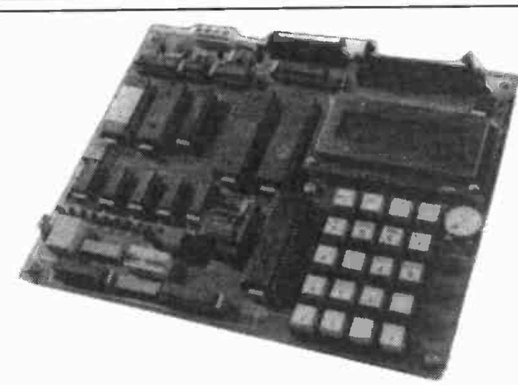

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ANOTHER ERA

Some interesting correspondence has come in recently from a couple of readers who would like us to support computers other than PCs – in both cases the readers are still using BBC Micros. We actually dropped our dedicated support of the BBC Micro through *Interface* back in December 1990 (over seven years ago now). Frankly it is simply no longer possible for us to offer any special support for machines from another era, the time and cost involved in doing this is simply not commercially sensible. While we do try to offer a service to readers we do also need to make a living and therefore make a profit.

This led me to take a look at how many readers own or have access to PCs and I was pleased to see that ninety-five per cent of *EPE* readers can get their hands on a PC, while seventy-nine per cent of readers own their own PCs. In fact these figures came from our Readership Survey back in November 1996 and, at that time, nearly half of those readers who did not own a PC stated their intention to buy one, so the ownership figure could be even higher now.

It's interesting to see that a national survey of the public, carried out around the same time, indicated that only about eighteen per cent of the adult UK population regularly used a computer at home, and that over sixty per cent of those only used the computer for games.

IMMEASURABLE

Obviously electronics as a hobby can readily be enjoyed by those without a PC but we find that the use of computers extends the interest and possibilities of our hobby immeasurably. It is, therefore, not a surprise to find so many of our dedicated readers using PCs in conjunction with project development and building. Just take a look through the advertisements in this issue for an insight into the number and variety of software available to the hobbyist, student, technician, designer and engineer – all, of course, for PCs.

We can understand those who don't want to get involved with computers (computers do after all generate their own set of new problems – see last month's Editorial) and, as I have said before, I believe there will always be plenty in *EPE* to interest you, but we must also be aware of the needs of the vast majority of our readers and provide them with interesting, stimulating and innovative material, like *EPE PIC Tutor* coming next month (see page 83).

Progress, particularly in technology, forges ahead at an ever increasing rate; we cannot stop it, nor would we wish to try.

Mike Kenward

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.

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

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WATER WIZARD

ANDREW BUCKMASTER (Design) and MAX HORSEY (Text)

Learn to save water – shower with a friendly monitor!

THE Water Wizard is a water monitoring device designed for showers and hosepipes, which records the number of litres used on a digital display. It also includes a set of four l.e.d.s which progressively light at each 25 litres.

Since a typical bath requires about 100 litres of water, the l.e.d.s provide a reading in terms of each quarter of a bath used. An audible warning sounds at each 25 litre step.

A typical shower will consume about 25 litres of water. However, modern power showers can supply a surprising amount of water in a short time, in fact a typical power shower at full setting can deliver 14 litres per minute. The average shower time is seven minutes. This would use the same quantity of water as a bath – hence the justification for this project!

When using a hosepipe, water is consumed at an even greater rate, and the design should encourage the user to reduce consumption. The current water shortage in various parts of the UK, and the possibility of more extensive water metering, have made the use of this type of product more pressing.

HOW IT WORKS

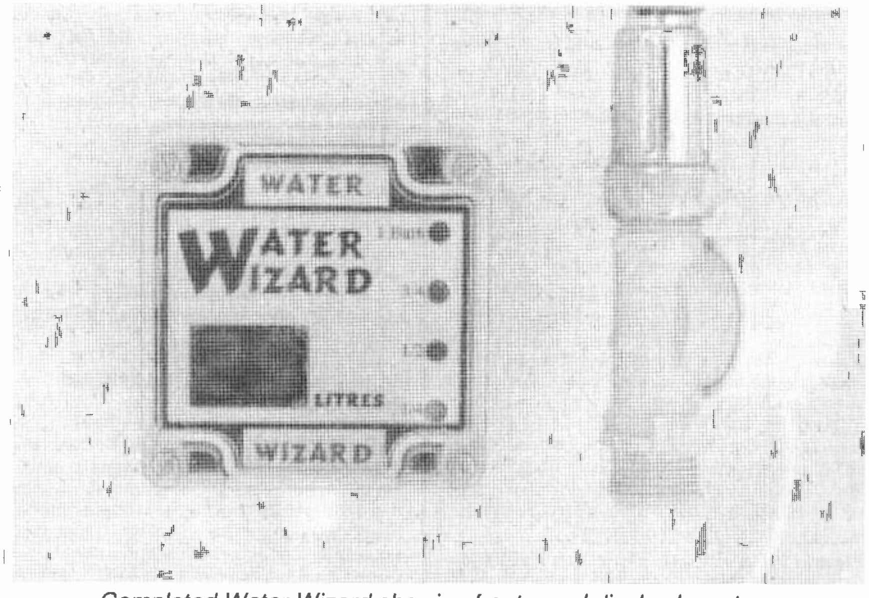
The design does not require an on/off switch, in fact there are no controls at all, making the casing easier to waterproof and the device simple to use. It switches on automatically when water begins to flow through the sensor and, when the water flow stops, the circuit waits for 30 seconds before switching off.

Just before it switches off, it stores the value displayed in memory so that this reading can be recalled the next time it starts up. This makes it possible to check the amount of water consumed by the previous user before displaying the new total.

The system allows counting to 499 litres. The digital readout counts to 99, and l.e.d.s indicate the equivalent fraction of a bath, i.e. quarter, half, three-quarters.

If the count exceeds 99, then the first l.e.d. flashes, indicating that the digital reading must be added to 100 litres. At 200 litres the next l.e.d. flashes, and so on, allowing a count to 499 litres.

The system is based around the PIC16C54 microcontroller, an electrically programmable read only memory (Eprom) device. The suggested system employs an external water flow sensor, and no plumbing skills are required. However, it would be possible to employ a larger case if preferred, and include an internal water flow sensor.



Completed Water Wizard showing front panel display layout.

CIRCUIT DESCRIPTION

The circuit diagram for the Water Wizard is shown in Fig.1. The PIC16C54 microcontroller is designated as IC1. A 2·4576MHz crystal (X1) drives the microcontroller's oscillator, aided by capacitors C1 and C2.

Capacitor C3, along with resistors R1 and R2 force IC1 to reset when power is first applied. This ensures reliable start-up. Diode D1 allows C3 to discharge quickly when power is removed.

The water flow sensor module (X2) is a ready-built device with compatible hosepipe/shower-hose connections. It comprises an infrared l.e.d. (D2) and sensor unit in a single housing complete with a set of blades which revolve as water passes through the unit. As the blades revolve, they interrupt the infrared beam between the l.e.d. and sensor causing a square wave output to be generated. The frequency of the output is determined by the rate of water flow.

A schematic representation of the sensor's internal circuit is shown in Fig.2.

Be aware that the current flowing through the sensor's l.e.d., i.e. D2, affects the mark/space ratio of the output. Changing the value of R3 (Fig.1) will have a significant affect on this ratio.

The value of 680 ohms as shown is suitable for a 6V supply, but it may need reducing if a lower voltage power source is used. A value of about 470 ohms to 560 ohms may be more suited to a 5V supply. (The circuit ***must not*** be used with a supply greater than about 6·25V – the maximum that the PIC16C54 can accept.)

POWER SAVING

The Water Wizard has been designed to minimise electrical current consumption. For example, if the cathode (k) side of l.e.d. D2, and the 0V connection of the sensor had been connected directly to 0V in the circuit, power would undesirably flow through the sensor and l.e.d. when the circuit is inactive. This is avoided by controlling the sensor via the PIC.

The PIC is programmed to "wake up" at regular intervals in order to switch on the sensor and check for an output waveform. If no waveform is present, the PIC returns to its Sleep mode.

Ideally, the sensor and l.e.d. should be switched on and off via one of the pins of the PIC dedicated to this task. However, no spare pins were available but, when the PIC is active, at least one of the outputs RA0, RA1 and RA2 is always at 0V. Hence the negative (0V) power supply for the sensor and l.e.d. is via these outputs and diodes D3, D4 and D5.

The inclusion of the diodes allows the pins RA0, RA1 and RA2 to fulfil their normal task, namely to drive l.e.d.s D6 to D9. These are the l.e.d.s which indicate the fraction of a bath of water used.

Since each output RA0, RA1 and RA2 can be at logic 1, logic 0 or open circuit, the combinations shown in Table 1 allow full control of the four l.e.d.s.

Notice that when the PIC is in Sleep mode (circuit inactive), the outputs are all open circuit (X), so preventing current wastefully flowing through the sensor and D2. When the PIC is active, the three outputs are switched to logic 0, allowing the sensor to operate, but still keeping l.e.d.s D6 to D9 switched off until required.

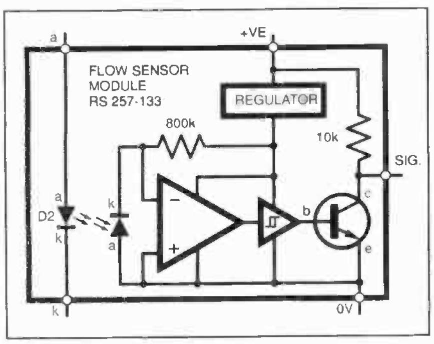


Fig.2. Internal circuit schematic of the water flow sensor module.

The output from the sensor is delivered to pin 3 of the PIC, which is configured as an input. This is the only input required and the status of the signal on it is used to sense when water is flowing, to set the PIC to its active state, and to determine the flow rate.

Output RA3 is used to control the buzzer (WD1) via transistor TR1.

DISPLAYS

The two 7-segment l.e.d. displays, X3 and X4, are strobed. In other words, the individual segment connections from the two displays are connected to a single set of outputs, namely RB1 to RB7. There is only one output pin remaining, RB0, and so this is made to control which display is on at any one time, by toggling between logic 0 and logic 1.

Output RB0 is connected to the bases of two transistors, TR2 and TR3. Transistor TR2 is a *pnp* type, and TR3 is an *npn*. Hence, when RB0 is low (logic 0), TR2 turns on, allowing current from display X3 to sink to 0V.

In this condition, the outputs RB1 to RB7 are taken high (logic 1) to turn on the selected segment of the display. For example, if RB1 to RB7 are all low, then X3 is blank. If RB1 to RB7 are all high, then an "8" is displayed. Note that X3 is a *common cathode* type, i.e. all the l.e.d. segment cathodes are joined to a single pin.

Table 1: L.E.D. Control Combinations

RA0	RA1	RA2	D6	D7	D8	D9
X	X	X	off	off	off	off
0	0	0	off	off	off	off
X	0	1	off	off	off	on
X	1	0	off	on	off	off
1	0	X	on	off	off	off
0	1	X	off	off	on	off

(X = open circuit)

Andrew demonstrating his water monitor at the 1997 Young Electronics Designer Awards co-sponsored by Texas and Mercury.

When RB0 is low, transistor TR3 will be switched off since it is an *npn* type and requires its base to be at least 0·7V before turning on. Hence X4 will be blank.

If RB0 is switched high by the PIC, then TR2 will turn off, making X3 blank regardless of the logic levels at RB1 to RB7. However, TR3 will now turn on, causing X4 to display a number determined by the outputs RB1 to RB7.

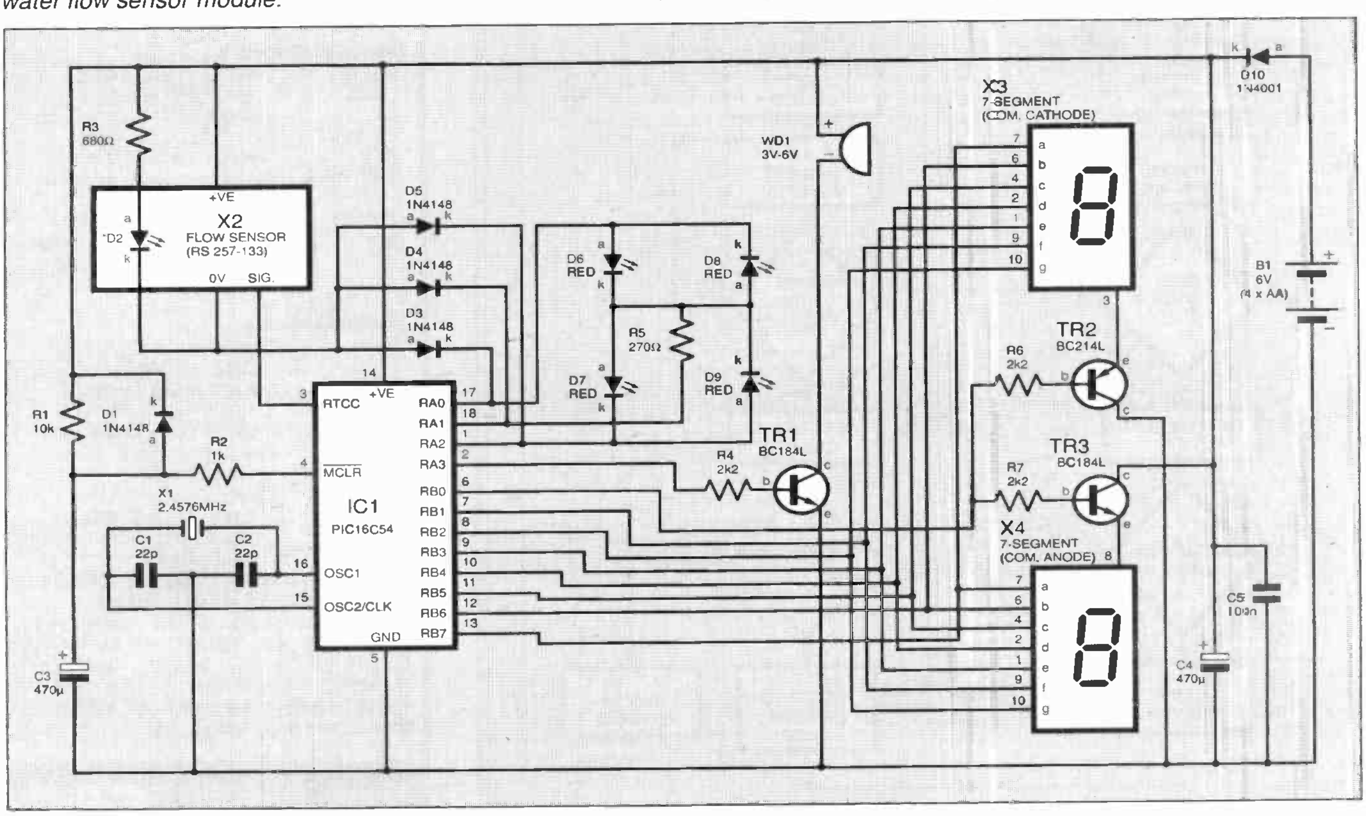


Fig.1. Complete circuit diagram of the Water Wizard water flow monitor.

Note that since X4 is a *common anode* type, each segment will turned on by a logic 0 rather than a logic 1. Hence if RB1 to RB7 are low, then X4 will display a number "8". If RB1 to RB7 are high, then X4 will be blank.

The PIC program causes RB0 to change state very quickly so that both displays appear to be lit continuously. This is known as strobing or multiplexing. Output levels on RB1 to RB7 must be synchronised with RB0, noting that when RB0 is low, then "highs" determine the number on X3, and when RB0 is high, then "lows" determine the number on X4. This complicates the programming, but allows two displays to be controlled by only eight pins.

Capacitors C4 and C5 decouple the circuit power lines, and diode D10 protects the circuit if the battery is connected the wrong way round.

PROGRAM

The Water Wizard program flow chart is shown in Table 2. The left hand chain of boxes deals with the count from one to 100 litres, the right hand side deals with counts from 100 to 500 litres. The chart is slightly simplified, for example the buzzer produces three bleeps when 25 litres have passed, five bleeps at 50 litres, etc.

When the system goes into Sleep mode, the reading on the display is stored in a file register. At wake-up, this reading is displayed until the first litre has been used.

For example, if you used 27 litres of water in the shower, the reading of 27 will remain on the display for 30 seconds after switching off the water. After 30 seconds the display will blank, and the circuit will shut down.

When the water is turned on again, the reading of 27 will be displayed until the first litre has been used, at which time the display will revert to 1. This enables members of a family to check on each other's water consumption! The count value is lost if power is removed from the circuit.

The program was written and assembled using the system supplied by Microchip, namely MPASM and MPLAB. Details about obtaining the software and preprogrammed PIC16C54 chips are given in the *Shop Talk* column and on the *EPE PCB Service* page.

Note that as the PIC16C54 microcontroller is an Eprom device, once programmed it can only be reprogrammed after being erased by an ultraviolet erasure unit.

CONSTRUCTION

A fairly compact printed circuit board

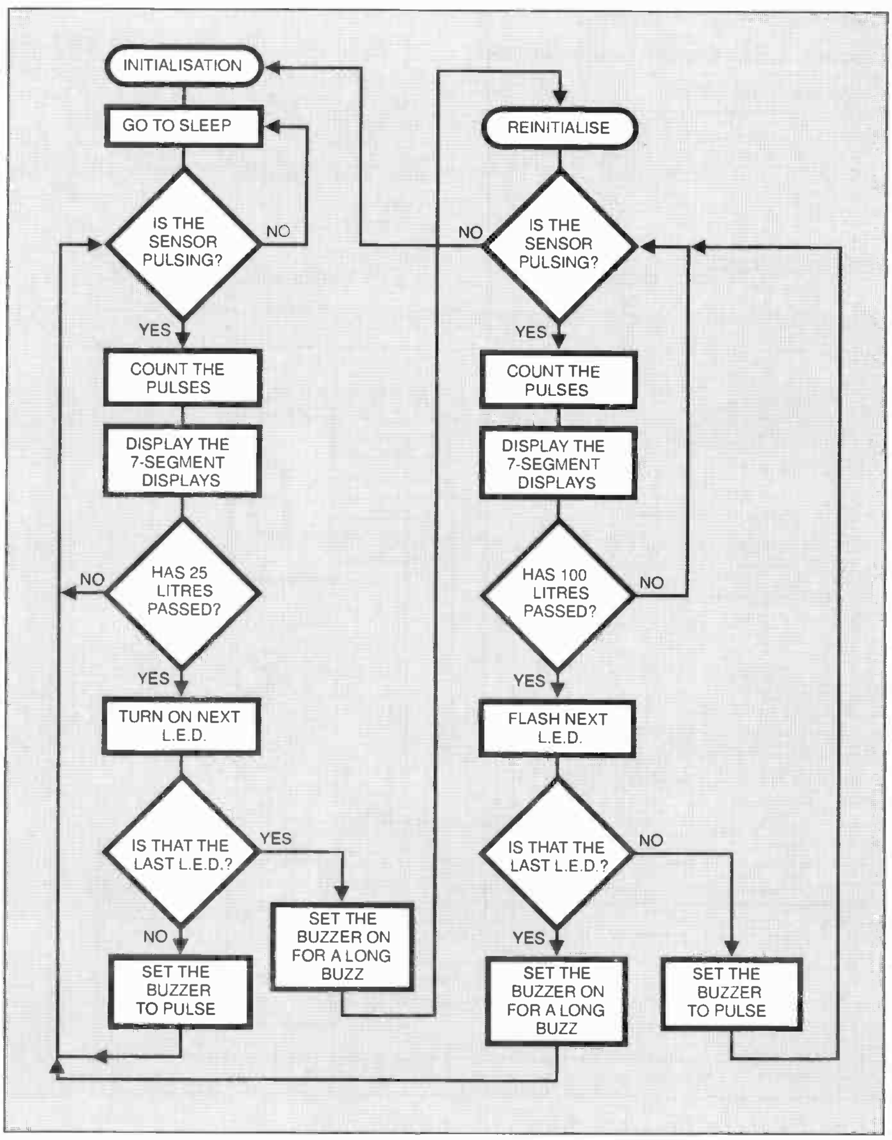
Printed card facia panel

(p.c.b.) layout, as shown in Fig.3, is required in order to fit the board into the suggested case. This board is available from the *EPE PCB Service*, code 180.

Ensure that the p.c.b. fits the case before starting work.

Begin by soldering in an 18-pin dual-in-line (d.i.l.) socket for the PIC and two

Table 2: Water Wizard Program Flow Chart



COMPONENTS

Resistor

R1	10k
R2	1k
R3	680Ω
R4, R6, R7	2k2 (3 off)
R5	270Ω

See SHOP TALK Page

Capacitors

C1, C2	22p ceramic disc (2 off)
C3, C4	470µ radial elect. 10V (2 off)
C5	100n ceramic disc

Semiconductors

D1, D3 to D5	1N4148 signal diode (4 off)
D2	(integral with sensor X2)
D6 to D9	5mm red l.e.d. (4 off)
D10	1N4001 rectifier diode
TR1, TR3	BC184L *npn* transistor (2 off)
TR2	BC214L *pnp* transistor
IC1	PIC16C54 microcontroller, preprogrammed (see text)

Miscellaneous

B1	6V battery (4 x AA) and clips (see text)
WD1	buzzer, 3V to 6V, p.c.b. mounting
X1	2·4576MHz crystal
X2	flow sensor type RS257-133
X3	7-segment common cathode l.e.d. display
X4	7-segment common anode l.e.d. display

Printed circuit board, available from the *EPE PCB Service*, code 180; splashproof plastic case with transparent lid, 82mm × 80mm × 55mm; 18-pin d.i.l. socket; 10-pin s.i.l. socket (2 off); red filter; 4-core cable (1 metre approx.); shower hose extension to suit (see text); solder, etc.

Approx Cost Guidance Only £50

single-in-line (s.i.l.) sockets for the 7-segment displays. Then solder in the resistors, crystal and small capacitors. Take care to fit the diodes, transistors and electrolytic capacitors the correct way round as shown. Also take care not to create any solder bridges, particularly where tracks run between the pins of IC1.

The four l.e.d.s should be fitted the correct way round, noting that the longer of the two leads is the anode (a). Note that the l.e.d.s are not in line, and D6 and D8 are displaced in order to allow the p.c.b. to be clipped into place inside the case.

It is necessary to bend the l.e.d. wires a little so that all the l.e.d.s are aligned, and their tops are at the same height as the 7-segment displays. If necessary, push the displays into their sockets to check this, but be sure to note which is the common cathode display, and which is the common anode. No great harm will occur if they have become mixed up, but if in doubt, test the circuit with one display chosen at random to see if it works.

FLOW SENSOR

The flow sensor should be connected to the p.c.b. via a length of 4-core cable. Use the thinnest cable available, and do not forget to push the cable through the hole in the sensor cover.

The sensor cover is a push-fit and should be removed to expose the five connections. These include two for the internal l.e.d. and three for the sensor itself, as seen in Fig.4.

Note that the cathode of the l.e.d. should be connected to the sensor's 0V pin with an insulated wire link. Although this point is intended to be connected to diodes D3, D4 and D5 when the unit is in normal use, a direct 0V connection is provided on the p.c.b. and is shown in Fig.3 as "0V Test Point". This is useful for initial testing as the output signal from the sensor may be tested without the PIC being active.

Connect the 4-core cable to the p.c.b. on the *trackside*, so that the cable does not show above the p.c.b. Note that the connection is temporary at this stage, since the cable will have to be fitted through a hole in the case.

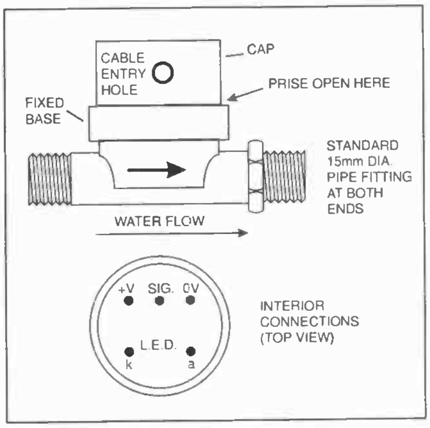


Fig.4. Connecting details for the Water Flow sensor.

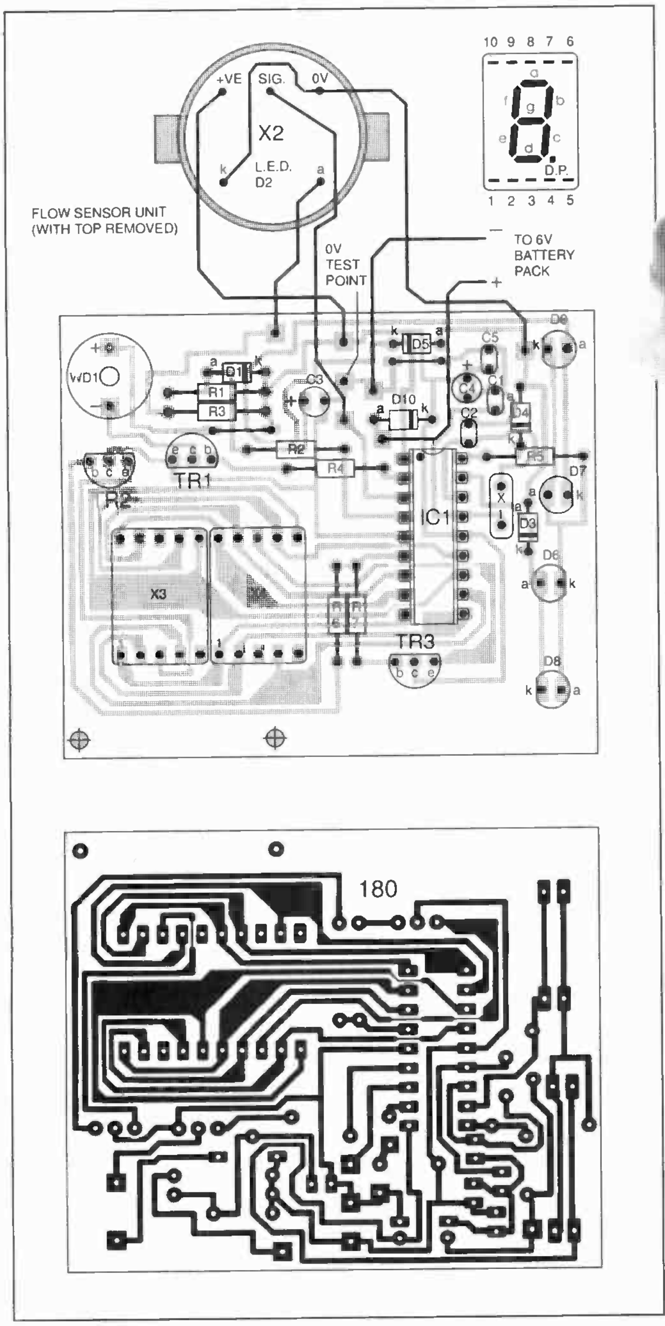
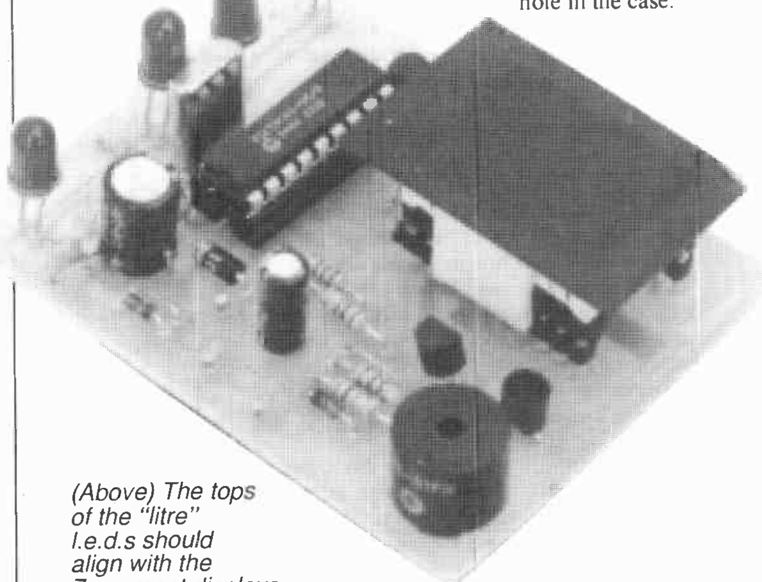
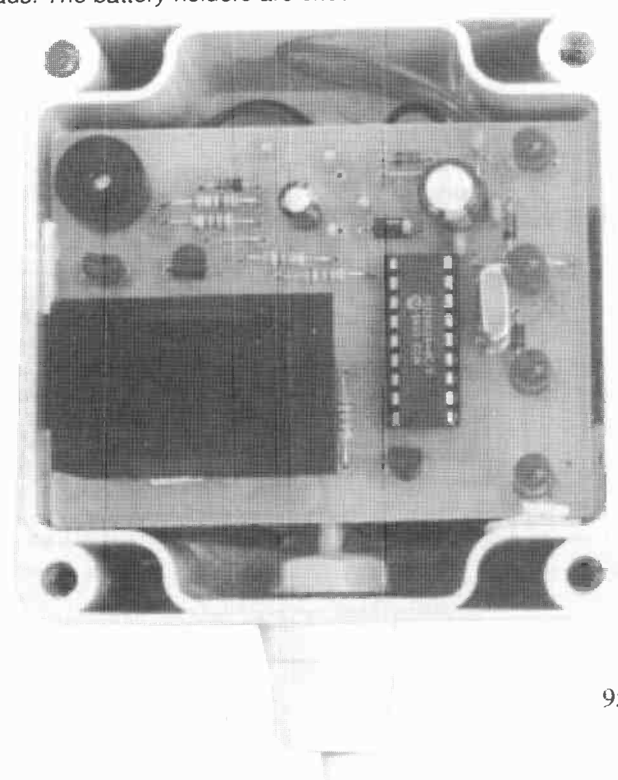


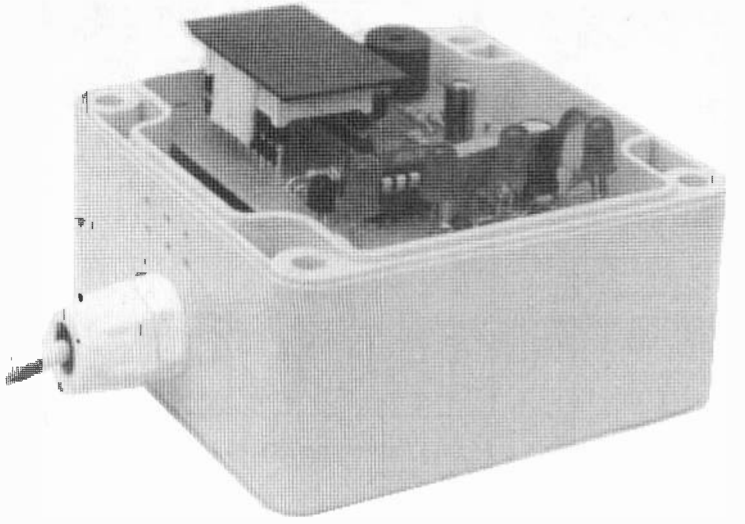
Fig.3. Water Wizard printed circuit board component layout, wiring to flow sensor, and full-size coppr foil master. Note the lead-off wires should be soldered to the trackside.



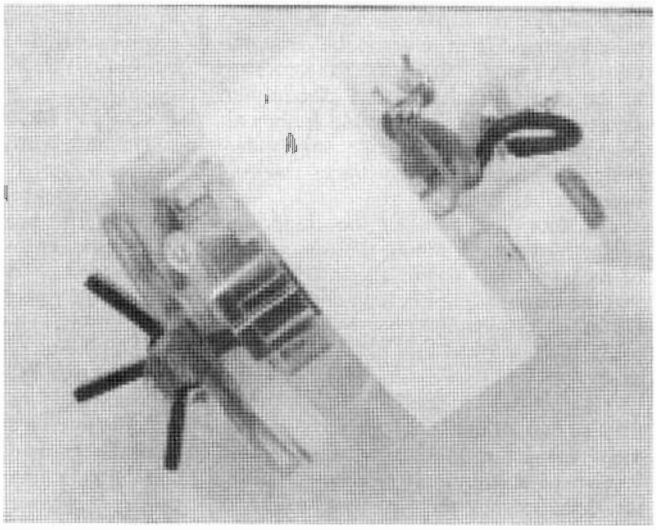
(Above) The tops of the "litre" l.e.d.s should align with the 7-segment displays.

(Below) The p.c.b. is wedged into its case using adhesive pads. The battery holders are sited in the bottom.





Control unit with lid removed. The 7-segment displays and l.e.d.s should protrude into the lid area.



Dismantled sensor showing "water paddle" rotor and wiring.

The battery clip should also be connected to the power supply pads on the trackside of the p.c.b.

Finally, fit the programmed PIC, checking that its notch faces towards the top of the circuit board, as shown in Fig.3.

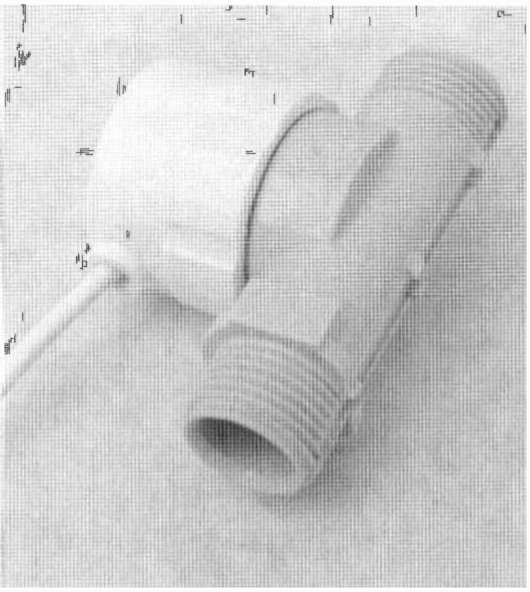
TESTING

The circuit can now be tested by connecting a 5V power supply or 6V battery pack. Blowing air through the sensor should make its rotor spin and produce a square wave output signal, which can be checked by an oscilloscope, if available.

If all is well, the display should light when air is blown through the sensor. Continuous blowing should cause the display reading to increase, and at 25 litres the first l.e.d. should light and the buzzer should pulse for a short time.

Remember that the PIC will not "wake up" until a square wave is present on pin 3 of the PIC.

Since continual blowing into the water flow sensor unit is inconvenient, if not stressful, it may be helpful to apply a square wave (not above 6V) from a signal generator to IC1 pin 3 (with the sensor's signal lead disconnected).



Water Flow Sensor module. Check the water flow direction indicated on the body of the module.

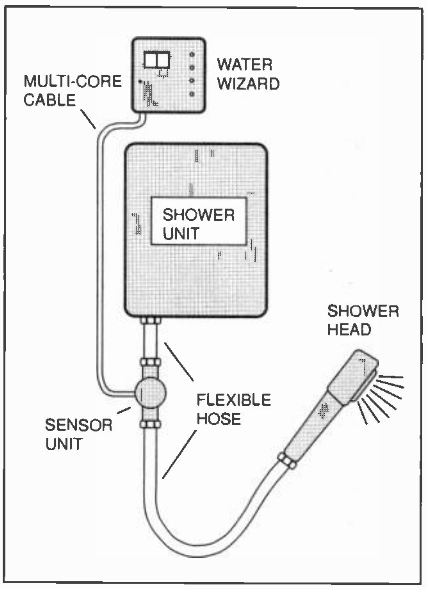


Fig.5. One suggested method of attaching the Water Wizard to a shower unit.

The whole sequence may then be observed at higher speed to 500 litres, without wasting any water or breath!

CASE DETAILS

The Water Wizard prototype was housed in a plastic case measuring 82mm × 80mm × 55mm, with a clear lid. The case *must be sealed and water resistant* as it may well be splashed with water.

Several holes are required in the case, one for the 4-core cable, and a few *very small* holes for the sound to penetrate from the internal buzzer.

The cable entry should be protected with a tight fitting grommet, and the sound holes possibly protected with a thin membrane, although if located at the base or rear of the unit (as with the prototype – six small holes), water penetration should not be a problem.

It may be necessary to drill small securing holes in the rear section if the unit is to be fitted to a wall.

A 6V battery supply is required, and this is achieved with four AA-size cells. Two 3V battery packs will fit the case more easily than a single 6V pack. The two 3V packs may be glued inside to the rear of the case, although the type used in the prototype were wedged into place without the need for glue.

Ensure that the packs are connected in series, i.e. the red wire from one should be connected to the black wire from the other. The remaining red and black wires then provide the positive and negative supply to the circuit.

The p.c.b. may be mounted at the top of the lower section of the case, or in the transparent lid using adhesive wedges. A red filter may be placed over the 7-segment displays to improve their appearance; it should be fitted directly on the displays, as any space between the displays and the filter will cause blurring.

The prototype's cover panel seen in the photographs was drawn on coloured card, the l.e.d. circles and 7-segment display box being cut out with a craft knife. The panel was fitted inside the clear case top to provide a neat finish.

INSTALLATION

A diagrammatic representation of how the Water Wizard is attached to the shower unit via an additional flexible hose is shown in Fig.5. With the prototype, the additional hose was reduced in length so that the sensor was immediately below the shower unit. However, this type of alteration requires a degree of plumbing skill to produce a water tight joint, and it may be wiser to leave the additional hose at its standard length.

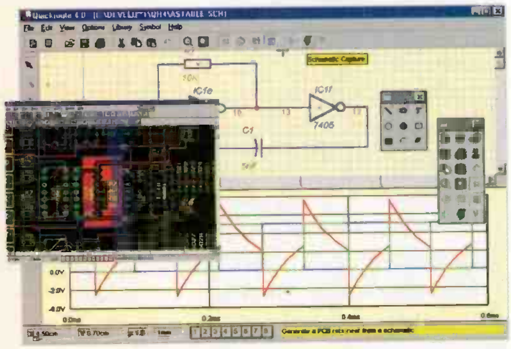
The 4-core cable links the sensor to the Water Wizard, and the cable may be routed neatly behind the hose and shower unit. □

EDITORIAL NOTE

Andrew Buckmaster received "Highly Commended" recognition for his Water Wizard in the Intermediate (15 to 17 years) category of the *Young Electronic Designer Awards* (YEDA) for 1997, as reported in our June '97 issue. For his achievement, he was awarded a certificate and the prize of a Texas Instruments T180 graphics calculator.

Andrew is a pupil at Radley College, Abingdon, near Oxford, where Max Horsey is Head of Electronics.

Looks like Quickroute 4.0 has Got the Lot!



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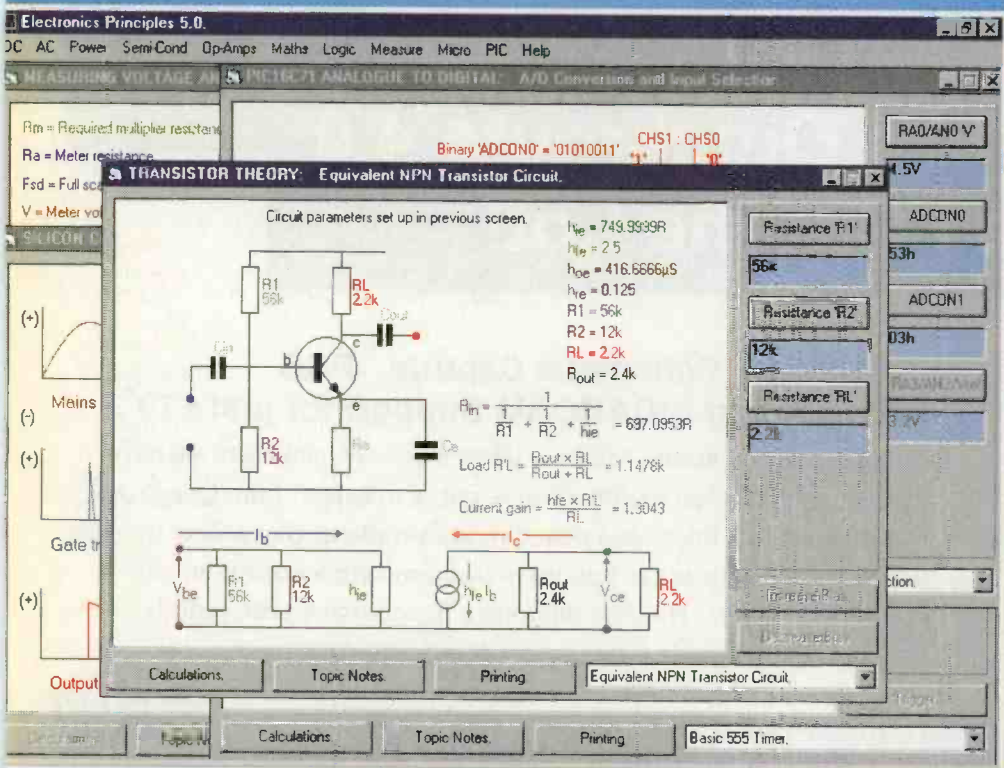

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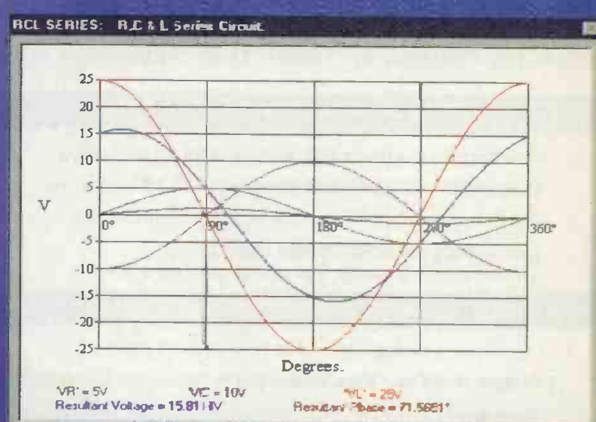
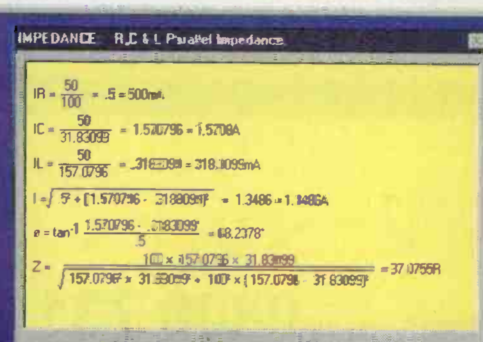
Graphics presentation has been enhanced and speeded-up with new menus and indexing which enables a quicker access and more informative description of the extended range of five hundred and sixty electronics and mathematics topics.

The PIC16C84 microcontroller hardware and instruction set has been introduced and brought to life through colourful interactive graphics where you can study the architecture of this device by changing the data values to simulate all of the registers, direct/indirect addressing, program/data memory and input/output port configuration. Along with those analogue to digital functions of the PIC16C71. If you would like to learn more about the principles of these popular microcontrollers then it could not be made easier.

Electronics Principles software is currently used in hundreds of UK and overseas schools and colleges to support City & Guilds, GCSE, A-level, BTEC and university foundation courses. Also NVQ's and GNVQ's where students are required to have an understanding of electronics principles.





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Innovations

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

PC SPEECH TRANSLATION

Real-time translation between spoken languages is a mere two years away, reveals Barry Fox.

