EVERYDAY

PRACTICAL ELECTRONICS

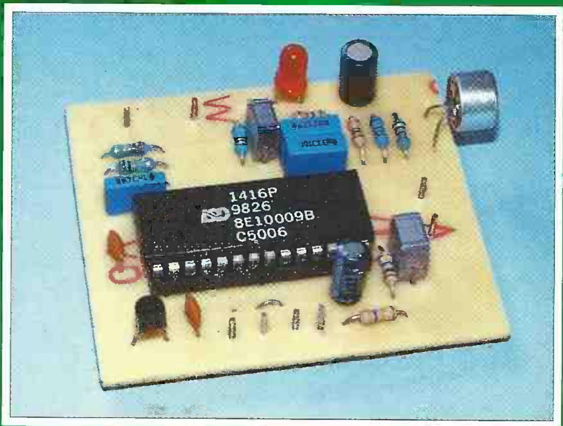
APRIL 1999

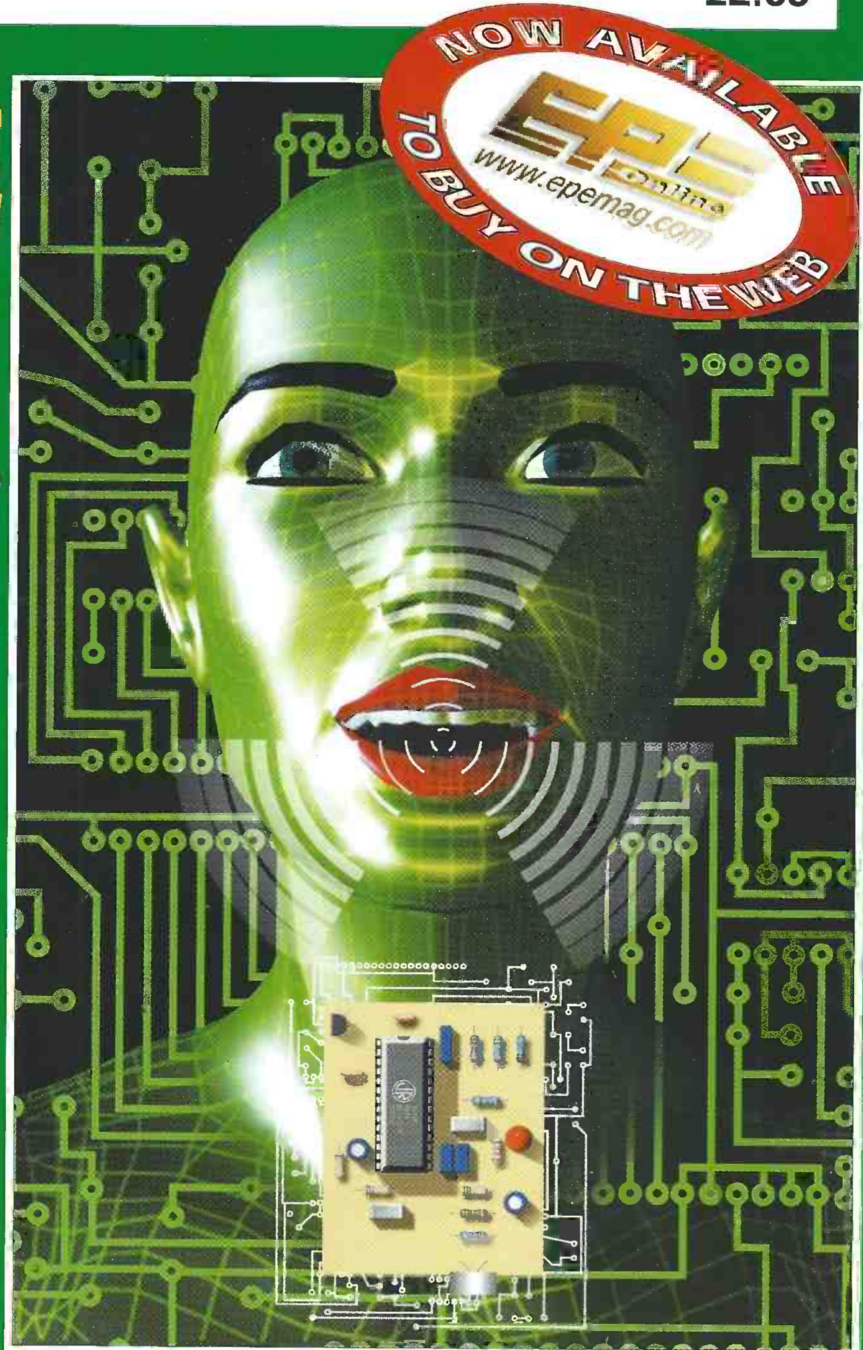
With ETI ELECTRONICS TODAY INTERNATIONAL

£2.65

VOICE RECORD/ PLAYBACK MODULE

A digital voice warning or memo pad





PIC 16F87x MICROCONTROLLERS

Reviewing Microchip's new Flash PICs

MECHANICAL RADIO

Wind the handle to charge it up

VERSATILE EVENT COUNTER

Times or counts pulses, sounds, etc.

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

04

9 770262 361089

PLUS Ingenuity Unlimited • Circuit Surgery • News

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

HYDROPONICS DO YOU GROW YOUR OWN? We have a full colour hydroponics catalogue available containing nutrients, pumps, fittings, enviromental control, light fittings,

WINDOWS 95 CD As supplied with Hewlet Packard PC's these CD's have all the window files on them and were intended to be used to restore windows on a PC after a crash etc.£15 REF SX06

SATELLITE MODULATOR MODULES prices from just 9p Surface mount modulators full of components. Fitted with an F type connector and a uhf type connector. Pack of 100 £9.95 ref SS20

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

REMOTE HEATING CONTROLLERS WITH 30A MAINS RELAY from just 99p These units were designed to be plugged into a telephone socket. You then called the phone and some how it turned the heating on. Each box contains lots of bits including a mains 30A relay. pack of 20 £20 ref SS34

.TALKING COINBOXES Prices from just 95p These units were made to convert standard telephones into pay phones, complete with coinslot assemblies and switches etc. OFFERED TO YOU AT A BARGAIN PRICE BECAUSE WE NEED THE SPACE! Pack of 10 £19 ref SS29

AC MOTOR BONANZA! prices from just 59p Again we have piles and piles of these brand new mixed motors which we need to clear in bulk at ridiculous prices! Pack of 50 for £30 ref SS13

PIR CAMERA Built in CCTV camera (composite output) IR strobe light,PIR detector and battery backup. Designed to 'squirt' pictures down the 'phone line but works well as a standalone unit. Bargain price £49.95 ref SS81, 3 or more £44.95 ref SS80.These units are brand new modules designed to take 'pictures' of intruders and then transmit the pictures down the telephone line. The PIR detects the intruder, fires the strobe light this ensures a perfect picture even in total darkness. The picture is stored in memory inside the module and then sent by modem (not included) down the telephone line. The units also have a nicad battery pack included presumably to maintain operation in the event of mains power failure. Output from the camera is standard b/w composite 320x240 pixels with a 90x65 degree field of view, the picture quality is excellent.Each PIR also contains a video capture and compression unit.The infra red strobe has a range of 15m.The pir has a range of 12m.Power requirements are 12v dc 400mA. Power supplies available at £5 ref SS80The units are supplied with connection details etc but we do not have any information on using the compression and capture unit or interfacing to modems etc.The units do have operational PIR's, strobes and camera's (camera is 12vdc and gives out standard composite 1v p-pvideo) how you adapt these to work together is entirely up to you!Retail price for the units was in excess of £200 each sale price £39.95ref **SS81**JPower supplies £5 ref SS80

TELEPHONES Just in this week is a huge delivery of telephones, all brand new and boxed. Two piece construction with the following features- Illuminated keypad, tone or pulse (switchable), reacall, redial and pause, high/low and off ringer switch and quality construction. finished in a smart 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 also available at £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 sufficent in electricity! £12 ref LOT81

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

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

CENTRAL POINT PC TOOLS Award winning software, 1,300 virus checker, memory optimiser, disc optimiser, file compression, low level formatting, backup scheduler, disk defragmenter, undelete, 4 calculators, D base, disc editor, over 40 viewers, remote computing, password protection, encryption, comprehensive manual supplied etc £8 ref lot 97 3.5" disks. £10 ref LOT97

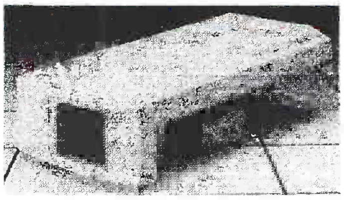
VIDEO PROCESSOR UNITS?/6v 10AH BATTS/ 24V 8A TX Not too sure what the function of these units is but they certainly make good strippers! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear. Inside 2 x 6v 10AH sealed lead acid batts, pcb's and a 8A? 24v torroidial transformer (mains in). sold as seen, may have one or two broken knobs etc due to poor storage. £15.99 ref VP2

DIFFERENTIAL THERMOSTAT KIT Perfect for heatrecovery, solar systems, boiler efficiency etc. Two sensors will operate a relay when a temp difference (adjustable) is detected. All components and pcb. £29 ref LOT93

SOLAR WATER HEATING PLANS £6 REF SOLP

PC POWER SUPPLIES PACK OF 8 £9.95

Thats right! 8 power supplies for £9.95! These are all fan cooled (usually 12v) our choice of specs etc, and are sold as seen. But worth it for the fans alone! ref XX17



COLOUR CCTV VIDEO CAMERAS From £99

Works with most modern video's, TV's, Composite monitors, video grabber cards. Pal, 1v P-P, composite, 75ohm, 1/3" CCD, 4mm F2.8, 500x582, 12vdc, mounting bracket, auto shutter, 100x50x180mm, 3 months warranty,1 off price £119 ref XEF150, 10 or more £99 ea 100+ £89

We get over 5,000 hits a day..... check us out!

http://www.bullnet.co.uk

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

ELECTRIC FENCE KIT Everything you need to build a 12vdc electric fence, complete with 200m of fence wire. £49 ref AR2

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

33 KILO LIFT MAGNET Neodynium, 32mm £15 ref MAG33

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, ranging from solar fountains to hydroponics! Small and compact yet powerful.works direct from our 10 watt solar panel in bright sun. Max hd:l7 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,
20 character 2 line, 83x19mm £3.99 ref SMC2024A
16 character 4 line, 62x25mm £5.99 ref SMC1640A
40 character 1 line 154x16mm £6.00 ref SMC4011A

LM255X HITACHI LAPTOP SCREENS 240x100mm, 640x200 dots. New with data £15 ref LM2

SEALED LEAD ACID BATTERIES 12V 7AH, S/HAND PACK OF 4 £10 REF XX1

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

REGISTER FOR OUR ELECTRONIC NEWSLETTERS BULL-ELECTRICAL.COM

BULL ELECTRICAL

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

MAIL ORDER TERMS: CASH, PO OR CHEQUE WITH ORDER PLUS £4.00 P&P PLUS VAT.

24 HOUR SERVICE £6.50 PLUS VAT.

OVERSEAS ORDERS AT COST PLUS £3.50

(ACCESS,VISA, SWITCH, AMERICAN EXPRESS).

'phone orders : 01273 203500

FAX 01273 323077

Sales@bull-electrical.com

200 WATT INVERTERS plugs 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

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 simulated 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

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

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

SONY STEREO TV CHASSIS assemblies comprising complete TV PCB excluding tube and scan coils. Nicam stereo, mains input. Appear to be unused but sold 'as seen' Would probably be good for spares or as a nicam stereo TV sound receiver and amplifier. For KV29F1U and KV25F1U(BE3D) PCB no's 1-659-827-12 1-659-826-14 1-711-800-11 £20 ref STV1

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

RADIO CONTROLLED CARS etc No remotes but good strippers for servo's motors and receivers. Sold as is, no returns, mixed types. £3 each ref RCC2

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

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

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

SOLAR POWER LAB SPECIAL 2x 6"x6" 6v 130mA cells, 4 LED's, wire, buzzer, switch + 1 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

5.25" FLOPPY DISKS, pack of 500 disks £25 ref FDJ

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

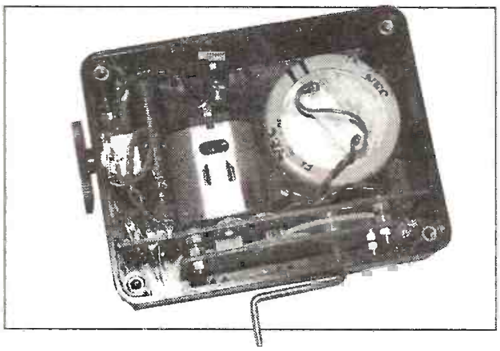
VOL. 28 No. 4 APRIL 1999

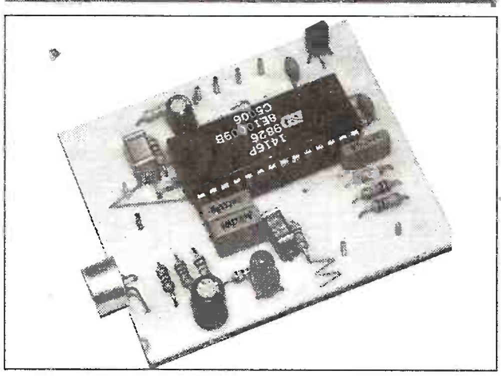
EVERYDAY PRACTICAL ELECTRONICS

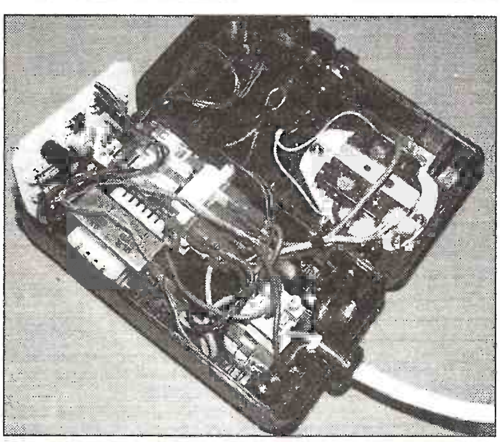
ETI ELECTRONICS TODAY INTERNATIONAL

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

The No. 1 Magazine for Electronics Technology and Computer Projects







Our May '99 issue will be published on Thursday, 1 April 1999. See page 227 for details.

Projects and Circuits

MECHANICAL RADIO by Bart Trepak — 236
Wrist power provides a renewable radio energy source!

VOICE RECORD/PLAYBACK MODULE by Robert Penfold — 248
Less cuddly than a Firby, but more useful!

VERSATILE EVENT COUNTER by John Becker — 260
Counting and timing music beats, rowing rates, clock ticks and more

PhizzyB COMPUTERS – 6 by Clive "Max" Maxfield, Alvin Brown and Alan Winstanley — 280
It's time to add feelers to PhizzyBot's guidance control

INGENUITY UNLIMITED hosted by Alan Winstanley — 284
Audio Limiter; I.R. Remote Control Tester; Video Amplifier

IRONING BOARD SAVER by Robert Hunt — 294
Save energy with this safety add-on

Series and Features

NEW TECHNOLOGY UPDATE by Ian Poole — 247
Micro-electromechanical systems offer computer security solutions

MODULAR CIRCUIT DESIGN CD-ROM by Robert Penfold — 253
Software to help hobbyist designers achieve their circuit goals

PIC16F87x MICROCONTROLLERS by John Becker — 257
Microchip's new EEPROM PICs have even more to offer than the '84s

MAX761 D.C. TO D.C. CONVERTER by Andy Flind — 269
How to squeeze the max out of your batteries

PhizzyB COMPUTERS – 6 by Clive "Max" Maxfield and Alvin Brown — 274
Routine discussions give you and PhizzyBot impact guidance

DATA-NET REVIEW by Robert Penfold — 286
A ten CD-ROM library of semiconductor data is put to the test

INTERFACE by Robert Penfold — 288
AD8300 serial digital to analogue converter – PC controlled

CIRCUIT SURGERY by Alan Winstanley — 300
Solid State Relays; Photovoltaic Relays; Electret Microphones – the plot thickens; Endangered Species

NET WORK - THE INTERNET PAGE surfed by Alan Winstanley — 307
Freeserve support costs less; Freeserve sans CD; BT Click goes free; Checking out at Tesco

Regulars and Services

EDITORIAL — 233

NEWS – Barry Fox highlights technology's leading edge — 242
Plus everyday news from the world of electronics

ELECTRONICS VIDEOS Our range of educational videos — 266

READOUT John Becker addresses general points arising — 271

CD-ROMS FOR ELECTRONICS — 290
Parts Gallery + Electronic Circuits and Components; Digital Electronics; *plus* PICtutor, *plus* Modular Circuit Design

BACK ISSUES Did you miss these? — 292

SHOPTALK with David Barrington — 298
The *essential* guide to component buying for *EPE* projects

PLEASE TAKE NOTE Wireless Monitoring System (Feb '99) — 298

DIRECT BOOK SERVICE — 304
A wide range of technical books available by mail order

PRINTED CIRCUIT BOARD SERVICE — 308
PCBs for *EPE* projects – some at "knockdown" prices! Plus *EPE* software

ADVERTISERS INDEX — *312*

FREE
SOLDERING GUIDE BOOKLET — ***Cover Mounted***

Readers Services • Editorial and Advertisement Departments — ***233***

Surplus always wanted for cash!

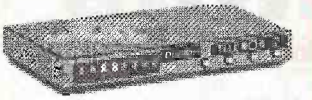
THE *ORIGINAL* SURPLUS WONDERLAND!

Surplus always wanted for cash!

THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER
CABLE COMPATIBLE*

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

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

For overseas PAL versions state 5.5 or 6 mHz sound specification.
*For cable / hyperband signal reception Telebox MB should be connected to a cable type service. Shipping on all Teleboxe'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 software control via a **simple 2 wire link** to any IBM 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)

FLOPPY DISK DRIVES 2½" - 14"

Massive purchases of standard 5¼" and 3½" drives enables us to present prime product at industry beating low prices! All units (unless stated) are *BRAND NEW* or removed from often brand new equipment and are fully tested, aligned and shipped to you with a full 90 day guarantee. *Call* for over 2000 unlisted drives for spares or repair.

3½" **Panasonic** JU363/4 720K or equivalent RFE	£24.95(B)
3½" **Mitsubishi** MF355C-L. 1.4 Meg. Laptops only	£25.95(B)
3½" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop	£18.95(B)
5¼" **Teac** FD-55GFR 1.2 Meg (for IBM pc's) RFE	£18.95(B)
5¼" **Teac** FD-55F-03-U 720K 40/80 (for BBC's etc) RFE	£29.95(B)
5¼" **BRAND NEW Mitsubishi** MF501B 360K	£22.95(B)
Table top case with integral PSU for HH 5¼" Flopp or HD	£29.95(B)
8" **Shugart 800/801** 8" SS refurbished & tested	£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" **TOSHIBA**.(19 mm H) MK2101MAN 2.16 Gb. *New*	£199.00
2½" **TOSH.**(12.5 mm H) MK1002MAV 1.1 Gb laptop. *New*	£115.00
2½" to 3½" conversion kit for Pc's, complete with connectors	£12.95
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 40mb IDE I/F (or equiv.) RFE	£69.00
3½" **RODIME** RO3057S 45mb SCSI I/F (Mac & Acorn)	£69.00
3½" **QUANTUM 40S Prodrive** 42mb SCSI I/F, New RFE	£49.00
3½" **WESTERN DIGITAL** 850mb IDE I/F *New*	£185.00
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 (D)

IC's -TRANSISTORS - DIODES

OBSOLETE - SHORT SUPPLY - BULK

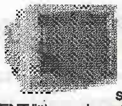
6,000,000 Items EX STOCK

For *MAJOR SAVINGS* - CALL OR SEE OUR WEBSITE

VIDEO MONITOR SPECIALS

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

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



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

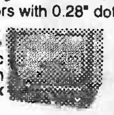
As New - Ex Demo
17" 0.28 SVGA Mitsubishi Diamond Pro monitors
Full multisync etc. Full 90 day guarantee. £325.00 (E)

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

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with **both RGB and standard composite 15.625 Khz video inputs** via **SCART socket** and separate phono jacks. Integral audio **power amp and speaker for all audio visual uses**. Will connect direct to **Amiga and Atari** BBC computers. Ideal for all **video monitoring / security** applications with **direct connection to most colour cameras**. High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested - guaranteed
Dimensions: W14" x H12¾" x 15½" D. **Only £99** (E)

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

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



20" 22" and 26" AV SPECIALS

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

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

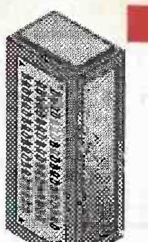
DC POWER SUPPLIES

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

LOW COST PC's

Always over 1000 PC's from stock. 1000's of spares and accessories. Call or see our web site for info.

19" RACK CABINETS



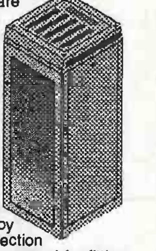
Superb quality 6 foot 40U Virtually New, Ultra Smart
Less than Half Price!

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

OPT Rack 1 Complete with removable side panels.	**£345.00** (G)
OPT Rack 2 Rack, Less side panels	**£245.00** (G)

Over 1000 racks, shelves, accessories 19" 22" & 24" wide 3 to 46 U high. Available from stock !!.

32U - High Quality - All steel RakCab



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

A superb buy at only £245.00 (G)

42U version of the above only £345 - CALL

BATTERY SCOOP - 50% off !!

