Special Issue 8 EXTRA PAGES

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

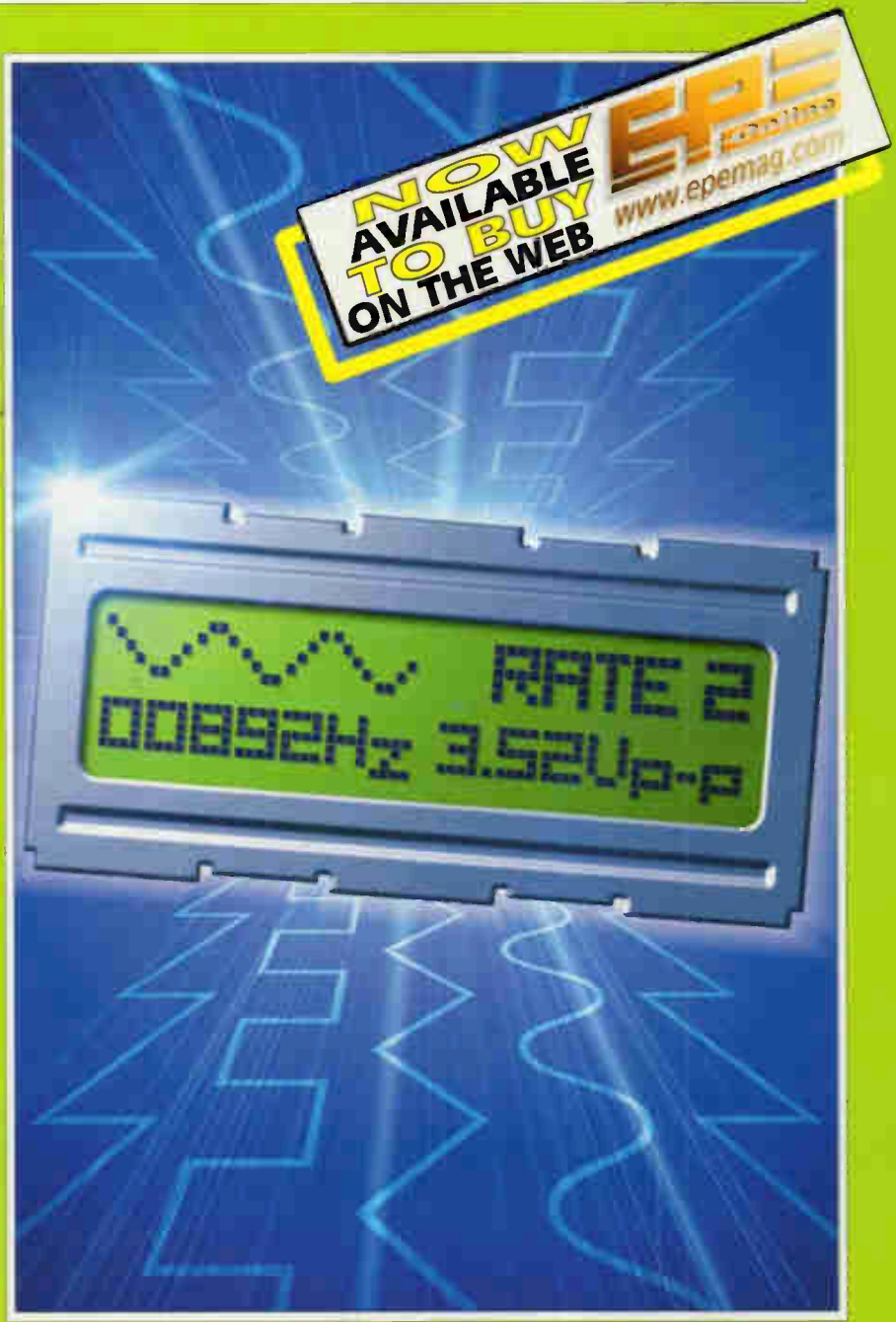
EVERYDAY PRACTICAL ELECTRONICS

APRIL 2000

INCORPORATING ELECTRONICS TODAY INTERNATIONAL £2.65

MICRO-PICSCOPE

Probably the simplest & cheapest 'scope ever



Starter Project

FLASH SLAVE

Enhance your photography

GARAGE LINK

Never leave the doors open again

PLUS

Teach-In 2000 6

Technology Timelines 3

Ingenuity Unlimited • Interface

Circuit Surgery • Net Work

New Technology Update

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

12v 18Ah SEALED LEAD ACID BATTERIES, new and boxed, unused pack of 4 £39.95 ref CYC7 or £15 each ref CYC6

AUTOMATIC CHARGER For the above battenes, charges 2 at once, charge level indicator circuitry, 6 hour charge. £10 ref CYC8

A new range of 12v to 240v INVERTERS
IV400S (400 watt) £89,IV800S (800 watt) £159.IV1200S (1200 watt) £219

ECG MACHINES ?/6v 10AH BATTS/24V 8A TX Ex government ECG machines! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear including video out etc On the front panel are two DIN sockets for connecting the body sensors to Sensors not included, Inside 2 x 6v 10AH lead acid batts (not in good condition) 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 £15 99 ref VP2

SODIUM LAMP SYSTEMS £75.70 Complete system with 250w or 400 watt SON-T Agro bulb, reflector with bulb holder and remote ballast and starter(uncased) all you need is wire. 250W system ref SLS1, 400W system SLS2.

PC SUPPORT HANDBOOK The ultimate technical guide to building and maintaining PC's. Over 460 A4 pages packed with technical data and diagrams just £10 ref PCBK. If you want 4 copies for £33 ref PCBK2. Also available is a CD packed with diagnostic programmes to use with the book £5 ref PCBK1

D SIZE NICADS Tagged, 1200mA, 1.2v pack of 4 for £6 ref CYC9 or as a pack of 24 for £22 ref CYC10

D SIZE SEALED LEAD ACID BATTERIES
2v 2 5ah rechargeable sealed lead acid battery made by Cyclon 60x45mm (standard D size) supplied as a pack of 12 or 20 giving you options for battery configerations eg 12v at 5ah, 24v at 2 5ah, 6v at 10ah. These battenes are particularly useful in that you can arrange them in your project to optimise space etc (eg boat ballast etc) Pack of 12 £10 ref CYC4, pack of 20 £16 ref CYC5

HYDROPONICS DO YOU GROW YOUR OWN?
We have a full colour hydroponics catalogue available containing nutrients, pumps, fittings, environmental control, light fittings, plants, test equipment etc Ring for your free copy.

PC COMBINED UPS AND PSU The unit has a total power of 292 watts, standard mother board connectors and 12 peripheral power leads for drives etc Inside is 3 12v 7 2aH sealed lead acid batteries. Backup time is 8 mins at full load or 30 mins at half load Made in the UK by Magnum, 110 or 240vac input, +5v at 35A, -5v at 5A, +12v at 9A, -12v at 5A outputs 170x260x220mm new and boxed £29 95 Ref PCUPS2

ALTERNATIVE ENERGY CD, PACKED WITH HUNDREDS OF ALTERNATIVE ENERGY RELATED ARTICLES PLANS AND INFORMATION ETC £14.50 REF CD56

AERIAL PHOTOGRAPHY KIT This rocket comes with a built in camera! it flies up to 500 feet (150 m) turns over, and takes an aerial photograph of the ground below The rocket then returns with its film via its paracute Takes 110 film. Supplied complete with everything including a launch pad and 3 motors (no film) £29 98 ref astro

PROJECT BOXES Another bargain for you are these smart ABS project boxes, smart two piece screw together case measuring approx 6"x5"x2" complete with panel mounted LED Inside you will find loads of free bits, tape heads, motors, chips resistors, transistors etc Pack of 20 £19.95 ref MD2

TELEPHONES Just in this week is a huge delivery of telephones, all brand new and boxed Two piece construction - illuminated keypad, tone or pulse (switchable), recall, redial and pause, high/low and off ringer switch and quality construction Off white colour and is supplied with a standard international lead (same as US or modems) if you wish to have a BT lead supplied to convert the phones these are £1 55 each ref BTLX **Phones £4.99 each ref PH2 10 off £30 ref SS2**

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

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

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS Could be adapted for laser listener long range comms etc Double beam units designed to fit in the barrel of a tank, each unit has 2 semi conductor lasers and motor drive units for alignement 7 mile range, no circuit diagrams due to MOD, new price £50,000? us? £199. Each unit has two gallium Arsenide injection lasers, 1 x 9 watt, 1 x 3 watt, 900nm wavelength, 28vdc, 600hz pulse freq The units also contain a receiver to detect reflected signals from targets £199 Ref LOT4

MAGNETIC CREDIT CARD READERS AND ENCODING MANUAL £9.95 Cased with flyleads, designed to read standard credit cards! complete with control elctronics PCB and manual covering everything you could want to know about whats hidden in that magnetic strip on your card! just £9 95 ref BAR31

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

SOLAR NICAD CHARGERS 4 x AA size £9 99 ref 6P476, 2 x C size £9 99 ref 6P477**YOUR HOME COULD BE SELF SUFFICENT IN ELECTRICITY** Comprehensive plans with loads of info on designing systems, panels, control electronics etc £7 ref PV1

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead and cigar plug 12v 2w **£12.99** REF AUG10P3 **STEPPER MOTORS** Brand new stepper motors 4mm fixing holes with 47 14mm fixing centres, 20mm shaft, 6 35mm diameter, 5v/phase, 0 7A/phase, 1 8 deg step (200 step) Body 56x36mm £14 99 ea ref STEP6, pack of 4 for £49 95 PIC based variable speedcontroller kit £15 ref STEP7

WAREHOUSE CLOSING SALE

Come and vist our Sussex warehouse, fill you car (or van) with loads of goodies at bargain prices. We must clear this warehouse regardless of cost, first come, first served, 10,000 square feet of bargains to browse. Call us for an appointment and directions. Appointments only.

Hydrogen fuel cells

Our new Hydrogen fuel cells are 1v at up tp 1A output, Hydrogen input, easily driven from a small electrolosis assembly or from a hydrogen source, our demo model uses a solar panel with the output leads in a glass of salt water to produce the hydrogen! Each cell is designed to be completely taken apart, put back together and expanded to what ever capacity you like, (up to 10watts and 12v per assembly. Cells cost £49 ref HFC11

PHILIPS VP406 LASER DISC PLAYERS, SCART OUTPUT, JUST PUT YOUR VIDEO DISK IN AND PRESS PLAY, STANDARD AUDIO AND VIDEO OUTPUTS, FULLY TESTED AND WORKING. £24.95 REF VP406

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

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

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

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

12V SOLAR POWERED WATER PUMP Perfect for many 12v DC uses from solar fountains to hydroponics! Small and compact yet powerful works direct from our 10 watt solar panel in bright sun Max hd 17 ft Max flow = 8 Lpm 1 5A Ref AC8 £18 99

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

PINHOLE CAMERA MODULE WITH AUDIO!
Superb board camera with on board sound! extra small just 28mm square (including microphone) ideal for covert surveillance Can be hidden inside anything , even a matchbox! Complete with 15 metre cable, psu and tv/vcr connnectors £49 95 ref CC6J

SOLAR MOTORS Tiny motors which run quite happily on voltages from3-12vdc Works on our 6v amorphous 6" panels and you can run them from the sun! 32mm dia 20mm thick £1 50 each

WALKIE TALKIES 1 MILE RANGE £37/PAIR REF MAG30

LIQUID CRYSTAL DISPLAYS Bargain prices,
16 character 4 line, 62x25mm £5.99 ref SMC1640A
40 character 1 line 154x16mm £6.00 ref SMC4011A

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

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead and cigar plug 12v 2w **£12.99** REF AUG10P3

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

SOLAR NICAD CHARGERS 4 x AA size £9 99 ref 6P476, 2 x C size £9 99 ref 6P477

MINATURE TOGGLE SWITCHES These top quality Japanese panel mount toggle switches measure 35x13x12mm, are 2 pole changeover and will switch 1A at 250vac, or 3 A at 125vac Complete with mounting washers and nuts Supplied as a box of 100 switches for £29 95 ref SWT35 or a bag of 15 for £4 99 ref SWT34

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

BULL ELECTRICAL

250 PORTLAND ROAD, HOVE, SUSSEX. BN3 5QT. (ESTABLISHED 50 YEARS).
MAIL ORDER TERMS: CASH, PO OR CHEQUE WITH ORDER PLUS £4.00 P&P PLUS VAT.
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OVERSEAS ORDERS AT COST PLUS £3.50
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'phone orders : 01273 203500
FAX 01273 323077
Sales@bull-electrical.com

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

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

THE TRUTH MACHINE Tells if someone is lying by micro tremors in their voice, battery operated, works in general conversation and on the 'phone and TV as well! £42 49 ref TD3

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

33 KILO LIFT MAGNET Neodynium,32mm diameter with a fixing bolt on the back for easy mounting. Each magnet will lift 33 kilos, 4 magnets bolted to a plate will lift an incredible 132 kilos! £15 ref MAG33 Pack of 4 just £39 reg MAG33AA

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

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

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

12V OPERATED SMOKE BOMBS Type 3 is a 12v trigger and 3 smoke cannisters, each cannister will fill a room in a very short space of time! £14 99 ref SB3 Type 2 is 20 smaller cannisters (suitable for mock equipment fires etc) and 1 trigger module for £29 ref SB2 Type 1 is a 12v trigger and 20 large cannisters £49 ref SB1

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

NEW LASER POINTERS 4 5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 670nm £29 ref DEC49J

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

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

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

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

SUPER WIDEBAND RADAR DETECTOR Detects both radar and laser , X K and KA bands, speed cameras, and all known speed detection systems. 360 degree coverage, front&r earwaveguides, 1 1"X2 7"x4 6" fits on visor or dash £149

LOPTX Made by Samsung for colour TV £3 each ref SS52

LAPTOP LCD SCREENS 240x175mm, £12 ref SS51

WANT TO MAKE SOME MONEY? STUCK FOR AN IDEA? We have collated 140 business manuals that give you information on setting up different businesses, you peruse these at your leisure using the text editor on your PC Also included is the certificate enabling you to reproduce (and sell) the manuals as much as you like! £14 ref EP74

HIGH POWER DC MOTORS, PERMANENT MAGNET 12 - 24v operation, probably about 1/4 horse power, body measures 100m x 75mm with a 60mm x 5mm output shaft with a machined flat on it Fixing is simple using the two threaded bolts protruding from the front £22 ref MOT4

Online web catalogue bull-electrical.com

ELECTRONIC SPEED CONTROLLER KIT For the above motor is £19 ref MAG17 Save £5 if you buy them both together. 1 motor plus speed controller rrp is £41, offer price £36 ref MOT5A

INFRA RED REMOTE CONTROLS made for TV's but may have other uses pack of 100 £39 ref IREM

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

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EVERYDAY PRACTICAL ELECTRONICS
INCORPORATING ELECTRONICS TODAY INTERNATIONAL

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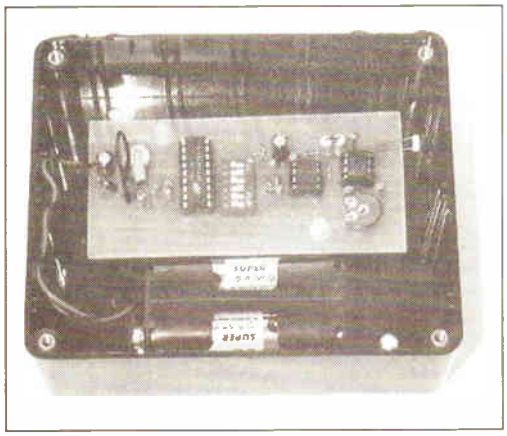

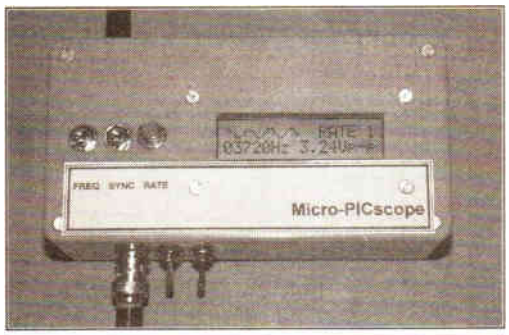

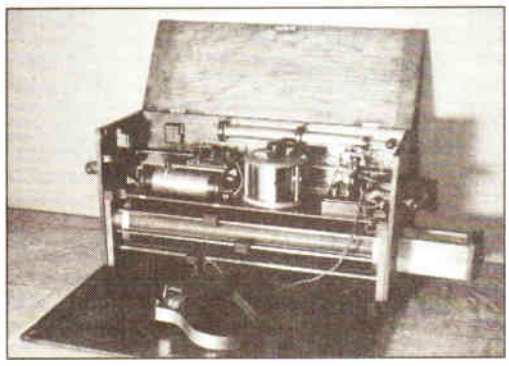

Projects and Circuits

Series and Features

Regulars and Services

Our May 2000 issue will be published on Friday, 7 April 2000. See page 235 for details

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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 or AV equipment which are fitted with a composite video or SCART input. 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. Ideal for desktop computer video systems & PIP (picture in picture) setups. 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. Brand new - fully guaranteed.

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 signal reception Telebox MB should be connected to a cable type service. Shipping on all Telebox's, code (B)

NEW State of the art PAL (UK spec) UHF TV tuner module with composite 1V pp video & NICAM hi fi stereo sound outputs. Micro electronics all on one small PCB only 73 x 160 x 52 mm enable full tuning control via a simple 3 wire link to an IBM pc type computer. Supplied complete with simple working program and documentation. Requires +12V & + 5V DC to operate.
BRAND NEW - Order as MY00. Only £49.95 code (B)
See www.distel.co.uk/data_my00.htm for picture + full details

FLOPPY DISK DRIVES 2½" - 8"

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 full 90 day guarantee. Call or see our web site *www.distel.co.uk* for over 2000 unlisted drives for spares or repair.

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" Floppy / HD £29.95(B)
8" Shugart 800/801 8" SS refurbished & tested £210.00(E)
8" Shugart 810 8" SS HH *Brand New* £195.00(E)
8" Shugart 851 8" double sided refurbished & tested £260.00(E)
8" Mitsubishi M2894-63 double sided *NEW* £295.00(E)
8" Mitsubishi M2896-63-02U DS slimline *NEW* £295.00(E)
Dual 8" cased drives with integral power supply 2 Mb £499.00(E)

HARD DISK DRIVES 2½" - 14"

2½" TOSHIBA MK1002MAV 1.1Gb laptop(12.5 mm H) *New* £79.95
2½"TOSHIBA MK2101MAN 2.16 Gb laptop (19 mm H) *New* £89.50
2½" TOSHIBA MK4309MAT 4.3Gb laptop (8.2 mm H) *New* £105.00
2½" TOSHIBAMK6409MAV 6.1Gb laptop (12.7 mm H) *New* £190.00
2½" to 3½" conversion kit for Pc's, complete with connectors £14.95
3½" FUJI FK-309-26 20mb MFM I/F RFE £59.95
3½" CONNER CP3024 20 mb IDE I/F (or equiv.) RFE £59.95
3½" CONNER CP3044 40 mb IDE I/F (or equiv.) RFE £69.00
3½" QUANTUM 40S Prodri ve 42mb SCSI I/F, New RFE £49.00
5¼" MINISCRIBE 3425 20mb MFM I/F (or equiv.) RFE £49.95
5¼" SEAGATE ST-238R 30 mb RLL I/F Refurb £69.95
5¼" CDC 94205-51 40mb HH MFM I/F RFE tested £69.95
5¼" HP 97548 850 Mb SCSI RFE tested £99.00
5¼" HP C3010 2 Gbyte SCSI *differential* RFE tested £195.00
8" NEC D2246 85 Mb SMD interface. *New* £199.00
8" FUJITSU M2322K 160Mb SMD I/F RFE tested £195.00
8" FUJITSU M2392K 2 Gb SMD I/F RFE tested £345.00
Many other drives in stock - Shipping on all drives is code (C1)

IC's -TRANSISTORS - DIODES

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10,000,000 items EX STOCK
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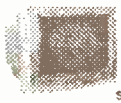
VIDEO MONITOR SPECIALS

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, in EXCELLENT little used condition.



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

Ex demo 17" 0.28 SVGA Mitsubishi Diamond Pro monitors, Full multisync etc. Full 90 day guarantee. Only £199.00 (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 **Only £99.00** (E)
Dimensions: W14" x H12¾" x 15½" D.

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)

We probably have the largest range of video monitors in Europe, All sizes and types from 4" to 42" call for info.

DC POWER SUPPLIES

Virtually every type of power supply you can imagine.Over 10,000 Power Supplies Ex Stock Call or see our web site.

TEST EQUIPMENT & SPECIAL INTEREST ITEMS

MITS. FA3445ETKL 14" Industrial spec SVGA monitors £245
FARNELL 0-60V DC @ 50 Amps, bench Power Supplies £995
FARNELL AP3080 0-30V DC @ 80 Amps, bench Suppy £1850
1kW to 400 kW - 400 Hz 3 phase power sources - ex stock £POA
IBM 8230 Type 1, Token ring base unit driver £760
Wayne Kerr RA200 Audio frequency response analyser £2500
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
ALLGON 8360.11805-1880 MHz hybrid power combiners £250
Trend DSA 274 Data Analyser with G703(2M) 64 i/o £POA
Marconi 6310 Programmable 2 to 22 GHz sweep generator £6500
Marconi 2022C 10KHz-1GHz RF signal generator £1550
Marconi 2030 opt 03 10KHz-1.3 GHz signal generator,New £4995
HP1650B Logic Analyser £3750
HP3781A Pattern generator & HP3782A Error Detector £POA
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts £1800
HP6264 Rack mount variable 0-20V @ 20A metered PSU £675
HP54121A DC to 22 GHz four channel test set £POA
HP8130A opt 020 300 MHz pulse generator, GPIB etc £7900
HP A1, A0 8 pen HPGL high speed drum plotters - from £550
HP DRAFTMASTER 1 8 pen high speed plotter £750
EG+G Brookdeal 95035C Precision lock in amp £1800
View Eng. Mod 1200 computerised inspection system £POA
Sony DXC-3000A High quality CCD colour TV camera £995
Keithley 590 CV capacitor / voltage analyser £POA
Racal ICR40 dual 40 channel voice recorder system £3750
Fiskers 45KVA 3 ph On Line UPS - New batteries £9500
Emerson AP130 2.5KVA industrial spec.UPS £2100
Mann Tally MT645 High speed line printer £2200
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram £945
Siemens K4400 64Kb to 140Mb demux analyser £2950

HP6030A 0-200V DC @ 17 Amps bench power supply £1950
Intel SBC 486/125C08 Enhanced Multibus (MSA) New £1150
Nikon HFX-11 (Ephiphot) exposure control unit £1450
PHILIPS PM5518 pro. TV signal generator £1250
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 high speed band printer £1950
Fujitsu M3041D 600 LPM printer with network interface £1250
Perkin Elmer 299B Infrared spectrophotometer £500
Perkin Elmer 597 Infrared spectrophotometer £3500
VG Electronics 1035 TELETEXT Decoding Margin Meter £3250
LightBand 60 output high spec 2u rack mount Video VDA's £495
Sekonic SD 150H 18 channel digital Hybrid chart recorder £1995
B&K 2633 Microphone pre amp £300
Taylor Hobson Tallysurf amplifier / recorder £750
ADC SS200 Carbon dioxide gas detector / monitor £1450
BBC AM20/3 PPM Meter (Ernest Turner) + drive electronics £75
ANRITSU 9654A Optical DC-2.5G/b waveform monitor £5650
ANRITSU MS9001B1 0.6-1.7 uM optical spectrum analyser £POA
ANRITSU ML93A optical power meter £990
ANRITSU Fibre optic characteristic test set £POA
R&S FTDZ Dual sound unit £650
R&S SBUF-E1 Vision modulator £775
WILTRON 6630B 12.4 / 20GHz RF sweep generator £5750
TEK 2445 150 MHz 4 trace oscilloscope £1250
TEK 2465 300 Mhz 300 MHz oscilloscope rack mount £1955
TEK TDS380 400Mhz digital realtime + disk drive, FFT etc £2900
TEK TDS524A 500Mhz digital realtime + colour display etc £5100
HP3585A Opt 907 20Hz to 40 Mhz spectrum analyser £3950
PHILIPS PW1730/10 60KV XRAY generator & accessories £POA
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NEXT MONTH

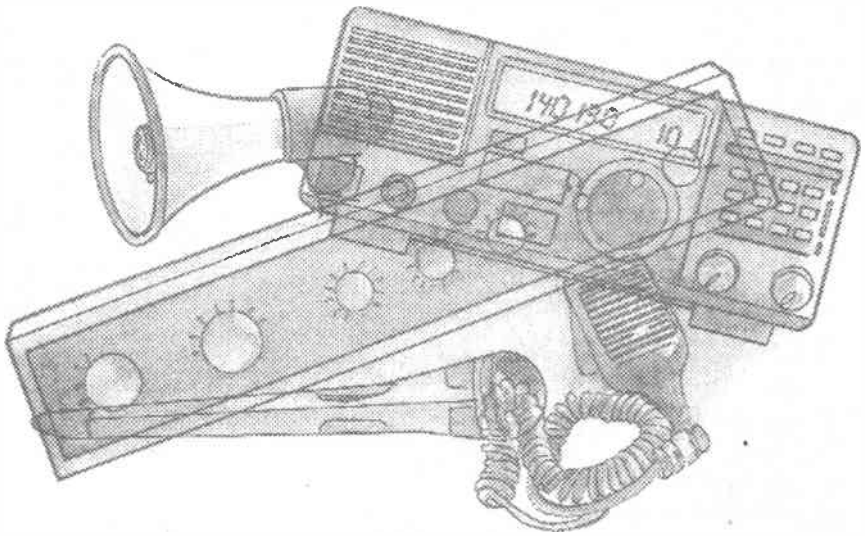
FREE POSTER

TECHNOLOGY TIMELINES

We've put all the Timelines together in order, added some new illustrations and displayed the whole lot on a wall chart that will be given away with next month's issue. It's fascinating to see when everything happened – and what the people and their inventions looked like. Don't miss it.

VERSATILE MICROPHONE/ AUDIO PREAMPLIFIER

One of the latest chips on the block, the Analog Device SSM2166P, is a low noise, low distortion, dynamic range compressor with a number of interesting features. In this design it provides a very versatile preamplifier with automatic gain control, signal limiting, variable compression and noise reduction circuitry. The design is suitable for a wide range of applications from PA and surveillance systems to amateur radio and audio. Additional circuitry is given for readers who require a signal strength meter.



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Hewlett Packard 1740A, 1741A, 1744A, 100MHz Dual Channel ..... from £300
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Hewlett Packard 54200A – 50MHz Digitizing £500
Hewlett Packard 54201A – 300MHz Digitizing £1250
Hewlett Packard 54512B – 300MHz – 1 GS/s 4-Channel £2250
Hewlett Packard 54501A – 100MHz – 100 Ms/s 4-Channel £1250
Hitachi V152F/V302B/V302F/V353F/V550B/V650F ..... from £105
Hitachi V650F – 60MHz Dual Channel £200
Hitachi V1100A – 100MHz 4-Channel £900
Intron 2020 – 20MHz Digital Storage (NEW) £450
Iwatsu SS5710/SS5702 – 20MHz ..... from £125
Meguro – MSO 1270A – 20 MHz Digital Storage (NEW) £450
Lecroy 9304 AM – 200MHz – 100 Ms/s 4-Channel £3000
Lecroy 9450A – 300MHz/400 Ms/s D.S.O. 2-Channel £2250
Philips PM 3055 – 50MHz Dual Timebase £450
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Tektronix 468 – 100MHz D.S.O. £500
Tektronix TAS 475 – 100MHz – 4-Channel £995
Tektronix 475/475A – 200MHz/250MHz Dual Channel ..... from £400
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Tektronix 2211 – Digital Storage – 50MHz £800
Tektronix 2213 – 60MHz Dual Channel £350
Tektronix 2215 – 60MHz Dual Trace £375
Tektronix 2220 – 60MHz Dual Channel D.S.O. £950
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Tektronix 2225 – 50MHz Dual Channel £350
Tektronix 2235 – 100MHz Dual trace £600
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Anritsu MS610B – 10kHz-2GHz – (Mint) £4500
Anritsu MS710F – 100kHz-23GHz Spectrum Analyser £5500
Avcom PSA65B – 1000MHz – portable £850
Hameg 8028/8038 – Spectrum Analyser/Tracking Gen + 100MHz Oscilloscope £1000
Hewlett Packard 182R with **8559A** (10MHz-21GHz) £2750
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MISCELLANEOUS

Adret 740A – 100kHz-1120MHz Synthesised Signal Generator £800
Anritsu MG 3601A Signal Generator 0·1-1040MHz £1250
Anritsu ME 462B DF/3 Transmission Analyser £2500
Anritsu MG 645B Signal Generator 0-05-1050MHz £750
Boonton 92C R/F Millivoltmeter £195
Boonton 93A True RMS Voltmeter £195
Dranetz 626 – AC/DC – Multifunction Analyser £500
EIP 331 – Frequency Counter 18GHz £450
EIP 545 – Frequency Counter 18GHz £1250
EIP 575 – Frequency Counter 18GHz £1450
Eltek SMPS – Power Supply 60V-30V £350
Farnell TSV-70 MKII Power Supply (70V – 5A or 35V – 10A) £200
Farnell DSG-1 Synthesised Signal Generator £125
Farnell AP 30250A Power Supply 3V – 250A £1750
Feedback PFG 605 Power Function Generator £150
Fluke 5100A – Calibrator £1950
GN ELMI EPR31 PCM Signalling Recorder £2000
Guildline 9152 – T12 Battery Standard Cell £550
Hewlett Packard 1630D – Logic Analyser (43 Channels) £500
Hewlett Packard 16500A/B and C – Fitted with 16510A/1651A/161530A/16531A – Logic Analyser ..... from £2000
Hewlett Packard 331A – Distortion Analyser £300
Hewlett Packard 333A – Distortion Analyser £300
Hewlett Packard 334A – Distortion Analyser £300
Hewlett Packard 3325A – 21MHz Synthesiser/Function Generator £900
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Hewlett Packard 3711A/3712A/3791B/3793B – Microwave Link Analyser £1500
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Hewlett Packard 3776A – PCM Terminal Test Set £1000
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Tektronix 577 – Curve Tracer £1150
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MAINS SUPPRESSOR CAPS, 0·1uf 250V AC, pack of 5. Order Ref: 1050.
MES LAMP HOLDERS, slide onto 1/4in. tag, pack of 10. Order Ref: 1054.
PAX TUBING, 1/4in. internal diameter, pack of 2, 12in. lengths. Order Ref: 1056.
HALL EFFECT DEVICES, mounted on small heatsink, pack of 2. Order Ref: 1022.
12V POLARISED RELAY, 2 changeover contacts. Order Ref: 1032.
PAXOLIN PANEL, 12in. x 12in., 1/16in. thick. Order Ref: 1033.
MINI POTTED TRANSFORMER, only 1·5VA, 15V-0V-15V or 30V. Order Ref: 964.
PRE-SET POTS, 1 meg, pack of 5. Order Ref: 998.
WHITE PROJECT BOX with rocker switch in top left-hand side, size 78mm x 115mm x 35mm, unprinted. Order Ref: 1006.
6V **SOLENOID,** good strong pull but quite small, pack of 2. Order Ref: 1012.
FIGURE 8 MAINS FLEX, alsoo makes good speaker lead, 15m. Order Ref: 1014.
HIGH CURRENT RELAY, 24V AC or 12V DC, 3 change-over contacts. Order Ref: 1016.
LOUDSPEAKER, 8 ohm 5W, 3·7in. round. Order Ref: 962.
NEON PILOT LIGHTS, oblong for front panel mounting, with internal resistor for normal mains operation, pack of 4. Order Ref: 970.
3·5mm **JACK PLUGS,** pack of 10. Order Ref: 975.
WANDER PLUGS, pack of 10. Order Ref: 986.
PSU, mains operated, 2 outputs, one 9·5V at 550mA and the other 15V at 150mA. Order Ref: 988.
ANOTHER PSU, mains operated, output 15V AC at 320mA. Order Ref: 989.
PHOTOCELLS, silicon chip type, pack of 4. Order Ref: 939.
LOUDSPEAKER, 5in. 4ohm 5W rating. Order Ref: 946.
LOUDSPEAER, 7in. x 5in. 4 ohm 5W. Order Ref: 949.
LOUDSPEAKER, 4in. circular 6ohm 3W, pack of 2. Order Ref: 951.
FERRITE POT CORES, 30mm x 15mm x 25mm, matching pair. Order Ref: 901.
CAR SOCKET PLUG with PCB compartment. Order Ref: 917.
PROJECT CASE, 95mm x 66mm x 23mm with removal lid held by 4 screws, pack off 2. Order Ref: 876.
SOLENOIDS, 12V to 24V, will push or pull, pack of 2. Order Ref: 877.
2M MAINS LEAD, 3-core with instrument plug moulded on. Order Ref: 879.
MICROPHONE, dynamic with normal body for hand holding. Order Ref: 885.
BATTERY CONNECTOR FOR PP3, superior quality, pack of 4. Order Ref: 887.
LIGHTWEIGHT STEREO HEADPHONES, Order Ref: 898.
PRESETS, 470ohm and 220K, mounted on single panel, pack of 10. Order Ref: 849.
THERMOSTAT for ovens with 1/4in. spindle to take control knob. Order Ref: 857.
12V-0V-12V 10W MAINS TRANSFORMER. Order Ref: 811.
18V-0V-18V 10W MAINS TRANSFORMER. Order Ref: 813.
AIR-SPACED TRIMMER CAPS, 2pf to 20pf, pack of 2. order Ref: 818.
2 **CIRCUIT MICRO SWITCHES,** licon, pack of 4. Order Ref: 825.
LARGE SIZE MICRO SWITCHES (20mm x 6mm x 10mm), changeover contacts, pack of 2. Order Ref: 826.
MAINS VOLTAGE PUSH SWITCH with white dolly through panel mounting hexagonal nut.
POINTER KNOB for spindle which is just under 1/4in., like most thermostats, pack of 4. Order Ref: 833.
AC MAINS CAPACITOR, 4uf metal cased with screw terminal, made by TCC. Order Ref: 1/26R7.
DITTO but 2·5uf. This is actually 350V rms, pack of 2. Order Ref: 1/26R8.
REED SWITCH, 1in. 6W, pack of 2. Order Ref: 1/26R13.
LINEAR POT, 10k with good length 1/4in. spindle, pack of 2. Order Ref: 1/26R14.
4-POLE 3-WAY WAFER SWITCH, with extra long 1/4in. sindle, pac of 2. Order Ref: 1/26R15.
DITTO but one pole 12-way, pack of 2. Order Ref: 1/26R32.
NEON LAMP with resistor for mains voltage in plastic tube, approx. 3/8in. dia. with yellow lens and good length leads, pack of 2. Order Ref: 1/26R18.
BC LAMP HOLDER ADAPTOR, made by Ashley, pack of 2. Order Ref: 1/26R20.
MAINS BUZZER, open, built on solid open metal frame with terminals. Order Ref: 1/26R23.
6 DIGIT COUNTER, nice silver plated case, 12V DC or 24V AC, has its own fixing bracket. Order Ref: 1/26R28.

BIG BUYERS PARCELS

Many of those listed last month are still available and there is a new list. If you want this, please phone.

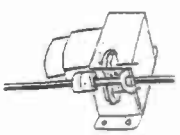
MOTORS AND ACCESSORIES

RECHARGEABLE 12V JELLY ACID BATTERY

Yuasa 12V 2·3AH. These are 7in. long, 3in. high and $1\frac{1}{2}$in. wise with robust terminals protruding through the top. Price £3.50 or 5 for £15. Order Ref: 3.5P11.
DITTO but 12V 18AH. This is 7in. long. 7in. high and 3in. wide. Brand new with 12 month guarantee, one for £12.50 or pck of 4 for £48, including VAT and carriage. Order Ref: 12.5P3.
Note – This battery will start a car and is ideal for golf trolleys, etc.
CHARGER for these batteries and other sealed lead acid batteries, £5. Order Ref: 5P269.

1·5V-6V BATTERY MOTORS

3 DIFFERENT, small, medium and large, for models, £1. Order Ref: 35.
SPIN TO START 3V, ideal model aircraft, 5 for £1, £15 per 100. Order Ref: 134.
SOLAR POWER MOTOR, £1.50. Order Ref: 1.5P33.
MINI 1·5V-3V MOTOR, 4 for £1, £20 per 100. Order Ref: D305.
MOTOR WITH GEARBOX. Unit comprises motor mounted on gearbox with interchangeable gears giving a range of speeds and motor torques. With instructions for changing gears and calculating speeds. Price £6. Order Ref: 7P26.



REVERSIBLE 12V DC MOTORS

1/5HP 12V by Smiths, very powerful. £12. Order Ref: 12P101.
1/8HP 12V by Smiths, £8. Order Ref: 8P54.
1/10HP 12V by Smiths, £6. Order Ref: 6P47.
MINI but quite powerful, 32mm diameter, 25mm body length, £1.50. Order Ref: 1.5P33.

VERY POWERFUL BATTERY MOTORS

Were intended to operate portable screwdrivers. Approximately $2\frac{1}{2}$in. long, $1\frac{1}{2}$in. diameter, with a good length of spindle. Will operate with considerable power off any voltage between 6V and 12V DC. Price £2. Order Ref: 2P456. Quantity discount 25% for 100.

BATTERY MOTOR WITH GEARBOX

The motor will operate on any DC voltage between 6 and 24, price £3. Order Ref: 3P108. The speed at 6V is approximately 200 rpm and at 12V approximately 400rpm, but the speed controller listed below will in all probability give you just the right speed you require.

AC MAINS MOTORS WITH GEARBOXES

5 RPM 30W, £8. Order ef: 8P55.
80 RPM 60W, £10. Order Ref: 10P159.
110 RPM 60W, £8. Order Ref: 8P67.
BRUSH TYPE MOTOR with angle gearbox as used on food mixers, £8. Order Ref: 8P68.
DITTO but less gearbox, £4.50. Order Ref: 4.5P11.

MINI AC MOTORS WITH GEARBOXES

1 REV PER 24 HRS 2W, £1. Order Ref: 89.
1 REV PER 4 HRS 2W, £2. Order Ref: 2P239.
1 REV PER HOUR 2W, extra small, 2 for £1. Order Ref: 500.
6 RPH 2W, £2. Order Ref: 2P430.
12 RPH, £2. Order Ref: 2P342.
20 RPH, £1. Order Ref: 1010.
1/3 RPM, £2. Order Ref: 2P460.
1 RPM, £3. Order Ref: 2P2251.
2 RPM 2W, £3. Order Ref: 3P249.
4 RPM 2W, £2. Order Ref: 2P393.
10 RPM 2W, £3. Order Ref: 3P217.
15 RPM 2W, £2. Order Ref: 2P321.
20 RPM 2W, £2. Order Ref: 2P432.
250 RPM 2W, £1. Order Ref: 750.

MAINS MOTORS

SUPER CROMPTON PARKINSON MOTOR. Really well made, totally enclosed by ventilated framework. Size approx. 4in. dia., 4in. high and 2in. of a 3/8in. spindle. Speed is 875 rpm, hp is not quoted but we estimate this to be around 1/6hp. Price £10. Order Ref: 10P149.
SHADED POLE MOTORS. The stack size indicates the power. 3/4in. stack. £2. Order Ref: 2P850. 1in. stack with extra long spindle, £3. Order Ref: 3P203. $1\frac{1}{2}$in. stack with good length of spindle from each side, £3.50. Order Ref: 3.5P22.

REVERSIBLE 230V AC MOTORS

1/8HP MOTOR by EMI, 2 speeds, 100rpm and 500rpm. £4. Order Ref: 4P80.
1/20HP PRECISION MOTOR, Japanese made, totally enclosed. £4. Order Ref: 4P94.

MOTOR CONTROLLERS

DC MOTOR SPEED CONTROLLER for 12V motors up to 1/6HP. £12 in kit form. Order Ref: 12P34, and £20 made up and working. Order Ref: 20P39.
REVERSING SWITCH, single pole 40A or double pole 20A. £1. Order Ref: 343.
30A DP SWITCH, panel mounting. £1. Order Ref: 166.
MAINS DRIVEN DC OUTPUT CONTROLLER with switch to give 6V. 8V or 12V and reversing switch. Ideal to control a battery motor, price £2. Order Ref: 2P3.

STEPPER MOTORS

MINI MOTOR BY PHILIPS, 12V. 7·5 degree step, quite standard. only £2. Order Ref: 2P457.
MEDIUM POWERED, Jap made. 1·5 degree step, £5. Order Ref: 5P272.

MOTOR START CAPACITORS

All are 250V AC working so can have many other applications. 32uf. £2. Order Ref: 2P452. 40uf, £2.50. Order Ref: 222.5P30. 125uf, £3.00. Order Ref: 3P239. 165uf, £3.50. Order Ref: 3.5P16.

CAPACITORS FOR MOTOR RUNNING

440V AC working unless stated:
1 mfd, 2 for £1. Order Ref: 633.
1·3 mfd, 2 for £1. Order Ref: 279.
2 mfd, £1 each. Order Ref: 1036.
4 mfd, £1 each. Order Ref: 702.
6 mfd, £2 each. Order Ref: 2P246.
14uf at 40V. £3. Order Ref: 3P199.
15 mfd. £3 each. Order Ref: 3P190.
18 mfd, 500V. £4 each. Order Ref: 4P107.
25 mfd but 375V working, £3 each. Order Ref: 3P67.
35 mfd. 375V working, £4 each. Order Ref: 4P88.

GEARBOXES

METAL CASED, size approximately 4in. x 3in. x 3/4in. thick. Good length 1/4in. spindle in and out. All £10 each. 3 ratios available: 200-1. Order Ref: 10P121. 50-1. Order Ref: 10P127. 16-1. Order Ref: 10P125.

BALL RACES

Superior quality Jap made. Three sizes available: 1/2in. x 3/16in.. 26mm x 10mm and 33mm x 10mm, all 50p each.

SOLENOIDS

Metal clad coil, pulls in an iron plunger when energised.
Mains voltage. coil size approximately $1\frac{1}{4}$in. x $1\frac{1}{4}$in. x $1\frac{1}{4}$in.. price £1. Order Ref: 8771.
DITTO but with a prod that pushes instead of pulls, price £1. Order Ref: 872.
12V DC operated. £1. Order Ref: 232.
12V or 24V DC but smaller, only 1/2in. x 1/2in. x 1in. long, push or pull. 2 for £1. Order Ref: 877.
6V DC operated, 2 for £1. Order Ref: 1012.

FAN BLADES

$6\frac{1}{2}$**in.** – 5-bladed aluminium. Order Ref: 86A.
5in. – 4-bladed aluminium. Order Ref: 86.
3in. – 4-bladed plastic. Order Ref: 638.
7in. – 3-bladed plastic. Order Ref: D51.
All 75p each – discount for quantity.

THIN DRILLS

Order Ref 129 is 12 pack assortment of sizes between 0·1mm and 0·7mm. Order Ref 128 is 12 between 0·7mm and 1·5mm. Order Ref 130 is 12 varying sizes between 1·6mm and 2·5mm.

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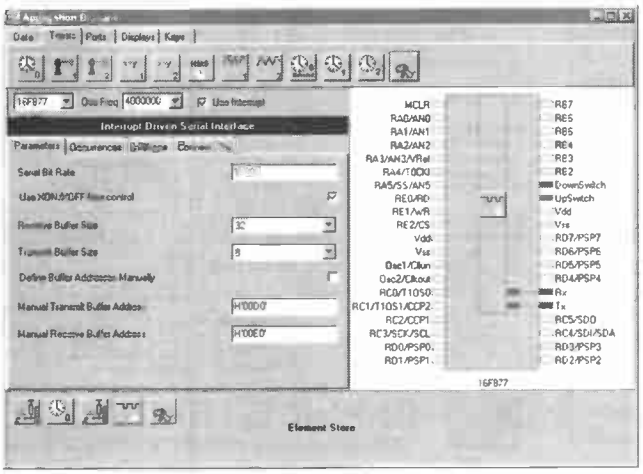
- Links your code automatically into library events (e.g. Button Pressed, Byte Received etc



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- WIZPIC supports all 14 bit core PIC's - 12C67x, 16C55x, 16C6x, 16C7x, 16C8x, 16C87x etc.

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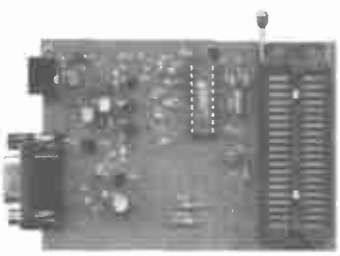
PICDESIM £20. WIZPIC - £30, or buy the WIZPIC CD-ROM including PIC data sheets & source material - £35. Upgrade - PICDESIM users £10.00 floppy / £15.00 CD-ROM

Programmers for PIC & AVR



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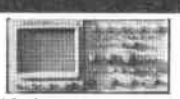

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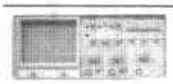

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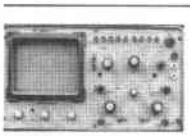

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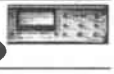

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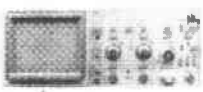

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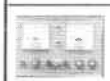

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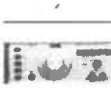

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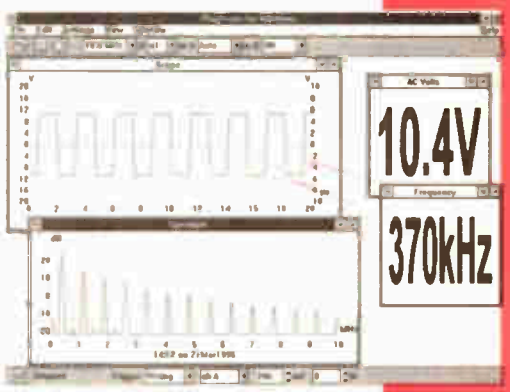

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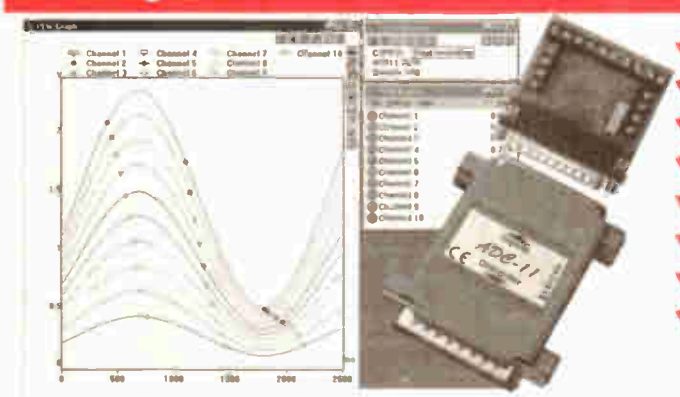

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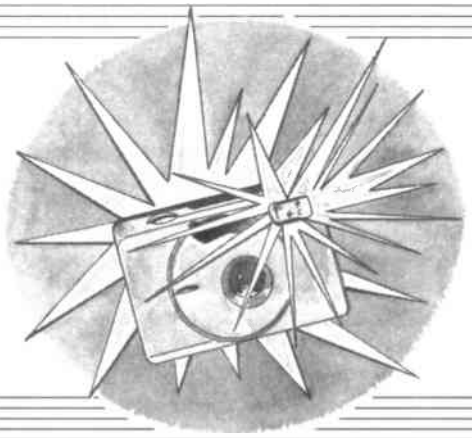


ROBERT PENFOLD

Create the right image with this low cost photographic aid.

CAMERAS have undoubtedly increased in sophistication over the last ten years or so, with features such as auto-focus and built-in flashguns now being commonplace. On the other hand, a few "standard" features seem to have become rarities that are featured on little more than a few up-market cameras.

The humble flash socket certainly falls into this category. At one time even the cheapest of compact cameras had this feature, but it seems to have disappeared in favour of an integral flashgun. It is actually quite a rarity on modern SLR cameras, although most sport a "hot shoe" that can be connected to a standard flash lead via an adapter. Most digital cameras seem to be styled on 35 millimetre and APS compact cameras, and have a built-in flashgun and no flash socket.

SECONDS OUT

For most users this lack of an external flash connector is probably of little consequence, but it is a major drawback for anyone wishing to go beyond simple "point and shoot" flash photography. The problem with a single flashgun is that it tends to produce a single shadow that is very strong and over-obvious. A balance of flash light and natural light generally gives better results, but is only possible if there is sufficient natural light and the camera can handle this type of lighting.

A more practical solution is to use a second flashgun, well separated from the main flashgun, to provide some fill-in lighting. Ideally the second gun should be a type that has variable output power so that the fill-in light can be balanced properly with the main light. However, even the cheapest of flashguns is good enough to provide a bit of fill-in lighting.

If a camera lacks a flash socket but does have a built-in flashgun, it is actually possible to use a second gun. In fact several additional guns can be used, but with more flashguns it obviously becomes more difficult to get the required lighting effect and the correct exposure.

In order to fire the secondary guns it is merely necessary to have each one triggered via a slave unit. A flash slave is just a high-speed light activated switch that triggers a secondary flashgun when it detects the flash of light from the main gun.

Provided the camera has a built-in flash unit, flash slaves enable any number of extra flashguns to be used without the need for any form of external flash connections on the camera. Even if you use a camera that has a standard flash socket, it can still be advantageous to use flash slave units.

Multi-flash photography using connecting cables is slightly risky because there are inevitably long trailing cables that are easily tripped over. Apart from the personal safety aspect, with such a set up it is very easy to do a lot of expensive damage to the equipment.

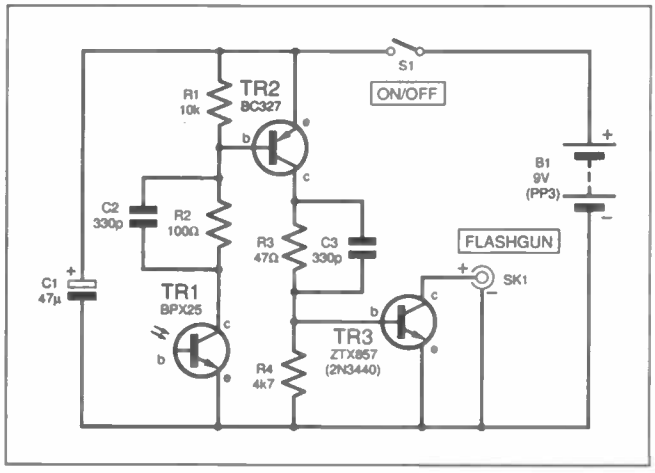


Fig.1. Complete circuit diagram for the Flash Slave.

CIRCUIT OPERATION

The full circuit diagram for the Flash Slave appears in Fig.1. For many years flash slave units used a triac or a thyristor as the switching device at the output. A device of either type was a good choice in the days when flashguns had high voltage trigger circuits that operated at around 150V to 180V.

An inexpensive thyristor or triac could handle the high voltages, and the switching action provided by one of these devices was all that was needed in this application. Unfortunately, most modern flashguns operate with much lower trigger voltages of around 12V to 24V, and the voltage drop through a triac or thyristor can prevent them from triggering these flashguns reliably.

Another common problem is that of the flash being triggered correctly the first time, but not firing on subsequent attempts. The unit can be made to work again by switching it off, waiting a few seconds, and then turning it back on. However, the flash only triggers once and then refuses to co-operate again!

The significant current that flows once the flash has been triggered causes this odd behaviour. Unlike a transistor, a triac or thyristor remains switched on until the current flow falls to a low level.

With older flashguns there is a high current flow during triggering, followed by a negligible current flow thereafter, causing the device to switch off. With low voltage trigger

Finished unit showing the "light window" and extension lead socket.

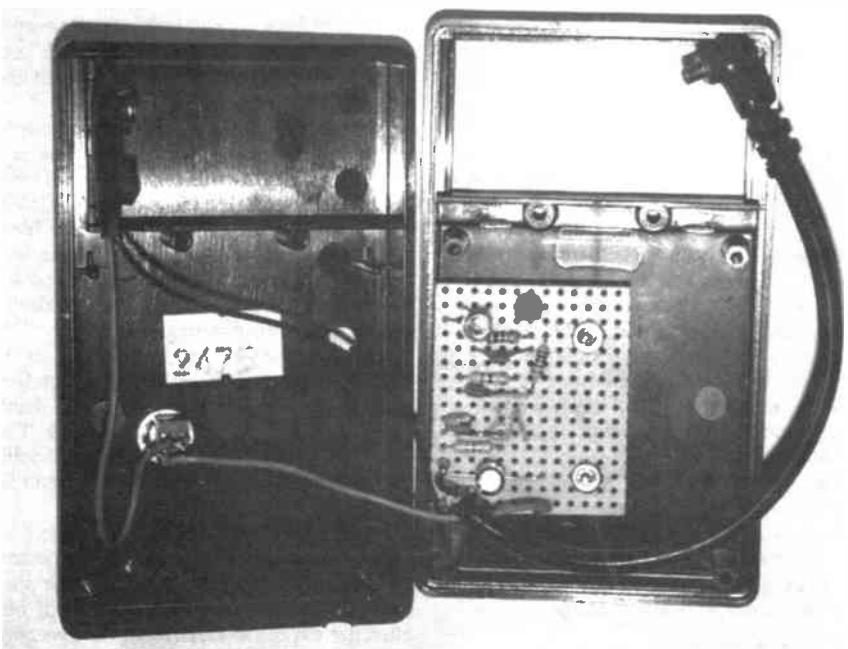
circuits the current flow is high enough to hold the triac or thyristor switched on. This usually stops the gun from operating, rather than causing it to fire each time an adequate charge is reached.

TRANSISTOR SWITCHING

Modern flash slave units use an ordinary transistor as the switching element. When driven with a suitably strong base (b) current a transistor will reliably trigger virtually any flashgun, ancient or modern. Once the pulse of light from the main gun has ceased, the base current to the transistor ends and the device switches off. This ensures that the flashgun can recycle properly, even if it is a type that has a low voltage trigger circuit.

This is not a problem if the camera gives a degree of manual control, since the user can set a shutter speed that is long enough to embrace the second flash. It is a potential problem if the camera automatically sets the minimum acceptable shutter speed for flash operation when the built-in flash unit is used. With the leaf shutters used in most compact cameras the highest shutter speed for flash can be less than two-milliseconds (1/500th second).

In order to ensure that the slave reacts quickly enough it is important to use a fast photocell, and in practice this means using either a phototransistor or a photodiode. Cadmium sulphide photo-resistors and photo-Darlington devices are not fast enough.



The two halves of the completed Flash Slave case showing positioning of the circuit board and mounting of the On/Off switch.

Of course, the transistor *must* be a high voltage type if the slave unit is to be used to trigger a flashgun that has a high voltage trigger circuit. The switching transistor in this circuit is TR3, and the specified component has a collector-to-emitter voltage rating of 300V, which is comfortably higher than the maximum voltage it is likely to receive. It also has a high peak collector (c) current rating of 5A, which is substantially higher than its likely operating current in this application.