MICROSOFT has paid $45 million for an eight per cent share in Belgian electronics company, Lernout and Hauspie. In return for the investment, Microsoft is free to use L&H's speech recognition and text-to-speech software in its Windows operating system. L&H will use the money to develop the translation software on which the licensed programs rely.

President and CEO Gaston Bastiaens (ex-Philips and ex-Apple) recently demonstrated where the technology is today, and predicted where it will go next.

Within two years, says Bastiaens, L&H will be selling a hand-held translator, which responds to an English voice and speaks a Chinese translation, and vice-versa. There will also be a Japanese-English version. Bastiaens predicts that video and computer games will very soon respond to speech "zap" commands.

"Expansion of the EC is good news for us", says Bastiaens. "As more European states with more unfamiliar languages join the EC, there will not be enough human translators to handle their conferences and meetings. They will have to use machine translation."

L&H now has a staff of seven hundred, five hundred of them engineers and linguists, working on the problem. Instantaneous translation is two years away, but only if the conversation uses a limited vocabulary. Complicated conversations, with innuendo and slang, could take up to ten years to translate in real-time.

"It is easier to handle this kind of translation in non-realtime batches", says Bastiaens. "The machine listens to the speech, then translates it and speaks".

At a recent demonstration, L&H showed how mail order catalogue firms and pizza chains in the US are already taking telephone orders without human involvement. A computer recognises the speech and repeats the order with virtually no delay. The core software is now on sale in Germany for 600Dm.

Although several companies are already selling speech recognition software which claims to let anyone talk to their computer instead of type at the keyboard, performance is erratic. This is often because the system has been tuned to recognise an American voice, and finds difficulty with the English accent. VoicePad Pro from US company Kurzweil suffered this problem. Significantly L&H has now bought Kurzweil.

Philips is also very active in speech recognition, and like L&H is aiming initially for vertical markets, where users in a specialised field call on a relatively limited vocabulary. Philips is supplying the Swiss Railways with a system which lets people phone and ask a computer for train times. L&H's first system will be aimed at American doctors, who are paranoid over law suits and thus need to dictate what they are doing during an operation.

Text translation is easier than speech translation, because there is no need for the computer to recognise words before translating them. But L&H is still selling text translation only to professional translators, who use a computer to make a first draft, and then polish the it to avoid contextual nonsenses which can arise when a word has several meanings.

The long-term aim is Internet ferret software, which takes a query in one language, translates it into several languages, searches the Internet, retrieves information in several languages, then translates the text back into the original language and condenses it into a summary. Again this is seen only as a professional tool.

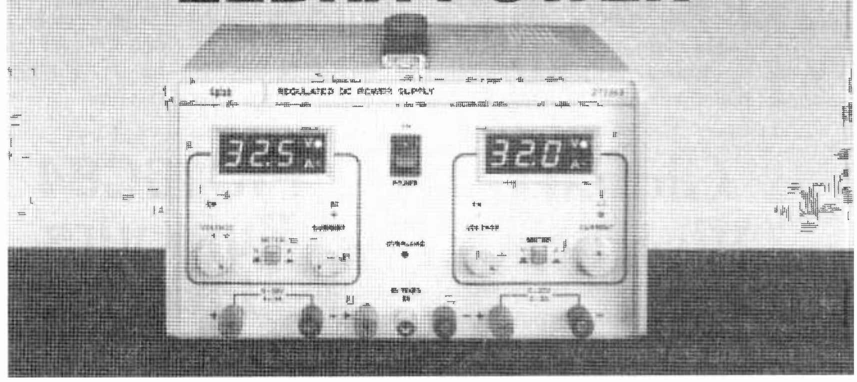
My Word – What Next!

But one L&H product will soon be available as a low cost consumer tool. For around £50, speech recognition software works with Windows 95 and Microsoft Word to edit and manipulate text. Instead of trying to remember which command in Word does what, the user simply speaks a plain English order, such as, "underline first word, italicize second line, use one inch margin, break into columns, highlight in red".

At a demonstration in London recently, L&H's chief technical officer Bob Kutnick, spoke to the PC in his American accent, then handed the microphone to several Brits with different English accents. All were able to control the edit functions.

"There are things I can do with Word by talking, that I don't know how to do with key strokes", admitted Kutnick, summing up the dilemma many users face with the increasingly bloated Word software. Small wonder Microsoft has bought a share in Lernout and Hauspie, and the right to use its speech recognition engine in all Microsoft software.

ZEBRA POWER

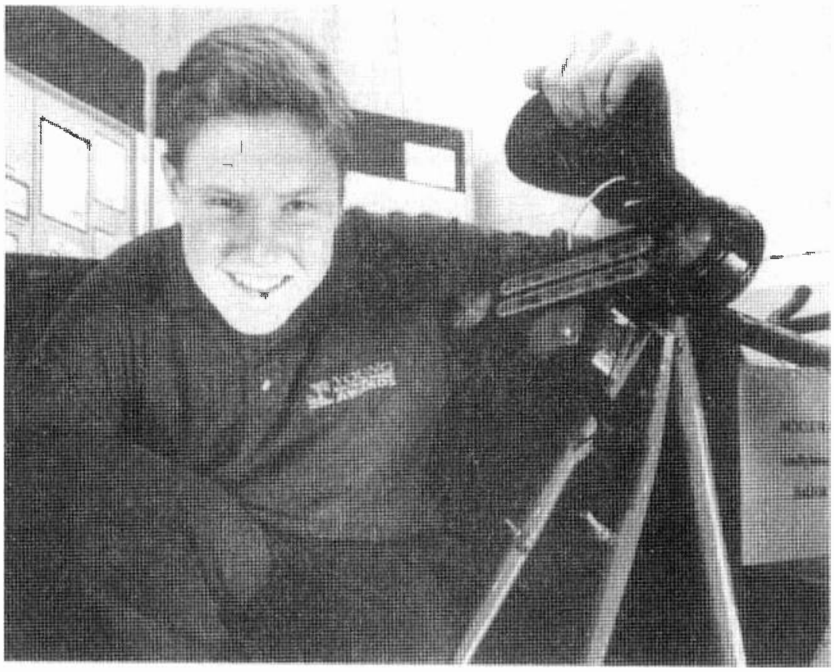


CROTECH have introduced their new Zebra series of bench power supplies. The company have over 30 years experience in design and manufacture of power supplies for both the educational and professional user.

They say that the Zebra range represents outstanding value for money, offering high quality, safe, rugged and easy to use bench power supplies. There are 20 different models in the range, in single, dual and triple output types. Many features are offered, such as independent series or parallel mode, constant current, tracking and large clear digital display meters for reading both voltage and current.

All models have low ripple and noise, combined with good voltage line and load regulation of <0·01% at full load, as well as full automatic overload and short circuit protection. They comply with BS EN 61010 Electrical Safety Standard, suitable for use in educational establishments.

For more information, contact Crotech Instruments Ltd., Dept. EPE, Unit A1, Farday Road, Newbury, Berks RG14 2AD. Tel: 01635 550789. Fax: 01635 49305.



YEDA CALLING

THE CALL for entries to the *Young Electronics Designer of the Year Award* (YEDA) 1998 has been made.

There are three categories, Junior (under 15 years}, Intermediate (15-17 incl.), and Senior (18-25 incl.). To enter YEDA, all you need to do is obtain an entry form, fill it in with a brief description of the device or system which you have invented, and return the form to YEDA before 2 March 1998. Your design will then have to be ready for regional judging between 20 April and 1 May 1998.

If you are successful at this stage, you will then have the opportunity to develop your project further before the national final in Manchester on 28-29 June 1998.

The judges will be looking for five principle qualities in your design: originality, technical competence and reliability, construction and presentation, everyday usefulness, commercial feasibility.

Last year the Junior Category prize went to Edward Brocklebank of Radley College, Abingdon, for his bicycle enhanced visibility and indication system. Radley, of course, is where Max Horsey is Head of Electronics, Max being the author of our *Teach-In '96* series.

Interestingly, the Manchester presentation takes place as part of the celebrations marking the 50th anniversary of the world's first stored program computer. This machine – the antecedent of the programmable computers in use today – was unveiled in June 1948 by a team of engineers at the University of Manchester.

To find out more about the awards, contact The YEDA Trust, Dept EPE, 60 Lower Street, Pulborough, W. Sussex RH10 2BW. Tel: 01798 874767. Fax: 01798 873550. E-mail: postmaster@yeda.compulink.co.uk. Web: http://www.yeda.org.uk.

Global Weather

A GLOBAL network of weather satellites could mean significant new orders for the British space industry, according to John Battle, Minister for Science, Energy and Industry.

John Battle has confirmed the UK's £27 million commitment to the European Space Agency's METOP-1 programme, which could bring an estimated £55 million in orders to Britain.

The meteorological polar orbiting satellite (METOP) is the first of three European satellites which will form part of the World Meteorological Organisation's Global Observing System. From 2003 onwards, the three will cross the poles to provide a constant stream of weather data.

PIC16C84 Rumours False!

THERE are rumours circulating that the PIC16C84 microcontroller is to be deleted by Microchip. We have spoken with the UK office of Microchip who assure us that they have no intention of deleting it, or any of their PIC range.

There are further comments, about the PIC16C84 and sister PIC16F84 on the *Readout* pages.

For more information contact Arizona Microchip Technology Ltd, Dept EPE, Unit 6, The Courtyard, Meadowbank, Furlong Road, Bourne End, Bucks SL8 5AJ.

Tel: 01628 851077.
Fax: 01628 850259.

EMF Safety Update

THE NRPB (National Radiological Protection Board) has sent its annual report. In it is stated that "Whereas biological studies provide no persuasive evidence that power frequency EMFs can influence cancer processes, the epidemiological evidence remains equivocal".

The question as to whether EMFs (electromagnetic fields) can cause cancer was first posed some years ago. We periodically publicise the latest statements made by NRPB on the issue.

Two further statements in the report are interesting: "Restrictions on human exposure to low frequency magnetic fields recommended by the Board are based in part on the need to avoid the adverse effects of induced electric current on the brain and nervous system. Experiments at the Board have indicated that magnetic fields may temporarily affect certain types of memory"; and that a European Commission has recommended "a programme of international research on the effects related to the use of mobile phones".

For more information contact: NRPB, Dept EPE, Chilton, Didcot, Oxon OX11 0RQ.

Tel: 01235 831600.
Fax: 01235 833891.
E-mail: nrpb@nrpb.org.uk.
Web: http://www.nrpb.org.uk.

GREENS SHOCK STORE

FRIENDS of the Earth groups recently demonstrated outside Dixons stores calling for the UK electrical industry to pay for the collection of electrical goods for reuse and recycling, for products to be labelled with their expected lifespan, and for retailers to offer free extended guarantees.

Dixons are the UK's leading electrical retailer and the demonstrations were aimed at influencing discussions on a new European law which could ensure that electrical goods are designed for durability, repair, reuse and recycling.

Apparently six million electrical items are dumped every year in the UK. The proposed European Directive is the first "producer responsibility" Directive for household consumer goods that will ensure manufacturers take responsibility for their product from cradle to grave.

Friends of the Earth are at Dept EPE, 26-28 Underwood Street, London N1 7JQ.

Tel: 0171 490 1555.
Fax: 0171 490 0881.
Web: http://www.foe.co.uk.

POWER FROM TEXAS

NEWLY-FORMED company Power Innovations have acquired from Texas Instruments all that part of their business which designs, manufactures and markets the well established and highly successful range of TI discrete bipolar devices, including high voltage transistors.

This management buy-out included all the relevant patents and intellectual property rights, wafer fabrication facilities, processes and procedure. All these functions, and the people responsible for them, will continue to operate at the Manton Lane plant, which for many years has been TI's sole manufacturing centre for power devices.

Now the handover has taken place, PI has assumed responsibility for any inventory and for all products in the course of manufacture.

For more information contact Power Innovations, Dept EPE, Manton Lane, Bedford MK41 7BJ.
Tel: 01234 223001.
Fax: 01234 223000.
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Web: http://www.powinv.com.

Engaged US Telecoms

BT's rival, Mercury, has identified a puzzling problem for subscribers who use a BT line and Mercury 131 access code to make low cost transatlantic telephone calls. Sometimes the calls fail, giving the characteristic North American engaged or busy tone. But other times calls fail with the quite different British engaged tone. This suggests that the Mercury system is overloaded and unable to get calls out of Britain.

According to Mercury this is not so. Engineers have traced failed calls and found that when they are routed to the US by satellite, the UK caller hears a US engaged tone if the number is busy. But if the call goes to the US by optic fibre undersea cable, and the called number is busy, a signal is returned to the UK which triggers a locally generated engaged tone. So the two quite different tones mean the same, the US number is busy. Barry Fox

ADVERTISERS

Have you got an interesting new product you would like publicised in *Innovations?* If so drop us a line with details (and a photo if possible).

Overloud Movies

Barry Fox has some good news

DOLBY Laboratories, the US company which made it possible for cinemas to surround audiences with super loud-sound, admits that audiences do not always like what they hear. Many movie-goers now regularly complain that movies are too loud. Trailers, promoting future attractions, are the worst offenders. When cinema managers reduce the volume setting to curb audience complaints, the dialogue in the feature film becomes unintelligible. The engineers in the studios who record and mix the sound listen so loud that they risk damage to their hearing.

Following critical articles in *The Los Angeles Times*, *Miami Herald* and *Economist*, as well as the movie industry's trade press, Dolby's Vice President, Ian Allen, says he wants to take the "first step towards sanity" by proposing a standard for measuring cinema sound loudness. The new standard is based on techniques developed to safeguard factory workers from industrial noise.

In the 1970s, Dolby Labs developed high quality analogue stereo and surround systems for the cinema. These let cinemas play movies louder. Because the human ear's ability to hear speech through a mix of music and sound effects varies with the overall volume level, Dolby developed a calibration system.

FADE TO PINK

Before a movie studio mixes a soundtrack, it plays a random pink noise reference signal into the control room at 85 decibels. All cinemas play the same reference signal while adjusting their volume controls or "faders" so that the sound in the auditorium is also at 85dB. The mix of sound heard by the cinema audience then always matches that heard by the studio engineers.

Dolby now realises that the recent transition from analogue to digital sound has given soundtracks more headroom. Like rock groups, movies start loud and then get louder. "Things have gone wrong", says Allen. "The phrase *cut to the chase* no longer has any meaning – the chase frequently starts at the beginning of reel one."

Trailers are even louder than the movies they advertise. The loudspeakers in the cinema may overload and cause distortion which roughens the sound and offends the audience's ears.

When customers complain, the cinema manager reduces the overall volume level to around one half the calibrated setting. Speech is then swamped by music and effects, and audiences complain that they cannot hear what the actors are saying.

AUDIENCE ANNOYANCE

Dolby has tested audience reaction to a selection of film excerpts and trailers and found that conventional meters give no useful indication of nuisance value. Loudness meters as now used to monitor TV commercials are no help because they give an instantaneous reading which does not measure audience annoyance over a two or three hour screening.

Dolby is now modifying a system used to safeguard factory workers from hearing loss caused by intermittent exposure to loud but varying noise. An LEQ (equivalent continuous sound level) meter measures the sound energy dose over an exposure period and averages it over an 8-hour day. Because movie soundtracks do not usually resemble factory noise, and audiences find overloud music and speech frequencies in the 2kHz to 4kHz band most upsetting, Dolby "weights" the LEQ measurement to be more sensitive in this range.

Weighted LEQ provides a measurement tool which quantifies loudness in the cinema, and Dolby is proposing that the Society of Motion Picture and Television Engineers now agree an LEQ value which defines the threshold between too loud and acceptable. Cinema managers can then go back to using standard settings for their faders. Movies will still contain loud passages but the overall effect will not be so wearing on the audience.

Allen warns SMPTE members that it is in their interests to take urgent action on the special case of trailers. Analysis of trailers produced in Hollywood shows them to have much higher LEQ levels than the movies they advertise. Worst offenders include *The Empire Strikes Back, Twister* and *Star Wars.* If sound engineers work for four hours a day mixing the sound for these trailers, they exceed the safe dose for industrial noise and "have a real chance of hearing damage".

Environmental Health Officers now look to the Health and Safety Executives for guidelines on noise risk, both to audiences and cinema staff, who are subjected to prolonged exposure. The HSE says "a number of Councils have now drawn our attention to the problem". The HSE is now working on guidelines for Environmental Health Officers through the Broadcasting and Performing Arts Joint Advisory Committee, which is a forum for unions and employers.

New Technology Update

50 years on from its invention, the transistor still dominates electronics and its development continues apace. Ian Poole reports.

THE TRANSISTOR is now 50 years old! Its invention was announced in 1948 after the first demonstrations took place late in 1947. The team of Shockley, Bardeen and Brattain made their first transistor on 16th December 1947, and demonstrated it to senior managers at Bell Laboratories the day before Christmas Eve.

No one at that demonstration could have realised the enormous effect the invention would have on daily life. Research started after Bell Labs realised the importance of the work which had taken place into semiconductors during the Second World War. In this work, new semiconductor diodes were used to give improved performance for radar systems. These developments lead to Bell seeing the possibilities in new technologies and they set up specialised research teams.

First Investigations

Initially, Shockley, Bardeen and Brattain had been investigating a field effect device, but had been unable to make the device work. After several setbacks they finally looked at the effect of two *p-n* junctions placed close together. First experiments showed promising indications but they realised they had to place the two junctions very close together – about 0·05mm apart – if they were to achieve sufficient gain.

This they did in a rather crude fashion by today's standards. They took a small wedge of perspex and plated it with gold. A razor blade was taken down the edge to cut the gold on either side of the wedge. This was placed onto the substrate of germanium, and held in place by the force from a small spring. The device worked first time and the transistor age had dawned.

It took several years before production devices were available. Materials technology still needed developing so that the devices could be made reliably. This slowly improved over the years with Shockley making the first transistor manufactured using doping techniques.

A major step forwards occurred in 1954 at a conference organised by the Institute of Radio Engineers. Up until this time transistors had all been made from germanium. Several speakers mentioned that it would be several years before a silicon transistor could be manufactured. To their surprise an ex-Bell employee named Teal demonstrated one at the conference, on behalf of a little known company called Texas Instruments.

Since then the development of the transistor has progressed unabated. Higher frequencies, lower noise levels, higher levels of gain and improvements in all other specifications have been seen. Now the transistor and its developments are all part of today's electronics scene.

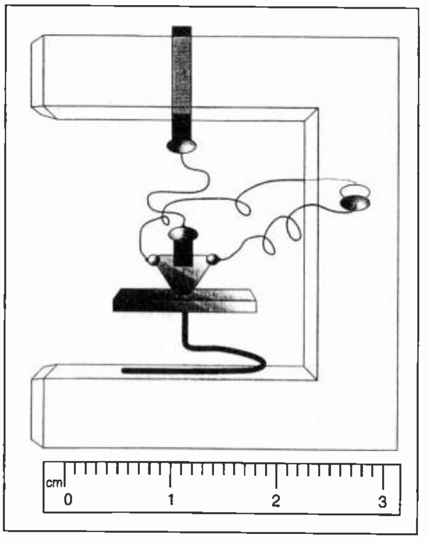


Fig.1. The first commercial transistor, from Western Electric (1951).

High Frequencies

One of the main areas for development these days is in increasing the speed of transistors. Bipolar devices are often used in radio frequency applications. With the radio spectrum becoming increasingly congested at lower frequencies more activity is taking place at higher frequencies. Many mobile phones operate at frequencies around 1800MHz. This can result in more expensive components having to be used than for 900MHz bands.

A process taken over by Maxim from Tektronix is being employed to make bipolar devices. It is being used to manufacture items for frequencies up to 2GHz. With costs being kept to a minimum, it is ideal for devices aimed at the mobile phone market in both bands, i.e. at both 900MHz and 1800MHz.

Called the GST-2 (Giga-speed Sampling Technology) process, it has an f_t of 27GHz. It uses trench isolation between different areas and a self-aligned double poly-silicon process. It operates down to voltages in the region of 2V, making it ideal for use in handheld phones.

The original process developed by Tektronix was used for giga sample-per-second ADCs. The new process gives a three-fold improvement over its predecessor, and now that Maxim have taken the process over they have been able to use its speed for radio frequency applications.

The process is relatively complicated, although it can still be made at a sufficiently low cost to make it attractive for mobile phones. Despite its complexity, yields are high and this means that low costs can be maintained.

To produce the i.c.s, a variety of processes are required. The more usual processes of epitaxial growth, photolithography and etching are central to the process, together with very fine geometries and ion implantation. However, the major differences with other technologies are found in the use of gold, and barrier metals. Another innovation is the use of active ions to achieve geometry tightness. These all combine to give the exceedingly high performance of the technology.

This new process gives the possibility of manufacturing radio frequency i.c.s, low noise amplifiers, power amplifiers, Schottky diodes and a variety of other devices, all of which could find widespread use in vast quantities in mobile phones.

High Voltage Transistor

A new transistor which has been launched recently by SGS Thomson Microelectronics combines both bipolar and f.e.t. technology in a single device to allow voltages of up to 1·5kV to be switched. Essentially it consists of a bipolar-f.e.t. cascode pair which can be controlled by logic signals.

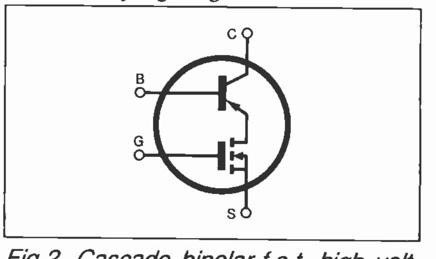
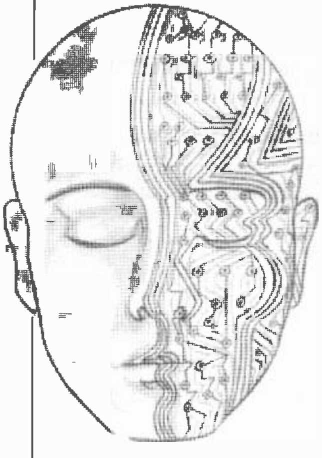


Fig.2. Cascade bipolar-f.e.t. high voltage switch.

From the circuit symbol of the device it can be seen that the emitter of the bipolar transistor is connected to the load though the f.e.t. By maintaining the emitter at a constant voltage, it can be switched on and off by switching the f.e.t. Both the bipolar transistor and the f.e.t. take the full load current, but the way in which the circuit operates means that the bipolar transistor takes the high voltage.

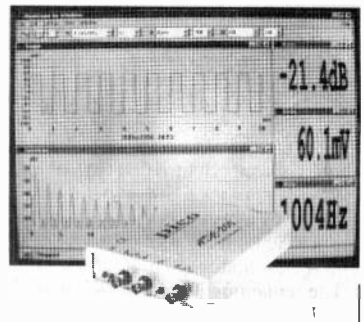
Often high voltage semiconductor devices have a slow turn-off speed in view of the large amounts of stored charge. This device has a much faster turn-off than many others because of its unusual configuration. The f.e.t. device turns off and collector current can no longer flow through the emitter for the transistor. Instead, it flows back through the gate, removing the stored charge and turning the device off much faster than would normally happen. Typically, turn-off times of under 100ns are quoted, which is very fast for a device of this nature.



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.

Cheap L.E.D. Blinker – Flash Back

THE OBJECTIVE of the circuit of Fig.1 was to flash an l.e.d. once per second, using a 1·5V battery, at such a low current that it would last up to the shelf life of the battery. The solution uses two transistors and is cheaper than using a custom l.e.d. flasher chip.

When current flows through resistor R1, transistor TR1 turns on along with TR2. Inductor L1 initially presents a high impedance so TR2 collector (c) is pulled low. This is passed by capacitor C2 to provide some regenerative feedback to TR1 base (b).

Soon, L1 starts to pass current and eventually TR1 collector starts to swing high due to feedback passed via C2. Thus TR1 is switched out, which consequently switches off TR2 very quickly.

The inductor's collapsing field will try to induce a current towards TR2 collector but instead serves to illuminate l.e.d. D1, the induced voltage being more than enough to do this. This occurs many times in approximately 20ms. The cycle starts again about a second later.

The circuit could be used as a bicycle l.e.d. flasher or imitation burglar alarm blinker.

John Hyland,
Strood, Kent.

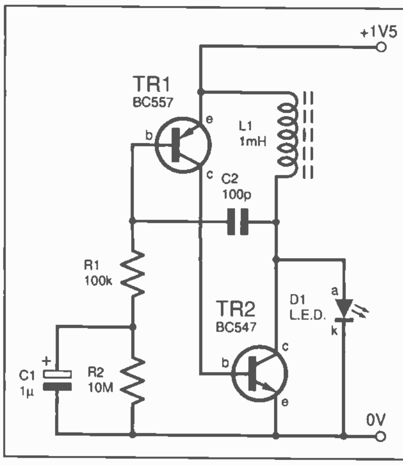


Fig. 1. Cheap L.E.D. Blinker circuit.

Simple Thermostat – Keeping it Cool

WHEN challenged to design a cheap system to switch on a cooling fan for an electronics enclosure when a certain cabinet temperature was reached, the circuit of Fig. 2 was eventually arrived at. The fan relay RLA had to switch when the detected temperature rose to a certain value above ambient, so a differential thermostat was required.

Probably the cheapest transducer available is the ordinary silicon diode: 1N4148s cost 50 pence per hundred! A normal diode has a forward voltage drop which varies by 2·3mV per degree Celsius.

When fed with a constant current, it forms a simple and reliable temperature sensor which is reasonably linear over a wide range. If a differential temperature control is required, it is a fairly simple matter to use a pair of diodes in a bridge circuit, and use a potentiometer to set up any offset required.

In Fig. 2, both the sensor and reference diodes are "doubled up" to give an increased sensitivity of about 4·5mV per degree Celsius. The op.amp IC1 has no feedback and operates in open-loop mode as a comparator, fed by the bridge network which itself is supplied with a 12V regulated supply (Zener D5); one pair of diodes D3, D4 acting as an ambient temperature reference whilst the other set (Sense) is used as a probe, with capacitor C1 removing noise.

The trimmer potentiometer VR1 provides any offset required and allows temperature control of around 12°C. The fan is switched by relay RLA which is driven by the transistor switch TR1. An ordinary 741 op.amp will be quite adequate in this application although a CA3140 was used for IC1 in the prototype.

Ted Whittaker, Stone, Staffs.

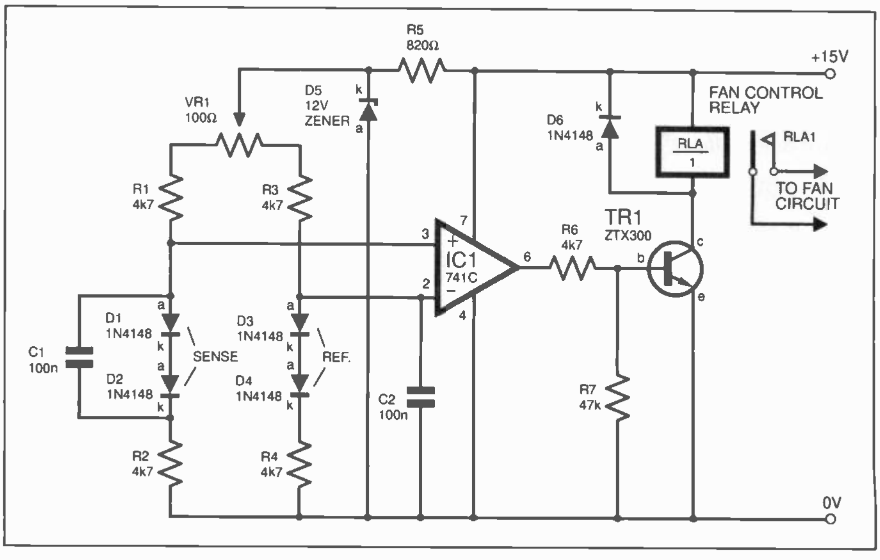


Fig.2. Circuit diagram for a Cooling Fan Thermostat.

Simple Liquid Crystal Display Tester – Enlightened Performance

A SIMPLE circuit which will help test the performance of an l.c.d., and is ideal for experimenters, is shown in Fig.3. The circuit produces a bi-phase square wave with negligible d.c. content and uses a hex Schmitt inverter, 40106.

An oscillator is based around IC1a whilst IC1b is a phase splitter. The remaining inverters form a pair of buffers and drivers.

The outputs of the circuit are terminated with 47k (kilohms) resistors in series with a pair of test probes. With the values shown, IC1 generates a square wave of approximately 45Hz, and the circuit will operate on a d.c. voltage from 3V to 15V d.c.

To test a particular l.c.d., touch the backplane using either of the test probes – usually the backplane is the left-hand or right-hand connection – and apply the other probe to any segment connection. The segment should change accordingly. If the display is a multiplexed type, then all segments should change.

Rupen Chanda,
Madras, India.

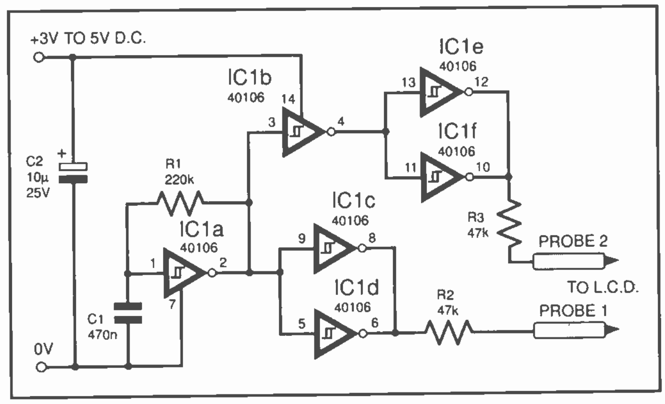


Fig.3. Circuit diagram for a simple Liquid Crystal Display (LCD) Tester.

Isolated Multi-output Power Supply – Four for One

A CIRCUIT was required which would provide several *isolated* power supplies, for use in driving a power FET bridge network. Multiple mains transformers could have been used but this would have been bulky and expensive, and because the current demanded by the power supplies was low, the circuit show in Fig.4 was devised.

The secondary of a mains transformer (not shown) is rectified by diodes D1 to D4 and filtered to provide a regulated +15V supply via voltage regulator IC1. This is used as the input to a small inverter circuit. Resistor R1, capacitor C5 and IC3a form a 200kHz oscillator which is passed to a flip-flop formed by IC2b, one half of a 4027, the output of which is 100kHz with 50 per cent duty cycle applied alternately to the two MOSFETs TR1 and TR2.

A delay is included by the diode and *RC* networks present on the inputs to the inverters IC3e and IC3d. This eliminates the possibility that both transistors could switch on together for a short period. Both transistors then drive the primary winding (18 turns each) of transformer T1 which is a small custom-wound high frequency transformer.

Transformer T1 is wound on a standard "RM8" bobbin with an inductance factor (A_L) of 250. The circuit has four secondary windings (20 turns each) which are rectified and filtered to provide the isolated supplies. Each output is easily capable of providing 15V at 20mA.

Duncan Boyd,
Blackburn, West Lothian.

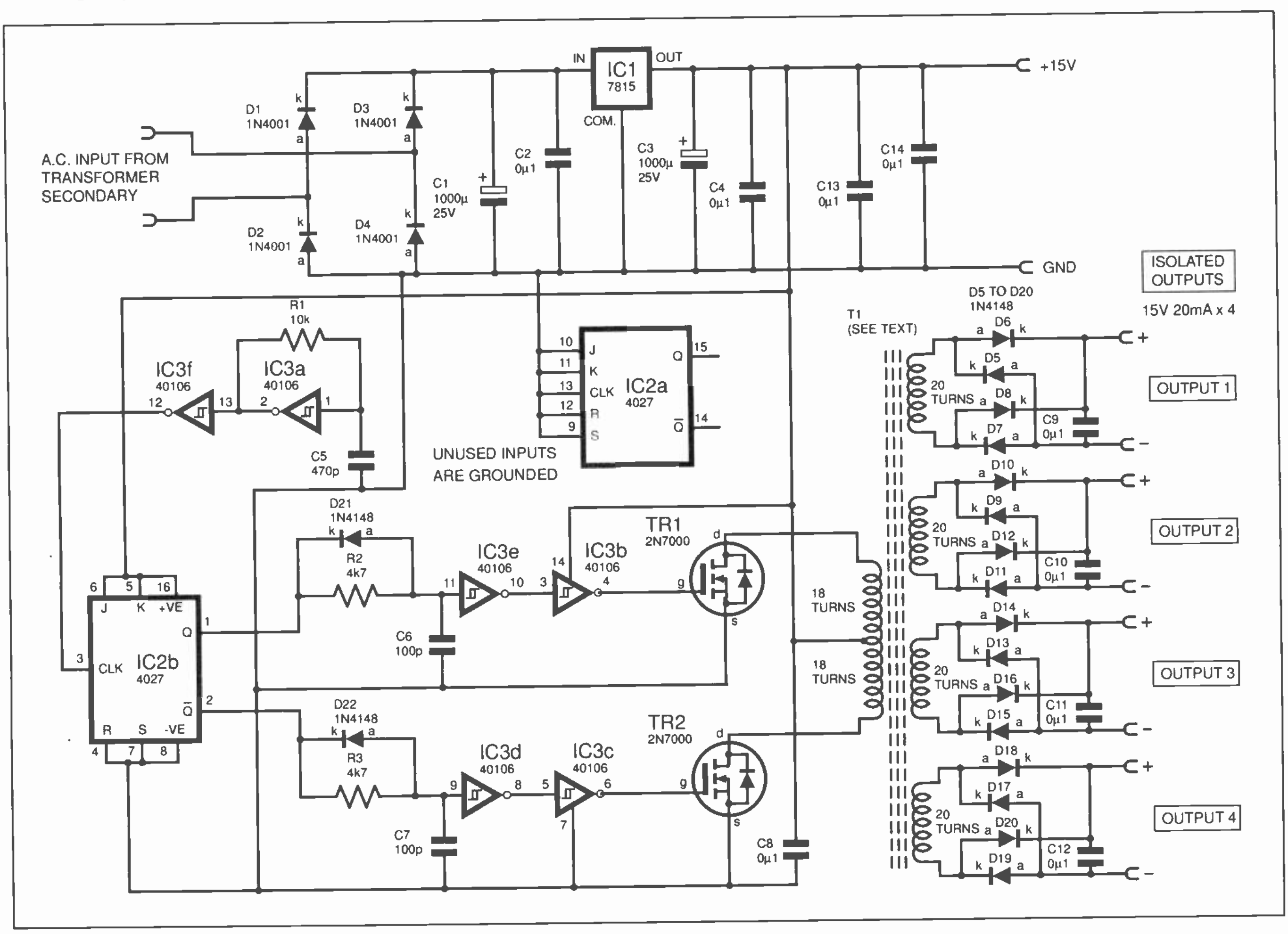


Fig.1. Circuit diagram for the Isolated Multi-output Power Supply

Daisy-chaining Decoder Chips – A Thorny Problem

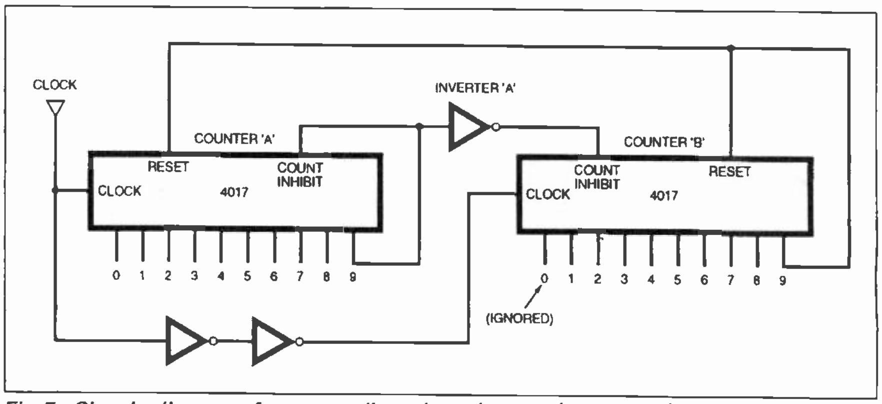


Fig.5. Circuit diagram for cascading decoders to improve the resolution of an artificial sine wave signal.

THE JOHNSON counter with fully decoded outputs can be a very useful device indeed. However, as far as I can discover, the only readily available CMOS chips are the CD4022, with eight fully decoded outputs, and the CD4017, with ten.

A recent project involved the generation of three-phase signals using digital techniques, based upon the synthesis of sinewaves as a series of voltage levels. This was accomplished using a Johnson counter with a set of "weighted" resistors to create an artificial sine wave. To improve the resolution of the sinewave, I wanted to "daisy chain" several counters and after much consideration arrived at the circuit of Fig. 5.

If we consider the state after reset, both counters will have a logic high on their 0 output. Since the 9 output of counter "A" will be low and this is wired to its Count Inhibit pin, counter "A" is enabled, and the inverter "A" causes counter "B" to be disabled.

As the clock cycles, a logic High ripples along the outputs of counter "A" until it reaches 9. At this point, several things happen very rapidly! Counter "A" is disabled, and conversely counter "B" is enabled via the inverter "A". The clock pulse, which is very slightly delayed by the two inverters in series, clocks the high from the 0 output to the 1 output in counter "B".

Subsequent clock pulses ripple the logic-high along counter "B" until it reaches the 9 output, when the system will reset and we are back to 0. Consequently a fully-decoded ring counter with up to 17 outputs (nine in counter "A", eight in counter "B") is produced. The system could be extended further if necessary.

Ted Whittaker,
Stone,
Staffordshire.

• See also *Circuit Surgery*, November 1997 in which Ian Bell of the University of Hull discusses further techniques for cascading digital counters. A.R.W.

Neon Torch – Electronic Gas Light

AN electronic version of a torch which uses a neon gas-filled bulb instead of a filament bulb, is shown in Fig. 6. It is based on a 555 running in astable mode. T1 is a 3V-0V-3V transformer wired in reverse "step up" mode which is used to step up pulses delivered by the timer.

A small neon indicator (LP1), of a type called a "green fluorescent glow lamp" (an ordinary neon indicator will give poor results) is used for the bulb.

The neon bulb also has a much longer life expectancy than a traditional filament bulb.

The frequency of operation is determined by the resistor-capacitor network R1-R4/C1, and this is adjusted using a d.p.d.t. switch (S1) to offer "bright" and "economy" settings. Although not as bright as a conventional torch, the Neon Torch can easily light the way three or four metres in front.

Whereas an ordinary krypton torch consumes some 3W of electricity, this novel design uses 0·7W in "bright" modes and 0·3W in "economy" setting – one tenth that of an ordinary torch. Powered by six AA size alkaline cells in bright mode, the torch will shine for two days and two nights continuously. For best results, the neon bulb should be set into a reflector salvaged from a torch.

Rev. Thomas A. Scarborough,
Fresnaye, Cape Town,
South Africa.

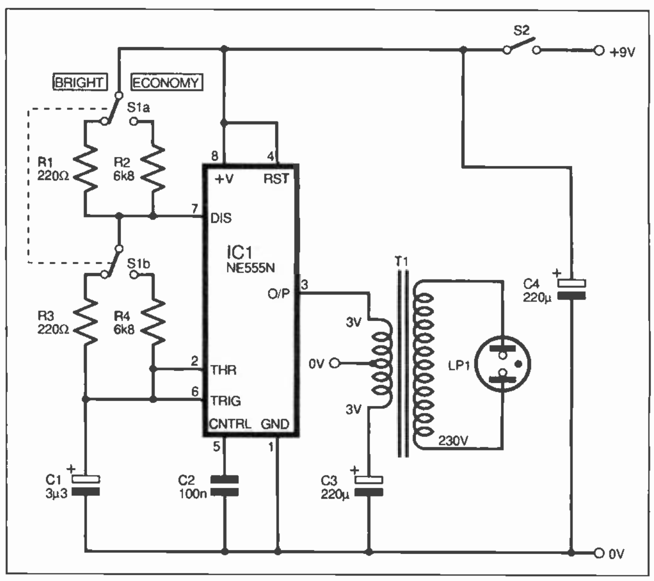
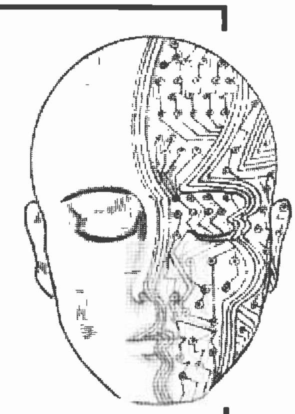


Fig.6. Circuit diagram for a Neon Torch.



READOUT

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

ALCHEMY?

Dear EPE,

To answer JB's question about conflicting evidence concerning water descalers (*Readout* Dec. '97), the reason my father had his descaler removed was because it was sold as an "electric water softener" and if it did anything it certainly didn't soften the water!

Some manufacturers make vague claims which seem to imply a softening effect which overlooks the fact that the terms *hard* and *soft* water have a specific meaning chemically, and unless calcium and magnesium ions are removed from hard water, or exchanged for sodium ions, then the water will remain hard.

I'm not prepared to believe that a descaler does this unless the alchemists were on the right track after all but looking for the wrong product! However, I have found that scale around my kitchen sink is reduced and cleans off more easily, so while I accept that the scale seems to be less "sticky" I cannot accept that the water is softened in any way.

As regards research, yes I do spend quite a bit of time researching my various interests. In the case of electronics, I have a 2-drawer filing cabinet full of notes, cuttings, data sheets etc., as well as a decent collection of technical books including even my old A Level text books.

I thoroughly recommend keeping notes on everything one tries even if it was unsuccessful. I also study every circuit in *EPE* and make note of any sub-circuit that strikes me as ingenious, even if the whole project is of no interest to me.

JB's request for info on a Kirlian camera rang a bell and a hunt through my cuttings turned up a design published in *Elektor* (Oct '77). The article gives reference to an item by Pehek, Kyler and Faust entitled *Image Modulation in Corona Discharge Photography* published in *Science*, Oct. '76, page 263. Photography is another interest of mine, by the way; strange how it often seems to go with an interest in electronics.

Best of luck JB, I'll be interested to see what design you come up with, but don't ask me to believe it will produce a photograph of something's "psychic aura"!

Barry J. Taylor,
Rickmansworth,
Herts

What a useful contributor you are! Thanks for all the info – sorry we have to cut your letters down, but do keep communicating.

I would also refer readers to Don Phillips' Kirlian Camera *of* PE *(not* EPE*) May '89 (if their local reference library has a copy on file). I liaised with Don in the publishing of that article while I was on* PE*, before* PE *and* EE *combined to become* EPE.

My hope is to try to achieve the same effect using modern tech-nology and "daylight" processing photographic materials (photography has featured greatly in my life too – but that's another story!).

Any more info on Kirlian Cameras and Water Descalers will be appreciated.

PIC-ING PIPES

Dear EPE,

I would wish to attempt the *PIC Water Descaler* (Oct. '97), but the article appears to assume that *all* water pipes are of copper. My inlet (the house was built in 1938) is lead. There is, of course, a "normal" internal stop-cock and I suppose the windings could be wound around this, but not in one run. I assume that lead is an insulative material and the diameter is a lot more than 15mm.

G. Wilsher,
Hanwell,
London W7 2AP

We do not believe that the descaler will work correctly if wound around a stop-cock. If the pipe after the stop-cock is copper or plastic, then wind it onto that.