A special bulk purchase from a **cancelled export order** brings you the most **amazing savings** on these ultra high spec **12v DC** 14 Ah rechargeable batteries. Made by **Hawker Energy Ltd, type SBS15** featuring **pure lead** plates which offer a far superior shelf & guaranteed 15 year service life. **Fully BT & BS6290 approved.** Supplied **BRAND NEW** and boxed. Dimensions 200 wide, 137 high, 77 deep. M6 bolt terminals. Fully guaranteed. Current makers price over £70 each ***Our Price £35 each*** (C) ***or 4 for £99*** (D)

RELAYS - 200,000 FROM STOCK

Save ££££'s by choosing your next relay from our Massive stocks covering types such as - Military, Octal, Cradle, Hermetically Sealed, Contactors, Time Delay, Reed, Mercury Wetted, Solid State, Printed Circuit Mounting, CALL US WITH YOUR NEEDS. Many obsolete types from stock. Save ££££'s

LOW COST RAM & CPU'S

INTEL 'ABOVE' Memory Expansion Board. Full length PC-XT and PC-AT compatible card with **2 Mbytes** of memory on board. Card is fully selectable for Expanded or Extended (286 processor and above) memory. **Full data and driver disks supplied.** RFE. Fully tested and guaranteed. Windows compatible. **£59.95**
Half length 8 bit memory upgrade cards for PC AT XT expands memory either 256k or 512k in 64k steps. May also be used to fill in RAM above 640k DOS limit. Complete with data.
Order as: XT RAM UG. 256k. £34.95 *or* **512k £39.95**

SIMM SPECIALS

1 MB x 9 SIMM 9 chip 120ns	Only	**£8.50**
1 MB x 9 SIMM 3 chip 80 ns **£10.50**	or 70ns	**£11.95**
1 MB x 9 SIMM 9 chip 80 ns **£10.50**	or 70ns	**£11.75**
4 MB 70 ns 72 pin SIMM *-with parity-*	Only	**£35.00**

INTEL 486-DX33 CPU **£19.95** INTEL 486-DX66 CPU **£59.00**
FULL RANGE OF CO-PROCESSOR'S EX STOCK - CALL FOR £££
MOTOROLA 25 Mhz 68040 (XC68040RC25M) CPU'S £59.00
shipping charges for RAM / CPU upgrades is code B

SOFTWARE SPECIALS

NT4 WorkStation, complete with service pack 3 and licence - OEM packaged.
Special Price ONLY £99.00

Microsoft - Windows for Workgroups 3.11 & DOS 6.22. Supplied on 3½" disks with licence & concise documentation.	***£39.95***
DOS 5.0 on 3½" disks with concise books c/w QBasic .	***£14.95***
Wordperfect 6 for DOS supplied on 3½" disks with manual	**£24.95**

shipping charges for software is code B

TEST EQUIPMENT & SPECIAL INTEREST ITEMS

MITS. FA3445ETKL 14" Industrial spec SVGA monitors	£245
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	£5150
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.	£8500
HP A1, A0 8 pen HPGL high speed drum plotters - from	£950
EG+G Brookdeal 95035C Precision lock in amp	£650
View Eng. Mod 1200 computerised inspection system	£POA
Sony DXC-3000A High quality CCD colour TV camera	£1100
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
ICI R5030UV34 Cleanline ultrasonic cleaning system	£POA
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
Intel SBC 486/125C08 Enhanced Multibus (MSA) NEW	£1450
Zeta 3220-05 A0 4 pen HPGL *fast* drum plotters	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
Motorola VME Bus Boards & Components List. SAE / CALL	£POA
Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
Fujitsu M3041R 600 LPM band printer	£1950
Fujitsu M3041D 600 LPM printer with network interface	£1250
Perkin Elmer 299B Infrared spectrophotometer A	£500
Perkin Elmer 597 Infrared spectrophotometer	£3500
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3750
LightBand 60 output high spec 2u rack mount Video VDA's	£495
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
Taylor Hobson Tallysurf amplifier / recorder	£750
ADC SB200 Carbon dioxide gas detector / monitor	£1450
System Video 1152 PAL waveform monitor	£485
ANRITSU 9654A Optical DC-2.5G/b waveform monitor	£5,650
ANRITSU MS9001B1 0.6-1.7 uM optical spectrum analyser	£POA
ANRITSU ML93A optical power meter	£990
ANRITSU Fibre optic chracateristic test set	£POA
VISION ENGINEERING TS3 Dynascopic microscope	£1850
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 1502 Portable TDR (time domain reflectometer)	£600
PHILIPS PW1730/10 XRAY generator with accessories	£POA
CLAUDE LYONS 12A 240V single phase auto. volt. regs	£325
CLAUDE LYONS 100A 240/415V 3 phase auto. volt. regs.	£2900

DISTEL on the web !! - Over 16,000,000 items from stock - www.distel.co.uk

DISPLAY
-ELECTRONICS-

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

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

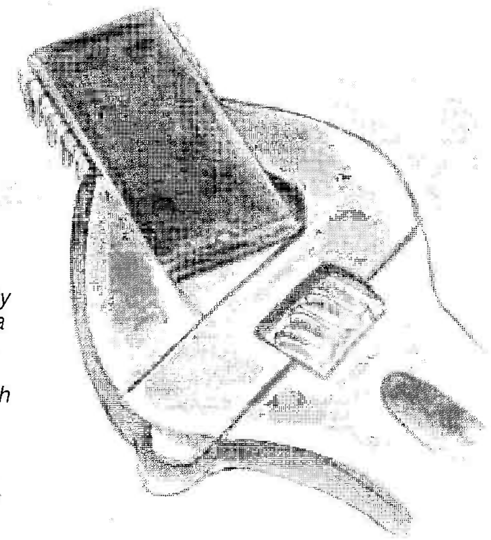
NEW **DISTEL©**
Visit our web site
www.distel.co.uk
email admin@distel.co.uk

ALL ☎ ENQUIRIES
0181 679 4414
FAX 0181 679 1927

SWITCH MasterCard VISA EST. 25 YEARS

All prices for UK Mainland. UK customers add 17.5% VAT to TOTAL order amount. Minimum order £10. Bona Fide account orders accepted from Government, Schools, Universities and Local Authorities - minimum account order £50. Cheques over £100 are subject to 10 working days clearance. Carriage charges (A)=£3.00, (A1)=£4.00, (B)=£5.50, (C)=£8.50, (D)=£12.00, (E)=£15.00, (F)=£18.00, (G)=CALL. Allow approx 6 days for shipping - faster CALL. All goods supplied to our Standard Conditions of Sale and unless stated guaranteed for 90 days. All guarantees on a return to base basis. All rights reserved to change prices / specifications without prior notice. Orders subject to stock. Discounts for volume. Top CASH prices paid for surplus goods. All trademarks, tradenames etc acknowledged. © Display Electronics 1998. E & O E. 06/98

NEXT MONTH



PIC TOOLKIT MK2

Microchip's new PIC16F87x series of EEPROM microcontrollers offer greater program capacity and more facilities than the familiar PIC16x84 series. The latter, though, will still find a plethora of uses in less-demanding circuits where the greater sophistication of the '87s is not required. There are roles for both families.

Consequently, the PIC16x84 Toolkit *of July '98 has been upgraded to make it compatible with both the '84 and the '87. The printed circuit board has been redesigned to accept the 18-pin '84s and the 28/40-pin '87s. The power supply control has been redesigned to remove the need for a regulated 12V/14V PSU – the Mk2 will run from any d.c. supply of between 5V and 20V (at around 10mA).*

Additionally, the controlling software has been considerably enhanced in a number of ways, offering more functions than the Mk1 version.

The Mk2 has the same basic options as the Mk1:

- *Configure PIC*
- *Program PIC with TASM .OBJ*
- *Program PIC with MPASM .HEX*
- *Translate MPASM .HEX to TASM .OBJ*
- *Translate TASM .OBJ to MPASM .HEX*
- *Disassemble PIC to TASM .OBJ*
- *Disassemble PIC to MPASM .HEX*
- *Translate TASM .ASM to MPASM .ASM*
- *Translate MPASM .ASM to TASM .ASM*

It also has the following additional options:

- *Assemble TASM .ASM to .OBJ (totally replacing the need for a TASM shareware assembler)*
- *Directory paths display/change – eliminating any need to make changes to the Basic program (as required by Mk1)*
- *Directory display/select – displays file directories of choice, and allows automatic loading of selected file for use in any main program option.*
- *Setup function allows PC ports to be tested and selected, and the PC's ability/inability to read (for PIC verify/disassemble) from its selected port established.*
- *Load/read data to/from the PIC's internal EEPROM data memory*

This software is considerably more sophisticated than the Mk1 version and is supplied as a suite of four chained programs which call each other as required without the user's intervention. It can be run in QBasic, QuickBASIC, or as a stand-alone (.EXE) program without any need for a Basic controller.

The software can also control Toolkit Mk1 without modification to either. Information on using it with the PIC Tutorial *(March to May '98) and the* PIC Tutor *(CD-ROM) is provided in the text.*

VERSATILE AM/FM REMOTE CONTROL SYSTEM

Remote control systems are increasingly popular, and the introduction of pre-tuned radio modules and their steadily falling prices has made radio a viable alternative to infra-red. The advantage of radio is the ability of the signal to pass through objects and walls. Its range is also impressive, 100 metres or more (in free space) being typical.

No licence is required in the UK, providing the radio modules operate on the 418MHz waveband, and there are a number of conditions, one of which is that setting up and tuning is carried out by a DTI approved company. Hence if the module is purchased from such a company the home constructor can enjoy the benefits of radio remote control.

The article will describe how to use the radio modules in a similar way to the infra-red system which appeared in the October and November '98 issues. We will examine both a.m. and f.m. systems, and begin with a brief outline of the difference between these.

MIDI "HAND BELLS"

This project was primarily designed with children in mind, and was actually produced in response to a request from a reader who required the gadget for a group of handicapped children. However, it is capable of providing hours of fun for "children" of all ages! It could be regarded as a modern equivalent to a set of hand bells. It is really a form of MIDI interface, and is incapable of making any sound without the aid of a MIDI equipped synthesiser, sound sampler, or other instrument.

The output of the interface connects to the MIDI input of the instrument, which is set to produce a bell sound or any other sound you like. Up to 11 pushbutton switches can be connected to the input of the interface. The general idea is for each player to control one or two pushbutton switches. By operating the switches in the correct sequence and with the correct timing the desired tune can be produced. In other words, the melody is played in much the same way that it would be produced by traditional hand bell players.

PLUS • ALL THE REGULARS

NO ONE DOES IT BETTER

EVERYDAY PRACTICAL ELECTRONICS

ETI ELECTRONICS TODAY INTERNATIONAL

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

Demand is bound to be high

MAY ISSUE ON SALE THURSDAY, APRIL 1

EVERYDAY PRACTICAL ELECTRONICS With ETI ELECTRONICS TODAY INTERNATIONAL

VOL. 28 No. 4 **APRIL '99**

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

READ PLEASE

If all else fails, read the article! I know I have mentioned this before, but it is becoming an increasing problem – people asking questions about projects that are clearly covered in the article. It seems that the ease with which people can e-mail us is part of the cause – just bang off a quick e-mail, it's so easy and costs so little, and you will get a quick reply back. Problem solved with minimum effort! However, increasingly, that reply may say "Please read the article" or "Please read *Shoptalk*".

It's a bit like buying some new gadget; how many people read the instructions before turning it on and playing with all the functions? Most of us (yes, I'm guilty too) try it out and only read the instructions when we can't get something to work. Our PIC projects and, in particular, the *PIC Toolkit* seem to give rise to many requests for help – usually from readers who have not followed the correct procedures because they have not read all of the material. There's more on *Toolkit* in this month's *Readout*.

IN A PICKLE

If you are building a PIC project and simply buy a ready programmed chip for it then there is rarely a problem – most of the PIC projects are, after all, fairly simple in terms of construction. If, however, you are programming your own chip and get into a PICkle (sorry, couldn't resist it) then make sure you know how to use the programmer you have, and that you follow the instructions supplied with it, or with the article from which you built it. For instance, you must initialise the chip with the correct configuration before doing anything else.

Whilst we try to be as helpful as we can, we are increasingly finding our time taken up with this type of query; unfortunately it's time we don't have and it's time that is being wasted because we have already supplied the information. We know it is not always easy when you are learning something new like PIC programming or, when your project refuses to work, and we do not want to put off the genuine queries from readers. Just check that you have read everything and tried to sort it out yourself before you grab the 'phone or the keyboard, please.

Not only will you have the satisfaction of knowing that you have solved the problem, you will also have gained some knowledge and experience along the way and that, surely, is part of what our hobby is all about.

AVAILABILITY

Copies of *EPE/ETI* are available on subscription anywhere in the world (see right), from all UK newsagents (distributed by Seymour) and from the following UK electronic component retailers: Maplin – all stores throughout the UK (and in S. Africa); Greenweld Electronics; Omni Electronics. *EPE* can also be purchased from retail magazine outlets around the world. An on-line version can be purchased from **www.epemag.com**

SUBSCRIPTIONS

Annual subscriptions for delivery direct to any address in the UK: £26.50. Overseas: £32.50 standard air service, £50 express airmail. Cheques or bank drafts (**in £ sterling only**) payable to *Everyday Practical Electronics* and sent to EPE Subscriptions Dept., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749. Fax: 01202 841692. **E-mail:** subs@epemag.wimborne.co.uk. Subscriptions start with the next available issue. We accept MasterCard or Visa. (For past issues see the *Back Issues* page.)

BINDERS

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

Payment in £ sterling only please. Visa and Master-Card accepted, minimum credit card order £5. Send, fax or phone your card number and card expiry date with your name, address etc. Or order on our secure server via our web site. Overseas customers – your credit card will be charged by the card provider in your local currency at the existing exchange rate.

Editor: MIKE KENWARD
Secretary: PAM BROWN
Deputy Editor: DAVID BARRINGTON
Technical Editor: JOHN BECKER
On-Line Editor: ALAN WINSTANLEY
Business Manager: DAVID J. LEAVER
Subscriptions: MARILYN GOLDBERG
Editorial: Wimborne (01202) 881749
Advertisement Manager:
PETER J. MEW, Frinton (01255) 861161
Advertisement Copy Controller:
PETER SHERIDAN, Wimborne (01202) 882299

READERS' ENQUIRIES

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

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

COMPONENT SUPPLIES

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

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

ADVERTISEMENTS

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

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

TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

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

MAGENTA ELECTRONICS LTD

EE200 135 Hunter Street, Burton-on-Trent, Staffs. DE14 2ST
Tel 01283 565435 Fax 546932
http://www.magenta2000.co.uk
E-mail: sales@magenta2000.co.uk
All Prices include V.A.T. Add £3.00 per order p&p. £6.99 next day

EUROCARD MasterCard VISA SWITCH

MAIL ORDER ONLY • CALLERS BY APPOINTMENT

EPE MICROCONTROLLER P.I. TREASURE HUNTER

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

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

KIT 847......................£63.95

PIC PIPE DESCALER

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

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

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

SPACEWRITER

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

KIT 849.......................£16.99

12V EPROM ERASER

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

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

MICRO PEsT SCARER

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

- **RANDOM PULSES**
- **HIGH POWER**
- **DUAL OPTION**

Plug-in power supply £4.99

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

SUPER BAT DETECTOR

NEW!

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

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

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

PORTABLE ULTRASONIC PEsT SCARER

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

KIT 842.......................£22.56

WINDICATOR

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

KIT 856...£28.00

SUPER ACOUSTIC PROBE

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

KIT 865.......................£29.95

★ TENS UNIT ★

DUAL OUTPUT TENS UNIT

As featured in March '97 issue.

Set of 4 spare electrodes £6.50

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

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

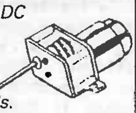
E.E. TREASURE HUNTER P.I. METAL DETECTOR MKI

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

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

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

DC Motor/Gearboxes



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

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

Stepping Motors

MD38...Mini 48 step...£8.65
MD35...Std 48 step...£9.99
MD200...200 step...£12.99
MD24...Large 200 step...£22.95

1000V & 500V INSULATION TESTER

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

KIT 848..................£32.95

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

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

Kit No. 845................£64.95

EPE PROJECT PICs

NOW £5.90

Programmed PICs for all* EPE Projects
Now one price
£5.90 each
(*some projects are copyright)

ULTRASONIC PEsT SCARER

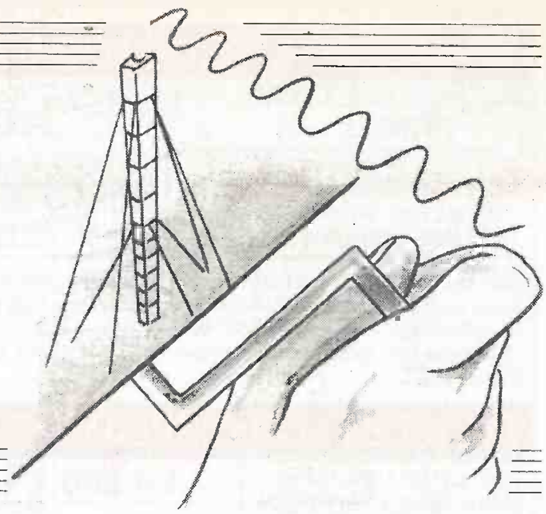
Keep pets/pests away from newly sown areas, fruit, vegetable and flower beds, children's play areas, patios etc. This project produces intense pulses of ultrasound which deter visiting animals.

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

KIT 812...£14.81

Constructional Project

MECHANICAL RADIO



BART TREPAK

Build a battery-less portable radio – it's revolutionary!

EVERY now and then, an invention is made which is so simple and obvious that many people's reaction on hearing about it for the first time is "why didn't I think of it myself?".

This was certainly the author's reaction when he first heard about the Clockwork Radio which has since gone on to make its inventor, Trevor Bayliss, a great deal of money, as well as improving the life of many people in the Third World.

The brilliance of any invention is in the initial leap of imagination which results in a new product rather than the initial method of its implementation or the evolution of a concept. Having watched a documentary on the Clockwork Radio on TV a year or so ago, which traced the development of the radio from its initial idea to its eventual production, the author thought it was a great idea and determined to buy one as soon as they became available.

Recently, thumbing through one of those "New Inventions" booklets which seem to arrive every now and again, the author was delighted to see a Clockwork Radio listed. On checking the price, however, he soon changed his mind – £60 seemed to be an excessive price to pay to save a few pounds on batteries. It was time to have another look at the design to see if it could be made simpler and cheaper...

CART BEFORE HORSE

The basic concept behind the Clockwork Radio is shown in the block diagram in Fig.1a. In essence, the mechanical energy produced by turning a handle is stored in a spring. This is fed to a generator which converts the stored mechanical energy into the electrical energy required to power the radio.

The amount of energy which needs to be stored depends, of course, on the amount of power required by the radio and the length of time for which it is required to play and this will determine the size and sophistication of the spring.

Interestingly, by changing the order of the blocks in Fig.1a to that shown in Fig.1b, the energy can be stored electrically which requires no development of costly mechanical components as the components are available off the shelf and the design therefore lends itself more readily to home construction.

An electrical storage means, of course, some kind of rechargeable cell, but here we come up against a problem. Anyone who has ever charged a NiCad battery will know that even with a relatively large current, a battery will need to be on charge for a good few hours to be of use. Consequently, many hours of turning the handle of a small hand-powered generator would be required to charge the battery, which is clearly unacceptable.

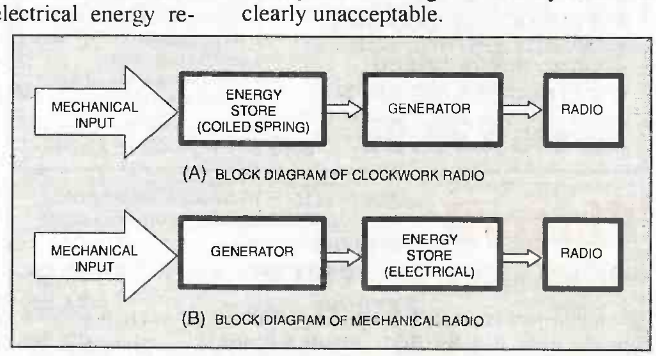
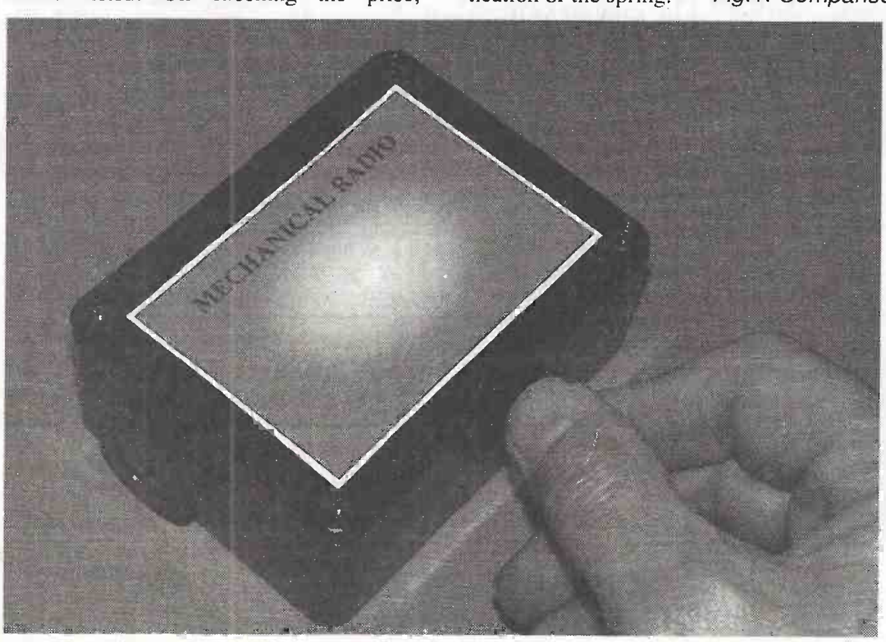


Fig.1. Comparison of the two energy generation methods.