Other transistors having a similarly high voltage and current ratings should work equally well in this design, such as the 2N3440 (which has a TO39 encapsulation and not an E-Line type). Lower voltage types should only be used if the unit will be used exclusively to control guns having low voltage trigger circuits.

RESPONSE TIME

It is important that the slave unit has a very short response time. If there is fast subject movement, a gap of even a few milliseconds between the two flashes could produce a noticeable double-image effect. Another problem is that of the shutter closing before the second flash has a chance to fire.

A phototransistor (TR1) is used in this design, but a photodiode can be used if preferred. Under dark conditions a phototransistor operates much like any other transistor, and with no base current applied only minute leakage currents flow in the collector-emitter circuit.

When a phototransistor is subject to light the leakage currents become much larger. The higher the light level the greater the leakage current that flows. Under standby conditions the leakage current through phototransistor TR1 is inadequate to bias the *pnp* transistor TR2 into conduction, but TR2 is switched on during the brief pulse of current from the primary flashgun. It in turn supplies a strong base current to transistor TR3, which conducts heavily and triggers the secondary flashgun. *Note that the flashgun must be connected to TR3 with the polarity shown in Fig.1 in order to obtain reliable triggering.*

Resistors R2 and R3 respectively limit the collector currents of TR1 and TR2 to safe levels, and capacitors C2 and C3 slightly improve the response time of the circuit. A BPX25 is specified for TR1, but on trying several silicon *npn* phototransistor in the circuit they all provided satisfactory results.

For the fastest response time a photodiode should be used in place of TR1. Connect the anode (a) and cathode (k) terminals in place of TR1's emitter (e) and collector (c) respectively.

The sensitivity of a photodiode is much less than that of a phototransistor, but omitting resistor R1 will largely compensate for this. Any general-purpose photodiode should be suitable, but infra-red types *do* not seem to work well in this application.

COMPONENTS

Resistors

R1	10k
R2	100Ω
R3	47Ω
R4	4k7

All 0·25W 5% carbon film

See SHOP TALK page

Capacitors

C1	47μ radial elect. 25V
C2, C3	330p ceramic plate (2 off)

Semiconductors

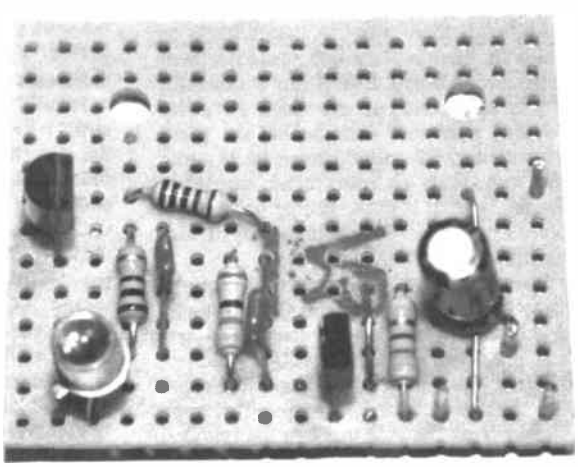
TR1	BPX25 silicon *npn* phototransistor (see text)
TR2	BC327 *pnp*, medium power, transistor
TR3	ZTX857 (or 2N3440) *npn*, high voltage, transistor

Miscellaneous

SK1	flash socket (see text)
B1	9V (PP3 size) battery
S1	s.p.s.t. min toggle switch

Small plastic case, 100mm x 60mm x 23mm approx.; 0·1in. strippboard, 16 holes by 13 strips; battery connector; multistrand connecting wire; solder pins; solder etc.

Approx. Cost Guidance Only **£14** *excluding batts.*



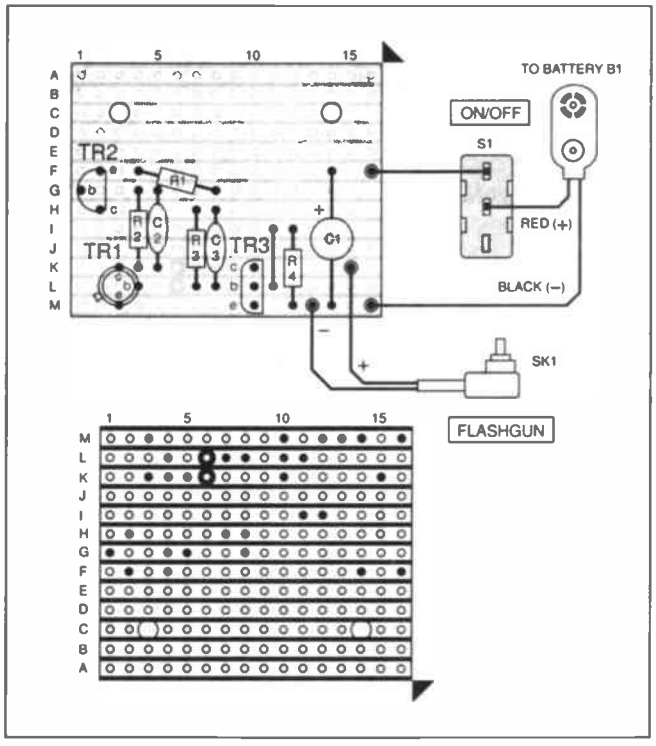


Fig.2. Flash Slave component layout and interwiring.

The current consumption of the circuit under standby conditions is only the leakage current through phototransistor TR1, which is normally less than 50μA. A PP3 size battery is therefore adequate to power the unit, and should provide more than 1000 hours of operation.

CONSTRUCTION

The Flash Slave circuit is built up on a small piece of stripboard having 16 holes by 13 copper strips. The topside component layout, together with the underside details, is shown in Fig.2. Only two breaks in the copper strips are needed.

Unless you have a suitable off-cut, commence construction by cutting a standard piece of stripboard down to size using a hacksaw and then drilling the two 3·3mm dia. mounting holes. These will accept either 6BA or metric M3 mounting bolts.

Plastic stand-offs are not a good choice for use with stripboard because most types do not provide a secure mounting when used with this type of board. The two breaks in the strips can be made using the special tool, or a twist drill bit of about 5mm in diameter will do the job well.

Although there are few components to deal with, there is not much space for them on the circuit board. Everything should still fit into place without too much difficulty provided miniature components are used. In particular, C2 and C3 must be ceramic plate capacitors or some other miniature ceramic type. It is unlikely that other types such as polystyrene capacitors will fit successfully into this layout.

Transistor TR3, used in the prototype, has an unusual encapsulation know as an E-Line case. At first glance it looks symmetrical, but if you look at it closely it becomes apparent that one side is flat and the other has slightly rounded corners. The type number is on the side that has the rounded corners, and this side faces towards capacitor C3, see Fig.2 and photographs. Fit solder pins to the board at the points where connections will be made to the in-line socket SK1, switch S1, and the battery.

CASING UP

Virtually any small plastic box should be adequate to accommodate this small project. The prototype is housed in a case that measures about 100mm × 60mm × 23mm, and this is slightly larger than the bare minimum.

The circuit board is mounted on the rear panel of the case, well towards one end so that there is sufficient space for the battery at the other end. On/Off switch S1 is mounted at any convenient position on the front panel.

A "window" for photocell TR1 is needed in the front panel, and there are two ways of tackling this. The method used on the prototype is to drill a hole of about 5mm dia. in the front panel, directly in front of TR1. With the leads of TR1 left quite long this brings it into the hole when the two halves of the case are fitted together.

The alternative, and slightly easier method, is to crop the leads of TR1 quite short, and to make a much larger "window" in the front panel. Some clear plastic should be glued over the rear of the "window" to keep dust out of the case.

FLASH CONNECTOR

The miniature coaxial connectors used for flashguns seem to be impossible to obtain these days, but flash extension leads can be obtained from photographic shops at reasonable prices. Cut the socket from the extension lead, together with about 150mm to 250mm of cable. Incidentally, the in-line version of the socket fitted to flash extension leads is actually the one that looks like a plug.

Drill a hole of about 4mm dia. in the case for the lead, thread it through the hole, prepare the end of the cable, and then connect the two wires to the circuit board. The unit will not work properly unless the flash lead is connected with the polarity indicated in Fig.2.

Ideally a voltmeter should be used to check the polarity of the potential on this lead, but trial and error can be used if necessary. It is very unlikely that connecting the flash lead with the wrong polarity will damage anything. Most flash leads have black and white insulation on the leads, and the black lead is usually the negative (–) lead.

To complete the unit, connect the black (–) battery clip lead and the lead from switch S1 to the circuit board. The red (+) lead from the battery clip goes to the switch, see Fig.2. After a final check through the unit is now ready for testing.

IN USE

When initially testing the unit it is best to try it at almost point blank range. If all is well try it at longer ranges, but switch off immediately and recheck the wiring if it fails to trigger the flashgun properly. Avoid aiming photocell TR1 towards strong light sources as this could result in the unit being held in the triggered state. This will prevent it from working and will greatly reduce the life of the battery.

The maximum range depends on the power of the primary flashgun and the precise characteristics of the photocell used for TR1, but it should be several metres or more. Raising the value of resistor R1 will increase the sensitivity of the unit, but this also increases the possibility of a strong ambient light level holding the unit in the triggered state.

When used indoors it is not normally necessary to aim the photocell at the primary flashgun, because light reflected from the walls, ceiling, etc. is usually sufficient to trigger the unit. When used in a large building or out of doors there will be less reflected light and it will then be necessary to aim it at the master flash unit in order to obtain reliable triggering.

The easy way of handling this is to fix the slave on one side of the secondary flashgun or on a separate lighting stand using something like Bostik Blu-Tack. The Blu-Tack provides a sort of universal joint that makes it easy to aim the flashgun in practically any desired direction.

Bear in mind that the light from the secondary flashgun will increase the exposure slightly. Provided the light from the secondary gun is relatively weak it will not alter the exposure sufficiently to give any major problems, even when using transparency film. The exposure latitude of print films is such that even an extra stop or so of exposure from the secondary flashgun should still achieve good results.

If you wish to check that the unit is responding quickly enough, the only sure test is to take some test shots. If you take a photograph of the slave flashgun and it comes out properly, the slave is not acting quickly enough and a longer shutter speed must be used. If you get what looks like a photograph of an explosion (below), the slave flashgun is being triggered fast enough. □

Test shot result showing "light burst" produced by pointing the "master" directly at the "slave".

News . . .

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

WATERMARKING MUSIC

Barry Fox reports on the arrival of a new method to prevent unauthorised music copying.

THE music and electronics industries have agreed on the technology they will use to bury a watermark in music recordings to control unauthorised copying from the Internet. The Secure Digital Music Initiative, a committee of 120 hardware and software companies, has chosen MusiCode from Aris Technologies of Cambridge, Massachussetts, USA.

The SDMI was formed when record industry trade body the Recording Industry Association of America failed in its legal bid to block sales of Diamond Multimedia's Rio, the pager-sized solid state recorder that uses MP3 compression technology to download and replay music from the Internet.

Watermarked Source

SDMI agreed that music will be watermarked at the recording studio with digital code which identifies the copyright owner and tells how the music is intended to be sold, for instance on a CD. An "SDMI-compliant" Internet music player will search for any watermark which reveals that a recording is an unauthorised copy from the Internet, and refuse to play it. Laws will be tightened to stop people modifying players so that they ignore "don't play me" marks.

The SDMI wanted a mark which can survive to-and-fro conversion between the analogue and digital domains and resist hackers who try and wash it out, while not degrading the sound. 4C Entity, a consortium of IBM, Intel, Matsushita (Panasonic) and Toshiba, took on the job of testing 11 different proposals.

Some spread a thin layer of modulated noise under the audio; others suck notches from the music and add modulated noise to the gaps. MusiCode works in a completely different way.

Coded Symbols

The encoder in the recording studio holds a library of symbols, digitally coded letters of the alphabet and numbers, which are represented by pre-determined patterns of a musical waveform. These can be peaks within a limited range of heights, which occur within a fixed period of time. The encoder analyses the music, looking for patterns that are similar to the library patterns. When a close match is found for a symbol that is to be buried in the music, the encoder modifies the music peaks so that they exactly match the library symbol.

A decoder in the player holds a library of symbol representations like those in the encoder. When it finds a matching pattern in the music it triggers the appropriate symbol. Together the symbols build up a copyright message.

The symbol data rate varies depending on the music content, but is typically around 100 bits per second. So it takes a few seconds for the decoder to recognise all the symbols needed for a copyright message or copy-control signal.

Golden Ear Tests

Aris claims that although the music waveform is slightly altered to convey the symbols, there is no noticeable effect on the sound, even when it comes from a super hi-fi source such as a DVD-Audio player, with frequency range of 100kHz and dynamic volume range of 140dB.

Audio enthusiasts have always been wary of anything that alters the sound but Aris says the tests done by 4C prove the system works. 4C built on the so-called Muse tests of CD watermarking which were carried out in Europe with EU funding by the music industry's trade body the International Federation of the Phonographic Industry. All the major record companies played music in their studios to panels of "golden ear" audio experts listening to marked and unmarked music without knowing which was which.

Paul Jessop, the IFPI's Technical Director, organised the European tests has confidence in the SDMI's findings.

"I am delighted" he says "that we have found a technology that independent listening tests have shown to be inaudible".

Scepticism May Remain

The SDMI, like the IFPI, refuses to name any of the "internationally recognised golden ears" which it claims were satisfied. Paul Jessop says he knows what this means. Audio enthusiasts will refuse to believe that any mark can be inaudible and be sure they can hear degradation even when there is none.

Renowned US mastering and recording engineer Bob Ludwig had previously warned that although watermarking might be inaudible on lo-fi Internet music, its effect on super hi-fi DVD-Audio would be noticeable. He said he was wary of any reassurances from the RIAA, which had argued in the 1980s that the Copycode notch system was inaudible.

Ludwig now says "my fervent hope is that digital signal processing has improved to the point where watermarking can be totally inaudible under all reasonable circumstances".

LIFE, THE UNIVERSE AND THE UK

THE British National Space Centre has announced that the search in the UK for life in the Universe is on! Astrobiology – a new science to search for life across the Universe – was launched in mid-December '99 and the excellence of UK scientists puts us in a strong world position.

Dr Don Cowan, Chair of the panel of experts which spent last year investigating work currently underway in the UK, recently made the following statement:

"This is a really exciting time in Astrobiology. In our investigation we found many British scientists who were Astrobiologists without knowing it; biologists were studying how life survives in the harsh environment of Antarctica, astronomers were developing new missions to find new planets, chemists were developing new techniques to identify biochemical markers, geologists were studying the way life transforms the properties of our planet.

"Brought together they make a powerful force in Astrobiology which will enable us to find out still more about where we come from and what other life might exist or have existed in the universe.

In a separate statement, Science Minister Lord Sainsbury has announced that the UK is to invest £1.4m in the experimental and research opportunities offered by the European Space Agency's EMIR-2 programme. The funding includes £15m investment in the UK small satellite sector, helping transfer the UK's world-leading capability in small satellites from the academic into scientific and commercial markets.

Furthermore, Surrey Space Centre, run by the University of Súrrey at Guildford, tell us that NASA has once again selected Surrey Satellite Technology Ltd (SSTL) as the only non-US supplier for its Rapid Spacecraft Acquisition contracts over the next five years.

Under the contract, SSTL will supply its flight-proven off-the-shelf mini-satellite platform for space and science technology missions to all of NASA's centres and other US Government agencies.

SSTL's first mini-satellite, UoSAT-12 was launched in early '99 and their sixteenth, Clementine, was launched in December '99.

All-in-all it seems an excellent start to the new millennium for the UK's involvement with Space. Surf **www.sstl.co.uk**.

QX3 INTELPLAY MICROSCOPE

MATTEL, the world's best known toy maker responsible for favourites such as the Barbie doll, has teamed up with Intel to produce a range of toys to complement the personal computer. Aimed at the six year-plus market, the marvellous Intelplay QX3 microscope is a Universal Serial Bus (USB) compatible device that allows colour images to be captured on a Pentium PC at several magnification factors, from x10 to x200. This allows youngsters to explore the fascinating world of microscopy and see images live on-screen.

Magnification factors refer approximately to the size of the image when viewed on a 15in computer monitor, say Mattel: this would, for example, enable a 1mm mustard seed to become a wonderful 20cm knobbly spheroid on a 19in monitor. The microscope resolution is 512 x 384 pixels, which is more than adequate for most investigations.

The excellent Windows software, replete with brilliant and fun sound effects, permits live viewing of the object (the frame delay depends on the throughput performance of the PC – it can appear virtually real-time on a 350MHz desktop). Still-capture and time-lapse movies can also be produced, perhaps to illustrate the growth of a mung bean or the movement of star-struck creepy crawlies. Slide-shows of microscopic montages, accompanied by some great sound tracks, can easily be put together by budding young boffins. Images can be printed or exported as bitmaps, and there is a great paint package included which allows pictures to be suitably enhanced.

The microscope has colourful chunky controls to allow youngsters to control the magnification and focus, and a push-button allows still images to be captured on disk for future reference. The QX3 incorporates two filament light sources (above or backlit) which are selectable through the software. The microscope unit can be detached from its stand to allow free-standing use, and the USB lead is approximately three metres long for this purpose.

It is completely powered through the USB connection and requires no extra mains adaptor or batteries. This also means that it could be used as a stand-alone device with a USB-enabled laptop computer, perhaps for junior field studies.

A complete kit is supplied by Mattel, including an Activity Book, sample slides and containment capsules. Everything is safely moulded in plastic of a high quality, with no glass parts or sharp edges being present.

Although it was launched towards the end of 1999 in the USA, our reviewer managed to obtain one of the first in Europe earlier this year, and had great fun exploring various natural objects, such as seeds, shrimps, sugar crystals and the anatomy of honey bees. Surface-mount electronic devices found their way under the lens too, and some reasonable photos captured of SMD chips and close-ups of soldering.

The QX3 is a fantastically creative educational gadget – much more than a toy – and is bound to be a big success with children, parents and teachers. Expect a UK launch in late Summer 2000, at a price of approximately £90.

Alan Winstanley

Guiding Inventors

A step-by-step guide to help inventors make an informed choice about using invention promotion companies has recently been published on the Internet by Lord Sainsbury, DTI (Department of Trade and Industry) Minister with responsibility for science and innovation. The guide is intended to help inventors get the most out of promotion services and provides advice on finding sources of free or low cost information.

Said Lord Sainsbury, "I do not want creative individuals to become unsuspecting victims of unscrupulous firms. I am confident that the easy-to-follow steps will help inventors avoid making costly mistakes".

The DTI factsheet can be accessed at **www.innovation.gov.uk.** Another useful Web address is that of the Patent Office, at **www.patent.gov.uk.** The DTI's phone number is 0171 215 5000.

EMF Facts

THERE has been a lot of publicity for the topic of EMF (electromagnetic fields), much of it having a negatively-biased approach. We have been advised that the new Safety Test Solutions web site, **www.safety-test-solutions.de**, offers a wide range of information on this topic. It tells you about the characteristics of EMF, where they occur and their effects. It also explains technical terms.

The website information is available in English, French, German and Spanish, on a wide variety of subject areas. "On our new website, every visitor will quickly find the information they need, no matter whether they are getting involved with electromagnetic fields for the first time, or if they are an EMF expert looking for detailed information", stated Hans J. Forster, Executive Director of Safety Test Solutions.

TITANIC RECEIVER DISCOVERED

A UNIQUE and valuable Edwardian crystal receiver, made in England in 1910, has recently been unearthed by a Midlands antique dealer, and has been acquired for a major private wireless collection in this country.

Early radios of this period are rare enough, but what makes this particular set especially unique is that its maker, Mr George Leadbetter (a machine turner and clock repairer then living in Ledbury, Worcestershire), while listening-in on the set's earphone on the morning of Monday 15th April 1912, suddenly tuned into the sinking *Titanic's* CQD/SOS Morse distress signals.

Unfortunately, having run round to the local police station to tell the sergeant what he had heard, he was turned away, none of the police officers on duty believing what he had to say!

It would be difficult to know what help Mr Leadbetter"s news could have been had he been believed (the *Titanic* was some 3,000 miles away across the other side of the Atlantic), but help was nearby and the distress signals were picked up by ships close at hand, resulting in the rescue of over 700 passengers and crew.

Such a pivotal role did wireless play in saving many hundreds of lives on board the stricken ship that its value was dramatically demonstrated and acknowledged around the world.

This beautiful engineer-made radio, measuring some 24in × 14in × 9in (60cm × 35mm × 7cm) and weighing 42lb (18kgs), is the only surviving radio receiver documented as having heard the distress cries from the *Titanic* – a fantastic relic from this most famous of historic disasters. A photo of the receiver is shown in this month's *Technology Timelines* feature.

The receiver will be on show in pride of place at the next *National Vintage Communications Fair* which will be held at the NEC in Birmingham on Sunday 30th April 2000.

Other exhibition items on show at the fair will be a comprehensive collection of WWII spy radio transmitters and receivers, a Horophone time-signal receiver (another unique Edwardian radio), and a display depicting the history of recorded sound.

For more information contact The National Vintage Communications Fair, Spice House, 13 Belmont Road, Exeter, Devon EX1 2HF. Tel: 01392 411565. E-mail:sunpress@eurobell.co.uk.Web:www.angelfire.com/tx/sunpress/index.html.

(If you are interested in vintage radio, why not take out a subscription to our sister magazine, *Radio Bygones*? For details see page 284.)

418MHz Band To Go

THE Radiocommunications Agency has announced a forthcoming change in the use of the 417.9 to 418.1MHz band, known as the 418MHz band, which is currently allocated for use by Short Range Devices (SRDs). We have published many projects which use this frequency, including one in this issue, and have more in the pipeline. From 31 December 2007, this band will be reassigned for use by terrestrial trunked radio (TETRA). Short-range devices are currently allowed to operate on the 418MHz band on a licence-exempt basis and without protection from interference from licensed radio services.

SRD equipment certified under the Radio and Telecommunications Terminal Equipment (R&TTE) Directive before 31 December 2002 may continue to be sold and used in the UK until 31 December 2007. After this date, SRD equipment using the 418MHz band may no longer be sold for use in the UK, but equipment already in use may continue to operate within the band, provided that it does not cause interference to the TETRA network.

The Agency states that it recognises the very real concerns of the low-power radio community in response to this change. Details of alternative European harmonised frequencies for SRDs are available in the Agency's SRD information sheet RA114, available on the RA web site: **www.radio.gov.uk/document/ra114/ra114.htm**, or from the RA library, tel: 0207 211 0502/0505.

The postal address of the Radio communications Agency is: New King's Beam House, 22 Upper Ground, London SE1 9SA.

Future PIC

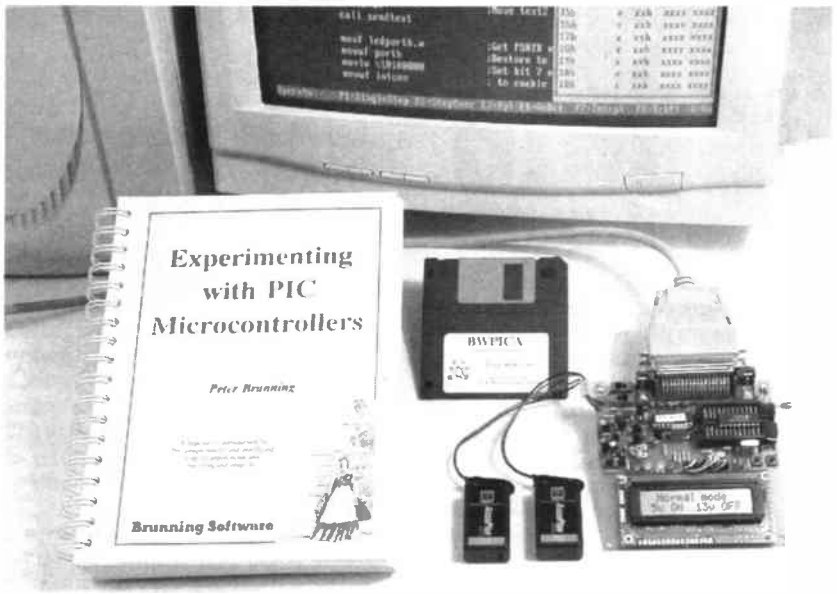
BROWSING the Web recently revealed that Microchip have another new PIC microcontroller series in preparation – the PIC18Cxxx. It appears to be worth keeping track of its progress.

According to the manufacturers, the evolutionary PIC18Cxxx architecture will allow existing PIC users to "seemlessly migrate their designs to higher integration while maintaining their code investment". In other words, code routines you have already developed (for PIC16C5x 12-bit, 12Cxxx 14-bit, 16Cxxx 14-bit and 17Cxxx 16-bit) can be transferred to the new series without rewriting them.

The PIC18Cxxx architecture has two million bytes of program memory address space, 4K bytes of data memory, and 10 MIPS (million instructions per second) performance. Multiply and divide commands are expected to be included (hooray!). This PIC series uses 16-bit instructions and 8-bit ALU architecture.

We shall keep track of the PIC18's progress – as can you, via web site **www.microchip.com**.

PIC EXPERIMENTING



BRUNNING Software have announced the third release in their "*Experimenting with.....*" series. The latest package "*Experimenting with PIC Microcontrollers*" concentrates on the PIC16F84 and PIC16C711 and consists of a book, a programmer/experimental module and an integrated suite of programs to run on a PC.

The book is the heart of the system with details of 22 experiments and two complete projects. The software, a text editor, assembler, disassembler simulator and programming software, has been specially written to complement the book. Its entire operation centres around the text editor. As the text is typed in the assembler tests each line so that errors are immediately highlighted.

When the typing is done the simulator can be used to single step or run the program. Boxes pop up showing the contents of registers and the result of any text written to a standard 2-line by 16-character display. When the program works correctly plug the programmer/experimental module onto the end of your printer lead and test it using a real live PIC.

All operations work directly from the assembler text in the editor, and the experiments are all performed using the programmer/experimental module which is already wired with l.e.d.s, push-buttons and an alphanumeric liquid crystal display.

Flashing l.e.d.s, text display, real time clock, period timer, beeps and music, including a rendition of Beethoven's *Für Elise*! Then there are two projects to work through; building a sinewave generator covering 0.2Hz to 20kHz in five ranges, and investigating measurement of the power taken by domestic appliances. The system assumes no prior programming or electronic knowledge and is suitable for absolute beginners and experienced programmers.

The book is £24.00. The programmer/experimental board with the software suite is £64. Contact: Brunning Software, 138 The Street, Little Clacton, Clacton-on-Sea, Essex, CO16 9LS. Tel: 01255-862308.

B.A.E.C.

IT'S good to see from the British Amateur Electronics Club (B.A.E.C.) that *EPE* readers are periodically following our suggestion that the club is well worthwhile joining. The latest newsletter shows that overseas readers are joining, as well as those living in the UK.

The B.A.E.C. is open to anyone who is interested in electronics. It operates on a self-help basis. Club members write articles for the Newsletter on the basis of their own knowledge or experience. The Newsletter is published quarterly and Membership costs £8 per year (UK).

If you wish to join the Club, contact the Hon Secretary, Martyn Moses, 5 The Paddocks, Aberaman, Aberdare, Mid Glam CF44 6YU. Tel: 01685 879025. E-mail: MPMOSES@compuserve.com. Mention *EPE* as your source of info.

Vann Draper Moves

REGULAR advertiser Vann Draper Electronics has moved to new larger premises – into a Grade II listed building, built in the 1800s and set in three acres of grounds. The new site offers extensive office and warehouse space, with visitor car parking adjacent to the main building.

The new contact details are: Vann Draper Electronics Ltd., Stenson House, Stenson, Derby DE73 1HL. Tel: 01283 704706. Fax: 01283 704707.

E-mail: sales@vanndraper.co.uk.

Web: www.vanndraper.co.uk.

Free plugs

ADVERTISERS, you could have your new products plugged here – send us details!

New Technology Update

Ian Poole reports that the development of electronic ink may indeed help to achieve that elusive dream, the paper-less office.

THE paperless office is something that has been long talked about but has never happened. Rather than reducing the amount of paper that is produced, computers and computer technology appear to have had exactly the opposite effect, causing paper to be used in vastly greater quantities than before the computer revolution.

Using computers it is far easier to produce enormous quantities of paper. Multiple copies of a document can easily be printed out. Also looking at a document on screen is never there same as reading a hard copy. Proof checking and even looking at the document or picture to see whether it is right can all be done more easily when a hard copy is to hand.

There have been many attempts to introduce the paperless office. New facilities like E-mail have been introduced and have helped in many ways, but initiatives like these often just seem to increase the amount of traffic travelling to and fro without reducing the actual amount of paper produced.

Many companies would like to reduce the amount of paper that is produced. Apart from important factors like green issues, paper documents and drawings are costly and take space to store. If they could be stored electronically and the impetus to print things onto a hard copy could be reduced then the paperless office might have a chance.

New Idea

In an attempt to overcome this problem a new idea know as electronic ink is being developed. A new company named ImmediaTM is developing a thin light weight display. Its format is such that it can almost be considered as paper on which messages can be displayed and changed electronically.

This gives an enormous scope for new methods of displaying information. Not only can it be used for emulating paper, but it can also be used in many other ways for displays on a variety of surfaces, as the technology does not have the limitations of cathode ray or liquid crystal technology where rigid constructions are needed.

The idea involves the use of two new and developing technologies. The first is the electronic ink itself and the second is the carbon based organic transistors that are being developed by Lucent Technology's Bell Laboratories.

Electronic Ink

The ink consists of millions of minute spheres. These are the key to the new technology, containing a dark dye and very small particles of titanium oxide suspended in a light oil. The titanium oxide pigments are white in colour and carry a negative charge. Accordingly under the influence of an electric field the oxide particles will either move to the back or front of the sphere. With the oxide particles at the back of the sphere, the dye is seen, and the area appears dark, but when the oxide particles are at the front of the sphere, the area appears white. In view of the size of the microcapsules, the definition of the display is governed by the control of the electric charge.

One of the advantages of paper is that it offers a very high degree of contrast providing a true black on white image, rather than the grey on grey provided by a liquid crystal display. A further advantage is that the electronic ink gives a very wide angle of view. This is one of the main disadvantages of liquid crystal displays.

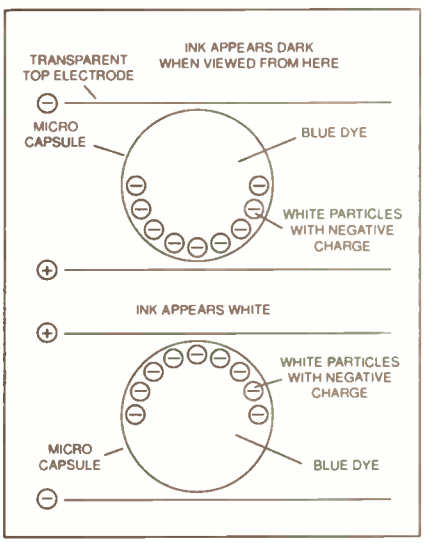


Fig.1. Operation of electronic ink.

Running from supplies between 10 and 100 volts, the displays consume very little power, as they operate by the attraction of charges and do not require current to flow. This will be of particular interest to developers of battery powered equipment. It is also found that once the control is removed the pattern remains in place, providing a non-volatile display – a facet that could be widely used to advantage.

Flexible Transistors

The charge required to control the ink capsules can be applied through transistors. However to enable the display to be made sufficiently thin, the new organic transistor technology being developed by Lucent will be used. These devices have the further advantage that they are also flexible, enabling the display to be printed onto a variety of surfaces and not be contained by a rigid mechanical environment like that of a cathode ray tube, or a liquid crystal display.

It is also anticipated that it will be possible to print the displays onto other surfaces using traditional printing technology. This would be a tremendous step forward, enabling electronic displays to be situated almost anywhere. This is achieved by suspending the microcapsules in traditional ink as the transport mechanism. It would then be possible to control the capsules.

The goal is to be able to print the transistors onto a flexible plastic film containing the microcapsules. The transistors will then be able to activate small areas (pixels) within the display area to create whatever shapes are required.

Development of both areas of the technology required for the display is still under way. Nevertheless a prototype display using traditional semiconductor technology has been put together and has shown encouraging results.

Developments

Although the basic idea has been proven there is still much development to be undertaken before displays in the final form are seen. Those developing the drive system using the new transistors are exploring the requirements for them. Decisions have to be made about the characteristics of the devices including whether they should be *p*-type or *n*-type.

Research is also progressing in the area of the electronic ink itself. One area they are investigating is the combinations of dye and white pigment. These too are crucial to the operation of the system.

Obviously the first aim is to move towards a small scale demonstration of the system. It is hoped to build a display with about 100 pixels within the next year. This will demonstrate the performance of the whole system, and give information to enable the development to move on to the next stage.

Moving on from this, the first major goal will be to produce signs or paper that can be remotely updated. At this stage it may also be possible to produce low cost flexible displays for the many portable products that will be available. Ultimately the goal is to produce an electronic book, with pages that can be viewed in the same way that a traditional paper book can be viewed. Whether this becomes reality, or whether technology takes the development down a different road remains to be seen.

However, it is certainly an interesting development and one that may have a significant effect on the format of electronic products and the man machine interface in the years to come. It may even help resolve the problem of the paperless office.

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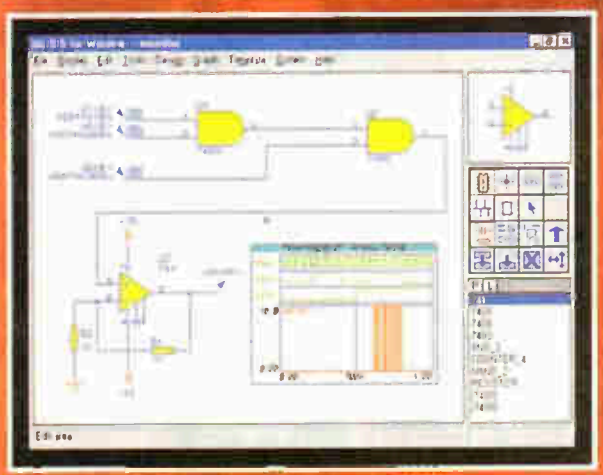

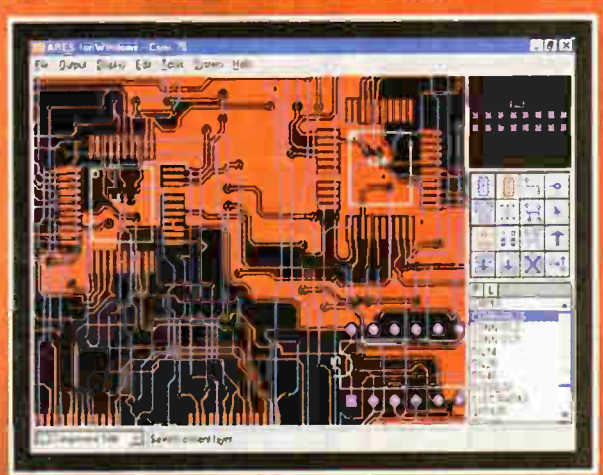

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- Berkeley SPICE3F5 analogue simulation kernel.
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● **1W+1W STEREO AMPLIFIER MODULE** Uses Samsung KA2209 IC (equivalent to the TDA2822) designed for portable cassette players & radios. 1-8-9VDC. PCB 35x50mm. **3087-KT £4.25**

● **10W+10W STEREO AMPLIFIER MODULE** Uses TDA2009 class audio power amp IC designed for high quality stereo applications. 8-28VDC. PCB 45x80mm. **3088-KT £9.95**

● **18W BTL AUDIO AMPLIFIER MODULE** Low voltage, high power mono 18W BTL amp using HA13118 IC. Delivers 14W into 4 Ohms (1% THD) with 13.2V supply. Thermal/surge protection. 8-18VDC. Heatsink provided. PCB 57x55mm. **3105-KT £8.95**

● **3-CHANNEL WIRELESS LIGHT MODULATOR** No electrical connection with amplifier. Light modulation achieved via a sensitive electret microphone. Separate sensitivity control per channel. Power handling 400W/channel. PCB 54x112mm. Mains powered. Box provided. **6014-KT £23.45**

● **12 RUNNING LIGHT EFFECT** Exciting 12 LED light effect ideal for parties, discos, shop-windows & eye-catching signs. PCB design allows replacement of LEDs with 220V bulbs by inserting 3 TRIACs. Adjustable rotation speed & direction. PCB 54x112mm. **1026-KT £10.95; BOX (for mains operation) 2026-KT £8.50**

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● **SOUND EFFECTS GENERATOR** Easy to build. Create an almost infinite variety of interesting/unusual sound effects from birds chirping to sirens. 9VDC. PCB 54x85mm. **1045-KT £8.95**

● **ROBOT VOICE EFFECT** Make your voice sound similar to a robot or Darlek. Great fun for discos, school plays, theatre productions, radio stations & playing jokes on your friends when answering the phone! PCB 42x71mm. **1131-KT £7.95**

● **AUDIO TO LIGHT MODULATOR** Controls intensity of one or more lights in response to an audio input. Safe, modern opto-coupler design. Mains voltage experience required. **3012-KT £7.95**

● **MUSIC BOX** Activated by light. Plays 8 Christmas songs and 5 other tunes. **3104-KT £6.95**

● **20 SECOND VOICE RECORDER** Uses non-volatile memory - no battery backup needed. Record/replay messages over & over. Playback as required to greet customers etc. Volume control & built-in mic. 6VDC. PCB 50x73mm. **3131-KT £11.95**

● **TRAIN SOUNDS** 4 selectable sounds: whistle blowing, level crossing bell, 'clickety-clack' & 4 in sequence. **SG01M £4.95**

● **ANIMAL SOUNDS** Cat, dog, chicken & cow. Ideal for kids farmyard toys & schools. **SG10M £4.50**

● **3 1/2 DIGIT LED PANEL METER** Use for basic voltage/current displays or customise to measure temperature, light, weight, movement, sound levels, etc with appropriate sensors (not supplied). Various input circuit designs provided. **3061-KT £11.95**

● **IR REMOTE TOGGLE SWITCH** Use any TV/VCR remote control unit to switch onboard 12V/1A relay on/off. **3058-KT £9.95**

SPEED CONTROLLER For any common DC motor up to 100V/5A. Pulse width modulation gives maximum torque at all speeds. 5-15VDC. Box provided. **3067-KT £10.95**

● **3 x 8 CHANNEL IR RELAY BOARD** Control eight 12V/1A relays by Infra Red (IR) remote control over a 20m range in sunlight. 6 relays turn on only the other 2 toggle on/off. 3 operation ranges determined by jumpers. Transmitter case & all components provided. Receiver PCB 76x89mm. **3072-KT £44.95**

● **PC CONTROLLED RELAY BOARD** Convert any 286 upward PC into a dedicated automatic controller to independently turn on/off up to eight lights, motors & other devices around the home, office, laboratory or factory using 8 240VAC/12A onboard relays. DOS utilities, sample test program, full-featured Windows utility & all components (except cable) provided. 12VDC. PCB 70x200mm. **3074-KT £29.95**

● **2 CHANNEL UHF RELAY SWITCH** Contains the same transmitter/receiver pair as 30A15 below plus the components and PCB to control two 240VAC/10A relays (also supplied). Ultra bright LEDs used to indicate relay status. **3082-KT £26.95**

● **TRANSMITTER RECEIVER PAIR** 2-button keyfob style 300-375MHz Tx with 30m range. Receiver encoder module with matched decoder IC. Components must be built into a circuit like kit 3082 above. **30A15 £13.95**

● **TELEPHONE LINE RELAY SWITCH** Turn on/off 4 relays over your phone line from anywhere in the world. 4-digit security code. Line protection circuitry built-in (non-approved). PCB 78x105mm. **3086-KT £39.95**

● **PC DATA ACQUISITION/CONTROL UNIT** Use your PC to monitor physical variables (e.g. pressure, temperature, light, weight, switch state, movement, relays etc.) process the information & use results to control physical devices like motors, sirens, relays, servo & stepper motors. Inputs: 16 digital & 11 analogue. Outputs: 8 digital & 1 analogue. Plastic case with printed front/rear panels, software utilities, programming examples & all components (except sensors & cable) provided. 12VDC. **3093-KT £79.95**

● **PIC 16C71 FOUR SERVO MOTOR DRIVER** Simultaneously control up to 4 servo motors. Software & all components (except servos/control pots) supplied. 5VDC. PCB 50x70mm. **3102-KT £14.95**

● **PC SERIAL PORT ISOLATED I/O BOARD** Provides eight 240VAC/10A relay outputs & 4 optically isolated inputs. Designed for use in various control & sensing applications e.g. load switching, external switch input sensing, contact closure & external voltage sensing. Controlled via serial port & a terminal emulator program (built into Windows). Can be used with ANY computer operating system. Plastic case with printed front/rear panels & all components (except cable) provided. **3108-KT £49.95**

● **UNIPOLAR STEPPER MOTOR DRIVER** for any 5/6/8 lead motor. Fast/slow & single step rates. Direction control & on/off switch. Wave, 2-phase & half-wave step modes. 4 LED indicators. PCB 50x65mm. **3109-KT £13.95**

● **PC CONTROLLED STEPPER MOTOR DRIVER** Control two unipolar stepper motors (3A max each) via PC printer port. Wave, 2-phase & half-wave step modes. Software accepts 4 digital inputs from external switches & will single step motors. PCB fits in D-shell case provided. **3113-KT £16.95**

● **12-BIT PC DATA ACQUISITION/CONTROL UNIT** Similar to kit 3093 above but uses a 12 bit Analogue-to-Digital Converter (ADC) with internal analogue multiplexor. Reads 8 single ended channels or 4 differential inputs or a mixture of both. Analogue inputs read 0-4V. Four TTL/CMOS compatible digital input/outputs. ADC conversion time <10uS. Software (C, QB & Win), extended D shell case & all components (except sensors & cable) provided. **3118-KT £47.95**

● **LIQUID LEVEL SENSOR/RAIN ALARM** Will indicate fluid levels or simply the presence of fluid. Relay output to control a pump to add/remove water when it reaches a certain level. **1080-KT £6.95**

● **UNIVERSAL TIMER** Seven crystal controlled timing operations in steps of 0.1s from 0.1 - 6553.6s or 1 second steps from 0.1-65536s. Allows 4 signal input types from push button to electrically isolated voltage switching sources. On board relay will switch 240V/5A. Box, software & all components provided. PCB 56 x 97mm. **3054-KT £24.95**

● **STEREO VU METER** shows peak music power using 2 rows of 10 LED's (mixed green & red) moving bar display. 0-30dB. **3089-KT £10.95**

● **AM RADIO KIT** 1 Tuned Radio Frequency front end, single chip AM radio IC & 2 stages of audio amplification. All components (inc speaker) provided. PCB 32x102mm. **3063-KT £9.95**

● **DRILL SPEED CONTROLLER** Adjust the speed of your electric drill according to the job at hand. Suitable for 240V AC mains powered drills up to 700W power. PCB 48mm x 65mm. Box provided. **6074-KT £15.90**

● **3 INPUT MONO MIXER** Independent level control for each input and separate bass/treble controls. Input sensitivity: 240mV. 18V DC. PCB 60mm x 185mm. **1052-KT £16.95**

● **ELECTRONIC SIREN** 5 Watt. Impressive 5W power output. Suitable for alarm systems, car motorbikes, etc. Output frequency 1-2kHz. 6-12V DC. PCB 37mm x 71mm. Siren not provided. **1003-KT £5.95**

● **NEGATIVE/POSITIVE ION GENERATOR** Standard Cockcroft-Walton multiplier circuit. Mains voltage experience required. **3057-KT £9.95**

● **LED DICE** Classic intro to electronics & circuit analysis. 7 LED's simulate dice roll, slow down & land on a number at random. 555 IC circuit. **3003-KT £7.95**

● **STAIRWAY TO HEAVEN** Tests hand-eye co-ordination. Press switch when green segment of LED lights to climb the stairway - miss & start again! Good intro to several basic circuits. **3005-KT £7.95**

● **ROULETTE LED** Ball spins round the wheel, slows down & drops into a slot. 10 LED's. Good intro to CMOS decade counters & Op-Amps. **3006-KT £9.95**

● **DUAL LED DICE** PIC 16C54 circuit performs similar function to 3003-KT above but two dice. Good intro to micro-controllers. **3071-KT £11.95**

● **9V XENON TUBE FLASHER** Transformer circuit steps up 9V battery to flash a 25mm Xenon tube. Adjustable flash rate (0-25-2 Sec's). **3022-KT £10.95**

● **LED FLASHER 1** 5 ultra bright red LED's flash in 7 selectable patterns. **3037M-KT £4.50**

● **LED FLASHER 2** Similar to above but flash in sequence or randomly. Ideal for model railways. **3052M-KT £4.50**

● **16C84 PIC PROGRAMMER** Reads programs & verifies. Uses any PC parallel port. All hardware, software & documentation needed to learn & test this uC provided. **3081-KT £21.95**

● **SERIAL PIC PROGRAMMER** for all 8/18/28/40 pin DIP serial programmed PICs. 3rd party software supplied expires after 21 days (costs US$25 to register). **3096-KT £12.95**

● **'PICALL' SERIAL & PARALLEL PIC PROGRAMMER** for all 8/18/28/40 pin DIP parallel AND serial PICs. Includes fully functional & registered software (DOS, W3.1, W95/8). **3117-KT £54.95**

● **ATMEL 89Cx051 PROGRAMMER** Simple-to-use yet powerful programmer for the Atmel 89C1051, 89C2051 & 89C4051 uC's. Programmer does NOT require special software other than a terminal emulator program (built into Windows). Can be used with ANY computer operating system. **3121-KT £24.95**

● **3V/1.5V TO 9V BATTERY CONVERTER** Replace expensive 9V batteries with economic 1.5V batteries. IC based circuit steps up 1 or 2 AA batteries to give 9V/18mA. **3035-KT £4.95**

● **STABILISED POWER SUPPLY 3-30V/2.5A** Ideal for hobbyist & professional laboratory. Very reliable & versatile design at an extremely reasonable price. Short circuit protection. Variable DC voltages (3-30V). Rated output 2.5 Amps. Large heatsink supplied. You just supply a 24VAC/3A transformer. PCB 55x112mm. Mains operation. **1007-KT £17.50. Custom Designed Box 2007 £34.95**

● **STABILISED POWER SUPPLY 2-30V/5A** As kit 1007 above but rated at 5Amp. Requires a 24VAC/5A transformer. **1096-KT £29.95. Custom Designed Box 2096 £34.95**

● **RFI POWER SUPPLY** Designed to power RF transmitters/receivers. Blocks high frequencies & eliminates problems like noise, overheating, standing waves, etc. Output 12-14VDC/3A. Thermal/short circuit protection & electronic stabilisation. You just supply a 18VAC/3A transformer. PCB 72x82mm. **1171-KT £24.95**

● **MOTORBIKE ALARM** Uses a reliable vibration sensor (adjustable sensitivity) to detect movement of the bike to trigger the alarm & switch the output relay to which a siren, bikes horn, indicators or other warning device can be attached. Auto-reset. 6-12VDC. PCB 57x64mm. **1011-KT £10.95. Box £5.95**

● **CAR ALARM SYSTEM** Protect your car from theft. Features vibration sensor, courtesy/boot light voltage drop sensor and bonnet/boot earth switch sensor. Entry/exit delays, auto-reset and adjustable alarm duration. 6-12V DC. PCB 47mm x 55mm. **1019-KT £9.95. Box £6.50**

● **LIGHT ALARM** Protect your valuables. Alarm sounds if circuit detects smallest amount of light. Place in cash box etc. **3008-KT £4.50**

● **PIEZO SCREAMER** 110dB of ear piercing noise. Fits in box with 2 x 35mm piezo elements built into their own resonant cavity. Use as an alarm siren or just for fun! 6-9VDC. **3015-KT £9.95**

● **COMBINATION LOCK** Versatile electronic lock comprising main circuit & separate keypad for remote opening of lock. Relay supplied. **3029-KT £9.95**

● **ULTRASONIC MOVEMENT DETECTOR** Crystal locked detector frequency for stability & reliability. PCB 75x40mm houses all components. 4.7m range. Adjustable sensitivity. Output will drive external relay circuits. 9VDC. **3049-KT £12.95.**

PIR DETECTOR MODULE 3-lead assembled unit just 25x35mm as used in commercial burglar alarm systems. **3076-KT £7.95**

● **INFRARED SECURITY BEAM** When the invisible IR beam is broken a relay is tripped that can be used to sound a bell or alarm. 25 metre range. Mains rated relays provided. 12VDC operation. **3130-KT £11.95**

● **FUNCTION GENERATOR** Quad Op-Amp oscillator & wave shaper circuit generates audio range square waves (6Hz-6KHz), triangle & pseudo sine outputs. 9VDC. **3023-KT £3.95**

● **LOGIC PROBE** tests CMOS & TTL circuits & detects fast pulses. Visual & audio indication of logic state. Full instructions supplied. **3024-KT £6.95**

● **SQUARE WAVE OSCILLATOR** Generates square waves at 6 preset frequencies in factors of 10 from 1Hz-100KHz. Visual output indicator. 5-18VDC. Box provided. **3111-KT £7.95**

● **PC DRIVEN POCKET SAMPLER/DATA LOGGER** Analogue voltage sampler records voltages up to 2V or 20V over periods from milli-seconds to months. Can also be used as a simple digital scope to examine audio & other signals up to about 5KHz. Software & D-shell case provided. **3112-KT £18.95**

● **20 MHz FUNCTION GENERATOR** Square, triangular and sine waveform up to 20MHz over 3 ranges using coarse and fine frequency adjustment controls. Adjustable output from 0-2V p-p. A TTL output is also provided for connection to a frequency meter. Uses MAX038 IC. Plastic case with printed front/rear panels & all components provided. **7-12VAC 3101-KT**

SURVEILLANCE

High performance surveillance bugs. Room transmitters supplied with sensitive electret microphone & battery holder/clip. All transmitters can be received on an ordinary VHF FM radio between 88-108MHz. Available in Kit Form (KT) or Assembled & Tested (AS).

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● ***MTX*** **- MINIATURE 3V TRANSMITTER** Easy to build & guaranteed to transmit 300m @ 3V. Long battery life 3.5V operation. Only 45x18mm. ● **3007KT £5.95 AS3007 £10.95**

MRTX **- MINIATURE 9V TRANSMITTER** Our best selling bug. Super sensitive, high power. 500m range @ 9V (over 1km with 18V supply and better aerial). 45x19mm. **3018KT £6.95 AS3018 £11.95**

HPTX **- HIGH POWER TRANSMITTER** High performance 2 stage transmitter gives greater stability & higher quality reception. 1000m range 6-12V DC operation. Size 70x15mm. **3032KT £8.95 AS3032 £17.95**

● ***MMTX*** **- MICRO-MINIATURE 9V TRANSMITTER** The ultimate bug for its size, performance and price. Just 15x25mm. 500m range @ 9V. Good stability 6-18V operation. **3051KT £7.95 AS3051 £13.95**

● ***VTX*** **- VOICE ACTIVATED TRANSMITTER** Operates only when sounds detected. Low standby current. Variable trigger sensitivity. 500m range. Peaking circuit supplied for maximum RF output. On/off switch. 6V operation. Only 63x38mm. **3028KT £9.95 AS3028 £22.95**

HARD-WIRED BUG/TWO STATION INTERCOM Each station has its own amplifier, speaker and mic. Can be set up as either a hard-wired bug or two-station intercom. 10m x 2-core cable supplied. 9V operation. **3021KT £13.95** (kit form only)

● ***TRVS*** **- TAPE RECORDER VOX SWITCH** Used to automatically operate a tape recorder (not supplied) via its REMOTE socket when sounds are detected. All conversations recorded. Adjustable sensitivity & turn-off delay. 115x19mm. **3013KT £7.95 AS3013 £19.95**

TELEPHONE SURVEILLANCE

● ***MTTX*** **- MINIATURE TELEPHONE TRANSMITTER** Attaches anywhere to phone line. Transmits only when phone is used. Tune in your radio and hear both parties. 300m range. Uses line as aerial & power source. 20x45mm. **3016KT £6.95 AS3016 £12.95**

● ***TRI*** **- TELEPHONE RECORDING INTERFACE** Automatically record all conversations. Connects between phone line & tape recorder (not supplied). Operates recorders with 1.5-12V battery systems. Powered from line. 50x33mm. **3033KT £7.95 AS3033 £16.95**

● ***TPA*** **- TELEPHONE PICK-UP AMPLIFIER/WIRELESS PHONE BUG** Place pick-up coil on the phone line or near phone earpiece and hear both sides of the conversation. **3055KT £9.95 AS3055 £19.95**

● **1 WATT FM TRANSMITTER** Easy to construct. Delivers a crisp, clear signal. Two stage circuit. Kit includes microphone and requires a simple open dipole aerial. 8-30VDC. PCB 42x45mm. **1009-KT £9.95**

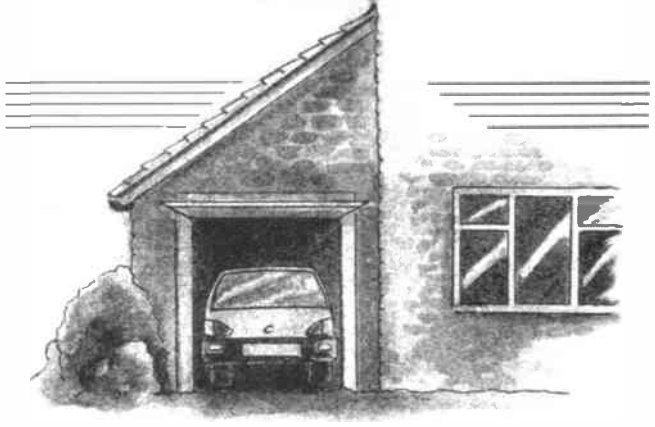
● **4 WATT FM TRANSMITTER** Comprises three RF stages and an audio preamplifier stage. Piezoelectric microphone supplied or you can use a separate preamplifier circuit. Antenna can be an open dipole or Ground Plane. Ideal project for those who wish to get started in the fascinating world of FM broadcasting and want a good basic circuit to experiment with. 12-18VDC. PCB 44x146mm. **1028-KT. £19.95**

● **15 WATT FM TRANSMITTER (PRE-ASSEMBLED & TESTED)** Four transistor based stages with Philips BLY 88 in final stage. 15 Watts RF power on the air. 88-108MHz. Accepts open dipole, Ground Plane, 5/8 J or YAGI configuration antennas. 12-18VDC. PCB 70x220mm. SWS meter needed for alignment. **1021-KT £64.95**

● **SIMILAR TO ABOVE BUT 25W Output. 1028-KT £19.95**

Constructional Project

GARAGE LINK



TERRY de VAUX-BALBIRNIE

Have you left the garage door open all night again? You need this versatile, licence exempt, coded radio link.

HAVE you ever gone to get the car out of the garage and found that you left the door open all night? With luck, the car is still there and everything inside the garage untouched. You breath a sigh of relief and vow to be more careful in future.

OPEN DOOR

But what if the car had been stolen? How would you square that with the insurance company when you declared that the car is left overnight "in a secure garage"? What about expensive power tools, bicycles and gardening equipment which you keep there?