If you have no copper or plastic pipes, but only steal or lead (which we understood had all been replaced because of the health hazard – contact your local Water Board with urgency about yours!) then you will not be able to use the descaler.

We are not clear why you think lead insulative – certainly it is resistant to penetration by radioactivity, but to electricity it is highly conductive.

★ LETTER OF THE MONTH ★

PSEUDO SCIENCE

Dear EPE,

I was somewhat disappointed with your reply to Mr Taylor (*Readout* Dec. '97) and would take issue with you as to how you should present such pseudo science, if that it is.

When people buy a magazine such as yours, they learn to rely upon the information that you give. For example, if you recommend a transistor to carry a certain current then it is accepted because you have the relevant technical knowledge and you know that the recommended transistor has certain operating characteristics within limits. You also know that those operating characteristics will be near enough the same if they are measured in a blue agate pyramid or whist chanting an esoteric mantra. This reproducibility is surely the basis of Scientific Method.

Because your readers expect such objectivity from your magazine, by virtue of the act of publishing anything, you appear to give your imprimatur to the scientific basis of that subject; I must admit that I assumed that "water descalers" were more scientifically based after seeing the project in the Oct. '97 issue.

I think, therefore, that if there are such doubts about such projects these should be clearly stated. Just because something is for sale does not give it any more credibility; I trust that you do not drive around with a strap hanging from the rear bumper of your car to prevent car sickness!

Martin Chandler M.Sc,
Ashford,
Kent

In principle we agree with what you say, although it is a subject that is worthy of a good debate. Suffice to say for the moment that we tried to find out more about electronic water descaling, including through one university, but we have been unable to find out more.

METEORS

Dear EPE,

In his *Satellite Celebration* article in the November '97 issue, Barry Fox refers to meteors as "the scraps of dust and rock which travel through space at high speed and eventually fall to earth as shooting stars".

I would like to highlight a popular misconception regarding the nature of a meteor.

Barry Fox should, in fact, be referring to *meteoroids* which only become *meteors* when they enter our atmosphere at a height of approximately 60 miles and are seen as flashes of light. A meteoroid which survives its path through the Earth's atmosphere and actually reaches the ground is then referred to as a *meteorite*.

A satellite at risk from meteor damage would therefore need to be in a rather low orbit!

Martin R. Sturgess,
via the Net

Which, of course, we all ought to have known from the days when we had Patrick Moore's Space Watch *column in* PE!

CHEERS TO THE BEEB

Dear EPE,

I actually cheered when I saw the letter from I. Scott-Young in the December '97 issue. No, he is not the only one with a BBC "B"! I am also enduring the same frustration regarding programming PIC devices.

I do fully understand the impracticalities as explained by JB in his reply. However, I am sure that I speak for many when I say that, we "vintage" computer types are NOT asking for listings for our individual "ancient" machines. Most of us enjoy the challenge of writing our own programs which we can tailor to our particular need.

To do this, all we really need to know are the input requirements for the PIC device, i.e. the sequence, timing and clocking in of the data program. (Mr Scott-Young is ahead of me there!) Also, in the case of a published project, a listing of the PIC's actual program. This wouldn't be all that lengthy, would it?

Fear not, we'll get the program in there if you'll just tell us what the darn thing is supposed to contain!

Excellent mag none-the-less! I am looking forward to the *PIC Tutorial*, hoping and praying that it will provide some information which we enthusiasts with "steam driven" computers can use.

Raymond Ridgwell,
Torrington, Devon

Editor Mike Kenward offers his comments on the non-PC problem in his Editorial this month. In may ways, I've already offered my thoughts in my reply to I. Scott-Young.

I have to re-iterate, though, that we cannot publish PIC software on the magazine pages – it IS too long. My Time Machine *source listing is 1216 lines long and up to 70 characters wide. Its object code (binary) is not printable without conversion to hex in an ASCII character format, then it would be 86 lines by 59 characters – still too long.*

Don't you, and others who are in a similar predicament, know someone who has access to a PC who can do printouts or conversions for you? It's also not hard to interface a PC to a BEEB via the PC's parallel or serial ports and the BEEB's User Port. I did it between an Amstrad 1640 and a PET 32K (very similar in command architecture to the BEEB) some year's back. Although I wrote machine code for both machines in order to do it (8086 and 6502), that was only for speed; Basic will do it just as accurately, if at a slower rate.

Come on folks, you're obviously into computing – surely you and a friend or colleague can come up with a solution that uses our disks!

PSEUDO-CODE

Dear EPE,

As someone who at the moment is in the programming camp, but who wishes to learn more about electronics, I have started buying *EPE*. I note in your December issue a letter (*How QBasic?*) which makes the statement that Microsoft and QuickBASIC introduced the idea of pseudo-code as a stepping stone between the source code and machine code.

As far as I am aware, this was first used by Nick Wirth when he designed PASCAL in the early 1970s, using P-code. If it had been an MS invention, then we wouldn't have heard the last of it!

As a point of interest, this idea of an interim code has made a comeback in recent years in the shape of Java, the current flavour of the programming month, as it allows a 2-stage translation process. The first stage is from source to P-code. This is the same for all processors. The P-code is then used as the input for a translator unique to each processor.

In this way, one initial program can be run on any type of computer for which the second stage, called a Java Virtual Machine, has been written. Perhaps one day PICs will have a JVM of their own!

I hope this is of interest – have fun, it's not worth it otherwise!

Bob Wightman,
via the Net

It is of interest, and we do have fun! You might be interested to know that TASM, which we supply as our PIC16C84 compiler, is capable of compiling code to suit many processors other than the PIC. It is also possible to write your own translation table for use with processors of your own choice – as Derren Crome did for the PIC16C84.

TIMELY TICKINGS AND PIC-INGS

Dear EPE,

I have just recently completed the construction of the *EPE Time Machine* clock featured in the November issue. The preprogrammed PIC chip was purchased from Magenta.

However, I was surprised to discover that the time displayed after the Rugby time signal had been correctly decoded is one second fast. It appears that the seconds counter is being reset on second number 59, i.e. at the end of the frame code sync pulse.

I should add that I have built two different types of Rugby clock which work perfectly to the exact second.

J.M. Baldwin, Bradford, Yorks,
via the Net

Absolutely right and my error (of +800ms, not +1s)! In an early prototype of the software, I had another flag which was set on receipt of the Rugby sync pulse. On detection of this flag, one second later, the Rugby decoding process was then entered, and the time updated correctly.

In the complex process of compacting the code in order to make room for the Millennium countdown, I was desperately in need of more dedicated registers than I had available. Somehow I made a fundamental mistake when recoding to do without that flag register, entering the decoding routine on receipt of the sync code, rather than on the second following it.

I have corrected the error, using the sync register itself as the flag, and putting the decoding routine call prior to updating the shift register chain. As confirmed by the "time sponsored by Accurist" via BT's 123 code, the pips and the seconds now correspond within about −200ms!

It should be pointed out that the updating can never occur immediately on the leading edge of "second zero" due to the sequential nature of the program commands that cause the updating. Pure electronic circuitry could achieve such synchronisation, but software (even if triggered by an external interrupt generated by the occurrence of the Rugby pulse) automatically introduces a delay before the update actually occurs.

In theory, the period could be shortened by decoding prior to the receipt of the trigger signal, but this would require additional temporary storage registers to hold the decoded data prior to putting it onto the l.c.d. screen. Such additional registers were not available, nor was there enough program data space available to use the technique anyway.

The decoding actually commences at the end of the first pulse of "second zero", i.e. 200ms after the pulse begins, the updating is then complete well within then next 1/50th of a second.

If any reader who has bought the* Time Machine's *pre-programmed PIC16C84 from Magenta would care to send it to me at the editorial address I will be pleased to re-program it with the new software. Similarly, I will update anyone's* EPE PIC-Disk *if they return it to me. The amended software is also on our website. Please send an adequately stamped and self-addressed package for me to return the PIC or disk to you. Also note that for security reasons the disk or PIC must be the same one you received from us or Magenta.

Interestingly, the programming for the Time Machine *might have been simplified had the new PIC16F84 been available at the time. In many ways the PIC16F84 is totally interchangeable with the PIC16C84. It does, though, have 68 RAM data bytes (compared to the C84's 36), which is a significant advantage.*

Microchip describe the F84 as having a "flash" program memory instead of conventional E^2prom memory. They are coy, though, with information about what flash actually means in this context. It does not mean that the F84 can be programmed faster than the C84, nor does it run at a faster speed (still 10MHz max.); the program memory capacity remains at 1KB.

There are false rumours circulating that the C84 is to be dropped in favour of the F84. We are assured by Microchip that they have no intention of dropping it. They say that while they will encourage the use of the F84, the C84 will continue to be available. Microchip also commented that they never delete products from their range.

It is likely that I, as a designer/author, will probably move over to the F84 when the greater number of registers are needed. This may mean in future that programs written for the F84 may not be usable on the C84. But, anything written for the C84 will always run on the F84.

A further advantage of the F84, as said by Microchip, is that its price is likely to become lower than that of the C84. As to whether component suppliers will pass on any price advantage to customers remains to be seen. Do encourage your supplier to stock the F84 and to offer a good price on it.

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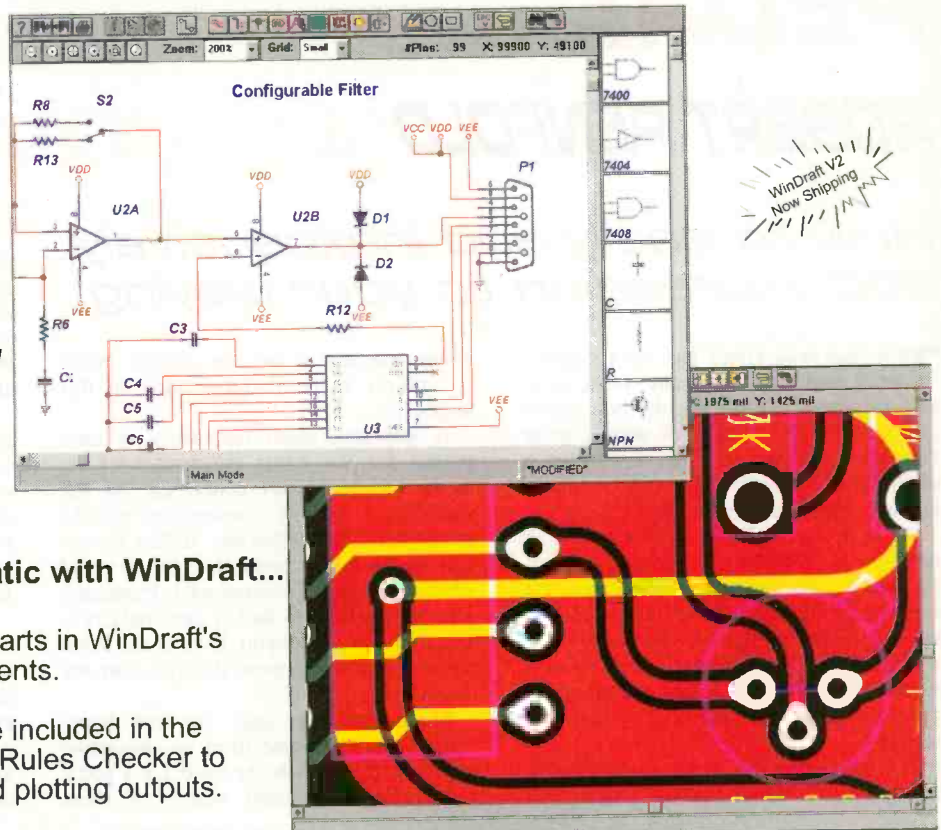

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Constructional Project

WAA-WAA EFFECTS PEDAL

ROBERT PENFOLD

How to easily and inexpensively add expression to your playing.

THE waa-waa effect has been popular with guitarists 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. As the pedal is operated, 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.

A waa-waa pedal represents an easy project for the home constructor as far as the electronics are concerned, but the mechanical side of construction can be problematic. The difficulty is that the effect is normally controlled by a pedal which operates a potentiometer. Producing a pedal mechanism that is genuinely reliable and will not let you down at the worst possible moment is more difficult than one might expect.

Most waa-waa units for the home constructor use some form of alternative approach that avoids the need for a pedal mechanism. The most simple of these alternatives is to use a low frequency oscillator to automatically operate the effect at a preset rate, but this gives rather "mechanical" results with no real opportunity for the player to add expression to the music.

The other alternative, and the one used here, is to have the effect controlled via a pushbutton switch. The switch is foot operated, and acts as a sort of pseudo foot-pedal. Operating the switch results in the effect being swept upwards in frequency, and releasing the switch results in the effect being swept back down again.

This is not quite as versatile as using a conventional foot-pedal mechanism, since the pushbutton switch does not give any control over the rate at which the effect is swept up and down.

However, these rates are individually adjustable via front panel controls and can be set at appropriate rates prior to

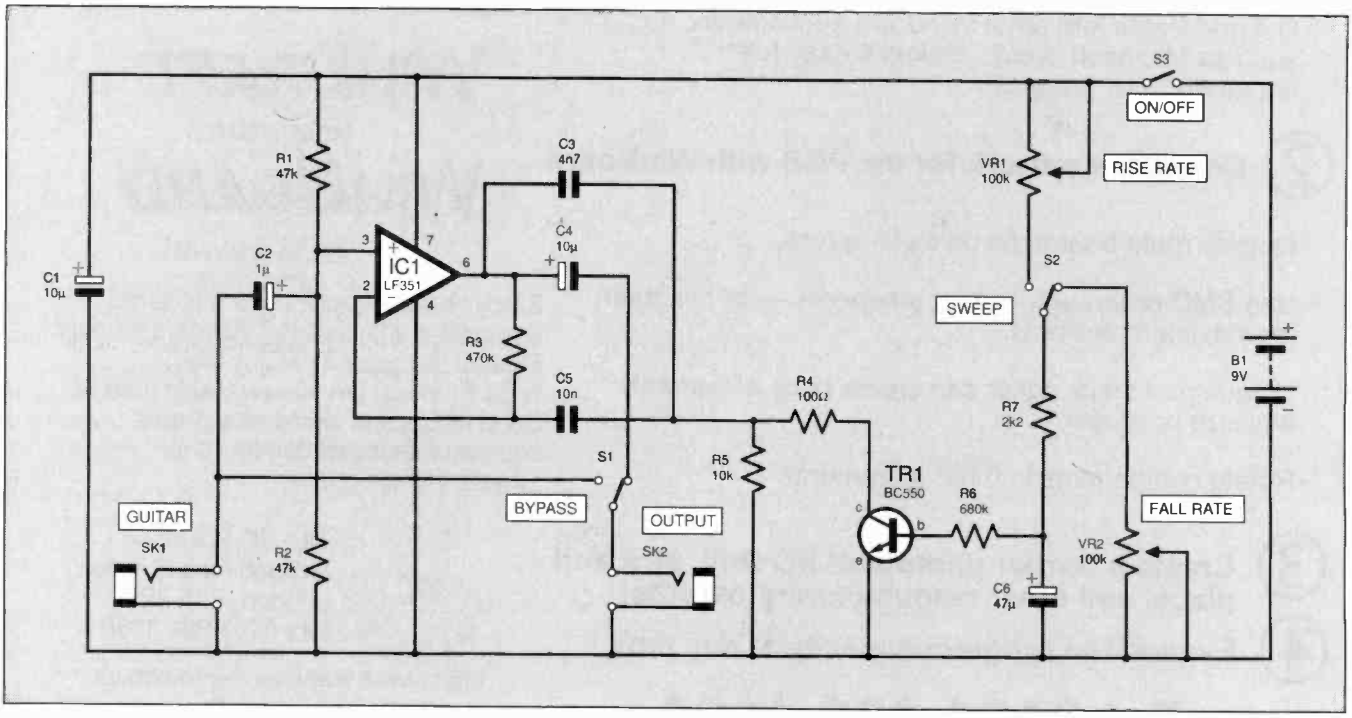


Fig. 1. Complete circuit diagram for the Wah-Wah Effects Pedal.

commencing a piece. This gives the player much better control of the effect than simple automatic control, and does enable the effect to be used in an expressive fashion.

CIRCUIT OPERATION

The circuit diagram for the Waa-Waa Effects Pedal is shown in Fig.1. IC1 is an operational amplifier which is used in the non-inverting mode, with input biasing provided by resistors R1 and R2. These set the input impedance at 11 kilohms.

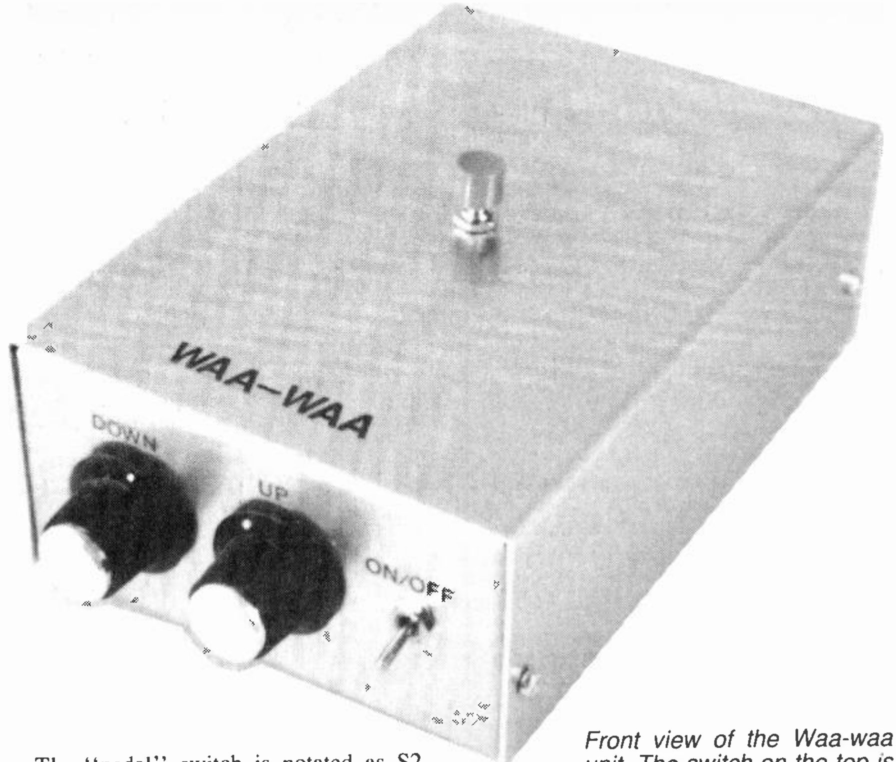
The negative feedback circuit includes a simple *R-C* (resistor-capacitor) network that provides frequency selective feedback, and produces a bandpass filter action. The configuration used is almost the standard op.amp bandpass filter circuit, with the frequency selective negative feedback provided by capacitors C3, C5 and resistor R3, together with the series resistance of R4 and R5.

These components set the centre frequency of the circuit at a middle audio range, but in this application we need the filter frequency to be variable over middle to high audio frequencies.

It is possible to tune the filter by adding a variable resistance in parallel with resistor R5. This is the purpose of transistor TR1, which acts as a sort of crude voltage controlled resistor. The resistance across TR1's collector (c) and emitter (e) terminals depends on its base (b) input current, with higher currents giving reduced collector to emitter resistance.

Resistor R6 effectively converts TR1 from current to voltage operation, and also provides a boost in input resistance. There is a slight drawback in using an ordinary bipolar transistor as a voltage controlled resistor, which is simply that it does not provide pure resistance.

Changes in the signal voltage result in variations in the effective resistance provided by TR1, which in turn produce distortion on the output signal. Hi-fi performance is not really essential in this application, but the distortion will be reasonably low provided the circuit is not fed with an excessive input level.

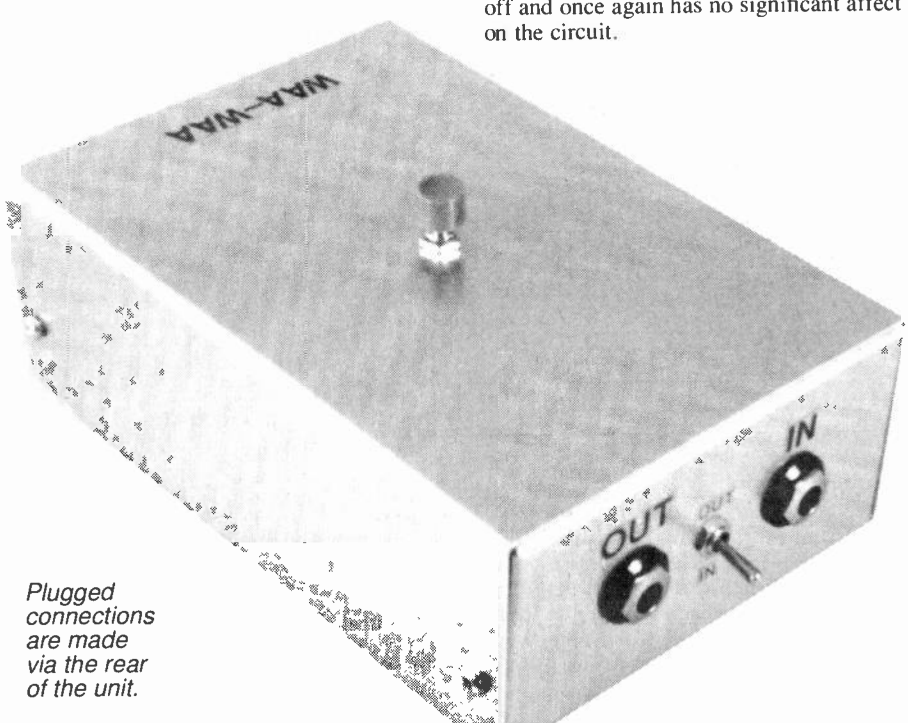


Front view of the Waa-waa unit. The switch on the top is the sweep control, S2.

The "pedal" switch is notated as S2, and it is biased to the position shown in Fig.1. Under standby conditions, no current flows into the base of TR1, and the resistance provided by TR1 is, therefore, so high that it has no significant affect on the circuit.

Operating S2 results in capacitor C6 starting to charge via potentiometer VR1 and resistor R7. As the charge potential on C6 rises TR1 receives an increasing base bias current. This results in its collector to emitter resistance steadily reducing, and the centre frequency of the filter being swept upwards.

This continues until the charge voltage on C6 reaches almost the full supply potential, but the filter frequency then remains constant until S2 is released. C6 then starts to discharge via R7 and VR2, causing the resistance provided by TR1 to increase and the centre frequency of the filter to decrease. This action continues until the charge on C6 drops below about 0·7 volts, at which point TR1 becomes cut off and once again has no significant affect on the circuit.



Plugged connections are made via the rear of the unit.

The required action is therefore obtained, with the filter frequency being swept upwards when S2 is operated, and swept back down again when it is released. VR1 controls the rate at which the filter frequency rises, and VR2 controls the rate at which the filter frequency falls. In both cases the rate of change is very rapid at minimum resistance, but takes several seconds for a full sweep at maximum resistance.

This type of voltage controlled bandpass filter is very simple, but it is slightly flawed in that the *Q* (quality) value of the filter rises as the operating frequency is increased. This results in a narrower response and higher maximum gain at high frequencies, and a broader response with lower maximum gain at low operating frequencies.

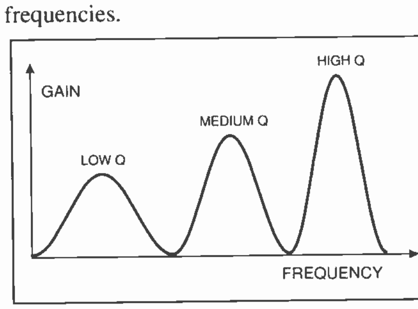


Fig.2. Filtered frequency response.

In Fig.2 is shown the general way in which the response changes as the filter frequency is altered. In practice, this does not seem to have a detrimental affect on results, and the effect obtained is perfectly acceptable. In fact, it is probably better to have things this way, as it avoids having a high level of boost on the fundamental signal, which could easily cause overloading.

Switch S1 enables the circuit to be bypassed when the waa-waa effect is not required.

The circuit is powered from a small 9V battery, and this should have a very long operating life as the current consumption of the circuit is typically just under two milliamps.

COMPONENTS

Resistors

R1, R2	47k (2 off)
R3	470k
R4	100Ω
R5	10k
R6	680k
R7	2k2

All 0.25W 5% carbon film

See SHOP TALK Page

Potentiometers

VR1, VR2	100k rotary carbon lin. (2 off)

Capacitors

C1, C4	10μ radial elect. 25V (2 off)
C2	1μ radial elect. 50V
C3	4n7 mylar
C5	10n mylar
C6	47μ radial elect. 16V

Semiconductors

TR1	BC550 *npn* transistor
IC1	LF351N bifet op.amp

Miscellaneous

S1	s.p.d.t. min. toggle switch (see text)
S2	s.p.d.t. pushbutton switch (see text)
S3	s.p.s.t. min. toggle switch
SK1, SK2	standard mono jack socket (2 off)
B1	9V battery (PP3 size)

Printed circuit board, available from the *EPE PCB Service*, code 932; metal case (see text); control knob (2 off); battery connector; 8-pin d.i.l. socket; wire; solder; nuts and bolts, etc.

Approx Cost Guidance Only £20 excluding batteries

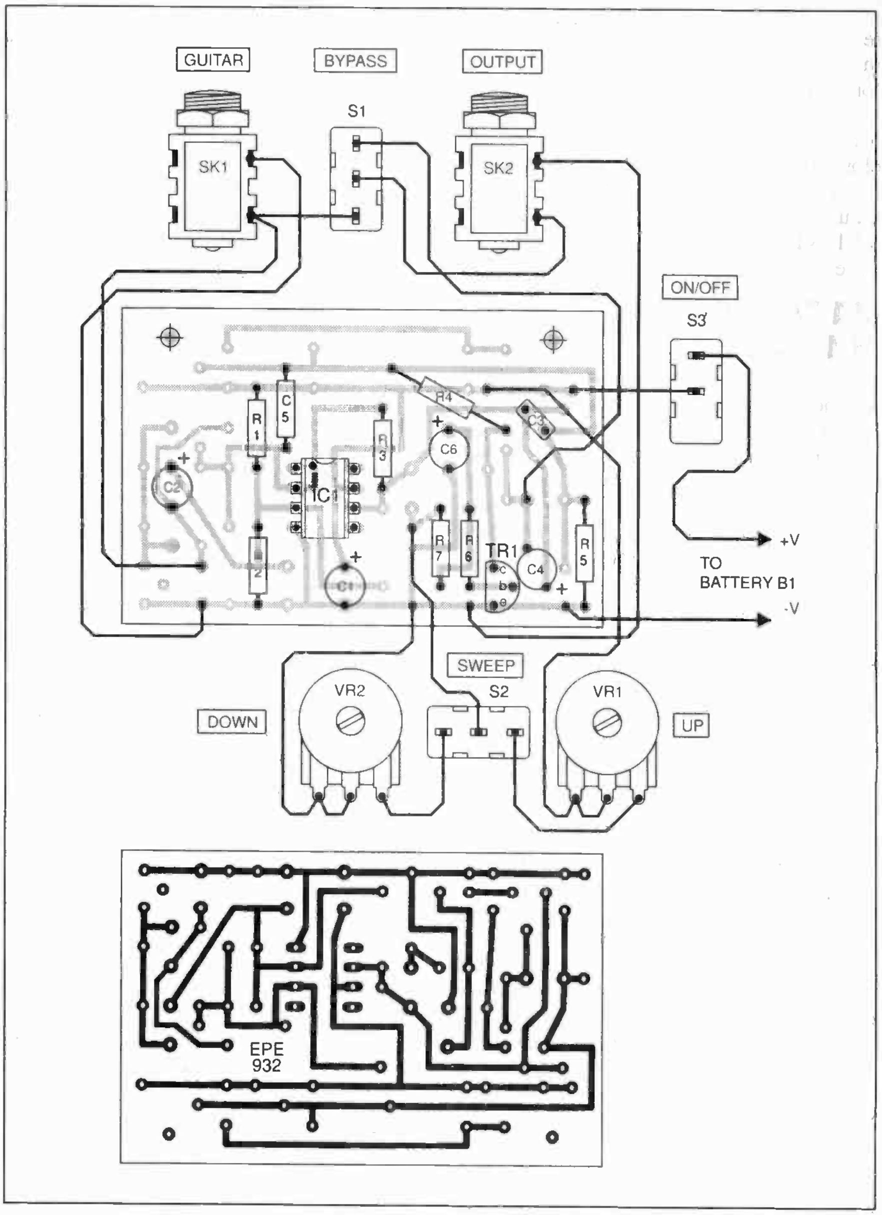
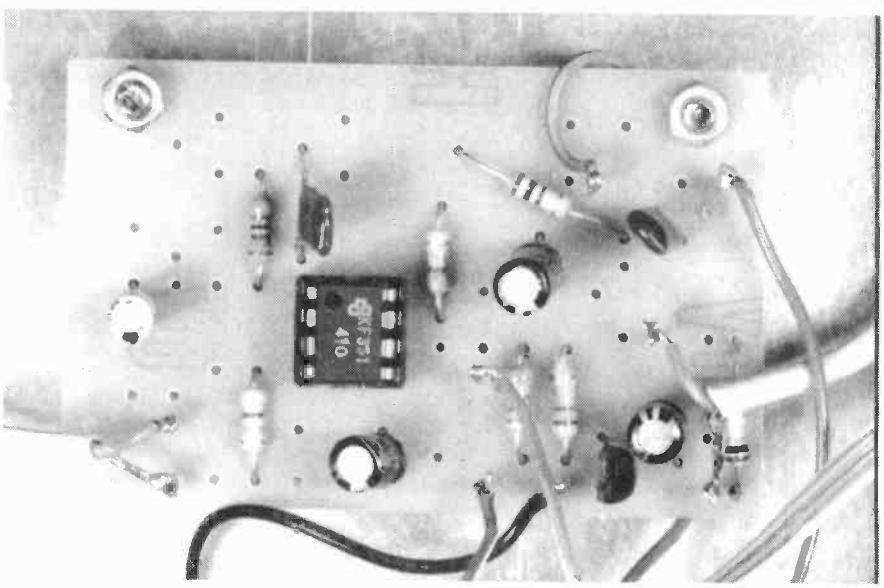


Fig.3. Printed circuit board component layout and full size underside copper foil track master pattern for the Waa-Waa Effects Pedal.



CONSTRUCTION

The Waa-Waa Effects Pedal is built using the *EPE* multi-project printed circuit board. This board is available from the *EPE PCB Service*, code 932.

Construction of this board is mainly straightforward, but the usual warning has to be given. This is not a custom printed circuit board in the conventional sense, and many of the holes in the board are left unused. Consequently, it is relatively easy to get a component fitted in the wrong place and extra care, therefore, has to be exercised when fitting the components.

The board's component overlay, master track pattern and hard wiring details are shown in Fig.3.

IC1 is not a static sensitive device, but it is a good idea to use a holder for any d.i.l. integrated circuit. Be careful to fit IC1 and the electrolytic capacitors with the correct orientation. From the electrical point of view, C3 and C5 can be any form of plastic foil capacitor, but mylar capacitors are the easiest type to fit into this layout.

Fit single-sided solder pins to the board at the points where connections will be made to the controls and sockets. "Tin" the tops of the pins with plenty of solder, but do not make any connections to them at this stage.

As this project will be controlled by foot, it is clearly essential for it to be housed in a tough case that will not crush or crack easily. It is also a good idea to use a metal case as this will provide the circuit with good screening from mains "hum" and other electrical noise.

A diecast aluminium box is ideal, but might prove to be rather expensive. A case of folded aluminium construction is just about strong enough, and represents a good low-cost alternative. It is possible to fit everything into quite a small case, but the use of a medium size box is recommended as this will be more stable in use. It also provides more panel space for the controls and sockets.

The exact layout used is not critical, but it is advisable to have switch S1 mounted close to the input and output sockets. On the prototype, S1 and the sockets are mounted on one end panel, with controls VR1, VR2 and S3 fitted on the other end panel.

JACKS AND SWITCHES

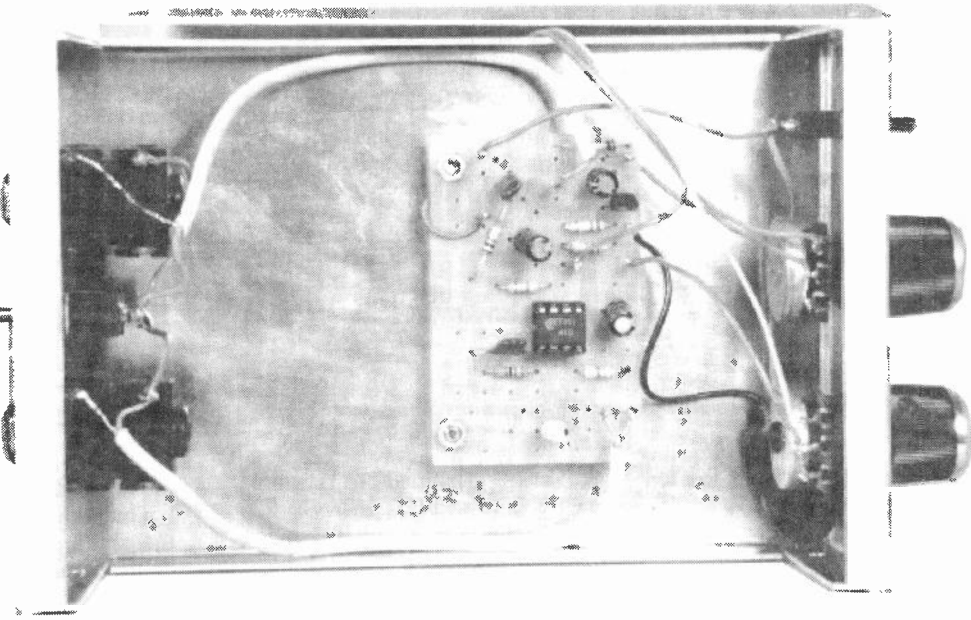
In Fig.3, the input and output sockets are shown as insulated jacks, which are the type favoured by many guitarists. These are often fitted with switch contacts, and then have two extra tags which are left unused in this application. Open style jack sockets can of course be used if preferred.

Switch S2 is a pushbutton type that must be mounted on the top panel of the case so that it can be operated by foot. It has single-pole changeover contacts, and it must be of the non-locking variety. Ideally, S2 would be a heavy duty switch, but a suitable component seems to be unobtainable. An ordinary type should be adequate provided it is of good quality.

Switch S1 could also be a pushbutton type mounted on the top panel of the case so that it can be operated by foot. This enables the effect to be totally eliminated while playing the guitar. Totally switching out the effect is not essential though, as the unit has little effect if the filter is left at its minimum frequency and is not swept.

The printed circuit board is mounted on the base panel of the case using either plastic stand-offs or metric M3 bolts. If you use mounting bolts it is essential to include spacers about 6mm or more in length to hold the connections on the underside of the circuit board well clear of the metal case.

It is not essential to use screened leads for any of the connections, but try to keep



the wiring reasonably short and direct. The wires to S2 must be quite long as this switch is mounted on the removable lid of the case, but long wires here should not compromise performance.

TESTING AND USE

Standard screened jack leads are used to connect the guitar to SK1, and SK2 to the input of the guitar amplifier. With the unit switched on, the signal should be coupled straight through to the amplifier with S1 set to the bypass position.

With S1 switched to the other position, the waa-waa effect should be obtained when S2 is operated. If the filter is swept downwards when S2 is pressed, and upwards when it is released, reverse the connections to the outer two tags of S2.

It is worth experimenting with the settings of VR1 and VR2 to obtain the control characteristic that you like best. Remember that you do not have to use the same settings all the time and that, if necessary, different settings can be used for each piece that you play.

If you intend to use many different settings it might be worthwhile using control knobs having "0" to "9" calibrated skirts. These make it easy to note down each pair of settings, and quickly dial them up when they are required again.

As pointed out previously, the circuit will only provide low distortion if it is used with a fairly low input level. When using the unit with a high output guitar pick-up it will almost certainly be necessary to back-off the volume control on the guitar, and advance the volume control on the guitar amplifier. Otherwise quite severe distortion may occur at some filter frequencies.

With low and medium output pick-ups there should be no problems with distortion, even if the guitar is set for maximum volume. □

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 Four: BINARY NUMBERS AND DIGITAL LOGIC SYSTEMS. GATES AND PROCESSING CIRCUITS. LOGIC IN THE REAL WORLD.

MANY people are aware that computers "work with 1s and 0s", but what does this mean, and why is it done this way?

The key points to understand here are the concepts of ***binary*** numbers, ***Boolean logic*** and the reasons for implementing computers and other circuits using these concepts. We introduce these ideas in this part of *Teach-In* and return to them at various points in the course.

Binary Numbers

Human beings, when working with numbers, usually use 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9 – that is, ten possible values each with their own "symbol". If we want to count larger numbers we use a "tens" column (so 23 is 2 10s and 3 units), and so on.

Mathematically, the system we are all so familiar with is called *decimal*, or "base-10". We probably use this base because we have a total of ten fingers and thumbs! A clever octopus, if one could count, would probably count up to eight in *octal*, or base-8, starting with 0 and carrying over to the next column (8s) when it reached 7.

However, numbers can be manipulated in any base, from 2 upwards. Base-2 (or **binary**) is used by digital computers (and other digital circuits) – only two symbols are used: 0 and 1. If we want to count above 1 in binary we need a 2s column (so 11 in binary is 1 two plus 1, or 3 in decimal).

Just as the digits in a decimal number represent powers of 10 (10 multiplied by itself a certain number of times: 10s, 100s (10×10), 1000s (10×10×10), and so on, the digits in a binary number represent powers of 2: 2s, 4s (2×2), 8s (2×2×2), and so on. Thus the binary number 1001011 is 75 in decimal. See Fig. 4.1.

64	32	16	8	4	2	1
1	0	0	1	0	1	1

64 + 8 + 2 + 1
= 75 IN DECIMAL

Fig.4.1. The binary 1001011 is 75 in decimal.

OK, so we can represent numbers using 1s and 0s, but what about other types of data? The answer is relatively straightforward, all we have to do is *code* the data using numbers.

If you are a computer user, the most obvious example is text, where for example, the well-known ASCII *(American Standard Code for Information Interchange)* code uses binary numbers from 0 to 127 (decimal) (0000000 to 1111111 binary) to represent upper and lower case letter, numerals, punctuation symbols and other information relating to typing text into a computer. In general, coding data into 1s and 0s in an efficient and useful way may be difficult, but the basic principle remains.

So far we have been concerned with *data* – numbers, text etc., but digital circuits and computers also deal with decision making and *control* of actions or operations. We also do this in 1s and 0s which are implemented in exactly the same as the data 1s and 0s – only their use and interpretation is different.

Boolean Logic

The 1s and 0s being used to form binary numbers also naturally represent basic two-way decision-making concepts such as *yes/no, true/false, on/off*, and *high/low*. The mathematical study of the processes of inference and reasoning is referred to as **logic** and a significant branch of this field concerns the processing of true/false values.

To get a better feel for this, imagine that I am going to go for a walk. If it rains, then I will get wet unless I use an umbrella. We could represent this using symbols for the state of being wet, rain, and not using an umbrella, so that the statement "if it is raining and I am not using an umbrella, I will get wet" would be written as shown in Fig. 4.2.

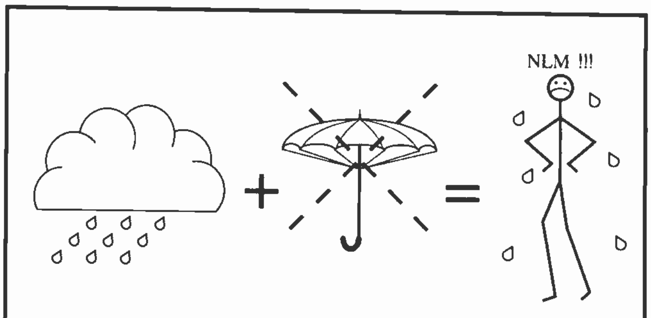


Fig.4.2. Symbolic representation of a simple logic statement – if it is raining, and I don't have an umbrella, I will get wet!

These symbols are fun and easy to understand, but they are not practical for serious use as not everyone is a good artist. Furthermore, some concepts we may wish to use are abstract and don't have an obvious picture.

So unfortunately we have to use letters instead of pictures. For example, I can use **W** (for "wet") which is *true* if I am wet and *false* if I am not wet, **U** (for "umbrella") which is *true* if I use my umbrella and *false* if I don't, and **R** (for "raining") which is *true* if it is raining and *false* if it is not raining.

Then I could write the statement "I will get wet if it is raining **and** I am **not** using an umbrella" using these symbols as:

W = R AND NOT U

Note that W, R and U are referred to as *variables* because they can take on more than one possible value (in this case either *true* or *false*).

Now to extend the example, if I am wet (i.e. if W = true) I will want to change my clothes. However, I will also want to change my clothes if they are dirty.

Thus, I can define two more variables: **C** for "changes clothes?", true or false (yes or no), and **D** to represent whether or not my clothes are dirty. Thus I can write the statement "I will change my clothes if they are dirty or wet" as:

C = D OR W

Just as we represent addition (or PLUS) with the symbol +, we can use symbols to represent the logic operations of AND, OR and NOT.

In "Boolean Algebra", **AND** and **OR** are usually written as • and + respectively (note the + symbol means OR, not AND, in logic), and **NOT** (inversion) is represented by a line above the variable: so "I am not wet" which is NOT W, can be written $\overline{W}$. Thus we can re-write our statements:

$W = R \bullet \overline{U}$
(wet = raining **AND** no umbrella)

$C = D + W$
(change clothes = dirty **OR** wet).

I can now combine these to give a single equation which tells me if I have to change my clothes:

$C = R \bullet \overline{U} + D$
(change clothes = raining **AND** no umbrella **OR** dirty).

Note that R, U and D can each be one of two possible values (true or false) so that there are actually a total of eight different possible combinations of all three. These can easily be listed as shown in Table 4.1.

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.

Table 4.1: Possible True or False Combinations

It is raining R	I am using an umbrella U	My clothes are dirty D	I need to change my clothes C
false	false	false	false
false	false	true	true
false	true	false	false
false	true	true	true
true	false	false	true
true	false	true	true
true	true	false	false
true	true	true	true

This is known as a ***Truth Table.*** Now if I represent *true* with a "1" and *false* with a "0" I can write the true table like this:

Table 4.2. True Truth Table

R	U	D	C
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

Notice that the R, U and D columns (4s, 2s and 1s respectively) of the truth table go through the binary numbers from 0 to decimal 7 in sequence. This illustrates the close link between binary numbers and logic. I may not want to build a circuit, or program a computer, to decide if I am to change my clothes but similar concepts can be used in more appropriate situations, for example: "switch valve 3 on if level detector is on or if temperature is high and valve 2 is off".

You may be thinking that the "change clothes" logic is not fool-proof as, for example, I may not need a change of clothes if the rain is very light or if I am wearing waterproofs. This is of course true, but we have to limit our example to something manageable.

There is also a more serious issue here which is fundamental to engineering *design*, that of understanding the problem, "modelling" (or describing) it, and specifying what we want to do to solve it. The logic will only do what we design it to do.

In our example we have "modelled" the rain as simply *on* or *off*, but we could be more detailed about the way we model it by adding a light/heavy variable (ignored if "rain" is false). Then we have an issue of specification: do we require a change of clothes for all rain, or just for heavy rain?