Batteries are efficient in storing a lot of electrical energy in a small physical size but because the energy storage depends on a chemical reaction which takes time to occur, a battery can only accept a charge relatively slowly. A capacitor, however, does not suffer from this limitation and if a large enough charging current is available, it can be charged almost instantly.

The energy storage capacity is, however, much smaller compared to a battery of the same physical size. But, how much energy do we need to store? To answer this question we need to know the power consumption of the radio and the length of time for which we want it to play.

The power consumption of a radio tuner can be made quite small so that the main factors governing this will be the audio amplifier and its loudspeaker. We therefore need to know how loud we want the radio to play and, inevitably, the answer will be as loud as possible for as long as possible.

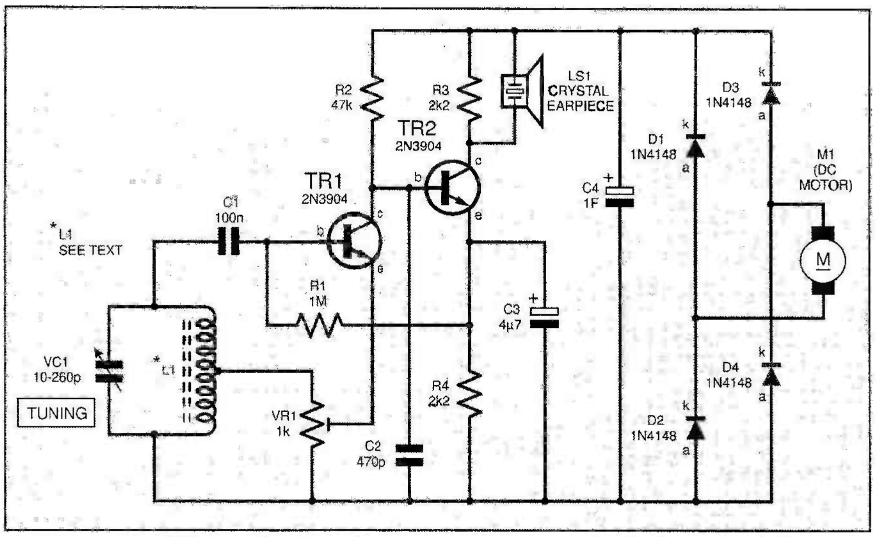


Fig.2. Complete circuit diagram for the Mechanical Radio.

HOW LONG IS A PIECE OF STRING?

It is perhaps better to start by determining how much energy can be stored and then seeing what can be done with it. The energy stored in a capacitor is given by $E = CV^2/2$ Joules, where C is the capacitance in Farads and V is the voltage to which it is charged.

The capacitance values normally encountered in electronic circuits are measured in microfarads but large values of capacitance are now available in relatively small volumes and are used in memory back-up applications in computers. A one Farad (1F) capacitor (5V working voltage), for example, is only 45mm diameter × 20mm high, which is a slightly larger volume than that of a C-size battery and costs about the same.

From the above formula, the energy stored by such a capacitor charged to 3V, say, would be 4·5 Joules. Unfortunately, not all of this energy would be available for powering the circuit because all electronic circuits need a certain minimum voltage supply to operate.

As current is taken from the capacitor to power the radio, the voltage will fall and once it has fallen below a certain level, operation will cease, despite there still being a certain amount of energy left in the capacitor.

To keep the arithmetic simple, let us assume that the circuit will work down to 1·5V, at which point the (unrecoverable) energy still left in the capacitor would be 1·125 Joules. A 1F capacitor would thus store around 3·4 Joules of recoverable energy. An energy expenditure of one Joule is equivalent to a power of one watt flowing for one second, so that if we want our radio to operate for, say, 15 minutes (900 seconds) the average power taken by the radio should not exceed 3·78mW (3·4 × 1000/900).

This power is, of course, very low for a radio fitted with a loudspeaker but more than sufficient for a personal radio driving an earpiece. The circuit to be described presently draws a current of only 0·2mA at 1·75V and will work down to 1·5V so that a very respectable playing time of about one hour can be achieved if the capacitor is initially charged to 3V.

Loudspeaker operation would be possible for shorter times, especially if an efficient audio power amplifier were used and the capacitor (or capacitors) charged to a higher initial voltage, although this has not been investigated by the author.

RADIO CIRCUIT

With the demise of the ZN414 radio receiver integrated circuit, which would have been ideal for this application, we have to "re-invent the wheel" to make a simple a.m. radio and the circuit shown in Fig.2 is one which would not have been out of place in the pages of this magazine in the 1960s!

This circuit has the advantage of not only being simple to make and uses readily available components, but also gives quite good results, although the audio quality is not hi-fi.

The signal picked up by the aerial L1 is tuned by capacitor C1 and applied to the base of transistor TR1 which functions as an r.f. (radio frequency) amplifier and a detector. The input impedance of this stage is high so that the tuned circuit is only lightly loaded, resulting in good selectivity.

High gain is achieved by the use of regenerative (positive) feedback by feeding some of the amplified signal back to the input via the small winding on L1, the amount of feedback being set by preset potentiometer VR1 to a level just below that which would cause the transistor to oscillate.

The transistor then exhibits a very high gain resulting in maximum sensitivity of the receiver. A short explanation of the regenerative receiver is given later.

The amplified signal is detected in the collector of TR1 with the residual r.f. signal being removed by capacitor C2. The resulting audio signal is further amplified by TR2 and used to drive the high impedance crystal earpiece, LS1. The volume is not ear-splitting, of course, and reduces with time as the supply voltage falls but is more than adequate for personal listening, even at a low supply voltage.

Transistor TR1 is biased almost to cut-off and TR2 has a relatively high impedance load resistor so that the total current consumption of the circuit is well below 1mA.

The power supply for the circuit consists of the hand-cranked generator (M1) together with the one Farad capacitor (C4) and a bridge rectifier (D1 to D4).

CAPACITOR CHARGING

So far, we have discussed the radio circuit and how it can be powered by the charge stored in the capacitor but we must now turn our attention on how this capacitor may be charged.

As most readers will know, when the spindle of a motor is turned, a voltage will appear at its terminals, so a standard permanent magnet motor has been used as the power generator in this design.

When used in the generator mode, the output of a motor is proportional to its speed. The actual voltage developed at the terminals at a given rotational speed will depend on the strength of the internal magnetic field and the number of turns in the armature coils and not all motors will be the same in this respect. (Note that specifications for motors being used as generators are not quoted by manufacturers and their output voltage and power varies from device to device.)

Motors intended for higher voltage operation (i.e. 6V as opposed to say 1·5V) will probably have more turns. Those with a higher torque will have a stronger internal magnetic field so that to generate a reasonable output without having to turn the spindle at impossible speeds, a high torque, high voltage motor is required. A 9V motor was chosen as this was not too big physically.

COMPONENTS

See SHOP TALK Page

Resistors

R1	1M
R2	47k
R3, R4	2k2 (2 off)

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

Potentiometer

VR1	1k min. horizontal preset

Capacitors

C1	100n ceramic disc
C2	470p ceramic disc
C3	4µ7 radial elect, 16V
C4	1 Farad tagged-can elect, 5V
VC1	10-260p tuning capacitor

Semiconductors

D1 to D4	1N4148 signal diode (4 off)
TR1, TR2	2N3904 *npn* transistor (2 off)

Miscellaneous

LS1	crystal earpiece
MO1	high torque 9V motor (see text)
L1	ferrite rod aerial (see text)

Printed circuit board, available from the *EPE PCB Service*, code 226A and B; gear wheel, 16 teeth; gear wheel, 60 teeth; gear wheel 42/10 teeth; 2mm diameter spindle; crystal earpiece; 3·5mm jack socket; knob for VC1; plastic case, 100mm × 77mm × 41mm; connecting wire; solder, etc.

Approx Cost Guidance Only £15

Although the output of such a motor is d.c., the polarity of the output will depend on the direction in which the spindle is rotated. To avoid having to specify the direction of rotation or to make some mechanical device to prevent the spindle being rotated the wrong way, a bridge rectifier has been included to ensure that the output always has the correct polarity.

It does mean, however, that the output will be reduced by two diode forward voltage drops instead of one (one diode would be required anyway to prevent the capacitor from discharging through the coil) but it makes the mechanical arrangement much simpler.

GETTING INTO GEAR

No matter what kind of handle was attached to the motor spindle, it was found impossible to turn it fast enough to obtain an output great enough to overcome the diode voltage drops let alone charge a capacitor, so the use of gears was unavoidable. Ready-made gear trains are available but these tend to be very expensive unless scrap or surplus ones can be found and these will then probably not be easy to connect to the motor, so it was decided to make one using available gear wheels.

Experiment showed that to obtain a suitable final speed, a ratio of about 1:15 was required. However, although gear wheels with 16 teeth and a diameter of 9mm are available, the driving wheel would need to have 240 (15×16) teeth, resulting in a wheel of around 135mm in diameter. This would be bigger than the rest of the radio and obviously unacceptable.

It is, though, also possible to get this ratio by using more stages as shown in Fig.3 so that if the 16-toothed wheel was driven by a one having 48 teeth, this larger wheel would rotate three times slower and have a diameter of 27mm. If this also contained a concentric 10-toothed wheel, for example, and this was in turn driven by a 50-toothed wheel (28mm diameter), this would give a further speed reduction of a factor of five giving an overall speed ratio of 1:15 in a much more manageable size.

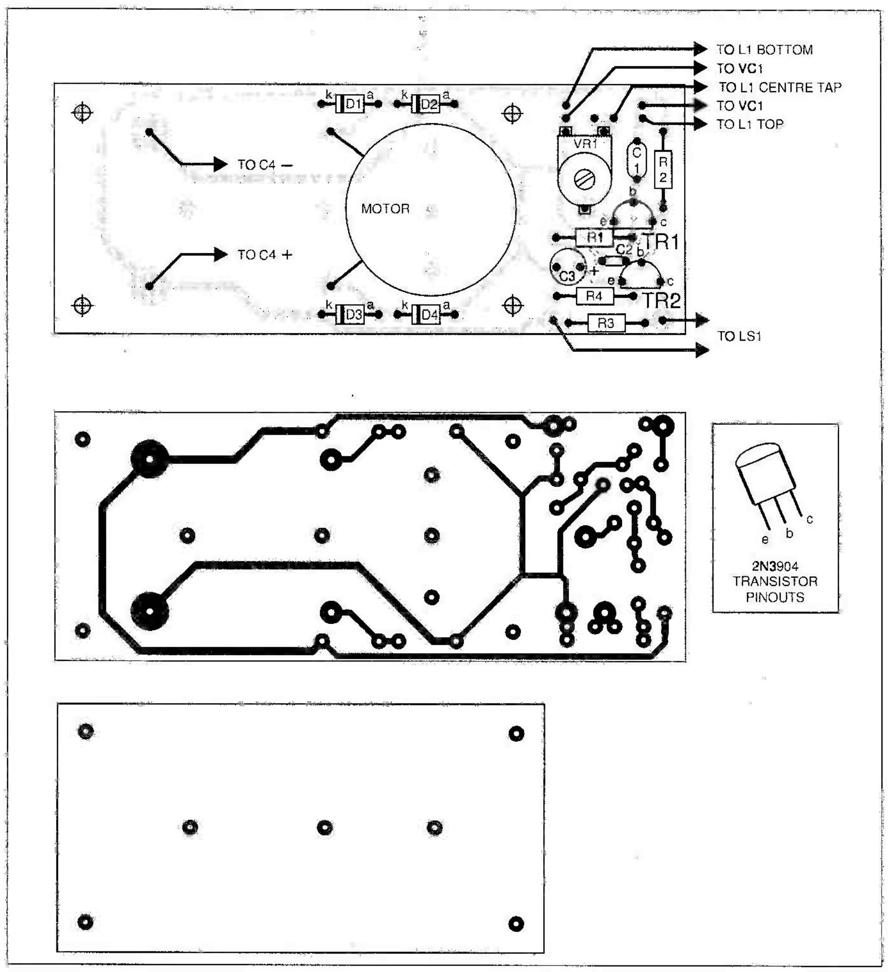


Fig.4. Component and full size track layouts for the printed circuit boards.

The final gear design uses 16, 42/10 and 60 toothed gear wheels to achieve this as these were readily available.

Note that since we are getting a speed increase, the torque is proportionally lower at each stage or, to put it another way, the force required to turn the first wheel will be 15 times larger than that required to turn the motor spindle directly. This is unlikely to tax even the weakest reader in this case.

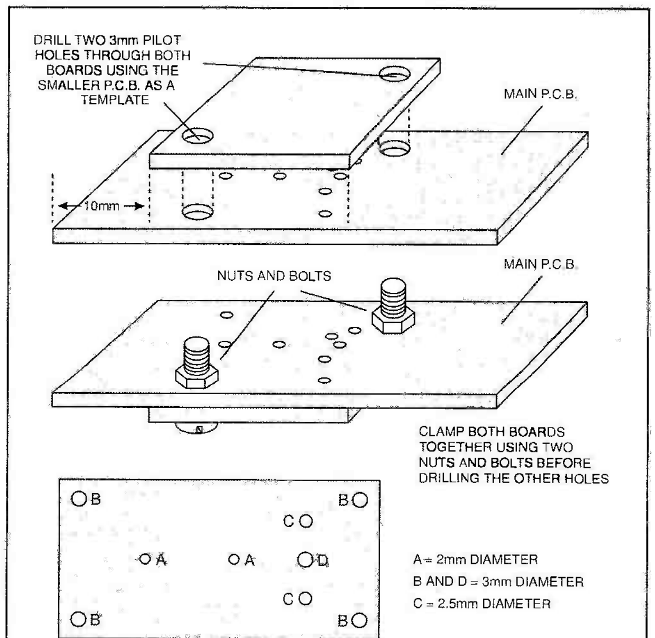


Fig.5. P.C.B. drilling details for the mechanical mountings.

It should be noted, though, that the simple plastic gear wheels used in this design are merely pushed onto the spindle and rely on a tight fit rather than a more robust method of fixing. Any misalignment of the wheels, which is likely to increase the torque required to turn them, could result in the wheel slipping on the spindle rather than turning. This is especially true of the largest wheel so that the gear train should be constructed carefully.

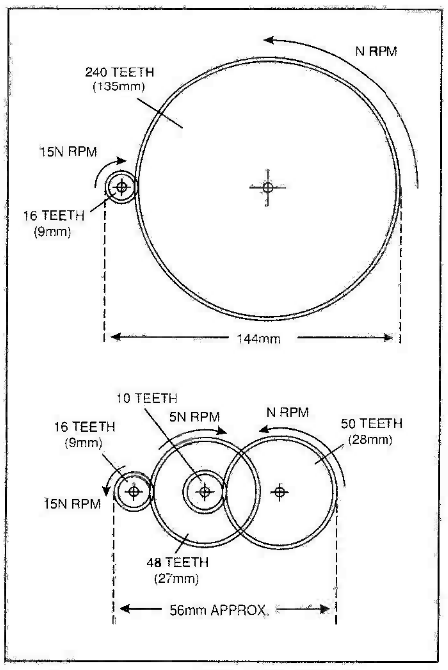
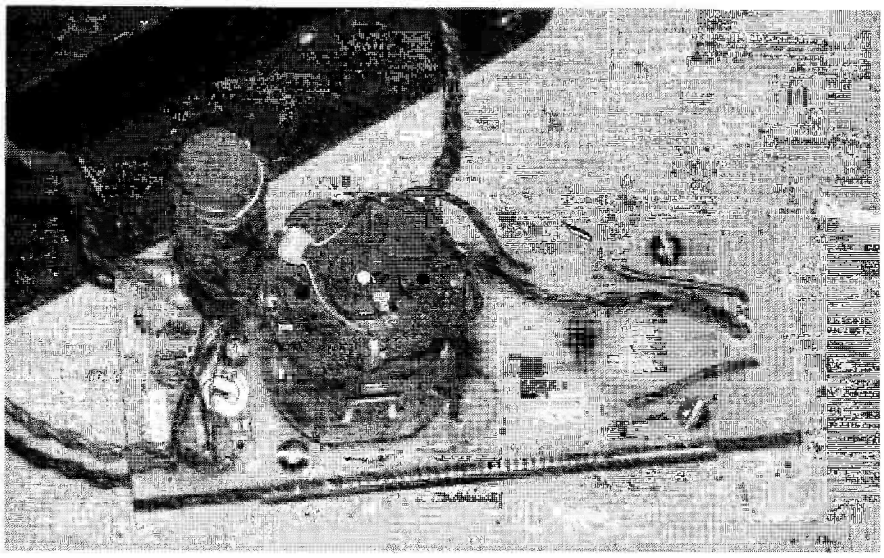


Fig.3. Gear trains with 1:15 ratio.

MECHANICAL CONSTRUCTION

The biggest problem in constructing this project is likely to be with the mechanical part rather than the electronics and the following instructions should therefore be followed closely.

The whole project, including the gear train, has been built on two printed circuit boards which have been designed



to perform not only an electrical function but a mechanical one as well. This simplifies construction considerably and because of this their use is mandatory unless other arrangements for mounting the gear wheels are made.

These boards are available from the *EPE PCB Service*, code 226A/B.

The first thing to do is to drill out the four holes in the corners of p.c.b. 226B to 3mm.

Next place this board over p.c.b. 226A, one centimetre (10mm) from the edge as shown in Fig.5 and drill corresponding holes in 226A using 226B as a template. Once this has been done, the two boards may be secured together with nuts and bolts. The holes for the gear spindles are drilled through both boards simultaneously. This method will ensure that the holes are drilled in the correct position and that they will also be correctly aligned.

The spindles are 2mm diameter so that a 2mm drill should be used for these holes (A). The motor spindle (hole D) has a larger diameter but since this shaft will be supported by the motor bearings rather than the holes in the p.c.b., the diameter of the hole for this is not too important and a 3mm drill may be used here to give sufficient clearance.

The position and size of the two holes (C) for fixing the motor is critical and these should be drilled using a 2·5mm drill.

ELECTRONIC CONSTRUCTION

Once the mechanical assembly has been completed, the two boards should be separated and the circuit assembled on 226A following the layout given in Fig.4.

All of the components, excluding the storage and tuning capacitors and the aerial, are mounted on this board and care should be taken to ensure that polarised components are inserted correctly. Pay particular attention to the transistors as the pinouts for the 2N3904 differ from the more usual format in that the emitter and collector connections are reversed (see Fig.4).

The one Farad capacitor (C4), which is not mounted on the board but connected to it by short leads, is also polarised and the negative terminal is marked by two stripes. This terminal is also connected to the metal plate at the base of the component.

Construction should begin with the lowest profile components such as diodes and resistors, progressing to the larger ones with the motor being mounted last. This should be secured to the p.c.b. by means of the two fixing screws and connected to the appropriate points on the board by short lengths of wire.

The small capacitor wired across the motor terminals may be left in place or removed as preferred as it performs no function in the circuit operation.

TUNING COMPONENTS

The prototype used a small ferrite rod aerial (50mm × 10mm diameter) with 70 turns of 28 s.w.g. wire and a tap at 10 turns, together with a 10-260pF tuning capacitor as these were to hand. These items may not be available from your usual component supplier but it is, however, perfectly acceptable to use other values/sizes and many suppliers list ready-wound ferrite aerials and matching tuning capacitors for small radio circuits.

Some windings may not have a tap for connecting the aerial but consist of two separate windings, one larger than the other. If this is the case, both windings should be connected in series to form one continuous tapped winding and it is important to ensure that the phase of both windings is correct (i.e. the end of the smaller winding is connected to the start of the other).

If this cannot be determined, simply connect the two windings together and adjust VR1 until the circuit oscillates (see later) and if this does not happen with any setting of the preset, reverse the connections of one of the coils.

The size of ferrite rods may vary from supplier to supplier but any size can be used provided it will fit the box. The mounting is left to the ingenuity of the constructor and as long as the components are connected to the appropriate points on the circuit board there should not be any problem. Leads should be kept as short as possible.

If the coil needs to be hand wound, it is probably best to start with more turns than are required so that these can be removed to obtain the required inductance to enable the required stations to be received with the tuning capacitor used.

Many tuning capacitors have one plate connected to the spindle and, to prevent hand capacitance effects, this terminal should be connected to the VR1 end of the coil (negative rail).

EARPIECE

The earpiece, which must be a high impedance crystal type, is normally available fitted with a 3·5mm jack plug so that the output of the radio should be fitted with a suitable socket, a panel mounted type being preferred. Alternatively, as there is no real advantage in having an earpiece which can be disconnected, the plug could be cut off and the wires soldered across resistor R3.

Note that only a *crystal* earpiece should be used as *magnetic* earpieces and headphones have too low an impedance to work in this circuit.

FINAL MECHANICS

When the electronic assembly work has been completed, the final mechanical assembly can begin. With the motor mounted on the p.c.b., the small 16-tooth wheel should be mounted onto the motor spindle. This is really designed to fit a 2mm diameter spindle and although the motor spindle is somewhat larger than this it can still be forced onto it providing a tight fit.

The best method of mounting the gear wheels onto spindles is to position them carefully in a vice and then tighten it slowly until the wheel is correctly positioned, as shown in Fig.6.

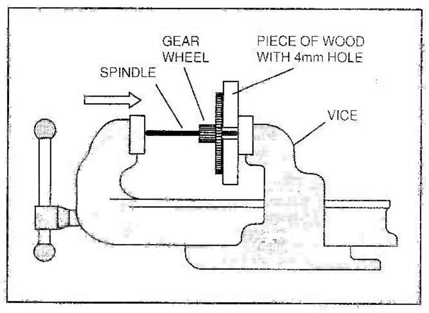


Fig.6. Mounting gear wheel onto spindle.

If the spindle protrudes from the other side of the wheel, a piece of wood with a 3mm or 4mm hole drilled in it should be placed beneath the wheel to support it while the vice is closed.