These would be easily removed by any opportunist prowler. You could hardly show the "forcible entry" needed to make a claim on your household policy when all he had to do was walk in and take what he wanted!

WIRELESS LINK

This Garage Link circuit helps to prevent the garage door (or either door in the case of a double garage having twin doors) being left open all night. It works by establishing a radio link between the garage transmitter and some point inside the house. The indoor receiver then provides an audible warning in the form of a short bleep every 45 seconds.

The likely operating range is difficult to predict. In the open air, the prototype operated reliably at a distance of over 20 metres. However, the range will be much less when used in buildings. The presence of metallic objects and even ordinary building materials will reduce the signal.

The prototype units were set up under "fair" conditions. The garage was built with single brick walls and the house with double walls made of brick and breeze block. The easily-obtainable range was approximately 8 to 10 metres (26ft to 33ft). Obviously working to as short a range as practicable will give the most reliable results.

ON SITE

With the likely operating distance in mind and before beginning construction work, it is essential to check that there are suitable positions for the two units. The garage Transmitter does not need to be particularly close to the door as long as a piece of twin wire can be connected to it from a "remote" trigger switch there. It is better, in fact, if it is kept away from the door if this is made of metal.

Both units should be sited clear of large metallic objects. There should be a mains socket near the house-based Receiver because it is operated using a plug-in power supply unit.

The garage section is battery-operated, using a pack of four "AA" size cells inside the case. This avoids the need for a mains supply in the garage with possible safety implications. The batteries should last for one year approximately.

Of course, applications for this circuit are not confined to monitoring garage doors and many readers will have their own ideas about how to use it. Because the Transmitter is self-contained, it could be used to monitor other doors, gates, windows, etc. In some situations, it would be necessary to use a waterproof enclosure but this is left up to the constructor.

LIGHT WORK

Since people often wish to leave the garage door open during the day, operation is held off until the light falls to a certain preset level. Another point is that the door might have been left open in the evening on purpose – perhaps because a member of the family is expected home soon.

This is one reason why the warning is given intermittently. It may then be ignored if required. The other reason is that it saves battery power.

Designing a circuit which would sound a warning if the garage door was left open would be easy if there was a clear path for a length of wire to be laid between a switch at the door and a unit inside the house. Unfortunately, this is not usually the case.

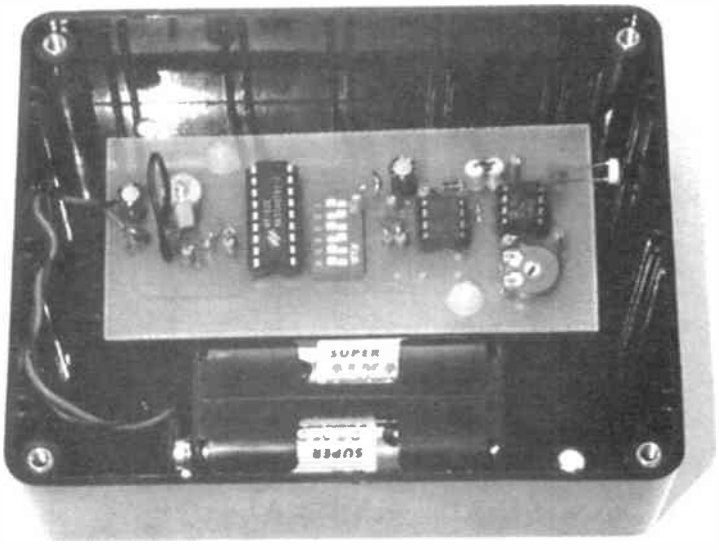
Even where it would be theoretically possible to run such a wire, it is unlikely that there would be a neat and simple way of doing it. It would also involve drilling holes through walls or window frames. This is why it was decided to use a different approach and base this system on a radio link.

FOLLOW THE BAND

The use of the radio frequency (r.f.) spectrum is carefully controlled with specific bands being allocated for various purposes. In the UK, the body which oversees this is the Department of Trade and Industry (DTI). Some frequency bands are reserved for radio and TV broadcasting, some for military, some for radio amateurs, some for the public services and so on.

Some small bands of frequencies are left on a licence-exempt basis and may be used by anyone. However, strict regulations exist for their use. In particular, the power radiated must be extremely small so that no appreciable signal may be detected more than a short distance from the transmitter.

One such frequency is 418MHz and this is used for certain local pagers, car security devices, "wireless" house alarms and so on. However, due to so-called TETRA services operating at around this



Self-contained Transmitter.

frequency and more so in the future, the DTI have licensed 433MHz for the same purpose.

This frequency is already in widespread use in mainland Europe. Note that these are actually narrow bands (that is, ranges) of frequencies but for the sake of simplicity they are stated as spot values – 418MHz and 433MHz.

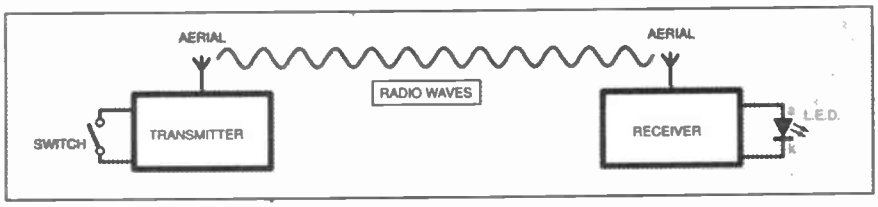


Fig.1. Block schematic of a simple radio link.

NO GUARANTEES

Although 433MHz equipment is probably less likely to suffer from interference problems especially in the coming years, there is always some risk of this occurring whichever frequency is used. Correct operation therefore cannot be guaranteed under all circumstances.

The prototype unit operates at 418MHz because the necessary modules were readily available at the time. However, there is no reason why similar 433MHz modules could not be used.

Another choice is whether to use a.m. (amplitude modulation) or f.m. (frequency modulation). Frequency modulation is more immune from interference, would provide a greater range and, for critical applications, would probably be better. However, here the less sophisticated a.m. system was used and it performed perfectly well.

For those who are interested, modulation is the way in which radio waves carry data. With a.m. it is the signal strength (amplitude of the waves) emitted by the transmitter which is varied with the frequency remaining constant. In the simplest case, this is performed by switching it on and off. With f.m. it is the frequency of the waves which is shifted slightly while keeping a constant amplitude.

COMMERCIAL MODULES

To allow the use of home-made transmitters would lead the way to potentially botched equipment causing interference with vital services. The actual transmitter (but not the circuit controlling it) must therefore be commercially-built to the prescribed specification. It is then said to be "DTI MPT1340 approved, W.T. licence exempt".

Appropriate commercial modular transmitters are available quite cheaply. The simplest variety has only two wires which are used for the power supply and aerial (antenna) and this is the type used in this project.

The receiver section is based on a matching receiver module. No traditional "radio" skills are therefore needed during construction and setting-up.

BASIC LINK

A simple radio link between two positions using a transmitter and receiver tuned to the same frequency is shown in Fig.1. Switching on ("keying") the transmitter would send out radio waves from its aerial. The signal would be picked up by an aerial at the receiver and, after suitable processing, the l.e.d. (light-emitting diode) connected to its output would operate. By switching the transmitter on and off, the l.e.d. would flash in sympathy.

However, this type of system would be vulnerable to false triggering. Every time the receiver picked up a signal from any other source of radio waves operating at or about the same frequency, the l.e.d. would come on.

To avoid this, the transmitter is keyed according to a certain pre-arranged digital code. Only if this code is matched at the receiver end will an output be given. The receiver may well pick up signals which carry no code at all or carry the wrong code (from similar equipment) but, in either case, it will have no effect.

CODED LINK

To illustrate this, suppose the code

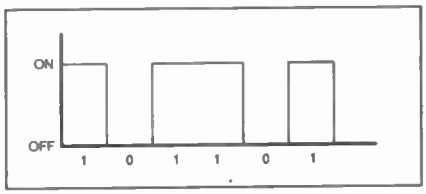


Fig.2. Transmitter code.

consists of the six-bit word: 1 0 1 1 0 1. A "1" would be given by switching the transmitter on for a certain time and a "0" by switching it off for the same time. The signal given by the transmitter is shown graphically in Fig.2. The receiver would then be pre-set to "see" this code and no other.

In the Garage Link, the code has twelve bits (although only six of them may be changed by the user). It is, therefore, very unlikely that any signal, apart from the intended one, would carry the correct code. If someone within range happened to be operating similar equipment and using the same code then all that would be necessary would be to change it.

Unfortunately, any strong signal at about the working frequency and not carrying the code could swamp the receiver so that it would not "see" the weaker signal from the transmitter. During that time, no output would be given.

CIRCUIT DETAILS – TRANSMITTER

The complete circuit diagram of the Transmitter section of the Garage Link is shown in Fig.3. While the garage door is open, it allows the normally-closed (n.c.) contacts of microswitch S7 to close and establish a supply to the circuit from the

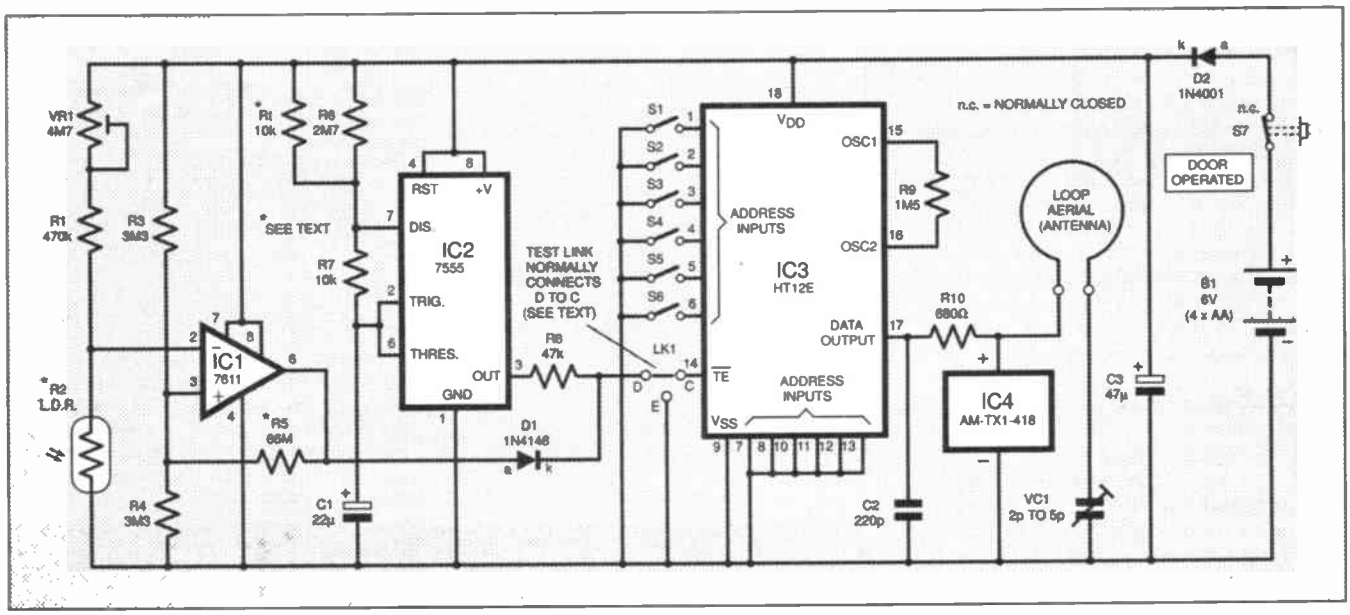


Fig.3. Circuit diagram for the Transmitter section of the Garage Link. Note that the normally closed contacts of microswitch S7 are used and that closing the garage door opens them. The TE designation at IC3 pin 14 means Transmit Enable.

6V battery pack, B1. When the door is closed, the switch contacts open and no current flows. This method has the advantage that for much of the time, the battery is not being drained.

Diode D2 prevents damage to the circuit if the supply were to be connected in the wrong sense. If it was, the diode would not conduct and nothing would happen. For the moment, ignore IC1 and IC2. IC3 is an encoder which keys the transmitter according to the pre-arranged code. IC4 is the transmitter module.

The twelve address inputs of IC3 are at pins 1 to 8 and pins 10 to 13. These may be set to logical 1 or 0 to provide the chosen code. Four of the addresses could also be used to carry separate data but this is not done here.

To establish the code some of the address pins are connected to the 0V line to provide logical 0 status. Any pin left unconnected automatically assumes logic 1.

CODE SETTING

Setting up the code is carried out using a set of d.i.p. (dual in-line package) switches (S1 to S6) on the p.c.b. (printed circuit board). With a switch on, a "0" is set and by switching it off, a "1". This gives a simple means of changing the code at any time if required.

It seemed unnecessary to allow user selection of all the addresses so here only IC3 pin 1 to pin 6 may be set using the d.i.p. switches. The other addresses (pins 7, 8 and 10 to 13) are tied to 0V together with pin 9 which is the 0V input, making them always logic "0".

When $\overline{TE}$ (transmit enable) pin 14 is made low (imagine this is so for the moment), the data present on the address pins is given serially at the data output, pin 17. This is in the form of four-word groups and continues as long at pin 14 $\overline{TE}$ is kept low.

If it is low for less than the time taken for one word, it will still transmit a four-word group. When the low state of pin 14 is removed, pin 17 finishes its current cycle then stops.

The rate at which data is transferred is determined by the frequency of an on-chip oscillator. This, in turn, is set by the value of resistor R9 connected between pin 15 and pin 16 (Osc1 and Osc2). The specified value sets a frequency of 2kHz approximately.

The data from IC3 pin 17 is used to power the transmitter module direct. When it is high, the transmitter (IC4) receives current and sends out a signal. When low, it is off. A short loop aerial (antenna) is used to radiate the waves and trimmer capacitor VC1 is used to tune it for maximum signal strength.

PULSE TIME

It is not necessary for the Transmitter to be providing data continuously — in fact, this would run down the batteries without good reason. IC3 pin 14 (transmit enable) only needs to be pulsed low for sufficient time to provide the bleeps at the Receiver.

To provide these pulses, IC3 pin 14 is connected via resistor R8 and test link LK1, to the output (pin 3) of the astable based on timer IC2. A continuous string of pulses is then produced.

The frequency and mark/space ratio (that is, how long each pulse is high compared with low) is determined by the values of resistors R6 and R7 in conjunction with capacitor C1. With the values specified, one cycle is produced every 42 seconds with each "low" taking 0·2s but this is subject to a fairly wide tolerance.

Test resistor *Rt* is connected in parallel with resistor R6 to begin with. This sets a much shorter time period (about half a second) so the buzzer bleeps rapidly. This will be useful for testing and setting-up purposes. At the end of setting up one of *Rt* end leads is cut to disconnect it from the circuit.

SEEING THE LIGHT

The light-sensing aspect of the circuit is based on operational amplifier (op.amp) IC1. This inhibits the action of the encoder when the light level is high enough. The op.amp is of a type which requires very little quiescent current (10µA approx.). It therefore has negligible effect on the life of the batteries.

The non-inverting input (pin 3) of IC1 receives a voltage equal to one-half that of the supply (nominally 3V) due to the potential divider action of resistors R3 and R4. The inverting input (pin 2) is connected to a further potential divider. Its top arm consists of fixed resistor R1 connected in series with preset potentiometer VR1. The lower arm is light-dependent resistor (l.d.r.) R2.

When the l.d.r. is brightly illuminated, its resistance will be lower than the R1/VR1 combination and the voltage at pin 2 will be less than 3V — that is, less than that at pin 3. With the op.amp non-inverting input voltage exceeding the inverting one, the output at pin 6 will be high.

COMPONENTS

TRANSMITTER

Resistors

R1	470k
R2	sub-min light dependent resistor (l.d.r.) — dark resistance 5MΩ approx (see text)
R3, R4	3M3 (2 off)
R5	66M (2 x 33M connected in series - see text)
R6	2M7
R7	10k
R8	47k
R9	1M5 (or 1M and 470k in series – see text)
R10	680Ω
Rt	10k (test - see text)

All 0·25W 5% carbon film, except R2

Potentiometer

VR1	4M7 min preset, horiz

See SHOP TALK page

Capacitors

C1	22µ radial elect.10V
C2	220p polystyrene
C3	47µ radial elect. 10V
VC1	min. preset trimmer 2pF to 5pF

Semiconductors

D1	1N4148 signal diode
D2	1N4001 1A 50V rectifier diode
IC1	ICL7611 micropower op.amp
IC2	ICM7555IPA CMOS timer
IC3	HT12E encoder
IC4	AM-TX1-418 transmitter module (see text)

Miscellaneous

S1 to S6	d.i.p. switches — one strip of six
S7	lever-arm microswitch
B1	6V battery pack (4 x AA)

Printed circuit board available from the *EPE PCB Service*, code 261 (Trans.); plastic case size 118mm × 98mm × 45mm; 8-pin d.i.l. i.c. socket (2 off); 18-pin d.i.l. i.c. socket; battery connector (PP3 type); bracket for microswitch – see text; connecting wire; solder; etc.

RECEIVER

Resistors

R1	100k
R2	10k

All 0·25W 5% carbon film

Capacitors

C1, C2	470n min metallised polyester — 2·5mm pin spacing (2 off)
C3, C4	220n min metallised polyester — 2·5mm pin spacing (2 off)
C5	100µ radial elect. 25V

Semiconductors

D1	1N4001 1A 50V rect. diode
TR1	ZTX300 *npn* general purpose transistor
IC1	AM-HRR3-418 receiver module
IC2	HT12F decoder
IC3	78L05 5V 100mA voltage regulator

Miscellaneous

S1 to S6	d.i.p. switches — one strip of six
WD1	piezo buzzer — d.c. operation 3V to 24V at 10mA
FS1	250mA miniature p.c.b. mounting fuse (see text)

Printed circuit board available from the *EPE PCB Service*, code 262 (Rec.); plastic case, size 102mm x 76mm x 38mm; 9V 300mA (unregulated) mains adaptor plus socket to suit; 18-pin d.i.l. i.c. socket; s.i.l. socket for receiver module, see text; connecting wire; solder, etc.

Approx. Cost Guidance Only

Transmitter excluding batts. **£17**

Receiver excluding mains adaptor **£23**

This state is transferred through diode D1 to IC3 pin 14. Whatever the state of IC2 output, IC3 "transmit enable" pin will be made high so operation is inhibited.

FAILING LIGHT

As the light level falls, the resistance of the l.d.r. increases and at some point will exceed that of the R1/VR1 combination. The voltage at the inverting input will then exceed 3V – that is, greater than that at the non-inverting one. The op.amp will switch off and pin 6 will go low. This state is blocked by diode D1 so it has no effect on the encoder (IC3) which is now controlled by the astable (IC2) alone.

The exact light level at which the transition occurs is determined by the adjustment of preset VR1. Resistor R5 connected between IC1 non-inverting input and the output, introduces a small amount of positive feedback and ensures a sharp switching action at the critical light level.

While actually transmitting data, the circuit requires some 2mA but between pulses, the prototype needs less than 95µA. Due to the short pulse length, the average current is very small. Remembering that when the garage door is closed there is no current drain at all, the overall current needed by the Transmitter is even less.

CONSTRUCTION – TRANSMITTER

Important Note: The design of the aerial is specified by regulations. There are two configurations possible but, of these, a *tuned loop* is used here. *The enclosed area must not exceed 700sq. mm and it must be integral within the unit — it cannot be placed externally and driven through a feeder.* Radio amateurs please note: *this transmitter is not type approved for use with a quarter wave or helical antenna .*

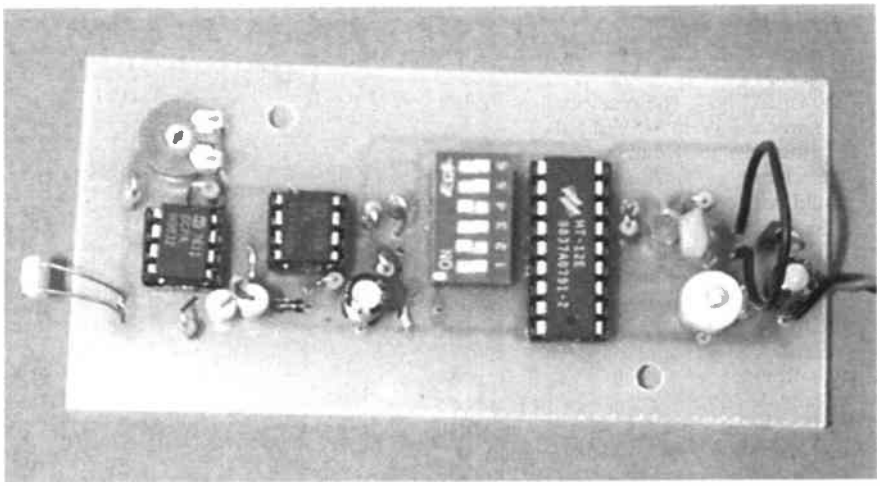
All components for the Transmitter (apart from the battery pack) are mounted on a single-sided printed circuit board (p.c.b.). The topside component layout and full size underside copper foil track master are shown in Fig. 4. This board is available from the *EPE PCB Service*, code 261.

Begin construction by drilling the two fixing holes and soldering the i.c. sockets, d.i.p. switches S1 to S6 and the two link wires in position. One of these is soldered between points A and B. The other is the *test link* (LK1 – C-D-E). The wire should be soldered as shown between C and D for normal operation.

Next, the resistors, capacitors and diodes (taking care with the polarity of capacitors C1, C3 and the diodes) can be mounted and soldered in position. If a 1·5MΩ resistor is not available for R9, connect one 1MΩ and one 470kΩ in series.

In the prototype, resistor R5 (66MΩ) consisted of two 33MΩ units connected in series to make up the value. You could use a single resistor having a value of between 56MΩ and 100MΩ if this is available.

Cut the l.d.r. (R2) leads to a length of about 15mm and solder it in place. Bend the leads through right angles so that the "window" points to the side (see photograph). Solder the positive (red) and negative (black) wires of the PP3-type battery connector to the "+6V" (via switch S7) and "0V" points respectively on the p.c.b.



Completed Transmitter circuit board. The "loop" aerial can be seen on the right. The l.d.r. leads have been carefully bent at right-angles to the p.c.b. to align with a "light-window" in the plastic case.

LOOP AERIAL

The prototype aerial was made using a piece of light-duty single-core insulated wire cut to a length of 80mm. The end 1mm or so was stripped and the wire bent into a loop. It was then soldered into the "aerial" position on the p.c.b.

TRANSMITTER MODULE

Before unpacking the transmitter module, remove any static charge which might exist on the body by touching something which is "earthed" such as a metal water tap. This is because it is a static-sensitive device and such charge could damage it.

Cut its leads to a length of 15mm and solder it in place on the p.c.b., using minimum heat from the soldering iron. Take care over the polarity – the positive end is identified by a black mark on the body.

Taking the same anti-static precautions, unpack IC2 and IC3. Insert them in their sockets taking care over the orientation. By leaving IC1 position empty for the moment, the light-sensing aspect of the circuit will be disabled and this will simplify testing.

Adjust trimmer capacitor VC1 so that the plates are *not* meshed or only slightly so (look closely at it while rotating the top screw). This gives the minimum capacitance of 2pF which worked well in the prototype.

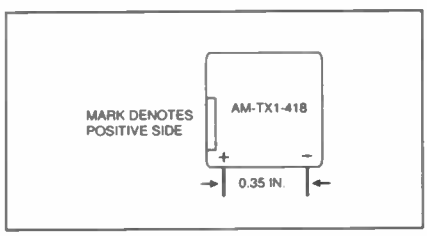


Fig.5. Transmitter module (IC4) pin polarity identification.

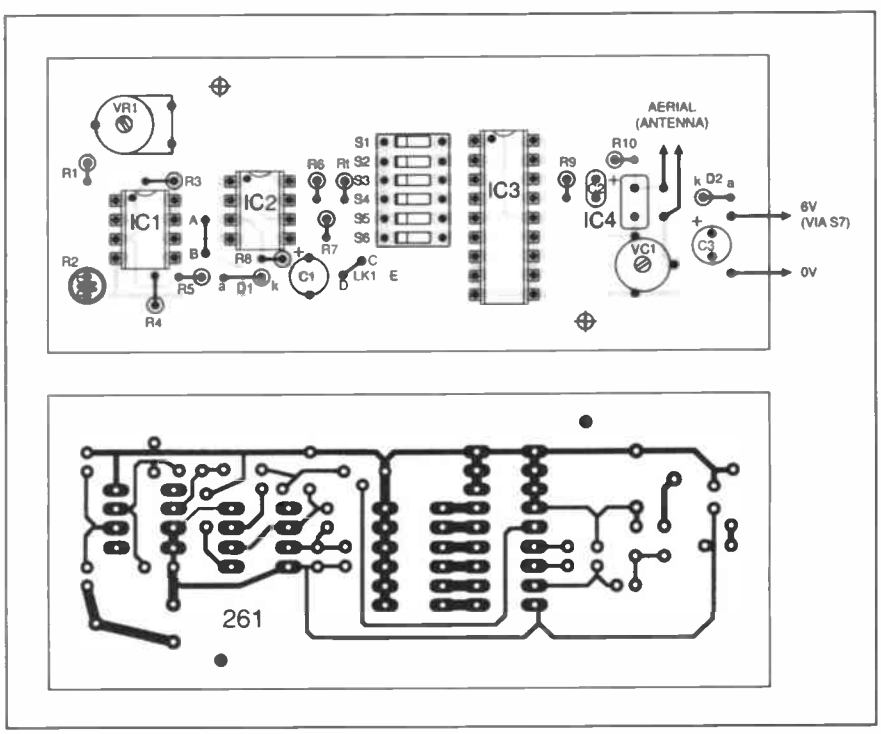


Fig.4. Printed circuit board component layout and full size underside copper foil master for the Transmitter.

RECEIVER

The complete circuit diagram of the Receiver section of the Garage Link is shown in Fig.6. The receiver module IC1 requires a 4·5V to 5·5V supply.

Since the total current requirement of the circuit is 5mA approximately, this could not be maintained by a battery over a long period of operation. This is why a mains power adaptor (sometimes referred to as a battery eliminator) is called for.

The power adaptor supplies a nominal 9V to the input of voltage regulator IC3, via fuse FS1 and diode D1. The output of IC3 provides the 5V needed by the receiver module and this is also used by the rest of the circuit. Fuse FS1 prevents possible damage in the event of a short-circuit.

Diode D1 prevents damage if the supply were to be connected the wrong way round. This is a possibility where plug-in power supply adaptors are used because the output polarity is sometimes uncertain. If the supply was reversed, D1 would not conduct and nothing would happen.

The receiver module is in the form of a single-in-line package – that is, it has only one row of pins. Not all the pins are present and gaps are left where they would have been. The numbering takes into account those which are present as well as those which are not so, although there are 15 numbered "pins", only 10 of them actually exist. The pin layout and designations are shown in Fig.7.

There are separate pins for the positive supply feed to the r.f. (radio frequency) and the a.f. (audio frequency) sections. These are pin 1 and pins 10, 12 and 15 respectively. There are also separate ground (0V) connections for these (pins 2 and 7 for r.f. and pin 11 for a.f.).

The same power supply is used for both sections but they are decoupled separately using capacitors C1 and C2. The aerial is connected to IC1 pin 3 (Data In). The amplified data appears at output pin 14.

DECODING

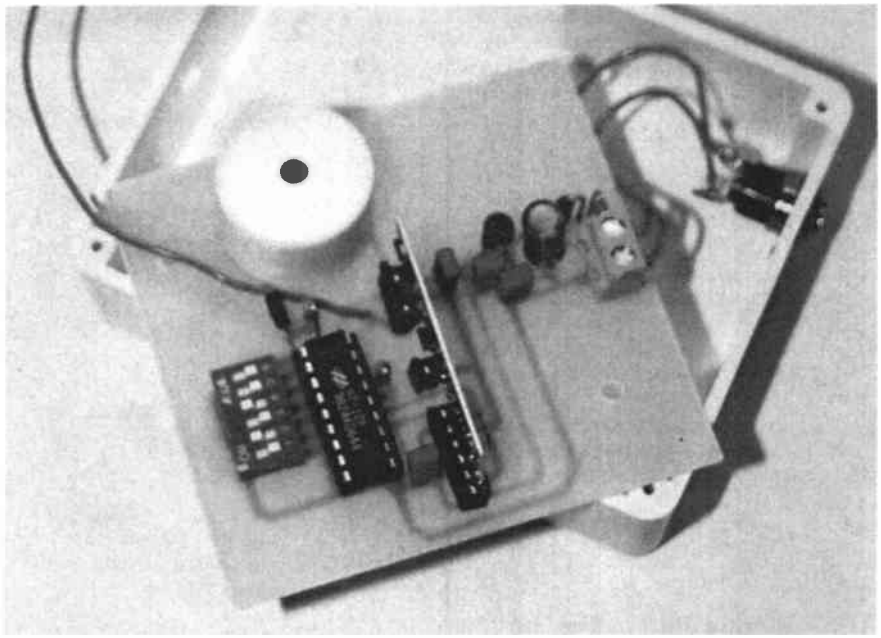
The decoder IC2 is, in many respects, similar to the encoder (IC3) in the Transmitter unit. The receiving code is set up in the same way using a set of d.i.p. switches S1 to S6. The non-settable address pins 7, 8 and 10 to 13 are fixed with a logic state of 0, by tying them to the 0V line. Pin 9 is connected along with these because it is the 0V input. Data is applied to pin 14 (Data In) from the receiver module output, pin 14.

Resistor R1 connected between pin 15 and pin 16 (Osc1 and Osc2) sets the decoder oscillator frequency. This needs to be approximately fifty times higher than that used in the transmitter section and the specified resistor sets it at 100kHz approximately.

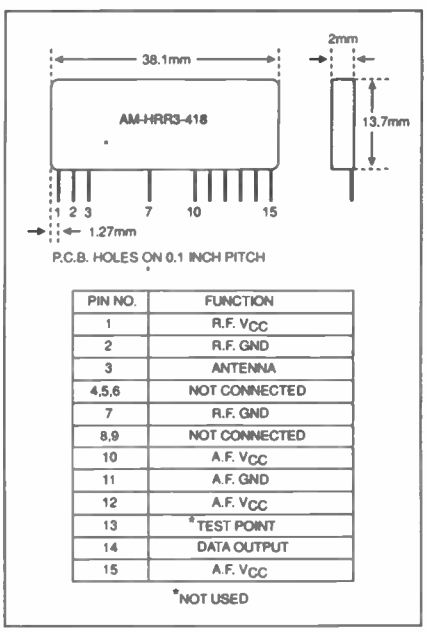
When correct data arrives at IC2 pin 14, pin 17 (Valid Transmission) goes high. Current then flows, via the resistor R2, into the base (b) of transistor TR1 and the buzzer WD1 in the collector (c) circuit operates. Since data is received in short bursts as determined by the Transmitter output, the buzzer will sound with regular bleeps.

CONSTRUCTION – RECEIVER

All components for the Receiver (apart from the supply input socket) are also mounted on a single-sided printed circuit board (p.c.b.). The topside component layout and full size underside copper foil track master are shown in Fig.8. This board is available from the *EPE PCB Service*, code 262.



Completed Receiver circuit board showing the receiver module plugged into an adapted d.i.l. socket.



PIN NO.	FUNCTION
1	R.F. V_{CC}
2	R.F. GND
3	ANTENNA
4,5,6	NOT CONNECTED
7	R.F. GND
8,9	NOT CONNECTED
10	A.F. V_{CC}
11	A.F. GND
12	A.F. V_{CC}
13	*TEST POINT
14	DATA OUTPUT
15	A.F. V_{CC}

*NOT USED

Fig.7. Receiver module pin layout and function details.

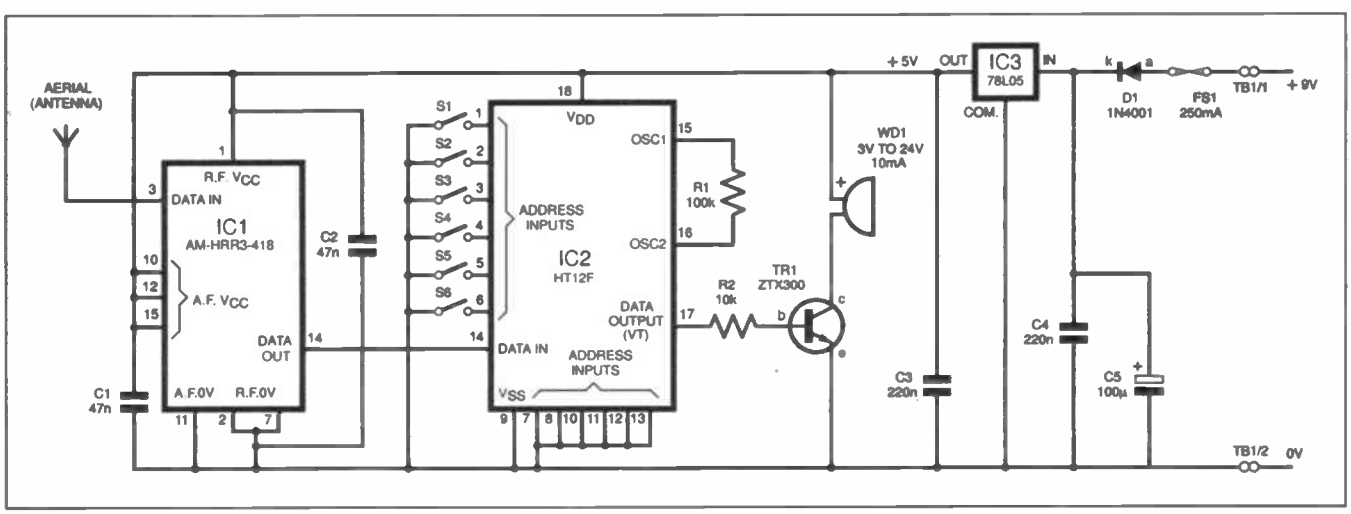


Fig.6. Full circuit diagram for the Receiver section of the Garage Link. The designation VT at IC2 pin 17 means Valid Transmission.

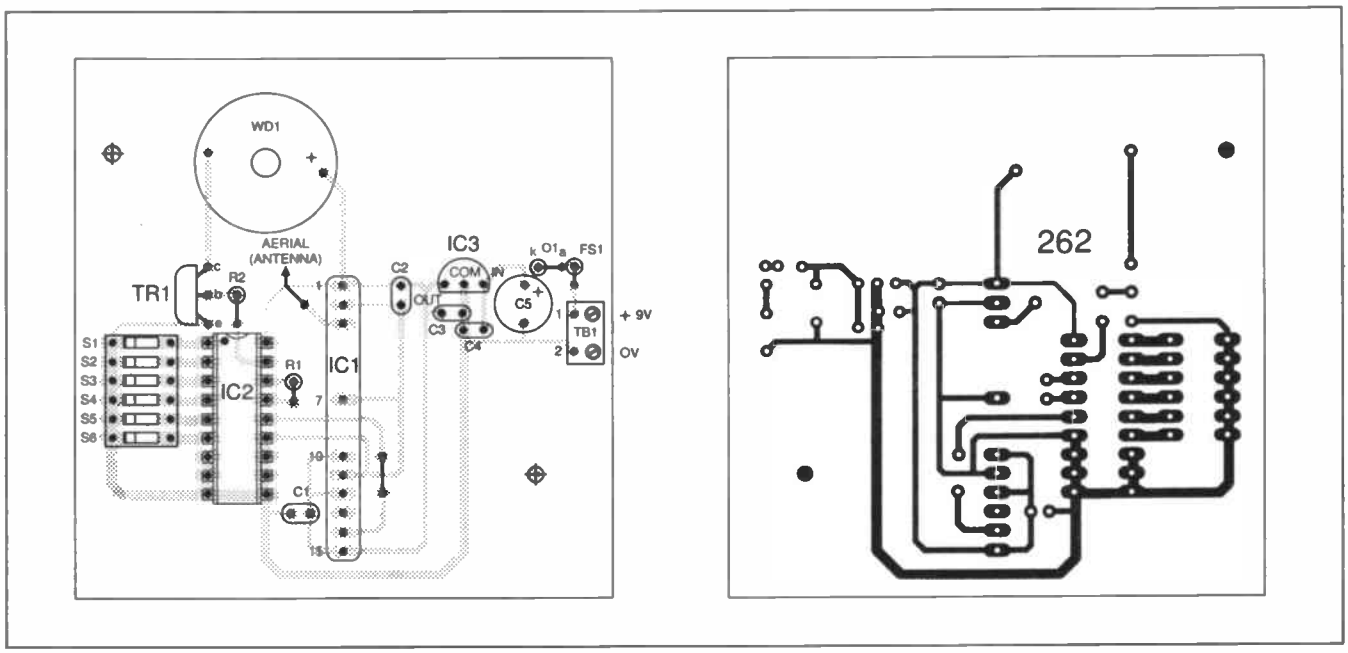


Fig.8. Printed circuit board component layout and full size copper foil track master for the Receiver.

Begin construction by drilling the two fixing holes then solder the terminal block TB1, link wire, i.c. sockets and d.i.p. switches S1 to S6 in position. Use pieces of single in-line (s.i.l.) socket for receiver module IC1 – *do not solder it directly onto the board.* You could make these by cutting up a dual-in-line socket.

Solder all resistors and capacitors in position taking care over the orientation of electrolytic capacitor C5. Add fuse FS1. In the prototype this was the p.c.b-mounting type; this is convenient because it will probably never blow.

Follow with diode D1, transistor TR1, regulator IC3 and buzzer WD1, again, taking care over their orientation. Note that the flat face of the regulator is *downwards* and that of the transistor to the *right*. Some regulators have a different pin arrangement so check this point if necessary.

PRELIMINARY SET-UP

Attach a PP3-type battery connector to terminal block TB1, taking care over the polarity. A 9V battery will be used for testing but it will be replaced with the plug-in, mains adaptor, power supply at the end.

Solder a piece of light-duty stranded wire 18cm long to the "aerial" point. This corresponds to one-quarter of a wavelength approximately. Note that, unlike the Transmitter aerial, this could be placed outside the case. You could even use a short telescopic aerial, if you wish.

Observing the anti-static precautions again, insert IC2 and the receiver module, IC1, into their sockets. IC1 will only fit one way – that is, with the components side facing IC2. *Take great care when inserting it.* If too much force is used, the pins will bend and possibly damage it. Note also that the pins are fairly long and will not push fully "home".

PRELIMINARY TESTS

Decide on a code for the two units. It does not matter what it is but the d.i.p. switches (S1 to S6) in each unit must be set in exactly the same way.

Connect a PP3 battery to the Receiver and pull out the aerial into a straight line. Place the two units approximately 2m (6ft approx.) apart. Insert the cells into the Transmitter battery holder and connect it up. Note that the maximum voltage to be used with the Transmitter is 6V – more than that will damage it.

With luck, the buzzer will begin sounding with rapid bleeps! Remember, resistor *Rt* is in the circuit and the time period has been reduced for testing.

If it fails to work, change the alignment of the transmitter aerial. Try moving the units closer together to see if that improves matters. Experiment with the adjustment of capacitor VC1.

If it still doesn't work, check that the code switches in each unit are definitely set in the same way. A faulty soldered joint at a d.i.p. switch in either unit could set the wrong code and prevent the system from working.

AT FAULT

If there is still a fault, it is more likely to be in the Transmitter because this has two distinct sections. These are the encoder and transmitter on one hand and the light sensor (but this part has been temporarily disabled) and astable on the other. If there is a persistent fault, you could try isolating it to one of these sections.

First, remove the i.c.s observing the anti-static precautions mentioned earlier. Now, change the connection of the "test link" LK1 on the p.c.b. so that C connects to E. This takes IC3 pin 14 to 0V and allows the Transmitter to send data continuously. If it now works, check the earlier stages. If nothing happens, it is more likely that the fault lies in the Receiver.

Assuming the two units are operating over a short range, try increasing it. Move them to the point where the buzzer operates intermittently or in a "chirping" way due to periods which lack proper data. Adjust VC1 using a *plastic* trimming tool (a metal screwdriver blade will affect operation) to tune the Transmitter aerial for the best signal. Increase the range to 10 metres and make further adjustments as necessary. Experiment with the orientation of the aerials.

LIGHT WORK

To check the light-sensing stage (IC1), first disconnect the Transmitter battery. Observing the anti-static precautions, insert IC1 taking care over the orientation. Adjust preset VR1 fully anti-clockwise (this means it does not have to be very dark to operate and simplifies testing).

Re-connect the battery and test the system. With sufficient light reaching the l.d.r. (R2) sensitive surface, the buzzer should stop sounding. When the l.d.r. is covered, it should begin again. If this does not work, try covering the l.d.r. more carefully — perhaps sufficient light is still reaching it. Cover the l.d.r. with black opaque p.v.c. tape so that the transmitter works continuously again.

ON TRIAL

With the aid of an assistant, hold the two units in various trial positions to find the best ones. As with any very low-power radio equipment, there will be good and bad spots. Check with the car in the garage. The orientation of the Transmitter loop is important. Set this and the Receiver aerial for best effect.

Do not use metal boxes to house the units – only plastic ones. Metal boxes would screen the circuits and prevent radio waves passing in or out!

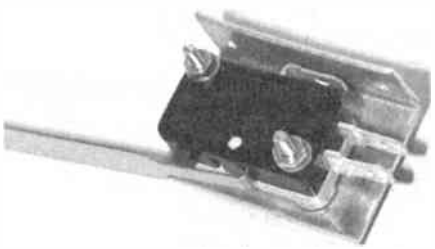
FINAL ASSEMBLY – TRANSMITTER

Place the Transmitter p.c.b. and battery holder on the bottom of the box in their correct positions. When deciding on the orientation of the p.c.b. take account of the direction from which the l.d.r. will receive light. Ideally, it should end up pointing towards the garage door so that when this is open, it will receive "outside" light. Alternatively, try to direct it towards a window.

Mark through the fixing holes, remove everything again and drill them through. Holding the p.c.b. in place, a small distance above the base of the box, mark the l.d.r. position. Measure the position of preset VR1 and mark the lid directly above it. Remove the p.c.b. and drill these holes.

The one for the l.d.r. should be about the same diameter as its window. The hole for VR1 should be large enough to allow it to be adjusted from the outside using a small screwdriver or trimming tool. Drill a hole near the right-hand side of the p.c.b. for the wires leading through from the garage door switch.

Before attaching the p.c.b., drill two holes in the back of the box clear of all internal components. These will be used for attaching the unit to the wall later. Secure the p.c.b. using plastic washers on the bolt shanks. The l.d.r. leads should be bent so that the window lies a few millimetres behind the hole drilled for it. Secure the battery holder using adhesive fixing pads or a small bracket.



The lever-arm microswitch mounted on a small metal bracket.

– RECEIVER

Disconnect the battery and remove the connector from the terminal block TB1. Place the Receiver p.c.b. on the bottom of its box and mark through the fixing holes. Take it out and drill these through. Measure the position of the buzzer and drill a hole in the lid larger than that in the buzzer itself for the sound to pass through.

Check the type of connector fitted to the mains adaptor power supply unit. Drill a hole in the side for a socket of the same type and attach it. Drill two holes in the back of the box, clear of the p.c.b., to attach it to the wall later. Secure the p.c.b. using plastic washers on the bolt shanks.

Solder two pieces of connecting wire to the power socket. Take care that the correct tags are used. Check the polarity of the power supply unit output and connect the wires to terminal block TB1 observing the correct polarity.

If you are unsure about this, do not worry. If the receiver does not work at the end it will be simply a matter of reversing these wires. If you are using a power supply unit with an adjustable output, you may find that the "6V" setting actually provides over 9V when used under the low-load conditions of this circuit.

Attach the Transmitter and Receiver units in their final positions.

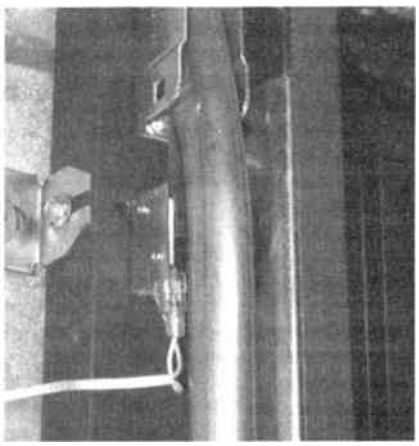
SWITCHED ON

Decide on the switching arrangement for switch (S7) at the garage door. In the prototype, a lever-arm microswitch was used. This was attached to a small aluminium bracket (see photograph) which was, in turn, secured to the door frame. The microswitch had a large paddle-style lever which allowed for some tolerance in fitting although any type could probably be used.

The switch should be operated by some part of the door mechanism which moves relatively slowly when the door is operated. This will avoid heavy jarring as the door closes.

Hold the switch assembly in position and check that the lever will be pressed to the point where the switch clicks as the door reaches its closed position. Check carefully that this does not interfere with normal operation of the door.

Attach the switch and make any adjustments as necessary. Make sure the switch lever still has some movement left when the door is closed so that it is not placed under any undue strain.



Garage door closed – microswitch arm compressed, power off!

CONNECTING UP

Identify the switch contacts which "break" when the door is closed (that is, the normally-closed contacts). There is usually a diagram of this on the side of the microswitch. Using spade receptacle connectors, attach a short piece of light-duty twin stranded wire to the appropriate tags. This should be sufficient to reach a small junction box (the burglar alarm type is ideal) attached near the door frame.

Referring to Fig.9, complete the external wiring. Any light-duty twin stranded wire will be suitable. You will need to place a 2-way piece of screw terminal block TB2 inside the transmitter case.

Cut the red battery connector wire and connect its free ends to the terminal block. Connect the switch wires to the block, via the junction box, as shown. If two switches are used for two doors, connect them in parallel.

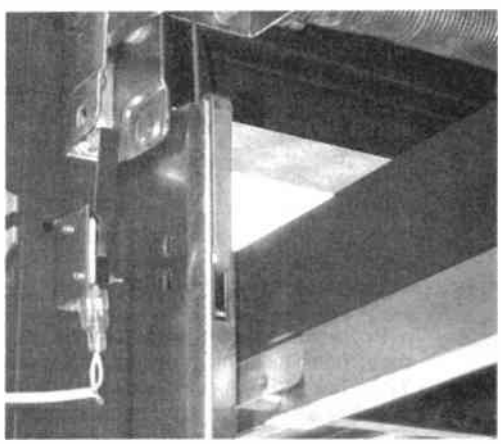
Connect the power supply unit to the Receiver and test the whole system. If it fails to work, reverse the polarity of the power supply wires.

The Receiver aerial wire could be either routed around the inside of the case (make sure the end is insulated so that it cannot make metallic contact with any internal components. Alternatively, it can be allowed to hang outside through a small hole.

LIGHTING-UP TIME

It is now time to remove the tape from the l.d.r. in the Transmitter so that the light-sensing part operates. Wait until it is dark enough and, with the lid in place and the garage door open, adjust preset VR1 so that the system just responds at this point.

You will find that the light level at which the unit starts to operate (going dark) is not quite the same as that at which it stops operating (going light). This is due to the effect of feedback resistor R5 in the Transmitter. If the effect is too pronounced, increase its value or remove it.



Garage door open – microswitch arm released, power on!

You may find that the l.d.r. "sees" the garage light when this is switched on. Of course, this would hold the buzzer *off*. This would probably be an advantage because if someone was working in the garage at night with the door open, the buzzer would not sound.

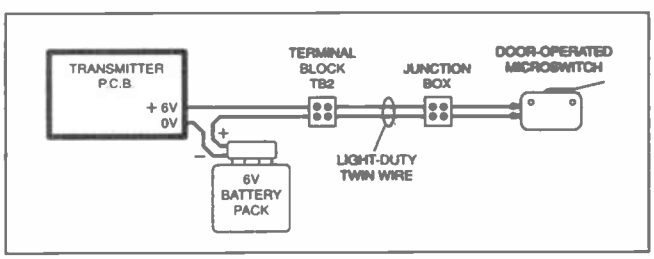


Fig.9. Interwiring between the Transmitter and remote door-operated microswitch.

If you want it to operate under these circumstances, shield the l.d.r. so that the garage light does not reach it. Bending its leads so that it lies further behind the hole and directing the unit more carefully at the source of "outside" light will also help.

Remove the Transmitter lid and cut through one of the leads of test resistor, *Rt*. Move the cut ends apart to prevent them from touching. The buzzer should now give a short bleep every 45 seconds approximately.

ON APPROVAL

Before putting the system into permanent service, it is important to display a mark on the transmitter stating that it conforms to DTI Specification MPT1340. This must state the wording "MPT1340 W.T. Licence Exempt". The size must not be less than 10mm × 15mm and the figure height must not be less than 2mm. □

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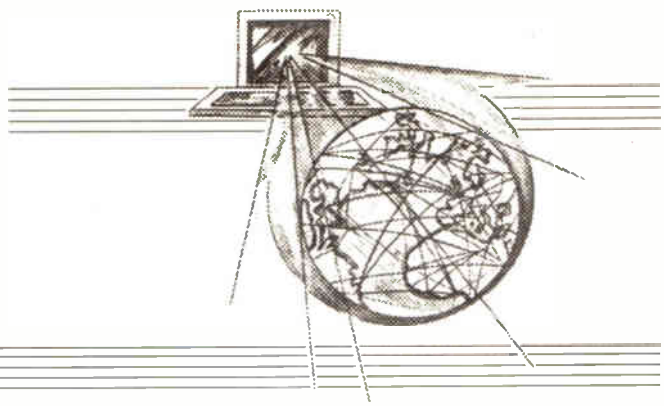
NET WORK

ALAN WINSTANLEY



I'm all .sch.uk up

ONE of the first things to ponder when creating an Internet presence is what domain name to adopt, and it is here that many organisations may immediately face a difficulty: someone may already have beaten them to it, so they may be forced into using something less relevant (or memorable) instead.

The fact is that the demand for domain names has rocketed since the late 1990's. In effect, if you can think of a name, a word or a place then there is a good chance that the domain name has already been spoken for. However the practice of "cybersquatting" on a domain name is increasingly frowned upon, and there have been several celebrated cases of failed attempts to profit from a name, by trying to sell it to its rightful but less forward-thinking owner (e.g. **marksandspencer.co.uk**).

The laws of attempted passing-off and trademark infringement may also be invoked. In short, you cannot apply for your "own" domain name soon enough, if only to prevent competitors from beating you to it, so if you are contemplating creating an Internet presence now or in the future, then you should investigate this aspect with some urgency.

The issuing of the **.uk** top-level domain (TLD) name is controlled by Nominet (**www.nominet.org.uk**), and the cost of a dot-UK name has fallen dramatically to reflect the increased uptake. Second-level domains (SLDs) include **.co.uk** for commercial organisations, or if the names are registered at Companies House, **.plc.uk** for public limited companies and **.ltd.uk** for limited liability companies, together with **.sch.uk** for UK schools.

It is important to note that domains are issued on a first-come, first-served basis, and names are sometimes bought as a defensive measure to prevent them falling into the hands of other parties. A whole different set of rules relates to the popular dot com domains, and you should refer to Network Solutions at **www.networksolutions.com** if necessary.

Although it is easier than ever before to apply for a domain name, things can get rather complicated because there are several parties to the Nominet agreement. Firstly, there's you – the Registrant. The domain name is registered in your name (literally), so you gain the right to its exclusive use provided that Nominet's fees and terms are met. An Administrative Contact will be assigned, together with Billing and Technical Contacts; often these are the same. Using the Nominet WHOIS look-up (**www.nominet.org.uk/whois.html**), you can find out if **.uk** domain names are already taken. Also see **www.netnames.co.uk** to search for **.uk** and **.com names**.

The simplest way of acquiring a domain name is to ask an ISP to arrange it for you. Hopefully they will be members of Nominet, noting that the ISP acts as your agent only when completing the formalities on your behalf, using their credit account with Nominet.

You can also opt to buy your name directly from Nominet at a cost of £80 + VAT for the first two years. The system is quite transparent as regards the registration costs, though, and Nominet members pay a heavily discounted price – only £5 plus VAT for two years, although membership itself costs £500 plus VAT to start with.

I'll name that domain in one

The market in web domains is now global, and on-line auctions such as those at **Amazon.co.uk** list names offered for sale for as much as $1,000,000. Some domain name and web design companies are doing a roaring trade in marketing domain names simply by cashing in on the ignorance of users in order to make a profit. One recent case involves an acquaintance working in the electronics industry who was approached by a dubious Internet company from the south of England. The representative phoned to say that somebody had recently tried to register my friend's company name as a domain and in order to prevent this happening again, he should register his name immediately. The Internet company "could do this for him for a fee" (surprise) and faxed through the application forms twice. I can imagine many inexperienced people falling for it.

Happily my friend suspected something fishy was going on. Clearly they were simply going through a directory of business names, picking out likely-looking sales leads and checking if a domain is already registered before phoning to drum up some trade. Beware of any such agreements, especially if they handicap your ability to move the name elsewhere. Most reputable ISPs will co-operate with each other if you decide to move, especially if they are ISPA members.

FREENETNAMES

In the event my colleague responded by getting his domain name for free instead! The Internet Service Provider Freenetname (**www.freenetname.co.uk**) adopts an altogether different approach. They will offer you your choice of domain name for free, along with 20MB of free web space and E-mail as well. You must dial in via a local rate Freenetname dial-up account, which is how the offer is financed. A CD ROM is provided with pre-configured software.

This deal almost seems too good to be true, yet there appear to be no catches. Rather confusingly, Freenetname says in its FAQ that the domain is registered "in the name of the person entered when the original Freenetname dialup account was created" and later says that "as long as the Freenetname Terms and Conditions... are upheld, the domain can continue to be used by the customer free of charge."

However, if your account lapses (after 90 days or more of disuse), or if your Freenetname dialup account is terminated, then the domain name "remains the property of Freenetname" says the FAQ. At least you can choose to buy it outright from Freenetname for payment of a nominal fee, or transfer it to another firm. The whole situation regarding the rights to use a domain name can become very confusing, and it's worth looking around the Nominet site and also downloading their terms and conditions.

An associate is currently testing Freenetname and the dial-up bandwidth appears to be average and fairly uninspiring (as a 5Mb download proved). However it beats paying a cold-calling salesman trying to cash in on your entitlement to a domain name.

Even English village names (15,000 of them) have been hoovered up and registered by the parochial portal builder Webhound Ltd. (**www.any-web.co.uk**). Judging by the defensive and indignant tone of their on-line FAQs (see **www.any-web.co.uk/Portal/Towns/Towns_FAQ.asp**),Webhound's shopping spree has had some stick and upset many prospective domain name users. The firm was forced to withdraw its original plan to sell a number of village domains to finance the rest of their portal-building project, saying that their site would ultimately be financed by paid-for advertising. They will also charge customers for the privilege of a domain-related E-mail address. Their proposal to develop an entire portal at **www.ANY-Town.co.uk** containing a localised web content for 15,000 villages in Great Britain, seems an overly ambitious undertaking.