We could design either circuit. A design may go wrong (i.e. a product lets us down) if the problem was not properly understood and described, or if the specification had some flaw in it, or if the design did not meet the specification.

All these points must be kept in mind when designing circuits and software. Companies carrying out designs often go to great lengths to ensure that all these steps are carried out correctly, but we can all probably think of examples where they didn't quite manage it!

The branch of mathematics concerning logic based on true/ false values is called **Boolean Algebra** after its inventor, English Mathematician George Boole (1815-1864). It is of fundamental importance to digital logic circuits, computers and programming and we will return to it in more detail later.

Why Binary Circuits?

As to why binary is used in computers, it is simply that this is the easiest and most cost effective system to implement using electronic technology. Furthermore, the special mathematical properties of Boolean algebra provide a powerful means of expressing and solving decision-making problems.

Both binary numbers and Boolean logic are based on 1s and 0s, i.e. there are two possibilities for each symbol, bit of information or digit within a number. This is easy to handle in circuitry because switches can be either *on* or *off* and a voltage can easily be switched between a fixed value (e.g. +5V) and ground (0V) – see Part 3 of *Teach-In*, in which we described MOSFET transistors and inverters.

What would happen if we tried a different number base, say base-3? This has three values per digit i.e. 0, 1 and 2. We can no longer directly relate this to a switch being on or off because a switch does not have a natural third state.

We could, of course, use a set of fixed voltages to represent the numbers, for example 0V, +2·5V, and +5V for 0, 1 and 2, but it turns out that if we do this, then the circuits to handle logic and numbers are far harder to design and have poor performance in terms of power consumption, speed and susceptibility to electrical noise.

A possible advantage of base-3 is that we could represent *"maybe"* as well as "yes" and "no", and in fact such systems are used in specialist circumstances ("fuzzy logic" plus Artificial Intelligence), but in most cases the practical disadvantages of the circuits used outweigh the conceptual advantages. We can always use another digit in binary to indicate a "maybe" condition if we require this.

Circuits which "Do Logic"

Using **transistors**, we can build small circuits which perform the basic logic operations of AND, OR, and NOT. These circuits are called **gates** and their logic gate symbols together with their Truth Tables are shown in Fig. 4.3.

The NOT gate (inverter) was actually introduced in the previous part of *Teach-In*. We can connect different gates together to form more complex functions, using *Combinational Logic*.

For example, if we have three inputs indicating if we have dirty clothes (D), if it is raining (R), and if we are using an umbrella (U) we can build a logic circuit which indicates if we need to change clothes (C), see Fig. 4.4.

Note that the "internal" wires of the circuit can also be labelled, in this case with $\overline{U}$(no umbrella) and W (wet). Here the internal wires have some easily definable meaning to us, but this may not be the case in all logic circuits.

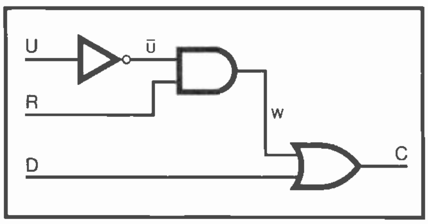


Fig.4.4. Circuit to decide if we should change our clothes using information on Dirt, Rainfall and Umbrella use.

Circuits which Process Data

We've seen the beginnings of how we can build circuits to make decisions, but how do we actually process data? For example how do we add two numbers together? Here's a simple "addition table" in decimal. (Adding a number from the top row to one in the side row gives the corresponding result.)

Table 4.3: Decimal Addition

+	0	1
0	0	1
1	1	2

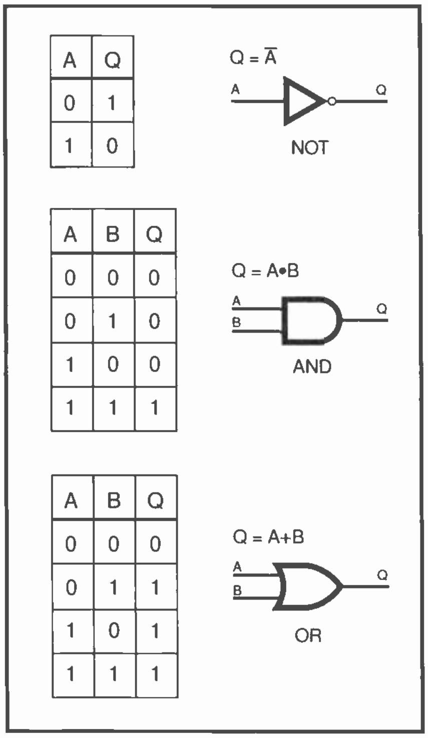
Now consider the same "addition table", this time written in binary.

Table 4.4: Binary Addition

+	0	1
0	00	01
1	01	10

Since we are adding together two one-digit binary numbers, we have a total of four possibilities. We can tabulate these as follows, one per line, rather than in the conventional "times table" format.

We have called the two numbers being added A_0 and B_0, where the 0 subscript indicates that they represent units (two to the power zero, or 2^0). The result (the sum) requires two binary digits to represent it, because its maximum value is 2 (10 in binary), so we've labelled these S_1 for the twos (2^1) and S_0 for the units.



A	Q
0	1
1	0

A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

Fig.4.3. Truth Tables and Boolean symbols for basic logic gates.

Numbers being added		Sum	
A_0	B_0	S_1	S_0
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

This looks like a Truth Table: in fact it is two Truth Tables – one for S0 and one for S1, which we can write separately as follows

A_0	B_0	S_1
0	0	0
0	1	0
1	0	0
1	1	1

A_0	B_0	S_0
0	0	0
0	1	1
1	0	1
1	1	0

You should be able to recognise A_0, B_0 andS_1 as being the AND truth table, so we can simply use a single AND gate to get S1. The logic function for S_0 is a little more difficult. We can see that S_0 is 1 (true) if A_0 is 0 AND B_0 is 1, OR if A_0 is 1 AND B_0 is 0. In Boolean algebra we write this as:

$$S_0 = \overline{A_0} \bullet B_0 + A_0 \bullet \overline{B_0}$$

It may help to recall that the overbar means "inversion". Hence, for example, if A_0 is 0 then $\overline{A_0}$ is 1. The table above can be used in comparison with the Truth Tables for AND and OR logic gates (earlier), to prove that the Boolean statement is correct.

Hopefully you can see from this that we need two AND gates, two NOT gates and one OR gate. You will see shortly that this can be simplified drastically by replacing them with another type of gate, the **Exclusive-OR**, or **XOR** gate.

Another word for a **binary digit** is **bit**. The full circuit of the "adder" is given in Fig. 4.5, which is a circuit that adds two "one-bit" binary numbers together (0 or 1), to give a "2-bit" binary result (from 00 to 11). Thus we see that we can use basic logic gates to build circuits which do *arithmetic* as well as make "logical" decisions – as with the "change of clothes" circuit. We will return to both types of function later in the course.

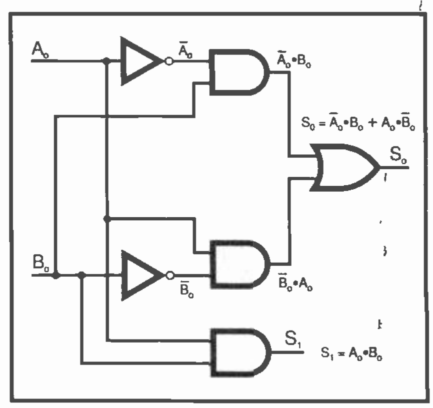
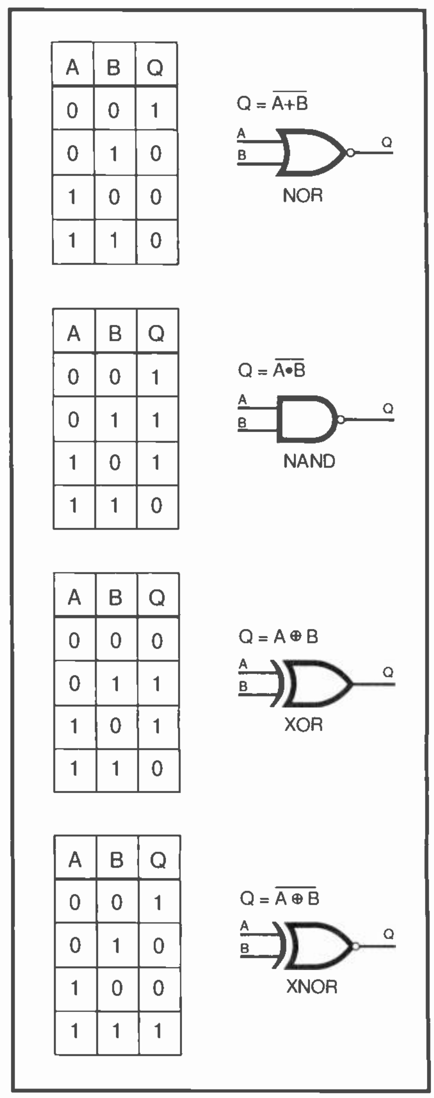


*Fig.4.5. Circuit to add two **1-bit** binary numbers together to give a **2-bit** binary result.*

More Gates

In addition to the AND, OR and NOT functions, other basic logic gates



A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	0

A	B	Q
0	0	1
0	1	0
1	0	0
1	1	1

Fig.4.6. Truth Tables and logic gate symbols for NOR, NAND, XOR and XNOR.

Check Out: Integrated Circuits

A "*discrete*" component is an individual part, e.g. a single MOSFET transistor. Technology being what it is (i.e., unstoppable), mankind has managed to miniaturise millions of MOSFETs on a sliver of silicon, to form an *integrated circuit* (**i.c.** for short). Whilst the first silicon chips contained one or two dozen miniaturised transistors, an Intel Pentium microprocessor (for example) contains millions, making the MOSFET the most common micro-electronic component in the world!

Using photographic and chemical methods, dozens of chips are simultaneously formed onto a wafer (a thin slice of single crystal silicon). After testing, individual chips or dies are separated from the wafer by sawing it up.

Each correctly functioning die is then glued into a package, and miniature wires (about 25 micrometers thick) are bonded between small metal "bond pads" (about 100 micrometers square) on the chip's surface and the pads on a "lead frame", thus connecting the die to the larger legs or pins on the outside world. The package is sealed to protect everything, and the chip is re-tested.

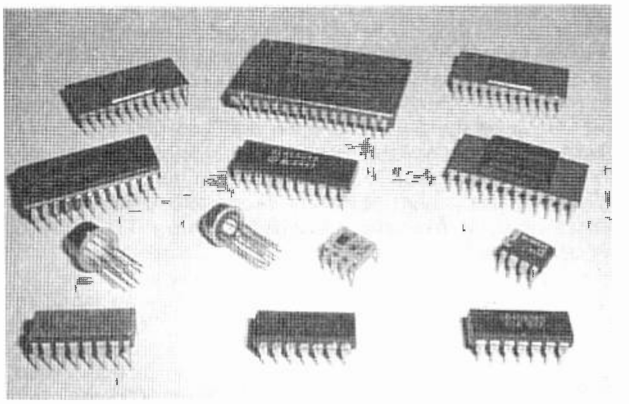
Many integrated circuits are comparatively large in size, but only because of the need for human beings to physically handle and connect to the package. The die embedded within the package is far smaller than the overall size suggests. Smaller packages suitable for automated handling systems are also available.

Get the Number

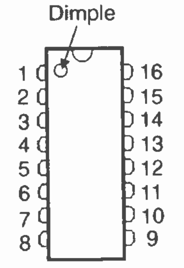
The most common type we use is the *dual-in-line* (**d.i.l.**) package, which has anything from 8 pins to 48 pins, aligned in two rows of 4 to 24 pins. The 4000 CMOS range we test in **Lab Work 4** uses a variety of chips in 14-pin and 16-pin dual-in-line packs. Pins are spaced 0·1 inch with rows 0·3 inch apart.

In order to identify the pin numbers, a notch will usually be found at one end of a d.i.l. chip, and/or a dimple may be used to indicate pin 1. The numbers then continue in an anti-clockwise direction – the diagram depicts 8-pin and 16-pin types.

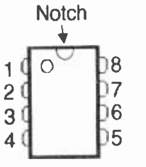
Dual-in-line chips can be soldered directly to a printed circuit board (p.c.b.), but it can then be a little tricky to desolder for replacement. It is wise therefore – although adding to the cost – to use dual-in-line *i.c. sockets*, so that you can easily "swap out" a chip at a later date.



Collection of multi-pin integrated circuit (i.c.) devices.



16 pin



8 pin

Care is needed to ensure that all pins align properly and that none are bent out of place. Special extractor tools are used by professionals.

Surface mount technology (SMT) is of enormous interest to manufacturing industry. These devices (SMDs) use much smaller package sizes (for i.c.s. as well as certain discrete parts) which requires highly specialist equipment to install them on top of circuit boards.

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are available. Two commonly used gates are **NAND** and **NOR**, which are complements (opposites) of the AND and OR functions (i.e. NOT-AND and NOT-OR). These are achieved by *inverting* the gate outputs, hence the small circle on the output of the logic symbol in Fig.4.6..

The function we met in the previous section for S_0 is also very commonly used. As well as being one-bit addition (without "carry") it can be thought of as an "A and B but not both" function and is therefore called exclusive-OR (abbreviated XOR or EXOR). The complement of the XOR is called the Exclusive-NOR, or XNOR.

Truth Tables for these gates are given in Fig. 4.6. Note the Boolean logic XOR symbol.

Logic in the Real World

Are **1** and **0** sufficient to describe what happens in real logic circuits? The answer of course depends on what you are trying to do and how accurately you need to model what is happening. There are some important issues to address when considering real logic circuits, including sensitivity to noise and speed of operation.

The first question is how we actually represent 1 and 0 in a real-life electronic circuit. We have already hinted that we could use two voltages, say +5V for logic 1 and 0V for logic 0, but this is arbitrary. It could be −2V for 0 and +2V for 1, or 0V for 1 and +5V for 0.

In general, if the more positive voltage is used for 1 we refer to this a ***positive logic*** and if the more negative voltage is used for 1 we have ***negative logic***. In this *Teach-In* course we always use positive logic, as do the most common off-the-shelf logic devices. We can also build logic circuits using *currents* to represent 1s and 0s, but again that is beyond the scope of this course.

If we select 5V for logic 1 and 0V for logic 0 then what does 4·9V mean? In real circuits we have to define a range of voltages which represent a valid logic level, say 0V to 2V for 0 and 3V to 5V for 1. We need to do this because we cannot build circuits which handle precisely fixed voltages under varying conditions of loading, temperature and factors affecting manufacture, particularly as they must be as small and as fast as possible.

In general, logic gates will accept a given range of inputs as 1 or 0 and are guaranteed to produce a smaller range of possible output voltages, closer to the ideal voltage (say 4V to 5V for 1 and 0V to 1V for 0 in our example). This means that each gate tends to restore the voltage towards the ideal for that logic level.

The difference between the worst case output level and worst acceptable input level for a given logic value is called the *noise margin*. This figure indicates how well the gate can cope with disturbances (such as external electrical interference) without losing the correct value of the data.

If the voltage is *in between* the defined logic levels for any reason (except for the brief time when switching between levels) then we have an undefined logic value and the circuit may behave unpredictably. The undefined condition is sometimes represented by the symbol X (for example, by logic simulators), meaning *"don't know"* and indicates that there is something wrong with the circuit or the design.

The symbol X is also used in the design and specification of logic functions to mean *"don't care"*, indicating that a value may legitimately be either 1 or 0 under certain conditions without affecting the outcome. Whether X means "don't know" or "don't care" should be obvious from the context in which it is used.

Logic Families

There are a bewildering number of "logic families", i.e. types of circuitry and technology for implementing digital systems. The first commercially available logic family was *resistor-transistor logic* (RTL), introduced in 1962. This was followed by diode-transistor logic (DTL) and then the *transistor-transistor logic* (TTL) of the classic *7400 series*. All these are based on the bipolar junction transistor (BJT), with TTL using a "multiple emitter" transistor at logic gate inputs.

New versions of TTL have continued to be introduced which provide higher operating speed and/or lower power dissipation, for example Advanced Schottky TTL (ASTTL). Another type of bipolar logic is Emitter-Coupled Logic (ECL) which provides a very high speed of operation.

MOS logic circuits on the other hand may be fabricated using *n*-type or *p*-type transistors alone (NMOS and PMOS), or both together (CMOS) as described in the previous part of *Teach-In*. NMOS provides higher performance than PMOS, but the advantages of CMOS mean that most MOS logic is of this complementary type.

Classic 4000

The classic CMOS logic family is the *4000 series*, but just to confuse you, CMOS versions of the 7400 series are also available (74HC00 and others)! CMOS 4000 series are static sensitive, can operate on 3V to 15V supplies but may behave unpredictably if inputs are left unconnected, as we demonstrate in **Lab Work 4**. The original 7400 and other TTL series must have a supply of 5V (±0·5V), are not static sensitive and their inputs behave as logic 1 when left floating.

The 4000 series provides some "multiplexers" which can be used for switching and selecting analogue signals, but there are no analogue functions in the standard 7400 series. Other series have different properties, for example 74LVC00 is CMOS series operating on a 3·3V supply. Not all functions are available in all families though.

Although there are differences in the behaviour and types of function available in the CMOS 4000 and TTL 7400 series, MOS and bipolar transistors can be used together to exploit the advantages of both, in Bi-CMOS, the 74ABTC series for instance.

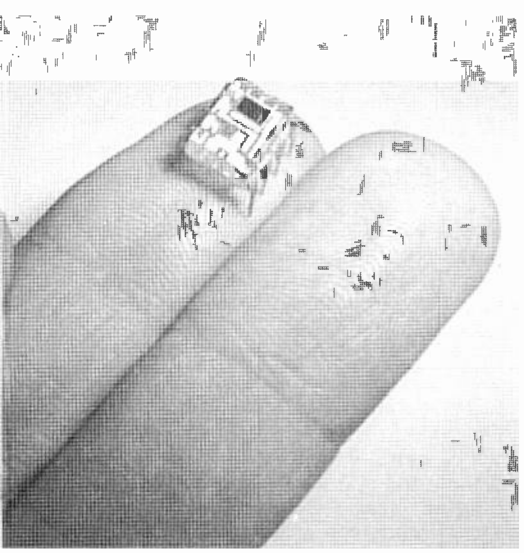
These are just some of the 74 series variations . . .

7400	Standard bipolar TTL, the originals!
74LS00	Early TTL "low-power Schottky" improvement over basic 7400 series
74ALS00	Higher speed, lower power TTL than LS
74F00	High speed "Fast" TTL improvement on LS
74HCT	Direct CMOS equivalents to LSTTL. 4·5V to 5·5V supply
74AC00	CMOS, with CMOS logic levels
74ACT00	CMOS, with TTL logic levels
74FCT00	CMOS. Lower power than 74F, by virtue of CMOS technology
74HC00	Basic high speed CMOS, similar to TTL. 2V to 6V supply
74LV00	CMOS 3·3V supply
74LVC00	CMOS 3·3V supply, faster, improved output over LV.

There are digital circuits which are able to disconnect and isolate their outputs (such circuits are used to control the flow of data around computers, for example between memory chips and the CPU). We will say more about this type of circuit later in the course.

The binary numbers 1 and 0 do not cover the situation where there is no value due to the output being physically disconnected, and X is not appropriate because the disconnection is a deliberate setting of a known condition.

We use the symbol Z to represent this state (Z for "high impedance", as Z is the symbol for impedance). Thus in real life, the specification of digital circuits (e.g. using Truth Tables) may use the symbols 0, 1, X and Z. Sometimes H and L (high and low) are used instead of 1 and 0.



This totally "transparent" light-to-frequency converter chip (TSL220) from Texas demonstrates just how small the "active" element (photodiode – black area) is in comparison to package size.

High Speed Switching

Another extremely important property of digital circuits is the *speed* with which they react to changes at their inputs. Boolean algebra and Truth Tables define what the output of a circuit will be with certain inputs, but do not convey the fact that it will take a finite time for this to happen.

If we look at the adder circuit we described earlier (Fig.4.5.), it should not be too surprising to learn that the S_1 output will react faster than the S_0 output because the signal has to go through three gates to reach S_0, but only one gate to reach S_1. Therefore, if the number at the input changes, the output may be "wrong" after S_1 has reacted, but before S_0 has done so. This time will be very short, probably nanoseconds or shorter, but time enough for another logic circuit to react.

In true-life digital design we have to be careful to make sure that intermediate states, which occur as circuits switch, do not cause incorrect behaviour. The term *glitch* is used to describe unwanted transient logic values which occur as circuits switch.

The switching delay is not only important as a complex factor in logic design, but also for economic reasons as faster circuits can be priced higher, or will attract more customers. A good example of this is the increase in speed of personal computers.

There are two ways of getting faster circuits: one is to improve the basic fabrication technology, usually by making the transistors and gates smaller. The second is to use clever design techniques (e.g. "pipelined burst cache"). Both approaches can be seen in the development of microprocessors in PCs: Intel 8086, 286, 386, 486 and Pentium.

Power Game

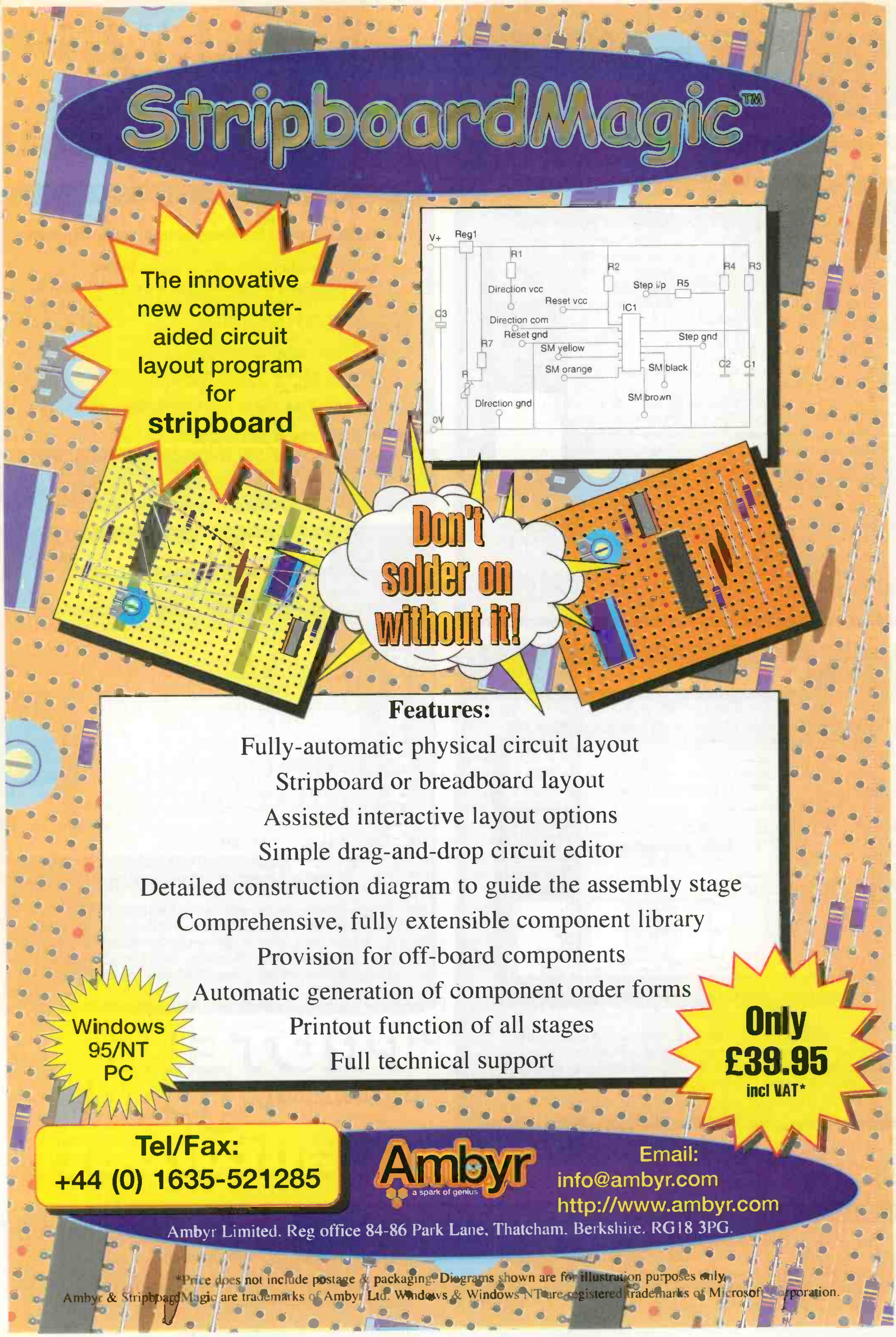
So far we have not mentioned anything about where the power comes from to make logic circuits work. Boolean algebra and truth tables have nothing to say on the matter and logic circuit schematics using gate symbols leave out power connections because they would overcrowd the diagram.

Logic chips do have power pins (usually 0V – GND or V_{SS}) and positive supply (V_{DD} or V_{CC})) which you connect to an appropriate source. Check the pin-out drawings in **Lab Work 4**.

Power consumption is an important issue in modern digital design, for two reasons. First, because all digital activity consumes power then the smaller the transistors become, the more power is consumed per unit area so the hotter the chips get. This is why you need a heatsink and a fan on a Pentium microprocessor, but didn't need one for a 386.

Second, there is a big market for portable, battery powered electronics such as mobile phones and laptop computers. Customers of these products want the batteries to last a reasonable period, so the circuits have to be designed to use a minimal amount of power. Every time a gate switches state, some power is consumed which will not be replaced until you can next plug in the charger!

Now go to the **Lab Work** section, where you will actually construct the circuits introduced here, using CMOS logic on a solderless breadboard, in conjunction with your 5V Add-on Regulated Power Supply built previously.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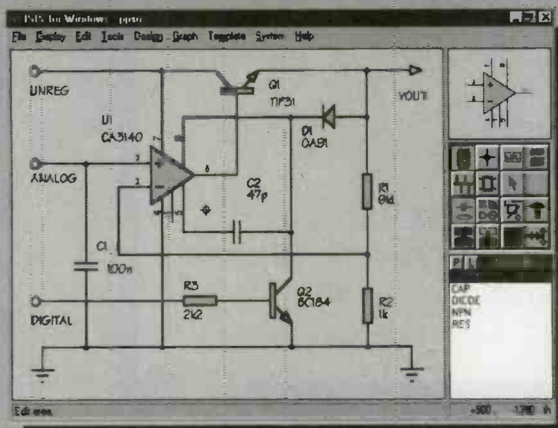

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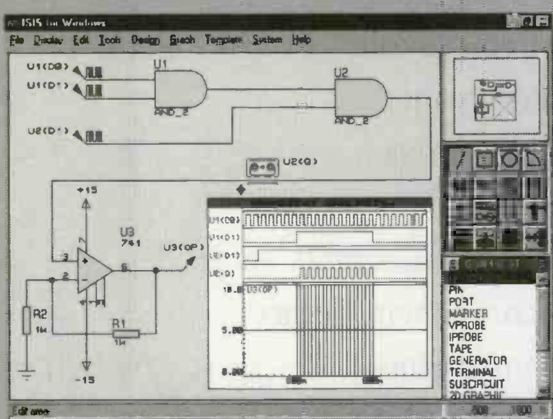

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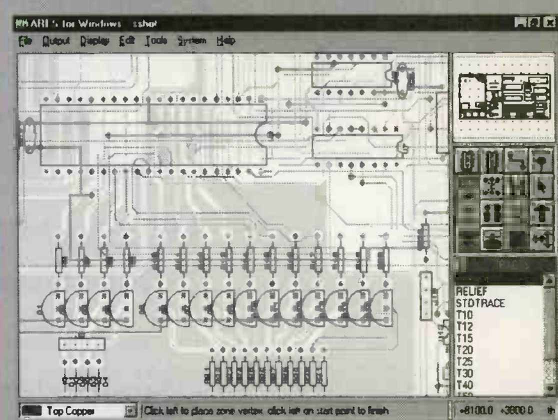

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TEACH-IN '98

LAB WORK 4

Objectives: To investigate the operation of fundamental logic gates. Observing the behaviour of "floating" logic inputs. The use of pull-up and pull-down resistors. Assembling combinational logic circuits and deducing truth tables by observing logic states using light-emitting diodes.

THIS month's Lab Work practical undertaking sets out to investigate the operation and behaviour of fundamental logic gates.

Lab 4.1

Our first experiment uses an inverter and an l.e.d. to monitor logic levels in our circuits. Fig. 4.7a shows an inverter with an l.e.d. connected directly to its output.

The l.e.d. used is a 5V "direct connection" type with an internal ballast resistor. "Standard" l.e.d.s require the use of an external resistor in series with it, typically 330Ω for a 5V supply.

The inverter is part of a CMOS CD4049 i.c. in a dual in-line package which contains six inverters (hence its name "*hex* inverter")

The l.e.d. D1 is connected between the positive supply rail and the inverter output (pin 2). When the inverter output is logic 0 (0V) the l.e.d. will ***illuminate*** because its anode (a) is connected to +5V and its cathode (k) to 0V via pin 2.

Therefore, for the l.e.d. to be **on**, (inverter output low), the inverter's input at pin 3 must be **high** (logic 1): so *l.e.d. on* indicates a logic 1 input, and l.e.d. *off* indicates logic 0 input. Check the Truth Table of inverters ("NOT" gates) in the main tutorial.

Using basic anti-static (ESD) precautions (refer back to Part Three), insert a CD4049 into the solderless breadboard, noting that the dimple or notch indicates the orientation of the chip i.e. pin 1. Fig. 4.7b is the pin-out diagram for the 4049.

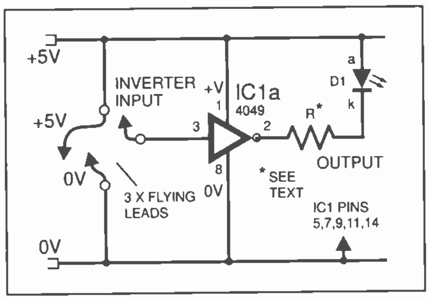


Fig.4.7a. A CMOS inverter is used as a "logic level" indicator. When l.e.d. D1 is lit it indicates Logic 1 (high) at its input.

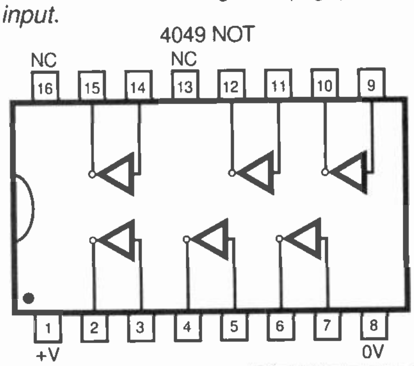


Fig.4.7b (above). Pinout details for a 4049 hex inverter i.c.

Only one inverter is used in this experiment, so all the other unused inputs should be connected to 0V (pins 5, 7, 9, 11, 14). Pin 1 of this 16-pin d.i.l. chip is connected to the +5V supply, and pin 8 to 0V, via two long "buses" set up on the breadboard to act as power rails. Both supply buses should then be hooked over to your 5V power supply adaptor.

To form the interconnections, use short pieces of solid-core hook-up wire and connect the chip as shown in Fig. 4.7c. Using fine-pointed pliers may help manipulate the wires, and the use of different coloured wires will aid identification.

Check back to Lab Work 1 if necessary, to recall how the breadboard sockets are interconnected. (We'll tell you now that, for future circuits, you may be expected to design the breadboard layout for yourself, cross-referring to the circuit diagram – the example of Fig. 4.7c shows how easy it is!)

The l.e.d. D1 is also placed on the breadboard, observing its polarity (flat notch = cathode). Also, a flying lead is to be connected to the invert input (pin 3), the other end stands out in "mid-air". Two more flying leads connect to the breadboard supply rails at +5V and 0V, offering a source of logic 1 and logic 0 signals.

How Does It Work?

Grasp the insulation of the +5V flying lead and briefly touch it to the inverter input wire. Release it, then do the same with the 0V lead, touching this briefly to the inverter input lead. For best results, try to keep your own hand well away from the inverter input wire, and obviously ***avoid connecting the +5V and 0V wires together!***

You should hopefully find that when you connect the 0V flying lead to the inverter input wire, the l.e.d. will extinguish (indicating logic 0 input), and when you touch the +5V lead to it instead, the l.e.d. will glow (indicating logic 1 input).

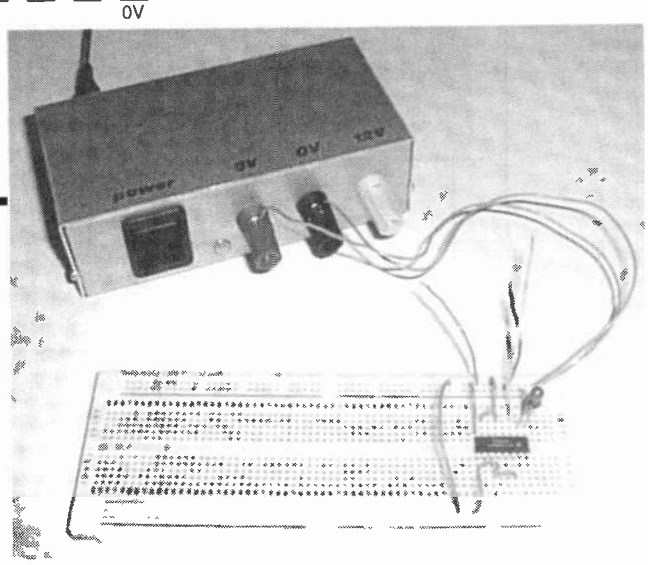
However, when *neither* lead is connected, the l.e.d. will remain in the state it was prior to disconnecting the flying leads. It may not be as bright, or it may flicker "on its own".

You Will Need

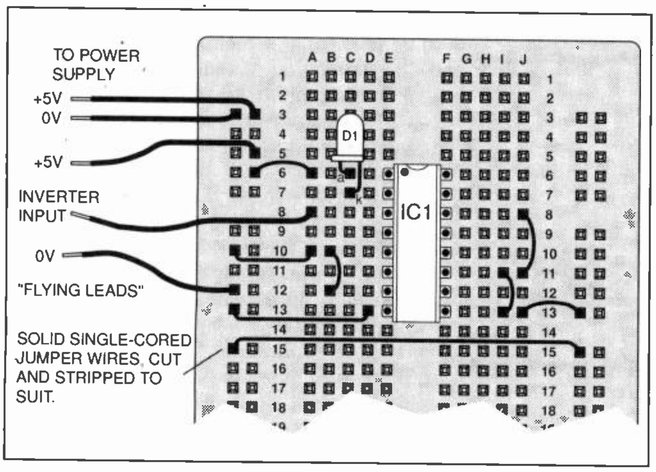
Resistors
R1 to R3 10k 0·25W 5% carbon film (3 off)

Integrated Circuits
CD4001 quad 2-input NOR
CD4011 quad 2-input NAND
CD4049 hex inverter buffer
CD4081 quad 2-input AND
CD4071 quad 2-input OR
CD4070 quad 2-input EXOR
(Retain CMOS chips in anti-static packaging until needed for use.)

Miscellaneous
Solderless breadboard; 5mm 5V direct connection light emitting diode (l.e.d.), red (4 off); 5V power supply unit (p.s.u.); hook-up wire.



Using the 5V Add-on Regulator, detailed in Lab Work 3, to power the breadboard demonstrations.



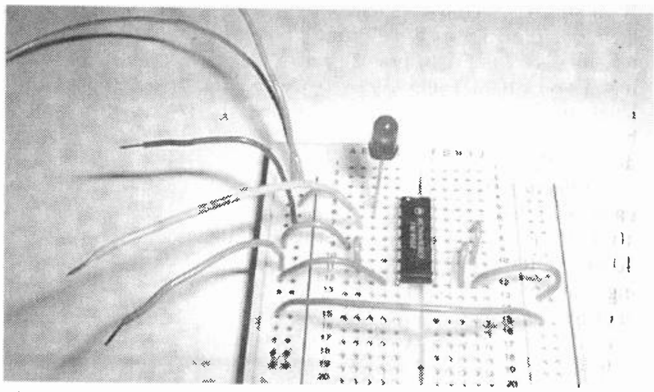


Fig.4.7c (left). Arrangement of IC1 and l.e.d. D1 of our simple logic level indicator circuit Fig.4.7a. (above) Practical layout of components on a breadboard.

• The 4049 is a special type of device classed as a **buffer** – it has a higher current rating than many ordinary CMOS devices, ideal for driving an l.e.d. directly, via an internal or external ballast resistor, of course.

• Because current flows from the +5V rail, through the l.e.d. (and its resistor) and then disappears ("sinks") *into* the inverter output pin (when at 0V), we call this *sink* current. The opposite state is called *source* current, which flows *out from* a high output, through a load, to 0V.

• Curiously, many logic devices are far better at *sinking* current than *sourcing* current. Just because an output has gone high to logic 1, doesn't necessarily mean that there is lots of current available to drive loads.

Lab 4.2

Now set the l.e.d. to "off" (0V wire) and disconnect both 0V and +5V flying leads. Touch the inverter input lead with your hand, and the l.e.d. may illuminate. We're not being definite about what happens here because the behaviour of CMOS with "floating" (unconnected) inputs can be unpredictable!

Experiment a bit to see what effect touching the input lead has. Do you need to touch the wire itself, or will just touching the insulated sleeving turn the l.e.d. on or off?

Lab 4.3

Now connect a 10k (kilohms) resistor (R1) between the inverter input (pin 3) and 0V as shown in Fig. 4.8. You will find that the circuit will now behave completely predictably.

The l.e.d. will be lit if the inverter input lead is connected to +5V (simply touch it to the +5V rail on the breadboard), and the l.e.d. will extinguish when pin 3 is grounded to 0V.

• The job of the resistor is to "bias" the input pin safely to 0V which prevents it from floating. It is called a **pull-down resistor**.

The opposite case – where the resistor is hooked to the +5V rail to bias it high – would be called a **pull-up resistor**.

• The unused pins of CMOS gates should be grounded to ensure that they don't float and behave unpredictably, which could affect the reliability of the gate or even the entire chip.

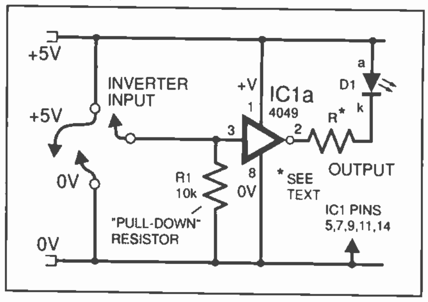


Fig.4.8. Using an additional "pull-down" resistor (R1) biases the inverter input to the 0V rail.

Lab 4.4

Now things are becoming more challenging – take your time and enjoy it! Fig.4.9 shows how the Truth Tables of all the basic 4000 CMOS **2-input** logic gates can be verified.

Three inverters are now used as logic level indicators with light-emitting diodes.

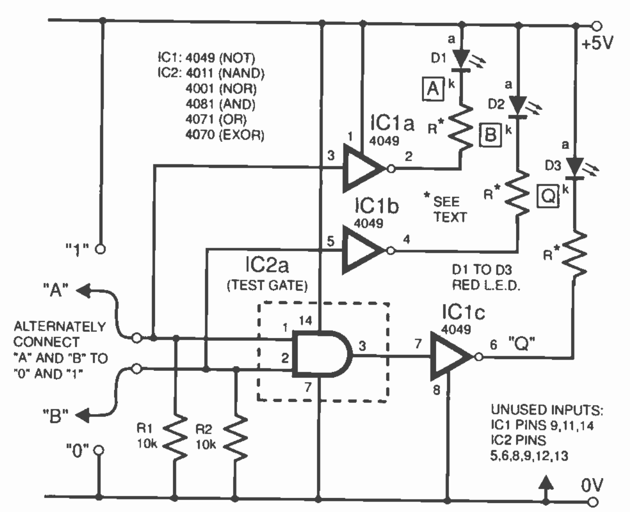
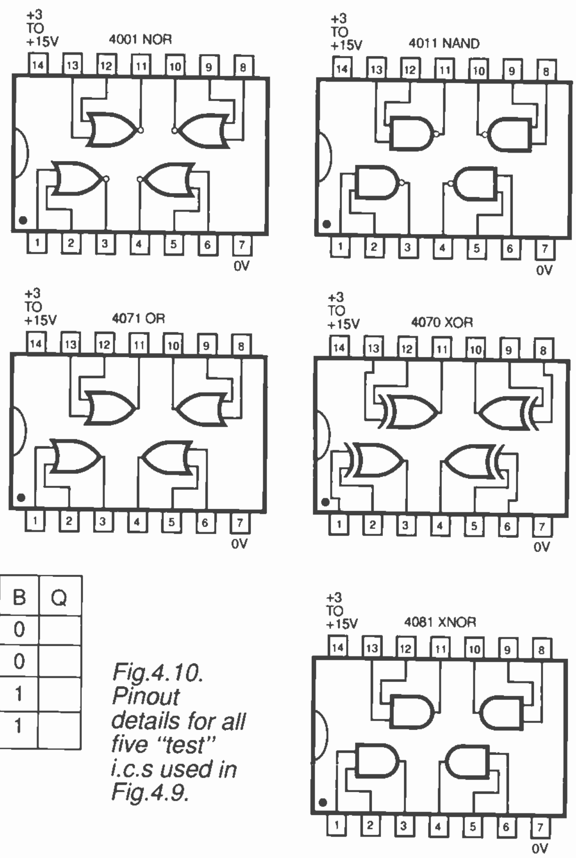


Fig.4.9. Complete CMOS logic gate tester circuit using three inverters to indicate the logic states of one gate. Construct a Truth Table for inputs A and B, and output Q.



A	B	Q
0	0	
1	0	
0	1	
1	1	

Fig.4.10. Pinout details for all five "test" i.c.s used in Fig.4.9.

IC1a and IC1b should be rewired on your breadboard using two 10k "pull-down" resistors R1 and R2 to prevent them floating. Two l.e.d.s D1 and D2 show the logic levels of the CMOS gate inputs (A and B) being tested, whilst D3 along with IC1c displays the output state of the gate (Q).

A selection from the 4000 series of logic gates will be tested: the 4011 (NAND), 4001 (NOR), 4081 (AND), 4071 (OR) and 4070 (XOR). Note that we are only testing one gate (IC2a) within a *14-pin* d.i.l. package, and so steps are taken to ensure that all the other unused pins are grounded.

In this example, the supply pins are the same for each chip, and the pinouts of all the following gates are also the same – it's only the logic function which differs. *So, all you have to do is swap IC2 for another type, leaving the wiring of your breadboard in place each time, provided that you align the chip properly on the breadboard.* We show the pinouts for all five chips separately, see Fig.4.10.

Breadboarding

There is plenty of space on the suggested breadboard to build the test circuit, so spread out. As an exercise, you should be able to translate the simple circuit diagram into the physical layout on the breadboard, remembering to follow the pin numbers given in the circuit diagram.

Ensure you polarise the chips correctly, looking for the dimple or notch identifier. All unused pins of both the 4049 inverter and the chip under test (IC2), should be connected to 0V. Also double check the +5V and 0V rails are wired the right way round!