Next, cut a 1cm piece off a 2mm diameter spindle with a hacksaw and mount the 42/10 wheel onto this as described above. The rest of the 2mm diameter shaft, which should measure a little over 6cm, should be bent into the shape of a handle according to the dimensions shown in Fig.7. This can easily be done by hand if the spindle is firmly clamped at the appropriate point in a vice.

The handle should be passed through the appropriate hole in the small piece of p.c.b. material before the large 60-tooth wheel is mounted on it as it will not be possible to pass the bent spindle through the hole once the wheel has been mounted.

Once this has been done, the gears may be assembled as shown in Fig.7 and the gap between the boards adjusted to about 5mm by means of the nuts and bolts, which should then be tightened securely. Check that the handle can be turned easily and, if necessary, a drop of oil should be applied to the spindles to ensure this.

If the handle does not turn easily or the spindle slips on the gear wheel, it is probably due to the two boards not being parallel in which case the spacing nuts on the four bolts should be adjusted accordingly.

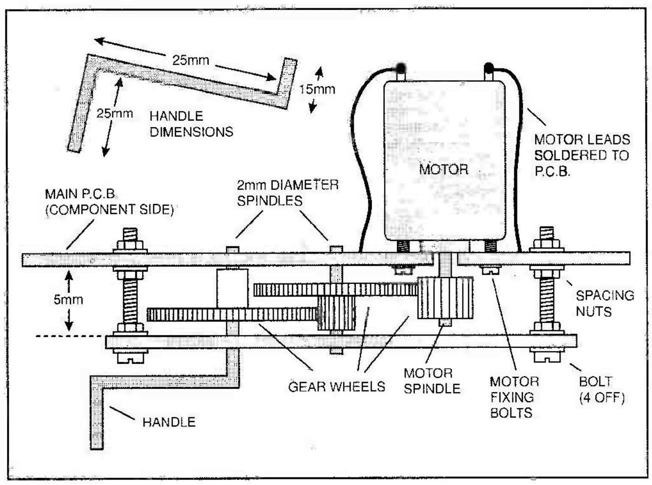


Fig.7. Mechanical assembly.

WIND-UP

When construction is complete, connect a voltmeter to the terminals of capacitor C4 and, turning the handle, the voltage should rise slowly. Continue to do this until the voltage reading is 3V, which should take about 30 seconds depending how fast the spindle is turned.

With VR1 turned fully clockwise, connect the earpiece and tune in a station. Adjust VR1 (turning it anti-clockwise) to increase the volume until the circuit begins to oscillate. This will be heard as an increase in the distortion accompanied by a buzzing sound reminiscent of a motor boat.

Back off this setting slightly and use VC1 to tune to other stations and check that this does not occur at any other settings, re-adjusting VR1 if it does.

The setting up is now complete and the radio is ready to mount in a box. The prototype was built into a 100mm × 77mm × 41mm ABS box which contains slots to support a printed circuit board.

A suitable slot must be made in the box to enable the handle to be mounted on the large wheel first and the completed assembly fitted into the box.

The gear/motor assembly should be mounted securely, as should the tuning capacitor and ferrite aerial to prevent them from rattling about inside, especially as these components are mounted off the board. The exact method of mounting the units inside the box is not critical.

In use, the radio will require winding for around 30 seconds to give an initial supply of about 3V and a playing time of about one hour. The initial voltage can be increased by turning the handle for longer periods, one minute giving about 4V. Although this will give longer operation, it could also cause the circuit to oscillate, requiring a re-adjustment of VR1, unless the circuit was originally set up at 4V.

Do not allow the capacitor to become charged above its rated working voltage (5V).

OTHER USES

For those who do not want to construct a radio but may have other uses for this device, the p.c.b. has been designed so that the storage capacitor can also be mounted on the board next to the motor. By cutting off the radio section, a kind of "mechanical battery" can be constructed enabling all sorts of other gadgets to be powered, so long as a supply of 3V or 4V is sufficient, and not too much current is required.

The circuit can easily supply a current of a few hundred milliamps, although not for very long, of course. It will, for example, power a small d.c. motor for about 10 seconds and would be ideal for circuits which require very low power or are used for only very short periods. After all, this "battery" can always be recharged in 30 seconds or so, which is a good deal faster than any NiCad!

REGENERATIVE RECEIVERS

All radio receivers, from the humble crystal set to the most sophisticated types, make use of a tuned circuit to select the frequency or station required by the listener from all of those which are being transmitted at any given time.

The tuned circuit consists of an inductor L1 and capacitor C1 connected in parallel, as shown in Fig.8. The signal is picked up by the aerial connected to the tuned circuit. The circuit presents a low impedance to the signal at all frequencies except the one to which it is tuned. Thus all frequencies are effectively shorted to earth except the one which is required.

In the simple crystal set shown, the r.f. (radio frequency) signal which is tuned in is detected using the diode and this, together with capacitor C2, recovers the audio signal, which is then heard in the headphones.

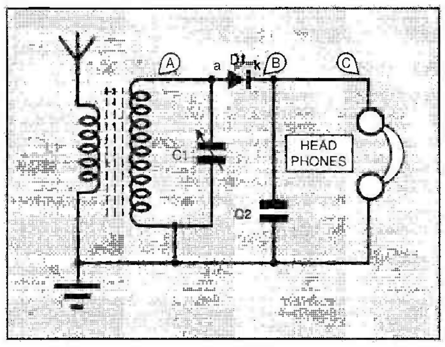


Fig.8. A simple crystal radio.

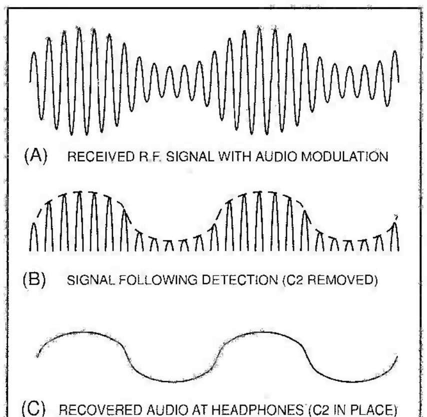
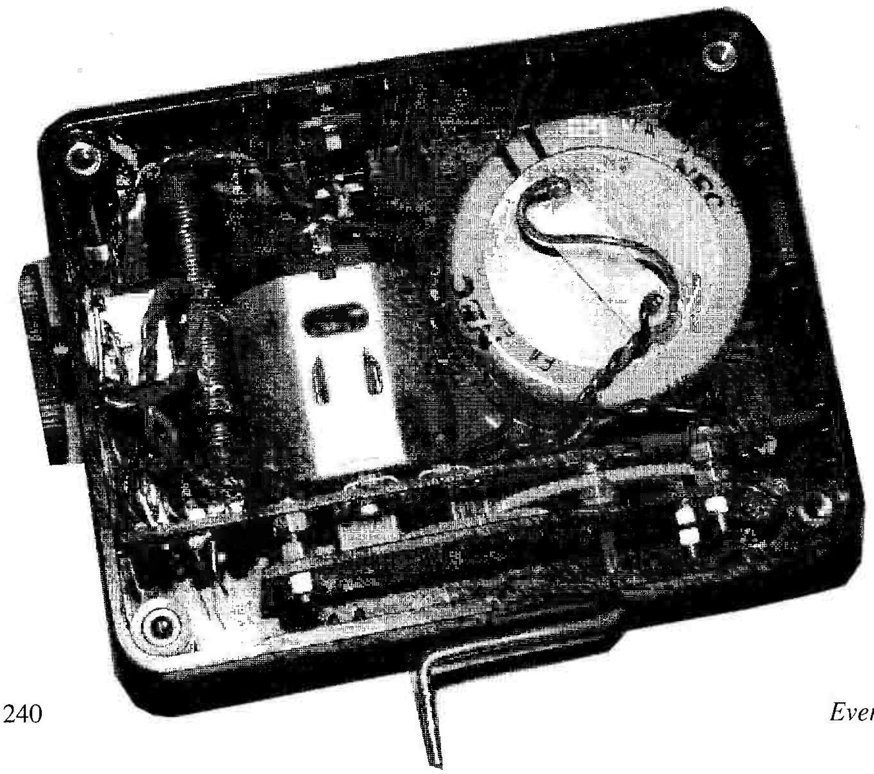


Fig.9. Example waveforms produced with Fig.8.



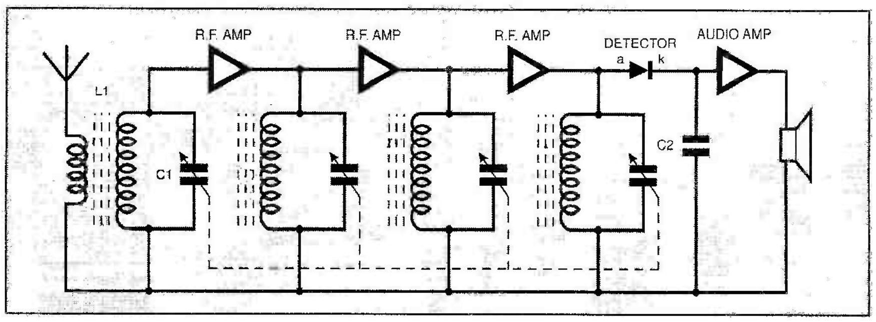


Fig.10. Simplified T.R.F. (tuned radio frequency) receiver.

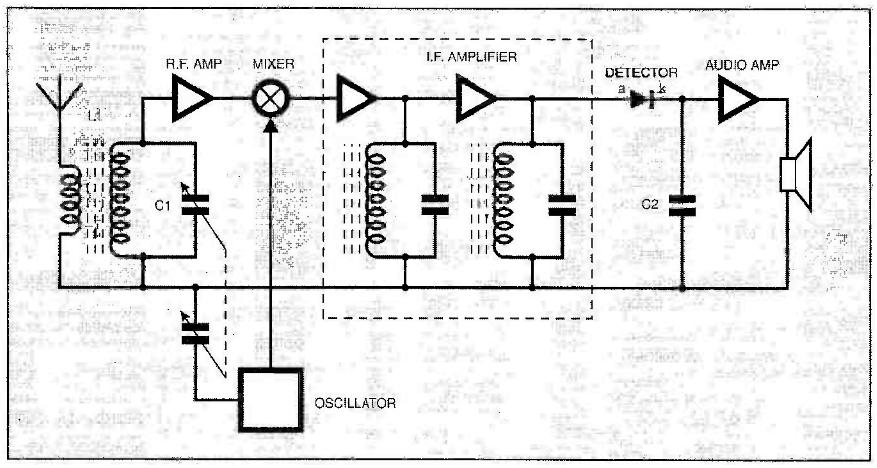


Fig.11. Simplified superhet receiver.

The waveforms for an amplitude modulated (a.m.) signal which would be seen at various points in the circuit on an oscilloscope are illustrated in Fig.9. Frequency modulated (f.m.) signals require different techniques and would not be detected by this circuit.

This circuit is just about usable if a long aerial and a good earth are provided. With a good set of high sensitivity headphones a strong local station will probably be picked up. This arrangement was fine in the early days of radio when only one or two stations were transmitting and the listener was prepared to put up an aerial several tens of metres long, but it is hardly suitable for use as a portable set.

PORTABILITY

For a portable set, a much smaller aerial (and no earth) is required and the resulting weaker signal means that considerable amplification of the signal is required before it is strong enough to be applied to a detector, let alone drive even the most sensitive of headphones or loudspeakers.

One stage of amplification would not normally be sufficient to produce a signal large enough to be detected by a diode so that many stages would need to be cascaded to obtain the required gain. A stable high gain wide band amplifier is very difficult to make as there will always be a frequency where stray coupling between the input and output will be great enough and in the correct phase to cause the circuit to oscillate.

This could be overcome by cascading narrow band amplifiers, each with its own tuned circuit adjusted for the frequency of interest to the listener as shown in Fig.10. This arrangement, however, is not used for a variety of reasons, not least of which being the difficulty of keeping all the tuned circuits in step while the tuning capacitor is varied to select different stations.

Such a circuit would require the use of high quality 3- or 4-gang tuning capacitors and most commercial receivers therefore use a neat trick to get around this.

SUPERHET

The trick is to mix the incoming signal with one generated inside the receiver (called the local oscillator) which produces a sum and difference frequency.

By making the local oscillator "track" the incoming frequency, a constant difference frequency will be generated irrespective of the frequency being tuned in. This frequency is known as the *intermediate frequency* or i.f. and all amplification is then carried out at this fixed frequency with special transformers (i.f. transformers) forming the tuned circuit for each stage.

This arrangement is known as a super heterodyne (or superhet) receiver and gives excellent performance. A circuit example is shown in Fig.11.

A basic problem with the circuit of Fig.8 is not only the lack of sensitivity which prevents weaker stations from being received but also the low selectivity which often results in two or more strong stations being received at once.

The graph in Fig.12 shows the response of a single tuned circuit to signals of various frequencies and it will be seen that two adjacent stations (frequencies *f1* and *f2*) are so close together that both will appear at almost the same level at the detector.

What is required is a response similar to the dotted curve, which would mean that frequency *f2* would be at a much lower level compared to *f1* (the required station) and would therefore not be heard.

FEEDBACK

The "flatness" of the response curve of a tuned circuit is caused by the losses in the inductor and capacitor. These losses can be "made up" in an oscillator circuit by amplifying and feeding back a portion of the signal to keep a tuned circuit oscillating instead of the signal simply decaying away. They can also be replaced in a receiver tuned circuit by the same technique, which will have the effect of sharpening the response curve (i.e. improving the selectivity).

To be successful, the fed back signal must be in phase with the original so that it will add to, rather than subtract from, the resulting output (in other words *positive feedback* – sometimes called *regenerative feedback*). However, since we are trying to make an amplifier and not an oscillator, its level must be carefully controlled so that the amount of signal fed back is just below that required to initiate/sustain oscillation.

At this point, the gain of the stage will also be at a maximum, giving a high sensitivity even from a single stage. By suitably biasing the transistor almost to cut-off, the circuit can even be made to amplify one half-cycle of the r.f. signal more than the other so that the stage will also effectively rectify the signal, making a separate detector stage unnecessary. This approach is shown in Fig.13.

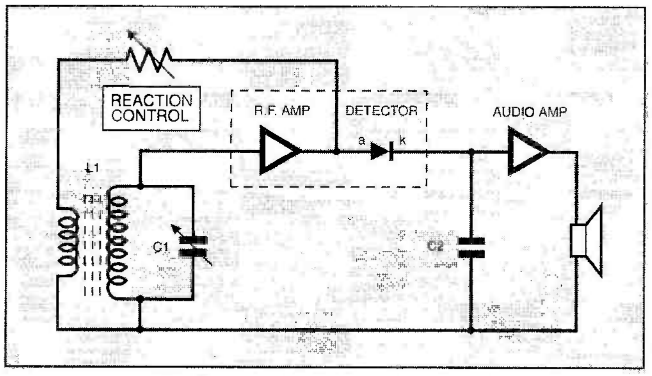


Fig.13. Simplified regenerative receiver.

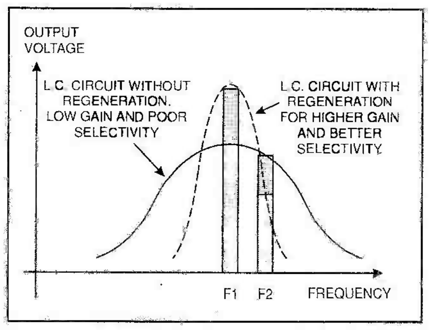


Fig.12. Response of single tuned circuit with and without regeneration.

News...

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

MINI OPTICAL CD

Barry Fox highlights the next generation of read-write CDs – small enough for the pocket.

THE race is on to market an erasable optical disc which is small enough to use in a pocket recorder that also plays low cost pre-recorded discs. Hard discs cannot be pre-recorded by pressing. Existing optical discs are either too large or have such limited capacity that heavy compression is needed for useful playing times.

New standards recently set for the Digital Versatile Disc, and new developments in Sony's Mini Disc, clear the way for tiny discs with at least twice the capacity of today's 12cm CDs. But consumers cannot expect a single standard.

Conventional 12cm CDs can store around 75 minutes of uncompressed stereo sound. An 8cm CD can hold only 20 minutes. Sony's Mini Disc is a 64mm disc in a protective caddy which records 74 minutes, but only by using heavy compression that throws away 80 per cent of the data.

A 12cm DVD can hold at least 4·7GB, which is enough for a full length movie. There are now three different varieties of DVD which can make erasable recordings. DVD-RAM is backed by Hitachi, Toshiba and Panasonic, while Philips and Sony prefer DVD+RW, and Pioneer proposes DVD – RW. All three rely on phase change technology; the disc is coated with material which switches between amorphous and crystalline state, and thus different reflectivity, when heated by a laser beam. All three disc types are embossed with a groove which guides the laser over the blank during recording. They vary in the way they record data in and alongside this groove, and are largely incompatible.

STANDARD SETTING

At a recent meeting (Oct/Nov '98) in Barcelona, the DVD Forum set the standard for 8cm versions of DVD. The small discs will record at least 1·4GB, and as much as 5·3GB if it is double-sided and each side has two recording layers. So a portable recorder will be able to record several hours of video or many hours of hi-fi surround sound.

Sony sees 8cm DVD as a serious threat to its existing Mini Disc audio recording system, which has a capacity of only 200MB so must compress audio by a factor of five to squeeze 74 minutes of stereo on the 64mm disc. Sony has now joined with Fujitsu to develop GigaMO, a high density version of MD based on laboratory work done by Sony in 1991 called Thermal Eclipse Recording.

Unlike phase change DVD, Mini Disc is a magneto-optical system. The disc is coated with a terbium ferrite cobalt mix. Heat from a laser makes the coating temporarily lose all magnetism. As the coating cools it picks up magnetism from a surrounding field which is switched to create a magnetic pattern of spots which change the polarisation of readout light.

CORE CAPACITY

Thermal eclipse can increase the capacity of a magneto-optical disc by a factor of six. The disc coating is made sensitive only to the hot central core of the laser beam. So a relatively thick beam records small spots.

To allow equally precise readout, the disc has a passive top coat which covers a lower layer that stores the magnetism. The central core of the readout beam heats fine spots in the top layer which then "sucks" magnetic information from the lower layer. So the beam "sees" only very fine spots of magnetism, effectively focussing more tightly than the long wavelength of the infra-red laser normally allows.

Japanese company TDK makes blank media for whatever recording systems people want to use. The company currently sells blank CDs, Mini Discs and DVDs and is ready to mass produce the new miniature formats as soon as hardware to use them is available. Jean-Paul Eekhout, TDK Europe's Product Manager, sees no prospect of the industry settling on one standard for portables because the gap between phase change and magneto-optical technology is too wide. "We already see a trend from CD to DVD, and we are developing improved MDs. By 2001 there will no longer be single systems for audio and video."

SLAUGHTERED LAPTOPS

It's become lap-top murder most horrid – but Barry Fox detects a solution.

TWO US companies have developed gadgets which protect travellers from a problem they only recognise when they find their laptop PC modems have been destroyed by hotel phones.

Modern hotels often use digital switchboards to route and bill calls. Some convert the digital pulses into analogue signals before they go to bedroom phones, but others send digital code to room phones which have built-in converters. The plugs and sockets are the same but, if a conventional analogue modem is plugged into a digital line, it will not work and the higher current, up to 0·5A, quickly burns out or "fries" the modem.

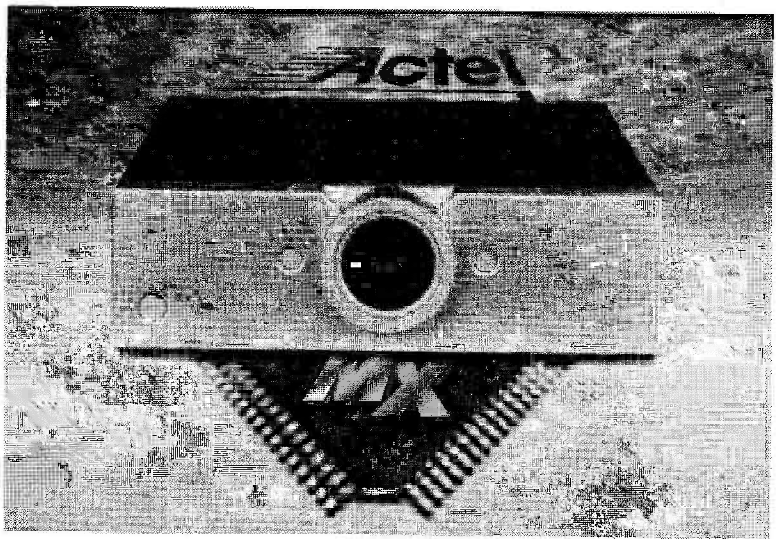
Analogue phones should be marked "Complies with Part 68, FCC Rules", but some are wrongly labelled. Passive fuses and trips may not work fast enough to protect a modem.

American Power Conversion (of West Kinston, Ri) has developed the SurgeArrest, a $40 connector which plugs between a laptop and its mains adaptor, and between the phone line and modem. The mains adaptor provides power for sensor circuitry inside the connector. As soon as this detects current of more than 140mA on the phone line it lights a warning lamp and at 200mA breaks the connection to the modem. APC will start selling the device in Europe during this year.

Konexx (of San Diego, Ca) goes one stage further with its new $200 AutoSet adaptor. This exploits the fact that all phones, whether digital or analogue, send an analogue signal to the handset. The Autoset plugs between the main body of the phone and the handset, and relies on the digital-to-analogue converter inside the digital phone to provide a safe working connection for a conventional analogue modem.

Because the level of the analogue signal flowing between the phone and handset can vary considerably between different phone types, the battery-powered AutoSet self-adjusts to a level which lets the modem operate normally.

WORLD'S FIRST DIGITAL AMPLIFIER



TACT Audio recently launched the first ever direct-drive digital amplifier aimed at the high end of the hi-fi market. The TACT Millennium achieves its high quality sound performance using two Actel MX FPGAs (field programmable gate arrays) whose antifuse technology has a proven track record as a piracy deterrent.