Webhound also aspires to build a genealogy portal site, and to facilitate this they claim unashamedly to have registered a large number of surnames as dot-com domains. Their web site declares that in their view "surname domain names should be shared by all people of that name and not the lucky individual who registered it first." Of course, this disingenuous ploy overlooks the fact that Webhound Ltd. was a "lucky" company which used exactly the same rules of first-come, first-served to grab all those surnames for itself in the first place. Perhaps the whole lot will be sold off one day in another Internet merger or takeover, village names and all. Winstanley dot com is already spoken for, by the way.

You can contact me by E-mail to **alan@epemag.demon.co.uk**. My web site is at **http://homepages.tcp.co.uk/~alanwin**.

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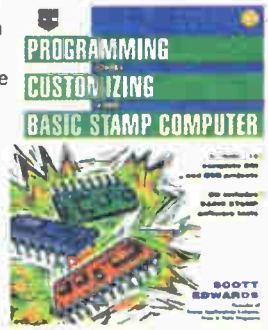

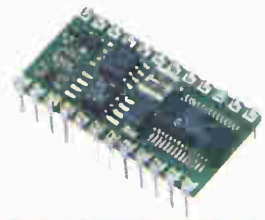

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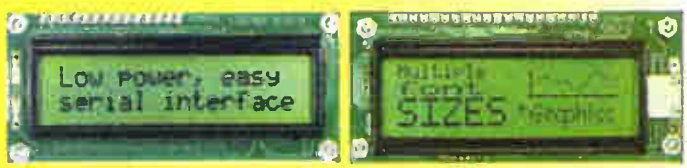

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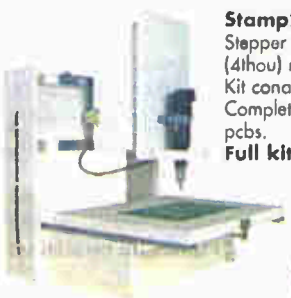

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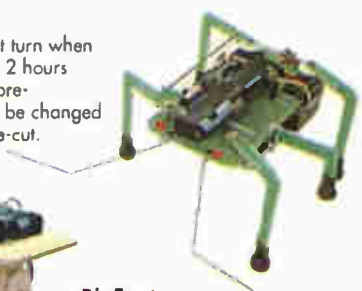

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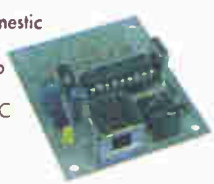

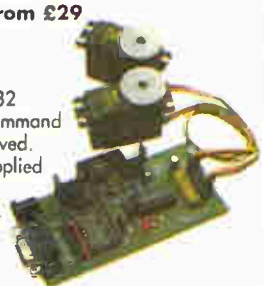

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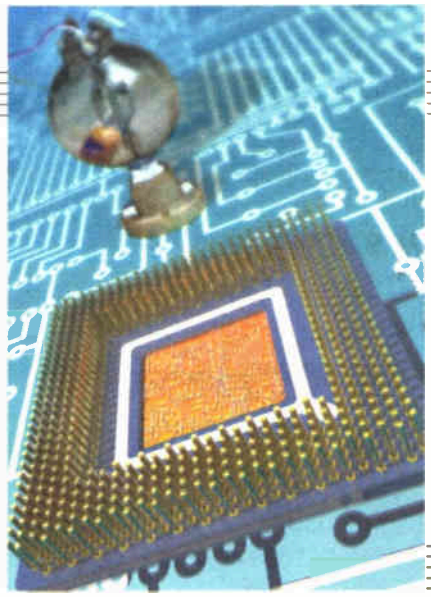


PART 3 – COMMUNICATIONS AND RELATED TECHNOLOGIES 1900-1999

CLIVE "MAX" MAXFIELD AND ALVIN BROWN

Boldly going behind the beyond, behind which no-one has boldly gone behind, beyond, before!

THE purpose of this series is to review how we came to be where we are day (technology-wise), and where we look like ending up tomorrow.

In Part 1 we cast our gaze into the depths of time to consider the state-of-the-art in electronics, communications, and computing leading up to 11:59pm on the 31st December 1899.

In Part 2 we discussed fundamental electronics between 1900 and 1999. Now, in Part 3 we consider some of the key discoveries in communications and related technologies that occurred during the 20th Century.

MIND BOGGLING!

When we originally set out to write this instalment, we had thought it would be possible to describe a linear progression of developments, starting with the Morse Telegraph in 1837 and leading steadily onwards and upwards to the present day (we were young and foolish then).

For example, surely television was simply the next step after radio? Well not quite, because the first televisions were mechanical in nature, and used cable as a transmission medium.

In fact, the communications arena is a complete mish-mash of developments. Many core concepts were developed in isolation (the telephone and the radio, for example) and then brought together sometime later.

Similarly, communications media tend to come into favour, fall by the wayside, and then reappear with "go faster stripes". For example, copper telephone cables were displaced by radio waves and satellites, but now fibre-optic cables are proving to offer more efficient and cost-effective solutions in certain cases.

However, if we take a high-level view of communications over the last 100 years, four core technologies stand out as being particularly significant: the *telephone*, *radio*, *television*, and the *Internet*. There are also the key underlying delivery media, including cable (copper and fibre-optic) and radio transmissions.

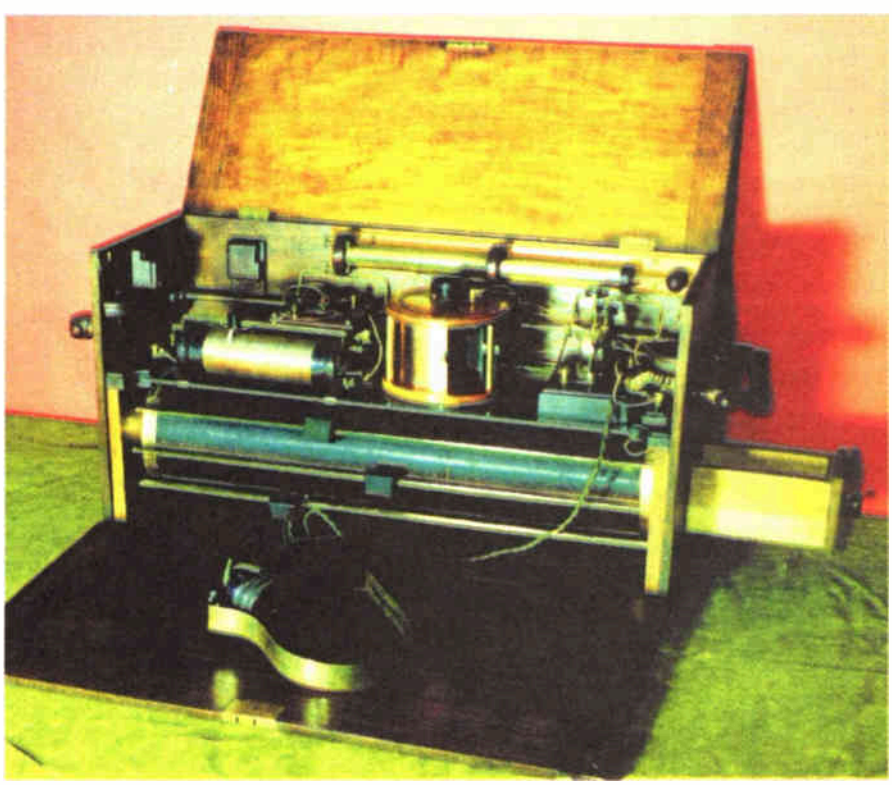
Similarly, there are enabling technologies such as satellites and computers, along with off-shoot technologies such as microwaves (leading to radar and microwave ovens), radio astronomy, and – the list goes on. Thus, rather than attempting to artificially force everything into a linear progression, we are going to consider some of these core developments areas in whatever order we think makes sense!

EARLY RADIO

As the world entered the 20th Century, communication by means of radio waves was still only just beginning to emerge. Even though the telephone had been around for nearly 25 years, there was little thought given to using radio waves to communicate verbal messages, because the best that could be achieved was to transmit and receive individual pulses.

This meant that the first use of radio as a communications mechanism was in the form of the RadioTelegraph, which was used to transmit messages in Morse Code.

During the early 1900s, Marconi's RadioTelegraphs were developed to the extent that they were installed on some ocean going vessels. However, these systems were mainly used to send commercial messages dubbed "Marconi Grams", and using them for such things as distress calls was not particularly high on anyone's priorities.



Crystal radio made by George Leadbetter, Worcestershire, 1910. This set is documented as having received Titantic's *distress call on 15 April 1912.* Courtesy National Vintage Communications Fair (also see this month's News pages).

In fact, it was not until 1912 that governments started to mandate the installation of wireless equipment on ships following the sinking of the *Titanic*, whose radio operator sent out distress signals after the vessel collided with an iceberg.

DIODES AND TRIODES

Meanwhile, as far back as 1883, William Hammer (an engineer working for the American inventor Thomas Alva Edison) observed that he could detect electrons flowing from the lighted filament to a metal plate mounted inside an incandescent light bulb. This *Edison Effect* was subsequently used to create a vacuum tube rectifier by the English electrical engineer, John Ambrose Fleming in 1904 (this device was called a *diode* because it had two terminals).

Diodes were soon used in radio receivers to convert a.c. to d.c., and also to detect radio frequency signals. Unfortunately, Fleming didn't fully appreciate the possibilities inherent in his device, and it was left to the American inventor Lee de Forest to take things to the next stage. In 1907, de Forest conceived the idea of placing an open-meshed grid between the cathode (the heated filament) and the positively biased anode (called the *plate*).

By applying a small voltage to the grid in his *Audion* tube (which soon became known as a *triode* because it had three terminals), de Forest could cause a much larger voltage change to be generated at the plate.

This was extremely significant for the fledgling radio industry, because it became possible to amplify radio signals captured by the antenna before passing them to the detector stage, which made it possible to use and detect much weaker signals over much larger distances than had previously been possible.

The triode was really rather cunning, but of more significance was de Forest's 1912 discovery that he could cause his device to oscillate. This allowed him to replace existing spark transmitters with vacuum tube-based oscillators that could generate purer, more stable radio waves.

RADIO SET

One question that is often asked is "Why is a radio commonly called a *radio set* or a *wireless set*? In fact, early radio systems intended for home use essentially consisted of three stages: the receiver (to detect and pre-amplify the signal), the demodulator (to extract the audio portion of the signal), and the main amplifier (to drive the loudspeaker).

All of these stages were packaged in their own cabinets, which had to be connected together. Hence the user had to purchase all three units which formed a *set*, and this term persisted long after all of the components started to be integrated into a single unit.

In addition to requiring a mains supply to provide their high internal voltages, vacuum tube-based radios tended to be somewhat large, so the thought of a pocket radio didn't strike many people as being practical. However, the invention of the transistor in 1947 opened the floodgates for a whole raft of new applications.

In 1954, the Regency TR-1, the first pocket transistor radio, was introduced in the USA. The Japanese transistor radio (TR-52) was produced, but not put on sale. It was the TR-55 which was the first *commercial* Japanese "tranny", introduced in 1955 by Sony. (SONY used to be called Tokyo Tsushin Kogyo Ltd in those now far-off days, but this didn't exactly roll off the tongue so you can see why they decided to change it).

A Strowger automatic telephone of about 1905. Courtesy of Science Museum/Science and Society Picture Library.

THE TELEPHONE

Considering the fact that Alexander Graham Bell filed his patent for the first telephone in 1876, the actual development of this device has, in many ways, been remarkably slow compared to other consumer-orientated technologies. In the early days this was due to several reasons, not the least that there was no existing infrastructure (why have a phone if none of your friends have one and there is no one to call?).

By some strange quirk of fate, when an infrastructure eventually came along, it was so costly and huge that the technology had to migrate forward slowly. The fact that new systems had to work alongside old ones served to curtail revolutionary changes and to dictate an evolutionary adoption of new technology.

For example, it took British Telecom more than ten years to transition from electromechanical technology to its digital equivalent. Furthermore, these electromechanical switching exchanges, many of which persisted well into the 1990s, were themselves based on techniques that had been invented in America by Almon B. Strowger 100 years earlier.

AUTOMATIC SWITCHING

As fate would have it, Strowger was an unlikely character to have had such an impact on the development of telephone exchanges around the world. As an undertaker in Kansas City, USA, Strowger was an "early adopter" of telephone technology, because he thought it would facilitate potential customers (or at least their relatives) contacting him.

However, telephone exchanges in those days were manual, which meant that the person placing the call first contacted an operator, who then physically made the connection between the caller and the intended recipient.

As fate would have it, the operator who handled Strowger's calls was the wife of a competing undertaker. Thus, when potential clients tried to contact Strowger, she would instead connect them to her husband's business (the little rascal).

Not surprisingly Strowger found this state of affairs to be somewhat frustrating, so he set about designing an automatic system that would remove the operator (in the form of his competitor's wife) from the picture.

In fact, Strowger did not really invent the concept of automatic switching – Connolly and McTigthe had discussed the idea as early as 1879 – but with the help of his nephew (Walter S. Strowger) he was the first to come up with a practical implementation based on banks of electromechanical relay selectors in 1888.

In 1901, Joseph Harris licensed Strowger's selectors to the Automatic Electric Co (AE). The first dial telephone was invented in 1905, and the combination of dial telephones and Strowger selectors paved the way for automatic telephone exchanges, such as the first public automatic telephone exchange in the UK, which opened in Epsom, Surrey in 1912.

Of course, Strowger exchanges were initially only used to process local calls – operator assistance was still required for long distance and international calls. In fact, it wasn't until 1971 that it became possible to direct-dial between the US and Europe!

TESTING, 1, 2, 3

With the advent of the triode valve in 1907 and the discovery of vacuum tube-based oscillators in 1912, it became apparent that speech could be transmitted by radio. The first significant demonstration of this concept occurred in 1915, when speech signals were successfully transmitted across the Atlantic between Arlington, Virginia, and Paris, France.

One year later, a ground-to-air radiotelephone message was transmitted from an airfield at Brooklands, England, to an aircraft flying overhead.

The first commercial radiotelephone service came into being in St Louis, Missouri,

USA in 1946, but once again progress was somewhat slow due to the infrastructure and bureaucracy.

Following a number of attempts, the first mobile phone service started operating in North America in 1978. Across the Atlantic, the first cellular service was introduced in Europe in 1981 in the form of the Nordic mobile telephone system.

In fact, it is interesting to note that although America was the first to deploy a cellular service, the multiple competing standards in the USA have caused that market to become segmented and fragmented.

By comparison, Europe and Japan are now years ahead of the USA, because they were quick to adopt a common standard. For example, as of 1998 there were 100 million cellphone subscribers in Europe, with 5 million new subscribers joining each month.

MECHANICAL TV

Television, which comes from the Greek *tele*, meaning *distant* and the Latin *visio*, meaning *seeing* or *sight*, has arguably become one of the wonders of the 20th Century.

Prior to the advent of electronic scanning, all workable television systems depended on some form or variation of the mechanical sequential scanning method exemplified by the Nipkow disk (as discussed in Part 1).

Modern television systems are based on the cathode ray tube (CRT). The idea of using a cathode ray tube to display television images was proposed as early as 1905, but progress was hard fought for, and it wasn't until the latter half of the 1920s that the first rudimentary television systems based on cathode ray tubes became operational in the laboratory.

There are two primary requirements for a functional television system: a technique for capturing an image and a way to display it. Following Nipkow's experiments, other inventors tried to move things forward with limited success. The history books mention several names in this regard, such as John Logie Baird, a Scotsman who used a derivation of Nipkow's disks for capturing and displaying pictures during the latter half of the 1920s and the early 1930s.

The British Broadcasting Corporation (BBC) allowed Baird to transmit his pictures on their unused radio channels in the evening. By 1934, even though he could only transmit simple pictures with a maximum resolution of around 50 lines, Baird had sold thousands of his *Televisor* receivers around Europe in the form of do-it-yourself kits.

Meanwhile, on the other side of the Atlantic, the Radio Corporation of America (RCA) experimented with a system consisting of a mechanical disk camera combined with a cathode ray tube display. Using this system, RCA transmitted a picture of a model of Felix the Cat endlessly rotating on the turntable of a record player in the early 1930s.

QUOTABLE QUOTES

"The radio craze will die out in time", Thomas Edison, 1922

"While theoretically and technically television may be feasible, commercially and financially I consider it an impossibility", Lee de Forest, 1926

Ferguson Model 993T 14-inch console television, original invoice dated 29/5/54 for £75-12s-0d. Courtesy Dreweatt-Neate.

PHILO FARNSWORTH

Strange as it may seem, relatively few reference sources seem to be aware of the real genius behind television as we know it today – an American farm boy named Philo T. Farnsworth from Rigby, Idaho. In 1922, at the age of 14, with virtually no knowledge of electronics, Philo conceived the idea for a fully electronic television system. Flushed with enthusiasm, he sketched his idea on a blackboard for his high school science teacher.

Over the years, Philo solved the problems that had thwarted other contenders. He invented a device called an Image Dissector, which was the forerunner to modern television cameras, and he also designed the circuitry to implement horizontal and vertical flyback blanking signals on his cathode ray tube, which solved the problems of ghosting images.

By the early 1930s, Philo could transmit moving pictures with resolutions of several hundred lines, and all subsequent televisions are directly descended from his original designs.

As video historian Paul Schatzkin told the authors: "Many engineers and scientists contributed to the emergence of the television medium, but a careful examination of the record shows that no one really had a clue until Philo Farnsworth set up shop in San Francisco at the age of 20 and said: *"We'll do it this way!"*.

COLOUR TELEVISION

Perhaps the earliest proposal for colour television is to be found in a German patent from as far back as 1904. However, it was not until 1928 that Baird gave the first practical demonstration of a colour television using mechanical scanning based on a Nipkow disk having three spirals of 30 apertures, one spiral for each primary colour in sequence.

As we've already discussed, however, electronic techniques came to dominate the market, and creating colour variations of

TIMELINES

1901: Marconi sends a radio signal across the Atlantic.

1902: US Navy installs radio telephones aboard ships.

1902: Transpacific cable links Canada and Australia.

1904: Telephone answering machine is invented.

1905: Dial telephone is invented.

1906: Dunwoody and Pickard build a crystal-and-cats-whisker radio.

1906: America. First radio program of voice and music is broadcast.

1907: Lee de Forest begins regular radio music broadcasts.

1909: Radio distress signal saves 1900 lives after ships collide.

1909: Marconi shares Nobel prize in physics for outstanding contribution made to telegraphy.

1910: America. First installation of teleprinters on postal lines between New York City and Boston.

1912: Titanic sends out radio distress signal when it collides with iceberg.

1912: Feedback and heterodyne systems usher in modern radio reception.

1914: Better triode valve improves radio reception.

1914: Radio message is sent from the ground to an airplane.

1914: First trans-continental telephone call.

1915: First transatlantic radio telephone conversation.

1916: Radios get tuners.

1917: Frank Conrad builds a radio station (becomes KDKA – call sign still in use to this day).

1917: Condensor microphone aids broadcast recording.

1918: First radio link between UK and Australia.

1919: People can dial their own telephone numbers.

1919: Shortwave radio is invented.

1921: Quartz crystal keeps radio from wandering.

1922: First commercials broadcast ($100 for 10 minute advert).

1922: Lewis Alan Hazeltine invents the neutrodyne which eliminates squeaks and howls of earlier radio receivers.

1923: First ship-to-ship communications (people on one ship can talk to people on another).

1925: First commercial picture/facsimile radio service across USA.

1926: First commercial picture/facsimile radio service across Atlantic.

1926: John Logie Baird demonstrates an electromechanical TV system.

1927: Philo Farnsworth assembles complete electronic TV system.

1927: First public demonstration of long-distance television transmission (basically a Nipkow disk).

1928: John Logie Baird demonstrates colour TV on an electromechanical TV system.

1928: John Logie Baird invents video disk to record television.

1928: First scheduled television broadcast in Chenectady.

these systems was significantly more problematic. One big problem was the number of black and white television sets that had already been deployed, because it was decided that any proposed colour system had to be backwards compatible (that is, the colour signal had to be capable of driving both colour and black and white sets).

Public broadcasting of colour television began in 1954 in the United States. Widespread adoption of colour receivers began in the United States in 1964 and in Great Britain and West Germany in 1967.

TELEVISION STANDARDS

Standards are great, everybody should have one, as the old saying goes. Unfortunately the US settled on television pictures composed of 525 lines being refreshed at 30 frames per second, while Europe decided to use 625 lines at 25 frames per second. Other countries subsequently adopted one or the other of these standards (and don't get us talking about NTSC versus PAL, or the fact that the French decided to go their own way with SECAM).

UNDERSEA CABLES

As we discussed in Part 1, the first undersea telegraph cable was laid in 1845 between England and France. The Atlantic was spanned in 1858 between Ireland and Newfoundland, but the cable's insulation failed and it had to be abandoned. Following these early attempts, the first successful transatlantic telegraph cable was laid in 1866, and in the same year another cable, partially laid in 1865, was also completed.

These early attempts were plagued by deterioration of the signal over these huge distances and also by a lack of understanding of the environment 2,000 fathoms beneath the sea (could there be a film title here?).

Of course, the problems were significantly more daunting in the case of audio signals. In fact, these issues were not resolved until the invention of vacuum tube-based repeaters that could operate continuously and flawlessly with no attention for at least 20 years at these depths. These made possible the first transatlantic telephone cable, from Scotland to Newfoundland in 1956.

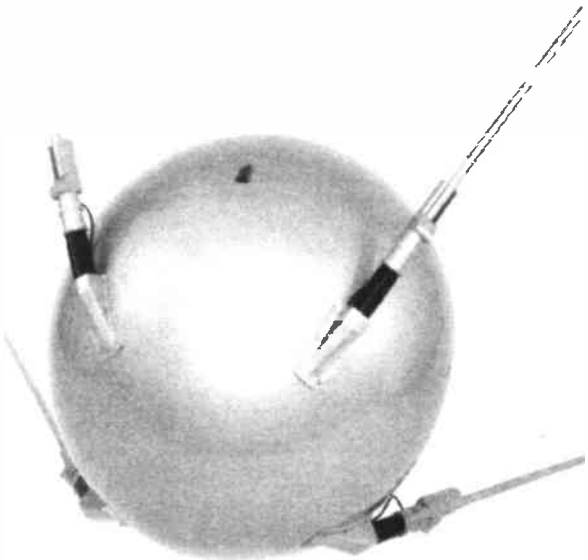
Following the success of this first cable, similar systems were deployed between California and Hawaii and between Hawaii and Japan in 1964. More recent undersea cables employ transistorised repeaters and provide even more voice circuits, and some are even capable of transmitting television pictures.

Today's cables, such as the Pacific cable laid in 1998, use technology based on fibre-optics and can handle 40,000 simultaneous conversations!

SATELLITES

In 1952, the International Council of Scientific Unions stated that July 1957 to December 1958 would be the *International Geophysical Year* (IGY), because solar activity would be at a high point during this period. Two years later, in October 1954, the council adopted a resolution calling for artificial satellites to be launched during the IGY to map the Earth's surface.

In 1955, in a fit of exuberance, the American government announced plans to launch an Earth-orbiting satellite for the IGY, and set to work on the project. But much to their dismay, the (former) Soviet Union successfully launched *Sputnik 1*, the world's first artificial satellite on October 4, 1957.



Reconstruction of Sputnik 1, *the world's first artificial satellite, launched 4 October 1957.* Courtesy Science Museum/Science and Society Picture Library.

Sputnik 1 was small (about the size of a basketball weighing in at 183 pounds, 83kg) and its sole function was to repeatedly beep a simple Morse Code-type message (to annoy the Americans). However, the significance of this event cannot be understated as it paved the way to a wide range of political, military, technological and scientific developments.

SPACE RACE

The Russian's ability to launch a satellite 50 times the mass of the American's proposed 3·5 pound(1·6kg) payload sent shivers of fear throughout the Western world. It was obvious to all that intercontinental ballistic missiles were now more than a possibility. Thus, in addition to causing the Americans to form NASA (which gave us Velcro fasteners and Teflon for our frying pans), *Sputnik 1* initiated the so-called "Space Race".

This culminated with America putting a man on the moon, but also led to deep space probes throughout the solar system, and drove electronic developments like miniaturisation in the form of integrated circuits, more efficient solar cells, and others too numerous to mention.

TIMELINES

1929: Experiments begin on electronic colour television.

1929: First ship-to-shore communications (passengers can call relatives at home – at a price).

1929: The first car radio is installed.

1929: In Germany, magnetic sound recording on plastic tape.

1929: British mechanical TVs roll off production lines

1933: Edwin Howard Armstrong conceives a new system for radio communication – wideband frequency modulation (FM).

1934: Half the homes in the USA have radios.

1935: Audio tape recordings go on sale.

1935: All-electronic VHF television comes out of the lab.

1935: England. First demonstration of radar, at Daventry.

1936: Munich Olympics televised.

1936: First electronic speech synthesis (vodar).

1937: Pulse-code modulation points the way towards digital transmission.

1938: John Logie Baird demonstrates live TV in colour.

1938: Television broadcasts can be taped and edited.

1938: Radio drama *War of the Worlds* causes widespread panic.

1939: Regular TV broadcasts begin.

1939: Bell labs begin testing high-frequency radar.

1940: Bell labs conceive the idea of cell phone (technology won't exist to bring it to market for another 30 years).

1941: First touch-tone phone systems (too expensive for general use).

1941: First microwave transmissions.

1945: Sci-fi author Arthur C. Clark envisions geo-synchronous communications satellites.

1946: Automobile radiotelephones connect to the telephone network.

1948: America. Airplane re-broadcasts TV signal to nine States.

1949: America. Start of network TV.

1950: Vidicon camera tubes improve TV pictures.

1952: Sony demonstrates first Japanese miniature transistor radio (produces it commercially in 1955).

1953: America. First TV dinner is marketed by the C.A. Swanson company.

1954: Launch of giant balloon called *Echo 1* – used to bounce telephone calls coast to coast.

1954: Number of radio sets in world out-numbers newspapers sold each day.

1956: First transatlantic telephone cable goes into operation.

1957: Russia launches *Sputnik 1*, the world's first artificial satellite.

1960: NASA and Bell Labs launch the first commercial communications satellite.

1960: DARPA begins work on what will become the Internet.

1960: Theodore Maiman creates the first laser

1962: America. Steven Hofstein and Fredric Heiman at RCA Research Lab invent field effect transistors (FETs).

BALLOONS

Whilst working at Bell Laboratories in 1960, John Robinson Pierce developed the first experimental communications satellite by bouncing radio signals of a 150-foot (45m) aluminium-coated high-altitude balloon called *Echo 1*.

These experiments were closely followed by the *Telstar* series of communications satellites, which initiated a new age in electronic communications. Unlike the passive reflection employed by *Echo 1*, *Telstar* received signals transmitted from a ground station, amplified them, and re-transmitted them to another ground station.

RADAR

When Heinrich Hertz first began experimenting with radio waves in 1887, he discovered that they could be transmitted through some materials, but that they would be reflected by others. Almost 50 years later, scientists began to discover how to use radio waves to detect and locate objects.

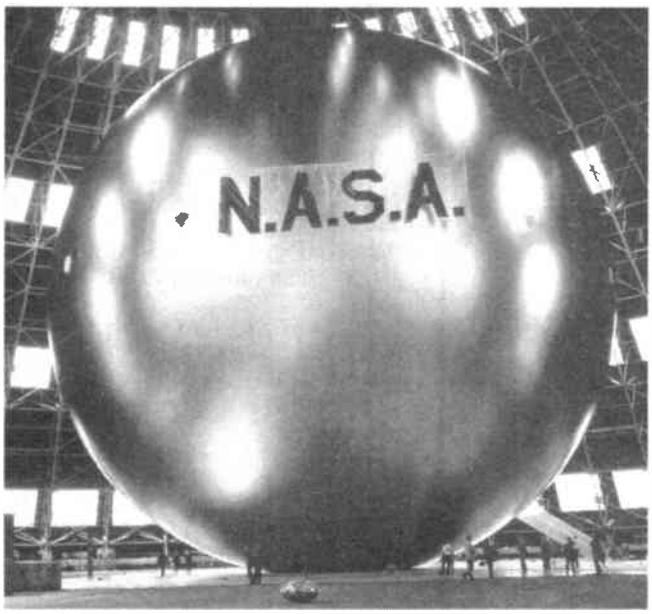
In 1935, a report entitled *The Detection of Aircraft by Radio Methods* was presented to the British Air Ministry by Sir Robert Watson-Watt and his assistant Arnold Wilkins. This was soon followed by a trial, in which the BBC's short wave radio transmitter at Daventry, England was used to detect a British Heyford Bomber.

The success of this trial led to a chain of *Radio Detecting and Ranging* (RADAR) stations along the South and East coasts of England. These were to provide vital advance information that was to help the Royal Air Force win the Battle of Britain.

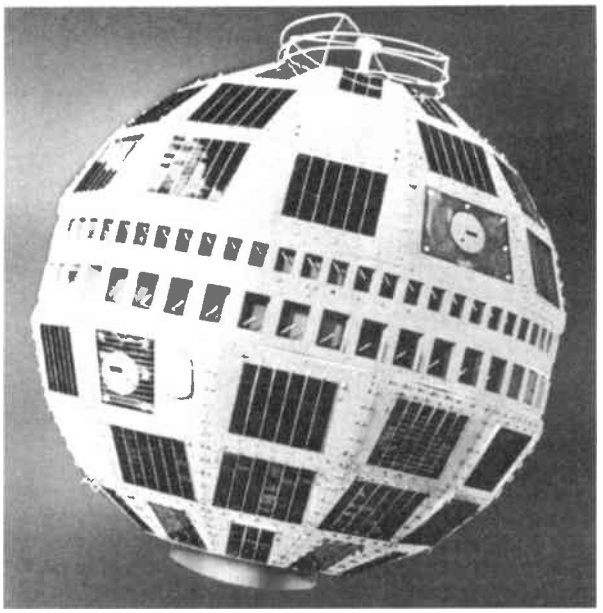
MAGNETRONS

Sad to relate, early RADAR sets were not as efficacious as one might have hoped for. What was required was a new generation of high and low power signal generators. One solution that was to find favour was the *magnetron*, which was developed by British physicists at the University of Birmingham in 1939.

A magnetron is a diode vacuum tube-like device that is capable of generating extremely high frequencies and also short bursts of very high power.



Echo 1, *the first experimental communications satellite, during inflation tests.* Courtesy Science Museum/Science and Society Picture Library.



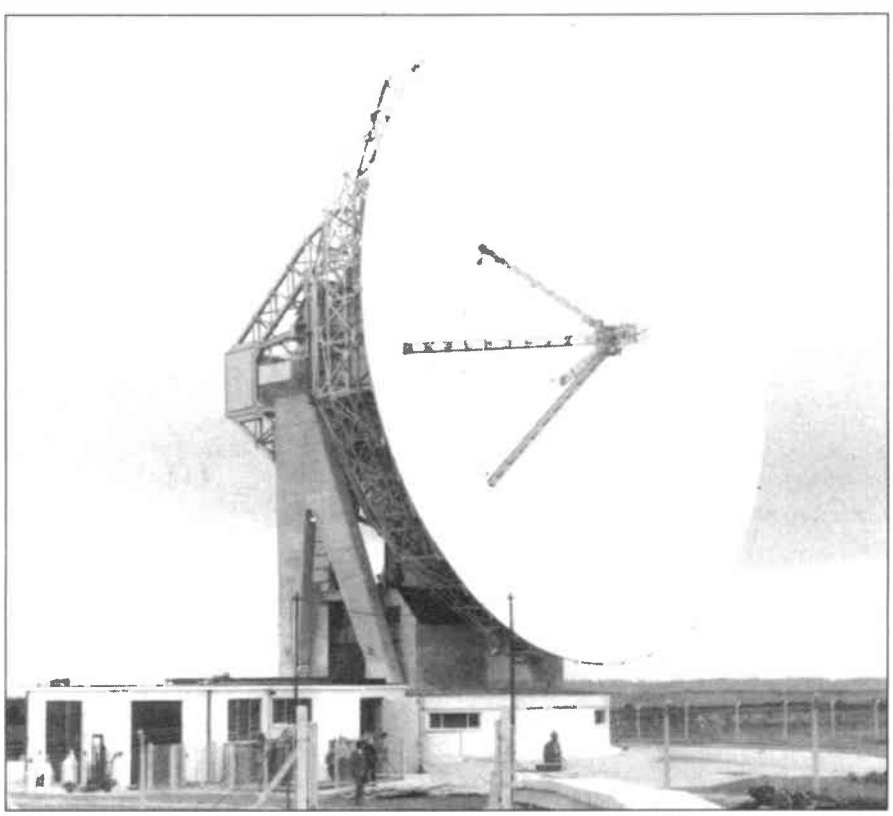
Telstar 1, *first commercial communications satellite. It was a multi-faceted sphere one metre in diameter.* Courtesy of BT Archives.

Following *Telstar's* launch on 10 July 1962, the first television pictures were transmitted across the Atlantic Ocean from a giant antenna near Andover, Maine, to a receiver located at Goonhilly in England. These television pictures were quickly followed by transmissions of telephone, telegraph, facsimile (FAX), and computer data.

CRYSTAL BALLS

As far back as 1945, Arthur C. Clarke (who was to gain fame as a Science Fiction writer) proposed that microwave signals could be beamed to an unmanned orbiting satellite and bounced back to a different part of the world. But his key suggestion was that three satellites parked in a geo-synchronous orbit 36,000 kilometres above the Equator could be used to provide world-wide coverage. Clark's vision was eventually realised by *Telstar's* successors.

Today, thousands of satellites race around the Earth, to the extent that it's becoming increasingly difficult to select an orbit for a new satellite so as to maintain a safe separation from existing devices.



Goonhilly Earth Station. Courtesy of BT Archives.

Original cavity magnetron, 1940. Developed by John Randall and Harry Boot of Birmingham University. Courtesy of Science Musem/Science and Society Picture Library.

The need to manufacture tens of thousands of magnetron tubes to satisfy the war effort drove the British government to seek help from American industry. One company that was consulted was Raytheon, which already had been experimenting with their own microwave tubes.

After listening to the British scientists describe their method of producing the magnetron tubes, one of Raytheon's engineers, Percy L. Spencer boldly stated that their technique was "awkward and impractical". Percy took the tube home over the weekend and came up with radical changes that would both simplify the manufacturing process and improve the functioning of the radar.

Britain awarded the little-known Raytheon a contract to supply the magnetrons, and by the end of the war Raytheon was producing 80 percent of all magnetrons in the world. Spencer, a man with only a basic school education, became Raytheon's chief engineer.

MICROWAVE OVENS

The discovery of microwave cooking in 1945 is also attributed to Raytheon's Percy Spencer. A candy bar in Spencer's pocket began to melt as he stood in front of a magnetron tube that had been switched on. Spencer next placed popcorn kernels in front of the tube – and they popped.

Scientists already knew that magnetrons generated heat whilst radiating microwaves, but Spencer was the first to discover that one could cook food using microwave radio signals.

Based on Spencer's discovery, Raytheon demonstrated the first commercial microwave oven in 1947. These beasts were presented in refrigerator-sized cabinets and cost $2000 to $3000 (which was an expensive way to cook one's popcorn).

THE INTERNET

The latest development in the communications arena is the Internet, which combines the widespread availability of computers with every other communications technology known to man.

The Internet had its origin in a US Department of Defence program called ARPANET (Advanced Research Projects Agency Network), which was established in 1969 to provide a secure and survivable communications network for organisations engaged in defence-related research.

By the 1980s, ARPANET had evolved into a fledgling version of today's Internet that was predominantly used by academics as a way to publish textual data and as a text-based search engine.

One of the original uses of the Internet was electronic mail (commonly called *E-mail*), bulletin boards and newsgroups, and remote computer access. The World Wide Web (WWW), which enables simple and intuitive navigation of Internet sites through a graphical interface called a *Web Browser* (such as Netscape or Internet Explorer) was popularised by the release of the MOSAIC web browser in 1993.

In December 1999, the number of daily E-mails passed daily conventional mail letters for the first time.

The Internet now uses radio, satellites, the telephone network, cable TV, amateur radio, and numerous other delivery media. In addition to raw computer data, the Internet is itself used to deliver static images, telephone conversations, music and television pictures. Cutting across national boundaries, the uncensored Internet is seen by many as being one of the most momentous achievements of the 20th Century.

The most amazing thing is that the Internet today is still in its infancy. In many ways the state of the Internet at the beginning of the year 2000 is comparable to that of the telephone as the world entered the 1900s. However, the speed of the Internet's development is exponential compared to that of the telephone, and the social impact of the Internet will be more profound than most people can conceive.

NEXT MONTH

In Part 4 we shall turn our attention to computing in the 20th Century, and in Part 5 we shall polish up our crystal ball and peer into the future in a desperate attempt to predict the new and wonderful ideas and techniques that are racing towards us like a runaway train at the beginning of this new millennium!

TIMELINES

1962: America. Unimation introduces the first industrial robot.

1962: First commercial touch-tone phone systems.

1962: First commercial communications satellite (*Telstar*) launched and operational.

1963: Philips introduces first audio cassette.

1964: Birth of *Practical Electronics* magazine.

1967: Dolby eliminates audio hiss.

1967: America. Fairchild introduce an integrated circuit called the Micromosaic (the forerunner of the modern ASIC).

1968: America. First Static RAM i.c. reaches the market.

1969: First radio signals transmitted by man on the moon.

1970: America. Fairchild introduce the first 256-bit static RAM called the 4100.

1970: America. Intel announce the first 1024-bit dynamic RAM, called the 1103.

1970: Researchers at Corning Glass develop first commercial/feasible optical fibre.

1971: Birth of *Everyday Electronics* magazine.

1971: First direct telephone dialing between USA and Europe.

1971: America. Intel creates the first microprocessor, the 4004

1975: England. First liquid crystal displays (l.c.d.s) are used for pocket calculators and digital clocks.

1977: First implementation of optical light-wave in operating telephone company.

1980: Development of the world wide web begins.

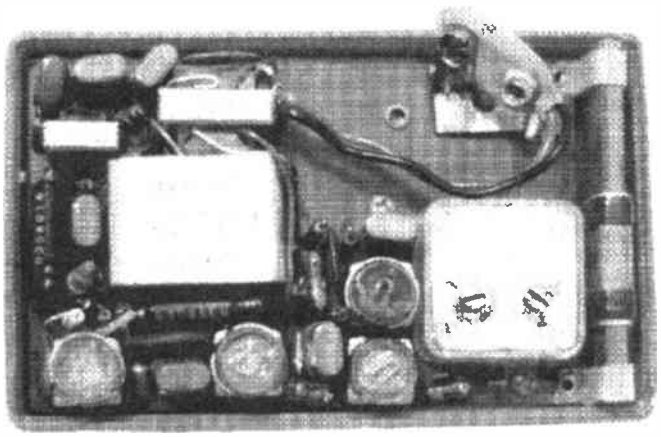
1980: Faxes can be sent over regular phone lines.

1980: Cordless and cell phones are developed.

1989: Pacific fibre-optic link/cable opens (supports 40,000 simultaneous conversations).

1992: *PE* and *EE* combine to become *EPE*.

1993: MOSAIC web browser becomes available.



Interior of a Sony TR-63 transistor radio. 114,536 of them were manufactured between March 1957 and November 1958. Courtesy Radio Bygones.

INTERFACE

Robert Penfold

BIDIRECTIONAL PRINTER PORTS

AS REGULAR readers will be aware, there have recently been changes to the way PC add-ons are tackled in this series of articles. Good old GW-BASIC and Q BASIC have been replaced by visual programming languages such as Visual BASIC 6.0 and Delphi 1 or 2.

Most projects now require a bidirectional printer port whereas those featured in the past needed only a standard printer port. I think most would agree that these changes have resulted in projects that are superior to their predecessors, even though in most cases the hardware and software are actually simpler.

However, these changes seem to have caused an increase in the number of letters and E-mails relating to *Interface* articles. A number of projects that utilize a bidirectional printer port and (or) software written in a visual language will feature in future *Interface* articles, so it is perhaps worthwhile clarifying some points raised by readers before getting embroiled in these designs.

Ongoing

I think it is worth making the point that the *Interface* articles are largely self-contained, but they are also part of an ongoing series. It is a series that is not really aimed at beginners. When a design is featured in an *Interface* article, most of the information provided is specific to that project.

In general, background information is not provided. Some of this information is the type of thing that anyone having a reasonable amount of experience with computer add-ons should know. The rest is subject matter that has been covered in recent *Interface* articles.

In short articles of this type there is not enough space available to keep repeating things over and over again. If an article does not tell you everything you need to know it may be necessary to delve back a few issues for the answers.

Bidirectional

One or two readers seem to have run into trouble because they have tried to use projects requiring a bidirectional port with old PCs that have standard printer ports. In general, Pentium PCs have bidirectional ports while 80486 and earlier PCs do not. However, some early Pentium PCs lack this facility and a few 80486 based PCs do have this bidirectional capability.

Some PCs that have bidirectional printer ports default to the standard mode of operation, and must be set to the bidirectional mode using the BIOS Setup program. The documentation supplied with the PC should give details of the BIOS Setup program and changing the mode of the printer port. It is SPP mode that is required, but EPP mode also seems to be suitable. ECP is an advanced mode that does not seem to support simple bidirectional operation.

The only sure way to determine whether or not a port can read data on its eight data lines is to run a simple test. Writing a value of 32 to the handshake output register sets a port to input operation, and data can then be read from the data lines at the base address of the port.

Right Address

This brings us to another source of problems, which is determining the right address range for the printer port. There are three address ranges used for printer ports, as shown here:

Data Register	*H/S Input Register*	*H/S Output Register*
&H3BC	&H3BD	&H3BE
&H378	&H379	&H37A
&H278	&H279	&H27A

Most PCs have one printer port as standard, and this is usually at a base address of &H378, but some seem to use &H3BC. Where there is more than one printer port the operating system designates the port at the highest address port one, the one at the next highest address port two, and if there are three ports, the one at the lowest address will be port three. If there are ports at addresses &H378 and &H278 for example, these will respectively be used as ports one and two by the operating system.

If you do not know the addresses of the ports in your PC the easiest way to find out is to use the Windows 95/98 System Information program. Operating the Windows Start button and then selecting Programs, Accessories, System Tools, and System Information will launch this program.

Double click on Resources and then on I/O to bring up a list of the input/output address assignments. This will provide a list of the type shown in Fig.1, which should include the serial and parallel ports.

Simple Test

A very simple test routine is all that is needed to check whether the port supports bidirectional operation. This GW BASIC program will do the job. The addresses are correct for what will normally be printer port two, but they are easily changed if necessary.

```
10 CLS
20 OUT &H27A,32
30 LOCATE 10,20
40 PRINT INP(&H278)
50 GOTO 10
```

Line 20 sets the port to the input mode, and a loop then repeatedly reads the data lines and prints the results at the same point on the screen. Feeding various logic patterns to the data inputs of the port (pins 2 to 9) should produce the appropriate readings on the screen.

It is best to drive the port via current limiting resistors of about 220 ohms in value. If the port is still working as an output type these resistors will limit the current flow to a level that will prevent anything from being damaged.

On The Cards

If the readings from the port do not change it is clearly not a bidirectional type. The easiest solution is to fit the PC with a printer port card (see Fig.2) and any modern card of this type should support simple bidirectional operation. A card of this type should cost about £10 to £20 from any large computer store, which is not bad for a port that provides a total of 17 input and output lines.

Since most PCs have a printer connected to parallel port one, adding a second

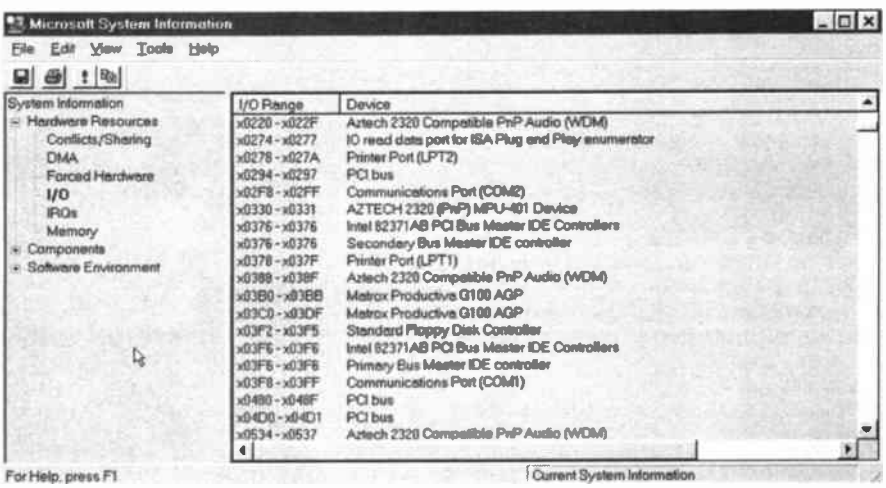


Fig.1. The Windows System Information program can provide a list of address ranges for the hardware.

port specifically for use with your add-ons is a good idea anyway. Assuming the existing port is at a base address of &H3BC or &H378, the new port should be configured for a base address of &H278, to use IRQ5, and for EPP or SPP operation.

Delphi

Using visual languages with your own add-on devices is not as straightforward as using a traditional BASIC such as GW BASIC. Direct accessing of ports is permitted under Windows 95 and 98, but there is little support for doing this with Windows programming languages.

Borland's Delphi (a sort of visual Pascal) does have a Port function that can be used to read from and write to ports. However, this facility is only supported by version One of the program, and is absent from all the subsequent versions. The software for most user add-ons is fairly basic, and Delphi 1.0 is more than adequate for this type of thing.

Although it is no longer available as a separate entity, it is supplied with later versions of Delphi (both the commercial versions and the "free" versions occasionally given away with computer magazines). The original Delphi language produces programs that will run under Windows 3.1, but later releases are strictly for use with the 32-bit versions of Windows. Version 1.0 of Delphi is therefore included with later versions to provide 16-bit compatibility. Delphi 1.0 programs will run properly under Windows 95 and 98 incidentally.

Delphi 1.0 has definite advantages over the alternatives, and will probably be used to produce the programs featured in future *Interface* articles. One advantage is that it produces stand-alone programs that do not have to be installed, and at around 200k to 250k they are not particularly big either.

As explained previously, Delphi 1.0 programs will run under Windows 3.1, 95, and 98. Because of the built-in Port function it is not necessary to resort to any software add-ons, keeping things simple and straightforward.

Getting In-line

Although Delphi 2.0 and beyond do not have a Port function they are equipped with a simple but effective in-line assembler. Reading from and writing to ports can therefore be accomplished using a few lines of assembler.

Due to the lack of a Port function it is not possible to compile any Delphi 1.0 listings provided in *Interface* articles using Delphi 2.0 or later. However, it should be possible to rewrite them to use assembler routines instead of the Port function, and the programs should then compile successfully under the 32-bit versions of Delphi.

As far as I am aware, the "free" versions of Delphi are not available for download at any web site. The size of these programs is such that it would take a very long time to download them anyway.

Versions up to Delphi 3.0 Professional have appeared from time to time as freebies on magazine cover discs. These are the same as the full commercial equivalents, but they are for personal use only. In other words, if you start to distribute your programs commercially you must buy "the real thing".

Programming user add-ons using Delphi 1.0 was covered in the June '99 issue of *EPE*, and using the assembler in later versions was covered briefly in the August '99 issue.

Going Visual

Visual BASIC is now the most popular programming language, and it is probably the most simple to use. In recent years I have received a steady flow of enquiries about using this language with PC projects.

Unfortunately, as far as I can ascertain there are no INP or OUT functions in Visual BASIC 6.0 or any of the earlier versions. Neither is there a built-in assembler or any other integral function that provides access to the ports.

It is possible to access the ports using this language, but only with the aid of a software add-on. Anyone interested in using Visual BASIC with user add-ons should certainly pay a visit to the web site at **http://www.lvr.com** where there is a lot of information, software add-ons, and links to other useful sites.

If nothing more than basic port access is needed, and this is certainly all that is needed for most projects, the freeware DLL called ***inpout32.dll*** would seem to be the best option. Use ***inpout16.dll*** for 16-bit versions of Visual BASIC. Using either of these adds INP and OUT functions to Visual BASIC, and these functions are used in exactly the same way as their GW BASIC counterparts.

One or two readers have queried whether or not this file will be included when a program is compiled. Visual BASIC does not compile programs into standalone files, but instead produces a group of files complete with an install/uninstall program. A DLL file such as ***inpout32.dll*** will be included with the program group, and the installed program will function properly. Unfortunately, the smallest of Visual BASIC programs seems to compile into almost two megabytes of files!

Working Model

There is a "working model" version of Visual BASIC 6, but this does not seem to be available as a download from the Microsoft web site. Again, it would probably take too long to download anyway.

The working model is almost the complete program, but it cannot compile programs. They can be run from within Visual BASIC though, rather like running programs under GW BASIC or Q BASIC. When run in this way the programs seem to run at full speed and without any restrictions.

The usual way of obtaining the Visual BASIC working model is to buy a book that includes it on the accompanying "free" CD-ROM. Although I hate to admit it, I found *"The Complete Idiot's Guide To Visual BASIC 6"* by Clayton Walnum (ISBN 0-7897-1812-X) an excellent introduction to Visual BASIC programming.

At around £15, complete with the working model version of the program, it probably represents the cheapest way of trying Visual BASIC 6. Using Visual BASIC with user add-ons was covered in the August '99 issue of *EPE* incidentally.

Windows NT4

Windows 3.1, 95, and 98 all permit direct accessing of the ports, but Windows NT4 does not. It is designed to be more secure than other versions of Windows, and it only permits port accesses via the operating system. This ensures that two programs cannot simultaneously attempt to access the same piece of hardware.

There are add-ons that can provide programming languages with a port access facility in Windows NT4 (see the **lvr.com** web site mentioned earlier), but this is doing things the hard way. Windows 95 and 98 are a better choice for a PC that will be used with PC based projects.

Liberty BASIC

It is perhaps worth mentioning a little known BASIC programming language called Liberty BASIC. This shareware program is a traditional BASIC that will produce Windows programs, and it includes INP and OUT functions.

Being shareware this program can be tried out for the cost of downloading it from one of the source web sites. There are several of these including **http://www.liberty-basic.com**.

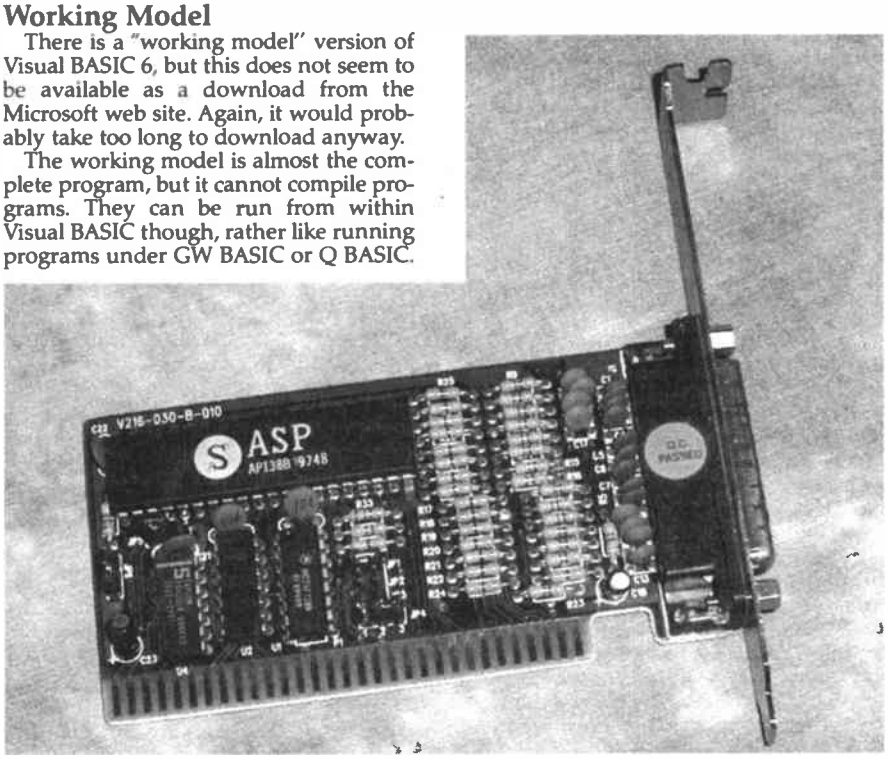
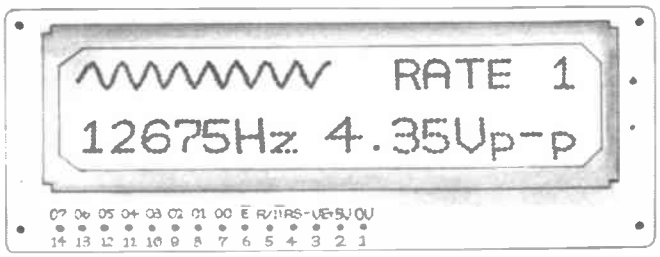


Fig.2. A bidirectional printer port card.

Constructional Project

MICRO-PICSCOPE



JOHN BECKER

Visual signal monitoring with frills!

IT IS astonishing what opportunities are continuing to be revealed for the recently introduced PIC16F87x series of microcontrollers. The Micro-PICscope is a prime example of a design idea whose implementation was greatly simplified by using one of these devices.

The Micro-PICscope is a handy little item of test gear and of benefit to anyone's workshop. Using an alphanumeric liquid crystal display (l.c.d.), it is basically a signal tracer, but one with the great advantage that it shows a representation of the signal waveform that is being traced. This is shown across eight of the l.c.d. character cells and is a real-time trace of the monitored waveform.

Not only that, the display also shows the frequency of the signal being monitored, and its peak-to-peak voltage. The frequency range covered is basically for audio, but frequencies well to either side of this range can be traced.

Several ranges of control are offered by switch selection, covering the sampling rate, and synchronisation on/off for the 'scope display. The signal input is switchable to provide different maximum peak voltage monitoring ranges. Selection of a.c. or d.c. input is provided.

The entire design requires only two i.c.s, a PIC micro and an op.amp, plus a 2-line by 16-character l.c.d. An optional third i.c. provides power regulation if required.

A typical example of the l.c.d. screen display is shown below.

DESIGN HISTORY

Some 12 or more years ago, when the author first became familiar with "intelligent" alphanumeric l.c.d.s, it became apparent that by using the internal programmable character generator, their screens might be capable of displaying a simple representation of a signal being monitored,

He had already designed and published a similar purpose unit based on multiplexed l.e.d. (light emitting diode) displays. In that unit (*PE* June '92), an LM3914 bargraph i.c. was used in conjunction with shift registers and digital multiplexers to portray a waveform across four 5 × 7 bit matrixed l.e.d.s. It was very effective, although somewhat power hungry.

At the time though, microcontrollers were an unknown to the author and a method by which an l.c.d. screen could be similarly used eluded him. Whereas l.e.d. matrices require only logic control, alphanumeric displays require a variety of data commands to be provided under program control.

For some simple operations l.c.d. commands can be generated using codes preprogrammed into an EPROM (electrically programmable read only memory). This technique had already been successfully used by the author in a real-time Morse Code decoder (*EE* Jan '87), but did not lend itself to circuit board signal tracing and monitoring.