Start by assembling the inverter (IC1) section with three l.e.d.s., using jumper wires as necessary to ensure that everything is connected together. Insert the first "test" chip (IC2), and complete all the hard wiring around it. The two test inputs (A and B) are effected with two jumper wires which can be hooked to high or low as needed.

Work through the possible combinations of input logic levels (00, 01, 10 and 11), and verify the Truth Tables for the first test gate by noting the pattern of l.e.d.s (remember, '1' = "alight"). Prise out the chip gently, then insert the next test device, and repeat your tests.

Lab 4.5

The circuit diagram of the "should I change my clothes?" demonstration, described in the main *Teach-In* tutorial, is shown in Fig.4.11. We have included all pin numbers, and identified those unused logic pins which should be connected to 0V, as well as which pins go where for the power supply connections.

Although it looks more complex, if you follow it methodically, you should have no difficulties in assembling this multi-chip demonstration circuit. By now, you should be able to identify the parts from the circuit diagram, and also assemble it on your solderless breadboard using solid-core insulated wires.

Three flying leads are used for the inputs which, you will recall, we labelled as "Umbrella", "Raining" and "Dirty clothing". Observe the pattern of l.e.d.s to confirm the Truth Table for the demo circuit.

• *Combinational Logic* uses a combination of **basic** logic functions to perform specific logic tasks. You have just constructed such a combinational logic circuit.

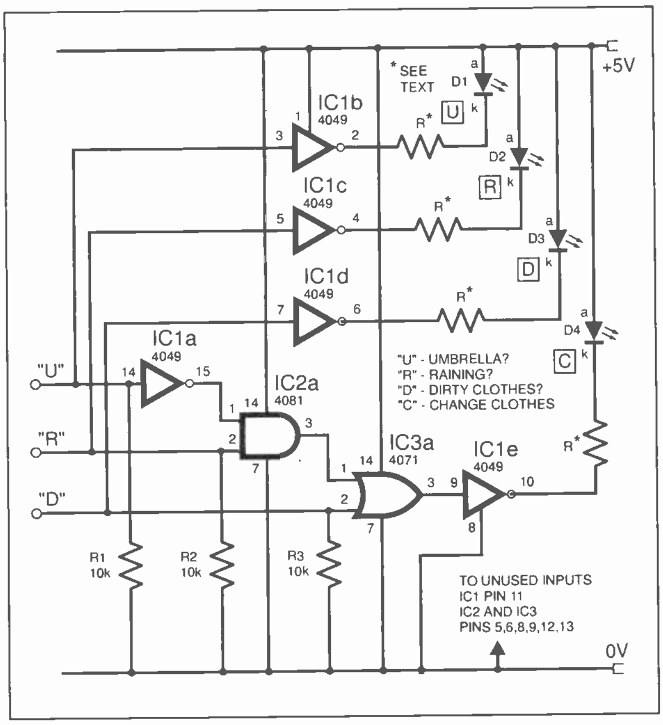


Fig.4.11. Circuit diagram of the complete "Change My Clothes" indicator. Use all three i.c.s on the breadboard, following the pin numbering carefully, construct the Truth Table for all combinations of U, R, D and observe the output C. (Refer to main tutorial text for circuit explanation.)

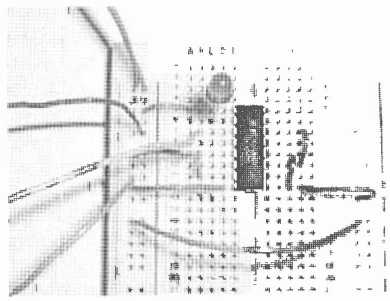
Lab 4.6

For more adventurous readers, try to assemble the "adder" circuit of Fig.4.5 in the main *Teach-In* text. Identify the chips used, deduce the pin numbers, then go ahead and construct this on the solderless breadboard. Then work out how to use the XOR gate to display S_0 instead.

End of Lab 4 Tasks

If you've followed us through Part 4 and completed the experiments in **Lab Work 4**, you're doing really well! You can now identify dual-in-line chips and their pinout numbering scheme, use CMOS logic gates in basic testing circuits, and assemble and deduce the Truth Tables for a combinational logic circuit containing a variety of different gates. Well done!

In Lab Work 5: We develop our knowledge of logic systems further, using more advanced combinational logic circuits, and "Karnaugh maps" – a multi-dimensional Truth Table which helps when developing logic functions.



Techniques

ACTUALLY DOING IT!

by Robert Penfold

THE FIRST stage of project construction is usually the building of the circuit board. Having successfully completed that task it is tempting to sit back and consider the project virtually finished. In reality, the mechanical aspects of construction and any hard wiring that is required may well take longer than building the circuit board.

Turning a completed circuit board into a finished project is definitely somewhat lower-tech than building the board itself, and to a large extent it involves familiar tools such as screwdrivers and pliers. There are still a few pitfalls to avoid though, and any lack of thought or care on this aspect of construction will at best result in a rather rough but working project. At worst, a circuit board which has been built correctly could be damaged and rendered useless by carelessness during the later parts of construction.

Guided Tour

Having constructed the circuit board it is obviously necessary to mount it in the case. This is not quite as straightforward as it once was, as there are now several common methods of mounting circuit boards, plus seemingly endless variations on these.

A few projects have a circuit board which simply slides into guide rails moulded into the case. Guide rails are often to be found in plastic and diecast aluminium boxes, but are not a feature of most other cases.

The boxes that have these guide rails almost invariably have a slightly tapered shape, and it is often necessary to file the board slightly to give it a matching taper. Apart from this, the guide rail method is perfectly straightforward.

Its only real drawback is that it is often impractical except where a circuit has been specifically designed to suit a particular case. It is sometimes possible to produce an over-length version of the circuit board so that it will fit into the rails, but this is only possible with stripboard construction or if you are making your own custom p.c.b.s.

There is a slight variation on the guide rail system which has four plastic clips fitted onto the board first, and then the board is slotted into the guide rails via these clips. The idea of this system is that it enables the circuit board to be mounted at right angles to the rails, which often enables a larger circuit board to be accommodated. It has a slight drawback, which is simply that getting everything into place can be awkward. Experience has shown that the board is not held as securely as one would wish.

Above Board

With most projects the circuit board must be held in place using either nuts, bolts, and spacers, or using some form of plastic stand-off. For the beginner it is tempting to simply bolt the board directly onto the case.

If the case is a metal type this will result in the soldered connections on the underside of the board short-circuiting through the case, almost certainly short-circuiting the battery or power supply in the process! Even if the case is made from plastic, the board must still be held slightly clear of the case.

The underside of the circuit board is far from flat, with the soldered joints standing a few millimetres proud of the board's surface. When the mounting nuts are tightened, the areas of board immediately around them are pressed flat against the case, but the areas around soldered joints are kept a few millimetres clear of the case.

There are two possible outcomes to this. If the circuit board is made from s.r.b.p. (silicon resin bonded paper) or some similar material, it will become badly distorted, and may even break. The brittleness of stripboard makes it especially vulnerable to this problem. If the board is made from fibreglass it might be distorted, but with something like a folded aluminium case it is quite possible that the case will be deformed and ruined.

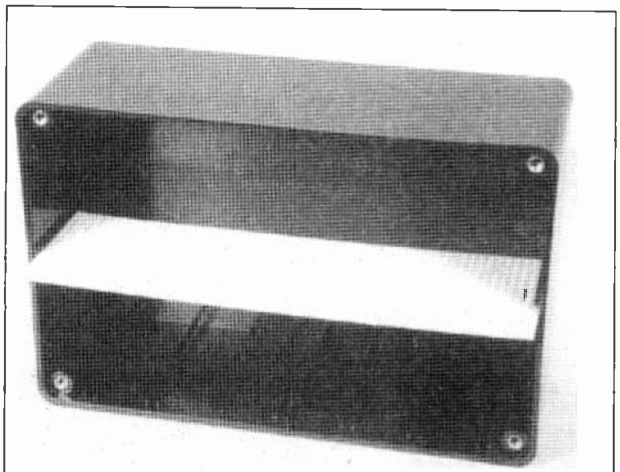
Omitting the spacers more or less guarantees disaster. In fact taking short cuts when building anything almost invariably proves to be a false economy.

Wobble Board

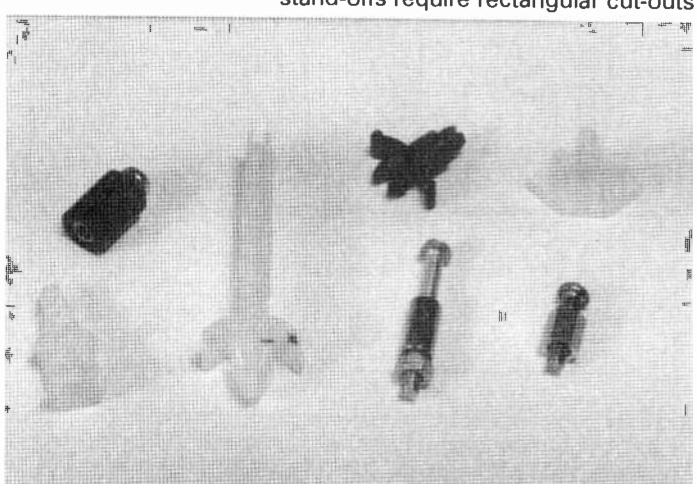
Plastic stand-offs exist in a variety of forms, so you need to look carefully at the descriptions and illustrations in catalogues to make sure you are getting the exact type you require. The original types were designed to clip into holes drilled in the case, with the circuit board then clipping in place onto the tops of the stand-offs.

This may seem to be a very convenient way of doing things, but it does not seem to hold the board as securely as other methods. In fact there seems to be a certain amount of built-in wobble with this method.

The mounting holes in the board and the case must be just the right size or the board will not clip into place properly at all. Many of these stand-offs require rectangular cut-outs



Many plastic cases have built-in guide rails, but they are little used in practice.



A selection of circuit board plastic stand-offs, plus threaded and non-threaded spacers.

in the case. Probably the easiest way of making these is to first drill a small circular hole, and then file it out to the right size and shape using a miniature square or triangular file.

There is an alternative type of stand-off which clips into holes in the case, but at the other end it has a long guide into which the circuit board is slotted. Unlike other forms of stand-off, the board is mounted at 180 degrees to the stand-offs rather than perpendicular to them.

This might mean having to mount the board on (say) the rear panel of the case rather than the base panel, and in some cases it might not be practical to use this kind of mounting at all. Also, a few millimetres at each end of the circuit board must be free from components so that board will fit into the guides properly.

Another form of stand-off is secured to the case by way of a self-tapping screw, and then the board clips in place on top of it. This seems to give better reliability, but it would not be a good idea to use it with circuit boards that carry the mains supply or any high current/voltage wiring.

Yet another type of mounting pillar has threaded bushes at both ends. The idea is that the pillars are bolted to the board using short screws (usually M3 size), and then the circuit board is fixed in place using the same method. This is a very secure way of mounting circuit boards, but the threaded mounting pillars are relatively expensive.

There is one final variation in the form of stand-offs which are glued to the case and clip into the circuit board. The bases of these are usually ready-fitted with self-adhesive pads.

This type of stand-off offers the ultimate in simplicity, since you can fit them onto the board, peel off the paper covers from the pads, and then simply press the board into place on the case. Self-adhesive stand-offs are ideal for small boards.

Spaced Out

In a similar vein, threaded metal spacers can be obtained. These are used with bolts that are several millimetres longer than the spacers, so that each bolt protrudes above the top of its spacer. The circuit board is then fitted onto the ends of the bolts, and nuts are used to fix it in place. This method works well, and holds the board securely in place.

There is a variation on this approach which utilizes non-threaded spacers, and this also works well. It can be a bit fiddly getting everything in place, especially if the board has three or four mounting bolts, but some Bostik Blu-Tack or Plasticine can be used to hold the bolts in place while everything is loosely assembled. With the Blu-Tack or Plasticine removed, the mounting nuts can be fully tightened. Spacers and mounting bolts are almost certainly the most popular method of fixing circuit boards in place.

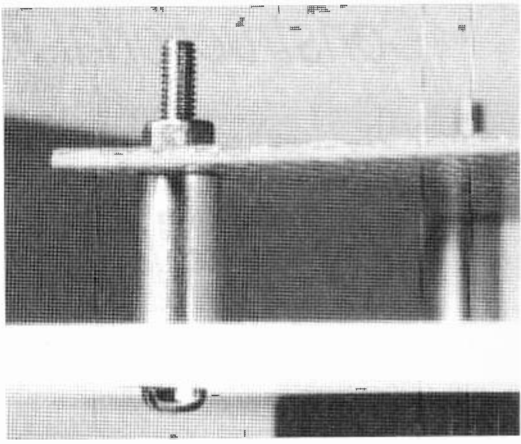
Call for M

The standard choice for mounting bolts used to be the 6BA variety, but the imperial sizes are gradually being phased out and replaced with the metric M* series. The number after the letter "M" is the bolt diameter in millimetres, and the most popular size for mounting circuit boards is M3. This is fractionally larger than 6BA, but the difference is small. In both cases mounting holes of about 3·2mm to 3·5mm are required.

When using stripboard there is something to be said for using slightly smaller mounting bolts, as it permits the use of smaller mounting holes in the board. Stripboard is drilled with one millimetre diameter holes on a 2·54mm matrix. Enlarging one of the holes to much more than about three millimetres can result in that hole starting to merge with the four holes that surround it.

This effectively gives a mounting hole which is much larger than is really needed. Experience suggests that M2·5 bolts together with mounting holes of 2·8mm to 3mm diameter are a better option for stripboard.

Stripboard and plastic stand-offs that clip onto the circuit board do not usually work well together. Plastic stand-offs of this type seem to require quite large mounting holes in the board, which inevitably means that there are problems with the existing matrix of holes. You end up with an odd shaped and oversized mounting hole which will not clip onto the stand-off properly. It is probably best to only use mounting bolts plus some form of spacer with stripboard, or plastic stand-offs of a type that bolt to the circuit board.

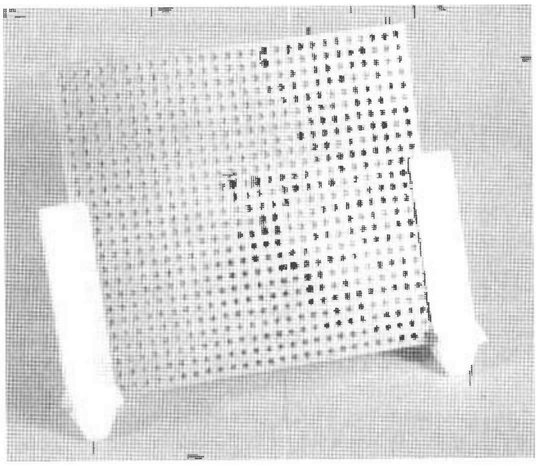


Although a board clamped to a case by a nut, bolt and spacer is perfectly adequate, adding a second "lock" nut between the spacer and board enables easy removal of the board, without the bolt and spacer being dislodged.

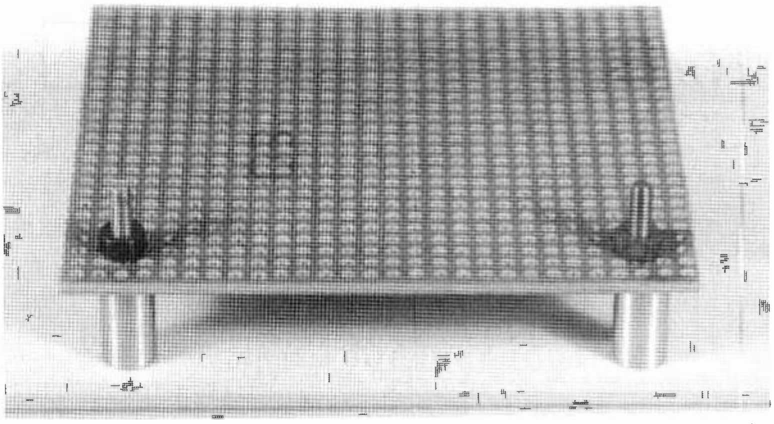
When using bolts and spacers it is essential to position the mounting holes in the case with a high degree of accuracy. Even quite small errors can put the board under a fair amount of stress when the mounting nuts are tightened.

When using stripboard, which tends to be quite brittle, there is a definite risk of the board shattering. Use the circuit board as a template when marking the positions of the mounting holes, and this makes it easy to achieve good accuracy.

Once the holes have been drilled, you should hold the board in place over them to check that there is a good match. If necessary, use a miniature round file to elongate one or two of the mounting holes in the case to obtain better correlation between the two sets of holes.



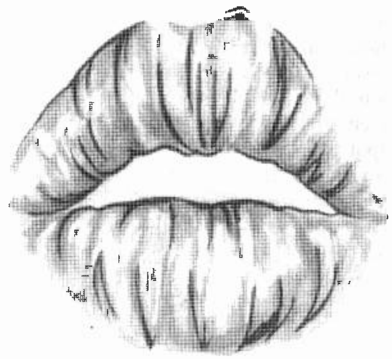
Printed circuit guides are a simple and effective means of mounting small to medium size boards.



Old fashioned nuts, bolts and spacers seem to be the most popular method of mounting printed circuit boards and stripboard.

Constructional Project

KISSOMETER



WILLIAM CHESTER

Find your true Valentine with this low-cost, fun project

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 !

If you have read this far, you must have at least identified with some originality in the title. However, you may be surprised to learn that some similar such "machines" have long since been an attraction in amusement arcades and similar environments. Even dating back to Victorian times, electromechanical novelties have exploited our human capacity for curiosity and . . . sometimes, loose change !

The Kissometer is very much an arbitrary title ; as you will see, with simple label changes it could be called almost any other kind of . . . -ometer. Presented here as the Kissometer, this project may well prove to be a worthy curiosity, especially on St. Valentines day, for instance.

SOFT TOUCH

In essence, if you have not already guessed, the principle of operation goes like this: 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 – and take delight in the visual wonder that is . . ., well, the means by which the Kissometer judges your "kissability".

The jumping light emitting diode (l.e.d.) 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.

The more observant individuals amongst you will realise that this "decision" is an almost perfectly random indication. But, before you reach for the nearest re-design engineer, remember one very appropriate saying; "most people can be fooled at least some of the time". Especially if love's mischievous cupids have let fly a stray arrow and temporarily blinded the Romeo or Juliet concerned.

Just remind them that their skin resistance falls as vigorous hormone activity causes small yet detectable changes in body perspiration. It's true, honestly!

SYSTEM OPERATION

A block diagram for the Kissometer is shown in Fig.1. The presence of a finger across the touch pads is detected and amplified to produce a voltage which is then stored on the plates of a capacitor. When this voltage exceeds a preset level, the threshold detector switches the audio amplifier on, and turns the display off.

The voltage stored in the charge reservoir capacitor continues to rise while the touch pads remain bridged. The voltage is also routed to the voltage controlled oscillator (v.c.o.), whose output frequency rises while the level at its control input rises. The varying frequency is taken to the audio amplifier and then output directly from the loudspeaker.

Although the display is turned off, the decade counter is clocked rapidly by the square wave output from the oscillator. When the finger is lifted, the reservoir capacitor is discharged in a controlled fashion. As the voltage falls back below the preset level, the threshold detector operates the display switch, turning the display back on.

By this time, the frequency has fallen sufficiently, allowing the individual on and off lighting action of each l.e.d. to be clearly seen. The moving l.e.d. dot display continues slowing down in speed and soon stops, as a consequence of full discharge of the reservoir capacitor.

Several factors introduce a random element to the operation. These include skin resistance, contact pressure, contact duration and frequency variation. At the time of design, it was not considered desirable to have the display showing the effects of the higher clock frequencies. The l.e.d.s would, in any case, be switched so fast that to the human eye they would all appear to be on simultaneously. This is why a display switch is used.

CIRCUIT DESCRIPTION

The full circuit diagram for the Kissometer is shown in Fig.2. The junction of the lower touch contact with resistor R1, is taken to the non-inverting input of IC1a. This is half of an LM358 operational amplifier. Here it is configured as a d.c. amplifier with a gain of ten.

When a finger is placed on the contacts, the surface skin resistance forms a potential divider with R1. The d.c. voltage at pin 3 input will rise, causing an amplified level to appear at the output pin 1.

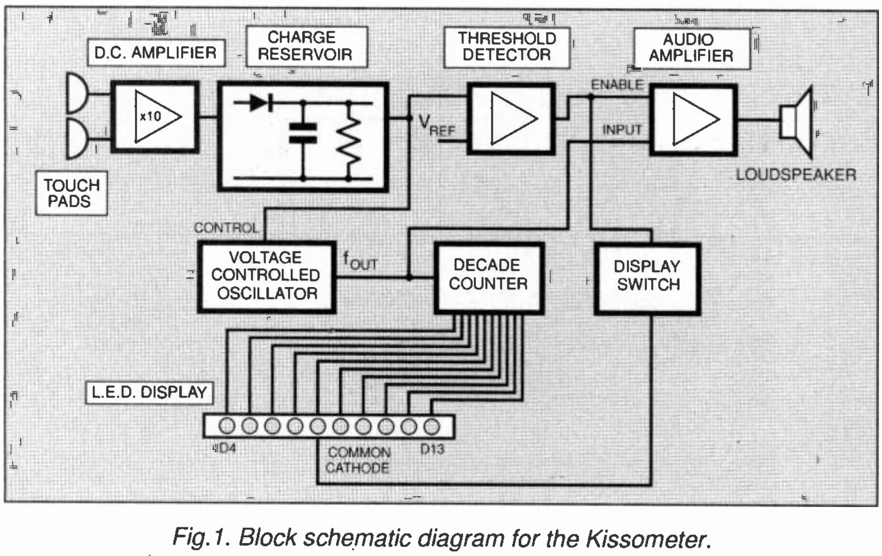


Fig.1. Block schematic diagram for the Kissometer.

Capacitor C1 is now charged, through resistor R4 and forward biased signal diode D1. Resistor R5 comes into effect later, providing a much longer discharge time-constant after the finger is lifted.

The rising voltage on capacitor C1 does two main things. First, when it exceeds the reference level, set at pin 5 of IC1b, the output of this comparator switches down to virtually the 0V supply. This level change enables the audio amplifier and buffer built around TR1 and also switches TR2 off – thereby blanking the l.e.d. display. Since resistor R7 is very small compared to the value of R6, the comparator threshold is reached quickly.

Second and simultaneously, the d.c. level on C1 is transferred through diode D3 to the control voltage input of IC2 at pin 9. Here the voltage is slightly delayed but further stored by electrolytic capacitor C4. Resistor R11 plays no part at this stage of events.

The popular 4046 CMOS phase-lock-loop is selected for IC2 and, in this application, it is only the internal v.c.o. which is used here. Components R12 and C5 set the maximum frequency, or upper limit of the v.c.o. output to approximately 1kHz.

SKIN EFFECT

The actual skin resistance, peculiar to each individual will determine the absolute value of the control voltage at pin 9 of IC2. The v.c.o. output, at pin 4 of IC2 is coupled, via R13 and C3 to the input of the audio amplfier TR1.

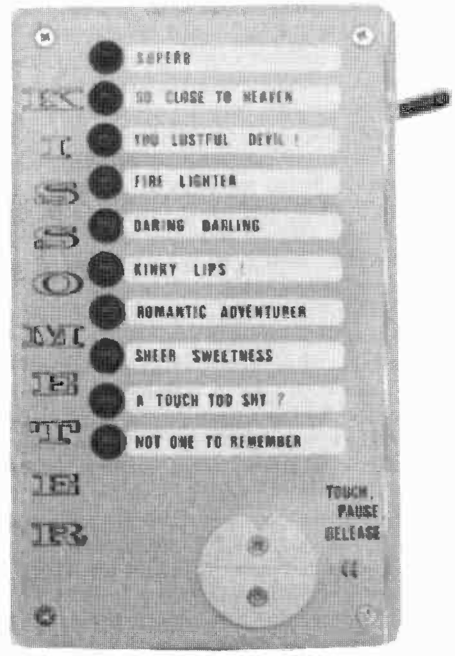
Once the threshold of IC1b has been reached, the subsequent antics of the v.c.o. frequency output will be heard from the loudspeaker LS1. The resulting siren-like din is certainly loud enough to alert people and other animate objects within about fifty metres. Actually the sound is more pleasing than confusing. As one's finger plays upon the Touch Pads, the fluctuating frequency content is rather reminiscent of a "wolf-whistle". Quite appropriate really.

When the person lifts their finger, either out of surprise or utter consternation, capacitor C1 will start to discharge, via resistor R5. This is due to IC1a pin 1 switching to "low" (0V) in response to now having 0V present at pin 3 input.

After a little time, the threshold set at IC1b pin 5 is passed but in the opposite direction. Consequently the output at pin 7 goes "high" (to within 2V of the d.c. supply line) which reverse biases diode D2, disabling transistor TR1 by removing the d.c. base bias current needed for its operation. At the same time, current fed through resistor R15 now turns TR2 back on and the l.e.d. display is lit.

YOUR POTENTIAL

As capacitor C1 continues to lose its stored potential, audio is now absent but in its place is the l.e.d. display. This behaves like a dot display, since only one l.e.d. is lit at any instant. However, the unique operation means that the l.e.d. movement gradually slows down and finally settles; an action that almost seems to suggest



the machine has some inbuilt capacity for decision making.

The l.e.d. movement slows because as the control voltage at IC2, pin 9 falls, so too does the output frequency. Capacitor C4 is included to ensure that a suitable delay exists between IC1b switching high and the v.c.o. halting. In other words, movement of the display continues for a time, determined by C4 and R11, after audio output has ceased.

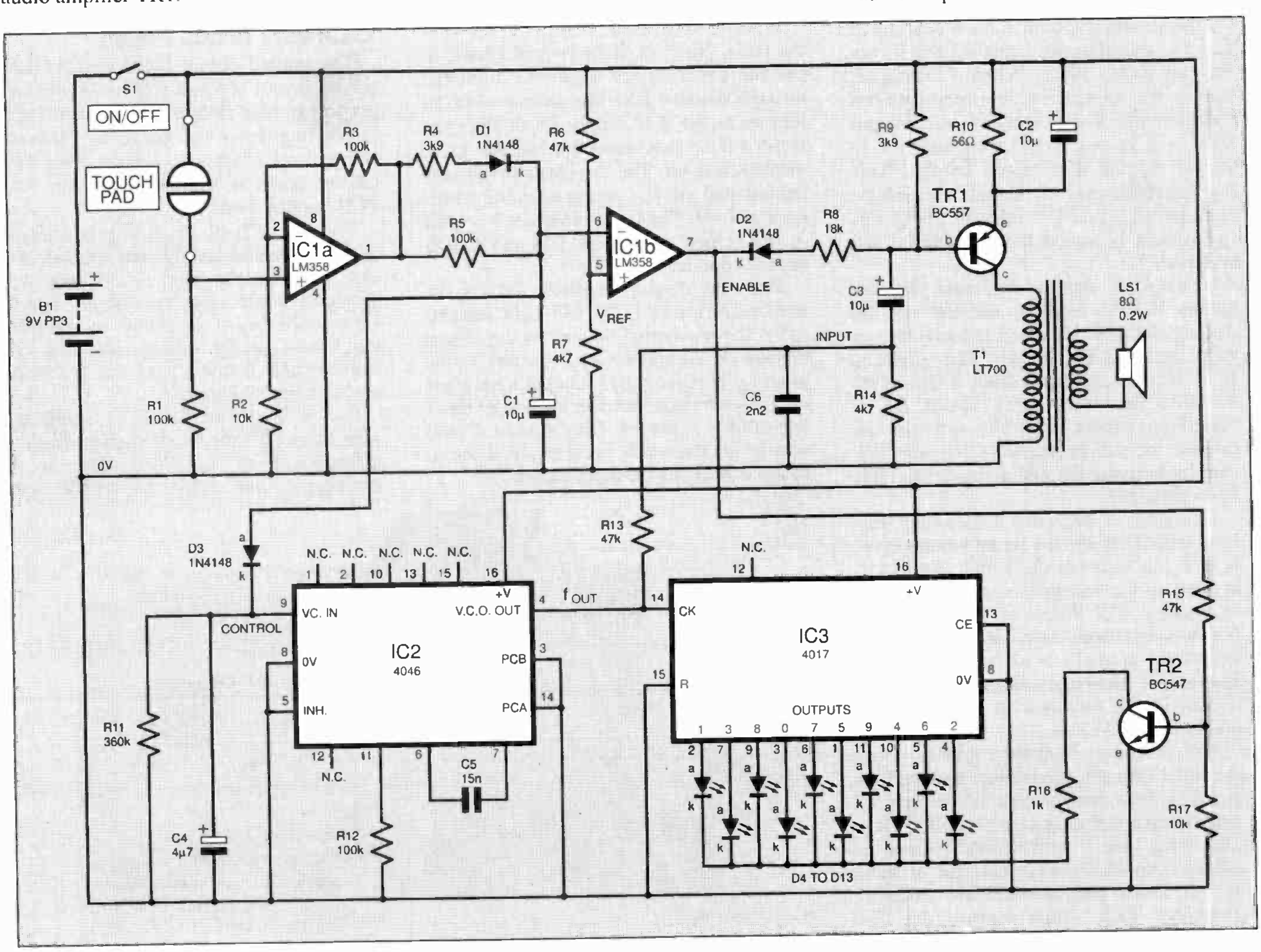


Fig.2. Complete circuit diagram for the Kissometer.

AUDIO AMPLIFIER

The amplifier, based around transistor TR1, is a rather crude but effective circuit block. It utilises transformer T1 to provide a better match between the transistor collector output and the low impedance of the small loudspeaker LS1. Capacitor C2 is used to boost the gain by bypassing the emitter d.c. stabilising resistor, R10. Excluding C2, or lowering its value will therefore reduce the gain and consequent output power level.

Transistor TR1 is a *pnp* type and is biased into operation when 0V is present at the D2 end of resistor R8. This primes TR1 to receive the v.c.o. output pulses through resistor R13 and capacitor C3.

Whenever the Touch Pads are bridged TR1 is biased on and a quiescent current of 14mA to 18mA flows through resistor R10. This current also flows in the primary winding of output coupling transformer T1. The magnetising effect of this d.c. current should not become a problem since the current is not flowing for most of the time that the unit is operated.

The potential divider formed by resistors R14 and R13, attenuates the full V_{dd} to 0V swinging oscillator waveform to a peak-to-peak swing of less than one tenth of V_{dd}. This prevents overloading the input of TR1 and gives a more pleasing, undistorted sound. Capacitor C6 is included to round-off the v.c.o. square wave switching transitions, so filtering out any unwanted harmonics.

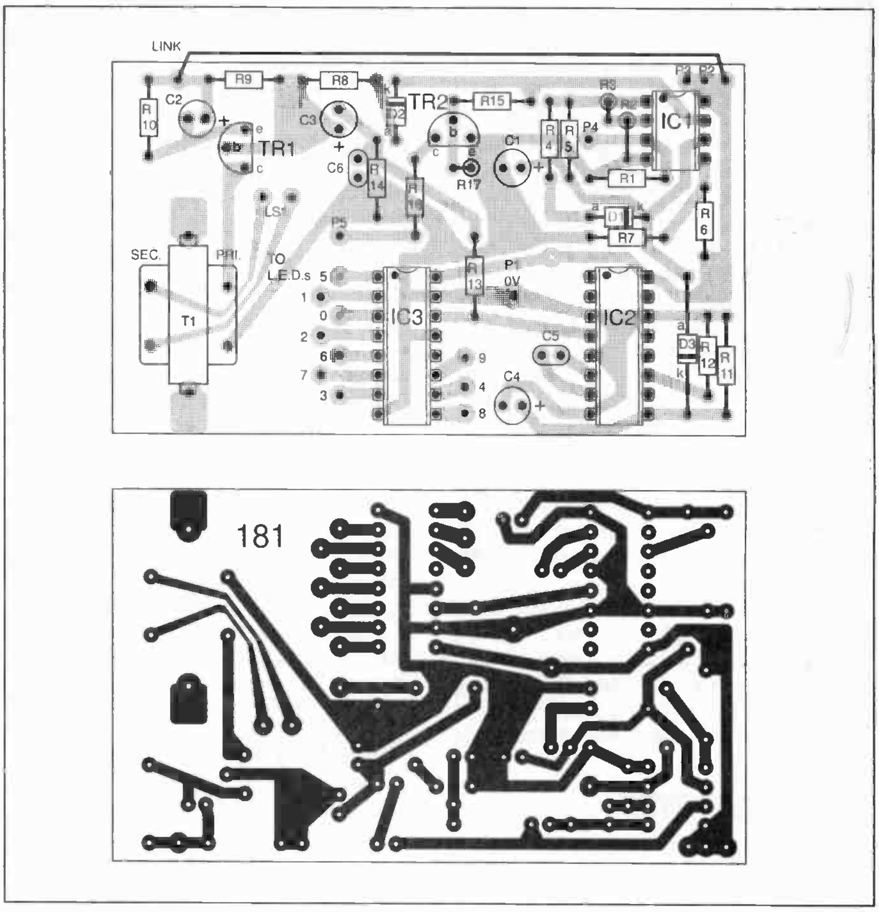


Fig.3. Printed circuit board component layout and full size underside copper foil master pattern.

HOW IT WORKS

Operational amplifier IC1a is configured as a d.c. amplifier. Resistors R2 and R3 set the gain to ten times. When a resistance, skin in this application, is placed between (bridges) the Touch Pads the d.c. output level at IC1a pin 1 rises from near 0V to almost the full d.c. supply voltage. This d.c. level is used to charge electrolytic capacitors C1 and C4, most of the charging current is routed through resistor R4 and diode D1.

Resistor R7 sets the threshold of comparator IC1b to less than one-tenth of the d.c. supply. This is passed quickly, on pin 6, as capacitor C1 charges. The output of IC1b at pin 7, switches from a high level down to near zero (0V). Diode D2 is biased into conduction which activates the divider formed by resistors R8 and R9, thereby bringing the audio amplifier, TR1, into operation.

Charging of capacitor C4 closely follows that of C1 and the rising voltage level at IC2, pin 9 causes the output frequency, at pin 4, of the voltage controlled oscillator to increase. The output of the v.c.o., IC2 pin 4, starts from zero Hertz and heads toward the upper limit set by R12 and C5. The values shown set the maximum frequency of the oscillator to approximately one kilohertz (1kHz).

The changing frequency square wave is routed through attenuator resistors R13 and R14, then presented to the base (b) of common emitter transistor amplifier TR1. The rising tone, "wolf-whistle" sound is output from loudspeaker LS1 for as long as the touch pad contacts are bridged. Transistor TR2, which controls the display, is also turned off while the touch pads are bridged and audio is enabled.

When the operating finger is lifted from the pads, pin 1 of IC1a switches back to 0V and capacitor C1 begins to discharge through resistor R5. The output of IC1b returns to the d.c. supply level, stopping audio output but now turning the l.e.d. display back on. The discharge of C4 lags behind that of C1, so maintaining oscillator activity. The falling frequency is used as the clock signal for IC3, a CMOS decade counter.

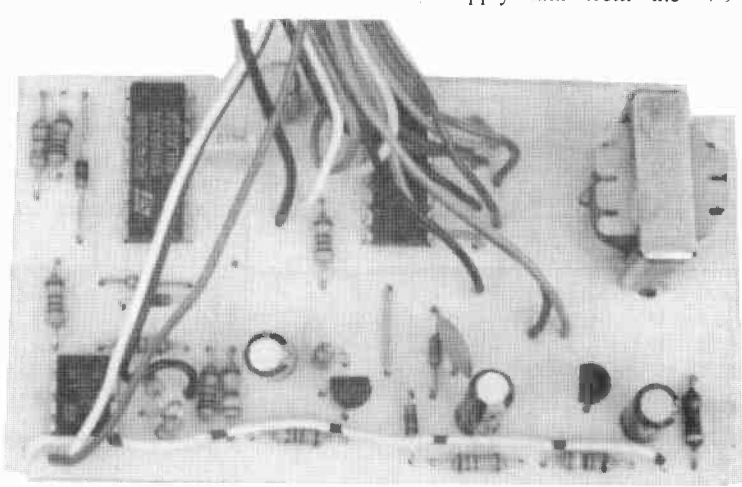
Since the display transistor TR2 is on, the l.e.d.s (D4 to D13) will light sequentially; the movement slowing as the charge voltage on capacitor C4 drops due to the presence of resistor R11. Output from pin 4 of IC2 soon stops, sending no further clock pulses to IC3 pin 14. Only one l.e.d. will now be lit. The whole cycle can be repeated by again bridging the touch plates.

CONSTRUCTION

The printed circuit board (p.c.b.) component layout and full size underside copper foil master pattern are given in Fig.3. Interwiring from the p.c.b. to off-board components is shown in Fig.4. The Kissometer board is available from the *EPE* PCB Service, code 181.

The size of p.c.b. used here is designed to fit neatly and snugly into the specified case. This has the inside walls lined with moulded guide slots for circuit boards. Commence board assembly by inserting the lowest profile components first; the resistors and diodes. Check that the diodes are orientated correctly.

Cut a length of insulated connecting wire, about 85mm, and remove 4mm of insulation from each end. This is the d.c. supply link from the +9V input



Layout of components on completed printed circuit board.

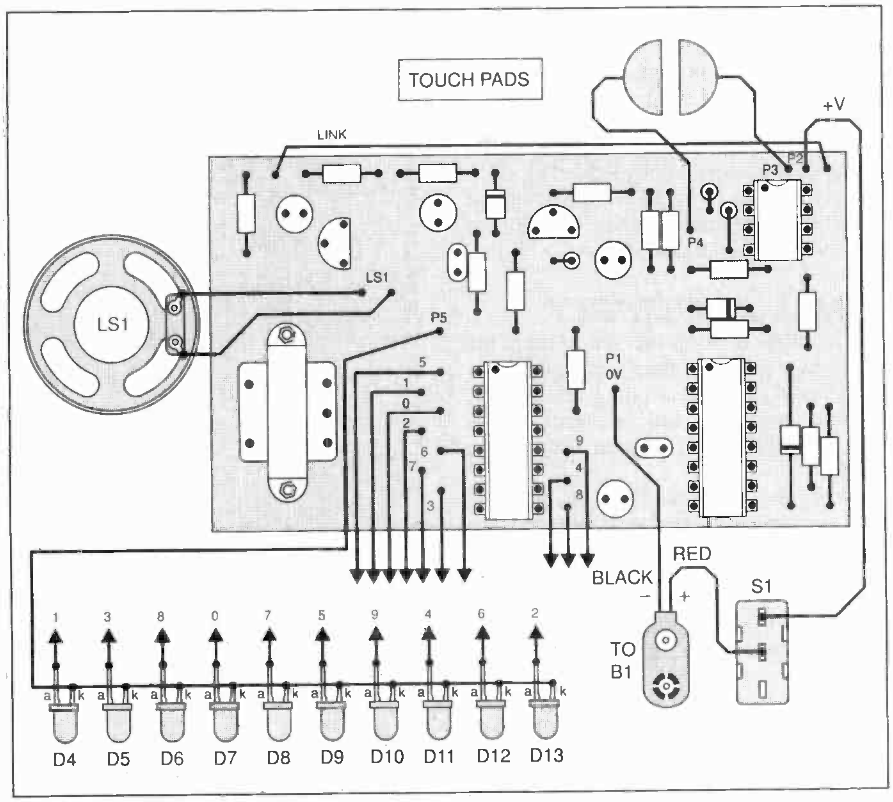


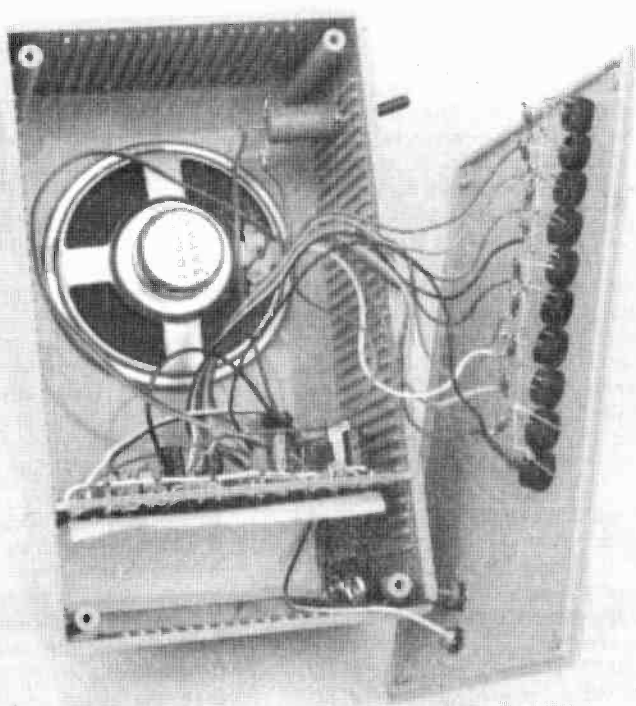
Fig.4. Interwiring from p.c.b. to off-board components. The wiring to the l.e.d.s is not in sequence to add to the random effect.

copper pads to the "positive" ends of TR1 amplifier components.

Follow this by mounting the low value capacitors, C5 and C6. Then the polarised, radial lead electrolytics; C1, C2 and C3, C4. Observe the correct polarity in each case.

The two transistors are next. Note that TR1 is a *pnp* type and TR2 a *npn* type. However, they both have the same lead-outs and the preformed lead variants will fit directly on the p.c.b., automatically giving correct orientation. If yours come with the leads in-line, just make sure that the flat side of the transistor body coincides with the component layout diagram.

Now fit the output transformer T1. The core mounting tags can be inserted through the board and then soldered underneath onto the copper lands. This method provides a rigid mechanical fixing, preferable to sole reliance on the strength of the winding leads. Position T1 so that the primary winding (three leads) is on the same side as IC3. Bend the unused middle lead upward, against the insulated windings.



Circuit board slotted into case and interwiring to display l.e.d.s. Note the protective card in the battery compartment.

PRELIMINARY WIRING

At this stage, before fitting the i.c.s, the flying leads from the p.c.b. can be attached (see Fig.4.). Take two of these, each about 200mm long, to the loudspeaker LS1 pads. Twist them together a few times to form a pair, in readiness for connection to the loudspeaker. Two separate wire lengths are also soldered to the Touch Pad points.

The black, negative (0V) wire from the battery clip is soldered to pad P1, beside R13. The battery positive lead (red) should be taken to the pole contact of the single-pole power switch S1. Depending upon what kind of switch is employed, S1 may need to be fitted into the case before solder connections to it can be completed. The other side of S1 is soldered to the +V solder terminal P2 on the p.c.b.