We highlight the product not only for its own sake (which costs around US $10k), but to give you an insight into the extent that some manufacturers are now going to in order to protect their products.

The heart of the amplifier is the patented Equibit PCM-to-PWM processing and output stage, developed by Toccata Technology, an independent research team. Just two Actel FPGAs were used to replace two 24-bit DSPs (digital signal processors) and two PLDs (programmable logic devices) running at greater than 90MHz. The FPGAs have on-chip program storage that is not easily compromised and use far less power than the original components.

Actel was approached after Toccata decided that the possible piracy of such a high value product and risk of a competitor using their proprietary algorithms simply could not be tolerated.

"Our antifuse FPGA technology has proven to be a secure way for companies like Toccata to protect their valuable intellectual property", commented Andy Biddle, Nordic District Manager for Actel Europe.

Actel devices are highly resistant to copying because of the difficulty in differentiating between a programmed and an unprogrammed antifuse. No non-destructive optical methods have been identified and the only way developed so far involves destructively sectioning a programmed device. This is a laborious high-precision process considering that the antifuse feature size is typically 0·5μm or less. This, coupled with the fact that a typical device can contain more than a million antifuses, make these parts extremely difficult to replicate and are likened to security offered by custom components.

The TACT Millennium is said to have made a major impact on the hi-fi market thanks to the Actel Devices it contains. The amplifier itself benefits from this technology with an efficiency of 96 per cent, a crisp and clear output with 150W r.m.s. per channel and a total harmonic distortion of less than 0·05 percent.

For more information contact Actel Europe Ltd., Daneshill House, Lutyens Close, Basingstoke, Hants RG24 8AG. Tel: 01256 305600. Fax: 01256 355420. Web: www.actel.com. Tact Audio have a web site at: www.tactaudio.com.

MARCONI CENTENARY

RADIO amateurs recently created a new world record when they re-enacted the first ever ship-to-shore radio message. The transmissions were from the same locations used by Guglielmo Marconi himself, namely the South Goodwin lightship and the South Foreland lighthouse.

Previous achievement records were smashed during the event, organised by The National Trust and sponsored by Marconi Communications, when more than 5000 messages were sent and received from enthusiasts all over the world over the four-day period from 19 to 22 December.

One of the operators, Richard Mortimer (GW4BVJ) single-handedly made a total of 2043 contacts in Morse code. To ensure that he broke the previous record, he remained at his Morse key for 24 hours non-stop on the last day.

Norfolk Island, some 17,000km in the south-west Pacific Ocean, was the destination of his furthest link-up – with Kirsty Smith (VK9NL) and her husband Jim (VK9NS).

Mike Parton, managing director of Marconi Communications, said "We congratulate the radio operators on their achievement and for their superb re-enactment of Marconi's first demonstration that radio could assist ships at sea".

V-MAILED E-MAIL

Pictures speak a thousand words – could V-mail replace E-mail? Barry Fox investigates the prediction.

ELECTRONIC mail is getting a new look. Philips will soon launch the $99 Videogram or V-Mail kit. A simple colour video camera with built-in microphone plugs into the USB (universal serial bus) socket of a Windows 98 PC. Videogram Creator software then lets the user click on an icon, talk to the camera and hit Escape to stop recording.

Clicking on Send then compresses the conventional AVI (Video for Windows format file) recording by a factor of 100, so that a one minute sound and video message can be stored on a standard 1·4MB floppy disk. The compressed file is then sent as an ordinary E-mail message.

Whereas previous video E-mail systems have only worked if the recipient has matching software to decode the sound and picture file, V-Mail bundles matching Player software with the message and packages it as an executable (EXE) file. The recipient then just clicks on the message, which unpacks itself and plays sound and pictures.

The player software works with any version of Windows (3.x, 95, 98, NT) or IBM's OS/2, and even runs on old 486 processors. The pictures display in a small window of the screen, while the sound comes out of the PC's speakers.

"V-Mail will replace E-mail in four or five years" predicts Hugh Brogan, Chief Executive Officer of Philips PC Peripherals Division.

RE-HOMING 5M PCs

"AROUND five million items of old IT equipment are thrown away in the UK each year", so said Dr Kim Howells, the UK's Competition and Consumer Affairs Minister, when recently launching *Unwanted Computer Equipment: a Guide to Re-use* at a workshop on environmental research and development at the DTI in London.

The handbook provides advice and help to businesses who want to find a good home for their old computer equipment. Markets for refurbished computers include schools, libraries, community centres, charities and households. The handbook contains a directory of UK refurbishers, so that businesses who want to donate their IT equipment, as well as the people who want to get hold of it, will know who to contact.

Copies of the handbook are available through the DTI publication orderline (quoting reference URN 98/979) tel: 0870 1502 500, fax: 0870 1502 333.

AMBIDEXTROUS PCS

Multitasking takes on a broader meaning for PC use – Barry Fox reports.

PHILIPS has now secured approval from the US Federal Communications Commission to sell Ambi, a wireless home network system which lets a single PC run two different applications at the same time, with their different images simultaneously displayed on the PC monitor screen and a conventional TV set in another room.

Ambi, which will go on sale in the US during this year for around $600, relies on spread spectrum technology, similar to that developed for secure military communications and now used by digital cellphones in the US. The data is spread over a 1MHz band at 2·4GHz.

A transceiver plugs into the PC and sends a 4Mbps data stream to a matching unit which is connected to the TV. The TV's unit can also send back data entered into an infra-red keyboard. The two-way radio line reaches 50m, so one member of the family can wordprocess or work on a spreadsheet while using the PC screen, while others play computer games or surf the Internet using the TV screen in another room. The video sent to the TV is converted from the VGA computer standard to NTSC TV format.

The PC can multitask on line, so that two people can surf the Internet at the same time, using the same phone connection to the same Service Provider. Ambi encrypts and labels the data sent on the radio link so that neighbours with similar hardware cannot tap in.

The same 2·4GHz frequency band is available in Europe for wireless networking, but Ambi cannot be sold until each country has approved the spread spectrum signal for local use.

DNA COMPUTER

By Barry Fox

NEC's Research Institute in Princeton, New Jersey, has patented (USP 5 804 373) a universal computer, as originally proposed by British scientist Alan Turing, that uses DNA strands instead of tape to store the program. NEC's researchers, Allan Schweitzer and Warren Smith, used circular loops of DNA, with groups of 20 molecules sequenced to represent letters of the alphabet. The loops are then cut with enzymes to create "sticky" ends which are then re-joined to explore every possible combination. Dyes are then used to expose the patterns formed.

Check sequences are added to expose errors, in a manner analogous to error correction in a digital bit stream. NEC is proving the system with traditional problems, like the best routes a travelling salesman should take to cover a number of cities, without ever visiting the same city twice.

NEC acknowledges that the invention builds on proposals made by Leonard Adelman of the University of Southern California in 1994, but makes the technique commercially viable. Although DNA computing is slow, taking hours per step instead on microseconds, a very large number of strands can be treated at the same time to create a massive parallel processor.

CLIVAN BBS

CLIVE BONNER (G3TGF) has asked us to publicise his Amateur Radio Telephone BBS. The BBS was set up originally to provide a user-friendly means of exchanging data, programs and weather pictures. It follows the success for many years of the Amateur Radio Weather Net which takes place on 3786MHz each morning throughout the year, usually between 0730-0930 GMT.

All software included on the BBS is either Shareware or Freeware and is for Amateur Radio purposes only, including SSTV and Weather satellite related programs. The system has been set up to be as simple and quick as possible, operating without "bells and whistles".

The 24-hour phone number for access to the CLIVAN BBS is 01435 830484, 3333. Clive emphasises the importance of including the last four digits in the modem dial-out string to ensure correct routing. Preferred FTP protocol is ZMODEM but other protocols are available.

PIC BASIC

A FREE PIC Basic compiler has been released by Leading Edge Technology Ltd. LET has released this program to encourage the use of PIC16Cxx series microcontrollers along with their range of low-cost ICE (In-Circuit Emulators), PIC Programmers and other related products.

The Basic compiler supports PIC54/55/56/57/71/84, the code produced is "stand-alone" and no run-time modules are required. It can be downloaded from LET's web site: **http://let.cambs.net.** LET are based in Malta.

Nepcon Webbed

OF LIKELY interest to those who would like to get to the Nepcon UK electronics exhibition but cannot, is the new web site at **www.nepcon.co.uk.**

Nepcon UK is the UK's leading annual event for the electronics manufacturing industry. The new web site aims to be the number-one source for industry information for the electronics manufacturing community in general. This year's event takes place at NEC in Birmingham from 13-15 April.

By filling in a short form over the Web, users can access the Product Index all year round. This is a free reference service that informs users by E-mail of any updated products as they appear on the site. It also offers a search facility whereby the index may be used to locate potential suppliers by product category.

Nepcon UK is organised by Reed Electronics Events, who can be contacted on 0181 910 7849.

Maplin Tailors PCs

MAPLIN ELECTRONICS have come up with a leading solution to what they say is the most asked question in the PC retailing world: "What system should I get?". Maplin believe that in this increasingly computer-orientated world, the need to have systems that meet the consumer's individual needs is crucial. Accordingly, they have awarded Compusys Ltd the "Build to Order" contract for supply of "customer-designed" PCs to all Maplin stores. Prices start at £699.99.

Staff are on-hand to offer expert advice to PC buyers when selecting from the wide range of options available. "Maplin have long had an exceptional reputation for high level technical expertise at the point of sale", said Gordon Davies, General Manager of Compusys.

For further information, contact any of Maplin's stores nationwide (and international), or their head office at PO Box 777, Rayleigh, Essex SS6 8LU. Tel: 01702 554000. Fax: 01702 554001. Web: http://www.maplin.co.uk.

SOLAR NIGHT-LIGHT

A REMARKABLY low cost solution to independent outdoor lighting at night is being offered by Solar Solutions Fountains. Their new Sentinel Solar Powered Light will, they say, be appreciated by anyone who "finds themselves holed up in the shed to twilight and beyond". The Sentinel provides reliable, powerful outdoor fluorescent lighting, with no need for costly or complicated mains wiring, and has no running costs.

"The beauty of the Sentinel," explains Alex Smith of Solar Solutions Fountains, "is that it is so easy to use and lends itself to such a wide variety of use. All you have to do is affix the solar panel outside your shed, garage or outhouse, position the fluorescent tube inside, and connect them with the cable supplied. The Sentinel will charge up even in watery winter light, and is then ready for use whenever you need it."

The Sentinel Solar Powered Light kit comes complete with an 18W fluorescent light with built-in battery, 5W top-quality solar panel, 5m cabling, fixings for panel and light, plus easy-to-follow instructions. It costs £98 including postage and packing. It is available by mail order from:

Solar Solutions Fountains, 6 High Street, Kington, Herefordshire HR5 3AX. Tel/fax: 01544 230303.

New Technology Update

Ian Poole investigates the use of micro-electromechanical systems in computer applications.

THE DEVELOPMENT of micro-electromechanical systems (MEMS) is progressing rapidly now. Over the past few years it has been seen that they have come from being a laboratory curiosity to a reality where many ideas are being developed for real applications.

These machines are subminiature mechanical devices made from silicon. They are manufactured using techniques used for semiconductor manufacture. As a result they can be made exceedingly small, allowing them to be used for applications that could not be conceived for small devices made by more traditional means. They can easily be made in large quantities. Although the initial development costs may be high, once these have been accounted for the actual incremental cost of the individual machines is relatively low.

MEMS LOCK

A novel application has been developed at the Sandia National Laboratories in Albuquerque, New Mexico, USA. It uses a MEMS as a combination lock. Not only is it of interest because of the MEMS technology, but it is also the first known mechanical device to be used as a computer firewall to prevent unwanted hackers from entering a computer system. Normally software firewalls are used, but hackers who are using ever more sophisticated methods can often manipulate them. This mechanical device cannot be manipulated in the same way.

There is only one chance in a million of choosing the right code to enter. If the wrong code is chosen then the lock has to be mechanically reset before the system can be accessed again. In the case of many software firewalls, repeated attempts can be made to access the system and it is only a matter of persistence before access is gained. There is normally not a complete reset as in the case of the mechanical device.

There are plenty of stories of people breaking into computer systems like those of the FBI, CIA and so forth. Whilst these stories hit the headlines, and these sites probably attract a lot of interest from amateur hackers, the danger is no less for other sites, where more professional organisations may have an interest. This means that it is exceedingly important for any computer that has links to the outside world to be well protected from invasion from external hackers.

In addressing this problem Sandia looked at ways of improving the current levels of security. It is a fact that mechanical systems are far harder to break than software ones. Accordingly a decision was made to adopt a mechanical solution to devise a system that would prevent unauthorised entry into computer systems.

The system took only three months from initial concept to the final design. Using ideas based around those used in weapon safety locks, the development team was able to design a system that was very simple. In fact its very simplicity makes it easy to analyse and ensure that there are no weaknesses that could be exploited by hackers.

CONSTRUCTION

The prototype consists of a total of six code wheels, each less than 300μm (micro-metres) across – see photo. These are driven by a series of combs that are electrostatically operated, turning the electrical impulses into mechanical movement. The design exploits all the available levels of polysilicon in Sandia's SUMMiT process. Three functional layers of polysilicon alone are needed to create the fail-safe discrimination capability of the design.

The whole lock can be fabricated onto a small chip and would typically measure about 5 × 10mm. It could then be mounted into the computer requiring the security function and driven electrically by pulses derived from the interface.

The device can be unlocked only when the correct code is entered. The lock translates the digital information that enters the lock into an angular rotation of the gears. To achieve its performance the design requires three individual levels of gear teeth where the teeth approach the mesh point from opposite directions, unlike conventional gears that approach from the same direction. This means that the device is specifically designed so that the gear teeth will interfere and the device will lock up if the wrong code entered.

Control of the lock can only be gained from the secure side. It is possible for the system controller to enter a new code as well as resetting the lock when it has been incorrectly accessed and locked up.

SUMMiT

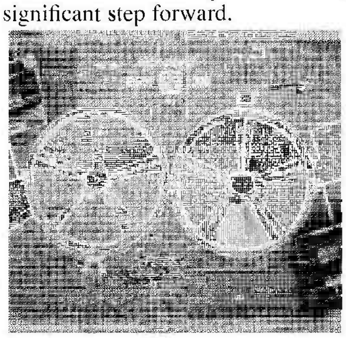
One of the keys to the success of the MEMS lock is the fabrication process that was devised at Sandia. The MEMS are made from polycrystalline silicon or polysilicon for short. This material is widely used in i.c. fabrication processes, and it is actually stronger than steel, making it ideal for mechanical structures.

The number of layers that are used governs the complexity of the machines that can be achieved. A process that contains a ground plane (i.e. the base plane for the structure) and one mechanical level is called a two level process and can be used to fabricate a structure such as a comb drive. A three level process is required for a gear on a hub. The addition of a further layer enables linkages to be fabricated so that they can be used to connect various actuators to other mechanisms. In this way it can be seen that the addition of further layers enables much greater flexibility to be obtained.

The Sandia SUMMiT process creates devices by successively setting down a film, then placing a pattern onto the film using photolithography, and then etching the material in line with the pattern to give the required shape. By repeating the process with alternate layers of silicon oxide and polysilicon it is possible to create the complicated shapes such as those required for the lock.

At the end of the process the silicon oxide is chemically removed. Once this has been done only the much stronger polysilicon remains, giving the required shapes for the machine. By designing the correct boundaries between the polysilicon and silicon oxide it is possible to end up with wheels on hubs that can move.

A mask is required for each stage in the process. The SUMMiT process requires a total of eleven different masks. This means that the complexity of the fabrication process is about the same as that required for a fairly simple CMOS i.c. However the SUMMiT process overcomes the problems of residual film stress that appear in many micromachine processes and this is one reason why its introduction is a significant step forward.



Part of the code lock. Photo courtesy of Sandia National Laboratories intelligent micromachine initiative.

Although the realisation of the process required much development effort it has now been satisfactorily introduced. It is relatively straightforward and uses the same basic concepts as integrated circuits. This means that once a process has been set up the incremental costs for these micromachines is very small.

In view of this many more ideas for these machines will undoubtedly be found in the next few years and they will start to appear in many everyday applications. It means that what was only a laboratory curiosity a few years ago will become an everyday fact in a few years time.

VOICE RECORD/ PLAYBACK MODULE

ROBERT PENFOLD

Your very own personal "voice box". Will digitally record up to 16 seconds of sound.

THE DAYS when gadgets capable of understanding what we say or able talk back to us were in the realms of science fiction are now well and truly behind us. This article is being dictated into a PC using (more or less) normal speech, and when checking the final piece for errors the computer will be instructed to read the text back.

It is not only in the computer world that this sort of voice interface is starting to emerge. All manner of electronic gadgets that can understand simple commands and (or) talk back to us are becoming available.

The device featured here is a general-purpose voice recording and playback module that can handle up to 16 seconds of speech. It can be used as a complete project in its own right, and it then operates as a simple messaging system.

In order to record a message you simply press a button, say a short message such as *"taken the cat to the vet, back at about 4-30"* and then release the button. Your message can then be played back as many times as required simply by pressing a second pushbutton switch. New messages can be recorded over existing ones as and when required.

RED ALERT

Another way of using the unit is as an alternative to an l.e.d. indicator or a low power audio alarm generator circuit. When used in this way you must first record a suitable message into the unit, such as a "warning – maximum temperature exceeded" or "red alert – this is not a drill" if your sense of humour gets the better of you!

A big advantage of this system is that you can use any words you like, and you are not restricted to very brief messages. When the module is activated the message can either be played back just once, or it can be repeated for as long as power is applied to the module, as preferred.

The basic recording and playback circuit is designed to operate from a supply potential of about 5V, but an optional voltage regulator enables the circuit to operate over a supply voltage range of about 7V to 15V. The module has a built-in electret microphone insert and will directly drive a small loudspeaker having an impedance rating of 16 ohms or more.

Current consumption of the module is insignificant when it is in the standby mode, but the non-volatile memory retains its contents even when the module is switched off. This avoids the need for any form of battery back-up circuit.

A unit of this type could easily be very complex and large, but by using a dedicated integrated circuit the component count of this circuit is kept to a minimum. The speech quality of many "talking" circuits leaves a lot to be desired, but in this case the quality is very good due to the use of a recorded voice rather than speech synthesis techniques. In fact the quality is surprisingly good, and is limited mainly by the quality of the microphone and loudspeaker used rather than the recording and playback circuit.

Although this module is quite simple, in most cases it will require a certain amount of technical knowledge in order to use it properly. Consequently, it cannot really be regarded as a beginner's project.

SYSTEM OPERATION

This project is based on the ISD1416 "ChipCorder" integrated circuit from ISD. It is an extremely complex chip that provides all the active circuitry needed for this application. The internal arrangement of this chip is shown in the simplified block diagram form of Fig 1.

The output level from an electret microphone is extremely small, and a large amount of amplification is needed in order to bring the signal to a level that will drive the analogue-to-digital converter properly.

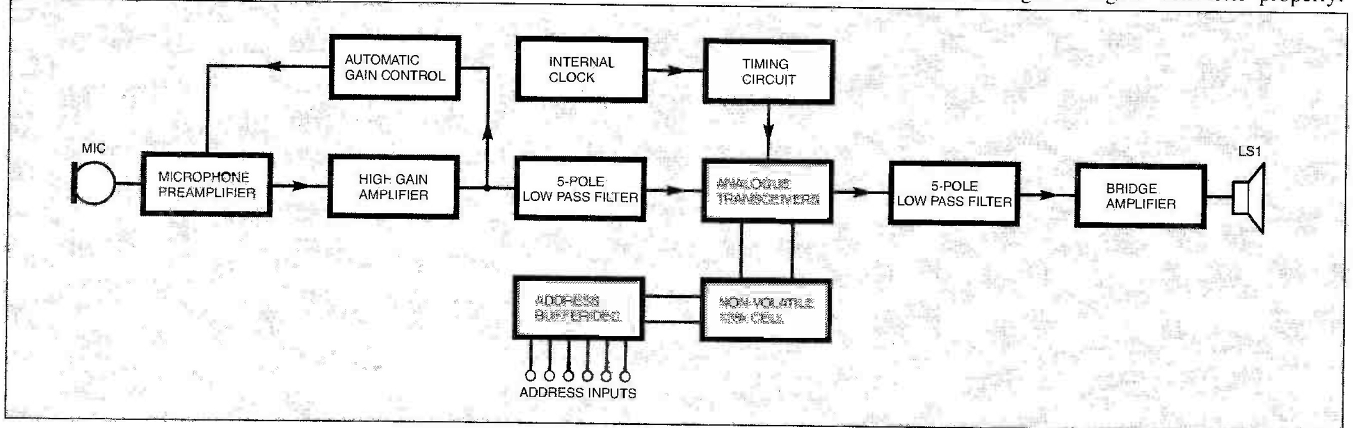


Fig. 1. Simplified block schematic diagram for the ISD1416 voice chip.

A low noise preamplifier followed by a high gain amplifier provides this amplification.

It is likely that the input level will vary enormously depending on factors such as the particular microphone used, the distance from the user to the microphone, and the loudness of the user's voice. The input stages of the device therefore incorporate a simple but effective a.g.c. (automatic gain control) action that prevents overloading and the extreme distortion this would produce.

ACTIVE FILTER

The next stage in the main signal path is a 5-pole lowpass filter. In common with other digital recordings systems, this one uses a system of sampling the input signal at regular intervals.

The sampled values are stored in memory, and then played back through a digital-to-analogue converter during playback. This converts the stored values back to the original sample voltages, and recreates the original signal.

One slight problem with any sampling system is that any input signals close to the sampling frequency produce a very severe form of distortion known as "aliasing" distortion. In this case the sampling frequency is just eight kilohertz (8kHz), which is well within the audio range. This makes it important to have a very effective filter to attenuate input signals at more than about one-third to one-half of the sampling frequency.