The introduction of the versatile PIC16x84 microcontroller resparked interest in the idea, and it could have been done using that PIC with a separate analogue-to-digital converter (ADC). Then along comes the PIC16F87x family – with built-in ADC. Bingo, the idea was now as good as constructed to full workshop working order as a single chip design – apart from writing the command program, of course!

Example of the screen display obtainable on the l.c.d. module.

CIRCUIT DETAILS

In fact, as you will see from the complete circuit diagram for the Micro-PICscope in Fig.1, the practical implementation of the idea has been expanded a bit to use more than just a microcontroller (IC2). A buffering and gain setting op.amp (IC1a) has been included as well. So too has a 5V regulator (IC3), allowing the unit to be powered from 9V or 12V supplies. If you have an existing well-stabilised 5V supply, IC3 may be omitted.

The signal being monitored is brought into op.amp IC1a. As set by resistors R1 to R3, the gain can be selected by switch S1 to be ×1 (unity – via R2) or ×10 (via R1). Other gain-setting values could be chosen instead. For example, a 10kΩ resistor could be used for R3 instead of a 100kΩ. This would provide switchable gains of unity and 1/10.

Switch S2 provides selection of a.c. or d.c. signal coupling, switching capacitor C1 in and out of circuit. The output from IC1 to the microcontroller is d.c. coupled. You will spot that the op.amp is used in inversion configuration. Software ensures that the signal is seen the "right way up"!

A MAX492 dual op.amp is used for IC1, with the second half ignored. This device is part of the author's stock "library" and has proved itself for its nearly rail-to-rail output swing. The circuit has also been used with a TL082 device, which provides good frequency range, although does not offer full rail-to-rail output (typically more like 4V swing for a 5V split supply as used here – split by resistors R4 and R5).

MICROCONTROLLER

Microcontroller IC2 is a PIC16F876 device, operated at a clock rate of 5MHz, as set by crystal X1. Because of this clock rate, the 20MHz version of the PIC should

be used. The "standard" version has a maximum guaranteed clock rate limit of 4MHz. However, you may find it interesting to note that the author has successfully used the 4MHz version at rates well in excess of 5MHz.

The PIC16F87x family has been discussed at length in previous issues of *EPE* and the '876 will not be described in detail here. Suffice to say that it has three input/output (I/O) ports, one of which, PORTA, can be used for analogue-to-digital conversion via five of its pins (RA0 to RA3, plus RA5). In this design, only RA0 (pin 2) is used, its input being taken directly from the output of op.amp IC1a at pin 1.

Internally, the PIC is programmed by the software so that the voltage reference for the ADC is taken as 0V to 5V (the power line voltage range). Consequently, an A-D conversion value of 255 results when the input to RA0 is at the positive supply line level of 5V. A result of zero occurs when the RA0 input is at 0V.

Output to the l.c.d. (X2) is via PORTB, using lines RB0 to RB5 to control the display in conventional 4-bit mode. Connections to the l.c.d. are via the terminal pin block TB1. The order of the pins, both physically on the printed circuit board (p.c.b.) and in terms of program control, is identical to that used by the author in many of his recently published designs. Display contrast of the l.c.d. screen is set by preset VR1.

EXTERNAL CONTROL

External control of the PIC's monitoring and timing functions is actioned via PORTC, through pins RC0 to RC2. The functions controlled are the ADC sampling rate (via S3), waveform synchronisation on/off (S4), and frequency counter display on/off (S5). These will be discussed later.

Pins RB6 and RB7, whilst not actively used by the design itself, can be used to program the PIC via a suitable programmer, such as *PIC Toolkit Mk2* (May-June '99). The $\overline{\text{MCLR}}$ pin (master reset) is normally powered at 4·3V (5V – 0·7V) via diode D1 and buffering resistor R6. This allows programming voltage control without disturbing the normal 5V supply rail from voltage regulator IC3.

Terminal pin block TB2 provides access to $\overline{\text{MCLR}}$, RB6, RB7 and the 0V common line. The pin order on the p.c.b. is the also same as that used by the author in previous designs. This will be welcomed by those who have established a plug-in link between *Toolkit Mk2* and such designs! (The author intends for all his future PIC designs to use this same pin configuration for l.c.d. and programming connections.)

Completed Micro-PICscope showing general layout of display and controls.

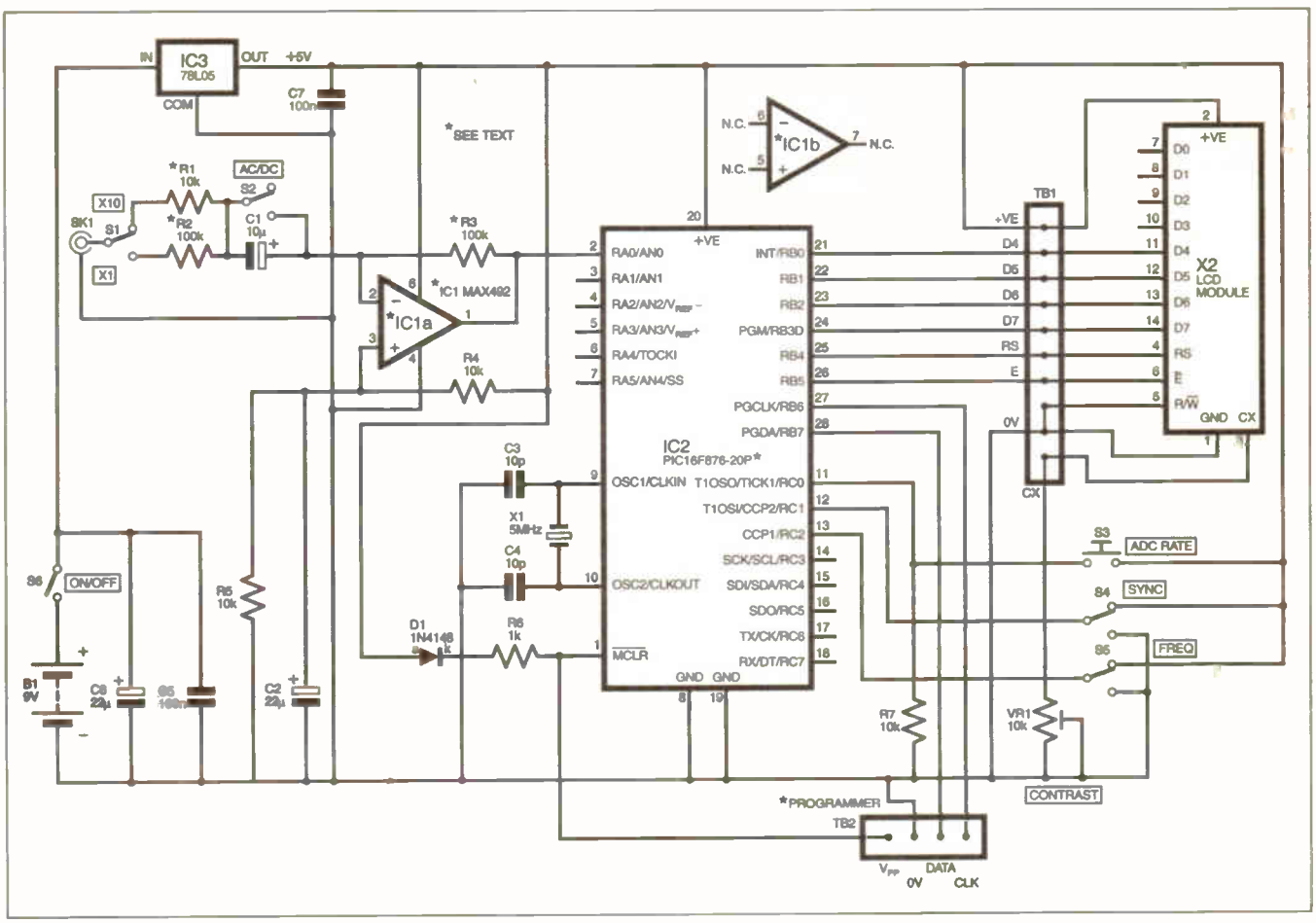


Fig.1. Complete circuit diagram for the Micro-PICscope. The voltage regulator IC3 is optional – see text.

CONSTRUCTION

Details of the p.c.b. component and track layouts are shown in Fig.2. This board is available from the *EPE PCB Service*, code 259.

Regular readers will know this author's preferred constructional order: wire links, resistors, diodes, small capacitors, i.c. sockets and then on upwards in order of component size.

Dual-in-line sockets should be used for IC1 and IC2. Note that microcontroller IC2 is the narrow version (0·3in width between pin rows, as opposed to 0·6in).

Details of the switch and signal input connections are also shown in Fig.2. Socket SK1 may be a different type to that shown if preferred.

The l.c.d. module might have one of two possible pin connection arrangments. They are shown in Fig.3.

As always, do a thorough check of the component positioning, orientation and solder joint integrity before applying power. Do not insert IC1, IC2 or the l.c.d. until the output from regulator IC3 has been validated, exactly 5V (within a few millivolts) for a supply between 7V and 12V.

An output voltage from IC3 other than 5V will usually indicate a fault in construction – too high and IC3 is wrongly inserted, too low and there may be a short circuit somewhere on the board.

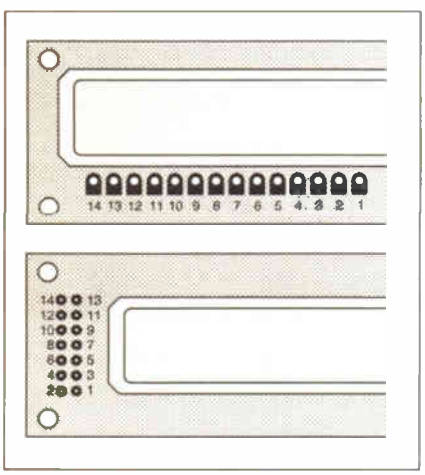


Fig.3. Pinout arrangement of the two basic l.c.d. formats.

FIRST RUN

When happy about the power supply, test the circuit with IC1, IC2 and the l.c.d. plugged in (correctly!). Set switch S4 (Sync) off and S5 (Frequency) on. When power is applied, the PIC first goes into an l.c.d. initialisation routine, in which it sets the l.c.d. for 2-line 4-bit mode.

Following this, text messages similar to those in the photographs should appear. The signal trace display in the top left l.c.d. character cells should show as a straight line about half way up the screen. Adjust preset VR1 to set the screen contrast (you may see nothing at all until you have adjusted it).

Having read the sections all about the control program, you can then feed in an audio signal, play with the switches, and see the results on screen. The input signal

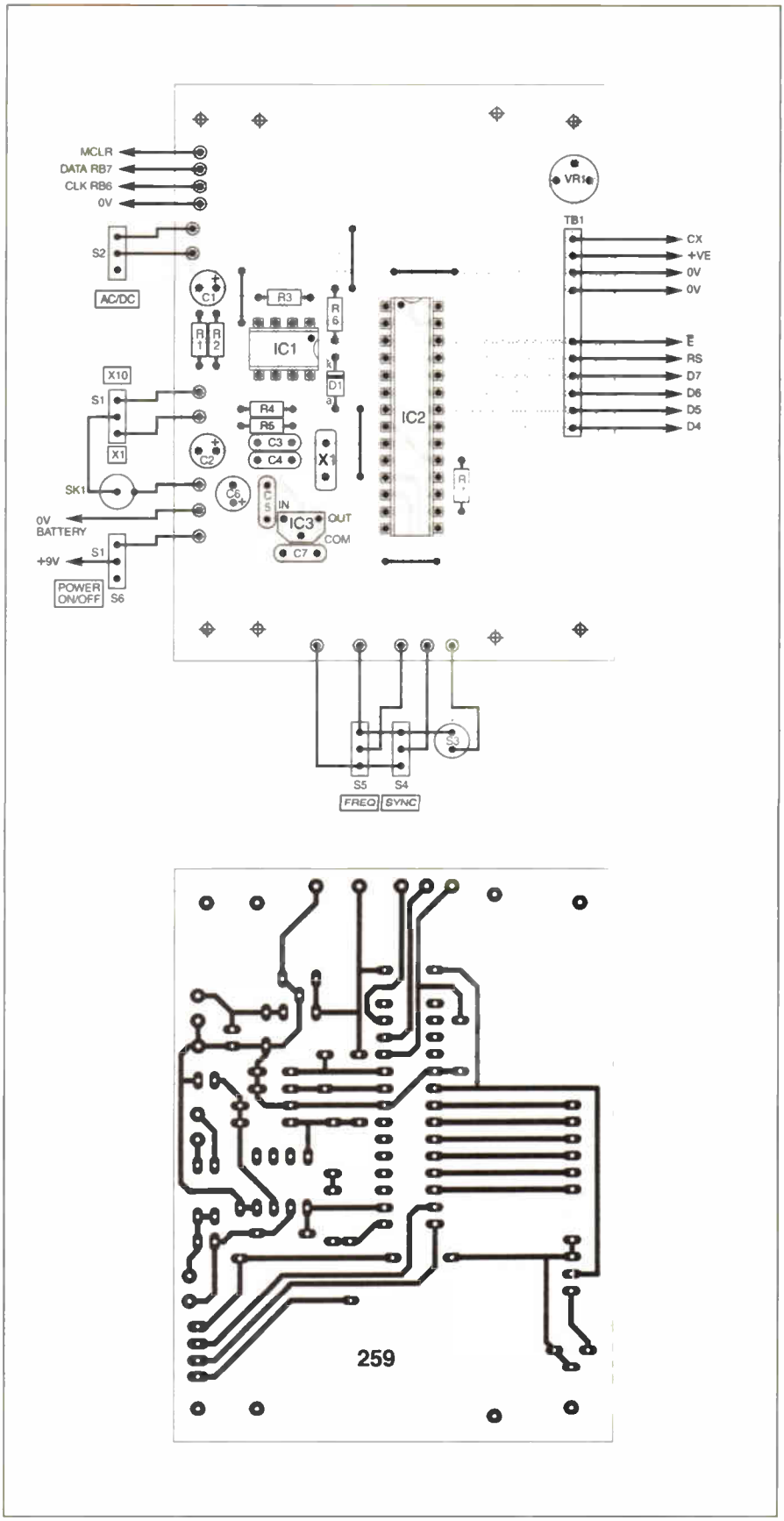


Fig.2. Printed circuit board component layout, wiring to the off-board components and full-size copper foil master for the Micro-PICscope.

amplitude should be selected so that the majority of the l.c.d. vertical pixel range is used.

ENCLOSURE

A small plastic box was used to house the prototype. The p.c.b. has been designed so that the l.c.d. can be mounted above it using stand-off pillars, although the prototype did not use this option.

The rectangular viewing slot was cut by first drilling small perimeter holes and using a file to smooth the edges to shape and size. Holes must also be drilled to suit the switches and input socket. The prototype used a 3·5mm jack socket for the power input, but other techniques, such as a battery connector, can be used.

A-TO-D CONVERSION

Basic A-to-D conversion using a PIC was discussed in the *Mini PIC16F87x Tutorial* of Oct '99. A simplified version of the routine described there is used here:

In the START routine while in PAGE1, register ADCON1 is set with the binary value of %00000101, which tells the PIC that the 2-byte ADC register is to be justified left, with RA0 as an analogue input referenced to +VE and 0V.

Then, back in PAGE0, by loading register ADCON0 with a binary value of %01000001, ADC conversion is activated at an oscillator rate of one-eighth of the clock rate (Fosc/8).

(Readers who write their own PIC software should note that in order for PAGE commands to be used with the *Toolkit* programmer and the PIC16F87x family, bit RP1 of the PIC's STATUS register must be set to 0 – as it is in the START routine of the Micro-PICscope source code.)

A single ADC sample is taken when the command **BSF ADCON,GO** is issued, where the quaint GO term (Microchip's description!) refers to bit 2. Sampling and conversion are not quite instantaneous and the program repeatedly polls the GO bit until it goes low, signifying an end to the conversion process. There are several subroutines which are used in the program to perform this task, one of them being:

```
WAITS1: BTFSC ADCON0,GO
        GOTO WAITS1
        MOVF ADRESH,W
```

When the GO bit is clear, the command **MOVF ADRESH,W** retrieves the high byte of the 2-byte conversion result. Because the

COMPONENTS

Approx. Cost Guidance Only **£19.50** excl. case

See SHOP TALK page

Resistors

R1, R4, R5, R7	10k (4 off)
R2, R3	100k (2 off)
R6	1k

All resistors 0·25W 5% carbon film or better.

Potentiometer

VR1	10k min. round preset

Capacitors

C1	10μ radial elect. 16V
C2, C6	22μ radial elect. 25V (2 off)
C3, C4	10p ceramic, 5mm. pin spacing (2 off)
C5, C7	100n ceramic, 5mm. pin spacing (2 off)

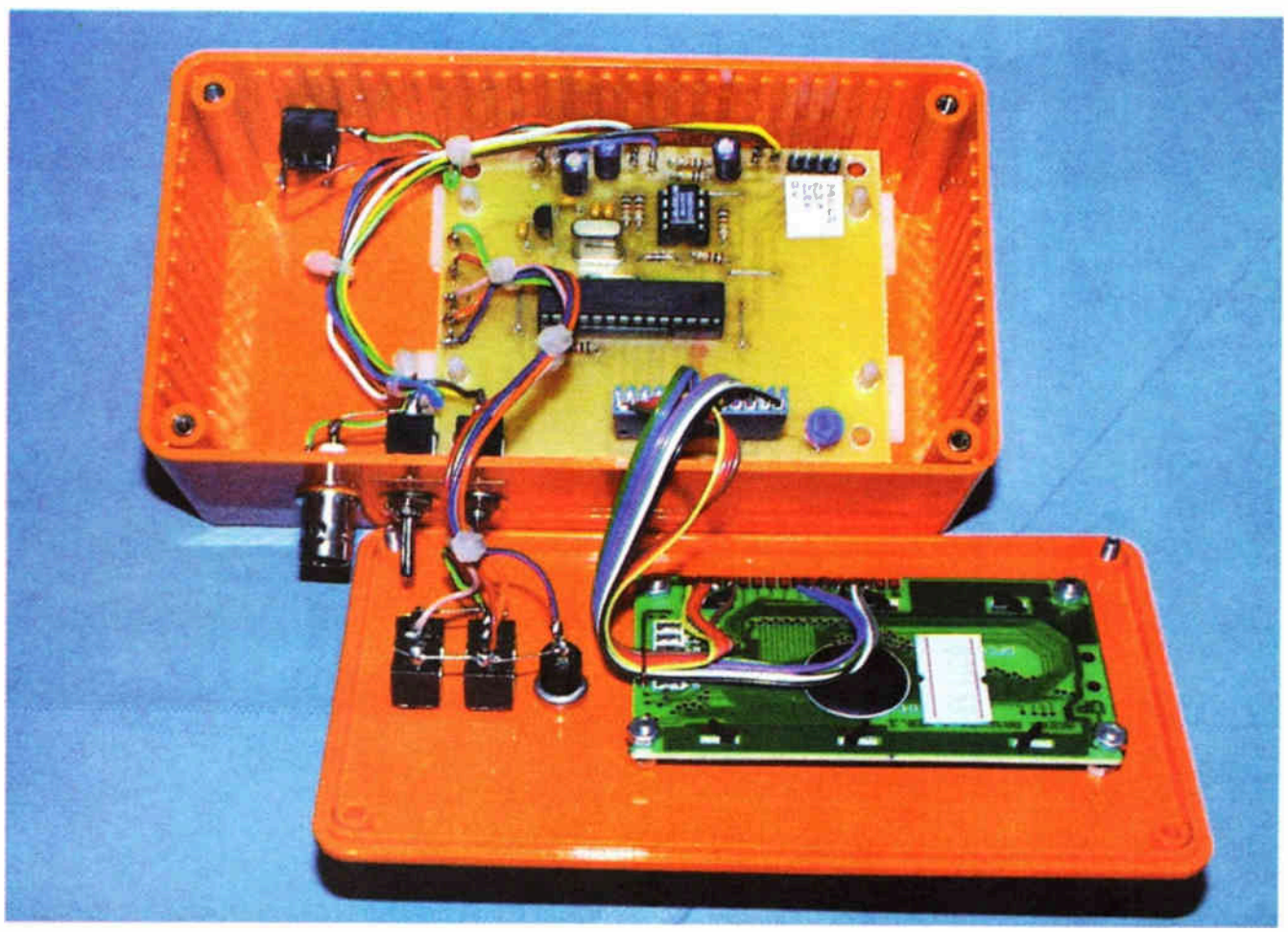
Semiconductors

D1	1N4148 signal diode
IC1	MAX492 dual op.amp
IC2	PIC16F876-20P microcontroller (20MHz version, 0.3-in width), preprogrammed
IC3	78L05 +5V 100mA voltage regulator (see text)

Miscellaneous

S1, S2, S4, S5	min. s.p.d.t. toggle switch (4 off)
S3	min. push-to-make switch
S6	min. s.p.s.t. (or s.p.d.t.) toggle switch
SK1	BNC socket (see text)
X1	5MHz crystal
X2	2-line x 16 characters per line alphanumeric liquid crystal display

Printed circuit board, available from the *EPE PCB Service*, code 259; power supply connector, – see text; plastic case, 150mm x 80mm x 50mm; 8-pin d.i.l. socket; 28-pin d.i.l. socket; 1mm terminal pins (or strips) for TB1 and TB2; p.c.b. and l.c.d. supports (8 off); connecting wire; cable ties; solder, etc.



Completed unit showing the l.c.d. module mounted on the lid of the case and wiring to the p.c.b.

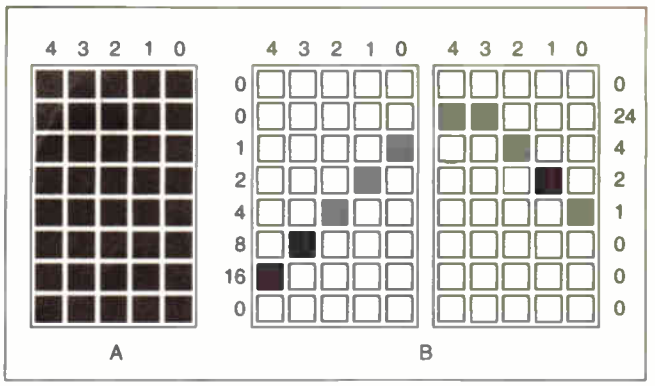


Fig.3(a). L.C.D. character cell matrix with all pixels on, (b) example of waveform representation across two character cells.

display is only eight pixels high, the low byte is not needed (see the *Mini Tutorial*, or the PIC16F87x data book, for details of the conversion result format options).

The value held in ADRESH (and now also in W) is that which represents the voltage level of the signal being sampled. It cannot yet, however, be put out to the l.c.d. screen, there's a great deal of work to be done first! For the moment, this value is simply stored in one of a set of temporary memory locations. The conversion and storage is performed 128 times before further action is needed.

DISPLAY PRINCIPLE

Before that "further action" is described, it is first necessary to understand the concept behind the way in which a waveform can be displayed on the l.c.d. by making use of its character generator.

You already know that the l.c.d. used here has two display lines each having 16 character cells. Each of these 32 cells consists of a matrix of l.c.d. pixels, arranged as five across by eight down (see Fig.4a).

Normally, the l.c.d. module places pre-programmed (as part of the module's control chip manufacturing process) alphanumeric data into these cells according to command codes from an external source, a PIC in this case.

However, the module has the facility to allow eight characters to be "designed" by the user and called as well as the standard alphanumeric set. These characters are stored at module address locations 0 to 7.

At first sight, when examining the l.c.d. data sheet, it might appear that address locations 8 to 15 can also be used to hold custom characters as well. Regretably for an application such as this PICscope, addresses 8 to 15 only hold repeats of the data at addresses 0 to 7. Thus only eight addresses can be used for alternative character data, hence the PICscope only having eight cells for waveform display.

Eight cells each having five pixels horizontally allows 40 waveform samples to have their values plotted at eight vertical pixel levels.

The reason that 128 samples are taken even though only 40 will be displayed from each block is to allow for frequency and amplitude values to be more readily established.

CHARACTER GENERATOR

The way in which data for a character cell is evaluated is illustrated in Fig.4b. Each of the seven rows which make up the cell display are treated individually. The five pixels of each row are numbered from 4 to 0, allowing a 5-bit binary number to be compiled. Logic 1 in a bit position turns on the equivalent pixel, logic 0 turns it off.

Close-up of typical screen display. There are three rates, the maximum counting frequency is about 17kHz.

Having established which bits are to be active, the 5-bit binary number for each row (expanded to 8-bit with zero in bits 7 to 5) is sent to the required character generator address, of between 0 and 7. The same procedure can be used for the other seven possible addresses, each of them storing different data, as appropriate.

When character data is being generated in this way, the l.c.d. is first told that the data about to arrive is destined for the character generator rather than for the screen display. In the program the initial command is given by:

```
MOVLW %01000000
CALL LCDLIN
BSF RSLINE,4
```

which sets the character generator to address 0 from which address onwards the "designed" data is to be stored, the address incrementing each time a data byte is written to the l.c.d. The LCDLIN call is to one of several standard routines which the author wrote some years ago to send various commands and data to an l.c.d. module.

For all eight character cells to be fully programmed, 8 × 8 = 64 bytes of data are written to the character generator.

Once the character generator has been programed, the data held at each of the eight address blocks can be called to the screen by simply accessing that address in the same way that "normal" alphanumeric data is accessed.

For example, to display letter "A" on screen you might use either **MOVLW 'A', CALL LCDOUT**, or **MOVLW 65, CALL LCDOUT**, the value of 65 being the ASCII value for capital letter 'A'. In both cases the character held at character generator address decimal 65 would be displayed on screen, which, fortunately for us all is indeed the letter "A".

Similarly, to show the character newly programmed into address 3, the commands would be **MOVLW 3, CALL LCDOUT**.

The data held at character generator addresses 0 to 7 can be changed as often as required. In this design it is typically changed about twice per second (faster with S4 and S5 off). All data at these addresses is lost when power is switched off.

WAVEFORM CHARACTERS

When a full block of samples has been converted and stored, the data is then analysed for amplitude and compiled into 64 bytes for sending to the character generator. Row 8 is the top row and (naturally) represents the highest voltage range that can be displayed. The display is, of course, compressed to one-eighth of the conversion value received.

The analysis procedure is far more complex than can be described here. It is not just a matter of ascertaining which row a value should be allocated to. The result also has to be "doctored" so that the active pixels are seen to be as close to a continuous line as possible.

For instance, suppose the waveform is alternating rapidly between high and low levels at a rate faster than the sampling can keep pace with. Without corrective action, you might only see pixels on the upper and lower lines, those between remaining blank.

The corrective action fills in those blank pixels so that they appear as though they naturally follow on from each other. This was an extremely difficult process to write the program for! Even experienced programmers might have difficulty analysing the way in which the source code has been written – be warned!

However, you don't need to understand the program in order to use it. Just load it into your PIC (or buy a ready-programmed PIC – see later).

Although there is a great deal of processing being carried out, each batch of

sampled data is displayed in rapid succession and really does give a "real-time" display of what is happening in a monitored circuit.

FREQUENCY AND AMPLITUDE

Each batch of data is also analysed for waveform frequency and peak-to-peak amplitude values.

Amplitude is easily determined by simply looking for the maximum and minimum conversion values and then relating them to the maximum possible sample level of 255. The latter, as said earlier, represents the positive line level, which has been assumed to be exactly 5V. If you need greater accuracy for signal level voltages use your multimeter to read them! The PICscope is only intended for providing an approximate value (but it's still pretty accurate).

Note that the PIC does not monitor which gain setting has been selected. It simply reports the voltage it finds on its RA0 pin. You must mentally adjust the value shown if the gain is other than unity.

Frequency is assessed by counting the number of times the voltage level crosses a preset threshold value. The result is then divided by two to obtain the equivalent number of cycles per batch, the rate of data acquisition being pre-determined by the sampling rate, which in turn is relative to the master clock rate.

Much effort went into writing the software so that relative timings were maintained consistently, irrespective of conditional branch timings in the sampling routines.

There are three rates at which the ADC can be set to sample waveforms, selectable by pressing switch S3. The rates cycle as a repeating group of three, numbered from 0 to 2. The number of the selected rate is shown at the top right of the screen. It is not a representation of the frequency range covered.

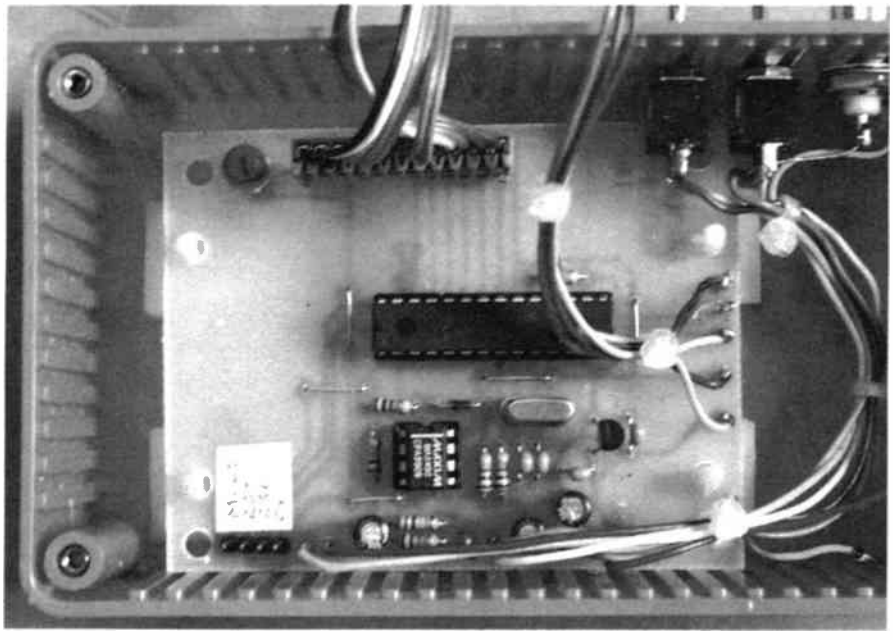
The rates are set according to the value by which the master clock oscillator is divided via the ADCON0 prescaler. This value is set by bits 6 and 7 in the ADCON0 register. Rate 0 sets Fosc/2, rate 1 sets Fosc/8, rate 2 sets Fosc/32. The routine which reads S3 and sets the bits commences at label **TESTIT**, following on into **GETRATE**, near the end of the source code listing.

FREQUENCY CALCULATION

Relating the ADCON0 sample rate to the actual frequency of the signal has to take into account the time taken for all the commands in the sampling routine to be performed. As experienced programmers will acknowledge, such matters are not always readily calculated (friend and *EPE* author Andy Flind has researched heavily into this – we hope he'll one day share it with us all!).

The solution here was to count the swings above and below the threshold level and then divide the answer by a conversion factor, with a separate factor for each of the three sampling rates.

Using a subtractive technique, the conversion involves fractions, which are fixed in the software as two-byte binary numbers.



Completed circuit board mounted on self-adhesive plastic stand-off pillars.

For example, for Rate 0, the MSB is set at decimal 85 and the LSB at 70, which has an equivalent decimal value of 21830 (256 × 85 + 70). From this value is repeatedly subtracted the count value determined when counting the swing changes, each successful subtraction incrementing a counter. Thus the cycle count is divided into the conversion factor, the secondary counter providing the answer. The result is remarkably accurate. (MSB and LSB, incidentally, mean Most and Least Significant Bytes, respectively.)

During prototype testing, the unit was fed with a frequency of 4000Hz and the "fraction" values repeatedly adjusted by trial and error until the l.c.d. also showed a value of 4000Hz.

Having established the values for the three ranges, the input frequency was raised to see how far accuracy was maintained, the results were:

Rate	Generator	Display
0	17007Hz	16984Hz
1	17007Hz	16998Hz
2	5827Hz	5812Hz

Beyond those frequencies, the unit began to display harmonic frequency values because the generator rate exceeded the rate at which the waveform could be sampled.

The values programmed into the unit depend, of course, on the exact frequency at which the crystal controlled oscillator functions. However, crystal controlled oscillators, while not being perfectly tuned to a given frequency, do stick closely to it. Consequently, other units should achieve results that are not too different from the author's.

Those who which to experiment are referred to the sub-routines at **GETFREQ0**, **GETFREQ1** and **GETFREQ2**, where the preset values can be changed. The program will naturally need to be re-assembled and reprogrammed into the PIC.

Analysis of the peak-to-peak and frequency values can be switched off using S5. This speeds up the rate at which the screen is fed with a fresh waveform display.

SYNCHRONISATION

Switch S4 turns the waveform synchronisation facility on and off. When synchronisation is on, before each sampling batch is started the software waits until the waveform voltage has twice passed through a preset trigger level. Only then does it start sampling the rest of that batch.

This facility allows the waveform display to start about half-way up the screen, providing a degree of stability to a repetitive waveform. Inevitably, the process increases the wait period before each new display is shown. There is a time-out counter which prevents the system from "locking-up" should the waveform not cross the sync thresholds.

It is best to start off sampling any new signal with sync off, only turning it on once adequate signal levels are being received. The source routines which control sync start at label **WAITS1**. The full batch sampling routine commences at **WAITAD0**.

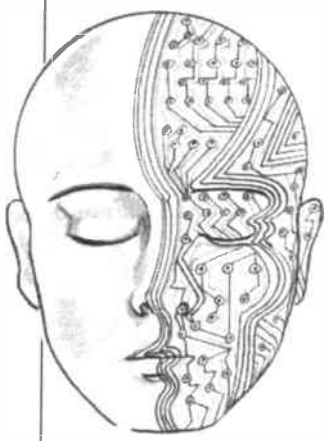
IN THE PIPELINE

That, in a nutshell, is really all there is to tell about this astonishingly simple signal monitor (simple in hardware terms – but certainly not regarding software writing!). Designing it has fulfilled one of the author's ambitions. Software is in TASM.

Another yet to be fulfilled is to design a more advanced l.c.d. based scope which will give far greater resolution to the waveform shapes displayed. Such a design, though will have to wait until the exorbitant cost of l.c.d. graphics displays comes down greatly!

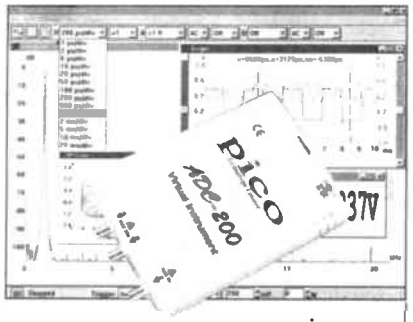
What is in the pipeline, however, is the *Virtual PICscope* in which one of the PIC16F87x family is used to sample two waveforms simultaneously and output the data to a PC computer for display on its screen.

If you have any ideas for PIC-based workshop designs (or any other type of design, of any sort), let us know. □



INGENUITY UNLIMITED

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

PC Controlled D.C. Motor – Keyboard Control

A PC can be used to control the speed and the direction of a d.c. motor using the circuit of Fig. 1 along with the brief BASIC listing provided. The circuit is used to interface a d.c. motor to the parallel port (LPT1) of an IBM-compatible PC. It consists of complementary transistors connected in an H-bridge network. Four diodes are used to provide a free-wheeling action.

Two general-purpose small-signal transistors TR5 and TR6 (type 2SC1483, or perhaps a BC548 or equivalent – *ARW*) are used to interface the power driver stage to the parallel port of the PC. The data bits D0 and D1 (pin 2 and pin 3) of the parallel port are used to drive the bridge circuit, whilst pin 25 is referenced to the ground of the bridge power supply. A simple QuickBasic program to run the d.c. motor at any speed and in any direction is given in Listing 1. The address of the parallel port is 378H. When a low on data bit D0 and a high on data bit D1 is sent, this switches transistors TR1 and TR3 on. The result is a current flow through the motor in one direction.

When a high on data bit D0 and a low on data bit D1 is sent, this switches transistor TR2 and transistor TR4 on instead. A current flows through the motor in the opposite direction hence changing its direction of rotation.

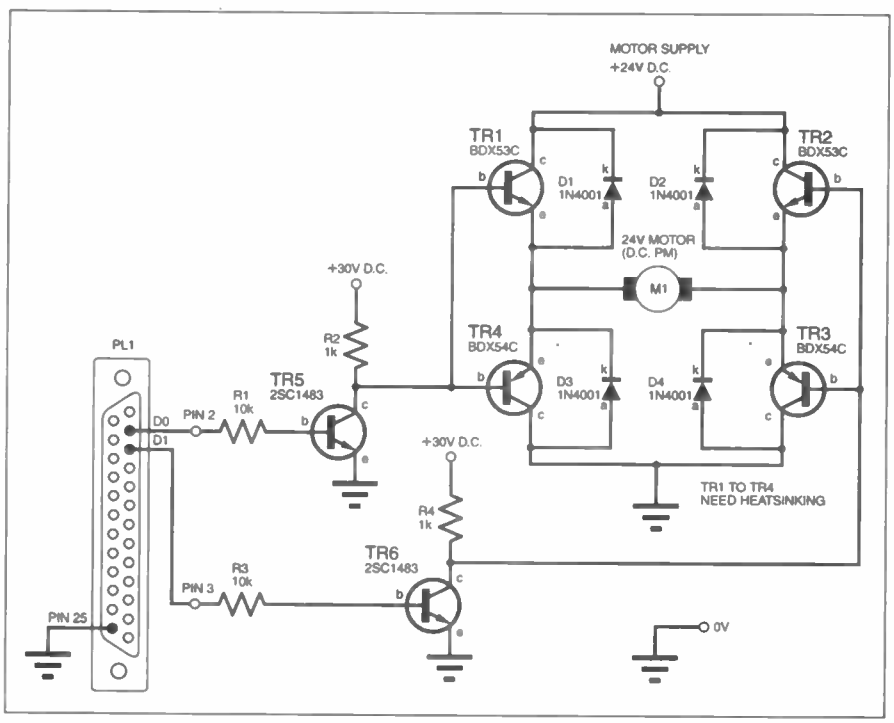


Fig.1. Circuit diagram for the PC Controlled D.C. Motor Speed Control.

Listing 1: Motor Speed Controller BASIC Program

```
ON KEY(1) GOSUB Speed
KEY(1) ON
ON KEY(2) GOSUB Direction
KEY(2) ON
d = 1: h = 500: M = 0

INPUT "Speed 0-500 = "; s
20 FOR i% = 0 TO h - s: NEXT i%
OUT &H378, d
FOR j% = 0 TO M + s: NEXT j%
OUT &H378, 0
GOTO 20

Speed:
INPUT "Speed 0-500 ="; s
RETURN

Direction:
INPUT "Direction 1=>CW;
            2=>CCW "; d
RETURN
```

Speed Control

The speed of the motor is controlled using pulse width modulation through software. If TR1 is on for example (D0 = low) then current flow through the motor is controlled by switching on alternately the transistor TR2 and TR3. The duration of two FOR TO NEXT loops in the program determines the speed of motor. If the duration of one FOR TO NEXT loop is increased, then the duration of the second FOR TO NEXT loop is decreased accordingly to maintain constant overall loop timing. This results in fixed-frequency output pulses at data bit D0 or data bit D1. The pulse width of the output is controlled by the loops' timing hence controlling the speed of motor. In my case the QuickBasic program running on a Pentium 166MHz PC produced a frequency of about 7kHz at the output, with the speed and direction of the motor controlled by the function keys F1 and F2. The H-bridge T0220 power transistor types shown are rated for 3A and alternative types could readily be used.

M T Iqbal,
Rawalpindi, Pakistan

Omnidirectional Pendulum – In The Swing

A PENDULUM swinging in a single plane is highly predictable, and can easily be enhanced electronically. An omnidirectional pendulum, however, falls towards its centre of gravity at different velocities and from many different angles, thus posing a greater electronic challenge.

My Omnidirectional Pendulum described here is continually in motion, swinging rapidly through its centre, or occasionally spiralling around it or bouncing away from it. It will form an interesting novelty display.

A neodymium (super-strength) permanent magnet is suspended from a point by an inelastic line which prevents the magnet from jumping to the core of an electromagnet L1. The electromagnet is fixed below the pendulum at its centre of gravity, see Fig.2b.

The pendulum's length of swing is about 25cm and the point of suspension is 25cm to 50cm above the electromagnet (28cm is recommended). The magnet should pass with about 5mm clearance above the electromagnet's core.

The electromagnet was salvaged from a 12V 200 ohm miniature mains relay, and is polarised to repel the pendulum when overhead. The magnet used was a small slug about 8mm long and 4mm in diameter. *(Consider a small voice coil magnet from an old speaker. ARW.)*

A network of miniature glass reed switches, S1 to S15, surrounds the electromagnet and detects the incoming pendulum. The trigger network is built by soldering the reed switches to a *thin* wire perimeter (thick wire might cause the magnet to jump to the wire) at 2cm intervals to form the outer circle, see Fig.2c.

A thin wire ring is then soldered around its centre to produce a circle of reed switches of about 11cm in diameter. The trigger network should be laid flush with the top of the electromagnet's core, and wires taken from its inner and outer rings to the rest of the circuit.

Circuit Detail

Referring to the circuit diagram of Fig2a, as the pendulum falls towards the trigger network's outer perimeter, monostable timer IC1 pulses and triggers 1C2a, which in turn disables the 555 monostable at pin 4 until the pendulum has crossed the entire trigger network.

At the same time, IC1 triggers 1C2b, via diode D3, which powers the electromagnet using transistor TR2. In order to kick-start the pendulum should it stall in a circular pattern of motion (particularly if a longer pendulum is used), components TR1 to C5 are included, causing the magnetic field to collapse at intervals indicated by l.e.d. D6. (It may be found that these components can be omitted.)

To set up, centralise all three presets VR1 to VR3 then power up (there will be a short delay before the pendulum kick-starts). Adjust preset VR1 so that green l.e.d. D1 pulses once only as the pendulum falls towards the centre of gravity – not as it shoots away.

Some experimentation is needed using preset VR2 to synchronise the electromagnet's repulsion with the pendulum's swing, as indicated by l.e.d. D4 (note that too vigorous a swing may render the kick-start useless).

A 12V mains adapter is recommended as a power supply, since batteries would soon be exhausted.

Rev. Thomas Scarborough,
Cape Town, South Africa.

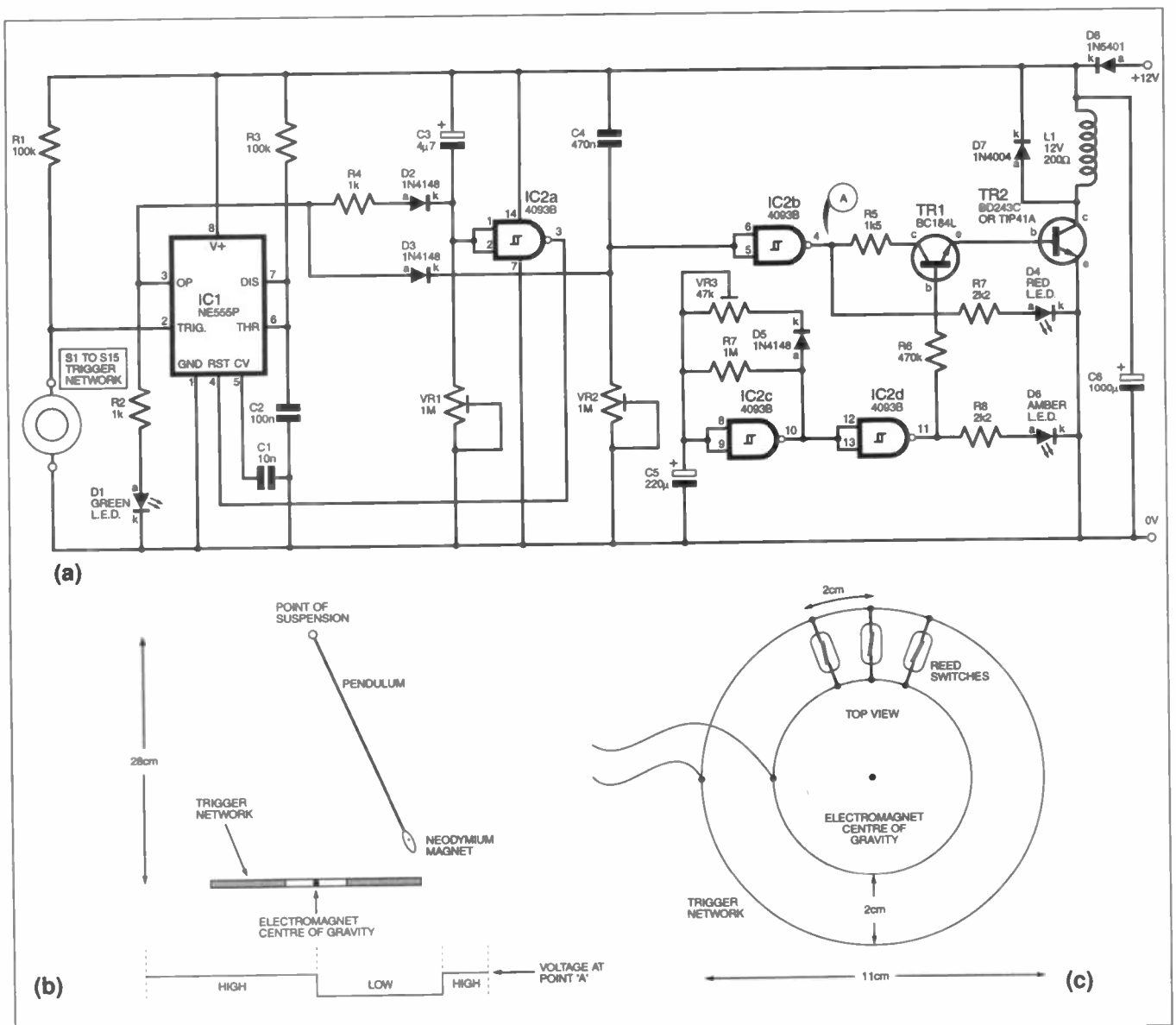


Fig.2. (a) Circuit diagram for an Omnidirectional Pendulum, (b) pendulum and magnet positioning and (c) reed switch arrangement surrounding the magnet.

Brushless Fan Speed Control – Fine Tuning

IT may not be generally realised that the speed of brushless fans commonly found in computers can be controlled down to just two or three revolutions per second if necessary. This could allow their use in other applications such as displays, lighting effects, or even driving the "Nipkow Disk" described in *IU* December 1999.

The motors within these fans generally consist of an outer revolving armature containing permanent magnets surrounding a static inner coil assembly. The coils are switched sequentially to produce the rotation by an internal electronic circuit, using Hall Effect devices to sense the position of the magnets. Although the motor speed can be reduced to some extent by lowering the supply voltage, a point is quickly reached where the voltage becomes too low for the electronics to operate, so it simply stops.

Much lower speeds can be achieved with a pulse-width modulated (PWM) supply where the power is applied as brief pulses of the full supply voltage, with a constant frequency but a variable width. The circuit of Fig. 3 has been used successfully to achieve this.

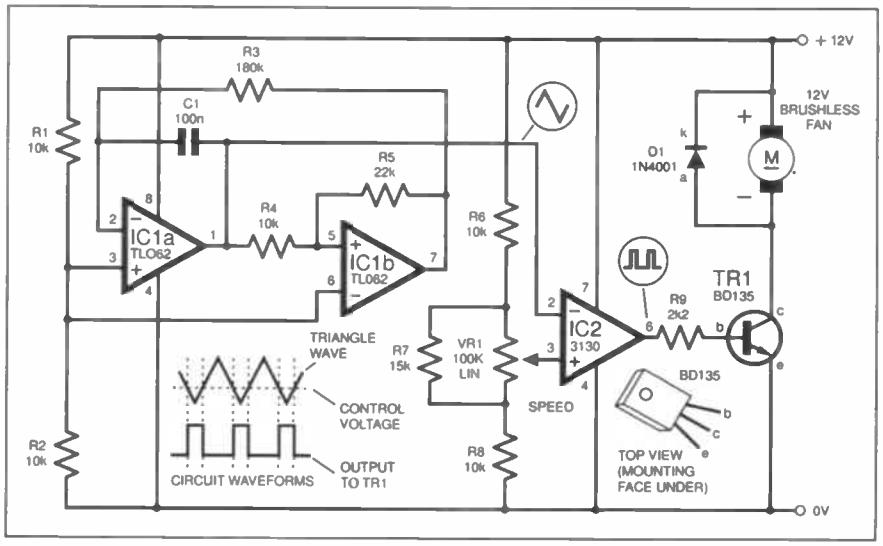


Fig.3. Circuit diagram for the Brushless Fan Speed Controller.

How It Works

The circuit works as follows. Op.amp IC1a acts as an integrator and IC1b as a comparator with hysteresis set by resistors R4 and R5. Together these two circuit elements form an oscillator with a triangle wave output. Note that the triangle wave from the output of IC1a is applied to the inverting input (pin 2) of IC2, whilst the non-inverting input of IC2 is connected to a control voltage set by VR1, the speed control which provides a range spanning zero to full power. The value of VR1 is shunted by resistor R7 to counteract the wide tolerance typical of these controls. IC2 acts as a comparator and drives output transistor TR1 (a general-purpose *npn* medium power transistor), which in turn powers the brushless motor. Diode D1 counters any back-e.m.f. which may be present.

The op.amp used for IC2, e.g. the 3130 should have an output capable of reaching negative rail so that the transistor is turned completely off when it is low. No external compensating capacitor is necessary for the op.amp in this switching application. Some other op.amps which could be used in this position include the 3140, half an LM358 or perhaps one of the new generation of rail-to-rail CMOS types. (Also see our Op.Amp Selector Chart in *Circuit Surgery*, March 2000 – *ARW*.)

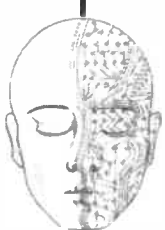
Motors used with this circuit should be 12V types. When tested, a 75mm fan from a scrapped 386 computer and a 47mm Pentium CPU fan both worked without any problems. The motors were surprisingly tolerant of high pulse rates, frequencies up to 100Hz being accepted with no performance loss. The larger fan produced some audio noise at higher frequencies, the smaller unit much less, and this could be minimised by adjusting the frequency through the values of R3 and C1. The values shown produce a frequency of about 33Hz for good performance and minimal noise. Experiment if necessary by attaching extra mass to the motor's armature to increase inertia, otherwise the rotation may be slightly jerky. A drop of dry lube oil on the bearing may also help.

Andy Flind,
Taunton, Somerset.

INGENUITY UNLIMITED

BE INTERACTIVE

IU is *your* forum where you can offer others readers the benefit of your Ingenuity. Share those ideas, earn some cash and possibly a prize!



SHOP TALK
with David Barrington

Micro-PICscope

For those readers who like the look of the neat orange plastic box used in the *Micro-PICscope* project, this is an RS (http://rswww.com) product and can be purchased through **Electromail** (☎ ***01536 204555***) code 281-681, their mail order outlet. They can also supply the MAX492 dual op.amp, code 182,2738.

The 2-line 16-character alphanumeric liquid crystal display module, complete with connector, used in the prototype was originally purchased from **Magenta Electronics** (☎ ***01283 565435*** or ***http://www.magenta2000.co.uk***). We understand they still have stocks.

The PIC16F876-20P used in this project is the 20MHz version. For those readers unable to program their own PICs, a ready-programmed 16F876 can be purchased from Magenta (see above) for the inclusive price of £10 (overseas readers add £1 for postage). Software for the *Micro-PICscope* is available on a 3·5in. PC-compatible disk from the *EPE* Editorial office (there is a small handling charge to cover admin costs) – see *PCB Service* page 308. It is also available *free* via the *EPE* web site: **ftp://epemag.wimborne.co.uk/pubs/PICS/picscope**. The software is written in TASM.

The printed circuit board is available from the *EPE PCB Service*, code 259 (see page 308). Finally, data sheets for the PIC16F87x family (and other PIC products) are available for free download from Microchip's web site: **www.microchip.com**. Maxim manufacture the MAX492 op.amp used in this design. Their web site is at: **www.maxim-ic.com**.

Garage Link

The main items of concern regarding the *Garage Link* project are likely to be the transmitter and receiver modules and the Holtek encoder and decoder chips.

Starting with the HT12E encoder and HT12F decoder, the last time we looked for similar Holtek chips they were in very short supply and **FML Electronics** (☎ ***01677 425840***) bought some in. Once again, we understand they are happy to supply the above encoder and decoder i.c.s.

Regarding the R.F. Solutions a.m. transmitter and receiver modules, several of our advertisers, such as **Suma Designs** (☎ ***01827 714476***), **Quasar Electronics** (☎ ***01279 306504***) and **Veronica Kits** (☎ ***01274 883434***) may be able to help. Also, **Maplin** (**www.maplin.co.uk**) are currently listing a low cost pair, quote code VY47B.

The last mentioned company also supplied the lever-arm microswitch (code NF21X) and the miniature l.d.r. (code AZ83E). You can, if you wish, use the good old ORP12. The 66MΩ resistor for R5 in the Transmitter was made up from two 33MΩ "high voltage" types (code V33M). The two printed circuit boards come as a pair and are available from the *EPE PCB Service*, codes 261 (Tran.) and 262 (Rec.), see page 308.

Flash Slave

Not much can go wrong when shopping for parts for the *Flash Slave*, this month's simple Starter Project. The phototransistor may cause some local sourcing concerns, but, as the author states in the article, several *npn* types have been successfully used in the unit. The BPX25 *npn* - phototransistor used in the prototype came from **Maplin** (***www.maplin.co.uk***), code QF30H.

We understand that some overseas readers are having difficulty finding ZTX type transistors locally, so we suggest they opt for the 2N3440 type. Other, high voltage and high current transistors should work equally well in this design. One important point though, like the 2N version, the pinout and encapsulation may differ and must be carefully checked before inserting on the circuit board.

High Performance Regenerative Receiver

As we highlighted last month, some of the type numbers quoted for the "plug-in" TOKO coils called for in the *High Performance Regenerative Receiver* did not tally with our information. However, thanks to the designer's, Raymond Haig, efforts, the TOKO coil numbers and ranges used in the Receiver have been set out in Table 2 in the article and were purchased from **Bonex Ltd** (☎ ***01753 549502***), type numbers and order codes are as follows: CAN1A350EK, 380-350; RWO6A7752EK, 3357-752; RWR331208NO, 351-208; 154FN8A6438EK, 356-438; KANK3426R, 363-426; KANK3337R, 363-337; MKXNAK3428R, 363-767. We have also been informed that **JAB Electronic Components** (☎ ***0121 682 7045***) stock an extensive range of TOKO coils.

One item we neglected last month was the slow-motion reduction balldrive for the tuning capacitor. Glancing through a "flyer" from **Mainline Surplus Sales** (☎ ***0870 241 0810***) we see they list one for just £2.50, plus a £3 (UK) post and packing charge. Quote order code 81-0224.

The three small printed circuit boards are available as a set from the *EPE PCB Service*, codes 254, 255 and 256 (see page 308).

PLEASE TAKE NOTE

Video Cleaner *Feb '00*

Amended software now available on *EPE* Disk 3 and via our web site. The INIT routine should read:

```
INIT    CLRF    PORTA
        BSF     STATUS, PAGE1
        MOVLW   B'00000000'
```

This configures PORT A as outputs only.