ON DISPLAY

The final connecting wires are those for the random l.e.d. display. Random is the

COMPONENTS

Resistor

R1, R3, R5, R12	100k (4 off)
R2, R17	10k (2 off)
R4, R9	3k9 (2 off)
R6, R13, R15	47k (3 off)
R7, R14	4k7 (2 off)
R8	18k
R10	56Ω
R11	360k
R16	1k

All 0·25W 2% metal film

See SHOP TALK Page

Capacitors

C1, C2, C3	10µ radial elect. 25V (3 off)
C4	4µ7 radial, elect. 25V
C5	15n polyester

Semiconductors

D1, D2, D3	1N4148 signal diode (3 off)
D4 to D13	5mm standard or high brightness l.e.d., with panel mounting clips (10 off)
TR1	BC557 *pnp* silicon transistor
TR2	BC547 *npn* silicon transistor
IC1	LM358 dual op.amp
IC2	4046B CMOS phase-locked loop
IC3	4017B CMOS decade counter

Miscellaneous

T1	LT700 transistor output transformer
LS1	8 ohm miniature loudspeaker (0·2W)
B1	9V battery (PP3), with clip
S1	on/off s.p.s.t. slider or toggle switch

Printed circuit board available from *EPE PCB Service*, code 181; plastic box, size 90mm × 149·5mm × 52·5mm; 8-pin d.i.l. socket; 16-pin d.i.l. socket (2 off); 10-way multi-coloured ribbon cable or multistrand connecting wire, approx. 200mm lengths; solder pins, if required; metal pieces (aluminium) for touch pads; rub-down decals (transfers); self-adhesive paper labels; solder etc.

Approx Cost Guidance Only £17

term used here since the sequential outputs of IC3 are not matched physically by the l.e.d. positions on the Kissometer front panel. In practice this adds to the element of surprise, especially when the counter is about to stop.

A suggested front panel display layout for the l.e.d.s is shown in the photographs of the completed unit. From the top to the bottom this follows the IC3 output sequence of: 1, 3, 8, 0, 7, 5, 9, 4, 6, 2.

A length of 10-way multi-coloured ribbon cable or individual connecting wires can be used to hook-up the l.e.d.s to the circuit board. Either way, an initial length of 200mm should prove adequate. Each wire can then be trimmed to length as they are soldered between the p.c.b. and top (lid) display panel during final assembly.

All the l.e.d. cathodes (adjacent to the flat side of the l.e.d. body) are commoned together. Take a flying lead from p.c.b. solder terminal P5 to the common cathode (k) link so formed. Mount the l.e.d.s into holders on the top panel, *before* wiring the cathode (k) leads together.

Finally, fit IC1, IC2 and IC3. A socket is not essential for IC1 but sockets are advisable for IC2 and IC3 since these are CMOS types and therefore sensitive to static.

CASE DETAILS

The case employed is a plastic type that is easy to obtain. Being plastic, holes and apertures are so much easier and faster to accomplish, compared with aluminium or steel panel work. Photographs of the completed "machine" show a suggested top panel layout. As can be seen, the mounting hole requirements are quite straight forward. Mark-out and drill the ten in-line holes for the l.e.d. display. Since these are on the front panel, take care to protect the surface from scuff and scratch marks. Self-adhesive clear tape may prove useful.

It is important that the p.c.b. occupies a slot in the case where it cannot foul with the leads of the bottom l.e.d. (D13) or the fixings for the Touch Pads. With this in mind, choose a suitable site for the touch pad mounting holes before carefully drilling them.

The design of these is really open to personal preference, allowing you to exercise your own brand of creativity. Relatively plain looking aluminium pads were fabricated for the prototype but the sheet material could so easily be shaped to resemble an upper and lower lip, for example.

Bear in mind the following factors, concerning the pads. Ideally they should be of a material that does not quickly oxidise in the presence of moisture. In an indoor environment, aluminium is fine. It might benefit from an occasional polish however. Zinc plated screws, bolts or sheet would provide ultimate reliability in more adverse conditions and stainless steel would give a real glitzy appearance.

The area of bodily skin making contact on each pad should be relatively high, compared with the gap between the pads themselves. Position the pads close together so that there is always adequate contact resistance to operate the circuit, no matter who is trying.

The lower half of the case needs an aperture cutout in one side panel to take the On/Off slider or toggle switch S1, and a matrix of sound output holes drilled in the "floor" for LS1. The loudspeaker itself can be fixed most simply by using double-sided sticky tape. The thick variety is best. The tape is applied so that it forms a continuous sealing ring around the cone to panel fixing surface.

FINAL ASSEMBLY

Complete construction by sliding the p.c.b. into the case, then wire all the appropriate flying leads to the l.e.d. display, switch, touch pads and loudspeaker. Use the interconnection diagram, Fig.4 as a guide.

Using the specified case, the p.c.b. is best positioned in the fourth slot from the bottom end. The battery can then be conveniently accommodated in the void created between the track side of the board and the case. Also, it avoids fouling the bottom l.e.d. and the touch pad fixings.

It is advisable to insert a pre-shaped piece of card or foam padding into the "battery compartment" to cushion the battery. This will stop it rattling around and possibly shorting out any solder joints on the underside of the p.c.b.

The final touch is effected by applying four self-adhesive feet on the underside of the case. These will lift the case clear of whatever surface the unit is placed upon, allowing the audio frequencies to escape.

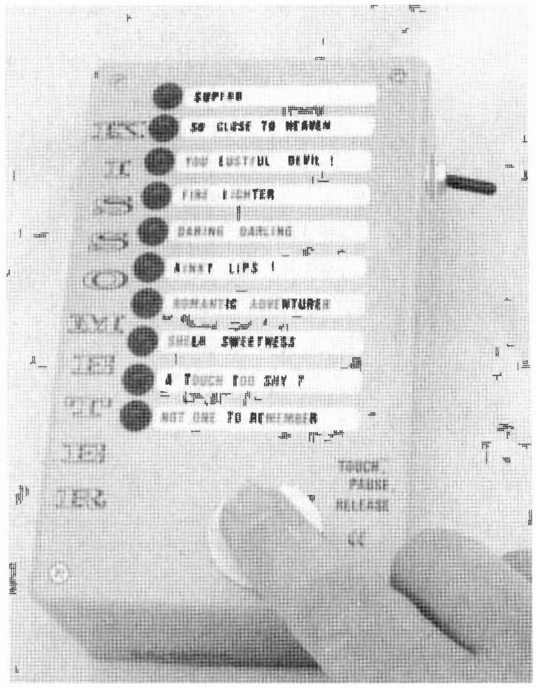
TESTING

Before applying battery power, recheck the battery clip connections. With a multimeter, set to an ohms range, check between solder pins P1 and P2 for any obvious short-circuits. Place the positive probe on terminal P2. A brief examination of your soldering workmanship at this stage will allow the quick location of unwanted anomalies like solder bridges and dry joints.

Connect the battery and switch S1 on, initially there should be no sound from the loudspeaker and only one l.e.d. should be lit. If some noise is present, check that the output of IC1b , at pin 7 is not more than 2V below the d.c. positive supply. The input at pin 6 of IC1 should be at the 0V level.

Place a finger or some conductive material across the touch pads. Almost immediately, sound will emanate from loudspeaker and the stationary, single l.e.d. will extinguish. If you are using a finger across the touch pads, the sound will vary in frequency in a fashion that is dependant on the applied pressure and skin resistance, as discussed earlier in the text.

In this state, the output of IC1b , at pin 7 should be within 2V of the 0V supply potential at terminal pin P1. For confirmation that the audio amplifier is biased on correctly, measure the voltage dropped across resistor R10. This level should be between 0·8V and 1V, indicating a collector current of, typically 16mA d.c. The l.e.d. display will be off since the voltage at the base (b) of transistor TR2 will be no higher than 0·3V.



If no activity occurs at all, first suspect the possible incorrect positioning of diode D3 before thinking that the amplifier may be at fault. If D3 is fitted the wrong way round, then no control voltage will reach the voltage controlled oscillator; therefore no output frequency will be available to the amplifier, or indeed to clock the counter of IC3.

Assuming all is well, finally lift the object off the touch pads and note what happens next. After a short delay the sound should cease and the l.e.d. display will light up. The movement of the l.e.d. light may be quite fast to begin with, or slower, depending on what upper frequency the oscillator was taken to. Whichever is the case, the l.e.d. should soon slow and then come to a stop.

If the l.e.d. settles at the same time as the sound stops, then check that capacitor C4 is correctlly positioned and in circuit, also that the value of resistor R11 is 360 kilohms.

IN USE

Operation of the Kissometer is quite straightforward; it is the specific application or interpretation of its output that is open to one's own imagination. With this in mind, it is a good idea to use a method of labelling each l.e.d. position that allows changes to be made with relative ease.

For the prototype model, the front panel l.e.d. annotations were made using self-adhesive white labels, upon which rub-down dry transfer lettering was applied. This was carried out *before* the labels were stuck on the front panel, adjacent to each l.e.d.

To ensure a good degree of reliability it is advisable to clean the Touch Pads from time to time. Over extended periods of use, the deposits of dust – even grease and grime of biological origin – will reduce the unit's response slightly.

Be aware that too much moisture could engage the sound output continuously. Certainly do not leave it out in the rain or take it into the bath!

Happy Valentine's Day! □

CHIP SPECIAL

HT7630 D.C. PIR CONTROLLER

ANDY FLIND

Taking a constructor's look at Holtek's extremely useful new PIR controller chip.

THE Holtek HT7630 is a complete PIR (Passive Infra-Red) amplifier and alarm control system contained in a single 16-pin d.i.l. i.c. With a "micro-power" standby current of around 30µA and a supply voltage range of 5V to 12V it is ideally suited to stand-alone battery-powered applications, although its various programmable control options could easily find other uses.

The pin functions for the HT7630 are shown in Fig.1. In broad terms it contains an analogue section consisting of two op.amps and a window comparator, and a digital section to process received signals and provide various control functions. Conveniently, all analogue inputs are on the left-hand side of the device, whilst all but one of the digital ones are on the right.

Intending users of this i.c. should be aware that much of the internal circuitry tends to treat the positive supply rail as "ground" instead of the more usual negative ground rail. This doesn't cause problems in stand-alone battery applications, and there should not be too much difficulty in adapting it to fit into other systems. However, it should be borne in mind when following the operation of the circuit.

ANALOGUE SECTION

Starting with the analogue section, this has an internal voltage reference output "V_{EE}" which is available from pin 1. A typical PIR amplifier circuit has high gain at very low frequency and is therefore easily affected by small changes in supply voltage, such as might occur when a battery power supply is called upon to operate a siren or similar warning device.

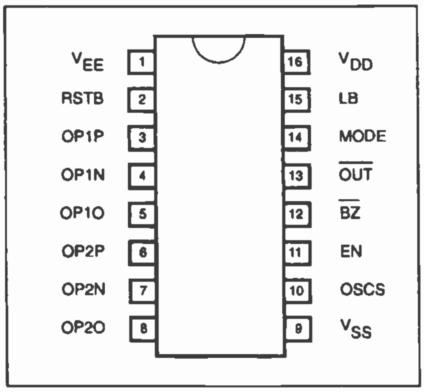


Fig.1. Pin connections for the HT7630.

The effect of these changes can be minimised by careful use of a stable voltage supply for the sensor and amplifier biasing. The "V_{EE}" output is nominally 4V, but note that this is a negative voltage with respect to the positive supply rail.

Two op.amps are provided, both having inputs and outputs fully accessible by the user. Those of the first, OP1, are uncommitted but the second, OP2, has a bias voltage applied internally to its non-inverting input and its output is connected to a window comparator stage as shown in Fig.2.

The two amplifiers can be used together with the reference voltage to construct circuits to suit most types of PIR sensor, and the internal comparator senses voltage excursions greater than about 0·25V in either direction as "trigger" signals.

The external circuit shown in Fig.2 was

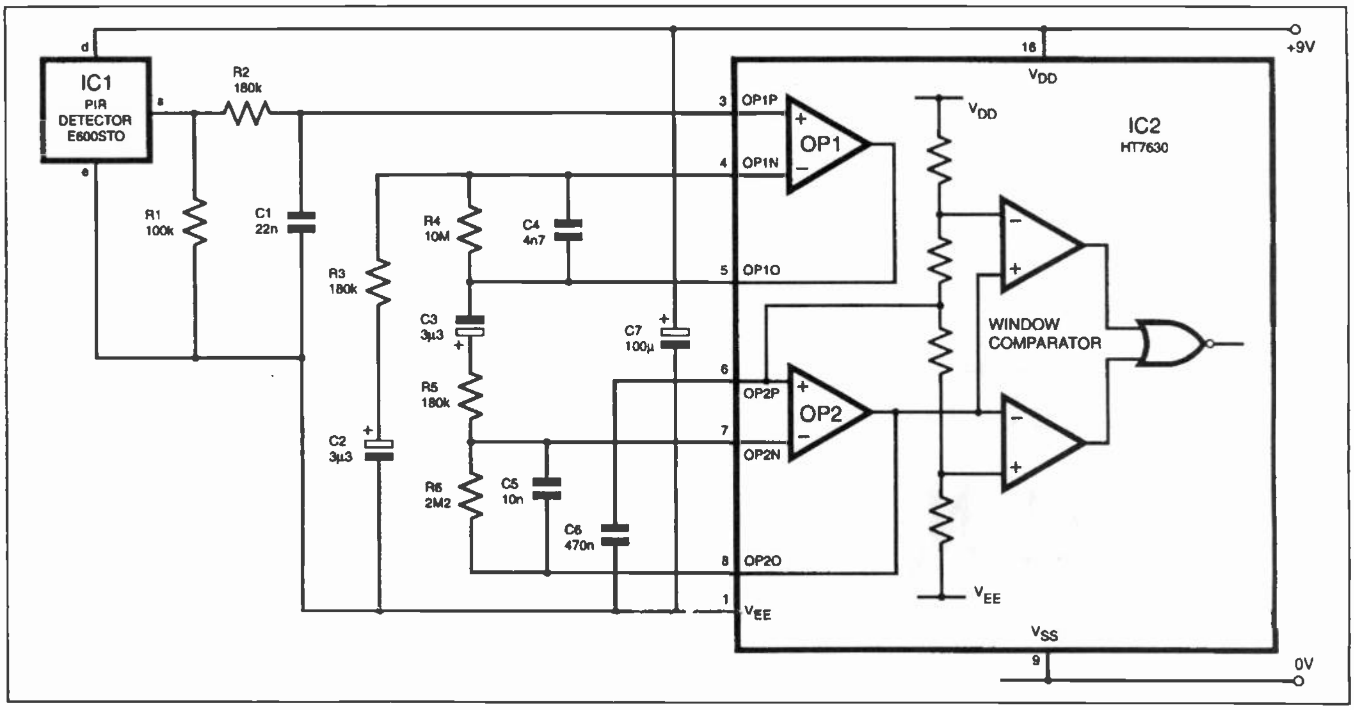


Fig.2. Internal analogue circuit and external input circuit for a PIR Detector.

developed from the author's *Micropower PIR* circuit in *EPE* July-Sept '97, and worked very well in bench tests. Sadly, the output of the internal comparator is not available to the user but goes directly to the control logic provided within the i.c.

The sensitivity of the circuit shown may be altered by adjustment of the value of resistor R6 and tests suggest that this could be doubled before general noise and drift would start generating false alarms. If the value of R6 is changed it is advisable to alter the value of C5 in roughly inverse proportion, e.g. with 4M7 for R6, C5 should be 4n7 or 5n6.

VALIDITY CHECKING

Before moving on to the control logic section of the device it is worth looking at the way input signals are interpreted for validity. Three types of signal will trigger the output. The first is simply three pulses from the comparator within two seconds. The second is two pulses where one continues for longer than 160ms and the third is a single pulse exceeding 340ms.

These timings assume a system clock of 8kHz, which will be described shortly. This combination is intended to eliminate most false triggering signals but its effectiveness will depend upon factors such as the type and position of the sensor.

The control logic offers some interesting functions and is easily programmed through simple pin connections. Readers wishing to experiment with the device might like to construct a "breadboard" version of the circuit shown in Fig.3, which will allow a "feel" for the various functions to be obtained without the complication of actually triggering it through a PIR circuit.

To provide trigger signals, OP2 is connected so that when the input to R2 is touched against either supply rail the comparator will give an output.

DIGITAL LOGIC

Moving to the logic side of the device, the first requirement is the system clock, which is set by resistor R4 and capacitor C2. The value of R4 given by the data sheet is 910k for a clock frequency of 8kHz but in practice the circuit works happily with the 1M shown. Note that other frequencies and timings described here all depend upon a correct clock frequency.

The next essential for circuit operation is a connection to the low supply voltage detection input LB, pin 15. If this function is not required it may be disabled by connecting pin 15 to V_{SS}, but with the two resistors R5 and R6 as shown it will detect supply voltages below about 6·8V. Other voltages can be programmed by selection of suitable resistor values using the formula $V_{trip} = 1{\cdot}45 \times (R5 + R6)/R5$.

A 100n capacitor, C1, is connected between the reset input, RSTB, pin 2, and the reference output V_{EE}. Input RSTB is active when pulled low, so this capacitor helps to ensure reliable start-up. During operation, RSTB settles to the supply voltage V_{DD}. If it is required to reset the device without switching off, this may be achieved by connecting it momentarily to V_{EE}, or through R1 to either V_{EE} or V_{SS}. It should *not* be connected directly to V_{SS} as this results in heavy current flow, which may cause damage.

Status indication is provided from the BZ output at pin 12. Signals from this pin consist of a burst of negative-going pulses with a frequency of 4kHz, which can drive an l.e.d. or a piezo buzzer or both, as shown. The buzzer should be of the simple type containing just the piezo element, not the variety with a built-in oscillator intended for d.c. operations.

WARMING UP

When first powered up, the i.c. provides a warm-up period of about 40 seconds. This is intended to allow the PIR circuit to settle, but will obviously also allow time for the user to leave the detection area after arming the device. For most of this period, the status output will give single output pulses at intervals of 1·5 seconds, but for the last eight seconds the output pulses will be in groups of four, indicating that active operation is imminent.

During the warm-up period, the i.c. checks for a low supply voltage condition. If this is detected a series of eight rapid pulses is given from output BZ and operation halts. Otherwise, following the warm-up period the system should become operational. Each valid trigger input will now result in four rapid pulses from output BZ, and with Mode and Enable (pins 14 and 11) wired to positive supply as shown, there should be a four-second output from the OUT connection, pin 13.

The latter is an open-drain output which can sink but not source current. If it is interfaced to a logic input it may require a pull-up resistor. Maximum load is about 12mA, so most sirens or similar output devices will require a current-boosting stage of some kind.

The Enable input, pin 11, enables operation of the main output when high (positive). If it is taken low (negative) it will disable this output, although the rest of the system will continue to operate as before.

OPERATING MODES

Two modes of operation are possible, selectable with the Mode input pin 14. If this is made positive as shown in Fig.3 (connection of V_{DD}), the i.c. will be in Doorbell mode. A valid trigger input will result in a four-second output, following which the system returns to the Ready state.

If Mode is made negative (connected to V_{SS}), the mode will change to Alarm. Triggered outputs will now last for 32 seconds, and in addition the status output, BZ, will pulse every three seconds until the system is manually reset to indicate that an alarm has taken place.

For initial experimenting and testing it is suggested that Mode is set to Doorbell.

PRACTICAL USES

There should be a host of applications for this i.c. From automatic doorbells to personal property protection systems, to alarms for garages and garden sheds where mains power is not available, possible uses seem endless. The logic section could be used by itself as part of a larger system, as it would be simpler (and cheaper) than a processor or a board full of timing logic.

For more sophisticated processing of trigger signals an output could be taken from BZ with the device in Doorbell mode. Sensors other than PIR detectors might be used, employing the two op.amps in the i.c. for any analogue functions.

The micropower supply requirements make long-term battery operation possible with circuits using HT7630 running for months or even years from an alkaline PP3 or a pack of AA cells.

ENJOY IT!

Finally, this i.c. is fun to play with! Using just a handful of external parts the experimenter can have it bleeping away and flashing l.e.d.s in no time as it goes through its warm-up and detection routines, and with very little extra effort it can be operating as a very sensitive PIR detector unit.

For those of us who enjoy this side of the hobby it's well worth investing in one for the entertainment value alone.

The HT7630 is available from Maplin, whose code is JA43W.

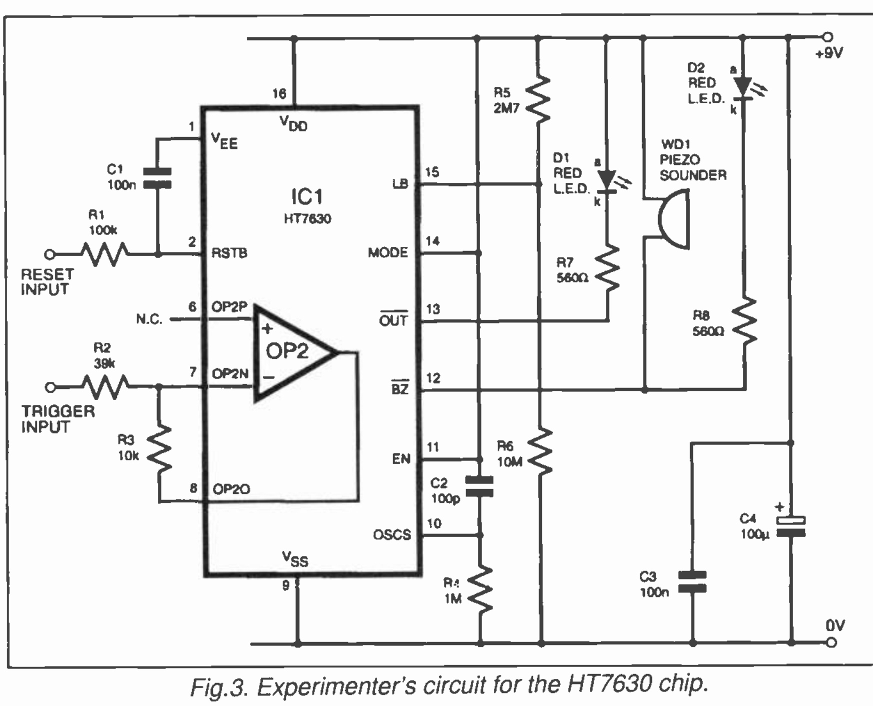
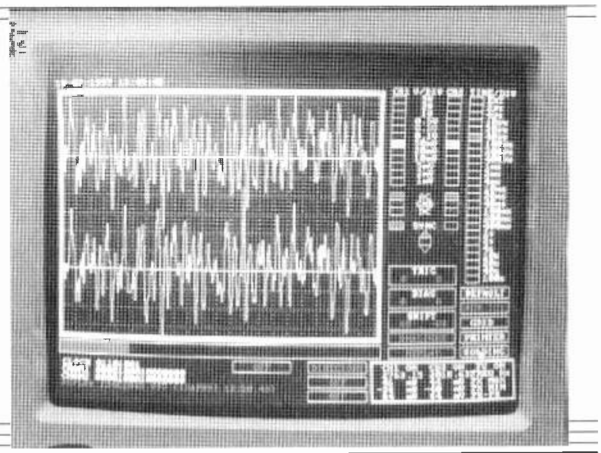


Fig.3. Experimenter's circuit for the HT7630 chip.

Constructional Project

EPE VIRTUAL SCOPE Part 2



JOHN BECKER

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

LAST month we made the statement "any computer with a screen display can be used as an oscilloscope, provided the right interfaces are used with it". We then proceeded to give all the circuits and components lists to make this possible, at least with most PCs.

We conclude this month with the constructional details for the Digital and Analogue circuit boards, setting-up and use.

CONSTRUCTION

Details of the Digital Control printed circuit board (p.c.b.) component layout, together with the full size copper foil master, are shown in Fig.8 and those for the Analogue p.c.b. are given in Fig.9. Both boards are available from the *EPE PCB Service*, codes 176 (Digital) and 177 (Analogue), respectively.

Two copies of the analogue p.c.b. are needed for the full dual channel system. Only one digital board is needed irrespective of whether you are building the single or dual channel version.

SCREENING PLATE

Before assembling the p.c.b.s, cut a sheet of copper-clad fibreglass to the same size as the digital p.c.b. This will serve as a screen between this board and the analogue boards, and also provide a mounting platform for the latter. A sheet of aluminium may be used instead.

With all the p.c.b.s, drill out to size (typically 4mm) the holes into which the p.c.b. supports will be pushed, and those for the bolt holes of sockets SK1 and SK2. Four 4mm holes should also be drilled into the screening plate in line with the four corner holes of the digital p.c.b. – use the latter as a template.

The holes for voltage regulator IC27 should be drilled out to 1·3mm, and those for all the terminal pins to 1·0mm. It may also be necessary to drill out to 1·0mm the pin holes for SK1 and SK2.

When enlarging any of the p.c.b. holes, use a drill bit of the correct size – trying to use "bodge" techniques will damage the copper track and pad adhesion on the p.c.b.

Numerous wire links are required by the p.c.b.s. These should be made the *first* assembly task. Use 24s.w.g. tinned annealed copper wire for the links – it is available on small bobbins from a variety of sources. You won't need the whole bobbin, but a roll of this wire is invaluable to have in the workshop.

Don't waste your time by trying to use ordinary stranded connecting wire; individual strands are too thin for convenience and stripping off the plastic sheathing is tedious.

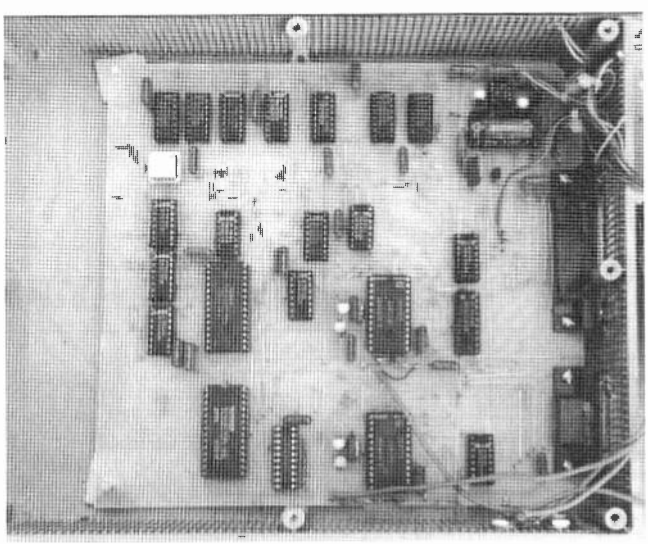
Note than many link wires will end up under the dual-in-line (d.i.l.) socket positions. The links should be neatly bent to shape using thin-nosed pliers.

Next insert all the d.i.l. sockets – do not solder the d.i.l. chips into the board. Then assemble the remaining components in ascending order of size, observing their polarities as appropriate.

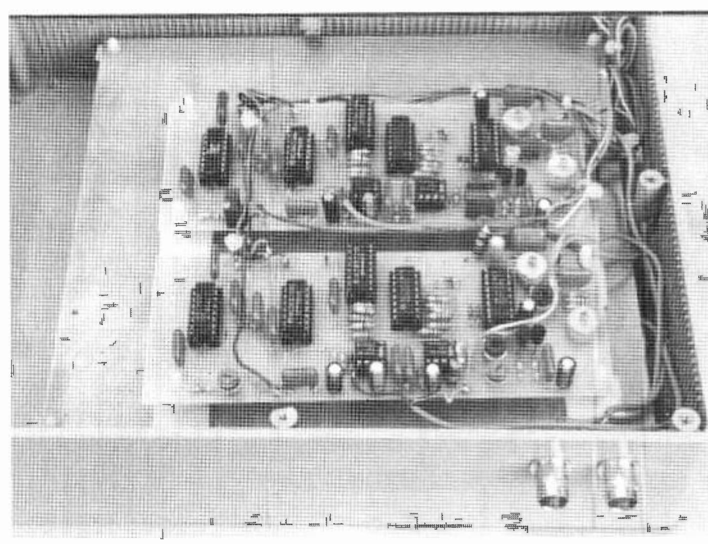
The analogue board has been designed to accept multi-turn or single turn presets. The latter are cheaper but less precise in their adjustment – let your wallet dictate your choice!

Insert sockets SK1 and SK2, bolt them to the board and tighten down the nuts *before* soldering their pins. Solder 1mm terminal pins into all the remaining holes.

Thoroughly check all soldered joints with a close-up magnifying glass, and recheck that all components are correctly inserted.



The digital circuit board is mounted on the case base via self-adhesive plastic supports.



Stacking pillars are used to attach the "screening plate" between the digital and analogue boards.

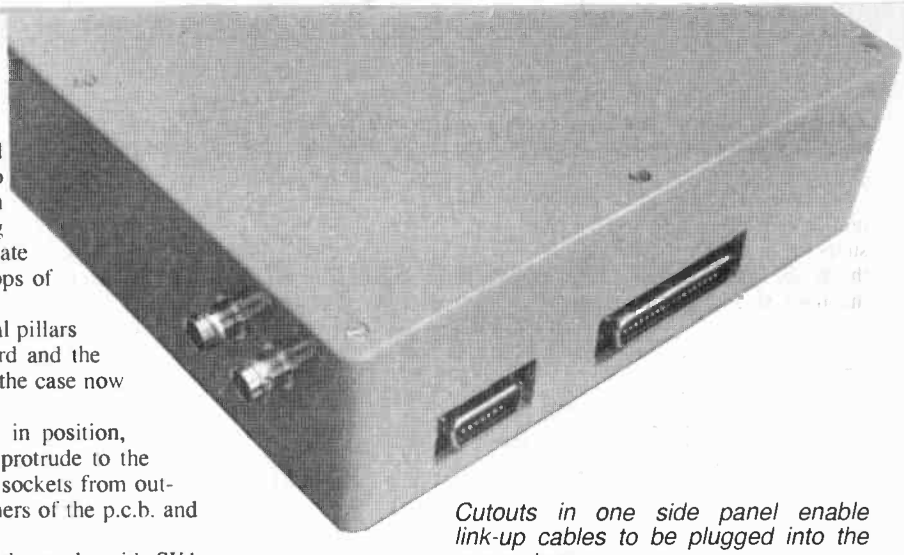
CASE PREPARATION

Temporarily remove the bolts from SK1 and SK2. Push the self-adhesive feet (supports) into all the p.c.b.s but leave their protective film in position for the moment. Push the four stacking pillars into the lower side of the screening plate (copper face upwards), and loosely onto the tops of the supports for the digital board.

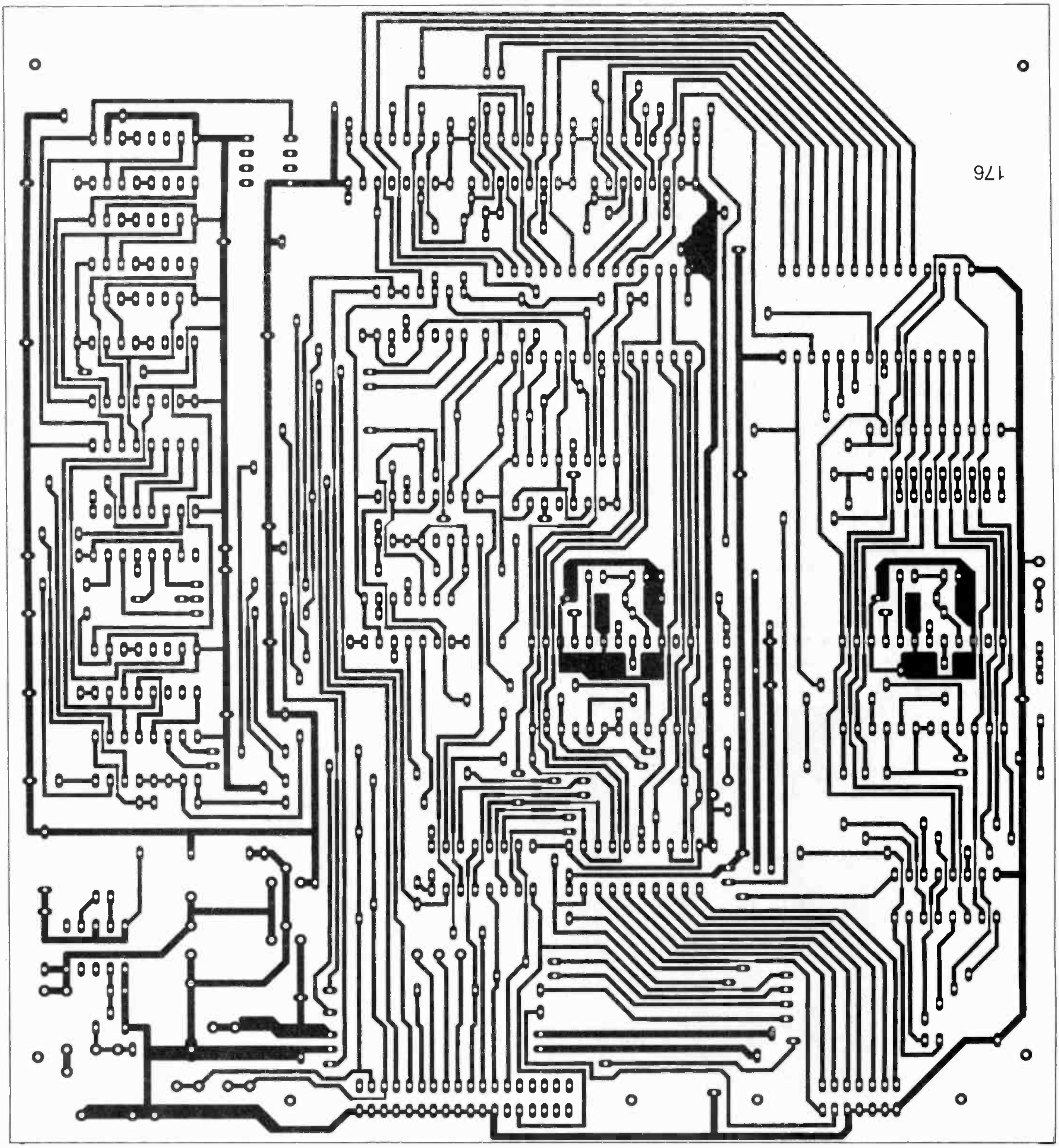
Cut (or file) horizontal slots in the two central pillars (long side) of the case so that the digital board and the screening plate can fit inside. Having done so, the case now needs to be drilled for the sockets.

With the digital board and screening plate in position, mark and cut out slots so that SK1 and SK2 protrude to the exterior. Check that the connectors fit into the sockets from outside. You may need to slightly file off the corners of the p.c.b. and screening plate.

Remove the screening plate and reposition the p.c.b. with SK1 and SK2 protruding correctly. Mark and drill holes through the base



Cutouts in one side panel enable link-up cables to be plugged into the connectors.



of the case in line with the downwards bolt holes of SK1 and SK2. Now cut these holes into slots lengthwise along the case floor.

Re-bolt SK1 and SK2, add additional nuts to each bolt so that they and the p.c.b. supports sit evenly on the case floor. Refit the p.c.b. with the bolts passing through the floor slots. Slide it into position and secure nuts to the bolts (with grip-washers) to hold the p.c.b. securely in place.

When bolting down, ensure that the spacer nuts prevent the p.c.b. from buckling when the external nuts are fully tightened.

Sockets SK3, SK4, SK102 and SK103 can be mounted where you prefer, but take care that their position will allow the digital board and screening plate to be removed if necessary. Sockets SK3 and SK103 are seen in the photographs; the author did not use SK4 and SK102.

Peel off the protective film from the feet of the self-adhesive supports for the analogue p.c.b.s. and *carefully* position both these boards on top of the screening plate (see photograph).

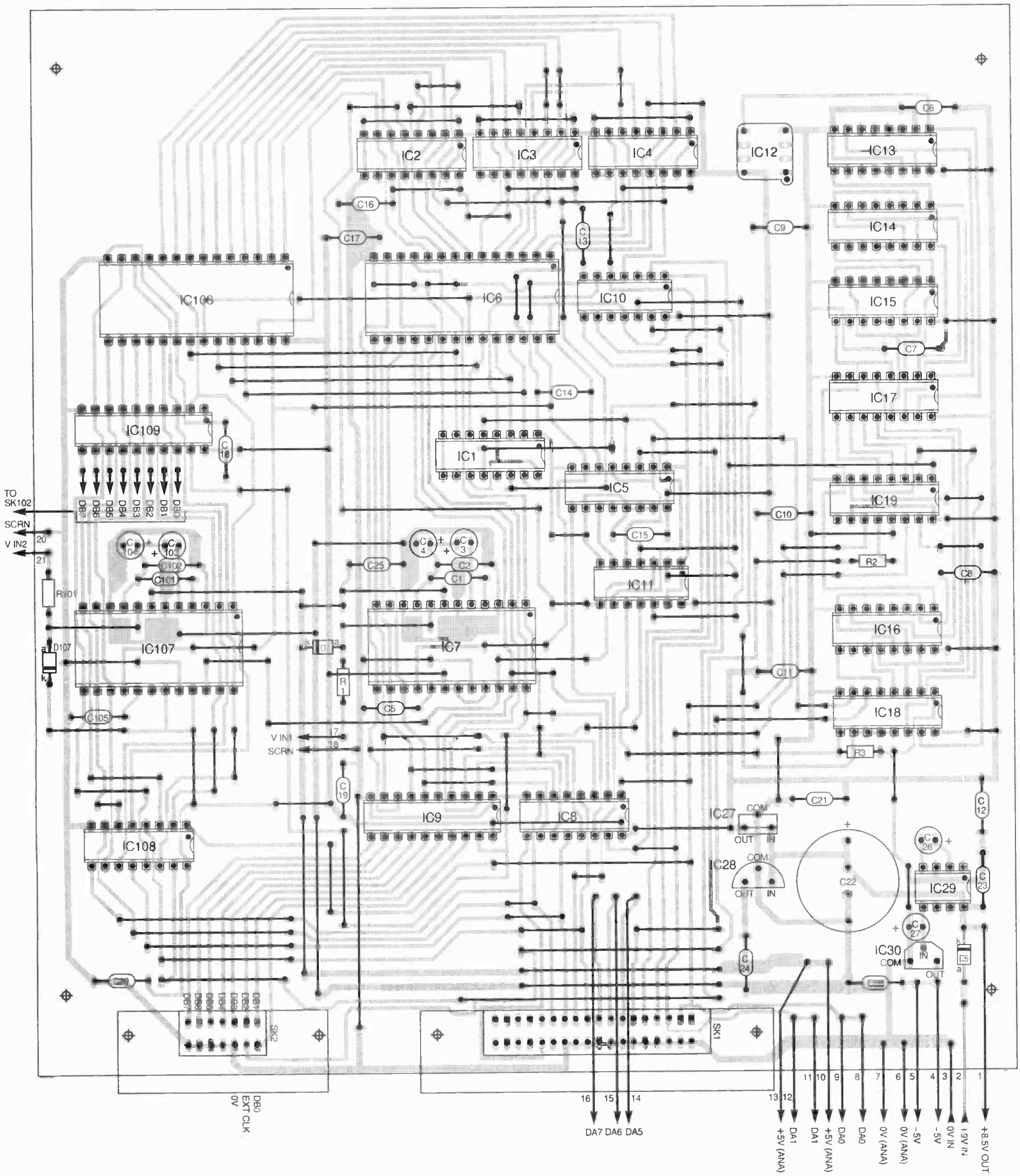


Fig.8. Digital printed circuit board component layout and (left) underside copper foil master pattern.

INTERWIRING

Remove the entire p.c.b. and screening plate assembly from the case and wire-up between the boards as detailed in Fig.10. Screened wire is required for the four analogue signal connections but normal stranded wire (plastic sheathed 7/0·2mm) can be used for all other connections.

It is preferable to keep the shift register connecting wires in a separate harness, held neatly by cable ties. These connections are numbered 9, 10, 11, 15 and 29 to 32.

Power supply lines should also be neatly harnessed (connections 1, 4, 6, 22, 23, 26). Solder the required 0V connection to the screening plate (via a bolted solder tag if the plate is aluminium).

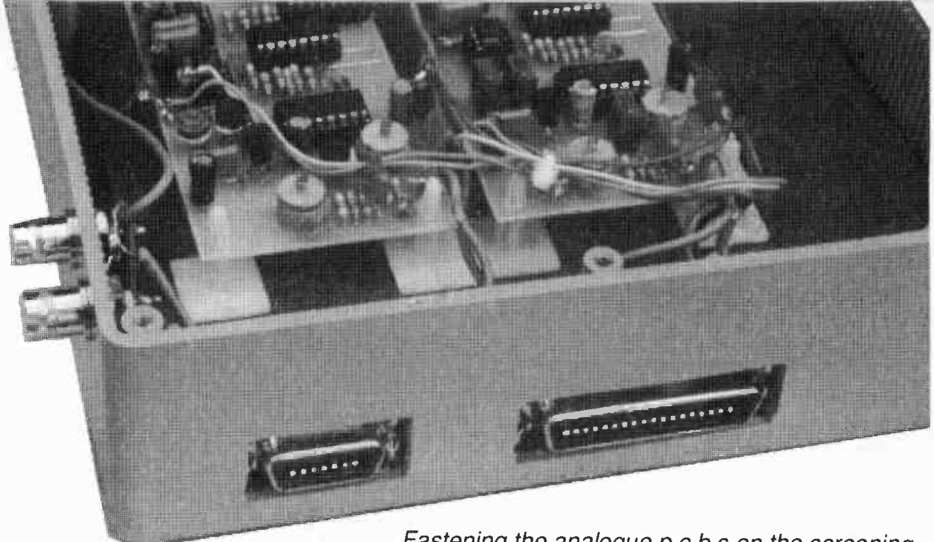
Keep all connections reasonably short but allow for the boards to be turned over for access to the track side if necessary.

Return the p.c.b. assembly to the case and complete the wiring to sockets SK3, SK102, SK103 and SK4. Neatly harness the SK102 connections.

DO NOT combine the separate wiring harnesses into one larger harness.

Now make up the external connectors for the digital input sockets. Use coloured ribbon cable of about one metre in length. Carefully solder the cable to the required connector pins, in colour coded order, i.e. black to DB0, brown to DB1, red to DB2 etc.

Connector SK102 does need the external clock input pin to be connected.



Fastening the analogue p.c.b.s on the screening plate is achieved by using self-adhesive stand-off pillars. The BNC analogue signal sockets can be seen on the left.

CHECKING OUT

It is imperative that the power supply is checked out first of all. Insert IC29 but do not insert any of the other d.i.l. chips. During overall checking, always switch off the power *before* making any corrections or inserting chips. All chips should be regarded as static-sensitive and treated accordingly – touch an earthed item before handling them.