This is the purpose of the 5-pole active lowpass filter at the input of the analogue-to-digital converter. With a sampling frequency of 8kHz, the maximum signal frequency that can be handled by the system is only about 3kHz or 4kHz, but this is perfectly adequate for good results with speech signals.

The ISD1416 data sheet is very vague about the analogue-to-digital and digital-to-analogue converters, which are simply referred to as "analogue transceivers", but the audio quality of the device would suggest that these have a resolution of at least 8-bits. The EEPROM has a capacity of 128 kilobytes, which together with the sampling rate of 8kHz gives a maximum message duration of 16 seconds.

Typically, the memory retains its contents for 100 years, and has a lifetime of one hundred thousand record cycles. Some of the address inputs are accessible, but in normal operation it is not necessary to take direct control of the memory. The internal control circuits automatically start playback at the beginning of the sample and halt it at the end.

It is not necessary to use the full 16 seconds of message time, and messages can have any duration up to the 16-second maximum available. The device has internal clock oscillator and timing circuits that provide suitable control signals to the converters, memory, etc.

OUTPUT

On the output side of the converter stage there is another 5-pole lowpass filter and a small audio power amplifier. Any sampling method of recording inevitably results in a stepped output waveform as the signal jumps from one sample level to the next.

This effectively provides an output signal that is modulated with the sampling frequency. In this case the sampling frequency is well within the audio range, and could produce a clearly audible tone on the output. The lowpass filter at the output smoothes the signal to remove the stepping, and in doing so it also removes any audible breakthrough of the clock signal.

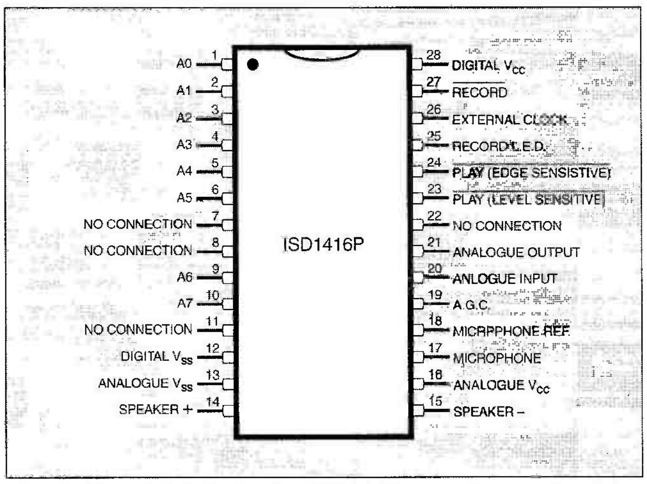


Fig.2. Pinout details for the ISD1416 speech recorder chip.

The power amplifier at the output of the device is a bridge circuit that can directly drive a loudspeaker that has an impedance of 16 ohms or more. Using a bridge circuit enables a reasonable output power to be obtained despite the fact that the supply potential is only 5V and the loudspeaker is a high impedance type.

The ISD1416 also includes a substantial amount of control logic that enables the recording and playback functions to be controlled by just two pushbutton switches. These control circuits also govern such things as whether the device operates in the one-shot mode or plays back samples continuously.

PINOUTS

Pinout details for the ISD1416, which is contained in a standard 28-pin d.i.l. encapsulation, is shown in Fig.2. There are separate supply pins for the analogue and digital circuits, but in normal use these are fed from a common supply.

Pins designated A0 to A7 are the address inputs, but in many applications these can simply be connected to the 0V supply rail and otherwise ignored. If the two most significant bits (A6 and A7) are high, the address inputs control the operating mode of the device.

Address input A3 is one of the most useful, and controls whether the chip operates in single-shot mode or loops continuously. This input is taken high in order to set the device into the continuous loop mode.

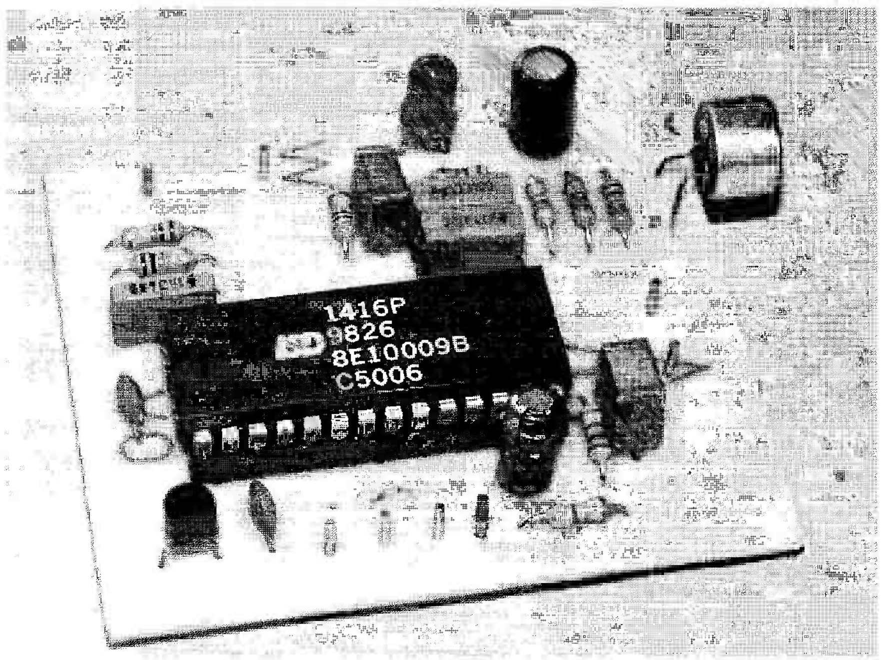
There is provision for an external clock circuit, and the clock signal can be applied to pin 26. This facility is not normally required, and pin 26 is then connected to the 0V supply rail.

RECORD/ PLAYBACK

Recording and playback are controlled via three inputs, one of which is used to produce record cycles (pin 27). Like the other control inputs, this pin is normally held high. However, it must be taken low and kept low while the message is recorded.

An open collector output at pin 25 is switched on during this period, and can be used to operate an l.e.d. indicator which confirms that the recording cycle is proceeding normally. If the recording has not been completed by the end of the 16-second maximum recording period the l.e.d. will switch off to indicate that the recording has finished.

Pin 23 and pin 24 control playback, and in most applications it is the edge sensitive input at pin 24 that is utilized. Taking this input low, even momentarily, results in the complete message being played back. When using the level sensitive input at pin 23 the message is only played back while the input is held low, and the message will



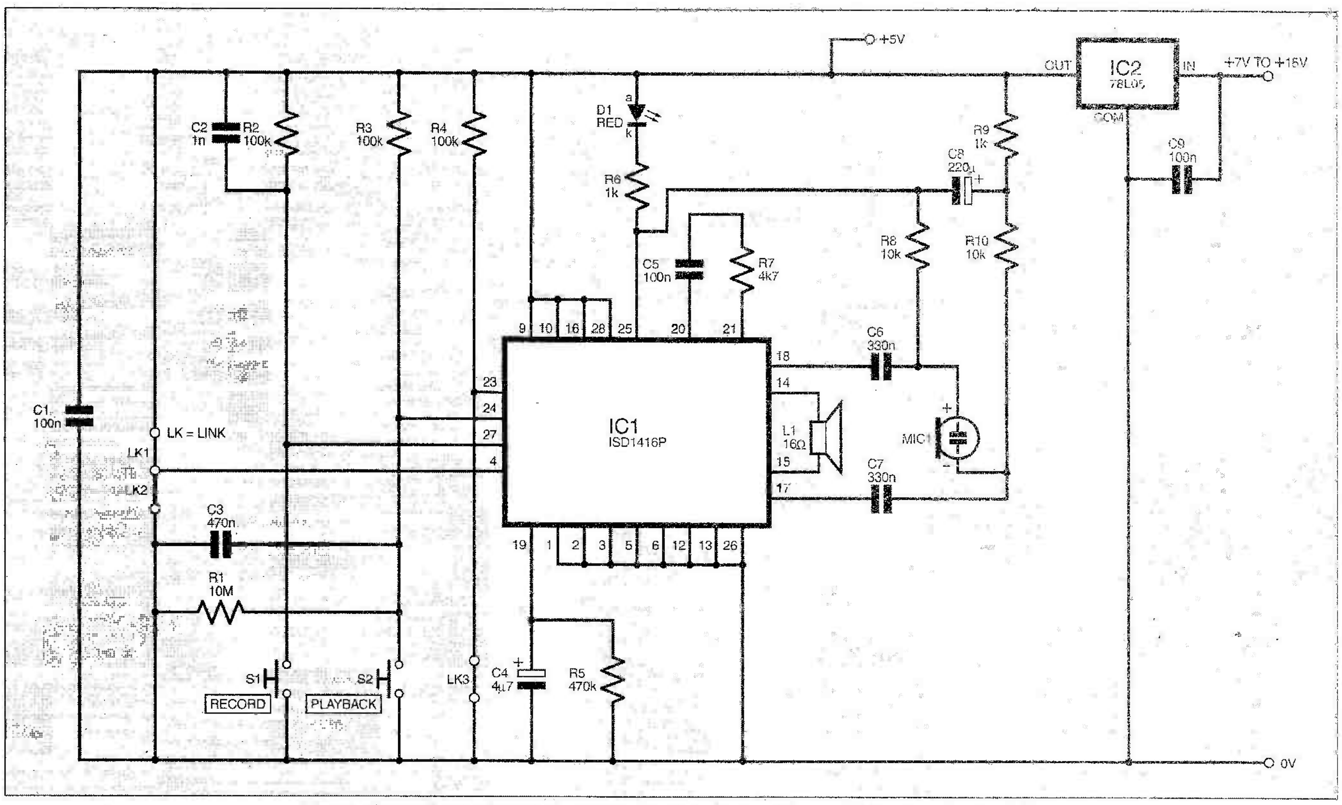


Fig.3. Complete circuit diagram for the Voice Record/Playback Module.

be truncated if this input is returned to the high state prematurely.

On the audio side of things there are differential inputs at pin 17 and pin 18. Differential inputs can help to ease problems with stray pick up of noise, but in most applications there will be no long microphone cables and this will be purely academic.

A resistor and capacitor network connected to pin 19 controls the decay time of the a.g.c. circuit. The output of the preamplifier and the input of the amplifier stage are available at pins 20 and 21 respectively, and an external capacitive coupling is required here. Four pins of the device have no internal connections.

CIRCUIT OPERATION

The full circuit diagram for the Voice Record/Playback Module appears in Fig.3. In practical applications not all of the components and links shown in the circuit diagram will be required. We will deal first with the components that MUST always be included.

The microphone MIC1 is capacitively coupled to the inputs of the voice chip IC1 by way of capacitors C6 and C7. Unlike most types of microphone, the electret variety has a built in preamplifier that requires a power source.

Modern electret microphones usually have just two terminals, and require an external load resistor for the preamplifier stage, as shown in of Fig.4a. The preamplifier is usually a simple j.f.e.t. circuit that will operate from a low supply potential and draws little supply current. In most cases the circuit will operate at supply potentials as low as one volt or so, and with a supply current of less than 100 microamps.

INPUT CIRCUIT

The input circuit used here may look a little unusual, but it uses the method recommended in the data sheet for the ISD1416. This produces differential output signals using the method of connection shown in Fig.4b.

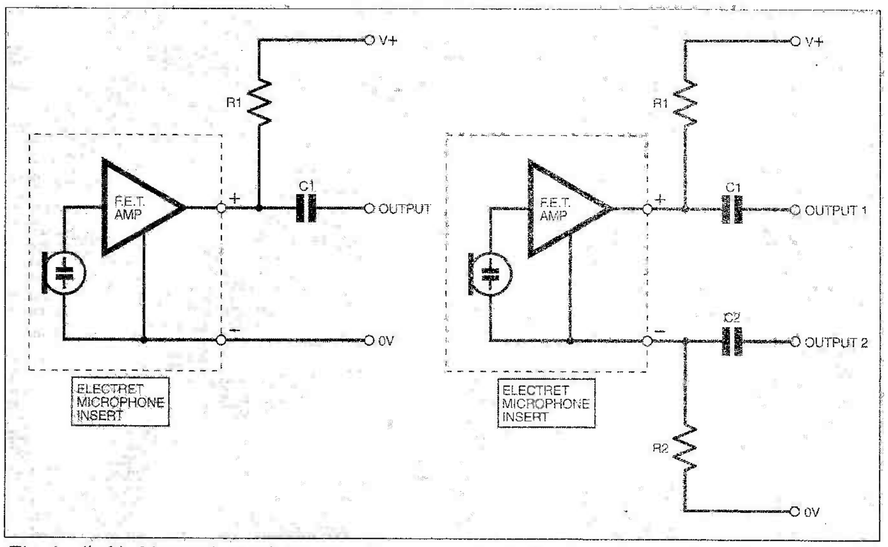


Fig.4. (left) Normal method of using an electret microphone insert, and (right) producing differential output signals.

Resistor R9 and capacitor C8 form a decoupling network in the supply to the microphone circuit, see Fig.3. This avoids problems with feedback through the supply lines, and digital noise being coupled into the audio path via the supply.

The 0V supply for the microphone circuit is obtained from pin 25 of IC1, which results in the microphone circuit being switched off except when a recording is being made. This maintains the very low standby supply current of less than a microamp.

Diode D1 is the Recording indicator l.e.d. and R6 is its current limiter resistor. Incidentally, this l.e.d. also flashes briefly at the end of each playback cycle.

Capacitor C5 and resistor R7 couple the output of the microphone preamplifier to the input of the amplifier stage. The *C-R* timing network for the a.g.c. circuit is comprised of C4 and R5. It is necessary to use a fairly long time constant here in order to avoid rapid changes in gain and consequent distortion.

Because the output amplifier is a bridge circuit it is not necessary to use a coupling capacitor in series with loudspeaker LS1. Under standby conditions both outputs are about half the supply potential, giving 0V across the loudspeaker.

In operation the outputs provide antiphase signals (i.e. as one output goes more positive the other goes negative by an identical amount). This gives a maximum output voltage that is twice as high as using a single-ended output stage, and in theory the peak-to-peak output voltage can be double the supply potential.

In terms of output power a bridge circuit gives up to four times the output of an equivalent single-ended circuit. Although the circuit only operates from a 5V supply, using a high impedance (about 64 ohms) loudspeaker provides adequate volume for most purposes.

If the unit will be used in a noisy environment it would be better to use a 16 ohm impedance loudspeaker, but a component of this impedance is unlikely to be available. Using two 8 ohm impedance loudspeakers connected in *series* is probably the best option. ***Note that using a loudspeaker having an impedance of less than 16 ohms could damage IC1.***

SUPPLY NEEDS

The ISD1416 is designed to operate from a 5V supply, and voltage regulator IC2 plus capacitor C9 are unnecessary if a supply of about 4·5 to 5·5V is available. If the unit is to be battery powered, three AA cells in a holder provide a nominal 4·5V supply and seem to give good results. Due to the very low quiescent current consumption of no more than 10µA (and typically just 0·5µA) it is unnecessary to use an on/off switch if the unit is used in a stand-alone application.

If the module is used instead of an l.e.d. indicator and has to operate from a supply of about 7V to 15V, it *must* be powered via IC2, and both IC2 and C9 *must* be included. Note that the standby current consumption of the circuit will be up to a few milliamps if IC2 is included, due to the current consumption of IC2 itself. This factor should not be important when the module is used in place of an l.e.d. indicator, because it should be switched off for the majority of the time.

Link LK1 is included if the unit must operate in the mode where it loops continuously, repeating the message for as long as power is applied to the circuit. For single-shot operation include link LK2 instead. One or other of these link-wires must be included, **but obviously not both**.

If the module is used as a stand-alone device for handling messages, both switch S1 and S2 should be included. S1 is operated while a message is recorded, and S2 is pressed briefly in order to play back messages.

These switches could be included if the unit is used in place of an l.e.d. indicator, but they are not really needed. A crocodile clip lead or virtually any short piece of wire can be used to connect the appropriate two pins on the circuit board while your message is recorded. The same method can be used to trigger the unit to check that your message has been recorded properly.

L.E.D. INDICATOR

Where the unit is used in place of an l.e.d. indicator it is clearly necessary to have the circuit trigger automatically when it is powered-up. One way of achieving this is to include capacitor C3 and resistor R1.

Capacitor C3 keeps pin 24 of IC1 low for several milliseconds after power-up, and this triggers it into a playback cycle. The message will, of course, be played back repeatedly if link LK1 is included. Resistor R1 discharges C3 when the power is removed so that the unit is soon ready to trigger again when power is restored.

Access to the level sensitive "play" input at pin 23 is provided, or link LK3 can be included so that this input is permanently held low. On the face of it this provides another means of automatically triggering the unit when it is powered-up, but this does not always seem to have the desired effect, and the author would recommend using R1 and C3 where automatic triggering is required.

CONSTRUCTION

The component layout and actual size copper pattern for the printed circuit board (p.c.b.) are shown in Fig.5. This p.c.b. is available from the *EPE PCB Service*, code 225

The board is fairly straightforward to construct, working from the smallest to largest component, but the ISD1416P is a CMOS device and is not particularly cheap. It is therefore essential to adhere to the standard anti-static handling precautions.

You *must* use a holder for the "voice" chip IC1, but *do not* plug it into its socket until the circuit board is otherwise complete. Try to touch the pins as little as possible, and keep the device away from any obvious sources of static charges such as computer monitors and television sets.

COMPONENTS

Resistors

R1	10M	
R2, R3, R4	100k (3 off)	
R5	470k	
R6, R9	1k (2 off)	
R7	4k7	
R8,R10	10k (2 off)	

All 0·25W 5% carbon film

See SHOP TALK Page

Capacitors

C1, C9	100n disc ceramic (2 off)
C2	1n polyester
C3	470n polyester
C4	4µ7 radial elect. 50V
C5	100n polyester
C6, C7	330n polyester (2 off)
C8	220µ radial elect. 10V

Semiconductors

D1	red panel l.e.d.
IC1	ISD1416P voice record/playback
IC2	78L05 +5V 100mA voltage regulator)

Miscellaneous

S1, S2	pushbutton switch, push-to-make, release-to-break (2 off)
MIC1	electret microphone insert
LS1	moving coil loudspeaker, 16 ohms or more impedance (see text)

Printed circuit board available from the *EPE PCB Service*, code 225; 28-pin d.i.l. holder; multistrand connecting wire; solder pins; solder etc.

Some components are not required, depending on the mode of operation. Refer to main text for detailed information on the components required for each method of use.

Approx Cost Guidance Only £25

The electret microphone must be connected with the right polarity if it is to function well. The lead that connects to the metal case of the insert is usually the negative supply terminal, but where possible this point should be checked using the manufacturers or retailers literature.

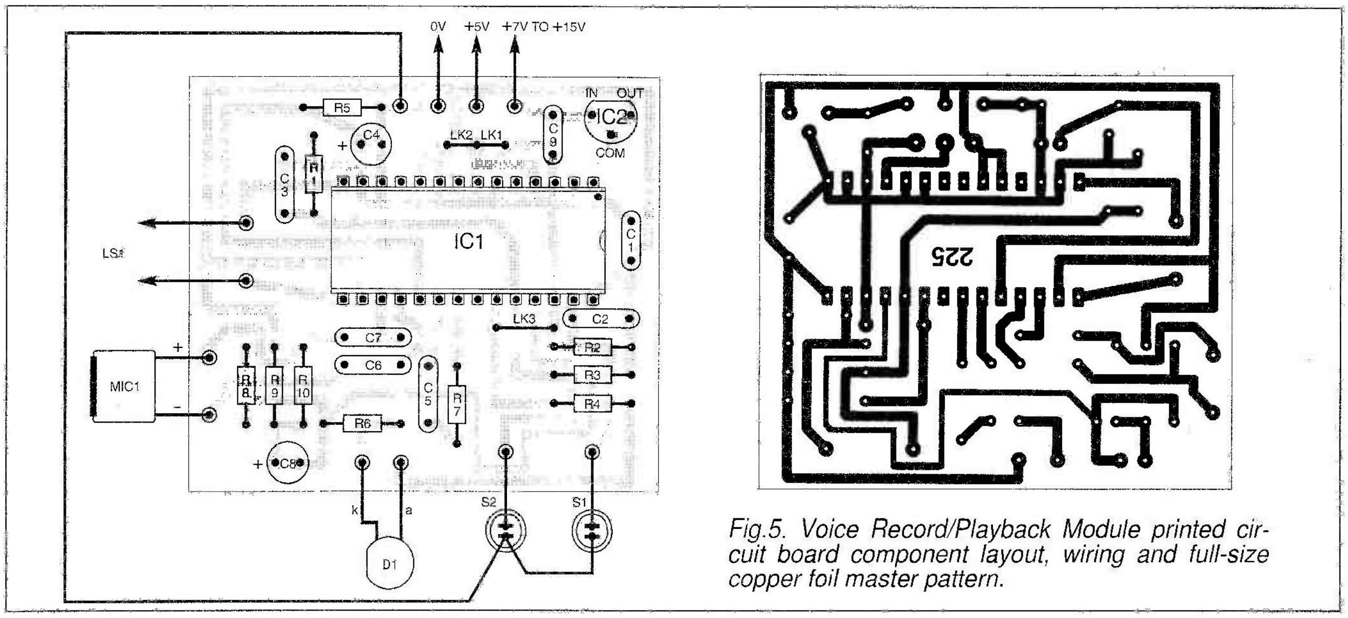


Fig.5. Voice Record/Playback Module printed circuit board component layout, wiring and full-size copper foil master pattern.