READOUT

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

WIN A DIGITAL MULTIMETER

A $3^1/_2$ digit pocket-sized l.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

Every month we will give a Digital Multimeter to the author of the best *Readout* letter.

★ LETTER OF THE MONTH ★

FUSED COIL FORMERS

Dear EPE,

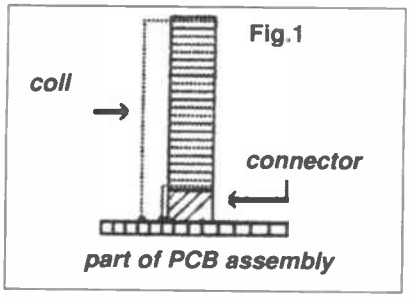
Reading much of the series recently on *Practical Oscillator Design* (Jul-Dec '99), has prompted me to come up with a practical idea for constructors of r.f. oscillators etc.

Basically the idea, which I have already put into practice, makes use of the ordinary household 3A/13A ceramic fuse. Prepare to dismantle the fuse by easing off one end with pliers, whilst the other end is secured by soldering it to a piece of scrap p.c.b. for support. Discard the internal fuse wire plus sand, and a very nice ceramic coil former remains, also keep the connector at one end, this will prove useful too.

Ceramic type coil formers are often referred to in the *ARRL Handbook* in numerous construction articles for VFOs etc, and apart from the excellent mechanical and temperature stability they offer, coils can easily be wound and secured using the following method:

By soldering the lower contact of the fuse to a small pad on the etched oscillator p.c.b., the coil can be wound as in Fig.1, and the turns held tightly, whilst the "hot end" of the coil is soldered to its intended point of the circuit, before any other components are mounted. By applying a smear of Araldite to the coil layers, and holding a 25W iron near, heat and melt the resin whilst turning the former, this will ensure a uniform, covering and ultimately hold the turns permanently in place.

In fact, many of your readers will probably be familiar with heating of Araldite to increase its flow and quicken its setting time, and in this application the coil will appear glazed, as if encased in glass!



Using 28 or 30swg enamelled copper wire and using most of the length of the former, popular MF frequencies and beyond can be covered with the appropriate value of capacitor.

Hopefully readers can be encouraged to experiment using items such as fuses to provide potentially excellent coil formers, rather than the seemingly ever elusive pre-wound coils – once found in constructors' catalogues. In fact the humble fuse can also be used as p.c.b. stand-offs!

D.B. Venuti, Thurgarton, Norwich

A very useful suggestion, and one which we are pleased to publicise. Thank you DB – enjoy your new meter!

PC SCREEN DUMPS

Dear EPE,

I commend John Becker and your team on your intuitive treatment and presentation of electronics in the *Teach-In 2000* series. The accompanying interactive computer program is also very impressive.

It looks as if the printed screen-shots are actual photographs of a PC monitor taken with a camera. Indeed, this seems to be your method for reproducing any PC graphical output. You probably have your own reasons, but just in case, I have a suggestion that would save time and effort, while also dramatically improving the quality of the reproductions. The following applies to IBM-compatible PCs only, running Windows 3.1, 95, 98 or NT.

Pressing the <PRINT SCREEN> button (located beside the <SCROLL LOCK> key) on the keyboard causes the monitor output at that time to be stored to the clipboard. The "Edit Paste" command, available in most Windows-based editing software, can then be used to dump the image into a document, or in the case of a graphics editing package, into an image file.

To capture DOS output, run the DOS-based program from Windows at the full screen setting, hit <PRINT SCREEN> to capture the desired output and use the <ALT> <TAB> key combination to return to the Windows editing program for subsequent pasting. It is then also very easy to label the image with graphics editing software if desired.

Active Dialog/Message boxes can be neatly captured to the clipboard by pressing <ALT> <PRINT SCREEN>. This causes the background graphics to be omitted from the capture.

I thoroughly enjoy your magazine, and with practical circuits, it certainly lives up to its name.

John Harris,
Co. Longford, Ireland, via the Net

Your assumption about using screen photos is absolutely correct. I did not know that my computers were capable of screen saving in this way from a DOS-based program. Other authors have previously provided us with electronically captured images but I had assumed they had special software.

I tried it when I saw your E-mail and it worked nicely, enabling the images to be stored to disk and passed to our in-house typesetting team. The screen images in this month's Teach-In *have been done this way. Thank you.*

Your E-mail was actually passed to us by Max, our Online edition editor in the USA. He added the following additional advice:

If you want to see how easy it is in normal Windows mode, just press (and release) the Print Screen button now, then use Start > Programs > Accessories > Paint to open the simplest of paint programs and then use Edit > Paste and see what happens – you can then save this image as a .BMP file, and then use Adobe Photoshop to shrink it and/or change it into other formats.

UP TO SCRATCH

Dear EPE,

EPE Jan 2000 – best issue for a long time, as well as being PIC-free! Glad I renewed my subscription.

The mag arrived as I was finishing writing up notes and drawing the circuit diagram for something I've just finished and I was trying to remember the symbol for a thermistor (not something you use everyday), so I was well pleased with Fig.3.3 on page 33. I really think the *Teach-Ins* are one of the best things you do. I have been a hobbyist on and off for nearly 50 years since I built a one-valve set, later converted to mains for the HT, given the price of 90V HT batteries, and my first serious electric shock (no namby-pamby PP3 batteries then!). I have found there is always something new to learn. In fact the reason I read *EPE* today is down to picking up the Jan '93 issue in WH Smiths, glancing through *Teach-In 93* Part 3 and that is why I subscribe!

Regarding "Notations" on page 32 (Jan '00), I have used quite a few pots made by Radiohm that are labelled, for example, 10KA, 10KB or 10KC where A, B and C indicate lin, log and reverse-log respectively. I always assumed that this was a house code but I have seen it used on published circuit diagrams too. Also, an Omeg pot I have is labelled 10K LIN.A. By the way, if you take two dual-gang Radiohm or Omeg pots and disassemble them you can rebuild them as one 3-gang and a single-gang pot (nothing wasted!). The 3-gang pot makes a passable 18dB/octave variable Sallen and Key filter a possibility. I have assembled a 4-gang pot but it's no good trying for a 24dB/octave filter as the matching is not good enough.

Robert Penfold's *Practically Speaking* feature on page 58 demonstrates how difficult it is to insulate transformers of the style illustrated in Fig.2 since the centre tap is not insulated nor are the vertical parts of the tags where the ends of the windings are soldered to. If possible, I usually try to mount a transformer so that the primary tags are difficult to touch and have often thought this would be easier if the primary tags were at the bottom of a transformer and not the top. Where this is impossible I have either stuck a piece of acrylic sheet on top of it with double-sided sticky foam pads or fashioned a shroud from "Masticard" as used by model makers. I cannot think of any better way and it does seem daft that you can buy a boot for the mains inlet but have to improvise on the transformer.

I also studied Robert's *Scratch Blanker* (Jan '00) very carefully as I am about to build a similar device using a Reticon SAD1024 CCD delay line that I bought years ago for the purpose and never got round to. I had dug out my old notes and cuttings. One of the cuttings was *An Experimental Scratch Eliminator* (*Hi-Fi News* Sept-Oct '79) by one R.A. Penfold, which makes me wonder if it is coincidence that 20 years later when I am about to build what I started thinking about in 1979, Robert Penfold publishes another design. Spooky!

Barry Taylor, via the Net

Thank you Barry for another interesting contribution to Readout. *Sorry we can't publish it in its entirety.*

WHAT'S PIC STAND FOR?

Dear EPE,

I keep reading about PIC programmers, but am having problems to find out what the abbreviation stands for. Could somebody clear it up for me?

Mark Zenier, Washington State, USA, via the Net

Our On-Line Editor Alan unearthed (or ungrounded, *in the USA) these answers:*

In the 1977 General Instruments databook, it's given as *Programmable Intelligent Computer*. A couple years later, they changed it to *Programmable Intelligent Controller*. There's a short history of the early 16xx series in *Computer Structures: Principles and Examples*, a computer architecture text from 1982. There were several families of PIC microcontrollers. The 16xx series is the same (with a few extensions since) as the current CMOS parts, although these were NMOS with a factory programmed ROM, so they didn't get wide hobby or small volume use.

The PIC7000 were a second source of the Texas Instruments TMS7000 series. Their widest known use was the brains inside of the Videocipher satellite TV video descrambler.

Alan Winstanley

Thanks Alan. But the plot thickens – in Readout *Oct '99, Joseph Birr-Pixton quoted Arizona Microchip's early literature stating* Peripheral Interface Controller. *It has to be remembered, though, that GI were (we understand) the company who first introduced PICs, with Microchip only taking over some years later.*

Interestingly, Brian Brooks of Magenta Electronics some time ago sent us a copy of a 1982 GI data book in which the PICs were described as being microcomputers *rather than* microcontrollers.

Brian comments that "we could have been publishing PIC projects 10 years or earlier than we have" (our first was in June '92). "I wonder if the timing of the PIC's success has more to do with the ownership of PCs to program with? Sometimes it seems, the market is not ready for something, no matter how good – there must be a lesson there!".

From a hobbyist point of view, I'm sure PCs formed one of the keys to PIC acceptance, although I know I could have programmed my 1979 Commodore PET 32K to handle PIC programming. What has really unlocked the door, though, is the availability of the electrically erasable PICs, such as the PIC16x84 devices.

HUMIDITY SENSING

Dear EPE,

Whilst on holiday in the UK last year, I came across your article on the construction of the *PIC Altimeter* in the Sept '98 issue. My interest in this is that it appears, in principle, to be adaptable as an all electronic hygrometer for measuring relative humidity. The accurate indication of relative humidity has been the subject of study at the Technical Centre in south Mexico and I should be pleased to pass-on information to you on a confidential disclosure basis, to have your opinion on some ideas.

Tim Warren, Merida, Yucatan, Mexico

In principle, the unit could be adapted but it is regretted that we cannot advise on modifying designs for other purposes, nor can we offer other advice of the type you are looking for.

We would suggest, though, that asking similar questions via the EPE Chat Zone *on our web site might prompt responses from other readers.*

Incidentally, some years ago I had intended to design a humidity meter and bought in the required sensor. By the time I got round to considering the idea further, the sensor had become obsolete. One day I might start to searching for another type.

CODE PROTECTION

Dear EPE,

I've had two instances of the PIC16F876 and PIC16F877 code protect bits being set – this has happened twice in approximately 100 programmings. It happens after programming, not while configuring the PIC, and occurs with a program that has been and continues to be OK (with a new PIC!). Has anybody else reported such problems and is there a known reason for this?

Darren Southee, via the Net

Assuming Darren was using the PIC Toolkit Mk2 *programmer, I replied that I did not know the reason but would look into it. Doing so, I could find no reason for code protect bits becoming erroneously set. Then back from Darren comes:*

I've just found out that it occurs occasionally on the PICSTART+ as well. My 16F877 was only partially code protected, i.e. with 1F00:1FF, which suggests corruption of bit CP0 in the configuration word.

Curious. Can anyone throw light on this, or has had similar experiences?

WEB OFFSET

Dear EPE,

Re: your rotten web site.

What is the point of having a web site if you don't put any information on it? God knows it's cheap enough to buy enough server space to do so. I wanted to order a p.c.b. and I don't have the latest copy of the magazine to see whether it is still available and at what price. So I thought "I'll look on their web site – it's bound to tell me". Some hope!

Like everybody else in the entire world, I don't need to order things on the Internet – we have a perfectly adequate postal service. I just need the information!

Brian Thompson, via the Net

Our On-line Editor Alan Winstanley received this attack. He politely replied to the assailant:

I am sorry you are not happy with our on-line service. Our future plans include a shopping cart which is at an advanced stage, but we cannot do everything all at once. We have plenty of server space at our disposal, which is not a problem (nor the bandwidth needed to serve it), the issue is obviously the time and resources needed to put it all together.

I looked at putting p.c.b. info on-line but the fill-in order form was already getting very cumbersome. The current page is an interim attempt to cater for those wanting to order Back Issues and p.c.b.s in the same credit card order, rather than placing a separate order for boards via a separate page.

I agree that you could already use ordinary letter post, or phone or fax instead, but our overseas readers particularly enjoy and welcome our Internet service. In particular they like the free information we do already give away, e.g. the *Basic Soldering Guide* which enjoys world-wide popularity, not forgetting the free source codes we publish for nearly all our PIC projects. The service is, however, continuing to evolve.

Most readers are courteous in their communications with us, as indeed should be the attitude of any human to another. Occasionally, though, we do receive unwarranted attacks over trivial matters. One can only speculate as to the frame of mind of those who do not observe the common decencies of courteousness.

At HQ, aggressive correspondence is likely to be binned forthwith. Alan, though, is a kind and courteous man who puts most of his waking hours into keeping EPE *readers happy and supplied with information, not only via our pages but especially via the Net. Accordingly, good natured as he is, Alan did respond to this ill-mannered E-mail. No doubt it's too much to hope that he will have received thanks and an apology from its sender.*

SCOPE CHOICE

Dear EPE,

I am what your magazine would probably describe as an Electronics Hobbyist, although I am not sure that even that may not be an overstatement.

For the last twenty years I have been retired from employment through ill health, during which time a previously curious interest has had time to deepen into dabbling. I have a very basic knowledge of electronics which has enabled me to construct small projects from magazine articles as well as repair my TV and VCR when occasion required.

My equipment is not extensive, the usual tools plus multimeters etc., but also includes a rather "ancient" oscilloscope which I purchased some years back for the princely sum of £40. It has served me well in spite of its age and cumbersome size but unfortunately the main transformer has blown, developing an internal short circuit in the high voltage winding that supplies the CRT final anode and focusing circuits. The scope being now obsolete means that spares are not available and because of the number of windings involved an alternative would not be suitable. I did have an attempt, twice in fact, at rewinding it but without success and to have one custom-made would not be economically viable.

In reading February's *EPE* and Part 4 of *Teach-In 2000* in particular, a comment of yours wherein you mentioned that you had built your first oscilloscope yourself from ex-government surplus components, rang a bell with me as I had read a book some years ago on oscilloscopes where the writer made the same statement.

In your opinion, would it be possible for me to rejuvenate my scope with the use of solid state components in place of the original valve circuitry. The final anode voltage of 4kV and the other high voltages required for the CRT seem to me to present quite a problem.

Do you know of any books or articles that would give practical as well as technical help as I am not up to designing the fairly complex circuits myself. The scope in question is a Solatron Type CD 1400 (twin-beam, double-gun, 5-inch CRT). If in your opinion it is not worth the effort or would not be financially practicable (and finance is an important issue, not having an income to speak of), then may I say that I have been toying with the possibility of purchasing a *Virtual Scope*, such as that advertised on page 100 in the same issue of *EPE*. (I have been given a thrown-out 386 computer which should be able cope.)

The alternative being a second-hand conventional scope, a number of which are also advertised in *EPE* for about the same outlay. In your opinion which would be the better way to go, are there any major advantages or disadvantages with either?

R.J. Spratt, Whitton, Middx

I too used to have a Solatron of ancient age. When it failed I felt it was not worth updating it. My Virtual Scope *of Jan-Feb '98 is good but complex to build. It has, though, provided vital assistance in analysing circuit waveforms which my conventional scope could not deal with. Consequently, I see great merits in having such a workshop tool.*

However, having been brought up on conventional scopes, I think on balance that should the situation arise I would still go for one those first. Against that is the enticing thought of all the facilities which a virtual design can offer. They would be especially enhanced, no doubt, by a modern fast computer. I wonder whether an old 386 would actually be up to the job? On this point you should check with those advertisers who sell virtual scopes.

Books-wise, I do not know any of the calibre which would suit you. If you have Internet access (and many libraries offer a free service for this), you could try browsing the major book sellers on the web, such as **www.amazon.com** *and* **www.bol.com**.

TEACH-IN 2000 HELP!

Dear EPE,

Thanks for the wonderful magazine. I had been trying to get involved with electronics for a while but our local library did not have enough info. Then I found out about *EPE*. I began reading the magazine in Aug '99, understanding little and eventually subscribed to *EPE Online*. The *Teach-In 2000* series has really helped me to begin understanding electronics.

I was working on the experimental section of Part 4 and found that on my computer the readings I get for the 8-bit data output are -5V for low and 0V for high. The same with the inputs. I reversed the polarity of my input voltage to get the programs to work. I hope this will not affect the programs in any way and that I will be able to continue with the wonderful Tutorials.

The computer was purchased as is, second-hand and has a Pentium 166MHz processor, that's about all I can tell you about it. I also used a length of 25-way ribbon cable with a male 25-way D-type snap-in adapter on one end and soldering the ends of the cable to strip board on the other end. I did this so I don't need to make a p.c.b. for the Centronics adaptor.

Hitesh Lala, South Africa, via the Net

Great to know you appreciate us! The only reason I can think of for the negative values is that you are connecting the meter in back-to-front. The COM lead should go to 0V, i.e. the negative terminal of your battery, or the metal chassis or other known ground (0V) point of your computer or its connecting lead.

The Centronics parallel connector to the breadboard for Teach-In *has more than just one pin which can be used for ground (0V) connection. Pins 19 to 29 provide separate grounds for the screening on individual signal wires, pin 16 is Logical ground, pin 17 is Chassis ground, while pins 30 and 33 are quoted in my source book as just being Ground.*

Look closely at the connector for the identity of the pins. Note that once you have found pin 1, the numbers follow sequentially to the end of that row, and continue on the second row from the pin immediately opposite pin 1. This is contrary to the order in which d.i.l. i.c. pins are numbered, going down one side and then back up the next. This explains the cause of the pin numbering error in Fig.4.6 (Feb), as reported last month (March); the author (me!) had erroneously counted in the wrong direction – how infantile!

TEACH-IN AND PSION (2)

Dear EPE,

As a person who is involved mainly in Computers/IT, and only dabbles in Electronics as a very part-time hobby, I feel relatively refreshed to be able to answer one of the questions posed in your *Readout* section.

I refer to the letter from Federica Appolloni in the January 2000 Issue of *EPE Online*. Federica is trying to use the *Teach-In* 2000 software on an XT-Emulator.

Normally, I don't think that there would be a significant problem in using the software on a Real XT based PC. I think that the problem is caused by the display mode used by the software. The display resolution required by the *Teach-In 2000* software is just not possible on a Psion series 5 palmtop. The error generated would be consistent with an attempt to switch to a different display mode failing.

Mike Insch, Aberdeen, via the Net

Thank you Mike. The resolution of the screen mode used (Screen 9 in QBasic/QuickBASIC, EGA/VGA) is 640 x 350 pixels, with text set for 80 characters x 25 lines, 16 colour attributes.

Interestingly, with regard to the "hieroglyphs" problem being experienced by some readers (see several previous Readouts*), I have succeeded in simulating the situation (via codepage commands) on two of my machines and found that problem then exists with text set for 80 x 25, but not with it set for 80 x 43.*

DOING IT RIGHT!

Dear EPE,

I bought a copy of your magazine the other day after a nine year gap. I was pleasantly surprised to find that the comfortable old format was pretty much intact, and that the regular contributors like Robert Penfold were still hard at it, doing their best to instil their wisdom to us readers, and even the familiar old Bull Electrical ad. inside the front cover was still there after all this time. The small details such as the component lists and the stripboard layouts, and even the little cartoon illustrations brought the memories back as if I'd only bought a copy last month.

The noticeable changes included things like the Internet feature *Net Work* and the fact that most advertisers now have web sites (which is good news), and that everyone seems to be going on about this PIC processor thingy (sorry to be an ignoramus). But it was reassuring to know that some institutions like *EPE* have remained essentially unchanged over nearly a decade, even despite a merger with another publication (when I was a regular reader in '91 it was of course *Everyday Electronics* I read).

Some might say that this shows a lack of progress on the part of the publication, but I say that in reality what it means is that the formula is right and therefore doesn't need to change.

My life veered away from electronics in '91, but now after the re-igniting of my interest in hobby electronics thanks to another interest of mine, cycling, and the desire to build a two-stage sealed lead acid battery charger to charge my self-designed front lighting rig, I am glad I did pick up a copy of *EPE*, as I found it as enjoyable to read now as I did back then.

I also found/find *EPE* a valuable source of suppliers of parts thanks to the ads, but I noticed that your *Online* issue (judging by the sample issue only) does not contain these ads. I see the adverts as almost as an important part of the magazine as the articles, and thus it seems a shame to omit them from the electronic version, especially when so many have web presence these days that overseas subscribers can also contact them very easily. Just a thought.

Please keep up the good work and the high quality of *EPE* and be assured that your publication is probably amongst a very small minority that seems to have got it right.

Jason Webb, Reading, Berks

Thanks for your kind comments, Jason. Some may regard us as a bit staid, but as you said, it seems to work OK. We are moving towards ads in the Online *version. Watch that space!*

TEACH-IN BUG

Dear EPE,

While using the TY2K (*Teach-In 2000*) software I have stumbled on a bug with the self-test of the Resistor Values and Colour Codes program. The first four questions ask for the resistance to be typed in and this is followed by four questions which ask for the resistance to be selected graphically.

When the last of these questions is answered correctly (eight questions), the program gets into a loop where the question remains unchanged and the graphical value of the resistance changes to what the program thinks should be the correct next answer. Typing <Enter> several times just gives the correct answer. After pressing <A> to get the answer, the program gets back to normal, only to repeat the same after the 16th question, and so on.

Thanks for a great *Teach-In* series and for a great magazine.

Federica Appolloni, via the Net

So it did! I've now fixed it and the fix will be released when software version V1.1 (with more demo routines) is released with Teach-In Part 7. *In the meantime, just remember that this bug is lurking (but it's not malignant and it's not a Y2K bug – has anyone encountered one of those yet? I haven't).*

SOLDERING TIP

Dear EPE,

I have a question on soldering iron tips. After a job is done I have been told to put a small amount of solder on the tip and then unplug the soldering iron. I have also been told do not do it. Who is right?

Michael Powell, via the Net

On-Line Editor Alan Winstanley received Michael's query, and replies to it:

I always dab a small amount of solder on the tip to tin it, wipe it clean on a damp sponge and then unplug the iron and let it cool while the tip is still nice and shiny. This preserves the cleanliness of the tip ready for the next job. However, you MUST WIPE it clean before unplugging, or the excess solder and flux will just burn and "dull" the tip and lead to unwanted deposits before the iron has gone cold.

If you don't use the iron for a time (say 5 to 10 minutes or more) before switching off, the tip is bound to be dirty when it cools down due to baked-on flux deposits, oxides etc. This could make it harder to clean up the tip when you next switch it on. (Brand new tips can gradually be made unusable for this reason. Hence you must always thoroughly tin a new tip straight away.)

If a tip is always kept nice and shiny, it is always easier to use. It will accept solder readily and let you solder accurately and more quickly. So whoever told you to add some solder is right – provided you wipe the tip to remove any excess solder, before the iron has gone cold.

SERIAL LOG

Dear EPE,

I'm designing and building an automatic weather station based around the PIC16F877. I've been pinching ideas and bits of circuit from your *PIC Data Logger* (Aug '99) and *PIC Altimeter* (Sep '98).

I've been trying to get a serial RS232 link from the PIC's USART to my PC working (to transfer results). I used exactly the circuit and cable pinout you have in the *Data Logger* except that, not finding a spare 7404 buffer in the components box, I used a couple of NAND gates with paralleled inputs from a 4011 instead. I eventually succeeded in getting it going, but only by using one of the gates, not two in sequence as in the *Data Logger* circuit. In other words I had to invert the output from the PIC's RC6 pin.

I checked with Microchip technical support about this. The RC6 output is indeed inverted, and is intended to be used with an RS232 transceiver, most of which invert the input signal (so that on the line side of the transceiver chip the output is correct).

Since your design puts the signal through two inverting buffers in sequence, i.e. retains the inverted signal as output by the PIC, how did you ever get it to work at all? I looked through your PC comms input program (**DATLOG02.BAS**), but I couldn't see anything that was doing anything strange to the hardware – but I don't use QuickBASIC so I'm not an expert in it.

But if you get any queries from folks with older kits who can't get it to work, you might suggest that they try using something like the MAX232CPE instead of the 74HC04. R.A. Penfold had a useful article on using this chip (*Interface* July '96).

Malcolm Wiles, via the Net

As I explained in the Data Logger *article, and advised to Malcolm, I am not an expert in comms port use and had to research heavily before achieving a working circuit, which was subsequently proved on my several computers.*

What Malcolm missed when examining the .BAS *code is that a machine code routine is also accessed, this doing the actual reading of the comms port. In it the data is indeed re-inverted. The full machine code text can be read in file* DATLOG02.J.

Everyday Practical Electronics are pleased to be able to offer all readers these

ELECTRONICS CD-ROMS

ANALOGUE ELECTRONICS
by Mike Tooley

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.

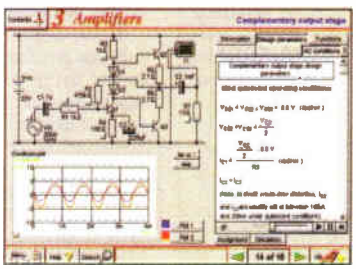
FUNCTIONS

The component values on all circuits can be edited and the user can use the simulation engine to see how the value of each component affects circuit performance. You can, for instance, alter frequency and phase angle and plot outputs on a virtual oscilloscope or show load line graphs etc.

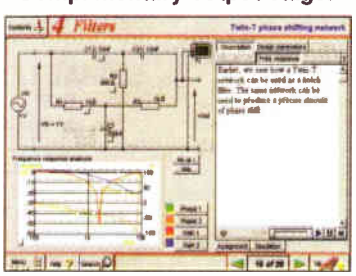
COVERAGE

Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections), Transistors (4 sections), Waveshaping Circuits (6 sections); **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators; **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections); **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections); **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators; **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

- **Includes SPICE circuit simulator with over 50 circuits**
- **Unique virtual laboratories**
- **Editable assignments**
- **Design parameters for circuits included**
- **Complete hi-fi amplifier case study**



Complimentary output stage.

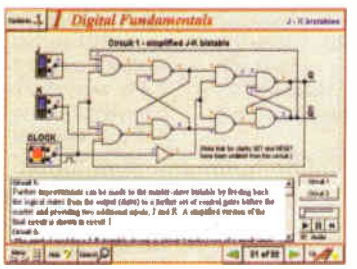


Twin-T phase shifting network

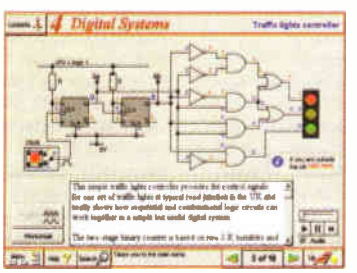
Gallery – Wideband Amplifier

DIGITAL ELECTRONICS
by Mike Tooley

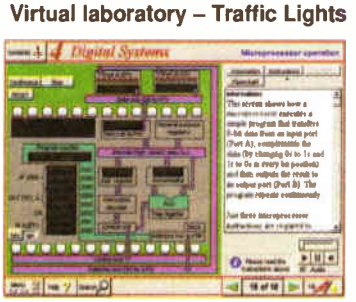
Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (below), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.



Virtual laboratory – Flip-Flops



Virtual laboratory – Traffic Lights



Microprocessor

FUNDAMENTALS

Fundamentals introduces the basics of digital electronics including binary and hexadecimal numbering systems, ASCII, basic logic gates and their operation, monostable action and circuits, and bistables – including JK and D-type flip-flops.

COMBINATIONAL LOGIC

Multiple gate circuits, equivalent logic functions and specialised logic functions such as majority vote, parity checker, scrambler, half and full adders. Includes fully interactive virtual laboratories for all circuits.

SEQUENTIAL LOGIC

Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers.

DIGITAL SYSTEMS

A/D and D/A converters and their parameters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units.

GALLERY

A catalogue of commonly used IC schematics taken from the 74xx and 40xx series. Also includes photographs of common digital integrated circuits and circuit technology.

Prices for each of the two CD-ROMs above are:

Hobbyist/Student .....£45 inc VAT
Institutional (Schools/HE/FE/Industry).....£99 *plus* VAT
Institutional 10 user (Network Licence).....£199 *plus* VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

TWO APPLICATIONS ON ONE CD-ROM

ELECTRONIC CIRCUITS & COMPONENTS + THE PARTS GALLERY *by Mike Tooley*

Electronic Circuits & Components provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding as they proceed through the sections on the CD-ROM. Sections on the disk include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits . Active Circuits***

The Parts Gallery – many students have a good understanding of electronic theory but still have difficulty in recognising the vast number of different types of electronic components and symbols.

The Parts Gallery helps overcome this problem; it will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Selections on the disk include: ***Components, Components Quiz, Symbols, Symbols Quiz, Circuit Technology***

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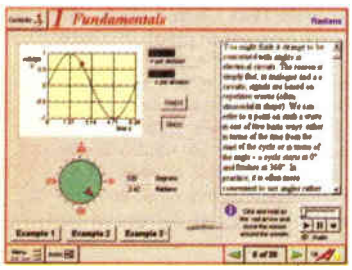

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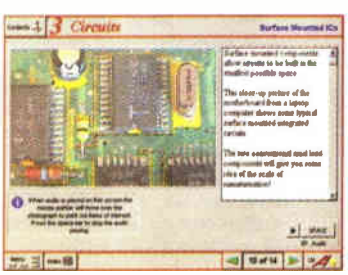

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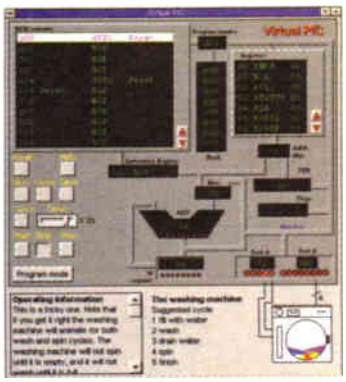

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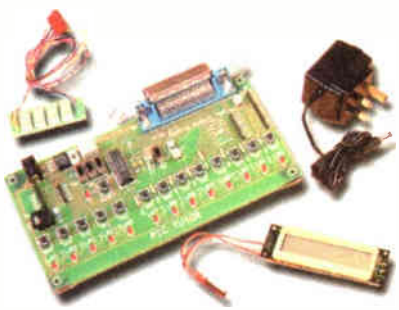

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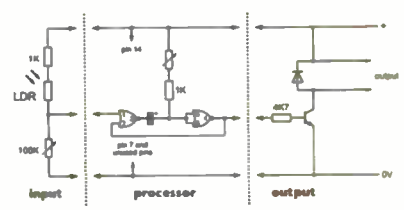

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EPE/ETI Tutorial Series

TEACH-IN 2000

Part Six – Logic Gates, Binary and Hex Logic

JOHN BECKER

So, it's five parts of *Teach-In 2000* under our belts and we know that you are greatly enjoying and learning from this 10-part series. We are pleased to have been told on many occasions that you appreciate the way in which we are leading you by the hand, on the assumption that you knew little or nothing about electronics before you started reading the series. Your complementary comments are very welcome.

We have covered the basic "passive" components and provided you with a means by which to create waveforms and display them on a PC-compatible computer screen. This enables us to now explore somewhat more sophisticated components of an "active" nature. Our experimental subjects this month are not only gates but binary counters to complement the Tutorial, and a decimal counter – for fun as well as instruction!

IN previous parts of *Teach-In*, the term AND has been used from time-to-time. Indeed, in Part 4 we gave a brief description of what it does. The term occurs in both computing and electronics. In both instances, the implementation of AND is physically carried out by an electronic device or circuit somewhere in the system.

We explained that if two logic bits are ANDed together then the result will be logic 1 only if *both* source bits are also at logic 1. If either or both bits are at logic 0, the result will also be logic 0.

AND NOW THE GATES

The first subject to be covered this month is the expansion of the AND concept, and to describe not only integrated devices that use AND, but those that use the other five main logic functions, NAND, OR, NOR, XOR and XNOR.

One of the uses for an AND gate is as a signal (data) switch, only allowing the signal on one input to pass to the output if the other input is high. Another is to indicate whether or not all inputs are high, allowing, for example, a process to start if several preceding processes have been completed.

Let's use your breadboard and the oscillator you were using last month, plus an electronic AND gate, to demonstrate the AND principle, and in doing so to show its use as a signal switch.

The symbol for a 2-input AND gate is given at the top of Fig.6.1a (the table below it will be discussed presently).

From your bag of components, select a 74HC08 integrated circuit (i.c.). This i.c. is another digital electronic device (as are the 74HC04 and 74HC14 inverters you have already been using). It is a *quad 2-input AND gate*, and as such has four separate AND gate circuits within it. Its pinouts are shown in Fig.6.2.

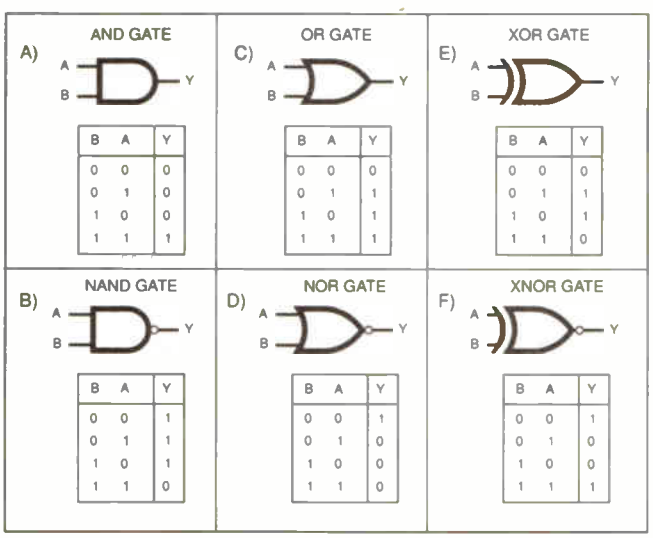


Fig.6.1. Symbols and truth tables for the six 2-input logic gate functions.

Whereas the inverters each had one input and one output, the AND gate we are about to use has two inputs (as stated in its functional title) and one output. The logic levels applied to the two inputs can be regarded as the *bits* to which we referred a few paragraphs earlier when stating what AND means in an electronic or computing context.

It is worth noting that there are other AND gates which have more than two inputs. We shall not discuss them, but just comment that similar principles apply to all types. There are also other quad 2-input AND gates with different type numbers (indeed all the devices we use in this Tutorial are available with different type numbers to those quoted, but not necessarily with the same pinouts).

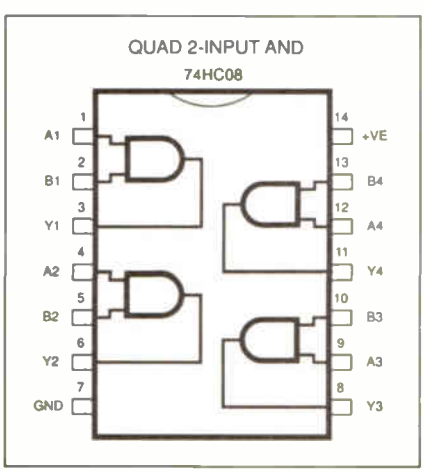


Fig.6.2. Pinouts for a 74HC08 2-input AND gate.

PRELIMINARIES

Before you remove the 74HC08 from its packaging, briefly touch something that is earthed to discharge any static electricity from your body. (See also Panel 6.1.)

Plug the i.c. (call it IC3) into your breadboard and connect it up as shown in Fig.6.3. Ensure that it is placed in the correct way round (as we discussed in Part 2).

We are using just one AND gate from within IC3, and shall refer to it as IC3a. Pin 1 (call it Input A) of IC3a connects back to the output of oscillator IC1a pin 2 (see Part 4). Pin 2 (Input B) of IC3a is linked to the positive power line via resistor R11.

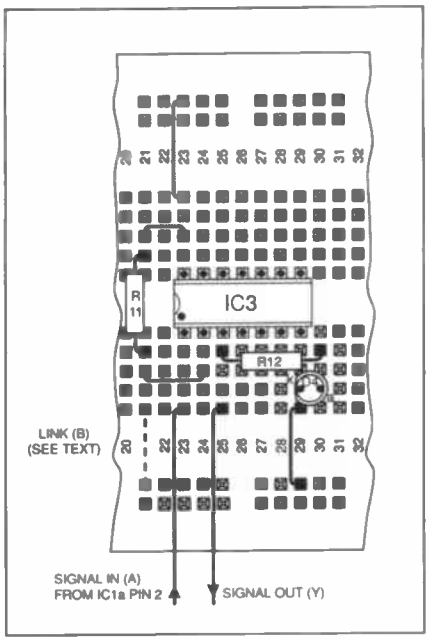


Fig.6.3. Breadboard layout for the AND, NAND, OR and XOR 2-input gate experiments.

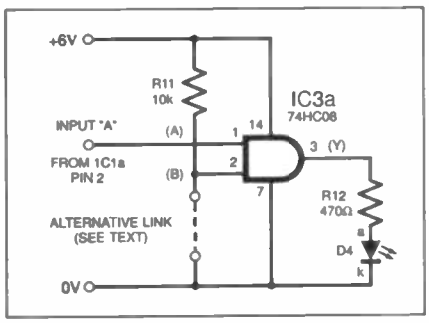


Fig.6.4. Circuit diagram for the AND gate experiment. The circuits for the other gates are similar.

The power line connections for IC3 are positive to pin 14 and 0V to pin 7. With the breadboard links as shown, these connections are automatically made to the battery when it is connected to the board as in previous experiments.

An l.e.d. (D4) is connected to the output of IC3a (pin 3) via the usual ballast resistor (R12).

The circuit diagram for this set up is shown in Fig.6.4.

Capacitor C1 of the oscillator should be 100µF.

Incidentally, the A and B names given to the gate inputs do not *have* to be in that order, or even with those names. They could even be called Input John and Input Gill if you wanted to. Nor is it necessary to use the same suffix letters as those used here, the gate having pins 1, 2 and 3 could be named IC3d in another circuit (or even IC54c). It is entirely up to the circuit designer to give i.c.s what ever circuit part numbers he or she prefers.

FIRST TEST

Connect power to the board and adjust preset VR1 (Fig.4.1 in Part 4) until the oscillator's l.e.d. (D1) flashes on and off at a fairly even and slow rate. You should see that l.e.d. D4 also flashes on and off in time with D1.

Now make a temporary link between IC3a pin 2 (Input B) and the 0V power line (see Fig.6.3 – Link B). Leave R11 in place – it prevents the input from "floating", a condition in which the gate would be unsure of what logic state is on that input should you remove and swap a link wire between it and either of the power lines.

You will now find that l.e.d. D1 continues to flash, but l.e.d. D4 is turned off. Remove the link and D4 should flash again. This is what's happening:

In the first instance, the data (bit) at Input A (pin 1) of the AND gate has been set to logic 1 via the 10kΩ resistor R11. The data (bit) for Input B (pin 2) is alternating between logic 1 and logic 0, as provided by the oscillator. As we said before, the conditions in which an AND gate will produce an output of logic 1 is when both ANDed bits are at logic 1.

In the circuit you are running, one bit (A) is already at logic 1 (via R11), and the other bit (B) is switching between the two logic states. When bit B is at logic 1, the AND condition has been met and the output goes high, to turn on l.e.d. D4. With bit B low, the condition is not met and so the output is low, and D4 is off.

When you take bit A low by connecting Input A to 0V, the AND condition can never be met, irrespective of what happens on Input B. Thus l.e.d. D4 remains off.

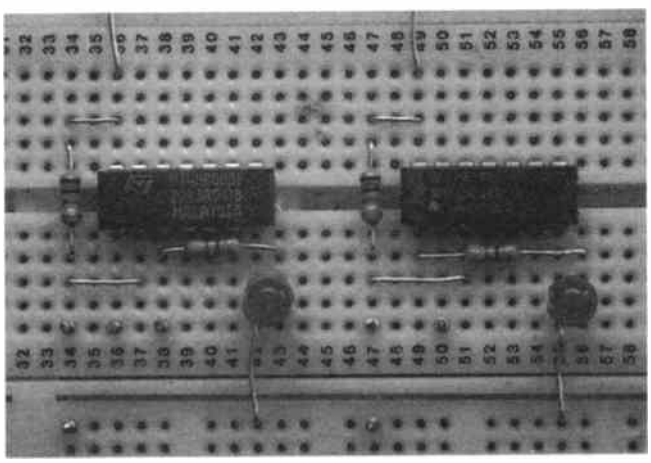


Photo 6.1. Breadboard showing the 74HC00 and 74HC02 configured for the demos. Note that they are not in the final recommended board positions.

TRUTH OF THE MATTER

As you will have deduced, there is a permutation of four logic states that can occur on the two inputs of the AND gate. There is only one combination of those input states in which the output can go high. This permutation of states and their resultant outputs can be tabulated, as in Fig.6.1a, below the gate's logic symbol. Tables such as this are called *Truth Tables*.

The truth table in Fig.6.1a (and in those we give later and in the computer program) is headed with the inputs in order of B and A, which allows the table to be arranged so that the logic on these inputs is shown in binary value order (discussed later in this Tutorial). The output is headed with a Y (a common letter encountered with many, but not all, output-indicating illustrations and tables).

Truth tables can be compiled for any number of inputs and outputs of any digital logic device. Some can become very long indeed! For example, AND gates (and other members of the logic family) can have three, four, eight or even more inputs. The number of permutations of 2-state (digital) logic on those inputs is *two to the power of the input quantity*, e.g.:

INPUTS	PERMUTATIONS
2	$2^2 = 4$
3	$2^3 = 8$
4	$2^4 = 16$
8	$2^8 = 256$

NAND GATE LOGIC

We stated earlier that as well as AND gates, other types of gate exist to meet other logical conditions. The repertoire comprises AND, NAND, OR, NOR, XOR, XNOR, NOT (another term for *inverter*). Having met AND and NOT (the 74HC04 and 74HC14 inverters you've been using in the oscillators), we shall now discuss the others in turn, starting with the NAND gate.

The term NAND simply means NOT-AND. A NAND gate is thus an AND gate whose output is inverted. Its logic symbol and truth table are shown in Fig.6.1b.

The symbol is almost identical to that for the AND gate, except that the output has a small circle on it. This symbol is frequently encountered on outputs (and inputs) to signify that the logic is inverted.

You can, in fact, achieve a NAND situation by taking the output of an AND gate through an inverter (try it sometime). There are, though, logic devices manufactured to specifically perform the NAND function. One such is the 74HC00.

The 74HC00 is a quad 2-input NAND gate, and its pinouts are shown in Fig.6.5. Note that the order of the pins per gate is identical to that for the 74HC08 AND gate.

With the breadboard power off, remove the 74HC08 and in its place put a 74HC00. Again touch something that is earthed

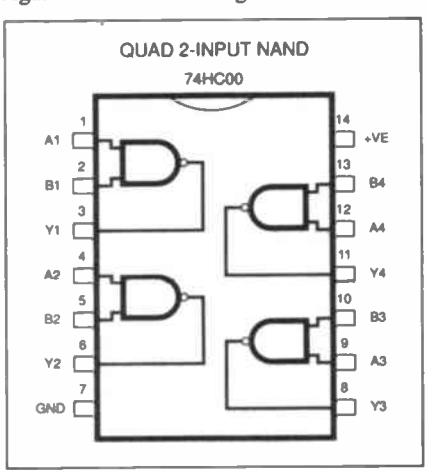


Fig.6.5. Pinouts for the 74HC00 quad 2-input NAND gate.

immediately prior to handling it (as we advise you in Panel 6.1).

With power on again, do the same tests as you did with the 74HC08, connecting Input A (pin 1) variously between +VE (via R11) and 0V. Note the way in which l.e.d. D4 flashes compared with l.e.d. D1.

You should find that D4 will only be turned *off* when inputs A and B are both at logic 1, the opposite of the situation with the AND gate. Indeed, your findings should correspond to the data shown in the NAND gate truth table in Fig.6.1b.

OR GATE LOGIC

With a 2-input OR gate, the output is high if *either* Input A *OR* Input B is high. If neither is high, the output will be low. As with the AND and NAND gates, OR gates are available with more than two inputs. In these cases if *any* of the inputs are high, so too will be the output.

OR gates allow, for example, a process to start or continue if *any* preceding processes have been completed or are still in progress.

The logic symbol and truth table for a 2-input OR gate are shown in Fig.6.1c.

An example of a quad 2-input OR gate is the 74HC32. Put one into your breadboard in place of the 74HC00. The pinouts are identical to the previous two gates.

Do the same tests as you did before, and compare your results with the truth table.

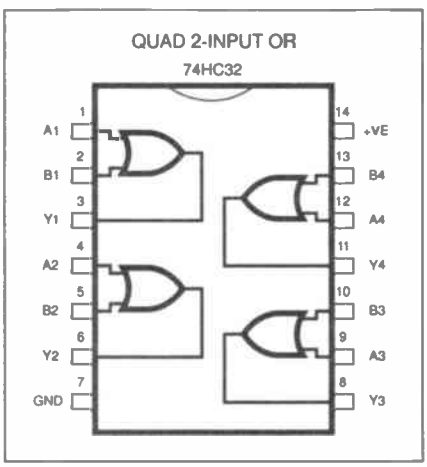


Fig.6.6. Pinouts for the 74HC32.

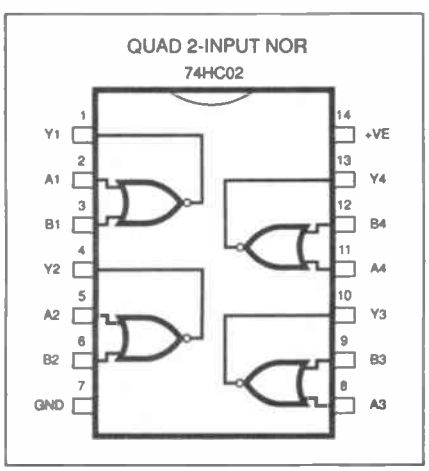


Fig.6.7. Pinouts for the 74HC02. Note that the pin order is different to the other gates discussed.

PANEL 6.1 – HANDLING INTEGRATED CIRCUITS

Although modern integrated circuits (i.c.s) are very reliable, they have to be handled with respect. They must be inserted into circuit boards the correct way round, stated maximum voltages should not be exceeded and current limits should be adhered to (although many devices have current limiting circuits built into them).

One point which must *always* be observed, is that i.c.s should not be exposed to the dangers created by static electricity discharges, especially i.c.s which have the term CMOS (complementary metal oxide silicon) in their datasheet/catalogue description.

Although we have not mentioned it before, all the i.c.s with the 74HC prefix that you have, and will be handling for this *Teach-In*, are CMOS devices. The 74HC type was chosen for its particularly hardy nature, including the ability to operate at up to 7V and to provide a reasonable amount of current to drive the l.e.d.s. (Note that there are many other digital logic devices with a 74 prefix, but with a different set of letters following it, and with different characteristics.)

Whilst CMOS devices have diodes protecting certain external connections, particularly the inputs, the diodes can only drain away excessive applied voltages up to finite limits. The discharges from static electricity can be many thousands of volts, levels which are way beyond what the protecting diodes can handle.

It is easy to avoid static electricity from discharging into an i.c. when handled by *always* touching a grounded item (one which is connected to electrical "earth") before touching it. This discharges static from your body or the tool you might be handling. The metal rear panel of a plugged-in mains-powered computer is a good place to touch; even its printer port cable has bare metal earthed connectors at each end.

In professional electronics, those handling i.c.s do so in conditions where sophisticated earthing techniques are used to prevent static electricity build-up. There is no need for the average constructor to go to such lengths and the "touching ground" method normally proves satisfactory. Also, any mains powered item of test or construction gear (e.g. soldering iron) should be firmly earthed.

Whenever possible, use sockets for i.c.s on any printed circuit board or stripboard (e.g. Veroboard) assembly where soldering is required. This enables the i.c.s to be easily replaced if necessary. It also prevents them from becoming overheated during soldering, even though they can be quite robust in this situation.

Do not feel *unduly* alarmed by the warnings about static electricity and its effect on i.c.s. Providing you observe the basic precautions, you can enjoy using i.c.s without endangering them, most are actually far more resilient than many texts suggest.

NOR GATE LOGIC

For a given input combination, a NOR (NOT-OR) gate produces an inverted output compared to that for an OR gate. The symbol and truth table for a 2-input NOR gate are shown in Fig.6.1d. Again note the inversion circle on the output.

Whilst NOR gates are available with several inputs, it is one of the quad 2-input types we use now, the 74HC02. Its pinouts are shown in Fig.6.7. *Note that its pinouts are different* per gate section to the previous gates.

The reason for this difference is unknown – it seems illogical. It has to be said, though, that there are occasional inconsistencies between what one might *expect* of a digital i.c. compared to what the situation actually is.

One reason given to the author many years ago is that digital logic devices were originally designed for the United States Military and that this had an affect upon how devices were manufactured.

Insert a 74HC02 into the breadboard in place of the previous OR gate, but connect it, plus the resistor and l.e.d., according to Fig.6.8. Do your tests in the same way as before.

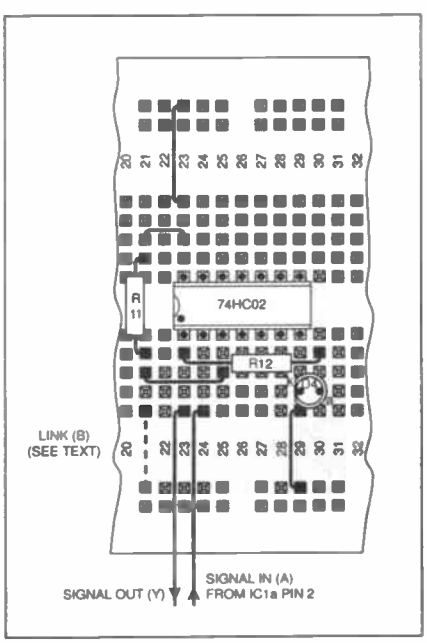


Fig.6.8. Breadboard layout for the NOR gate experiment.

XOR GATE LOGIC

The term XOR stands for Exclusive-OR and such gates are only likely to be encountered as 2-input types. The logic symbol and truth table are given in Fig.6.1e.

The important thing to note about an XOR gate is that the output only goes high if the two inputs *do not* have equal logic values on them. If the inputs *do* have equal logic, then the output will be low.

This condition is highly useful in many situations, such as when you need to compare whether or not signals from two sources have equal logic values. The principle in computing allows easy assessment

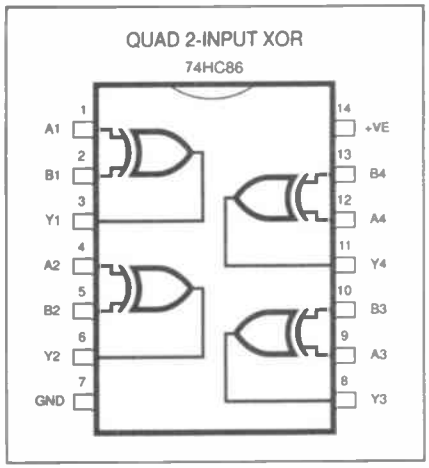


Fig. 6.9. Pinouts for the 74HC86.

for the equality between byte values (8-bits being compared simultaneously, with a single output bit being set to represent the answer).

XOR gates also allow, for instance, signal logic levels to be dealt with "as are" or inverted, just by changing the logic level on one input. One application for this is in the control of some simple types of liquid crystal display (l.c.d.) – as we shall see later in the *Teach-In* series.

The quad 2-input XOR gate we want you to examine now is the 74HC86. Its pinouts are shown in Fig.6.9 – they are in the same order as the first three gates you examined. Use the breadboard layout shown in Fig.6.3, and run the usual tests.

XNOR GATE LOGIC

With an XNOR gate (Exclusive-NOT-OR), the output logic is the inversion of that which applies to an XOR gate. The logic symbol and truth table are shown in Fig.6.1f. Again the circle on the output indicates the inversion.

Whilst XNOR gates are manufactured, they are not readily available through hobbyist retailers and are not amongst the list of components we suggested that you bought for this *Teach-In* series.

However, we can actively demonstrate an XNOR gate via another of our interactive computer programs. The same program allows you to examine on-screen the other logic gates we've been discussing. From the main menu, run the 2-Input Logic Gates program.

PANEL 6.2 – SAMPLING RATIOS

You will recall that when discussing frequency counting in Part 4, we commented on the problems created by sampling at too slow a rate.

There is a simple ratio of minimum sampling rate to original frequency rate that allows the *essence* of the waveform (whether it's above or below a midway reference level) to still be discerned. The ratio is 2:1, i.e. sampling should be at a frequency no less than twice that of the waveform being sampled.

It was a certain Mr Nyquist (dates and history unknown) who formally expressed this ratio, apparently defining the minimum sampling rate that allows accurate reconstruction of a signal in pulse-coded communications systems.

So far as *audio signal* sampling is concerned, where the *shape* of the waveform needs to be closely preserved, rather than its high or low status, a sampling frequency that is *much* higher than the frequency of the audio signal is required. This is very much apparent in the ADC Demo, which we discussed last month.

There does, though, seem to be a general concensus that for the upper audio frequencies (at the top end of human hearing) a minimum ratio of 3:1 is acceptable.

It is worth noting that when reconstituting a digitally sampled audio signal back to analogue, the harmonics created by the original sampling frequency need to be filtered out using additional electronic circuits.

LOGIC GATES PROGRAM

With the 2-Input Logic Gates program running, the screen displays the logic symbols and truth tables for the six 2-input gates just discussed.

You can interact with any of the symbols, using the left and right keyboard arrows to select which one. The selected table is indicated by a light-blue background in the table heading.

Up and down keyboard arrows highlight different rows in the selected table. Notations on the logic symbol reflect the logic shown for the selected row. It is stated in binary (0 or 1) and red "flags" also show whether the logic is high or low (just a bit of fun the author enjoyed putting in!).

We suggest you explore the symbols and try to memorise the logic tables (or at least the logic *behind* the creation of the tables, as discussed earlier).

SELF-TEST

When you are confident enough, have a go at another of our Self-Test options. Press <S> and correctly answer the questions asked! (We hope you will be mildly amused by the result of correctly answering each of them – and doubly so for getting all right!)

LOGIC WAVEFORMS DEMO

The next demonstration we've prepared illustrates two waveforms before and after they pass through three logic gates, AND, OR and XOR. Run program Digital Sampling and Logic Demo.

The cycle width for the input square waves displayed (Signals A and B) is changeable, and the waveforms traverse the screen to show how their relationships change with time.

All the control key options are stated on screen. When you press <P> the waveform for Signal B alternates between a narrow pulse and a square wave.

Whilst experimenting with different frequency rates, consider the implications of what the result would be if you were using one waveform to sample the other. In the screen demo, it's the AND result that is your best guide to sampling results.

You will see, for example, that when the edges of Signal A and Signal B cross, the ANDed result can be a pulse much shorter than Signal B's pulse. In any practical sampling circuit it is likely that some sort of additional circuit would be required to detect whether or not a sampled result occurs for less than a specified minimum duration.

If the result is too short, it could be that it has been caused by "noise" in other parts of a complex circuit (think of how the electrical noise from some vehicles can interfere with your TV or radio reception).