Connect the unit to a 9V d.c. supply. Check the voltages stated alongside the p.c.b. wiring connection pins as shown in Fig.8 and Fig.9. Also check that +5V

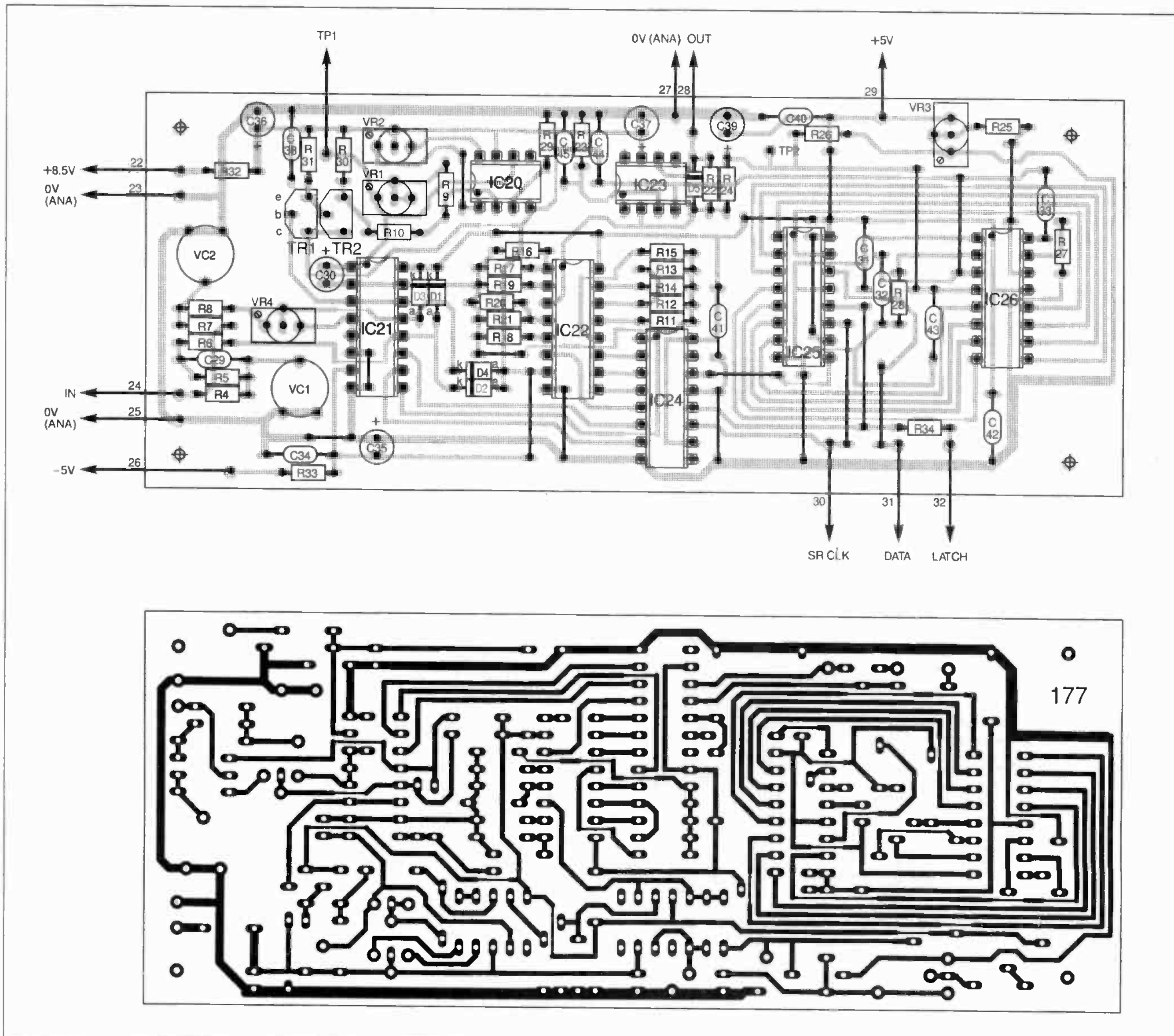


Fig.9. Printed circuit board and full size copper master pattern for one channel of the analogue section.

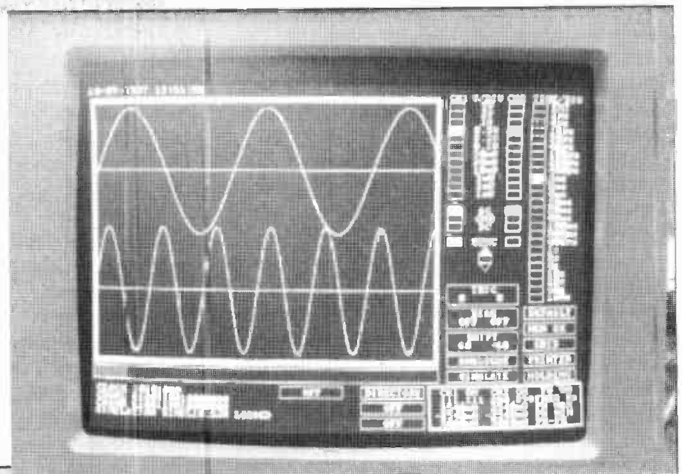
exists at the OUT pin of IC27. The value of 8·5V at pin 1 might be a bit lower, but the others should be almost identical to the voltages stated.

Insert the remaining chips and again check the voltages.

DISPLAY FUNCTIONS

Connect the unit to the computer, switch on and then load and run the program. The software will start running with all parameters set to default values. *Until setting-up has been done, DO NOT click the mouse on any box unless you are told to.* (See also the DEFAULT paragraphs later.)

The horizontal box below the display area should show a short light-blue bargraph fractionally changing length as various samples are read from the unit. The rate of change will be entirely dependent on the speed at which the computer is running. The maximum bargraph length reflects the amount of interface unit memory space in use.



Twin sine waves at different frequencies. Note the functional details in the boxes.

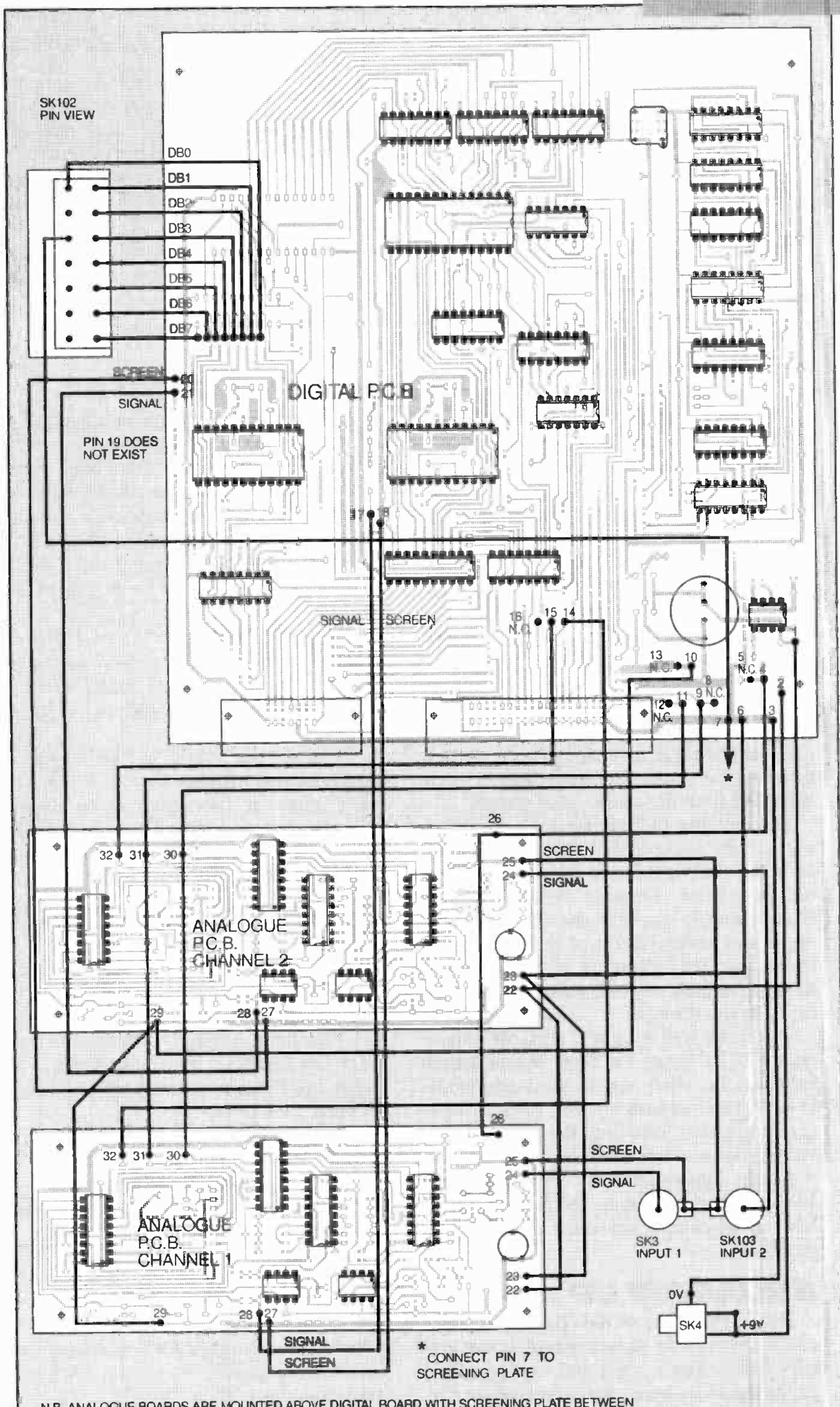


Fig.10. Interwiring details between the digital and analogue boards and off-board connectors.

Two other screen boxes should show that AC mode is selected for both analogue channels (the boxes being coloured yellow). Channel 1 is the left hand column of that section (CH1), Channel 2 its right hand column (CH2). Click the mouse on the two GND boxes; the boxes should turn yellow, and the AC boxes become clear (background-blue).

The far right hand column of boxes (TIME/DIV) is for selecting the sampling rate. The rate should be seen as 400µs per division.

ANALOGUE ALIGNMENT

Allow a few minutes for the unit to stabilise its running temperature. Then, with each analogue channel and using a multimeter on a range suitable to read +5V d.c., adjust preset VR2 until IC20 pin 6 has an output voltage as near to 0V as you can set it. Switch to a lower range for the final stages.

If you are using multiturn presets, you may find that it takes several turns before any response is noted. When clicks are heard from the preset, you have reached the end of its wiper travel.

Plug in the scope probes to sockets SK3 and SK103. They should be set to ×1 attenuation, using their ×1/×10 switch. Note that probes without attenuation switches are likely to have ×10 attenuation built in, consequently the screen display will appear to be ten times less than that expected.

Clip each probe's screening connection clip to the tip of the probe, thereby grounding the tip and its input to the unit. Click the mouse on DC for both channels and check that IC20 pin 6 is at the same 0V level. The accuracy of the 0V setting determines the unit's relative response to d.c. inputs (although some compensation is available via the software).

TRUE LINE-UP

Click both GNDs back on and observe the screen. Taking one channel at a time, establish which white horizontal lines in the display area are associated with which control box.

Now left-click on the TRIG box (its appropriate left or right numerical portion – zero at present) and, while still holding down the mouse button, press any keyboard key. One of the lines in the upper half of the screen should shift upwards and become apparent as a dotted line, revealing a continuous white line when doing so.

The dotted line is the one that shows the voltage level at which sync is triggered when Sync mode is on (it's off at the moment). It is only a software control and does not affect the unit itself.

The continuous line that has been revealed shows the 0V reference position for that channel. This is the position on the screen to which the signal display line for that channel has to be shifted by using the bias-setting preset VR3 (V-REF).

The value in the TRIG box will be seen to be incrementing from zero upwards while the mouse is clicked and a key pressed.

Changing to the mouse righthand button and with the key still pressed, allow the line to return to its start position at zero. It will descend below zero if the button and key remain pressed.

Adjust VR3 and watch for another (continuous) white line to start moving on the screen. Again, it may take some time before any movement becomes apparent. Move this line until it coincides with the dotted TRIG line (and the other continuous line); this is the required position for 0V.

While pressing a key, alternate between pressing each mouse button with the cursor on the BIAS box numeral area, to check that the newly set line can be shifted up and down the screen. The value associated with the BIAS box should change from zero and increment or decrement accordingly. Return the box value to zero.

SHIFT CONTROL

The SHIFT control can now be checked. This is purely a software control and does not affect the electronics of the unit. Periodically alternating between left and right mouse buttons, click the mouse on the number in the appropriate box while pressing a key. All three lines (0V REF, BIAS and TRIG) for this channel should be seen to shift together, appearing to be just one line moving.

You can also check that the lines move together in harmony by first changing the TRIG line position.

The default value for the SHIFT control is 60 for Channel 1 and −60 for Channel 2. This is purely for visual convenience so that the two signal traces can normally be observed at different parts of the screen. When direct comparison between two signals is required, the two waveforms can be shifted to coincide.

If you haven't already spotted it, each click on a mouse button increases or decreases a box's numerical value by one – useful for fine correction of settings.

You might also have noticed that three text lines at the bottom left of the screen may change their binary values when some functions are changed. These are the control codes that are output to the three shift registers. They may be helpful if you have to trouble-shoot the assembly. The same bit values should occur in order on the output pins of the relevant registers.

GAIN SETTING

Channel gain factors can be optimised using presets VR1 and VR4. First of all set the unity gain (×1) accuracy using an a.c. signal as the input.

Note that the gain setting values shown on the screen are in volts per screen grid division. Clicking on the value column changes the units to gain factors as set on the amplifier. The next click reinstates the voltage factors. Set the display for the gain factors. You should see that a gain of ×1 is indicated (the default value when the program is started).

Ensure that the SHIFT settings are at 60 and −60 respectively.

Connect both probes to the same output of a sine wave signal generator set for about 1kHz at an amplitude of exactly 1.0V peak-to-peak. A digital multimeter set to a suitable a.c. range can be used to precisely monitor the amplitude. A peak-to-peak voltage of a perfect sine wave has an r.m.s. value of 0.353V. Adjust the level control of the sine wave generator until this output value is read on the meter, then disconnect the meter.

Click the mouse on AC for both channels. Two similar sine waves should be seen traversing the screen. The box at the righthand bottom of the screen should be showing the calculated voltage and frequency values for both inputs. Set SYNC on for Channel 1 (see later).

Using preset VR1, adjust the gain of each channel until the peak-to-peak value is shown as 1000mV. The MIN and MAX values should show −500mV and +500mV respectively. (The frequency value should also be shown in the same box.)

Voltage and frequency calculations are performed only when the screen trace reaches the right hand side of the display. Therefore, if your computer is somewhat slow, the values shown may not immediately change with each fractional adjustment of VR1. Be patient!

Also note that since the ADC only has 8-bit resolution, decimal places of a value may not remain static even when the signal level is, and there may be slight disparities between the values for both channels even when fed from the same signal source.

The equality of both waveforms can be checked by using SHIFT for each channel to bring the waveforms into coincidence on the screen. Observe how using the BIAS controls results in the values for the upper and lower aspects of the waveforms (relative to 0V) changing accordingly, although the peak-to-peak value remains essentially the same.

To set the 1/10 accuracy, click the mouse on the 1/10 boxes for both channels and increase the input signal level amplitude to 10V peak-to-peak (3·53V r.m.s.). Now carefully adjust VR4 until the values in the voltage box correspond with this amplitude.

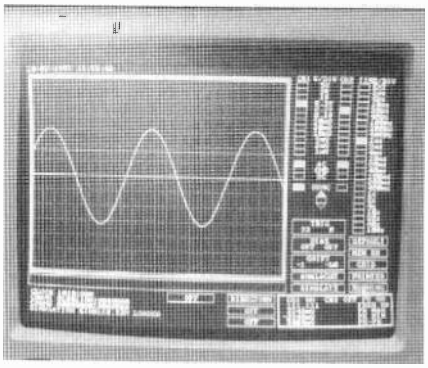
If your signal generator cannot produce a 10V p-p output, estimate the correctness of VR4 in relation to any other known input amplitude.

SQUARING UP

Due to the nature of the op.amps, the circuit's response to square waves is not totally linear. The leading and trailing edges of the square waves when observed on the screen may appear rounded or peaked. Full correction for this fact cannot be achieved, although it can be minimised using the variable capacitors VC1 and VC2.

Set the signal generator for a square wave output at about 1kHz and 1V peak to peak (neither value is critical). With the channels set for unity gain, adjust VC1 until the best shaped square wave is seen on the screen. Do the same with VC2 when the 1/10 setting is selected for a greater value input square wave.

It is worth while comparing the appearance of the waveform at different frequencies and choosing the VC1 and VC2 settings which produce the most uniform shape. (You may change the sampling rate via the TIME/DIV column if you wish.)



Single sine wave and grid background. Note the sync trigger line.

SAMPLING RATE

The sampling rate can be changed via the Rate boxes at the righthand side of the screen, clicking on the chosen one.

Be cautious when interpreting the screen display and calculated frequency factors. It is possible for the sampling and source frequencies to be at the wrong ratio and for harmonic waveforms to be displayed as a result.

This can cause a very fast input frequency to be seen as a slow frequency, because the samples are being taken on closely similar points of the waveform, but at several cycles apart.

Click on the values shown beside the rate selection column: instead of the sampling rates in time per screen division being shown, the values become the sampling frequency in Hertz. Clicking again returns to the time/division values.

CHANNEL SELECTION

At the bottom right hand side of the screen is the box which displays amplitude and frequency factors. Channel selection is performed via this box. Clicking the Channel 1 column cyclically switches between CH1 ON and CH1 OFF. Similarly, clicking in the Channel 2 column controls CH2 ON and CH2 OFF.

The software does not allow both channels to be switched off together. If you attempt to do so, the other channel will come back on. Channel selection is available in Analogue and Digital modes, but not in Lissajous.

Note that voltage and frequency calculation routines can be inhibited from within the same box by clicking on the FV ON column, revealing FV OFF. Clicking again restores the mode. Waveform plotting is somewhat faster with FV OFF.

Note that frequency is calculated in relation to at least four crossings of the sync trigger value "window" by the waveform. Although the trigger value is shown as a single line and value on the screen, the "window frame" is set ten sample bits above and below the value (a 20-bit window – just over one vertical grid division's worth). The respective frame value has to be crossed before the trigger value crossing is registered.

This hysteresis (Schmitt trigger principle) makes frequency analysis cleaner in the presence of slightly noisy source signals. If sufficient window crossings are not detected, the frequency value is displayed as zero.

WAVEFORM SYNC

You will have seen the waveforms shift their relative positions across the screen. As with a normal scope, the waveforms can be synchronised to begin at a set trigger value, stabilising their display. Synchronising can be set for a rising voltage or a falling one; it is a software control and does not affect the interface electronics.

Immediately below the word SYNC is a 3-section box with upwards and downwards triangles. At present, a yellow oblong will be seen between them. This is the OFF position for sync. Change the signal generator back to sine wave mode at a reasonable amplitude and a frequency at which just a few cycles of the waveform are seen.

Click on the upwards pointing triangle. It will change to yellow and both waveforms will appear far more stationary. Using the TRIG control, vary the value in the box for Channel 1. It will be seen that the position at which the waveform starts varies in amplitude.

Next click on the downwards pointing sync triangle and observe how the starting position has changed to the opposite side of the waveform. Now click on the box immediately to the right of the word SYNC. It will become yellow and the equivalent left hand box will clear. Synchronisation is now in relation to CH2, whereas before it was for CH1.

If you have a signal generator which can output two waveforms at different frequencies, couple one frequency into CH1 and the other into CH2. Experiment with different sync source selections, modes and triggering values, observing the results.

As with frequency calculation, a window technique is used for sync detection. It too is 10 bits above and below the sync trigger line. The waveform value has to cross through the window in both directions for a sync point, of either phase, to be recognised.

If a sync point is not found when SYNC is on, the display freezes while the software continues to sample in expectation of finding one. The situation can be remedied by increasing the signal amplitude, either at the input, or via the gain controls. It can also be terminated by clicking SYNC off.

It is not possible to synchronise both channels simultaneously.

Sync can be used in Digital mode but, unlike Analogue mode, a trigger level line is not shown. Consequently, the trigger level must be judged from the value in the TRIG box, or set via Analogue mode before entering Digital mode.

Whilst the sync function is available in Lissajous mode, its use appears to have little benefit.

GRID OPTION

The GRID box on the right hand side allows grid lines to be turned on or off. Click on it to see it in operation.

In Analogue mode, the grid boxes are spaced at 20 × 20 pixel intervals. Horizontally, each box covers 20 sample bytes; vertically it covers 20 sample value bits. The sub-division dots are at 4-pixel intervals.

In Digital mode, only the horizontal grid lines are shown, again at 20-pixel (sample) intervals. The grid is not available in Lissajous mode.

The grid is redrawn in machine code while the signal traces are being drawn. Trace drawing is marginally faster with the grid switched off, especially in Digital mode.

This is because only the screen sections where the digital waveforms need to be plotted have to be changed. These waveforms are of a fixed amplitude and so the screen area immediately above and below them does not need to be cleared.

In Analogue mode, however, the full screen area is available for waveform plotting, therefore the entire area has to be updated for each new screen display.

An additional fixed reference grid is provided in Digital mode. This takes the form of small red rectangles at the sides of the display area and indicates the range of each logic waveform. The top of the box is, of course, logic 1.

RUN AND HOLD

To the right of the screen is a box in which the yellow word RUNNING is shown. With Sync off and a waveform moving on the screen, click on this box to reveal the words HOLD ON. The waveform will freeze as soon as it reaches the right of the display and the word HOLDING will appear.

No further sampling takes place until you press a key or click the mouse again. Each time you press a key, another trace will traverse the screen and hold. This can continue for as many sweeps as you wish, allowing each display to be examined. The display always advances with time, you cannot step backwards to re-examine a previous display. To exit the Hold mode, click the mouse on the box, whereupon normal running will recommence.

LISSAJOUS MODE

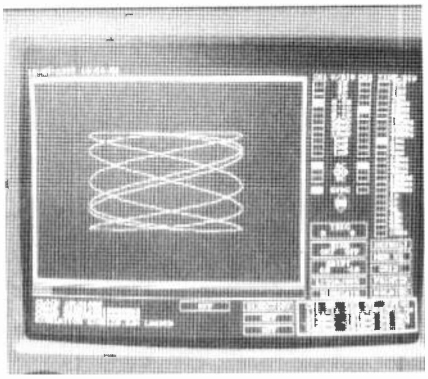
To examine the Lissajous function, input two sine waves at different frequencies while in normal running mode. Right-click on the box which says ANALOGUE. The word LISSAJOUS will appear and gyrating patterns will be seen. Adjusting the input frequencies so that they are nearly identical, more detail of these patterns will become apparent. (Inputting waveforms of equal frequency and phase will result in a single diagonal line.)

The vertical and horizontal aspects of the waveform can be increased or decreased by changing the channel gain settings. Their relative screen positions cannot be changed. Use the HOLD function to examine the waveform in detail.

As you will probably be aware, Lissajous patterns can be used for phase relationship analysis (it's beyond the scope of this article to discuss it, though).

To return from LISSAJOUS to ANALOGUE, left-click on LISSAJOUS. Should you inadvertently press the wrong mouse key on this box, DIGITAL mode will be selected. Unless a digital data source is connected to the unit via sockets SK2 and SK103, only garbage waveforms will be shown.

To get out of Digital mode, click the mouse button again. The mode selection operates on a repeating cycle of three. The left button clicks "forwards", the right button "backwards".



Displaying a Lissajous figure on screen.

DIGITAL MODE

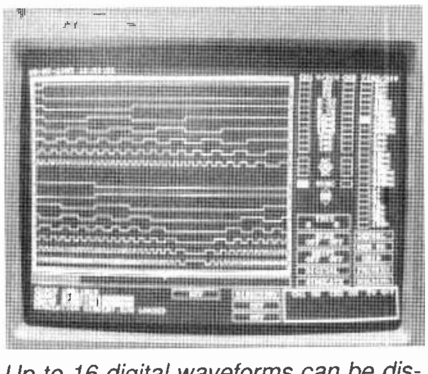
To use Digital mode, the "floating" ends of the ribbon cable are connected to the external circuit under examination. This must have the standard digital logic of 0V and 5V.

Do not use digital inputs with any other voltage range; at best the circuit will not respond correctly; at worst the interface chips IC9 and IC109 could die, with possible damage to other parts of the circuit. (There are "level-changing" chips available through which you could externally feed any non-standard logic signals if you need to examine them – the CMOS 4504, for example.)

It is not *necessary* to use the external clock input facility when in Digital mode. However, an external clock that is synchronous with the digital input will, in the case of rapidly changing input logic, result in cleaner sampling of the data.

Entering Digital mode (as you will have probably already found) is done by left-clicking on the ANALOGUE box so that DIGITAL is shown. Right-click on the same box to return to Analogue mode.

As with Analogue mode, either channel can be switched off by clicking on the



Up to 16 digital waveforms can be displayed on the screen.

channel selection box at the bottom right hand side.

MEMORY SIZE

There are three interface memory size options: MEM 2K, MEM 32K and MEM OFF. Normally, the mouse can be clicked to change to any setting – on another repeating cycle of three, left for "forwards", right for "backwards". There are, though, some situations where the memory size is fixed and when the mouse clicks are ignored. In Auto Save mode, for example, the size is fixed at 32K. (In Simulation mode, it's actually set at 8K, for file creation convenience.)

With a 2K memory, less interface memory has to be filled before being input for displaying on screen. The 32K capacity allows a longer continuous block of data to be sampled before being input for screen display.

When MEM OFF is selected, the computer causes the sampling to occur in direct response to individual commands from the computer itself, and in relation to the clock rate selected. Each separate sample taken is immediately plotted on screen. Input signal frequency factors are not calculated in this mode since the sampling rate is essentially unknown.

The advantage of being able to sample without interruption is that the samples are continuous, rather than in blocks.

How fast you can sample in this mode depends on your computer speed; there is a maximum rate limit which you can only find by trying.

Be aware that the display rate affects how fast the waveform crosses the screen. Since there are 440 pixels horizontally, 440 samples are needed to complete the display. A sampling rate of 0·2Hz thus takes a minimum of 2200 seconds for each full display crossing! It will take longer if SYNC is on.

SAVING DATA

Any Live waveform on the screen can be saved to disk (the Simulation test and Replay waveforms cannot, the program inhibits this). There are two Saving modes, automatic and manually triggered.

At the bottom centre of the screen are four boxes, AUTO SAVE, DIRECTORY, SAVE OFF and WAIT SAVE. Ignore DIRECTORY for the moment.

For manually saving waveforms, click on SAVE OFF. This display changes to SAVE ON. Simultaneously, the memory size defaults to 32K to ensure that the maximum amount of data is saved in each block.

When the next full screen display has been completed, the WAIT SAVE box changes to SAVE NOW. If you wish to save, left-click on SAVE NOW.

This action causes a uniquely-named disk file to be opened with a date and time related name. When Save mode is on, the data is also automatically stored in the computer's memory while being sampled. This 32K block of data is output to the disk immediately after the file has been opened.

Note that it is not a screen dump which is saved, but the actual source data. This allows the data to be subsequently re-input and manipulated on screen.

Having saved the data, the file is closed automatically and the next sample batch is taken and displayed, followed by the option to save this new 32K block. Even though the samples may be only a few seconds apart, their saved file name remains unique.

(The last statement assumes that your computer will not sample and save at a rate faster than one 32K block per second. The saved file name is only accurate to whole seconds and the computer will overwrite a previous file of the same date/time name.)

If you don't wish to save a particular block, right-click on SAVE NOW, or on any part of the screen except SAVE ON. This causes the next screenful of data to be plotted, followed again by the option to save. To turn off the Save mode, click on SAVE ON, restoring the SAVE OFF message.

Automatic Saving mode is entered by clicking on AUTO SAVE. The latter (normally-white) message changes colour to yellow. Simultaneously, SAVE OFF changes to SAVE ON, WAIT SAVE goes blank and the memory size defaults to 32K.

Now, each time the screen display completes its 32K data block, the data is automatically saved to unique file names again.

To exit AUTO SAVE, click on AUTO SAVE or SAVE ON to revert to SAVE OFF.

Be aware that Auto Save mode can consume a lot of disk space (32K per block). Its use is probably best reserved for short runs of high speed sampling or long runs of slow sampling. Remember to delete disk files (from DOS mode) when they are no longer wanted. The Virtual Scope's directory screen should not be allowed to become full.

DATA RECALL

To recall disk file data to the screen, left-click on DIRECTORY. The entire screen display now blanks out and displays all the file names having the extension .Y?? (where ?? is any two letters or numbers) in the order in which they are stored on disk. Note that the order is not sorted and depends on where DOS (Disk Operating System) finds the first space available when saving.

Moving the mouse will cause a highlight bar to appear on individual file names. To select one, left-click on it. At the bottom of the screen a text line asks if this is the file you want to load, quoting its name and concluding with *y/n*.

In answer for *yes*, you can either press keyboard letter *Y*, or just left-click the mouse. For *no* press *N* or right-click the mouse. (Key letters may be in caps or lower case.)

If *yes* is the answer, the file is loaded and the full normal screen display is resumed with the loaded file being played back as screen waveforms. If *no* is the answer, again the full normal screen resumes, but still showing the previous waveform before the directory was entered.

When a directory file is loaded, on return to the normal screen, various boxes will now be seen to be coloured red, and LIVE to now read REPLAY. The red settings are the ones that existed when the file was recorded. You may change some of the settings, such as gain and sync, but not memory size or rate.

When settings are changed, the new setting is coloured yellow. There is no facility for returning to the recorded settings once they have been changed, other than by reloading the same file via the directory.

Both screen modes show the name of the file currently loaded, both as its coded name and as the expanded translation. The directory listing itself, though, is only shown as the coded name.

FILE NAME CODING

Recorded disk file names are coded as indicated by the following example:

File name = 20910241.Y97
Imagine it is split as 20 9 1 02 41 .Y97
Digits 1 and 2 = day of the month (20)
Digit 3 = month number in hex from 1 to C (9 = September)
Digit 4 = hour in hex-fashion – 0 to 9 followed by A to N (0 to 23), in this case 1 = 1 a.m.
Digits 5 and 6 = minutes in decimal (02)
Digits 7 and 8 = seconds in decimal (41)
.Y97 = Year (19)97 (will become .Y00 for the year 2000 – thoroughly Non-Millennium Compliant, sorry!)

The above file name thus translates as 20th September 1997 at 1:02.41 a.m., and would be shown as 20SEP97 1:02.41 if selected.

To exit Directory mode, right-click on DIRECTORY. Immediately all red colours will change to yellow but the currently loaded file will continue to be displayed, and REPLAY will change to SIMULATE.

To return to Live sampling mode, click on SIMULATE to restore the word LIVE.

Note that all Save options are inhibited during Directory mode.

PRINTING DISPLAYS

When the screen display is HOLDING, it can be output to a dot matrix printer (Epson ESC/P2 compatible, 24-pin). This, though, requires the connector cable to be removed from the unit and plugged into the printer.

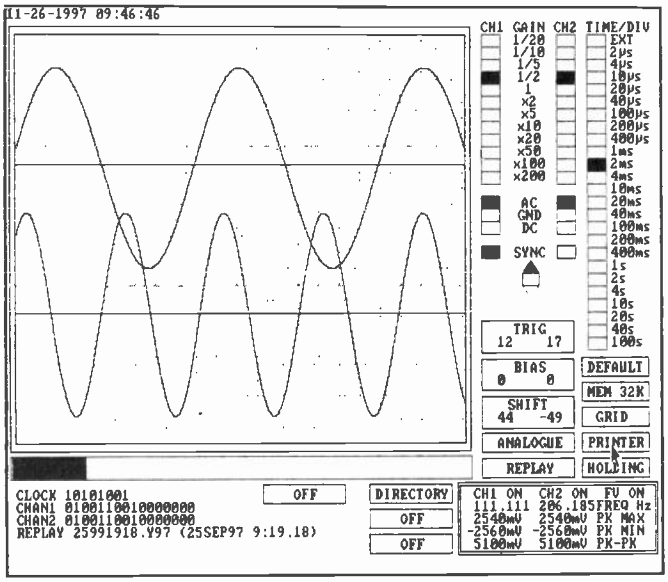
Having done so, click on PRINTER, whereupon the full screen display is printed, showing not only the waveforms, but also all the function parameters associated with it. The date and time at the top left of the screen is also printed for reference purposes.

Once the print has been completed, reconnect the cable to the unit, and click on DEFAULT as described in the next section.

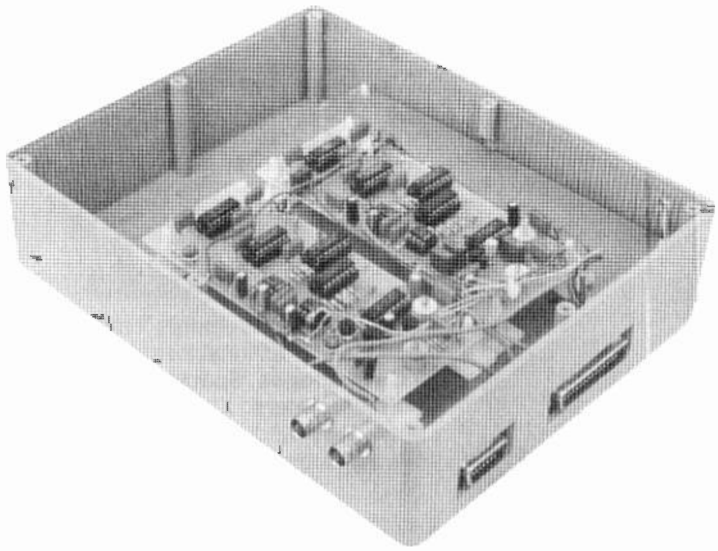
Do not click on PRINTER if the printer cable is not connected to the printer, or if the printer is not ready to receive data. Doing so will result in a **Device Fault** error from the computer and a program crash.

You may be able to recover from the crash by ensuring that the cable is plugged into the printer and that the printer is ready to receive data. Then press the Enter key on the screen display word OK. This will reveal the program listing at the point at which the error occurred. Now press function key F5.

If the computer finds that all is well, it will resume the program at the point where it crashed and send screen data to the printer.



Example screen display printout with function selection legends on the right.



Failing that, you will need to fully restart the program using shift-F5.

The data to be printed is collated and formatted by a dedicated routine within the main machine code program. It is then output to the printer from QBasic.

The code is specifically written for outputting bit-image graphics to an Epson-compatible ESC/P2 24-pin printer, using the codes and format detailed in the *Epson ESC/P Reference Manual, August 1991* (obtained from Epson). It is not suitable for other printers.

If your printer is different and you wish to inhibit the PRINTER option, search the QBasic listing for the routine labelled PRINTER: and insert the word RETURN: immediately after the label. Resave the program having done so.

DEFAULT CONTROL

On the screen righthand side is a DEFAULT box. Clicking on this causes the program to re-output all the current control register settings to the interface, and restart the sampling block from the beginning.

There are two principal situations where this action needs to be taken: after power to the interface has been switched off and on again, and following a screen printout to the printer.

Where the power supply for the unit is used to also power a circuit upon which you are working, you will sometimes need to switch off the power to make a change to the development circuit.

When power is switched back on, the interface configuration settings will need to be re-established. Clicking down on DEFAULT for a couple of seconds will usually achieve this.

For reasons unknown, however, the author has found on rare occasions that this fails to happen. Should it do so, the program should be halted (brought back into QBasic edit mode) by using the CTRL and BREAK keys together, and then re-run using shift-F5 (instead of just pressing F5).

Also, when first powering up and running, the use of DEFAULT has occasionally been found necessary.

The word DEFAULT changes colour to purple when the mouse is clicked on it, letting you know that it is responding. The white returns when the mouse button is released.

You may press DEFAULT any time you wish the interface sampling to restart.

EXTERNAL CLOCK

At the top of the rate selection column is a box marked EXT CLK. An external clock having an amplitude swing of 0V/+5V can be connected via socket SK2/PL2. This amplitude requirement must be respected – do not use any other level. To select EXT CLK, click on it. Clicking on any other rate box will restore the system to internal clock use at the rate selected.

The external clock may be used in Analogue or Digital modes (also see the Digital mode paragraphs). Note that when using an external clock in Analogue mode, frequency calculations are not performed because the software does not know the clock rate.

MOUSE SOFTWARE

Many readers may have previously wondered how the mouse can be used when running QBasic programs. The Virtual Scope software illustrates one way in which it can be done.

You cannot control it *directly* from QBasic (so far as the author can establish), but you can do so via a simple machine code program. This writes control data to the mouse registers and reads back position and button press data, storing it in locations which *are* readable from QBasic. It also causes the cursor to be shown as an arrow.

On return to QBasic from the machine code, the parameter data can then be acted on accordingly. A similar technique is used to transfer data from QBasic to the machine code.

The information for mouse control was found in the *The Programmer's PC Cookbook*, Second Edition (1991), Thom Hogan, Microsoft Press, ISBN 1-55615-321-X. Starting at page 5-40, the relevant section is *5.066 INT 33H, Mouse Functions Summary.*

You will find the book full of essential information on PC register use – ask your PC dealer or local library about it.

To see how the information was used for the Virtual Scope, refer to the *EPE* software disk and examine text file VSCOPEMS.J via a text editor, e.g. the EDIT program accessible from DOS. Also study the QBasic listing, searching for any reference to *mouse*. (The text for the main control program is VSCOPEDG.J.) Program MOUSE01.BAS also shows mouse control.

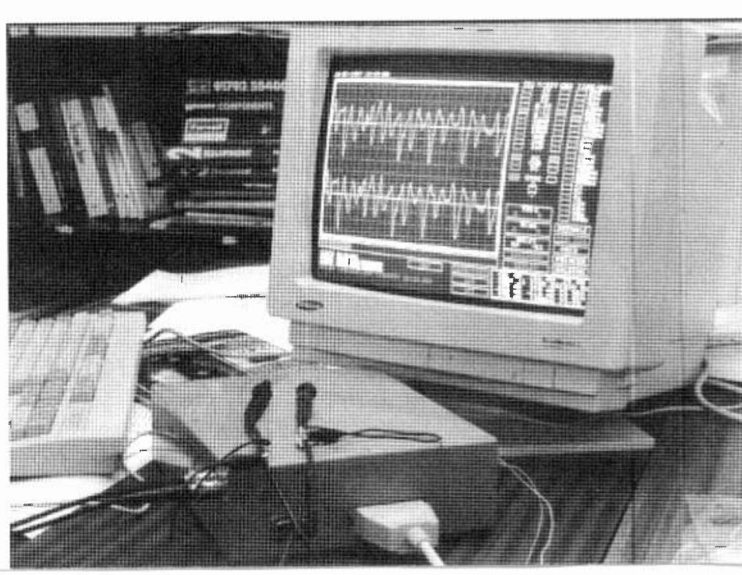
USING A SCOPE

It is not possible to discuss the general use of oscilloscopes here. You are, though, recommended to obtain books on the subject, from the *Direct Book Service* for example (as advertised in *EPE* as part of our service). We also published Roy Bebbington's articles on scope use, *More Scope for Good Measurements*, *EPE* June and July '96 – see the *Back Issues* page.

An oscilloscope really opens up a large window on the world of electronics. If you feel competent to take on the construction of this (admittedly) complex design, we are sure you will find its use to be an eye-opener! Even if you have a scope already, the *EPE Virtual Scope* will be a useful addition to the workshop. □

PLEASE NOTE

Fig.2, page 57 last month. The pin numbering of the lead-off leads above SK1 should read as follows, top to bottom: IC108 pin 1, 4, 12, 7 *and* 9.



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?

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

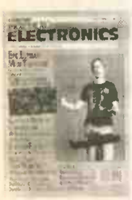
PROJECTS ● Analogue Delay and Flanger ● Simple Exposure Timer ● PIC-Tock Pendulum Clock ● Draught Detector ● Power Check.
FEATURES ● Circuit Surgery ● Ingenuity Unlimited ● Net Work – The Internet ● MAX038 Waveform Generator.

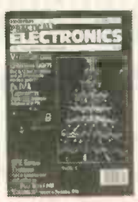
OCT '96

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 ● 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 ● 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.

JAN '98

PROJECTS ● Disco Lights Flasher ● Simple M.W. Radio ● EPE Virtual Scope–1 ● Surface Thermometer.
FEATURES ● TEACH-IN '98 – An Introduction to Digital Electronics–3 ● Circuit Surgery ● Ingenuity Unlimited ● Alternative and Future Technologies–2 ● Net Work – The Internet ● *Free* – Giant PIC Data Chart.

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M2/98

SHOP TALK
with David Barrington

Water Wizard

When selecting the 7-segment displays for the *Water Wizard*, it is important to choose ones that have the pin line-up across the top and bottom of the device, looking at the display underside, if they are to plug into the p.c.b. The ones in the model came from **Maplin**, codes FR1U (com. cath.) and FR39N (com. anode).

The splashproof case and water flow sensor are both RS components and can be ordered through their mail order outlet **Electromail** (☎ ***01356 204555***), codes 581-199 (case) and 257-133 (flow sensor).

The Wizard program for the PIC16C54 was written and assembled using the system supplied by Microchip, namely MPASM. For those readers who do not have facilities to program PIC chips, a ready-programmed 16C54 microcontroller is available (*Mail Order Only*) from the Electronics Dept at Radley College for the sum of £8; add £1 for overseas orders. Payments should be made out to *Radley College* and addressed to: **Mr Max Horsey, Radley College, Electronics Dept, Abingdon, Oxon, OX14 2HR.**

If you wish to do your own programming, the software is available on a 3·5 inch PC-compatible disk from the Editorial Offices – see *PCB Service* page for details. If you are an Internet user, it is available *Free* from our FTP site: **ftp//ftp.epemag.wimborne.co.uk./pub/PICS/Waterwizard.**

The small printed circuit board is obtainable from the *EPE PCB Service*, code 180 (see page 157).

Waa-Waa Effects Pedal

The single-pole, foot-operated "sweep" switch S1 required for the *Waa-Waa Effects Pedal* is a biased or non-locking type. Ideally, it should be a robust heavy duty type, but only a locking on/off switch seems to be available. An ordinary non-locking pushbutton switch should be adequate provided it is of good quality. Alternatively, for around £5 to £6 a custom "momentary" action footswitch pedal, with a 6·35mm mono jack plug attached, can be purchased from **Maplin**, code DU99H.

The unit is built on the multi-project printed circuit board available from the *EPE PCB Service*, code 932.

Kissometer

The miniature transistor output matching transformer type LT700 called for in the *Kissometer* project were once fairly common, but in case of local supply difficulties it can be sourced from **Maplin**, code LB14Q.

The plastic case is a Union Brothers PX-3 type sold by the above company (code YU54) and the miniature Lo-Z 8 ohm 0·2W loudspeaker also came from the same source, code WB08J.

The single-sided printed circuit board is available from the *EPE PCB Service*, code 181.

EPE Virtual Scope

Nearly 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***). Last month we gave the RS type numbers for the Centronics connectors used in the prototype. We have now learnt that these have been discontinued, but alternative types are: right-angle 36-way 239-1178, and 14-way 239-1156.

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 printed circuit boards are available from the *EPE PCB Service*, codes 176 (Digital) and 177 (Analogue) – See page 157.

The software for this design is available on a 3·5 inch PC-compatible disk from the *EPE PCB Service*, see page 157. Alternatively, the files can be downloaded *free* from our Internet FTP site:

ftp://ftp.epemag.wimborne.co.uk/pub/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 parts. 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.

Teach-In '98

Only one observation regarding parts for this month's *Lab Work 4* chapter of *Teach-In '98* Part 4 needs to be highlighted and that concerns the l.e.d.s. All the 4000 series of CMOS i.c.s specified should be reaily available.

The l.e.d. used in the breadboard demo model is a 5V "direct connection" type, with an integral ballast resistor. Most of our components advertisers should carry the 5mm version of this device. However, you can use a standard 5mm l.e.d. provided you use an external resistor in series with it, typically 330 ohm for a 5V supply.