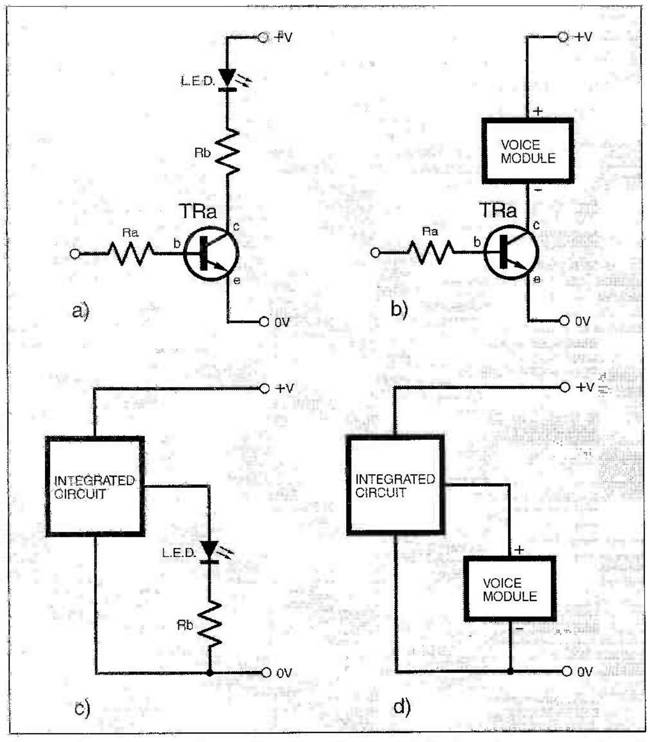


Fig.6. Two examples of using the module in place of an l.e.d.

OPERATING CHOICE

As pointed out previously, some of the components and link-wires will not be required, and which ones that have to be left out depends on your precise application. The following examples should help to clarify matters.

Stand-alone Messaging System

Omit IC2, C4, C9, link LK1, link LK3, and R1. Power the unit from a 4·5V battery and use the 0V and +5V supply inputs.

Indicator L.E.D. Replacement for 5V Supply

Omit IC2, C9, and link LK3. Include pushbutton switches S1 and S2 temporarily while the module is programmed and checked, or improvise with pieces of wire. For one-shot operation include link LK2 and omit link LK1. For continuous looping omit link LK2 and include link LK1. Use the 0V and +5V supply inputs.

Indicator L.E.D. Replacement for 7V to 15V Supply

Omit link LK3. Include switches S1 and S2 temporarily while the module is programmed and checked, or improvise with pieces of wire. For one-shot operation include link LK2 and omit link LK1. For continuous looping omit link LK2 and include link LK1. Use the 0V and +7V to 15V supply inputs.

CASING-UP

If the unit is constructed as a stand-alone messaging system it will obviously have to be fitted in its own case, and virtually any small to medium size case should accommodate everything. A grille is required for the loudspeaker, and there are various ways of producing this.

The standard approach is to make a large round cutout that is slightly smaller than the diameter of the loudspeaker. A piece of speaker cloth or fret is then glued in place behind the cutout. A simple alternative is to drill a matrix of holes about four or five millimetres in diameter, but this needs to be done very carefully if a neat appearance is to be obtained.

Miniature loudspeakers invariably lack any provision for screw fixing, leaving little alternative to gluing them in place. Only apply the adhesive to the front rim of the loudspeaker, taking care not to smear any over the diaphragm. Any good quality general-purpose adhesive should do the job quite well.

Building the unit into a larger project will require some careful planning, as space has to be found for both the circuit board and the loudspeaker. This will normally necessitate using a somewhat larger case than would otherwise be required. The notes on mounting the loudspeaker provided previously also apply here.

It might be possible to add the module into an existing project, but this is dependent on there being sufficient space available in the case. There must also be sufficient front panel space for the loudspeaker. It will be necessary to partially dismantle the project so that the cutout for the loudspeaker and mounting holes for the circuit board can be added without damaging any of the original components.

If there is not enough space available to add the module into an existing project, it might be better to construct it as an external add-on rather than rehousing the project in a larger case. A twin cable plus suitable connectors will then be needed to connect the two units together.

LINKING-UP

In order to use the module as part of a larger project it is essential to have a certain amount of technical knowledge. It is not possible to provide detailed connection information for a wide range of projects here, and this project is aimed at those who have some experience of electronic design and know what they are doing. In most cases a certain amount of experimentation will be needed in order to get things working well.

If the main project operates from a 5V supply it might be possible to use an output of the project to control the module via pin 23 or pin 24 of IC1. In most cases it will be easier to simply connect it in place of an l.e.d. indicator, making sure that it is connected with the correct supply polarity. *The ISD1416P will probably be destroyed if the supply is connected with the wrong polarity.*

The current consumption of the module is likely to be somewhat higher than that of an l.e.d., and can be as high as 30mA. There is no point in trying to use this module with outputs that can only supply a few milliamps.

Sometimes, l.e.d.s are driven from a switching transistor, as shown in Fig.6a. This type of stage can usually provide quite high output currents, and it should control the module without any problems. If necessary the base resistor (R_a) can be reduced in value slightly, but this will not normally be necessary.

Of course, the module should be driven direct from the collector of the transistor, as in Fig.6b, and current limiter resistor R_b should be omitted. If the l.e.d. is driven from the output of an integrated circuit via a current limiter resistor (Fig.6c), it will usually be possible to drive the voice module direct from the output of the integrated circuit, as in Fig.6d.

There are likely to be problems if the output is specifically designed to drive an l.e.d., and there is a built-in series resistor or current regulator circuit. Direct control of the voice module is then unlikely to work, and a switching stage will have to be added.

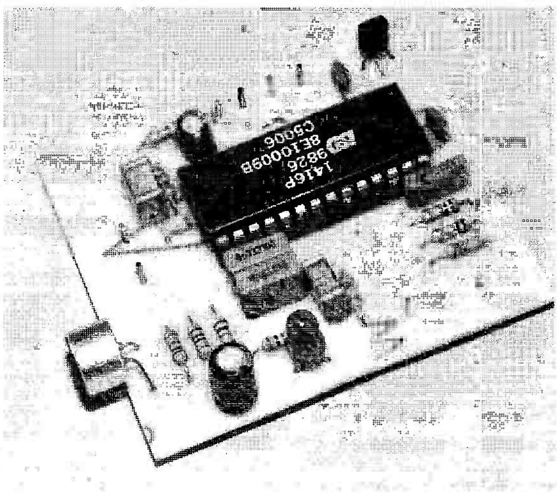
TESTING, TESTING, 1-2-3

Once the project has been completed and all the wiring has been thoroughly checked it is time to power-up the circuit board and record your message. Pressing switch S1 or wiring pin 27 of IC1 to the 0V supply rail will force the module into a record cycle, and l.e.d. D1 should light up to indicate that recording has commenced. If D1 fails to light, disconnect the power at once and recheck the circuit board.

Assuming all is well, speak your message clearly and in a reasonably loud voice. Electret microphone inserts are not usually very sensitive, so you will probably have to be within about 300mm of the microphone in order to obtain good results.

Release S1 or remove the wire link as soon as you have completed your message, which must be no longer than 16 seconds in duration. D1 should then switch off.

To play back your recording either press switch S2 briefly, or remove and reconnect the supply, as appropriate. If the volume is very low and the signal is distorted it is likely that the microphone insert has the wrong polarity. Reconnecting it with the correct polarity and recording your message again should rectify the problem.



MODULAR CIRCUIT DESIGN CD-ROM

ROBERT PENFOLD

Robert "test drives" a new software CD-ROM package.

THIS educational software is firmly based on the series of articles that appeared in *EPE* between November '95 and August '96 under the title *Teach-In '96 – A Guide to Modular Circuit Design*. It is not actually a program, but a set of HTML files. In effect it is an Internet site on a CD-ROM.

It should work with any PC that is equipped with an Internet browser, but note that no browser is included on the CD-ROM. This should not be a major problem since browser software is widely available free of charge, either via the Internet or on the cover disks of computer magazines. If you are using a modern operating system you may well find that a browser is included.

STARTING POINT

In order to use the software you locate the "Start" file and then use the browser to run it. It is then a matter of navigating your way around the "site" by clicking on the highlighted link words. The initial page (Fig.1) has links to sections that give general advice on using the system, and a more detailed introduction to the system.

As its name suggests, this software teaches the user about circuit design using a modular approach. Three types of module are available, and these are input, output, and signal processing modules.

As the accompanying text points out, in the real world it is not always possible to compartmentalise things quite a simply as this, and (say) an input module could be used as a signal processing stage. In general though, designs produced using this system consist of an input module, an output module, and (possibly) one or two signal processing stages in between.

A reasonable range of modules is provided, including simple sensors, amplifiers, triggers, timers, an audio mixer, relay drivers, and so on. Most of the modules are what would be broadly termed analogue circuits, but there are also a fair number of digital modules. These include such things as simple bistable latches, J-K flip/flops, and CMOS monostables. Using the modules it should be possible to produce circuits that cover a wide range of applications.

When you are familiar with the general concepts of the software the next step is to progress to the example designs. There are about a dozen of these covering such things as a Reaction Tester, a Flood Alert circuit, and a Temperature Warning system.

Clicking on the highlighted text for the design you require brings up a page that provides a brief description of the system as a whole, and each of the modules. There are then links to the circuit for each module together with a more detailed description of each one, plus a link to the complete circuit.

Unfortunately, most links are to general sections dealing with a range of sensors, signal processors, or whatever, which can be a bit confusing at first. The descriptions are also rather brief, but do cover the most important aspects of each module. Users are encouraged to experiment with the designs, and where appropriate there is advice on how to alter the characteristics of the modules.

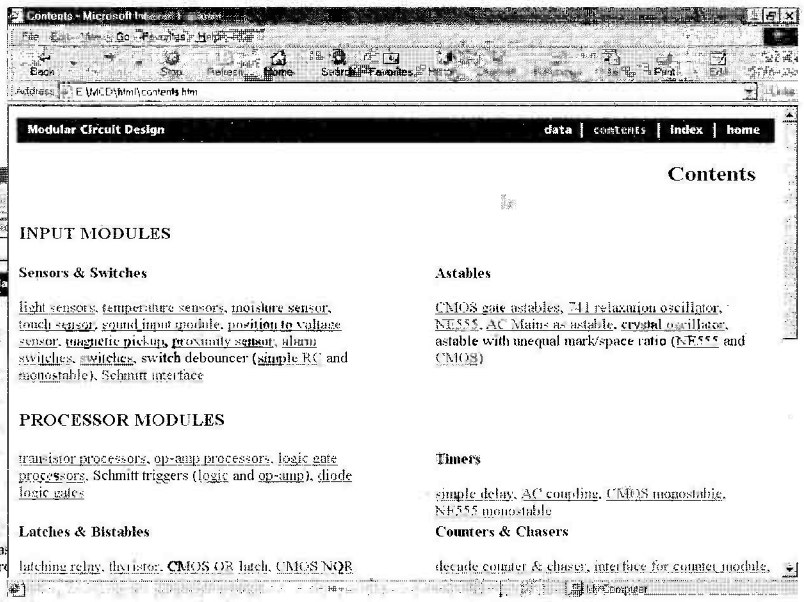


Fig.2. Contents screen listing page.

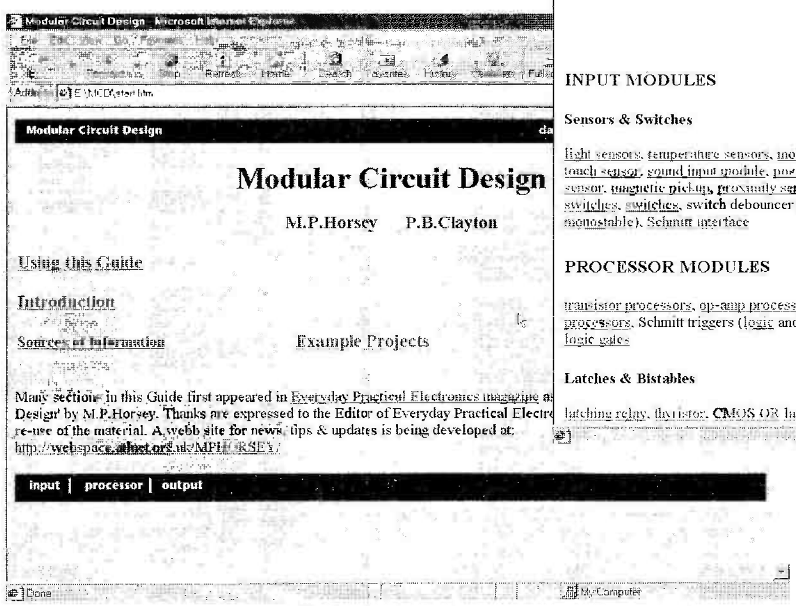


Fig.1. Start screen page.

ROLLING YOUR OWN

Once you have looked through some of the design examples, it is time to try your hand at designing a circuit from the supplied modules. The section called

"Realising your Design" gives some general advice on how to proceed, but from here onwards you are largely left to your own devices.

Suppose you wanted to produce a circuit that switched on an l.e.d. each time sound was detected. There is more than one way of seeking the appropriate modules for the job, but probably the best one is to go to the "Contents" page (Fig.2) and look through the various input and output modules. From here there are links to the sections dealing with the sound input module (Fig.3) and l.e.d.s (Fig.4).

You then have to consider whether or not a signal processing stage is required, which in this case it probably would be. Looking at the processing modules for a suitable amplifier shows nothing really suitable, but a second look at the output modules shows that various driver modules are available, including an l.e.d. driver type. This looks well suited to our example application.

After drawing up the complete circuit by joining together the appropriate two modules, it is time to either simulate or build the circuit to see how it performs. If you decide to build the circuit, which is almost certainly the best approach, there is a data section (Fig.5) which gives semiconductor pinout details and other useful data.

One drawback of this software is that it is not interactive, and does not have any form of built-in circuit simulator. If you wish to take the simulation route it will be necessary to obtain a separate circuit simulator, which is likely to be quite expensive. It should not be too difficult to test designs using either approach, since designs produced using this software will be reasonably simple.

It should, however, provide just the right level of information for those wishing to build GCSE projects, for example, encouraging some research in order to come up with the final design, rather than giving away too much instant assistance with a ready-made circuit diagram. In this respect, it will be a welcome addition to many school resources and to hobbyists who want to move on from just copying published designs.

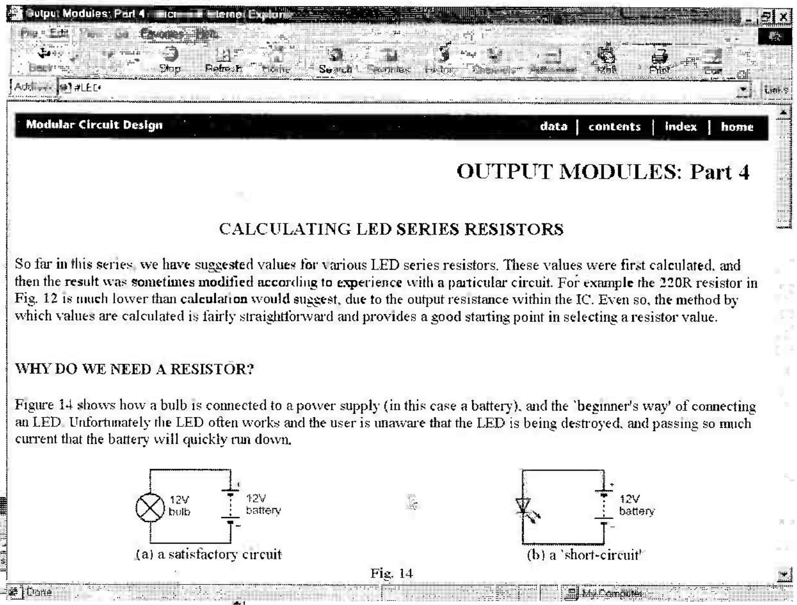


Fig.4. L.E.D. screen page.

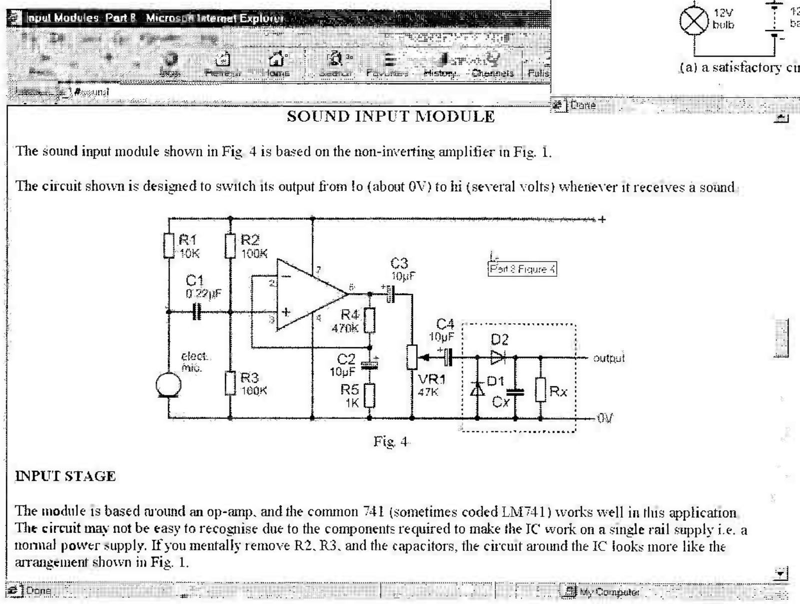


Fig.3. One of the Sound Input module "pages".

STABILITY

During the review period there were no signs of instability with this software, and no missing links were discovered. It does not require a powerful PC, and it should run reasonably well on any PC that can handle HTML files.

Obviously, a CD-ROM drive is required, and there is a potential problem here for some users. The review software was supplied on CDR rather than a pressed CD, and some of the older CD-ROM drives can have difficulties reading CDRs. It seems to be some of the CDR formats that cause the problems, rather than the CDR media itself. *(We believe this problem has now been solved – Ed.)* Fortunately, it is also available on 3.5 inch floppy disks.

It would obviously be pointless to include a large printed manual with software of this type, but there is a useful two-page leaflet to help new users get things underway.

BOTTOM LINE

This software is very simple when compared to most of the competition. It does not cover such a wide range of topics as the popular *Electronic Principles* program for example, and it does not have the built-in circuit simulator of *Crocodile Clips*. On the other hand, it costs much less than either of these.

Modular Circuit Design certainly provides a good introduction to circuit design. It is well suited to complete beginners provided they are guided by a tutor, and should also be usable by those who have gained some experience at project building and wish to progress to something more than cloning published designs.

Prices (including VAT) for the *Modular Circuit Design* CD-ROM are as follows:
Full version £19.95
Full version site license £39.95
Sample version £6.95

It is available by mail order from the *EPE/ETI Direct Book Service* (see page 290 in this issue).

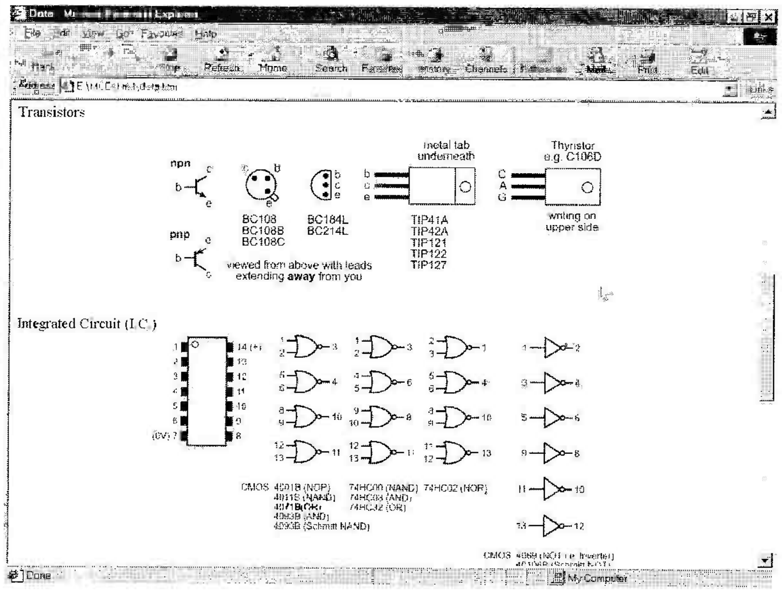


Fig.5. Data section screen page.

PIC16F87x MICROCONTROLLERS

JOHN BECKER

Microchip's new EEPROM microcontrollers have greater capacity and much more to offer than the familiar PIC16x84s.

THOUSANDS of you have become familiar with the PIC family of microcontrollers. Over the last three years we have published many designs that use them. The principal members of the family that have been used in the designs are the PIC16C84 and PIC16F84. Our *PIC Tutorial* series of March to May '98 was based upon them. *(This series is now available on CD-ROM – see this month's CD-ROM page).*

FAMILY ADDITION

Arizona Microchip, the manufacturers of the PIC devices, have now introduced a new range to the family, the PIC16F87x series. In many respects, these new devices can be regarded as greatly enhanced versions of the '84s (more specifically, they are CMOS Flash versions of the existing PIC16C73/74/76/77 devices).

Importantly, not only do they have greater capacity than the '84s, they offer more facilities that make them ideal candidates for use in many sophisticated designs for which the '84s could not readily provide complete control solutions.

Of particular importance are their several on-chip analogue-to-digital converters (ADCs), and their communications options based upon internal USART (Universal Synchronous Asynchronous Receiver Transmitter) protocols.

It is worth noting, however, that the 'F87s cannot be used with the *PIC Tutorial* printed circuit board, or with the *PIC 16x84 Toolkit* programmer (July '98). Methods by which they can be programmed are discussed later.

CORE FEATURES

There are currently four devices in the 'F87x series: PIC16F873, PIC16F874, PIC16F876 and PIC16F877. Their core features are shown in Table 1. The features that are improvements on the '84s are highlighted in bold.