There's a snippet of further info on sampling in Panel 6.2. You will find Panel 6.3 interesting as well (relatively speaking!).

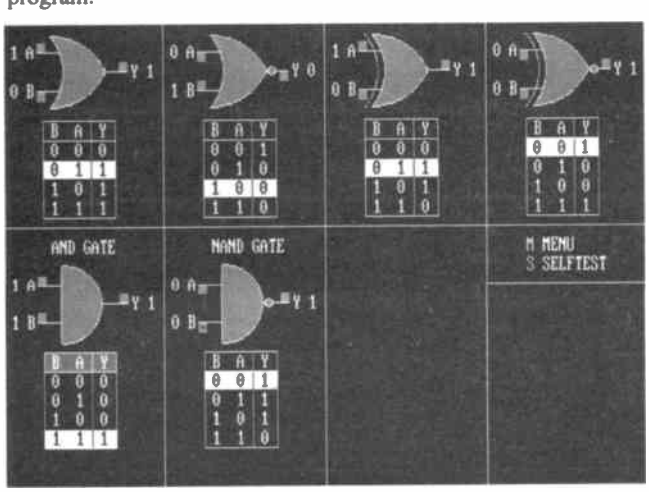


Photo 6.2. The interactive logic gates screen in which all permutations of 2-input logic are demonstrated.

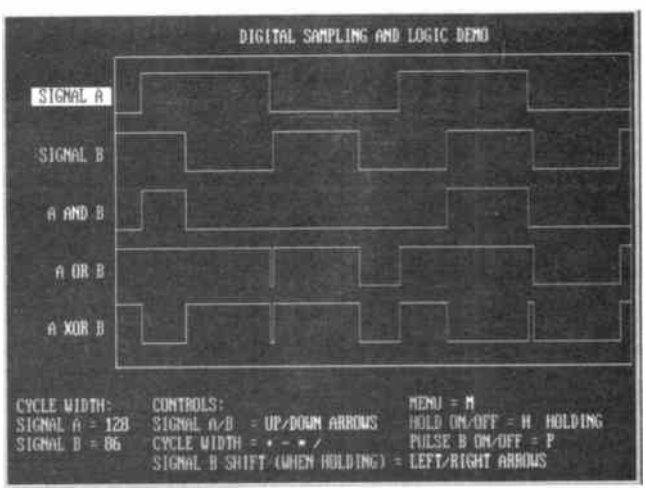


Photo 6.3. Interactive digital sampling demo screen which highlights the relationship between two logic signals.

8-BIT LOGIC

Earlier in this Tutorial we discussed digital logic from the point of view of 2-input (2-bit) gates. It is now worth considering 8-bit logic, not in terms of actual electronic logic gate devices, but from the point of view of computers and computing programs. From the main menu select 8-Bit Binary Logic.

The screen now displays six boxes comprising data for eight combined 2-bit versions (two bytes) of the logic functions previously discussed. The formula for each function is shown as (for example) Y = A OR B where the three letters are the same as those used in the 2-input gate logic demo.

Below the formulae are the eight 2-bit values for A and B, together with their Y answer. Eight steps are needed for you to produce the answer, taking each of the A/B bit pairs as separate items, combining them as required by the logic function stated. For information only, the decimal values for the full 8-bit binary values are given in green. (Binary/decimal conversion is examined a bit later in this Tutorial.)

We believe the rest of the screen's functions are obvious, including the Self-Test option. Except – there's a small clarification: when in the Self-Test mode and you want to use <M> or <S> to return to the menu or terminate Self-Test, you must press <ENTER> to activate the letter once keyed in. Otherwise, with the Control keys stated, just press and see what happens!

BINARY TABLE

Before we get into the business of illustrating binary conversion, have a look at the program Binary, Hex, Decimal Table 0-255. It's what it says it is, decimal values from 0 to 255, with their 8-bit binary and hexadecimal equivalents.

There are three screen pages, rotating on a cycle at each press of the space bar (or any key except <M>, which brings back the menu display).

This table will prove invaluable on many a future occasion! Keep it on screen while you read this next section.

There is also a text file of the data that you can print out from your usual word-processor software. It's in directory C:\TY2KPROG (where the rest of your *Teach-In 2000* programs are held) and is named TY2KBDHX.TXT.

BINARY CONVERSION

So, you've had a glance at the binary conversion program pages, and you've been exposed to binary numbers in various ways since we discussed the installation and operation of your computer interface board in Part 4.

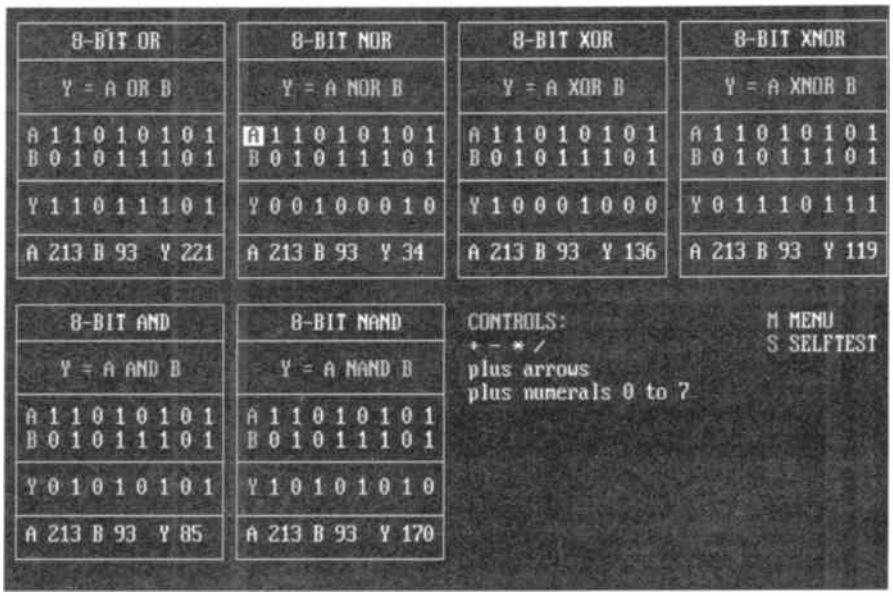


Photo 6.5. Interactive screen which illustrates the principle of 8-bit logic functions.

In case you've not yet figured-out the logic behind binary numbers, let's explain it here and now!

We've told you several times that digital logic can be in one of two states, variously expressed as high or low, logic 1 or logic 0, 1 or 0, on or off, H or L, set or cleared. Using 1 or 0 is the most convenient method of expressing binary numbers, in the same way that decimal values are expressed using the numeric symbols 0 to 9.

As you well know, in decimal we count from 0 to 9 and then cycle over to 0 again, but placing symbol 1 in front of 0 to produce 10 (ten), and so on.

In binary, we count from 0 to 1 and cycle back to 0, again placing a 1 in front of 0 to produce 10, but this time the symbol "10" represents decimal 2. Next we get "11" (decimal 3) followed by "100" (decimal 4), and so on. The sequence from 0 to 16 is as shown in Table 6.1.

In many instances it is conventional to place leading zeros before the binary value, so that its length is, for example, eight digits long (or 8 *bits* to use the commonplace term).

Referring back to the conversion table still on your screen, you will see the 8-bit structure applied to the first 256 binary values. Yes, we deliberately said "256" rather than "255" – remember that 0 is a value as well!

So what about binary numbers beyond decimal 255? You just extend the principle: keep on increasing the length of the binary number, but, perhaps showing as two (or more) 8-bit lengths, separated by a space, e.g. 256 could be shown as:

00000001 00000000 or just 100000000

What you have probably spotted is that there are several situations in a binary number when just one bit is a 1, the others being 0. Run through your screened binary table – confirm that the single bit numbers and their decimal conversions are as shown in Table 6.2. Each of the decimal values is, of course, twice that of the previous one, and

Table 6.1. Decimal and binary symbols.

DECIMAL	BINARY
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111
16	10000
etc.	

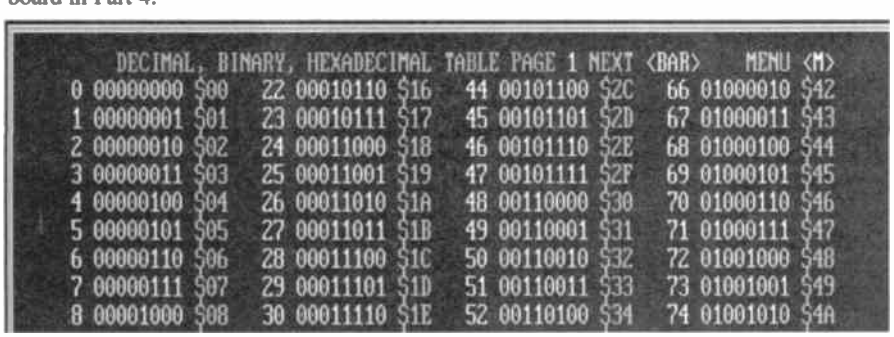


Photo 6.4. Part of the decimal-binary-hex conversion screen displays, covering decimal 0 to 255.

Table 6.2

BINARY	DECIMAL	POWER
00000001	1	2^0
00000010	2	2^1
00000100	4	2^2
00001000	8	2^3
00010000	16	2^4
00100000	32	2^5
01000000	64	2^6
10000000	128	2^7

Table 6.3

POWER	7	6	5	4	3	2	1	0
DECIMAL	128	64	32	16	8	4	2	1

it is also a power of 2, as shown in the third column. From Table 2 we can get the values shown in Table 6.3.

You will recall that the bit numbers in binary are numbered from left to right as 7 to 0, which is the same order and number of the above power values.

What we can say, then, is that if a bit in a binary number is a 1, it represents the same decimal power of 2 as its bit number. If there is a 0 in a bit position, the value represented by that bit is also 0. For example, take the binary number 11010110, we can analyse it as illustrated in Table 6.4.

Try this with other binary numbers you think up, and cross-check your result with the conversion table.

Table 6.4

BIT NO	7	6	5	4	3	2	1	0
DECIMAL	128	64	32	16	8	4	2	1
BINARY	1	1	0	1	0	1	1	0
VALUE	128	+ 64	+ 0	+ 16	+ 0	+ 4	+ 2	+ 0 = 214

HEXADECIMAL NUMBERS

We have commented that the symbols for decimal numbers run from 0 to 9 and that binary just uses 0 and 1. The *hexadecimal* (hex) system uses 16 symbols, 0 to 9 plus A to F. The following thus applies:

DECIMAL
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
HEX
0 1 2 3 4 5 6 7 8 9 A B C D E F

Decimal 16 then becomes hex 10, decimal 17 = hex 11, decimal 31 = hex 1F, decimal 32 = hex 20, etc., always incrementing through groups of 16 before roll-over to the next prefix symbol change, whereas in decimal you increment in groups of ten before roll-over.

This is illustrated in the conversion table on screen, where the blue values prefixed by "$" are the hexadecimal representations of the decimal and binary numbers to their left.

For incrementing from decimal 255 to 256, the roll-over becomes $FF to $100.

Hex values are indicated as such in a variety of ways. On screen now the symbol "$" indicates hex, the prefix "&H" is also used (as required by the QuickBASIC software in which the program you are now viewing was originally written). The letter "H" (or "h") is also often used as a prefix or suffix.

Value systems can also be stated by prefixes or suffixes of "b" or "B" (binary), and "d" or "D" (decimal). In some instances a numerical suffix is given to indicate the value system used, e.g.: 100_{10} (decimal), 100_2 (binary), 100_{16} (hex).

Obviously, when there is any doubt about which system a value is expressed in, clarification should always be given, either in words, or as a prefix or suffix, unless the context in which it appears makes its value obvious. If, for example, you saw the value 100 written on its own, you might not be sure if it meant decimal 100, binary 100 (decimal 4), or hex 100 (decimal 256) – scope for confusion!

For the remainder of this text we shall use "$" to indicate a hex value.

BINARY TO DECIMAL

For converting binary or hex numbers to decimal you need a pen and paper, and/or a calculator (or the program we discuss in a moment!). Neither conversion is difficult.

Take a binary number of 00001101 00011001, for example (16 bits split into two groups of eight as discussed a moment ago). From right to left, write down in a column the bit numbers for each bit that has a 1 in it. Beside each bit number write down the value of 2 to the power of that bit number:

BIT	VALUE
0	1
3	8
4	16
8	256
10	1024
11	2048

Now add up the second column: 3353 in this example.

HEX TO DECIMAL

Converting a hex value to decimal is nearly as easy. Take $FD58 for example: from right to left, write down in a column the place number for individual hex numbers within the full number. In column 2 write down the value of 16 to the power of each position. In column 3 write the individual hex values themselves, and beside them the decimal equivalent for each of those values. Now multiply the values in column 2 and column 4, and write down the answer in column 5. Then add up column 5:

PLACE (x)	16^x	HEX	DEC	RESULT
0	1	8	8	8
1	16	5	5	80
2	256	D	13	3328
3	4096	F	15	61440

The total for this example is 64856.

DECIMAL TO HEX

It gets a bit more complicated for decimal to hex conversion. First, have the following table to hand:

POWER	VALUE
16^0	1
16^1	16
16^2	256
16^3	4,096
16^4	65,536
16^5	1,048,576
16^6	16,777,216
16^7	268,435,456

Let's take decimal 39,923 as the example.

By inspection, establish which is the highest decimal value in the table that will divide into your starting value. In this case it is 4,096 and (noting that only integer values – whole numbers – are used in the division answers) the sequence becomes:

39923 / 4096	= 9	(= $9)
4096 × 9	= 36864	
39923 –36864	= 3059	
3059 / 256	= 11	(= $B)
256 × 11	= 2816	
3059 –2816	= 243	
243 / 16	= 15	(= $F)
16 × 15	= 240	
243 –240	= 3	(= $3)

Collecting the integer answers plus the final remainder gives us: 9, 11, 15, 3. Converting the decimal integer answers to hex gives: $9BF3.

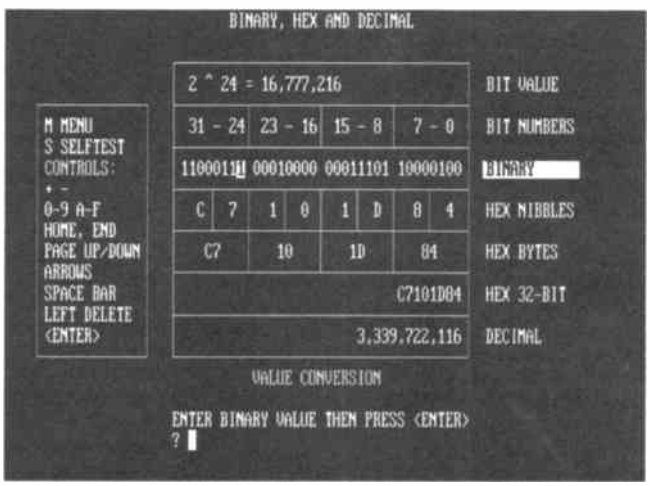


Photo 6.6. Interactive decimal-binary-hex conversion screen, catering for up to 32-bit numbers.

HEX TO BINARY

We before go any further we must explain the term *nibble* that's about to be used. A *nibble* (or *nybble*) is a quaint computing term and refers to a group of four bits, whereas a group of eight bits is generally known as a *byte*.

Conventionally, a byte is split equally into two nibbles, left and right, comprising bits 7 to 4, and 3 to 0. You would not, for example, take the group comprising bit 5 to 2 as being a nibble.

Having clarified that, here's how to convert a hex value to binary:

First write down as a table the powers of 2 that make up a 4-bit binary value (nibble):

POWER	2^3	2^2	2^1	2^0
DECIMAL	8	4	2	1

Take as our example $A75D. The right-hand value is $D. Hopefully, you will recall, or can work it out, that D is decimal 13, which is made up from the following power-of-two values:

8 + 4 + 1 = 13

So your table now becomes:

POWER	2^3	2^2	2^1	2^0	
DECIMAL	8	4	2	1	
$D = 13 =	8	4	0	1	
BINARY	1	1	0	1	(nibble 0)

Therefore $D = 13 decimal = binary 1101.

In a similar fashion, work right to left taking each hex value in turn. In this instance to produce:

$5 = 5 =	0	4	0	1
BINARY	0	1	0	1 (nibble 1)
$7 = 7 =	0	4	2	1
BINARY	0	1	1	1 (nibble 2)
$A = 10 =	8	0	2	0
BINARY	1	0	1	0 (nibble 3)

In reverse order, from 3 to 0, write down your nibbles:

1010 0111 0101 1101

which is the binary conversion for $A75D (or 10100111 01011101 as a 2-byte value rather than four nibbles).

VALUE CONVERSION PROGRAM

A program that allows conversion between decimal, binary and hex is available from the main menu: run Binary, Hex, Decimal Converter.

The program caters for binary numbers up to 32 bits long – decimal and hex maximums of 4,294,967,295 and $FFFFFFFF.

The central box is split into seven horizontal sections (see Photo 6.6). Sections 3 to 7 (Binary to Decimal) can be selected using the up/down arrow keys. In each section any individual character within the full value can be accessed using the left and right arrows.

The selected character can be changed and the result of that change is calculated in relation to the other four controllable sections and the results displayed. Try it! The full range of control keys available is stated in the left-hand box.

We believe the display and its options are obvious, but we will just clarify one small matter: the "^" symbol will be seen in the Bit Value line, this indicates that the following number is a power (index), e.g. 2^4 means 2^4.

DIRECT ENTRY

The Binary, Hex and Decimal Converter program allows you to directly enter your own values for conversion. When the highlight is active on one of the five Binary to Decimal options, press <ENTER>. At the bottom of the screen, value entry then becomes available. Enter the value, press <ENTER> again and the value is converted to the other modes.

There are a few intercepts to prevent you "crashing" the program with most practical joke entries! (But nothing to stop malicious intent if you are really set on it! If you do get the screen messed up, return to the menu and re-select the program.)

SELF-TEST

Press <S> to test your understanding of bin-hex-dec conversion! With a bit of practice, and reference to our earlier discussions, you should find that it's actually easier than you might think.

Note that when asked to convert a value to binary, you enter the answer in groups of nibbles separated by a space. This makes it easier to examine your answer if it's wrong.

If you really cannot work out an answer, press <A> plus <ENTER> for it to be revealed. But it's worth trying to get answers for yourself, the ability to do such conversions is invaluable.

MORE EXPERIMENTS

You've learned that you can count on us to offer you some interesting hands-on ideas each month – you can *count* on us again in this month's Experimental section, so clock onto it!

NEXT MONTH

In part 7 we examine op.amps, integrated circuits for use with analogue signals and voltages. Amongst other things, op.amps allow waveforms to be amplified, mixed and generally processed in a variety of ways. We shall illustrate their principles and some of the ways in which they can be used, to allow you, for example, to *listen* to the waveforms we discussed in Part 5.

PANEL 6.3 – RELATIVELY SPEAKING

An important concept to appreciate in electronics is that *nothing happens instantaneously*; everything takes a certain length of time to change from one state to another, whether it is a switch changing from on to off, or a voltage changing from one level to another, or just a fuse blowing.

It may seem that the switch is either open or closed, contacts either apart or touching, and at a molecular level this is true, but the physical nature of a switch means that because of the broad area of its conducting contacts, there is a period during switching off, for example, when the area of each contact which is actually touching the other is changing progressively from full-area contact to point contact, and only at the very final moment is the ultimate point contact broken.

During this period, the resistance between the contacts increases to the current flowing between them, and even at the moment when the physical point contact *is* broken, an electrical arc might be formed between the two open points, allowing current to still flow across them until they are even further apart. So much for the instantaneous nature of an on-off switch!

In digital electronic circuits, it is customary to think of the logic gates involved as responding to an *instantaneous* change from, say, logic 0 to logic 1 (from a low voltage to a high one). No such immediate change takes place, it takes time for the change to occur and there is a constant gradient through which the actual voltage level has to pass; it does not just suddenly jump from 0V to 5V, for example.

The time taken to make the transition may be short, possibly only fractions of a millionth of a second, but it still exists and the concept of synchronicity – two things occurring at the same moment – is only a convenience when working out the logic of a digital circuit.

In reality, the synchronisation of various actions taking place in order to create a further change is related to a "window" in time, during which all the required changes can occur at their own separate rates. The window could be a mere picosecond; it could be half of eternity; how it matters depends on what the circuit is required to do, and as long as all those changes happen while the window is "open", the circuit will behave as though they had all occurred at the same moment. But, if any of them occur outside the window, the result may be unpredictable and undesirable.

TEACH-IN 2000 – Experimental 6

BINARY AND DECIMAL COUNTERS

In the latter part of this month's Tutorial, we discussed binary numbers and the way in which they relate to decimal and hexadecimal values. We are now in a position to introduce an integrated circuit that allows you to physically see the binary counting process in action. We refer, of course, to a binary counter plus some l.e.d.s!

There are numerous types of counter manufactured, with such descriptive names as *binary ripple counter*, *synchronous binary counter*, *asynchronous binary counter*, *binary-coded-decimal counter*, *Gray counter*, *decade counter*, *Johnson counter*, *up/down counter*, and so on. Far too many to discuss in detail – and there are even variants on these!

We shall just concentrate on two types, a 7-bit *binary ripple counter*, and an 11-output *decade counter*.

BINARY COUNTER

The 7-bit binary ripple counter we shall use is the 74HC4024. Find one from your components bag and connect it into your breadboard, together with the required l.e.d.s and resistors, as shown in Fig.6.10. As usual, touch a grounded (earthed) item to discharge static electricity from your body before handling the device (and ensure that it's the right way round!).

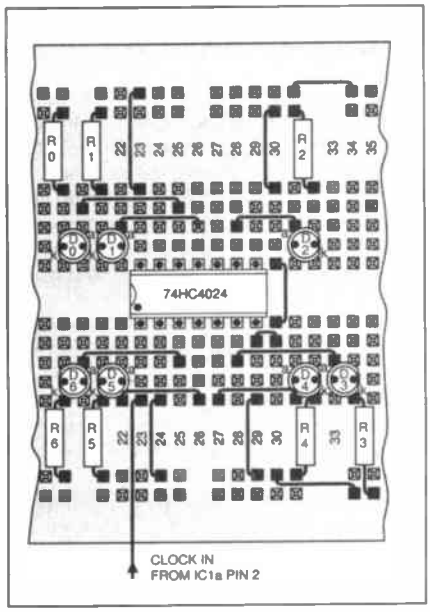


Fig.6.10. Breadboard layout for the binary ripple counter experiment.

If you only have five 470Ω resistors available, you could use any value between 100Ω and 1kΩ for the other two.

Connect up power and watch the l.e.d.s while adjusting the oscillator for different frequencies.

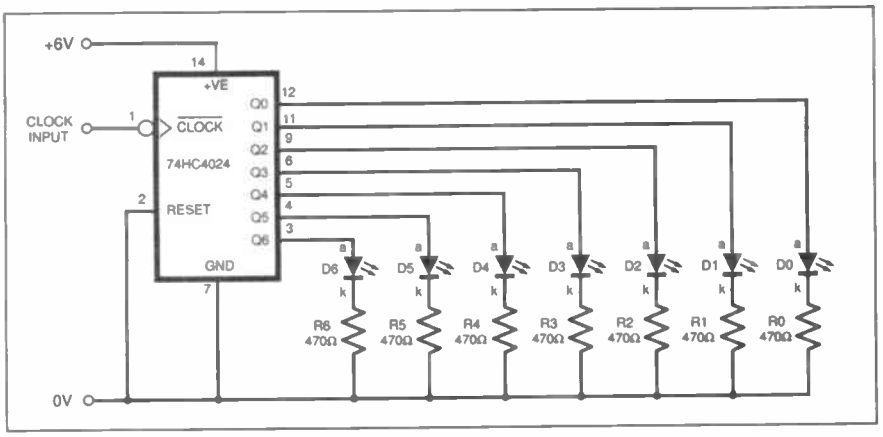


Fig.6.11. Circuit diagram for the binary ripple counter experiment.

The Clock input is the next important pin. This is the pin into which the data pulses that the counter has to count are input. The ">" symbol in the pinout diagram also indicates that this is the Clock input pin. It is frequently omitted in many circuit diagrams.

Note also the small circle at this input pin. It indicates that inside the device the pulse logic level to which the device responds is "inverted". You met a similar situation with the NAND, NOR and XNOR gates, although in their case the inversion took place on the output data.

we have done in Fig.6.11). Indeed, the use of a bar to signify inversion is arguably more commonplace than the circle.

RESET LOGIC

Pin 2 of the 74HC4024 is the Reset pin. When Reset is at logic 0 (low), the counter is permitted to count any pulses that enter the Clock pin. Two things happen when the Reset pin is taken high (logic 1). First, the entire count within the device is reset to zero. Second, the counter is prevented from counting any further pulses until Reset has been returned low.

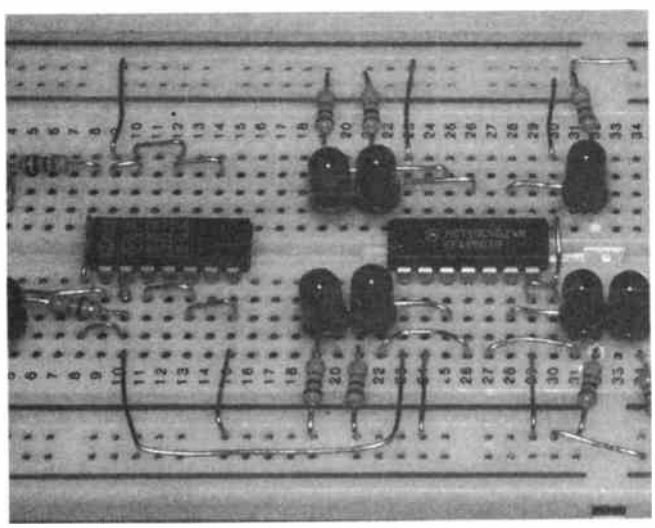


Photo 6.7. Breadboard showing the binary counter and l.e.d.s. Part of the oscillator is shown at the left.

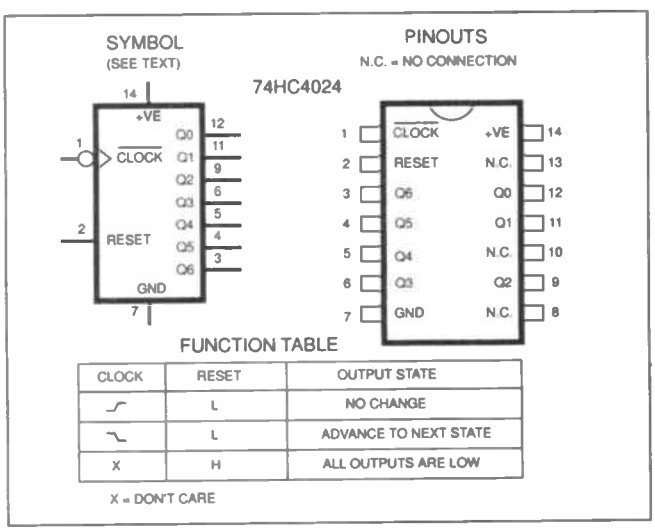


Fig.6.12. Symbol, pinouts and function table for a 74HC4024 binary ripple counter.

SYMBOLICS

The circuit diagram for this setup is shown in Fig.6.11, and the pinouts for the 74HC4024 are in Fig.6.12. Unlike with logic gates, there is no "official" symbol to illustrate the nature of this device (which is increasingly the case with integrated circuits that become more and more complex).

What we have to content ourselves with is a boxed outline with some pin numbers and their descriptions. In the circuit diagram, note first the pins to which the power lines are connected. As with the logic gates discussed in the Tutorial these are pin 7 for 0V (GND) and pin 14 for +VE (this is not always true for other digital devices). The recommended operating voltages are between 2V and 6V, although this device will withstand up to 7V for short periods (but never above 7V).

The significance about the logic level to which a device such as a counter responds is important to note. Many devices do not respond to the actual voltage *level* at an input (as did the logic gates in the Tutorial) but to the *change* in logic level.

In the case of the 74HC4024, the change responded to is that from high to low, and the counter adds 1 to its internal count value. The device is said to respond to the *trailing edge* of a pulse (a term we used when looking at pulses in the Tutorial).

When the pulse changes from low to high, the device does not respond in any way and the count remains as it was. (The 74HC4017 we shall use later responds to the change from low to high – i.e. to the *leading edge*).

Be aware that not all circuit diagrams show the inversion circle even though inversion occurs. Some circuits show a bar line above the description for such a pin (as

Note that in some types of counter, Reset may be *active-low*, in other words, Reset occurs when the pin is set low (logic 0), but counting is permitted when the pin is high.

The terms *active-low* and *active-high* are frequently encountered in electronics. The latter means that the stated function (Reset, Clock, Enable, etc.) is permitted or occurs when that pin is taken (or is already at) high.

"Q" OUTPUTS

The remaining useful pins are labeled Q0 to Q6 (in some circuits or pinout diagrams, they may be labeled as Q1 to Q7). Note that three pins have no function (8, 10 and 13). Note also the use of "Q" to signify an output; conventionally, this is the letter normally used with digital devices such as counters (whereas "Y" was used with the gates, earlier).

We have said that the 74H4024 is a *7-bit* counter. Pins Q0 to Q6 are the outputs at which the seven bits of the internal binary count value are accessed. Referring you back to what you have learned about binary numbers, output Q0 corresponds to bit 0, Q1 to bit 1, etc.

It is to tie in with this numbering that the resistors and l.e.d.s are numbered from 0 to 6 in Fig.6.11.

BINARY COUNT-UP

If you run the 8-Bit Binary Logic program and set the 8-Bit OR line A to zero, and then keep pressing the <+> key the binary sequence will count up in ones (*increment*) at each press, from 0 to 255 and then back to zero to start counting again.

This is what's happening inside the 74HC4024 (except that it only has seven bits). From a reset value of 0000000, it will increment each time the clock pulse goes from high to low. When it reaches a count of decimal 127 (binary 1111111), at the next negative-going clock pulse it rolls-over to 0000000 again.

That, then, is the sequence you should be seeing on the l.e.d.s connected to your 74HC4024 (although the breadboard space available prevents them from being inserted in the ideal visual sequence).

As with the logic gates, there is a truth table for the 74HC4024, except that it is actually referred to as a *Function Table* and takes a somewhat different format. It is shown as part of Fig.6.12.

The table shows the output state in relation to the conditions on the counter's Clock and Reset pins. Note the upwards and downwards waveforms in the clock column. The first signifies the rising (leading) edge of an input clock pulse, the second shows the falling (trailing) edge. These are commonly encountered symbols in digital electronics.

If the counter's Q0 to Q4 pins are linked to the computer interface input pins IN0 to IN4, you can observe the count sequence for the first five bits via the Parallel Port Data Display/Set program. With the oscillator rate set slow enough, the bits will be seen to change state in the two upper boxes, with the actual decimal value that the bits represent shown in the Corrected Input Byte box.

FREQUENCY DIVISION

A further experiment you can try is to select any of the counter outputs as the source of the data signal when running the Computer As Frequency Counter program.

This will enable you to really wind up the oscillator rate, yet still be able to see a meaningful frequency value displayed on screen (which you should mentally multiply by the division rate provided by the counter pin selected – each output is at half the rate of the previous one, remember!).

What we also suggest you do is to put the 74HC4024's Reset under computer control. Disconnect the link between the counter's pin 2 and 0V. Now link pin 2 to OUT2 of the interface. Repeatedly pressing key <2> will then cause the counter to run or be reset. You should be able to see the result on the l.e.d.s and on the screen.

If you are feeling further adventurous (and why not?!), also disconnect the counter's Clock input pin 1 from the oscillator, and couple it to interface OUT3 (controlled by key <3>). This puts the counter's Clock and Reset total under finger-tip control. The *Mutual Melding of Man, Mind and Machine*, no less!

RIPPLE

Ripple, incidentally (but significantly), in this context refers to the way that the counter's internal sections respond. (Note that *ripple* has a different meaning in the context of power supplies – which we discuss later in the *Teach-In* series.) In simple terms, the counter contains several divide-by-two circuits in a chain. It takes time for each counter to react to a trigger pulse from the preceding counter.

The delay is only short (nanoseconds for the 74HC4024), but the total delay as the pulses *ripple* through stages to the final output can be critical to other circuits, which may rely on the synchronisation between a multi-stage counter's clock pulse and the setting of an output pin.

There are counters in which the internal circuitry is designed so that each section is triggered at the same time. These counters are referred to as *synchronous*.

DECIMAL COUNTER

When you can tear yourself away from the fascination of binary counting, have a look at the attributes of a decade counter, the 74HC4017. Remove the 74HC4024 and insert the 74HC4017. Connect its pins as shown in Fig.6.13, complete with l.e.d.s D0 to D9 and resistors R1 and R2. You will need to "thieve" the tenth l.e.d. from the oscillator, unless you bought more than the suggested quantity of 10. Ignore D10 for the moment.

Power up your breadboard and watch the sequence of the l.e.d.s. Adjust the oscillator rate so that you clearly see the steps of the count.

Whereas the 74HC4024 counted in binary, from 0 to 127, the 74HC4017 decade counter counts in steps from 0 to 9, rolling over to begin the count from 0 again following 9. During the count only one output is ever high at any time.

The pinouts for the 74HC4017 are shown in Fig.6.15, the circuit diagram for the connections on your breadboard is illustrated in Fig.6.14. Again the l.e.d.s are numbered from zero to correspond with the output numbers. Note that only one ballast resistor (R1) is needed for the 10 l.e.d.s D0 to D9, since only one can ever be on at once.

You will see from the circuit diagram that, in common with the binary counter, this decade counter has a Clock input (pin 14) and a Reset pin (pin 15). As we said earlier, the 74HC4017 increments the count on each *rising* edge of the clock pulse.

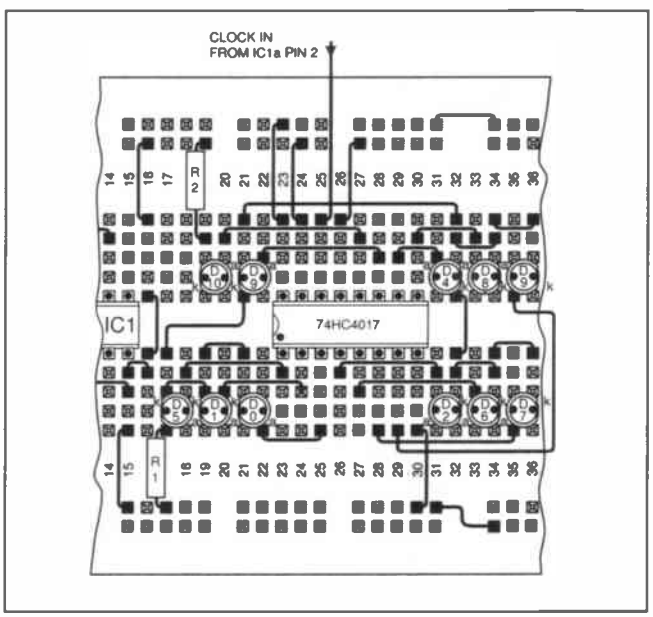


Fig.6.13. Breadboard layout for the 74HC4017 decade counter.

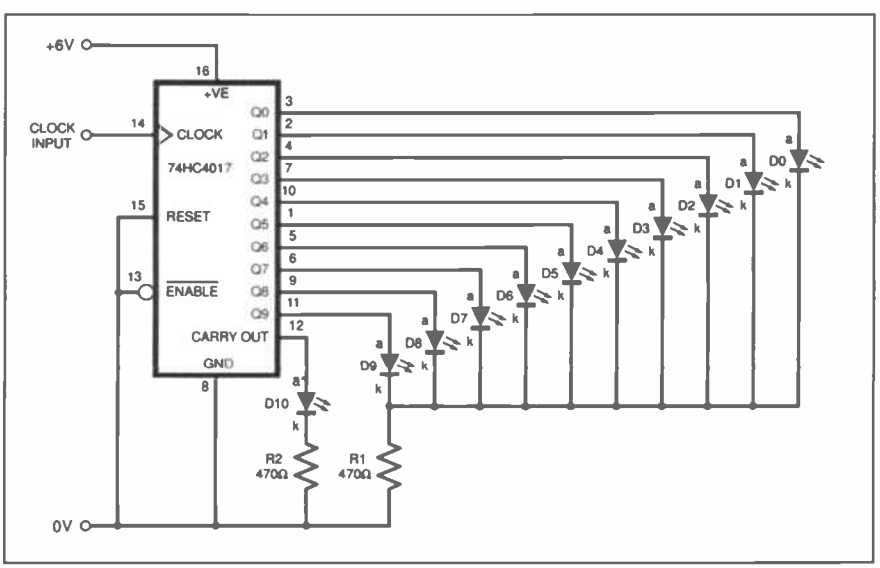


Fig.6.14. Circuit diagram for the 74HC4017 decade counter.

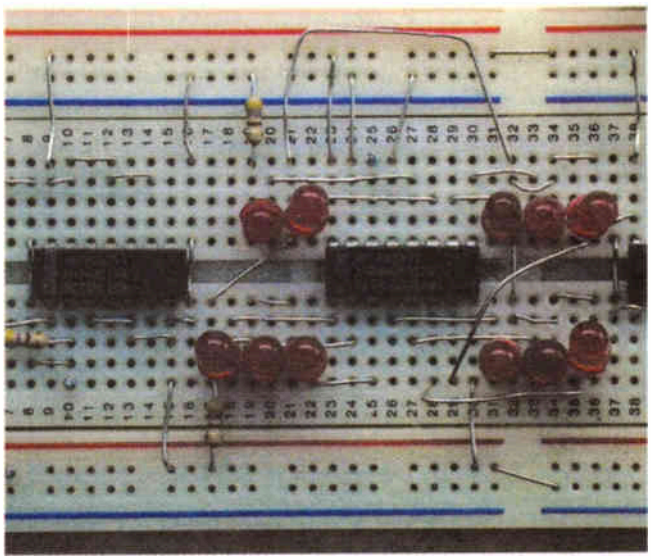
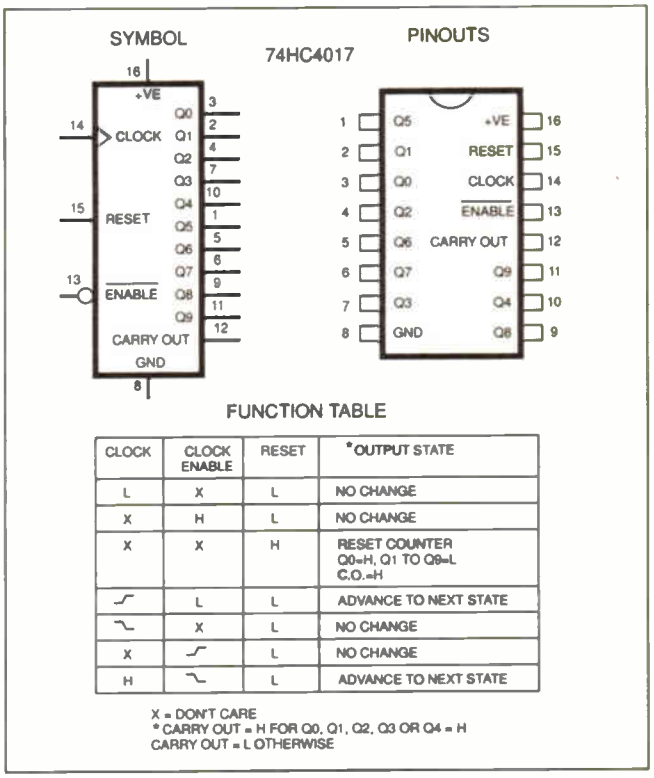


Photo 6.8. Breadboard showing the decade counter experimental circuit, with part of the oscillator seen to the left, and part of the ADC chip to the right. Take care that crossing link wires do not touch.



FUNCTION TABLE

CLOCK	CLOCK ENABLE	RESET	*OUTPUT STATE
L	X	L	NO CHANGE
X	H	L	NO CHANGE
X	X	H	RESET COUNTER Q0=H, Q1 TO Q9=L C.O.=H
↓	L	L	ADVANCE TO NEXT STATE
↑	X	L	NO CHANGE
X	↓	L	NO CHANGE
H	↑	L	ADVANCE TO NEXT STATE

X = DON'T CARE
* CARRY OUT = H FOR Q0, Q1, Q2, Q3 OR Q4 = H
CARRY OUT = L OTHERWISE

Fig.6.15. Symbol, pinouts and function table for the 74HC4017 decade counter.

The count is reset to 0 when the Reset pin is high. However, when the Reset pin is low, the continuation of the count depends on the status of a third pin, Enable, pin 13. Not surprisingly, this pin *enables* or *inhibits* the clock count. Because there is a bar-line above the word Enable (or a circle on its input), we know that the counter is *enabled* when the pin is *low*.

The ten outputs are labeled Q0 to Q9, which ties in with the count value that a logic 1 on the respective pin represents.

The function table for the 74HC4017 is shown as part of Fig.6.14. An interesting point to note is that the Enable pin can also act as a clock signal to the counter. When Clock is held high and Enable is taken from high to low, the count advances to the next state.

In most circuits it is more usual to use Clock rather than Enable as the clocking signal. However, what this option highlights is that Enable should never be taken low when the clock is high if you wish to preserve the count value existing at the last clock pulse.

It is subtleties like this that abound in digital electronic circuits, especially when the overall circuit complexity is great. You always need to consider the implications of how the timing of different signals can affect the response. In reality, at this stage of your learning, you need not concern yourself about them. When you are ready to consider them, you'll find that data sheets give typical timing values for practically everything!

There is an eleventh output pin, the Carry Out pin. This pin goes high when the counter is reset or rolls over to zero. It remains high until a count of five is reached.

The Carry Out signal is of benefit in a variety of situations; such as where you might wish to couple (*cascade*) two or more decade counters in series, for example. In this case the rising edge of the Carry Out signal would be used as the clock pulse for the next stage. Thus the first counter would count units from 0 to 9 and the second stage count the decades from 10 to 90. A third stage could count the hundreds, 100 to 900, and so on.

Observe the Carry Out pin in action by removing, say, the l.e.d. from one of the outputs (but not from outputs 0 or 5). Add the l.e.d. to the Carry Out pin as D10, via the already inserted resistor R2). Power back up again and observe the sequence.

As with the 74HC4024, you can connect up to five outputs to the computer interface at IN0 to IN4. You can also connect the Clock, Reset and Enable pins to the interface outputs OUT2 to OUT4, controlling them from your keyboard when running program Parallel Port Data Display/Set.

So there's a whole raft of ideas to play around with until next month. You could also include some experiments with the logic gates, interfacing them to the computer and counters as well. Till then this author's *out for the count*!

CORRECTION

Part 5, Fig.5.6. Add link wire to join rows E and F of column 42.

Constructional Project

HIGH PERFORMANCE REGENERATIVE RECEIVER

RAYMOND HAIGH

Part Two

Provides continuous coverage from 130kHz to 30MHz.

LAST month we explored the merits, and problems, of regenerative receivers and gave an in-depth circuit description. We also included the component listing and offered the option of "electronic tuning."

We conclude this month with the assembly, plug-in tuning coil details and setting-up procedure.

CONSTRUCTION

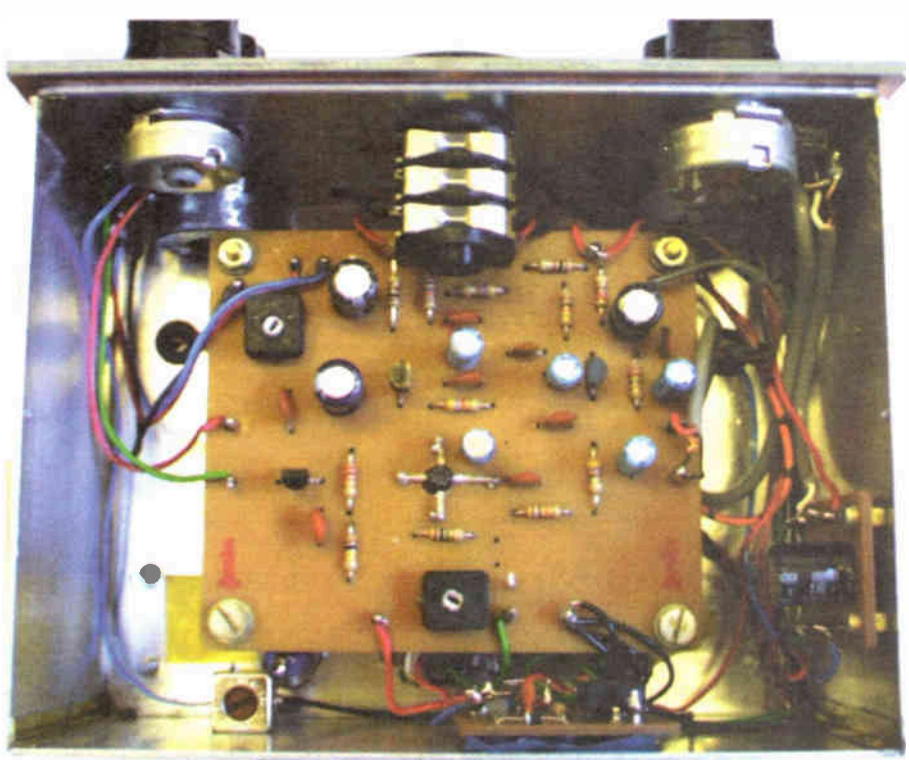
The receiver, power amplifier, and the alternative electronic tuning system, are assembled on three small printed circuit boards (p.c.b.s). This enables constructors to select what they want from the design and to use tuning components that may be to hand. Many will already have suitable audio amplifiers, and not everyone will wish to adopt electronic tuning.

The three printed circuit boards are available as a set from the *EPE PCB Service*, codes 254, 255 and 256. The top-side component layout and full size copper track masters of the three p.c.b.s are illustrated in Fig.4, Fig.5 and Fig.6.

Starting with the main Receiver board, mount the smallest components first, working up to the largest, but solder the semiconductors on to the board last. It is a wise precaution to clip a small heat shunt (such as a crocodile clip) to the leads of the f.e.t.s when they are being soldered.

Use solder pins, inserted through the board at the dual-gate MOSFET lead-outs, to enable it to be located on the component side. Solder pins should also be inserted, just to the right of VR4, so that capacitor C8 can be temporarily soldered across preset VR4 during the setting up process.

Solder pins inserted at the p.c.b. inter-wiring points will ease the task of off-board wiring. Use of an 8-pin d.i.l. socket will facilitate the substitution and checking of IC1.



Layout and wiring of the three p.c.b.s, headphone socket and under chassis controls.

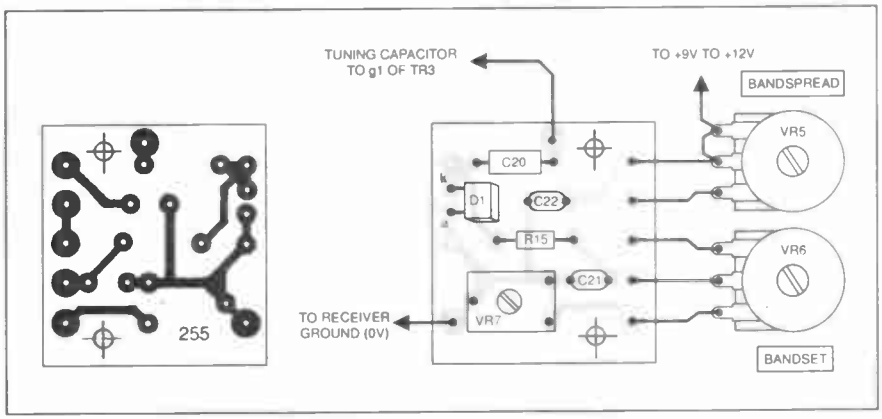


Fig.4. Printed circuit board layout for the electronic tuning system – shown full size.

Tuning board mounted on the side of the chassis.

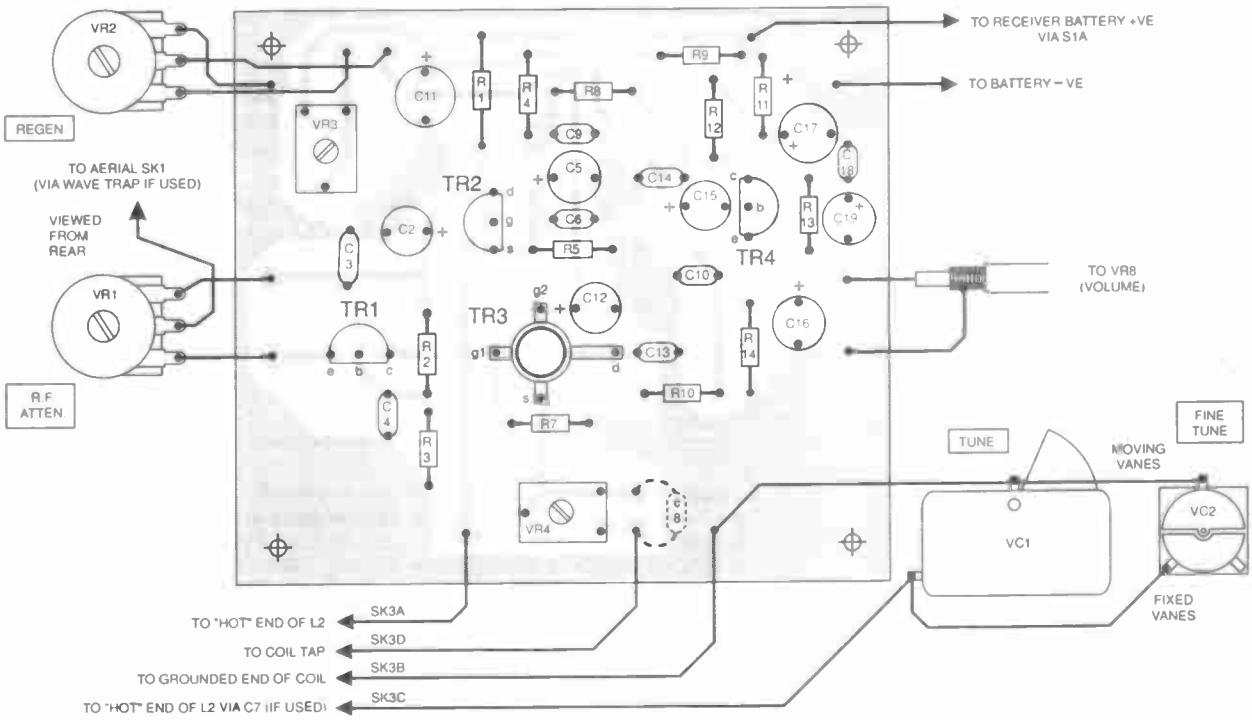
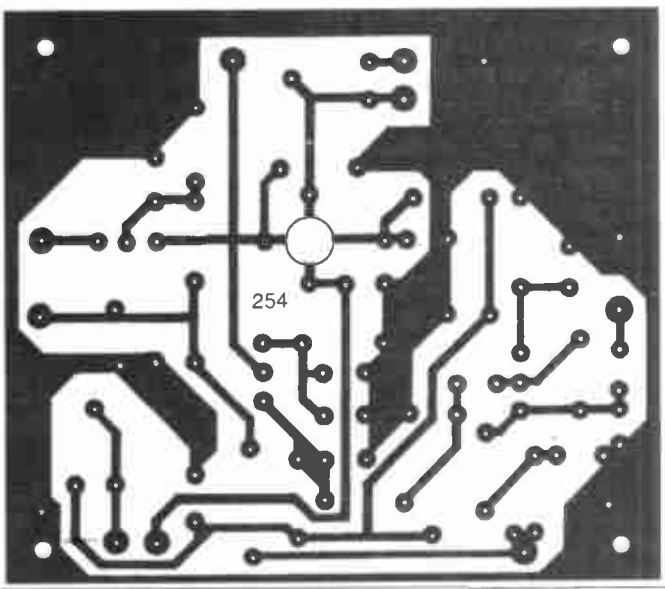


Fig.5. Main printed circuit board layout and wiring and (below) full size copper foil master for this p.c.b.



Chassis topside layout showing D-type socket for the tuning coils.

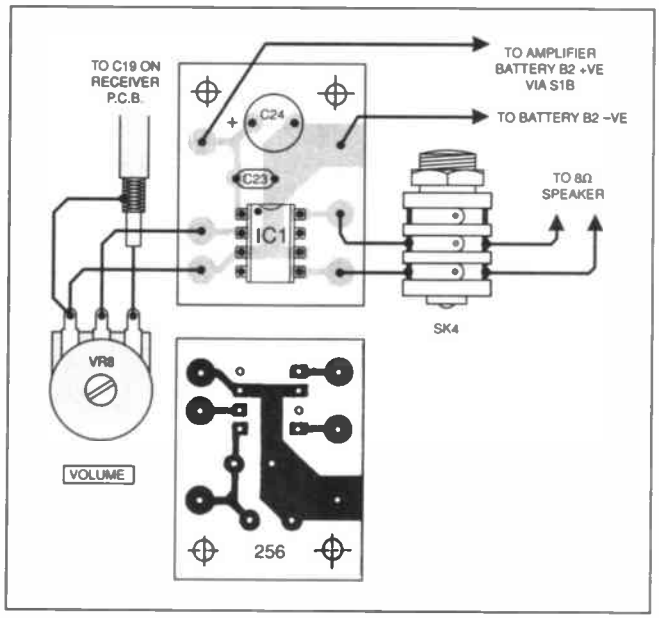
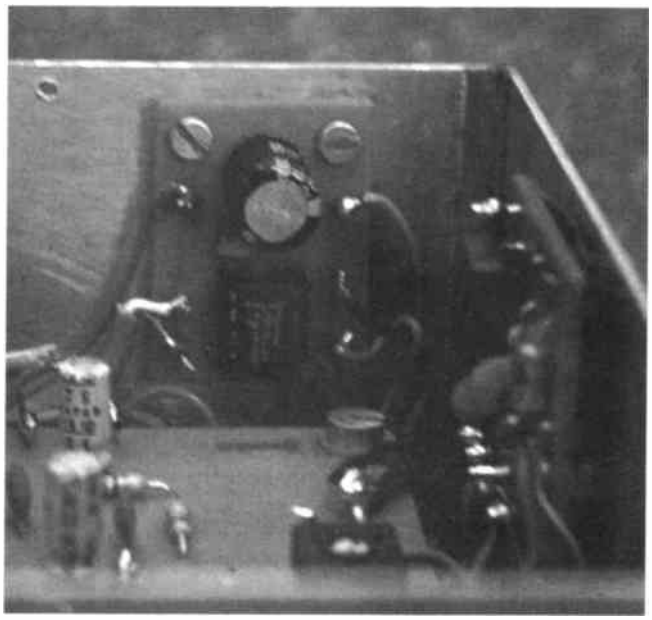
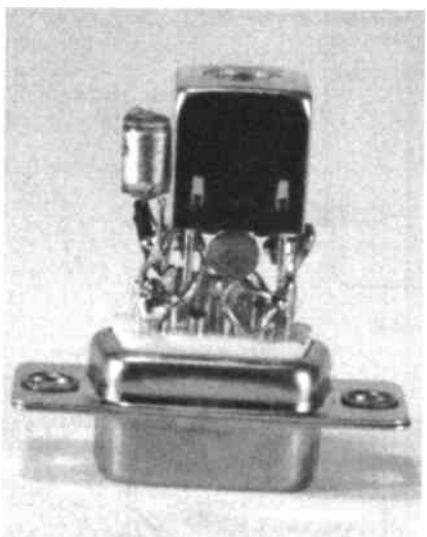


Fig.6. The audio power amplifier printed circuit board – shown full size.