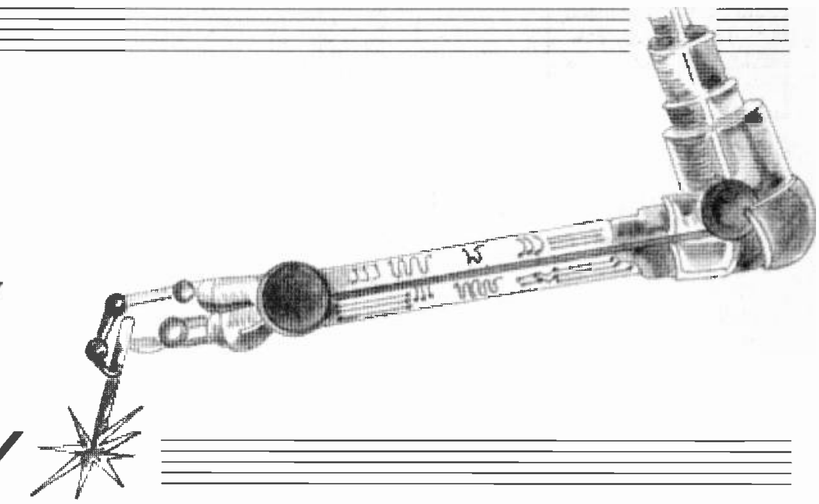
PLEASE TAKE NOTE

EPE Time Machine (Nov '97)

There has a minor software update, see *Readout* page 107. All software sources have been updated.

Regular Clinic

CIRCUIT SURGERY



ALAN WINSTANLEY

This month we help with a high-powered question on regulators, follow up on PLCs, put diode markings under the microscope and ponder resistor ratings.

High-Current Regulator

Power supply queries continue to crop up from time to time, and ***Mr. Philip Tate*** asks by E-mail:

I need to build a not-necessarily-highly-regulated power supply providing about 8V at 10A maximum. The switched-mode power supplies I have tried do not work down to zero load, so I hope to build a conventional power supply instead.

All the textbook designs stop short at the LM338 regulator, and hence at 5A output! My question is, can regulator i.c.s be wired up in parallel to provide higher currents? What happens if I don't match the output voltages perfectly? Alternatively, do you think I could build a good old-fashioned power supply around a hefty power transistor like the 2N3055, and expect it to survive at 80 watts?

In January's issue I showed some regulated power supply circuits using Zener diodes and external "pass" transistors. These are simple but effective, and might be adapted to your own application. The main problems are that the external pass element will dissipate (read: waste!) most power under maximum output (when the voltage across them and current through them is highest); also the circuits are not blow-out proof, with no protection built in.

Whether your power transistor can safely survive at 80W dissipation depends on the combination of collector-emitter voltage (Vce), collector current Ic, and temperature. Whilst the power dissipated by the transistor is the product of VceIc, the device should be operated within its *safe operating area* (SOA) for reliability.

Otherwise, you run the risk of "secondary breakdown", when areas of the transistor may overheat, thereby drawing more current, which generates more heat and eventually creating catastrophic thermal runaway.

Manufacturers' data will give the maximum permissible case temperatures for a range of power values, shown in a power derating curve. (In the example of a 2N3055, the maximum case temperature is 75°C at a power of 80W; it will dissipate up to 115W, but only if its case temperature does not exceed 25°C.) Furthermore, the safe operating area curves should be considered, as this restricts the maximum VceIc allowed before secondary breakdown occurs. (At 10A d.c., the maximum Vce is about 12V to remain within the recommended SOA.) So you are probably safe to use the 2N3055, but the thermal resistance of the heatsinking should ensure that the maximum case temperature stated is not exceeded.

The answer to your regulator query is, yes you can place regulator i.c.s in parallel, connecting them together for a higher output current. One problem is that the devices will not have identical "drop-out" voltages, so there will be a contest of wills, with the one that has the lowest drop-out voltage attempting to do more work by shunting the others, and it will be the first to current limit before the others start to "join in".

The work-around is to include a low-value series ballast resistor in series with each regulator output. The voltages across all parallel devices will balance out, with the resistors dropping any differences.

There are various circuits suggested in data sheets and application notes; Fig. 1 shows a typical circuit for an adjustable 10A regulator which uses two LM338 5A adjustable regulators (*National Semiconductor*). It requires a minimum 100mA load.

Allowing a drop-out voltage of at least 2·5V, then the input voltage must not fall below 8V + 2·5V, or 10·5V. The circuit's performance is also affected by the heatsinking used on each device, as they will shut down if their power dissipation becomes excessive.

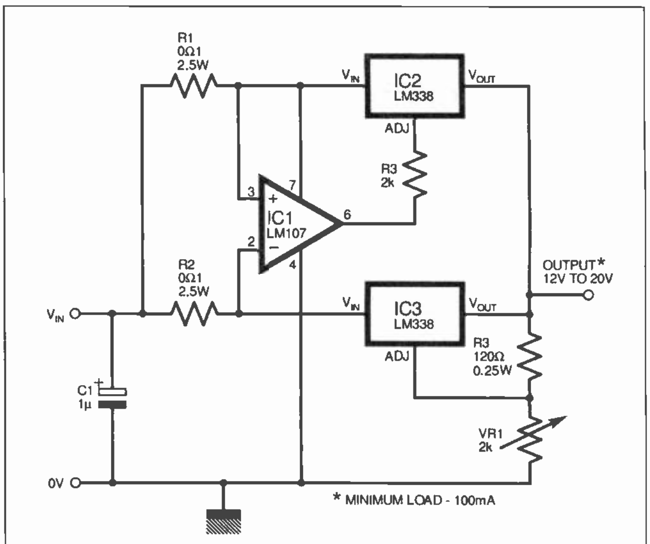


Fig.1. 10A regulator using a pair of 5A variable regulator i.c.s. (courtesy National Semiconductor).

Incidentally, even though the chips are thermally protected, long-term reliability might also be affected by totally inadequate heatsinking, causing an aggressive heating/cooling cycle (eventually creating a sort of thermal fatigue, apparently).

As an alternative, consider the National LM396, which is a fully-fledged 10A adjustable regulator with a guaranteed 10A output current, presettable from 1·25V to 15V, see Fig. 2. Its maximum power limit is 70W. Many other factors have to be taken into the design, though, including the gauge of the wiring and any unwanted resistance on the output, which may give rise to noise.

The circuit diagram in Fig.2 also shows how the 0V rail is grounded at a common point, and the load is taken from as close to the device output pin as possible, to avoid introducing any unwanted resistance on the output side. Once again, a major constriction is heatsinking (and consider fan cooling: maybe buy some surplus or ex-equipment fans), and again, National Semiconductor's data sheet is commendably informative. You will have to shop around and order the device specially, as I couldn't find it listed in the mainstream catalogues, but it is probably the ultimate answer to building a simple 10A regulator, 3-terminal style.

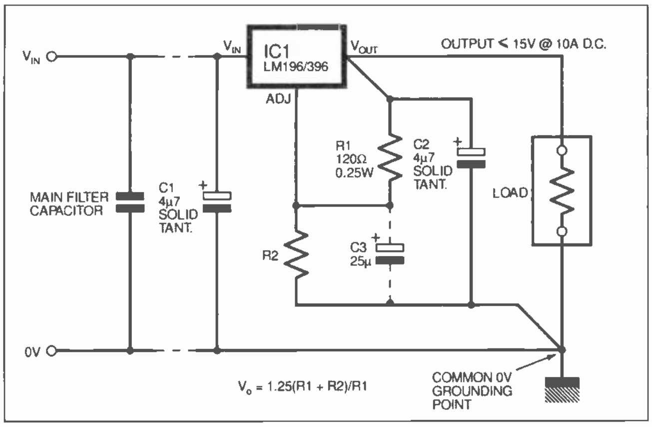


Fig.2. Variable voltage 10A regulator using a single 10A device (courtesy National Semiconductor).

Why no PLCs?

In December's issue I alluded to a product called the "PLC". R. Grodzik of Bradford comments on their use:

Following on from your item in the December issue, I was somewhat surprised and bemused to read that PLCs were outside the remit of EPE *since they are "designed for industrial process control applications".*

That is so, but the whole point of the PLC is the ease of programming, viz. ladder logic versus assembler if naked embedded controllers are used. Since the program is held in EEPROM and the PLC usually has a simple hand-held keypad, an electrician can easily debug the program – e.g. alter delay routines. The alternative for programming a processor or embedded controller is to edit the source code, reassemble or compile (if a run time library is used) and then program the memory (Flash, EPROM, EEPROM etc.).

Now that small PLCs are available with six inputs and eight outputs for under £200 there is no reason to use PLCs only in an industrial environment. I'm sure a PLC would be an ideal model train system controller, or could be the "brains" of a simple robot. So think again, EPE, *if it works on electricity we want to know about it!*

For the benefit of readers not acquainted with them, Programmable Logic Controllers (PLCs) – not to be confused with PIC microcontrollers – are sophisticated self-contained control units which are mainly intended for industrial process control. An engineering colleague agrees that they probably are under used, as they are mainly seen in industrial "mission critical" applications, from supervising the processes in a fizzy drinks production line, through to controlling the operation of a steel smelting works or a huge swing bridge. (A large bridge in the city of Hull apparently has "dual redundancy" PLCs – if one should fail, the other PLC takes over seamlessly.)

Curiously, the teaching of PLC programming and operation seems to be somewhat sporadic. This is probably because their use tends to be concentrated in certain regions where there is a considerable amount of PLC-equipped processing machinery in local industry. There has never been any mention of them in this magazine in the past, which should not be taken as our disapproving of them, simply that they are not relevant to what we know to be the expectations of our own core readership!

We are much more interested in what happens at component level (e.g. microcontrollers, integrated and discrete devices), whereas PLCs are electrically rugged, industrially-hardened boxes with memory, battery back-up, real time clocks, networkability and big screw terminals, all designed to be used by electrical fitters and engineers who don't (need to) know about component-level systems. For the same reasons, we don't talk about DIN rail (specially-profiled steel rail, onto which all sorts of electrical terminals, relays and gear can be clipped) or contactors, either!

As an academic exercise, it is true that a PLC would make a very fine model train controller or robotics control system, but in the context of *EPE*, simply buying a sturdy programmable control box plus programmer software, then programming it with relay ladder logic would really be inappropriate and is beyond the remit of the magazine.

We're, of course, primarily a hobbyist, project and educational journal, with a little bit of spin-off into other areas. Hence we can do nothing more than mention PLCs in passing, as a general interest item. Just like I have done, in fact.

Diodes and Resistor Queries

Mr. J.W. Pritchard of Holywell, Flintshire queries the symbology of diodes.

I work in p.c.b. assembly, and have a couple of queries: on some of our boards we orientate diodes with the cathode to '+', which is confusing when the diode must have its anode more positive than the cathode if it is to work! The other query is, why we choose 0·25W resistors when 0·5W types are freely available, both being metal film and of the same tolerance. In other words, do lower wattage resistors have any advantages over higher wattage resistors of the same type?

Your diode query first. A quick rummage through my groaning bookcases, and I turned up *Everyday Electronics*, May 1979 edition – an Intruder Alarm by the late F. G. Rayer, see the excerpt in Fig. 3. Yes, I thought as much – the cathodes of diodes were indeed marked on circuit diagrams with a plus sign! So we used to do the same.

I guess there was much confusion about the markings of diodes, and I seem to remember that a decision was taken years ago to drop the "+" sign as well as the circle (envelope) surrounding the symbol. This reduces the clutter of circuit diagrams.

We do however mark anode and cathode as "a" and "k", to help beginners. Traditionally, *Everyday Electronics* marked the terminals of bipolar transistors as e, b and c, (and MOSFETs, d, g, and s) also to assist newcomers. This habit has stuck as part of our house style. I guess the best way of dealing with it is to think that the plus sign on your boards indicates the striped or banded end of the diode body.

As to why use 0·25 watt resistors, well, when I first started out in electronics, I treated myself to a complete range of resistor values, ten of each, all in 0·5W ratings, purchased from Doram Ltd. (the adventurous "Doorway to Amateur Electronics" – as opened and slammed shut again by the major group which owned it). Most of them are still here, unopened in their packets.

Why? The trend is towards miniaturisation coupled with better power efficiency. 0·25W types are used universally in our projects as well as on traditionally-made commercial p.c.b.s (even 0·125W at times) and I guess economies of scale, which affect manufacturing industry enormously, created the demand for 0·25W types at the keenest prices.

From the practical point of view, it proves extremely difficult to use 0·5W resistors in many project boards. A quarter-watt resistor spans four or five holes on a 0·1-inch pitch, whereas a typical half-watt takes seven or eight. Power ratings permitting, they're generally just too big for most p.c.b.s, or for breadboarding, especially when resistors are placed adjacent to each other on a tight-fitting board.

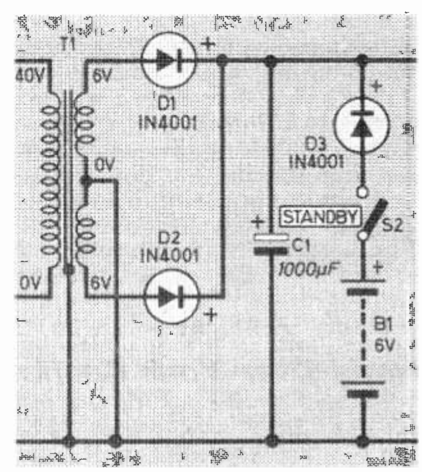


Fig.3. Traditional circuit diagrams showed diode cathodes marked with a "+" sign.

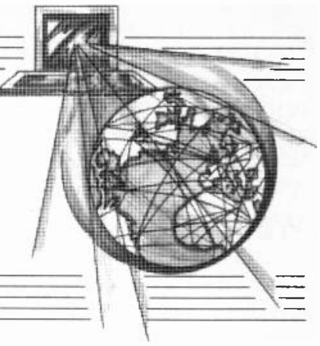
CIRCUIT THERAPY

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.

SURFING THE INTERNET

NET WORK

ALAN WINSTANLEY



REGULAR readers will know that *EPE* maintains a presence on the Internet in the form of our web site **http://www.epemag.wimborne.co.uk** where you can subscribe or renew a subscription via our secure server, also you can remind yourself about the main contents of recent issues, with snapshots of major projects. Don't forget to check the "What's Ahead" pages for details of our plans in the pipeline, and there are alphabetical indexes for 1996 and 1997 constructional projects, with the very few "Please Take Note" corrections preserved on line as well.

Our FTP site **ftp://ftp.epemag.wimborne.co.uk** contains a variety of text files and the source codes for most of our PIC projects (and other project files too), for you to download freely.

Software for the *EPE Virtual Scope* is at subdirectory **/pub/Vscope** and that for the *Water Wizard* is at **pub/PICS/WaterWizard.**

PC Technology Race

An acquaintance of mine works for a PC manufacturer in the States, and he's responsible for sending out samples of the latest machines to American computer magazines, for review purposes. A problem, he tells me, is that the lead time on publishing some magazines is up to four months, and such is the bewildering pace of technology at the moment that by the time the reviews are published, the PCs themselves are all but obsolete!

This has always been the way with personal computers. There is never a good time to buy one, unless you are prepared to wait until a particular processor falls out of favour and manufacturers have a clear-down sale, when the price will bottom out. You can thus save yourself something like £50-£75 per month in the interim, by sitting back and waiting.

There's plenty of hardware muscle around, and if you have say £1,000 or so to blow on a new PC and printer, you will not help but finish up with a fairly awesome machine; it's hard to come away with much less. However, just because a processor is no longer listed in mainstream adverts (which fuel the demand for the latest and fastest in the first place), doesn't necessarily mean that it is no longer available, and local suppliers may be able to sort out a slower, but still highly respectable, machine for a price you'll find unbeatable. By the time you read this, the Pentium II 233MHz will be the entry model being pushed by the PC giants.

Hand Over Your Cache

Netscape Navigator and *Microsoft Internet Explorer* each have their own "cache" sub-directories which are portions of your hard disk in which downloaded pages (**.htm** files, images, etc.) are retained for reference by the browser during on-line sessions.

The good thing about the cache is that it saves having to wait every time for every graphic or text to be downloaded onto your PC, because the browser refers first to any files already held in cache, and it will fetch it from there rather than from the network, provided that the files haven't changed on the web site subsequently.

You can control what the browser should do when it stumbles upon web pages which may have been previously cached:

Netscape: Options/Network Preferences/Cache and you can set the amount of space to be donated to cache, and how frequently *Netscape* should verify any cached pages. The settings can have a fundamental effect on your "surfing speed" – choose "Once per session" if in doubt.

Explorer: View/Options/Advanced/Temporary Internet Files/ Settings (or, View Files to have a peek in the cache contents – 2,500 items in my case). Again, frequency and cache size controls are available for you to tune up.

You can clear out the cache to make space, using the same controls. The bad thing about all this is that although the cached files can be trivial in size, say 1KB, the bigger your hard disk, then the bigger the "cluster size" will be. The cluster represents the minimum "chunk" of data which can be stored on your hard disk.

For example, a 100MB hard disk on my old 486 is reported as having a cluster size of 2,048 bytes. In contrast, my 1·6 Gigabyte hard disk has a cluster size of 32,768 bytes. So even a 1KB file held in cache will hog 32K – one cluster – of space. The net result is that 31K goes to waste. Hence of the 90MB allocated, my Temporary Internet Files cache wastes no less than 71MB of it! 330MB of my total hard disk is just wasted space! So, when spring-cleaning your hard disk, the first place to start is with the cache.

Users of the very latest release of Windows 95 (OE version only) and Windows 98 won't have such a problem: they use 4K cluster sizes for drives up to 8GB. Disk partitioning programs (e.g. *Quarterdeck Partition-It*) will let you resize and move disk partitions on the fly, shrinking the cluster size as needed. A freeware utility which emphasises this waste graphically is the *TreeSize* program, available from **www.jam-software.com/software.html**. This will analyse and display hard disk usage in a variety of ways.

Also try the impressive-looking program *More Space* by *Contact Plus* which will help free up disk space, manage your cache and it includes an excellent disk analyser which tells you all about the "overhang" or wasted disk space. It costs US$20, with W95 and W3.1 versions. Demo. from **www.contactplus.com**.

Suggested Links

Explorer 4 includes an option to "browse offline". It can now crawl all over any sites of interest and deliver them to your desktop, and you can browse them off-line at your leisure. By "subscribing" to them, *Explorer 4.0* will also notify you if any favourite sites have changed, all of which sound like cool features for the busy surfing executive.

This month, in place of the usual electronics URLs, I'm listing some interesting sites related to cache control software and viewing. Here are a few ways in which you can check your favourite sites and view them off-line, at leisure. *Unmozify* and *Near Site* from Info Evolution in the UK are two well-established programs which let you control your "cache", and view them off-line. Trial versions for each browser are available at **www.evolve.co.uk**. (Why *Unmozify*? It's named after Mozilla, the friendly dinosaur *Netscape* mascot, and cache files originally had their own "**.moz**" filename extension.)

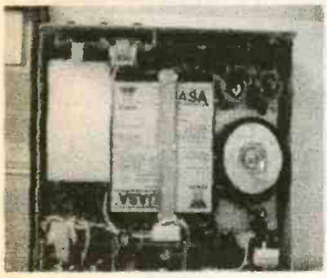
WebSnake by Anawave uses an *Explorer*-like window, with suitably serpent-like icons, and is an extremely cool way of grabbing an entire web site onto your hard disk for viewing later on, or for "snaking" E-mail addresses from a web site. It costs US$29.95. More at **www.anawave.com**.

Got It! by Go Ahead (**www.goahead.com**) is a caching control which works in the background. Based on what it learns from your pattern of access to the Web, Got It! prioritizes the retrieved data and caches it intelligently on your hard drive (it says here). It also claims to accelerate your web surfing. It costs US$19.95.

Forefront's *Webwhacker* (**www.ffg.com/whacker/**) for Windows, Macintosh and PowerPC costs US$49.95 and is another web accelerator and off-line browser worth investigating.

LinkSync (**www.bluesquirrel.com/linksync/**) is an accessory for both *Netscape Navigator* and *Internet Explorer* web browsers. It claims to let you merge your *Netscape* bookmarks and *MSIE* "favorites" folder without producing duplicates or unwanted bookmarks. *LinkSync* also applies any changes (add, delete, rename, move) made to your *Netscape* bookmarks, to your "favorites" folder and vice versa. US$19.95.

Don't forget to keep me posted with your favourite electronics sites. More next month. You can E-mail me at **alan@epemag.demon.co.uk**. My *Home Page* is at **homepages.tcp.co.uk/~alanwin**.



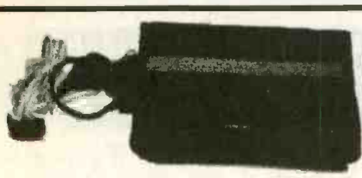
SALE PRICE £9.95

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

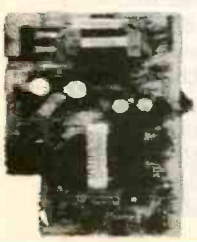
140x 150 x 90mm, fully cased with built in fan. +12 @ 13A, +5 @ 15A IEC power inlet, flylead output. £9.95 ref DEL2

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 £69 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

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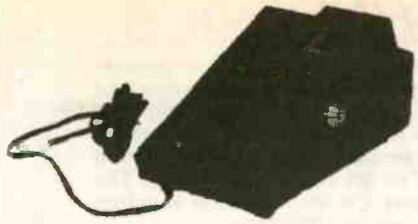

SALE PRICE £2.50

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

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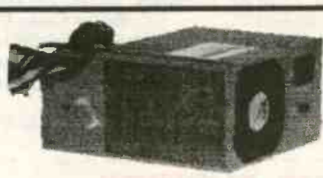

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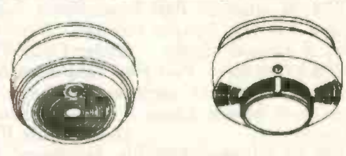
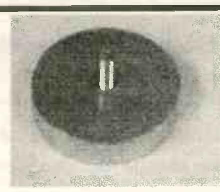


MAINS SMOKE ALARMS (GENT) NEW AND BOXED £4.99 ref SMKX

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 90mm, 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



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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**

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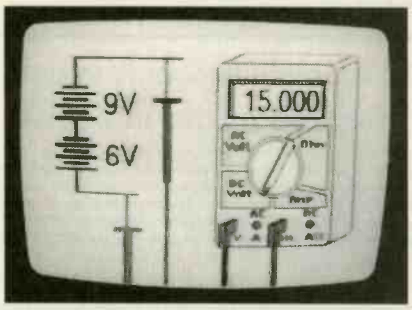

VT204 56 minutes. Part Four; Power Supplies. Guides you step-by-step through different sections of a power supply. **Order Code VT204**

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

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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**

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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**

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MISCELLANEOUS

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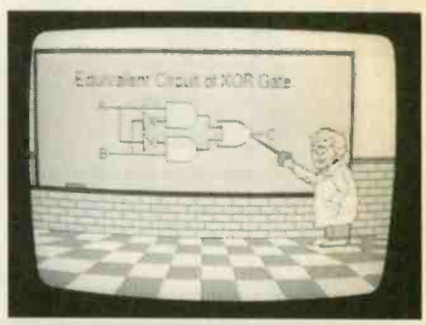

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The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order to your door. Full ordering details are given on the last book page.

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Also included are techniques for connecting a PC to a remote control system, the use of a microcontroller in remote control, as exemplified by the BASIC Stamp, and the application of ready-made type-approved 418MHz radio transmitter and receiver modules to remote control systems.
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The aim of this book is to provide the model railway enthusiast with a number of useful but reasonably simple projects that are easily constructed from readily available components. Stripboard layouts and wiring diagrams are provided for each project. The projects covered include: constant voltage controller; pulsed controller; pushbutton pulsed controller; pulsed controller with simulated inertia, momentum and braking; automatic signals; steam whistle sound effect; two-tone horn sound effect; automatic two-tone horn effect; automatic chuffer.
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Subjects such as p.c.b. design, chip control, soldering techniques and specialist tools for SM are fully explained and developed as the book progresses. Some useful constructional projects are also included.
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R. A. Penfold
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80 pages **Temporarily out of print**

AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold
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RADIO / TV VIDEO

ELECTRONIC PROJECTS FOR VIDEO ENTHUSIASTS
R. A. Penfold
This book provides a number of practical designs for video accessories that will help you get the best results from your camcorder and VCR. All the projects use inexpensive components that are readily available, and they are easy to construct. Full construction details are provided, including stripboard layouts and wiring diagrams. Where appropriate, simple setting up procedures are described in detail; no test equipment is needed.
The projects covered in this book include: Four channel audio mixer, Four channel stereo mixer, Dynamic noise limiter (DNL), Automatic audio fader, Video faders, Video wipers, Video crispener, Mains power supply unit.
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This concise book tells the story, and shows the reader how to construct and use 25 indoor and window aerials that the author has proven to be sure performers.
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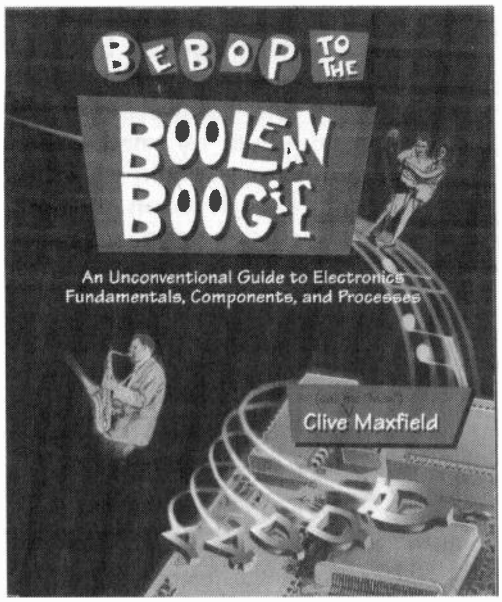

By Clive (call me Max) Maxfield

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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

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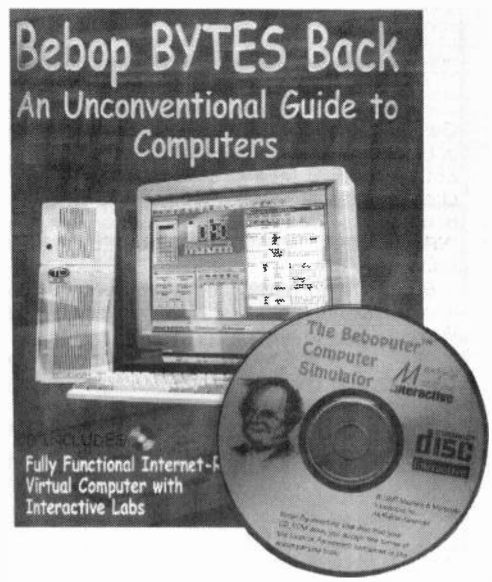

This book is not for everyone.

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.

bebop

CIRCUITS AND DESIGN

AN INTRODUCTION TO PIC MICROCONTROLLERS NEW
Robert Penfold
Designing your own PIC based projects may seem a daunting task, but it is really not too difficult providing you have some previous experience of electronics. The PIC processors have plenty of useful features, but they are still reasonably simple and straightforward to use. This book should contain everything you need to know.
Topics covered include: the PIC register set; numbering systems; bitwise operations and rotation; the PIC instruction set; using interrupts; using the analogue to digital converter; clock circuits; using the real time clock counter (RTCC); using subroutines; driving seven segment displays.
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A. Flind
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Various circuits using inductors and capacitors are covered, with emphasis on stable low frequency generation. Some of these are amazingly simple, but are still very useful signal sources.
Crystal oscillators have their own chapter. Many of the circuits shown are readily available special i.c.s for simplicity and reliability, and offer several output frequencies. Finally, complete constructional details are given for an audio sinewave generator.
133 pages **Order code BP393** £4.99

PRACTICAL ELECTRONIC CONTROL PROJECTS
Owen Bishop
Explains electronic control theory in simple, non-mathematical terms and is illustrated by 30 practical designs suitable for the student or hobbyist to build. Shows how to use sensors as input to the control system, and how to provide output to lamps, heaters, solenoids, relays and motors.
Computer based control is explained by practical examples that can be run on a PC. For stand-alone systems, the projects use microcontrollers, such as the inexpensive and easy-to-use Stamp BASIC microcontroller. These projects are chosen to introduce and demonstrate as many aspects as possible of the programming language and techniques.
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PRACTICAL ELECTRONICS HANDBOOK – Fourth Edition. Ian Sinclair
Contains all of the everyday information that anyone working in electronics will need.
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B. B. Babani
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AUDIO IC CIRCUITS MANUAL
R. M. Marston
A vast range of audio and audio-associated i.c.s are readily available for use by amateur and professional design engineers and technicians. This manual is a guide to the most popular and useful of these devices, with over 240 diagrams. It deals with i.c.s such as low frequency linear amplifiers, dual pre-amplifiers, audio power amplifiers, charge coupled device delay lines, bar-graph display drivers, and power supply regulators, and shows how to use these devices in circuits ranging from simple signal conditioners and filters to complex graphic equalizers, stereo amplifier systems, and echo/reverb delay lines etc.
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OPTOELECTRONICS CIRCUITS MANUAL
R. M. Marston
A useful single-volume guide to the optoelectronics device user, specifically aimed at the practical design engineer, technician, and the experimenter, as well as the electronics student and amateur. It deals with the subject in an easy-to-read, down-to-earth, and non-mathematical yet comprehensive manner, explaining the basic principles and characteristics of the best known devices, and presenting the reader with many practical applications and over 200 circuits. Most of the i.c.s and other devices used are inexpensive and readily available types, with universally recognised type numbers.
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R. A. Penfold
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120 pages **Order code BP335** £4.95

A BEGINNERS GUIDE TO CMOS DIGITAL ICs
R. A. Penfold
Getting started with logic circuits can be difficult, since many of the fundamental concepts of digital design tend to seem rather abstract, and remote from obviously useful applications. This book covers the basic theory of digital electronics and the use of CMOS integrated circuits, but does not lose sight of the fact that digital electronics has numerous "real world" applications.
The topics covered in this book include: the basic concepts of logic circuits; the functions of gates, inverters and other logic "building blocks"; CMOS logic i.c. characteristics, and their advantages in practical circuit design; oscillators and monostables (timers); flip/flops, binary dividers and binary counters; decade counters and display drivers.
The emphasis is on a practical treatment of the subject, and all the circuits are based on "real" CMOS devices. A number of the circuits demonstrate the use of CMOS logic i.c.s in practical applications.
119 pages **Order code BP333** £4.95

AUDIO AND MUSIC

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Ian Sinclair
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All this development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.
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128 pages **Order code PC102** £7.95

PROJECTS FOR THE ELECTRIC GUITAR
J. Chatwin
This book is for anyone interested in the electric guitar. It explains how the electronic functions of the instrument work together, and includes information on the various pickups and transducers that can be fitted. There are complete circuit diagrams for the major types of instrument, as well as a selection of wiring modifications and pickup switching circuits. These can be used to help you create your own custom wiring.
Along with the electric guitar, sections are also included relating to acoustic instruments. The function of specialised piezoelectric pickups is explained and there are detailed instructions on how to make your own contact and bridge transducers. The projects range from simple preamps and tone boosters, to complete active controls and equaliser units.
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Vic Lennard
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Over 40 cabling diagrams. Connect synths, sound modules, sequencers, drum machines and multitracks. How to budget and buy secondhand. Using switch, thru and merger boxes. Transfer songs between different sequencers. Get the best out of General MIDI. Understand MIDI implementation charts. No MIDI theory.
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R. A. Penfold
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Code	Title	Price
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BP387	Windows One Step at a Time	£4.95
BP388	Why Not Personalise Your PC	£4.99
BP389	Power Point for Windows Explained	£5.95
BP390	An Introduction to the World Wide Web for PC and Mac Users	£6.99
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BP405	MS Works for Windows 95 explained	£5.95
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BP407	Excel 95 Explained	£6.99
BP408	Access 95 – One Step at a Time	£5.99
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BP418	Word 95 Assistant	£6.99
BP419	Using Microsoft Explorer on the Internet	£6.99
BP420	E-Mail on the Internet	£6.99
BP421	Windows 95 Assistant	£6.99
BP422	Essentials of Computer Security	£5.99
BP424	Microsoft Exchange for Business and Home Use	£6.99
BP425	Microsoft Internet Explorer Assistant	£5.99
BP426	MS Office 97 Explained	£6.99
BP427	Netscape Internet Navigator Assistant	£5.99
BP428	MS Word 97 Explained	£6.99
BP429	MS Excel 97 Explained	£6.99
BP430	MS Access 97 – One Step at a Time	£5.99
BP432	Simple Sensor Terminal Block Projects	£4.99
BP434	PC Hardware Assistant	£6.99
BP435	Programming in C++	£6.99

IF NO PRICE IS SHOWN THE BOOK IS OUT OF PRINT (O.O.P.)

SEE PREVIOUS PAGE FOR FULL ORDERING DETAILS

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.

Special KNOCK DOWN SALE of PCBs.

We have a few p.c.b.s left from past projects these are being offered at the knock down price of **£2.00** each – *no matter what size they are* **(some of these boards are worth over £15.00 each)** while stocks last. This price includes VAT and UK post – overseas orders please add 50p postage (or £1 per board for airmail postage).

£2.00 EACH inc. VAT and p&p

Bike Odometer (pair of boards), 836/7; Amstrad PCW A to D Converter (double-sided), 838; 1W Stereo Amplifier, 851; Visual Doorbell, 863; CCD TV Camera - Combined Video, Test & Ext Plug Boards, 866a/e; EPE SounDAC PC Sound Board, 868; Microprocessor Smartswitch, 881; Print Timer, 874; Simple NiCad Charger, 884; Stereo HiFi Controller – Power Supply, 886 – Main Board, 887 – Expansion/Display Boards, (pair) 888; Dancing Fountains – Filter, 891 – PC-Compatible Interface (double-sided), 892; Seismograph – Sensor/Filter, 896 – PC-Compatible Interface (double-sided), 898 – Clock/Mixer, 897; Visual/Audio Guitar Tuner, 900; Audio Auxiplexer – Control Board, 903 – Receiver, 904; Power Controller, 905; 1000V/500V Insulation Tester, 906; Active Guitar Tone Control, 907; TV Off-er (pair), 908/909; Video Modules – 1 Simple Fader, 910 – Improved Fader, 911 – Video Enhancer, 912; Rodent Repeller, 913; Video Modules – 4-Channel Audio Mixer, 918; Spacewriter Wand, 921; Universal Digital Code Lock, 922; Video Modules – 3 Dynamic Noise Limiter, 919 – System Mains Power Supply, 920; Magnetic Field Detector, 923.

Any of the above for just £2 each inc. VAT and p&p.

Back numbers or photostats of articles are available see the *Back Issues* page for details.

PROJECT TITLE		Order Code	Cost
The Ultimate Screen Saver	FEB'95	927	£5.66
Foot-Operated Drill Controller		928	£5.73
Model Railway Signals		929	£5.96
12V 35W PA Amplifier		930	£12.25
Multi-Purpose Thermostat	MAR'95	931	£6.30
Multi-Project PCB		932	£3.00
Sound-Activated Switch			
Audio Amplifier			
Light Beam Communicator (2 boards required)			
Multi-Project PCB	APR'95	932	£3.00
Light-Activated Switch			
Switch On/Off Timer			
Continuity Tester			
Auto Battery Charger		934	£5.36
★National Lottery Predictor		935	£5.34
MIDI Pedal	MAY'95	938	£7.78
Club Vote Totaliser		939	£6.05
PIC-DATS Development System (double-sided p.t.h.)		940	£9.90
EPE HiFi Valve Amplifier –	JUNE'95		
Phase splitter		941	£6.71
PIC-DATS 4 -channel Light Chaser		942	£7.90
HV Capacitor Reformer	JULY'95	943	£5.60
Ramp Generator			
Logic Board (double-sided p.t.h.) & Analogue board (pair)		944/5	£32.00
Automatic Curtain Winder		946	£6.75
Windicator		947	£4.10
Microcontrolled 3-Digit Timer	AUG'95	933	£6.61
IR Remote Control – Transmitter		948	£5.76
Receiver		949	£6.14
Personal Practice Amplifier		950	£6.09
Low-Range Ohmmeter Adaptor	SEPT'95	926	£5.55
Simple Theremin		952	£6.68
Vandata			
Boot Control Unit		953	£10.52
Display Unit		954	£6.61
Sound Switch	OCT'95	915	£6.55
Multiple Project PCB		932	£3.00
Audio Sinewave Generator			
Treble Booster			
Infra-Red Controller/Alarm (2 boards required)			
Capacitor Check		955	£5.76
Ginormous VU Meter		956	£9.31
Multiple Project PCB	NOV'95	932	£3.00
Video Enhancer – Current Tracer – Distortion Effects Unit			
Digital Delay Line		958	£8.04
50Hz Field Meter		959	£8.32
Temperature Warning Alarm (Teach-In '96)		960	£6.15

PROJECT TITLE	Order Code	Cost
Stereo "Cordless " Headphones **DEC'95**		
Transmitter	961	£8.04
Receiver	962	£7.66
★EPE Met Office – Sensor/Rainfall/Vane	963/965	£11.33
Spiral transparency free with above p.c.b.		
Light-Operated Switch	966	£6.37
Modular Alarm System (Teach-In '96)	967a/b	£7.12
★EPE Met Office – **JAN'96**		
Computer Interface (double-sided)	964	£7.69
Audio Signal Generator	969	£6.58
Mains Signalling Unit, Transmitter and Receiver	970/971 (pr)	£9.09
Automatic Camera Panning (Teach-In '96)	972	£6.63
Printer Sharer	973	£9.93
Analogue Frequency Meter **FEB'96**	957	£6.70
Vari-Speed Dice (Teach-In '96)	974	£5.69
Mains Signalling Unit – 2 12V Capacitive PSU	975	£6.07
★PIC-Electric Meter – Sensor/PSU– Control/Display	977/978 (pr)	£9.90
Multi-Purpose Mini Amplifier **MAR'96**	976	£6.12
★PIC-Electric – Sensor/PSU – Control/Display	977/978 (pr)	£9.90
High Current Stabilised Power Supply	979	£6.62
Mind Machine Mk III – Sound and Lights	980	£7.39
Infra-Zapper Transmitter/Receiver (Teach-In '96)	981/982 (pr)	£8.01
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 **JULY'96**		
and Counter – Oscillator/L.C.D. Driver	994/995 (pr)	£12.72
Timed NiCad Charger	100	£6.99
Single-Station Radio 4 Tuner	101	£7.02
Twin-Beam Infra-Red Alarm –Transmitter/Receiver	102/103 (pr)	£10.50
★Games Compendium	104	£6.09
Mono "Cordless" Headphones **AUG'96**		
– Transmitter/Receiver	990/991 (pr)	£10.16
Component Analyser (double-sided p.t.h.)	105	£12.18
Garden Mole-Ester	106	£6.07
Mobile Miser	107	£6.36
Bike Speedo	108	£6.61
★PIC-Tock Pendulum Clock **SEPT'96**	109	£6.31
Power Check	110	£6.42
Analogue Delay/Flanger	111	£7.95
Draught Detector	112	£6.22
Simple Exposure Timer	113	£6.63
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 **DEC'96**		
(double-sided p.t.h.)	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 **JAN'97**		
Current Gen. – Amp/Rect.	131/132 (pr)	£12.70
Theremin MIDI/CV Interface (double-sided p.t.h.)	130 (set)	£40.00
Mains Failure Warning	126	£6.77
Pacific Waves **FEB'97**	136	£9.00
PsiCom Experimental Controller	137	£6.78
Oil Check Reminder **MAR'97**	125	£7.16
Video Negative Viewer	135	£6.75
Tri-Colour NiCad Checker	138	£6.45
Dual-Output TENS Unit (plus Free TENS info.)	139	£7.20
★PIC-Agoras – Wheelie Meter **APRIL'97**	141	£6.90
418MHz Remote Control – Transmitter	142	£5.36
– Receiver	143	£6.04
Puppy Puddle Probe	145	£6.10
MIDI Matrix – PSU	147	£5.42
– Interface	148	£5.91
Quasi-Bell Door Alert **MAY'97**	133	£6.59
2M F.M. Receiver	144	£7.69
★PIC-A-Tuner	149	£7.83
Window Closer – Trigger	150	£4.91
– Closer	151	£4.47

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
Disco Lights Flasher	178	£8.30
Waa-Waa Pedal (Multi-project PCB) **FEB'98**	932	£3.00
★Virtual Scope – 1		
Digital Board	176	£14.49
Analogue Board (per board)	177	£7.34
★Water Wizard	180	£7.69
Kissometer	181	£7.67

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..

....

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I enclose payment of £.............................(cheque/PO in **£ sterling only**) to:

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Everyday Practical Electronics

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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**

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For rates and information on display and classified advertising please contact our Advertisement Manager, Peter Mew as above.

Miscellaneous

EPE NET ADDRESSES

EPE FTP site: **ftp://ftp.epemag.wimborne.co.uk**
Access the FTP site by typing the above into your web browser, or by setting up an FTP session using appropriate FTP software, then go into quoted sub-directories:

PIC-project source code files: **/pub/PICS**
PIC projects each have their own folder; navigate to the correct folder and open it, then fetch all the files contained within. *Do not try to download the folder itself!*

EPE text files: **/pub/docs**
Basic Soldering Guide: **solder.txt**
EPE TENS Unit user advice: **tens.doc** and **tens.txt**
Ingenuity Unlimited submission guidance: **ing_unlt.txt**
New readers and subscribers info: **epe_info.txt**
Newsgroups or Usenet users advice: **usenet.txt**
Ni-Cad discussion: **nicadfaq.zip** and **nicad2.zip**
UK Sources FAQ: **uksource.zip**
Writing for *EPE* advice: **write4us.txt**
Ensure you set your FTP software to ASCII transfer when fetching text files, or they may be unreadable.

EPE Website: **http://www.epemag.wimborne.co.uk**
Check it for up-to-date information on FAQs, subscribing, buying PCBs and Back Issues via our new Secure Server.

E-mail addresses:
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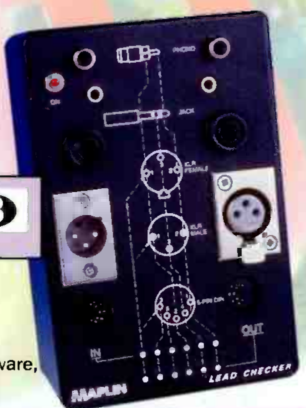
projects

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

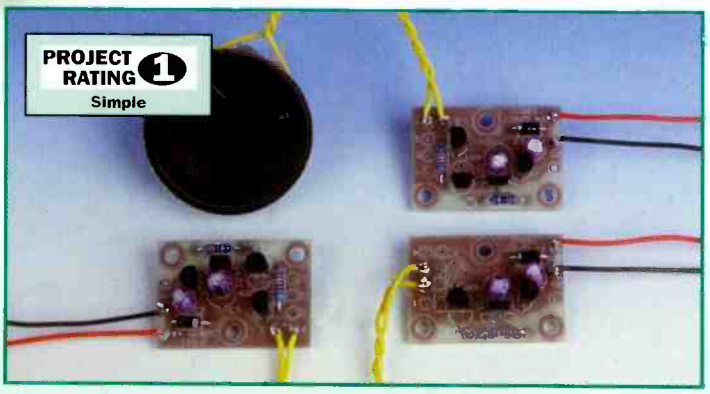
- Use to choose your lottery numbers!
- Excellent introduction to microcontrollers
- Use in other games

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

PROJECT RATING 1
Simple



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

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.

PAL COLOUR ENCODER KIT

PROJECT RATING 3
Average

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

ORDER NOW!

Tel: 01702 554000, Fax: 01702 554001, E-mail: Sales@maplin.co.uk
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Or Tel: 01702 554002 for details of your nearest Maplin or Mondo store.
Please quote **Priority Reference Code MA043** When ordering.

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