The audio amplifier p.c.b. mounted on the side of the chassis.



With care a neat construction for L2 can be achieved.

The same construction approach should be adopted for the two smaller boards.

BAND CHANGING

Tuning coils (L2) could be connected into circuit by means of miniature crocodile clips and short (50mm maximum) wire links. However, a much better arrangement is to wire them, together with C7, R6 and C8 (when used), to 9-pin D-type computer plugs to make up plug-in modules and to mount a matching socket on the Receiver frame (see photographs).

How this can be achieved is shown in Fig.7. Also illustrated are the different methods of connecting the coil windings.

RECEIVER ASSEMBLY

Layout is not critical, but connections between the tuning components and the receiver p.c.b. must be short and direct and signal input and output leads should be kept well separated.

For the satisfactory reception of weak, amateur, SSB transmissions (where correct

TABLE 2: Tuning Ranges

TOKO Coils and a 10pF-365pF Variable Capacitor
(See Fig.7 for details of coil base wiring)

TOKO Coil	*Base wiring*	*C7 pF*	*R6 Ω*	*C8 pF*	*Min. frequency MHz*	*Max. frequency MHz*
CAN1A350EK	C	-	12k	-	0·130	0·322
RWO6A7752EK	C	-	6k8	-	0·257	0·765
RWR331208NO	A	-	22k	1000	0·510	1·600
154FN8A6438EK	C	470	8k2	-	1·246	3·034
KANK3426R	A	470	12k	1000	2·143	5·100
KANK3337R	A	470	3k3	1000	4·900	11·970
MKXNAK3428R	A	220	8k2	1000	11·200	23·500
KXNK3767EK	B	47	12k	10	22·000	30·500

Notes:
(1) Adjustable cores permit wide variation in tuning range.
(2) The 470pF capacitor, C7, reduces the variable capacitor swing to 10pF-205pF; with the 220pF capacitor, the swing is 10pF-137pF; and, with a 47pF capacitor as C7, 8pF-40pF.
(3) The RWO6A7752EK coil is useful for covering the l.f. end of the Medium Wave band

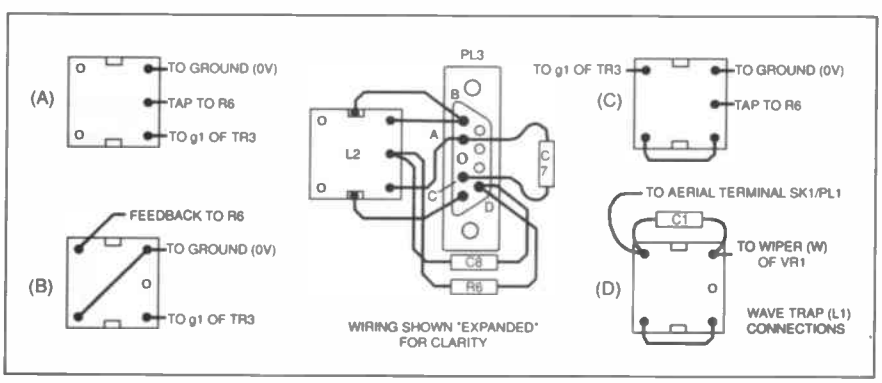
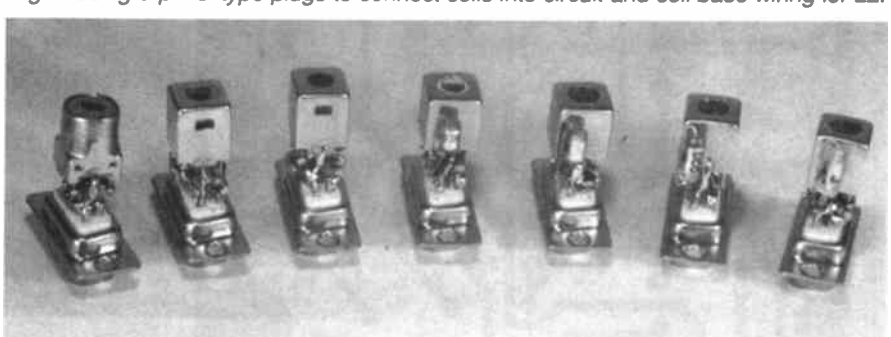


Fig.7. Using 9-pin D-type plugs to connect coils into circuit and coil base wiring for L2.



Various versions of L2 for full frequency coverage.

tuning is extremely critical), the p.c.b.s and tuning capacitors must be very rigidly mounted and screened in a metal box or case. The prototype is assembled in and on a small aluminium box with a piece of double-sided p.c.b. forming a screened front panel.

The photographs show how this is done. The arrangement has proved quite satisfactory, but a heavier, diecast metal box would be preferable, if one is to hand.

Some form of reduction drive to the Bandset capacitor VC1 will make tuning easier, and dial calibrations can be marked on a piece of card stuck to the front panel.

SETTING UP

This is very much a switch-on-and-go receiver, and the setting up process only involves optimising the feedback levels so that the Regen. control VR2 is smooth and effective over the full swing of the tuning capacitor on all coil ranges.

First, check the p.c.b.s for any bridged tracks or poor joints. Check the orientation of the semiconductors and polarised capacitors.

Set VR3 to minimum and VR4 to maximum resistance. Connect the Medium Wave coil into circuit, wire in capacitor C8, connect an aerial, and switch on.

Turn up the r.f. attenuator (VR1) and a.f. gain (VR8), then advance regeneration control VR2. Transmissions should be picked up, loud and clear, around the dial.

With the tuning capacitor VC1 fully meshed, set preset VR4 to the highest possible resistance consistent with the *Q*-multiplier just oscillating when Regen. control VR2 is turned to maximum. Measure the resistance of VR4 and permanently wire a fixed resistor of the same value, R6, in series with the tapping on the coil.

Preset potentiometer VR3 determines the voltage across the regeneration control. Set it to the highest possible resistance consistent with effective regeneration being obtained on all ranges.

The optimum values of resistor R6, measured on the prototype receiver, are listed in Table 2. They may not hold good for all dual-gate MOSFETs, but they will certainly be a useful guide.

Tabulated values of swing-reducing capacitors (C7) relate to a 365pF variable capacitor. If a different component is used, they will need modifying. Indeed, if its maximum value is as low as 200pF, swing reducers will only be required on the two highest shortwave ranges.

Coil cores should be set to give continuous coverage. Varying the inductance causes slight changes in the optimum value of resistor R6, and this part of the procedure should be carried out before the resistors are selected.

OPERATION

Best results will be obtained by attenuating the r.f. input as much as possible and adjusting a.f. gain to ensure audibility.

The regeneration control VR2 should be set just short of the oscillation point when receiving broadcast transmissions. When amateur SSB signals are being tuned in, it must be advanced until the *Q*-multiplier stage is just oscillating. (The internally generated oscillation replaces the carrier removed at the transmitter so that the detector can render the signal intelligible in the usual way.)

If the set is reluctant to regenerate, strong signals tend to spread across the dial, or difficulty is encountered when trying to clarify SSB signals, reducing the input from the aerial will invariably cure the problem. In cases where local Medium Wave or, less likely, Long Wave transmitters swamp the receiver, a wave trap (L1/C1) will have to be fitted.

CALIBRATION

A crystal marker or signal generator can be used for calibration purposes. Alternatively, an "all-band" radio with an accurate dial (preferably digital) should prove suitable.

Take a short aerial wire from the calibrating receiver and place it close to the *Q*-multiplier whilst it is oscillating. This will enable the radio to pick up the radiated energy.

The two receivers can now be tuned in step whilst the dial is marked out. Even if the calibrating receiver does not have a B.F.O. (beat frequency oscillator) to make the oscillations audible as a tone, the presence of the signal should be discernible.

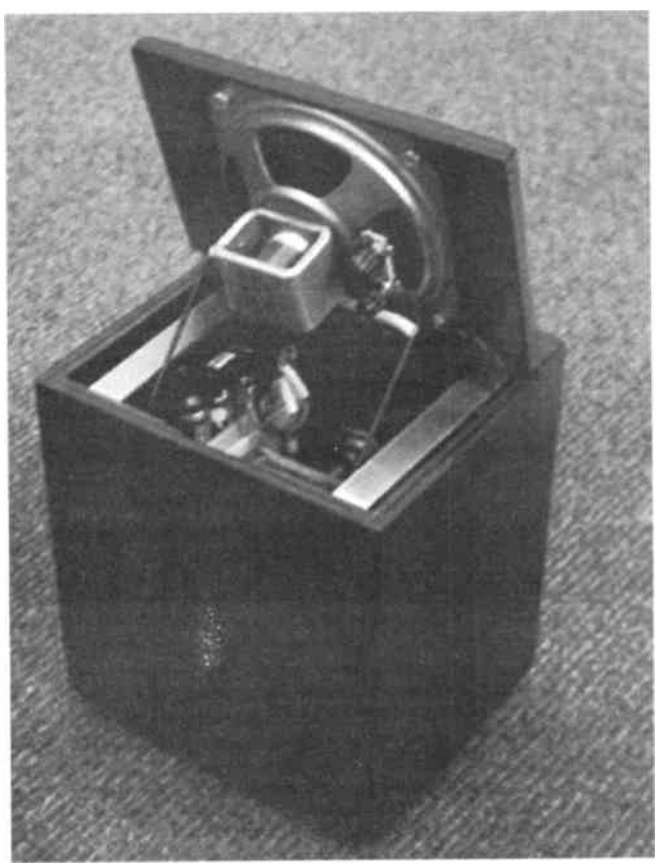
Refer to Table 2 for guidance on the frequency coverage to be expected with individual coils. It is easy to be confused by harmonics whatever method of calibration is adopted.

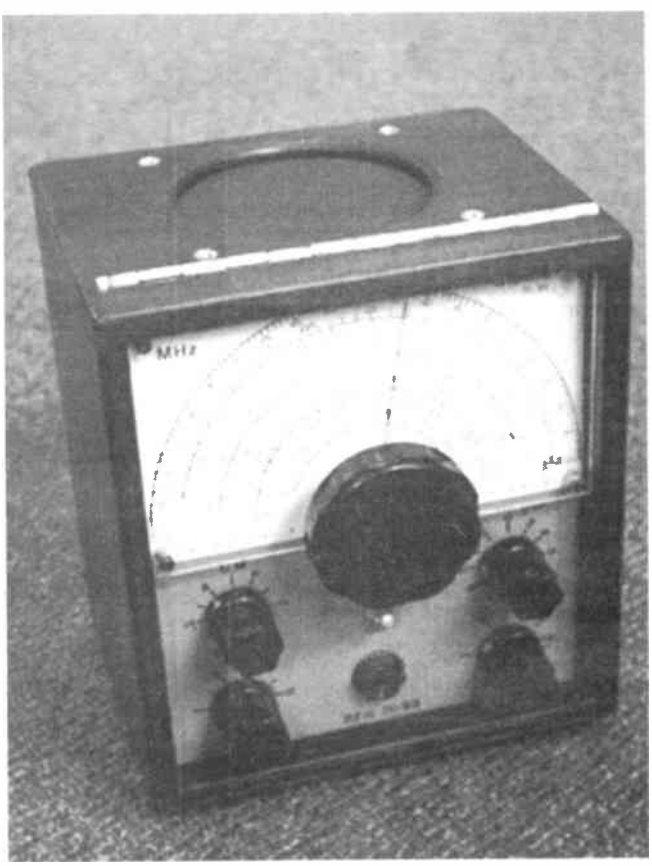
PERFORMANCE

When correctly set up and operated, the radio is sensitive, selective, and capable of receiving broadcast and amateur transmissions from all over the world.

If a reasonable aerial is used, say 15 metres or 20 metres of wire located as high as possible and clear of earthed objects, the r.f. input control will have to be turned well down when listening to all but the weakest stations. An earth (a metal rod in the ground) connection can improve reception, especially at low frequencies.

The receiver has a clear, pleasant tone, and audio output is more than adequate. □





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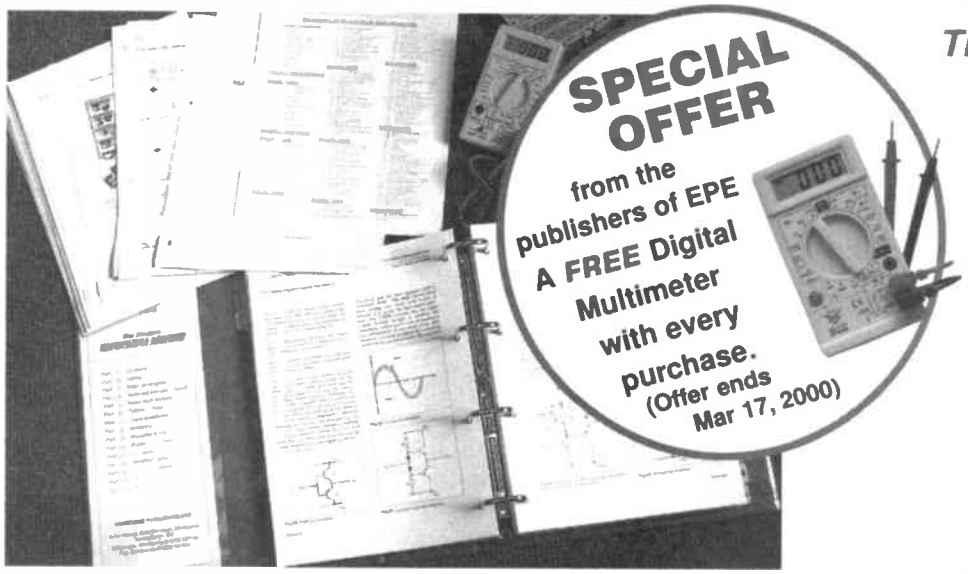

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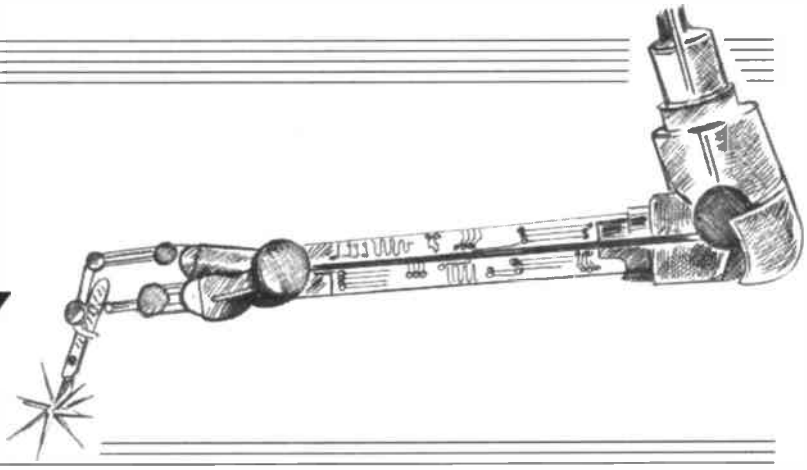

ALAN WINSTANLEY and IAN BELL

Onwards with our op.amps extravaganza we go, unearthing more of the inner workings of these essential electronic workhorses. Plus more questions and answers from our postbag as well.

FOLLOWING several readers' enquiries we received concerning op.amps, last month we provided a summary Op.Amp Selector chart which illustrates the often gargantuan differences between individual types. There are thousands of op.amps available, often optimised for a particular use and in demanding applications (e.g. instrumentation or low-power circuits) the choice of device type can be very critical.

It's a good idea to decide on the factors which are most important in your application (input impedance/slew rate/power consumption?) and then choose a likely-looking device using our selector as a guide, or check the major catalogues for guidance. Also, many manufacturers now have web sites from which data sheets can be downloaded, and using the data in our previous articles you will be able to navigate through the minefield of op.amp parameters and specifications more easily.

Op.Amps – Getting Loaded

We now continue to investigate op.amp characteristics and techniques. We described the basic *differential amplifier* last month, which we have drawn again in Fig.1. Op.amps should have a very high voltage gain, so the voltage gain of our differential amplifier should be as high as possible.

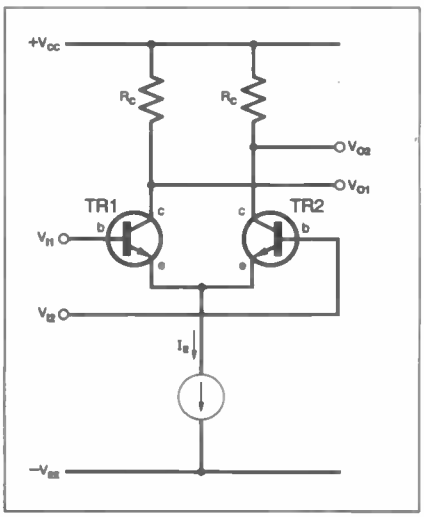

Fig.1. Differential amplifier formed from a matched pair of npn *transistors.*

Any transistor used in the amplifier will have a (more or less) fixed gain, but this is in terms of its *current* output, i.e. its *collector current*. Variations in the transistor's base-emitter voltage and base current will cause large variations in its collector current. The collector current flows through the collector resistor, R_c, giving rise to the output voltage, V_o.

By Ohm's Law, $V=IR$ so for a given current variation, then the larger we make R the larger the *voltage variation* will be. This means that the larger we make R_c, the larger the voltage gain of the differential amplifier. This seems straightforward enough – just use large values of R_c and we get a nice high gain: after all resistors are cheap and large values don't cost any more than smaller ones!

Unfortunately it's not that simple. First of all op.amps are usually integrated circuits where large resistors *do* cost more – they take up more space (silicon real estate!).

Furthermore, it is difficult for i.c. makers to fabricate precise resistance values, so there can be comparatively few resistors on a typical chip. Secondly, the transistors have to operate within a certain range of bias currents, below which they may give poor performance in terms of gain etc.

If we use large resistors and keep the supply voltage the same, we have to reduce the bias current, possibly to an unacceptable level. Alternatively, we can always increase the supply voltage, but do you really want an op.amp that needs a supply of 100V?

This seems like a no-win situation, but happily the **current mirror** circuit comes to our rescue. Although a current source has a very high resistance (ideally infinite, in fact), any current we choose can flow from it.

Thus, in our op.amp circuit we can set up a current source outputting the appropriate bias current, and use it in place of the collector resistor; the transistor gets the correct operating current it needs, and we get a high voltage gain due to the very large effective resistance of the current source. See May and June '99 *Circuit Surgery* for a detailed explanation of transistor current sources.

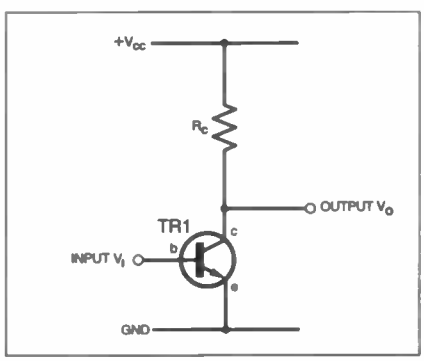

Fig.2. Simple single-transistor amplifier.

Biased Approach

Before seeing how we apply this to our differential amplifier, it is easier to have a look at a simple one-transistor amplifier, and at this point it is useful to recall the idea of biasing in more detail. Consider Fig.2, a very basic transistor amplifier. It is biased by applying a d.c. voltage to the base (not shown), and often a potential divider is used for this purpose.

The input signal varies around the bias voltage, so for example if the bias voltage was 0·65V and the signal was 0·02V peak-to-peak, then the bias voltage would vary from 0·64V to 0·66V. The bias current causes a certain collector current to flow (call this I_{bias}) which results in a certain voltage drop across the collector resistor.

As the signal varies, the collector current varies around I_{bias} causing the voltage drop across the collector resistor to vary as well. This action produces the (amplified) output voltage signal. We can think of the bias and the signal as two separate components of the collector signal, which when added together give the overall action of the circuit.

It does not matter where the bias "comes

from", so we could apply the bias current directly to the collector circuit by using a current source as shown in Fig.3. With no signal applied the base voltage would adopt the appropriate voltage (0·65V in our example), always assuming than the required base current could be supplied to the base (the means for this is not shown, but in a real circuit the base would obviously be connected somewhere to achieve this).

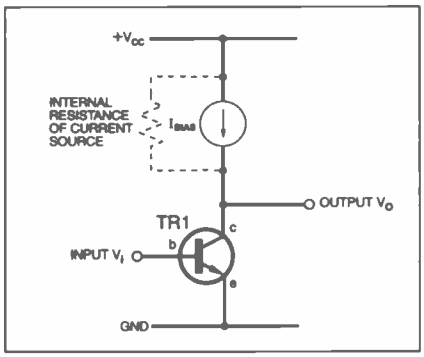

Fig.3. Simple transistor amplifier with current source load (active load).

Active Load

When we applied the signal to the amplifier, we would force the collector current to something other than I_{bias}, and in order for the current to be maintained through the constant current source the difference, i.e. the signal current, would flow in the internal resistance of the current source. Now this resistor is large and therefore results in a very large voltage gain (a small current change results in a large voltage change).

A current source used to get high gain from an ampifier in this manner is known as an *active load*. The schematic for a basic implementation of Fig.2 is shown in Fig.4.

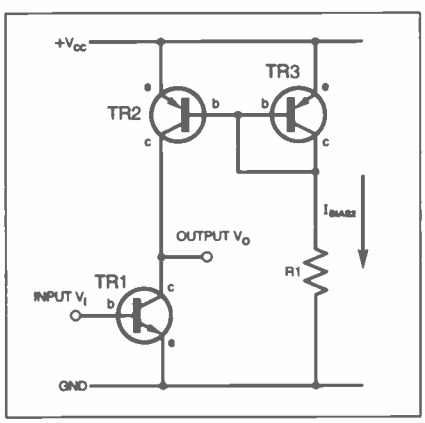

Fig.4. Schematic of transistor amplifier with active load.

We can use an active load with the differential amplifier, but the situation is a little more complex because we have to be careful not to upset the symmetry of the circuit. If we used two separate current sources for the two transistors, we may not be able to match the currents accurately enough to the emitter bias current.

The reason this matching is difficult (unlike the two transistors in the differential amplifier itself which are well matched) is that if the emitter current source and differential amplifier transistors are *npn* then the active load will be *pnp*, and it is difficult to match *npn* with *pnp* transistors. The solution is use a current mirror with its reference connected to one differential transistor and its output to other. This is shown in Fig.5.

It looks like even this approach breaks the symmetry of the circuit (TR3's base connection is not the same as TR4's), but as far as *current flow* is concerned the circuit is still symmetrical. When a differential input voltage is applied, the amplified output difference current on TR2's side is dropped across the current mirror's very large internal (output) resistance. So we get a highly amplified voltage signal at TR2's collector.

However, TR4 is wired like a forward biased diode (the transistor's base-emitter junction) and therefore has a low resistance. The *voltage gain* at TR1's collector is therefore low and this output cannot be used. With an active load the differential amplifier has to be used with a single ended output.

We'll be rounding off our op.amp mini-tutorial next month, by looking at the output side of things, including ways of implementing short-circuit protection. *IMB*.

Socket To Me

David Preston asks: *"I have a question on the use of dual in-line (d.i.l.) sockets. I have several designs which use an opto-triac operating at mains voltages. Could you tell me the maximum ratings of a d.i.l. socket? Would they be suitable for a d.i.l. opto-triac or should I solder the device straight to the board?"* (By E-mail.)

The typical contact rating of a d.i.l. socket is at least 1A or more. Harwin is a well-known maker and their catalogue of turned-pin sockets quotes a rating of 2A per pin, with an insulation resistance of 500V (which I would interpret as the maximum voltage allowed between two adjacent pins).

Another maker (Augat) is quoted at up to 3A with a dielectric strength of 1kV r.m.s. (1·4kV peak). However, I would hate to hang a 750W mains load on such a socket! I would prefer say 50W to 100W or so maximum as a safe rule of thumb.

There are two types of d.i.l. socket – the "leaf" type uses a pair of wiping spring contacts on every pin. The entrance to each contact is large, and the i.c. pins are gradually guided into alignment using automatic or manual insertion equipment.

More expensive precision "turned-pin" sockets make a good contact with the four corners of each i.c. pin and require that the chip must be pre-aligned, but they tend to be easier and smoother to work with. The idea is to produce a gas-tight seal around the four points of contact, to ensure a noise-free and reliable joint. The current ratings of both types is about the same, but I would say that the "leaf" type will have a stronger joint.

Personally speaking, with any opto-isolator or triac device controlling mains loads, I would want to solder it directly to the board, so that there are nice "meaty" solder joints that will help with the current-carrying capacity of the joint. The p.c.b.'s copper tracks will also help to heatsink the device as well, and for this reason audio amplifier i.c.s are always best soldered direct to the board rather than using a d.i.l. socket. *ARW*.

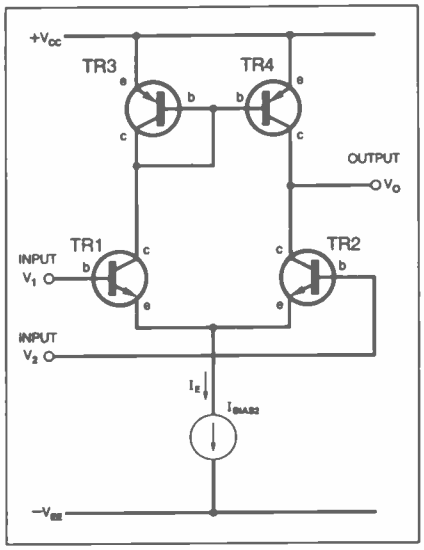

Fig.5. Differential amplifier with higher gain due to active load. Transistors TR3 and TR4 form a current mirror used as the active load.

Surface-Mount Selection

"I would like to ask what the term "MSOP" stands for: I have a school project in mind using a TC07 to detect temperature and wondered if the MSOP version would be suitable? Thank you!"

This question was posed in the *EPE Chat Zone* message board of our web site. MSOP simply means *Moulded Small Outline Package*. Anything with "SO" in its description means "Small Outline" and should immediately set alarm bells ringing!

It means you're looking at the tiny surface-mount version, which will be unsuitable for most school or hobbyist projects because of the steady hand needed to position and solder them reliably by hand, although you could try if you fancy a challenge. Otherwise be sure to buy the ordinary discrete version instead.

Here is a mini-glossary of some abbreviations used in this area:

CERDIP: Ceramic dual-in-line package
DIP: Dual-in line package
LCCC: Leadless ceramic chip carrier (20 to 84 pin, square body, no leads).
LDCC: Leaded ceramic chip carrier
PLCC: Plastic leaded chip carrier (square-style SM chip)
PQFP: Plastic quad flat-pack
QFP: Quad flat-pack
SMC: Surface mount component
SMD: Surface mount device
SMT: Surface mount technology
SOIC: Small-outline integrated circuit (generic surface-mount i.c.)
SOJ: Small-outline with "J"-shaped leads
SOMP/MSOP: Moulded small-outline package
SOP: Small-outline package (for surface mounting)
SOT: Small-outline transistor

Take it from someone who knows, it's dead easy to order a surface-mount device by accident so you need to pay close attention to the catalogues (and data sheets) when ordering. *ARW*.

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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 overseas orders or queries by Fax); E-mail: orders@epemag.wimborne.co.uk .** Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**

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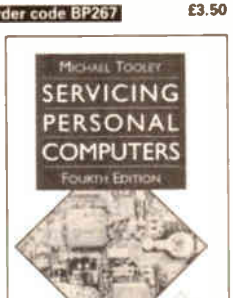

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Morris Rosenthal

More and more people are building the own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a state-of-the-art computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. For non-specialists, there's even a graphical glossary that clearly illustrates technical terms. The author goes "under the hood" and shows step-by-step how to create a socket 7 (Pentium and non-intel chipsets) and a Slot 1 (Pentium II) computer, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows 98.

The few existing books on this subject, although badly outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are eagerly looking for.

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UNDERSTANDING PC SPECIFICATIONS
R. A. Penfold (Revised Edition)

If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.

This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!

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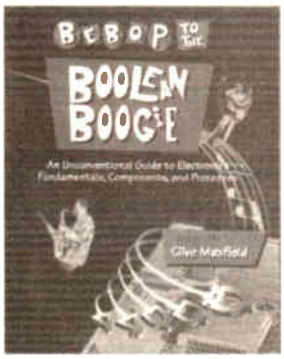

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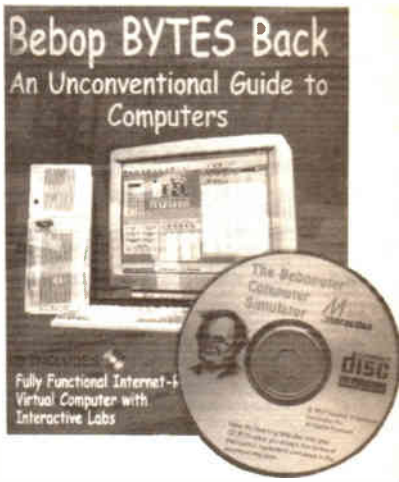

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Ian R. Sinclair

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Alan Dower Blumlein led an extraordinary life in which his inventive output rate easily surpassed that of Edison, but whose early death during the darkest days of World War Two led to a shroud of secrecy which has covered his life and achievements ever since.

His 1931 Patent for a Binaural Recording System was so revolutionary that most of his contemporaries regarded it as more than 20 years ahead of its time. Even years after his death, the full magnitude of its detail had not been fully utilized. Among his 128 patents are the principal electronic circuits critical to the development of the world's first electronic television system. During his short working life, Blumlein produced patent after patent breaking entirely new ground in electronic and audio engineering.

During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H2S' – blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

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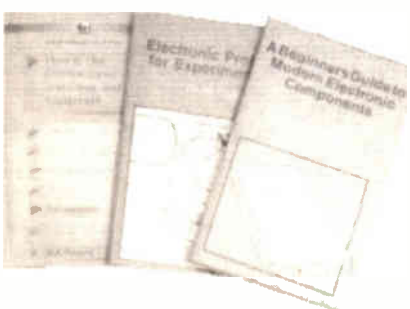

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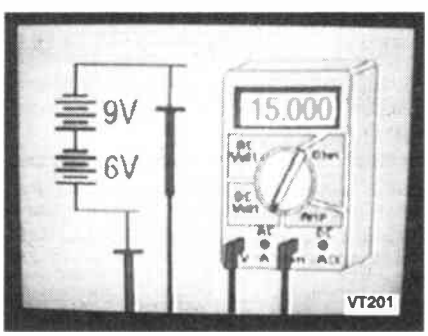

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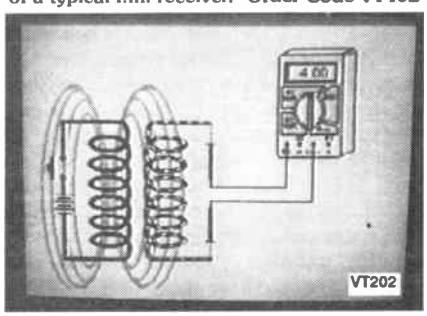

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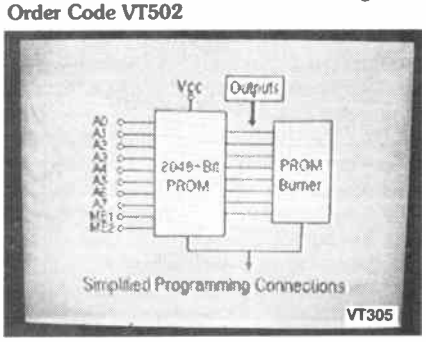

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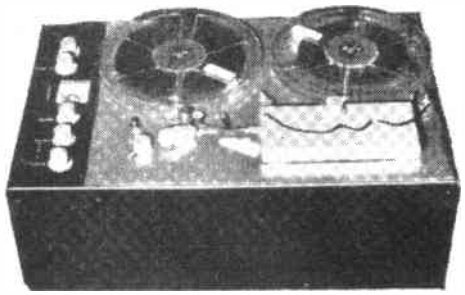

BARRIE BLAKE-COLEMAN

The true story of a British "first" in home video recording

BRITAIN stands pre-eminent in creative science and engineering but the depressingly long list of "lost" British firsts in invention shows how often thwarted or disillusioned British inventors and innovators have either abandoned their ideas or gone abroad, thereby reducing British competitiveness. Decades of British under-investment in British ideas and British technologies has meant that other nations either independently develop the same ideas, or directly capitalise on British technical creativity – and soon overtake us in our markets.

Just such a story is that of Norman Rutherford and his partner Michael Turner, who have learnt this lesson and are quick to remind us. They should know, back in the early 1960's they not only developed the first domestic video record and replay system, but also the first combined TV and VTR and the first Camcorder; but, it is claimed, poor foresight by their backers and investors lost them the edge.

Making a Picture

The announcement of the *Cathodian* Vidicon 3-inch TV camera tube early in 1960 took the attention of both Norman Turner and Michael Rutherford. The possibility of a new product for their Nottingham Electronic Valve Company (N.E.V.Co) was compelling. They wanted to develop a small CCTV system but the broadcast standard camera tubes were far too bulky and expensive.

The Cathodian device now made matters simpler. Cost was still a problem so, not requiring the full TV standard quality, they negotiated with Cathodian to buy all the slightly imperfect tubes (one or two drop-outs on the video array).

Oftimes a genius in circuit design, Michael developed the camera electronics using just four stages from two thermionic valves. This miracle of economy was based on an ECC82 double triode and an ECL82 triode pentode valve. The first provided a video amplifier and diode mixer, the second a triode r.f. oscillator and power output stage for the horizontal scan coils.

The vertical signal was obtained from a mains-ripple supply, giving a usable mains locked sawtooth. "It was a unique – if not eccentric, piece of design typical of Michael and myself, but it worked like an absolute dream," so commented Norman Rutherford recently.

The whole camera assembly, designated *NEV1 Mini-Eye* in its initial design, sold for £150 and outpriced and outperformed anything around. It was £250 less than its nearest competitor, but the "transistorised" version soon appeared from their development bench and at £72 was even more astonishing.

Advertisements elicited an inspiring response. Domestic and international sales rocketed – an order for 4000 cameras came in from Germany. An absolute triumph given that the Germans held the British electronics industry in low regard.

Take Over

The then senior engineer at Granada TV, Reg Hammons, saw a trade advert for the *NEV2* and thought the camera would be good for mobile outside broadcasts and rehearsals. He mentioned his viewing of the camera to Sidney (later Lord) Bernstein then head of Granada.

Bernstein flew to Nottingham and at a meeting with both Norman and Michael learnt that not only was manufacturing capacity very limited, but the development of the camera had so depleted the company's reserves that they were unable to meet anything approaching a substantial order. He then asked how much they would need to continue R&D and production. "Too much." said Norman "About half the value of the Company".

"What is that amount" asked Bernstein. "About £20,000," said Norman.

"That's petty cash." Bernstein said and instructed his accountant to write a cheque there and then.

The company now had a new owner, but though Bernstein had a 75 per cent stake, both the original partners were appointed directors with full management of the company's operations. All debts were paid off. More to the point they now had no limits to what they could spend on R&D.

In a Spin

Reg Hammons made frequent trips from Granada to liaise with the company on behalf of Bernstein. On one occasion he mentioned that he was aware of a large effort taking place in the US and Japan to develop a video system for recording broadcast TV at home. Ampex had developed the helical scan system for professional users in the US in the middle fifties and the same approach was being tried for domestic recorders.

Hammons thought there could be a large market for home video recorders and urged the two to have a go at developing a system for the British market. The idea found a receptive audience, the mini-eye camera had sold well but now orders were tailing off.

"There is a popular point of view, originated by Emerson, which assumes that building the first, or a better mousetrap, results in people beating a path to your door – this must be the most pernicious fallacy ever to misrepresent invention."

It was known that Ampex had solved the video tape problem using four rotating heads producing a helical scan – but this was an expensive option for a home video system. At first they tried a narrow bandwidth design based on a domestic audio recorder to emulate the high speed wire and metal tape recorders already used by the big broadcasting operations.

It was the path of least resistance – no one actually knew what the maximum frequency limit was on very high speed recording and so they converted two ¼in. reel-to-reel Grundig and Ferrograph AF recorders to run at 60 and 120 inches per second (i.p.s). Surprisingly, enough video information could be recorded at 60 i.p.s to create a shadow of a picture; at 120 i.p.s. it was "just recognisable" but a lot more work needed to be done.

But months of work gave little in the way of encouragement. Then, in January of 1962, Michael Turner discovered in the course of examining head driver methods that a considerable improvement in signal-to-noise could be achieved by introducing significant pre-emphasis on the driver signal.

The improvement was so profound that it implied that a broadcast quality picture could be achieved quite soon. Unfortunately it was also a damaging revelation – the improvement was genuine but simply took the existing operational limits in a different direction.

Head to Head

The main problem was identified as the record and replay heads. The head gap was too wide to give the high frequency response necessary to approach the ideal 3MHz needed to reproduce the full video bandwidth of the 405-line system. It was also determined that the lowest response able to give a wide enough grey scale to enable the picture to have clarity was 2·5MHz.

Something needed to be done to eliminate the head problem and give the designers a chance to grapple with the other aspects of the video processing. A narrow gap head was produced from an existing Ferrograph unit but even without a.c. bias on the tape (rather, a heavy d.c. bias directly applied to the tape by means of a permanent magnet) and heavy pre-emphasis on the video signal, the best that could be achieved was 2MHz. "It just got by" Norman Rutherford recounted, but it had to be better.

Unfortunately they had a seemingly intractable problem. The narrower the head gap, the lower the magnetic path reluctance around the gap became. Thus, the greater the flux shunt around the gap, the more the signal field was shared between the gap and the leakage path.

The result was that as the response was increased with a narrowing gap, so the signal-to-noise ratio worsened. A mu-metal Ampex head (intended for h.f. telemetry and imported from the States) was one possible solution, but it was prohibitively expensive. The only recourse was to design one themselves!

Many months of work led inevitably to a design which avoided the conventional problems associated with ordinary heads – they plumped for a cross-field head where the passive section was made of two screw adjustable copper arms nominally separated at the rear by a 200 micron gap with a tape face gap of just under 50 micron. The active section carrying the coil laterally straddled the two copper arms and this design gave the necessary bandwidth.

Nevertheless, d.c. bias was still employed as too a considerable amount of pre-emphasis. But by contriving an overwind on the final video driver stage's inductive load, the effective bandwidth shot up to well in excess of 2·6MHz. The replay signal was, of course, still highly differentiated and this was equalised by

Telcan unit playback demonstration at its launch in 1963. The early prototype (1962) model is shown in the heading.

First Meeting

Norman Rutherford and Michael Turner were school friends in the war years, having met one Wednesday afternoon on the school football field during a sports period. They found themselves in trouble when the sports master espied them rooted to the spot in midfield, deeply engrossed in discussing a design for a radio control circuit – a small error for both, since Michael was on one side and Norman was the opposing goalie!

Norman's father owned a radio retailers and then, later in the fifties, a television retail and repairs shop in Nottingham. Michael's father was the proprietor of a garage, and thus both boys developed against a background of technology and engineering.

Later, in 1952, the two boys met again as college chums at the *Peoples College* in Nottingham, where both developed an abiding interest in electronic design, becoming immersed in the white heat of the post war broadcasting and electronics age. They bought government surplus components and constructed the first television receiver in the East Midlands to operate from the London transmitters.

Norman Rutherford went on to study, at the (then) *Nottingham and District Technical College*, and lost contact with Michael for a few years until early 1957. Then, with a £100 stake scraped up and borrowed they started a partnership and the late fifties dawned with both men making a living reconditioning television Cathode Ray Tubes (CRT's).

They started in a converted garage with Norman, Michael and one employee learning the delicate art of cutting off tube necks, removing the electron guns and rejuvenating the cathodes. New TV tubes were notoriously unreliable (usually cathode poisoning due to poor vacuum or faulty assembly) and a replacement CRT cost in excess of £20 to purchase (equivalent to £230 today). However, the Nottingham partners were bringing the price of reconditioned CRT's down to 9 pounds and 10 shillings (£9.10s.0d) and in a good week could recycle well over 50 tubes through the process.

Not all CRT re-conditioning had been immediately within their grasp – Mullard tubes had removable cathodes, Mazda ones did not. But they soon solved the problem. A US company (Superior Electronics) began to sell complete electron-gun assemblies. Buying the new guns gave them an even greater edge – they had developed all the machinery and process technology (including the r.f. induction heating and most of the vacuum technology) for a universal CRT re-gunning process.

Now they started to make more money selling and instructing on complete re-gunning systems (proudly made by their now well established and well respected Nottingham Electronic Valve Company). The old workshops, in a disused cinema at Netherfield became hopelessly limited and the company, now with 12 employees and an accountant, moved to an old malt house at East Bridgford near Nottingham.

Norman Rutherford (right) and Michael Turner (left) with their wives and a Telcan "Combi" set at the press launch, June 1963.

employing a series of 3db/Octave integrators and phase correction circuits to recover the original signal.

Tape speed still needed to be high (120 i.p.s. for broadcast standard recording) but by using 12,000ft of ¼in. triple play tape on 10½in. spools (for increased play time and better head wrap) the record time was extended to over 20 minutes. An added advantage was the narrow video and audio track widths (the latter f.m. modulated on a second head), this narrow track enabled the tape to be turned over and recorded on the other side.

More to the point, the replay produced a very good video signal – normally (with high contrast pictures) hard to distinguish from the original 405 transmission even at lower speeds. Head fouling remained a problem with the relatively high oxide loss of early tapes, but the passive section of the head was designed to be quickly removable and cleaned

On Their Own Again

Demonstrations to Granada were unexpectantly cool, for reasons never fully explained by Bernstein. N.E.V.Co lost their sponsor at the very time it expected further investment. The reason given at the time was poor picture quality, but this was specious and clearly not the issue.

Whatever the reason, Norman Rutherford and Michael Turner had lost a major investor and somehow had to keep the business going. The Granada decision could not have come at a worse time, the tube reconditioning business had virtually collapsed with the ever improving quality and durability of new tubes, and the company payroll was now supporting some 70 plus people. That Bernstein allowed the directors of NEV to buy back his interest for the original buying price was no consolation.

Initially thinking themselves fortunate, they were quick to find a new partner with the US based Cinerama corporation which had made its shareholders a massive return with the film *'How the West Was Won'*. Cinerama bought in to N.E.V.Co to the value of £200,000 even though at this time Cinerama were, as an organisation, running at a substantial loss.

The "Combi" television/video recorder.

Well Kitted Out

Time had been lost, and though not personally financially embarrassed by the new US shareholding, the two partners were aware of their financial and business vulnerability – they were on their own once again and looking to develop their products and product range further. Hoping to salvage the profitable divisions of the company Norman, as Managing Director, split the operation by forming Telcan (Research and Development) and Telcan TV, the latter being mainly involved in manufacturing.

Close-up shot of the TV screen during Telcan replay.

Trading again in early 1963, the partners (now including a financial manager, Brian North) set out to provide the video units in kit form (as the *Telcan TKR 500*). The new operation manufactured every major component necessary including the record/replay heads, printed circuit boards, video circuits, tape transport and a variable capstan size system (¼h.p. motor). With variable speed operation (60, 120 or 180 inches per second) the kit, if correctly assembled, produced a recorder of very satisfactory performance.

A public demonstration and press conference at the Aldwich Hotel, London, held on June 24th 1963 created a wealth of interest and publicity, but the attitude of the press and the public appeared to be diffident. It was staggering that few could actually see the need for "home video recording" – even if they had the slightest notion of how technically awesome the development of Telcan was!

Norman Rutherford demonstrated Telcan on the BBC *9 O'clock News* (replaying the opening few minutes of the broadcast) but this was as ineffective as a next day ATV interview was ridiculous – the interviewer continually asking the originators if they thought Telcan a "gimmick". They were later to maintain that the interviewer could not grasp the concept of electronic recording, and mistakenly believed that the Telcan method involved the use of an 8mm movie camera (similar to a system already in use).

Orders for the Telcan units were slow. The kits sold for £60 (some £700 today) – only the technically skilled and well off could afford them. A number of pre-built units did sell well, as too did special "Combi" examples fitted into TV's, but of the total number sold the greater majority were kits.

As sales of the TKR 500 faltered, the partners designed a miniature battery driven portable record player for 7 inch 45 r.p.m. records which, entirely self contained and enclosed, operated like a modern floppy disk drive. A fair number were produced and for a short while were popular.

Orders from Overseas

However, Cinerama, already a stockholder in N.E.V.Co, proposed through its Chairman Nicholas Riesini, the formation of a joint company for exploitation of Telcan in the US and, given the other possible financial holdings of stock in N.E.V.Co, agreed to purchase any stock willing to be released by other interests. This ultimately resulted in a fairly large injection of new cash for the company and R&D was the first to benefit. For a moment there appeared to be yet another new beginning for the company.

Unfortunately, what was desirable in one context was not in another and the two partners found themselves embroiled in business negotiations and legal entanglements to the detriment of the company's main business. In December of 1963 Norman and Michael were asked to demonstrate the video recorder at a crucial shareholders meeting of the ailing Cinerama Corporation at the Capital Theatre, Broadway in New York.

However, they were asked to try something novel – to video the shareholders themselves at the meeting. Being away from base, and unable to get one of their own *Mini-Eye* 4 inch cameras, Norman got hold of a 525-line studio standard Vidicon camera and videoed all and sundry, amazing everyone by playing back the pictures at the meeting.

The technology was enough to placate all the unhappy shareholders – now absolutely convinced that Cinerama had a real winner. However, all was not sweetness and light, Cinerama itself was not actually able to invest any further – even though its individual principals were well able to. The partners returned from the US with the mistaken expectation of a large order for the new *"Telcan"* system but it failed to materialise.

As Cinerama floundered the Chairmanship changed to that of William Foreman, a creditor of Cinerama. Foreman was not slow to convey his personal distrust of the Telcan business to the new Executive.

Sensing mounting hostility from their new principals, the two partners decided to look further afield for investment and gave demonstrations in the US to the Filco (Ford Motor Co.) and Admiral Corporations. But the interest and enthusiasm was less than it might have been in the face of an ever growing hostility and starvation of funds.

Acknowledgements.
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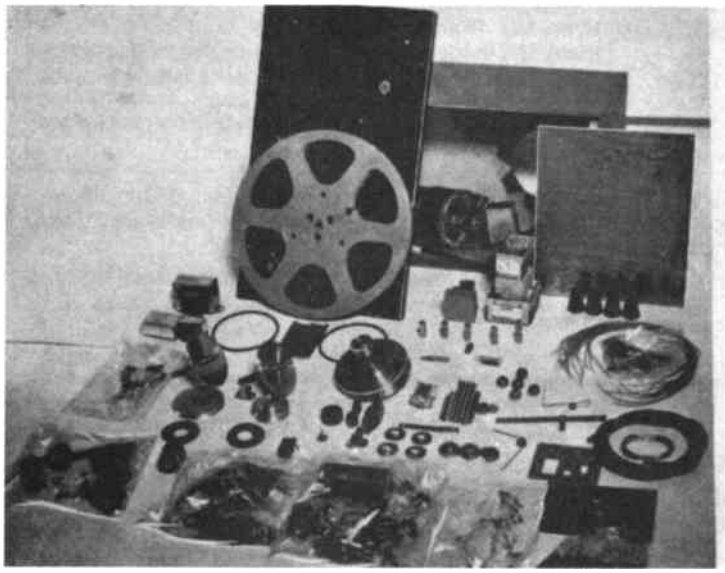

The Wesgrove (Telcan) kit of components (1963).

One of the last remaining examples of the Telcan video recorders on show at the Wollaton Hall Industrial Museum, Nottingham.

In hindsight, Norman Rutherford admits that had they "toadied" a little to their new partners things may have gone better. In short, there was only one way out and in August of 1964 Norman Rutherford, as Managing Director, put the company into voluntary liquidation.

Overstretched

Undaunted, and with the greater number of their 70 odd original staff still at hand, the two partners set up again at Basford under the name Wesgrove. Again this was a kit form recorder business though, as always, customers could purchase a fully assembled version.

Unfortunately, by this time, the Ampex helical scan system had already appeared in competing domestic video recorders. One leader was the Sony ½in. reel-to-reel video recorder; Philips were also competing while a further system was marketed by Loewe Opta in Germany.

The message was obvious, the Telcan linear system needed to be updated to record in the helical scan mode in order to rival other products. But this was beyond the resource of the already ailing and overstretched Telcan/Wesgrove operation. Talks with various potential backers, even Japanese interests, got nowhere. The Wesgrove business, like its predecessor, was put into voluntary liquidation just 19 months after the Cinerama debacle.

Epilogue

Only two of the original Telcan units built by Norman Rutherford and his Company survive to this day – one in San Francisco, owned by Al Cox the owner of a music shop and and f.m. radio station, and one now to be seen at the *Wollaton Hall Industrial Museum* in Nottingham. Norman and his partner Michael Turner became disaffected and parted company just after the firm was wound up.

Norman continued to do some consultancy work in electronics; he eventually gave up and went into property development with his brother, only returning to his first love in the early 1980's when he became involved in developing an infra-red transmission system for closed circuit TV. He finally found lasting fame by way of an entry into the *Guinness Book of Records* in 1982.

Much could be said about this lost opportunity for British enterprise in terms of too little too late, but the reality is different. The technical principle was only good enough to prove the value of the product – for all the negativity faced at the Telcan launch, everyone quickly came to see how useful a home video unit could be and that a massive market awaited.

Although the original technical principle of Telcan defined the operational limits, the linear record system was never going to have the technical flexibility required by the market (for convenient long play, high resolution monochrome or colour recording). Also, the short record /replay time, and poor long term head dependability were very much a weakness.

Yet, for all that the promise was there, and had the investment vision come anywhere close to the technical vision, then a good deal more might have been accomplished.

As it was, the two partners, Norman Rutherford, Michael Turner and their associates did unequivocally demonstrate and sell the first commercial *home* video recorder, the first Camcorder (and the first "Combi" TV and video recorder). What price "vision"?

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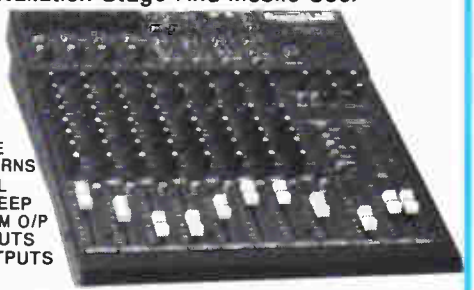

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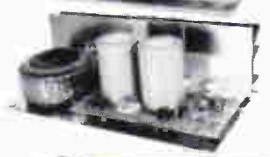

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PRICE:- £83.75 + £5.00 P&P

OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
PRICE:- £135.85 +£6.00 P&P

OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
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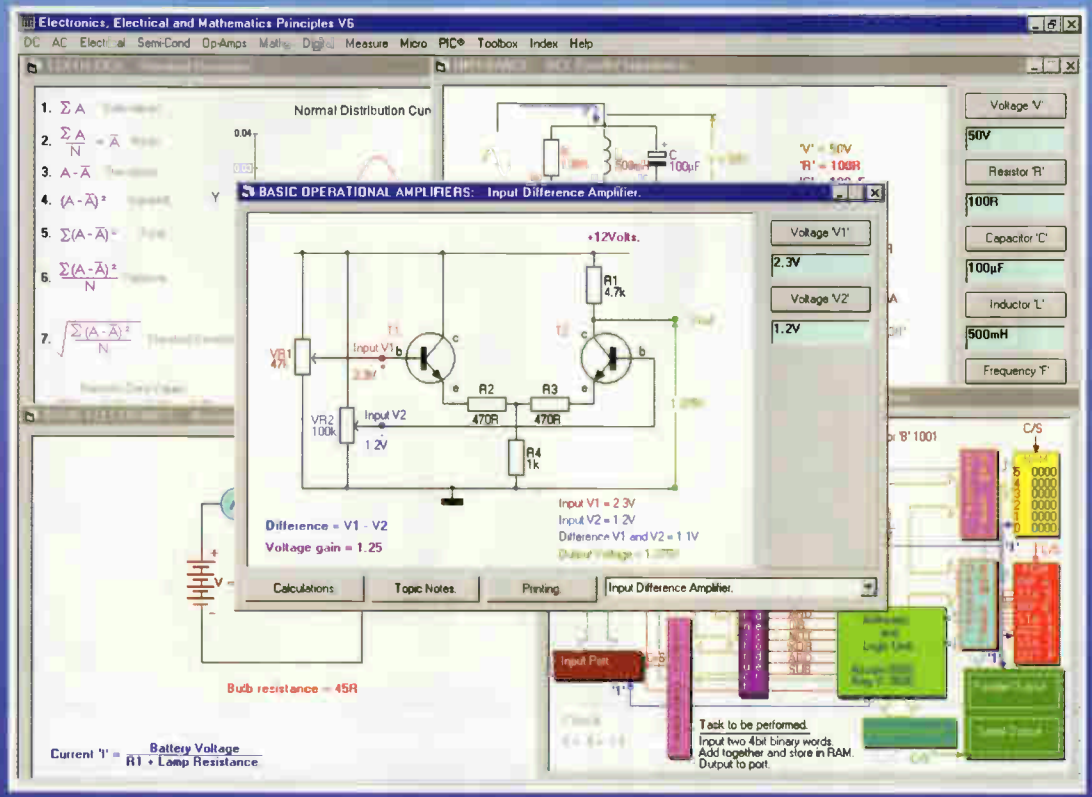

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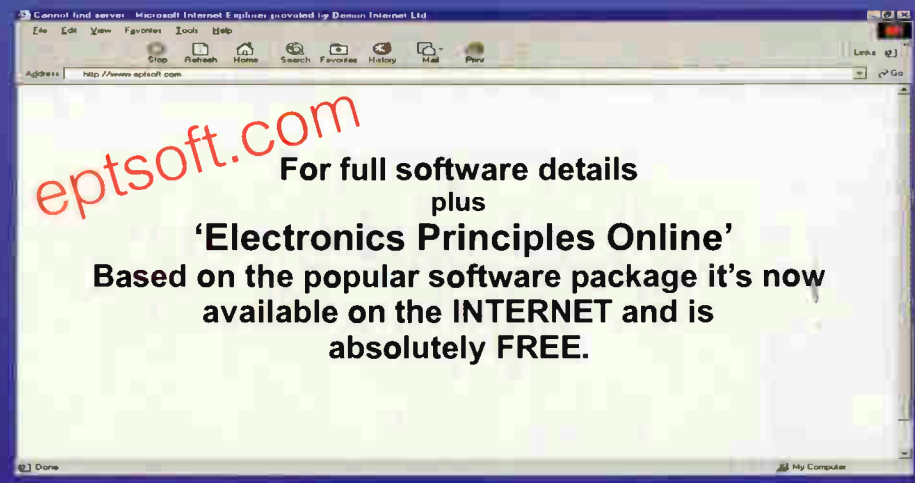

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