Their peripheral features (of which none except for Timer0 are included in the '84s) are shown in Table 2, whilst specific key features for the individual devices are shown in Table 3.

Pinouts on the standard plastic dual-in-line (DPIP) packages are given in Fig.1 (surface mount variations are also manufactured).

PORT FUNCTIONS

The following is a summary of the ports available on the 'F87x devices.

PORTA. This is a 6-bit wide (on the '84 this port is 5-bit) bi-directional port for which any of the pins may be individually set as inputs or outputs (as with the '84). Unlike the '84, however, this port has the extremely useful additional feature of having five pins that may be configured as analogue-to-digital inputs. Two of the pins may also be used as reference voltage inputs, although not at the same time that they are used as ADC pins.

PORTB. As with the '84, this is an 8-bit wide bi-directional port for which any of the pins may be individually set as inputs or outputs, and with the option of biasing the inputs high via internal pull-ups. In common with the '84, two of them (RB6 and RB7) can also be used as the Data and Clock pins when downloading program data to the device. However, an additional feature has been given to pin RB3, allowing it to be used to set the '87x devices for on-board low voltage programming (see later).

Table 1. Core features

- High-performance RISC CPU
- 35 single word (14-bit) instructions (identical to PIC16x84)
- All single cycle instructions except for program branches which are two cycle
- **Operating speed: d.c. to 20MHz**
  d.c. to 200ns instruction cycle
  (PIC16x84 max speed = 10MHz, 400ns)
- **Up to 8K × 14 words Flash Program memory**
  Up to 368 × 8 bytes Data Memory (RAM)
  Up to 256 bytes EEPROM Data Memory
  (PIC16x84 = 1K, 36, 64, respectively)
- **Pinouts compatible to the PIC16C73/74/76/77**
- **Up to 14 internal/external interrupt sources**
  (4 for 'x84)
- Eight level deep hardware stack
- Direct, indirect and relative addressing
- Power-on-Reset (POR)
- Power-up timer (PWRT)
- Oscillator start-up timer (OST)
- Watchdog timer (WDT) with on-chip RC oscillator
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options (as for 'x84)
- Low-power, high-speed, CMOS Flash/EEPROM technology
- **In-circuit 2-pin 5V serial programming**
- 3-pin 12V/14V serial programming
- **In-circuit Debugging via two pins**
- **Processor read/write access to program memory**
- **Operating voltage range 2.0V to 5.5V**
  ('x84 = 2V to 6V)
- Sink/source current 25mA
- **Power consumption, <2mA typical @ 5V 4MHz, 20µA typical @ 3V 32kHz, <1µA typical standby**
  ('x84 = <2mA, 60µA, 26µA, respectively)

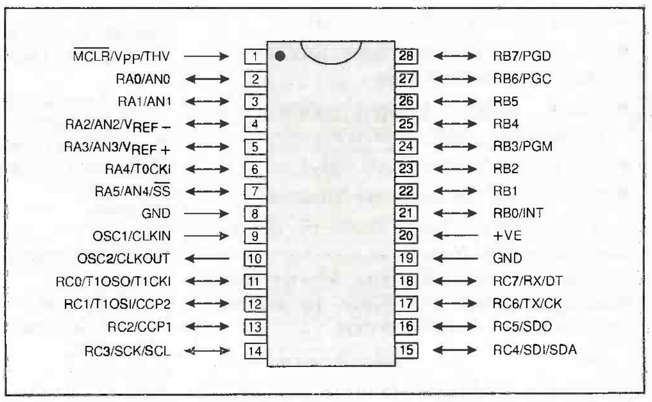


Fig.1. Pinout details for the PIC16F873/876 microcontrollers.

PORTC. This port is not available on the '84. It is an 8-bit wide bi-directional port for which any of the pins may be individually set as inputs or outputs. Several peripheral functions are multiplexed with this port, as outlined in Table 4. They will be described separately.

PORTD. Only the 40-pin 'F87x devices have this port available ('F874 and 'F877). It is an 8-bit bi-directional port and all its pins have Schmitt trigger inputs. It can be configured as an 8-bit wide Parallel Slave Port when interfacing to a microprocessor bus.

Table 2. Peripheral features

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM (pulse width modulation) modules
  Capture is 16-bit, max resolution 12.5ns
  Compare is 16-bit, max resolution 200ns.
  PWM resolution is 10-bit
- 10-bit multichannel ADC (analogue-to-digital) converter
- Synchronous Serial Port (SSP) with SPI (Master mode) and I²C (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) 8-bits wide, with external $\overline{RD}$, $\overline{WR}$ and $\overline{CS}$ controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

(PIC16x84 only has Timer0 – all other features specific to 'F87x)

PORTE. Only the 40-pin 'F87x devices have this port available ('F874 and 'F877). It only has three pins but each is bi-directional and has a Schmitt trigger input. All pins can be used as analogue-to-digital inputs. They can also be configured as control inputs when Parallel Slave Port mode has been configured for PORTD.

SERIAL PERIPHERAL INTERFACE (SPI)

The SPI mode allows eight bits of data to be synchronously transmitted and received simultaneously. Typically, three pins are used during communication, Serial Data Out (SDO), Serial Data In (SDI), Serial Clock (SCK). A fourth pin, Slave Select (SS), may be used when in Slave Mode operation.

Various control bits can be configured to allow the following to be specified:

- Master Mode (SCK as clock output)
- Slave Mode (SCK as clock input)
- Clock polarity (idle state of SCK)
- Data input sample phase (middle or end of data output time)
- Clock edge (output data on rising/falling edge of SCK)
- Clock rate (Master Mode only)
- Slave Select Mode (Slave Mode only)

When used in Master Mode, the device can initiate data transfer at any time since it controls the SCK. The Master also determines when the Slave (a second processor) is to broadcast data.

The SPI clock rate is user-programmable for the Master and can be set for Fosc/4, Fosc/16, Fosc/64 or Timer2 output/2, so allowing a maximum bit clock frequency (at 20MHz) of 5.0MHz.

In Slave Mode, the data is transmitted and received as the external clock pulses appear on SCK. When in Sleep mode, the Slave can transmit and receive data, although when a byte is received the device will wake up from Sleep.

To emulate 2-wire communication, the SDO pin can connected to the SDI pin. When the SDO pin needs to operate as a receiver, the SDO pin can be configured as an input, which disables transmissions from the SDO.

USART

The Universal Synchronous Asynchronous Receiver Transmitter is one of the two serial I/O modules. The USART (which is also known as a Serial Communications Interface, or SCI) can be configured as a full duplex asynchronous system that can communicate with peripheral devices such as CRT terminals and PCs. It may also be configured as a half duplex synchronous system that can communicate with peripheral devices such as A/D or D/A interface circuits, serial EEPROMs, etc.

The USART can be configured in the following modes:

- Asynchronous (full duplex)
- Synchronous – Master (half duplex)
- Synchronous – Slave (half duplex)

It also has a multi-processor communication capability using 9-bit address detection.

There is a dedicated 8-bit baud rate generator that supports both the asynchronous and synchronous modes of the USART. The baud rate is software controllable, between 19.53 kbaud and 5000 kbaud at a crystal oscillator rate of 20MHz when in synchronous mode.

In asynchronous mode, the USART uses standard non-return-to-zero (NRZ) format (one start bit, eight or nine data bits and one stop bit). The most common data format is eight bits. The USART transmits and receives the LSB first.

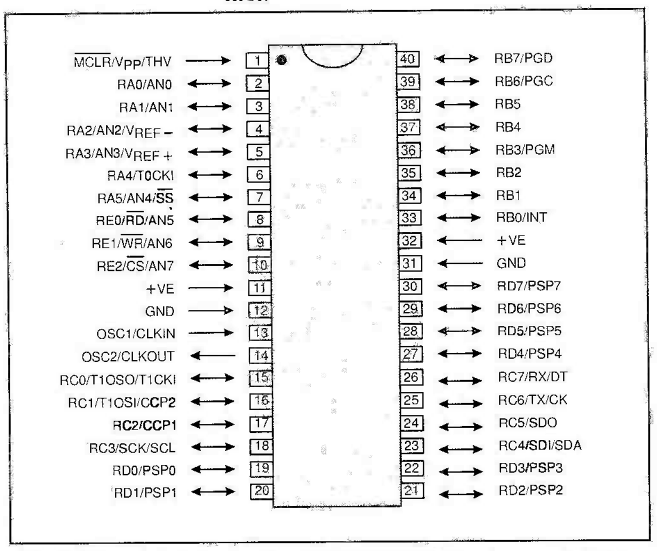


Fig.2. Pinout details for the PIC16F874/877 microcontrollers.

Whilst the USART's transmitter and receiver are functionally independent, they use the same format and baud rate. Parity is not supported in hardware but can be implemented in software.

The asynchronous module consists of the following elements:

- Baud Rate Generator
- Sampling Circuit
- Asynchronous Transmitter
- Asynchronous Receiver

ADC MODULE

The analogue-to-digital converter module has five inputs for the 28-pin devices ('F873, 'F876) and eight inputs for the others ('F874, 'F877).

The selected analogue input charges an internal sample and hold capacitor, the output of which is the input to the converter.

Table 3. Device specific key features

	PIC16F873	PIC16F874	PIC16F876	PIC16F877
Operating Frequency	d.c.-20MHz	d.c.-20MHz	d.c.-20MHz	d.c.-20MHz
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR . (PWRT, OST)
Flash Program Memory (14-bit words)	4K	4K	8K	4K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory	128	128	256	256
Interrupts	13	14	13	14
I/O Ports	A,B,C	A,B,C,D,E	A,B,C	A,B,C,D,E
Timers	3	3	3	3
Capture/Compare/PWM modules	2	2	2	2
Serial Comms	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Comms	–	PSP	–	PSP
10-bit ADC	5 inputs	8 inputs	5 inputs	8 inputs
Instructions	35	35	35	35
Pins	28	40	28	40

The converter then generates a 10-bit digital equivalent of this analogue level via successive approximation. The conversion result is stored in a 16-bit register which may be instructed to justify it left or right, with the extra bits set as zeros.

Accuracy of the conversion is dependent on the capacitor being allowed to fully charge to the input channel voltage level. The impedance of the external source and that of the internal sampling switch directly affect the charge acquisition time and must be taken into account when designing the analogue source circuit. The maximum recommended input source impedance is 10kΩ. Sampling rates can be selected under software control. At a crystal oscillator rate of 20MHz the minimum recommended sampling time is 1.6μs.

A unique feature of the ADC is that it is able to operate while the device is in Sleep Mode.

Voltage reference can be internally set at V_{DD} and V_{SS} levels, or at user-selected external levels set via pins RA2 and RA3. The reference source for each input can be individually selected for internal or external. Users are cautioned that the conversion accuracy degrades as the externally applied V_{ref} diverges from V_{DD}. Minimum differential between V_{ref+} and V_{ref-} is 2V. Quantisation error is typically ±1 LSB.

CAPTURE, COMPARE AND PWM

Each Capture/Compare/PWM module contains a 16-bit register which can operate as a 16-bit Capture register, as a 16-bit Compare register or as a PWM (pulse width modulation) master/slave Duty Cycle register.

In Capture mode, the 16-bit value of the TMR1 register is captured when an event occurs on pin RC2/CCP1, which sets an interrupt flag. An event can be defined as occurring on:

- every falling edge
- every rising edge
- every 4th rising edge
- every 16th rising edge

In Compare mode, the 16-bit register Capture is constantly compared against the TMR1 value. When a match occurs an interrupt flag it set and (depending on a pre-selected control code) the RC2/CCP1 pin is:

- driven high
- driven low
- remains unchanged

In PWM mode, the RC2/CCP1 pin produces a PWM output of up to 10-bit resolution. The PWM period and duty cycle can be set through software.

PRIMARY CONFIGURATION

The four 'F87x devices have a different primary configuration word (initialisation pattern) to the PIC16x84 devices. This means that, even with hardware permitting, the configuration associated with the TASM SEND and *PIC Toolkit* programs (their Mode 1) cannot be used to fully configure the 'F87x devices.

These two *EPE*-published programs have been written to provide the same common configuration data (oscillator type, WDT, Power-Up Timer) to bits 0-3 of the configuration register, but the remaining bits (4-13) are not accessible to the user.

In the 'F87x devices, however, bits 4-13 are variously used for configuring Code Protect, Brown-out Reset, Low Voltage Programming enable, EEPROM data memory code protect, Flash Program Memory Write enable, In-circuit Debugger mode.

LOW VOLTAGE PROGRAMMING

PIC16F87x devices can be serially programmed while in the end application circuit (as can the '84s), by means of three connections (plus ground). Interestingly, the 'F87x devices can also be programmed using two connections (plus ground) while in a low voltage programming (LVP) mode.

At first sight, this seems to be an exciting option – no more requirement for a 12V to 14V programming supply (V_{IHH}) on the $\overline{MCLR}$ pin. Regrettably, this is not the case. An 'F87x device has to be configured to accept the LVP mode and this configuration can only be done when the chip's programming voltage is at the usual V_{IHH} level.

Once the LVP option has been configured, though, future on-board re-programming can be done at the V_{DD} level. In this mode, the RB3/PGM pin is dedicated to the programming function and ceases to be a general purpose I/O pin. A V_{DD} of +5V (±10%) is applied to the $\overline{MCLR}$ pin (as it is for normal running mode with a supply of 5V) during low voltage programming, which is set by software outputting logic 1 to the RB3/PGM pin.

The LVP bit can only be programmed when programming is entered with V_{IHH} on $\overline{MCLR}$; it cannot be programmed when programming is entered with RB3/PGM. If the LVP option has not been enabled, only the high voltage programming mode can be used to program the device.

PROGRAMMING HARDWARE

PIC16F87x devices can be programmed via Microchip's suite of programming hardware and software (contact Microchip for more details).

Additionally, a Mk2 version of the *EPE PIC Toolkit* is in preparation. It will allow all current PIC16F87x and PIC16x84 devices to be programmed. The Mk2 version will also include software that assembles (compiles) the source codes (written in TASM or MPASM formats) to become object codes for sending to these devices via the same program. This program will remove the need for using TASM itself as the assembler for the '84 devices (we have no intention of upgrading TASM or its SEND program for the 'F87x devices).

Watch our pages for the publication date of *Toolkit Mk2*.

An example of one of the PIC16F87x devices in use is also in preparation. It is a Data Logger that makes use of the device's ADC and serial communications facilities, and introduces the use of a Microchip serial EEPROM memory device. Again, watch these pages!

PIC16F87x AVAILABILITY

All good suppliers of PIC microcontrollers should be stocking the PIC16F87x devices, including RS, Farnell, Magenta and Maplin (other suppliers are invited to advise us that they are doing so as well – we will publicise the fact through our news pages).

You will be interested to know that three data sheets are available from Microchip, their web site, and their latest CD-ROM. The data sheet for the PIC16F87x microcontrollers (200 pages of it (1·34Mb), but excluding serial programming data) is available as data sheet DS30292A. General details of serial programming for all PIC microcontrollers are given in the *In-Circuit Serial Programming Guide* (data sheet DS30277B). LVP programming for the 'F87x devices is detailed in the *PIC16F87x Programming Specification* (data sheet DS39025 – but not yet on the web site at the time of writing, mid-Jan).

Arizona Microchip Technology can be contacted at Microchip House, 505 Eskdale Road, Winnersh Triangle, Woking, Berks RG41 5TU. Tel: 0118 921 5858. Fax: 0118 921 5835. Web: **http://www.microchip.com**. Mail addresses for Microchip agents world-wide are also accessible via this web site.

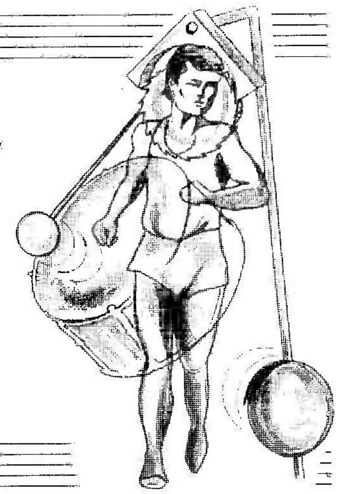
ACKNOWLEDGEMENT

We express our gratitude to Arizona Technologies Ltd (a sub-division of Arizona Microchip) for their helpful co-operation in connection with our introduction to and use of the PIC16F87x microcontrollers and associated serial EEPROM devices.

MICROCHIP C-ROM

We heartily recommend that anyone interested in PIC microcontrollers should obtain Microchip's CD-ROM. It contains a "snap-shot" of Microchip's web site and takes you to the complete selection of PIC microcontrollers (including the 'F87x), plus non-volatile memory devices, serial EEPROMs, Keeloq code hopping devices and a full-line of development tools.

VERSATILE EVENT COUNTER



JOHN BECKER

Time flies – and you can count it (or them) and much else that takes your fancy.

SOME weeks ago a reader rang the author at *EPE*:

I would like to be able to establish the beat rate of various musical tracks on CDs. I have made many enquiries but without success, apart from one company who suggested it could cost about £5000 to develop a suitable circuit. Can you help?

The above is the gist of a much lengthier conversion in which the caller (a note of his name has been lost – sorry dear Caller!) put forward other situations that could benefit from beat counting – keyboard typing rates, for example; rowing rates for another; object counting passed a point, and so on.

An immediate reaction by the author was that something could be written in BASIC in about a dozen lines that would display the rate at which keyboard keys were pressed. Such a program would satisfy the caller's desire to count beat rates – just hit a key at each beat while listening to the music.

This constructional article shows how BASIC can indeed do the job, but also takes the idea a lot further, presenting a PIC-microcontrolled design that will monitor the timing of all sorts of events. The results are displayed on an alphanumeric liquid crystal display (l.c.d.).

There are three ways of inputting the events – via built-in microphone, via a jack-plugged connection to other electronic circuits, and via a panel mounted switch.

Four modes are included:

- Mode 1 displays the time elapsed since monitoring began; the elapsed time at which the last event was detected; the total events counted; the average rate at which the events have been occurring, selectable for counts per second, counts per minute and counts per hour (CPS, CPM and CPH, respectively).
- Mode 2 is a frequency counter, principally for monitoring an external electronically generated frequency of 0V/+5V amplitude, up to about 20kHz.
- Mode 3 counts the elapsed time between pairs of events and is probably of best use with events that are longer than about a second apart.
- Mode 4 offers selection of microphone or external signal sourcing for use by Modes 1 to 3.

BASIC EVENTS

First though, let's briefly present and discuss the BASIC program that offers the simplest answer to the caller's query.

In fact, by the time the author had put in a bit of screen cosmetics, the program ended up a bit longer than a dozen lines, but not a lot. It is shown in Listing 1 and can be used with QBasic or QuickBASIC.

In the program, the keypress rate is displayed as three averages, counts per second, counts per minute and counts per hour. Type in the listing, save it as any name you like (EVENT.BAS, perhaps) and run it. (It's also available on disk with the PIC software – see later.)

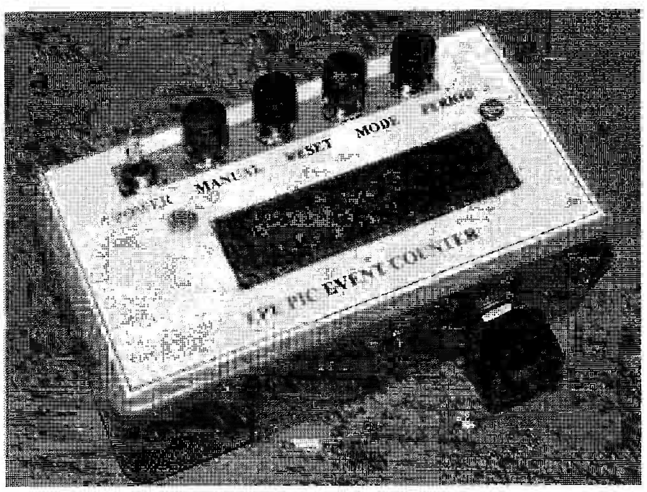
Using BASIC's seconds timer, the time in seconds (*b*) at which the program is started (or reset) is noted. Each time a keypress is received, time (*n*) of its receipt is noted and a counter (*c*) incremented. Subtracting *b* from *n* gives the time *t* elapsed so far. The count is now divided by *t* to give the average rate of keypresses per second (*s*).

This value is then multiplied by 60 to give the count rate per minute, and this in turn is multiplied by 60 to give the count

Listing 1

```
'EVENT.BAS 04DEC98 EVENT AND RATE COUNTER
SCREEN 9: COLOR 11, 1: CLS
LOCATE 6, 31: PRINT "EPE KEY RATE COUNTER"
LOCATE 9, 22: COLOR 14
PRINT "R RESET     ANY OTHER KEY FOR COUNT TRIG"
LOCATE 12, 14: COLOR 11
PRINT "START     LAST      COUNT"; TAB(44);
PRINT "C/sec     C/min     C/hour"
COLOR 15: LOCATE 14, 14: PRINT TIME$
b = INT(TIMER): GOTO wait2

waitit: z$ = INKEY$: IF z$ = "" THEN GOTO waitit
wait2: n = INT(TIMER): t$ = TIME$: LOCATE 14, 14
IF z$ = "r" THEN PRINT t$: c = 0: b = n: s = 0
t = n - b: IF t > 0 THEN s = c / t
m = s * 60: h = m * 60
LOCATE 14, 24: PRINT t$; TAB(33);
PRINT RIGHT$("      " + STR$(c), 6); TAB(43);
PRINT LEFT$(STR$(s) + "        ", 8); TAB(53);
PRINT LEFT$(STR$(m) + "        ", 8); TAB(63);
PRINT LEFT$(STR$(h) + "        ", 8)
c = c + 1: GOTO waitit
```



rate per hour. Following calculation, the answers are displayed in tabulated positions on screen.

Pressing key *r* (not capital *R*) resets the counter and starting time. Any other key could be nominated as the Reset key instead of *r*. When monitoring a succession of events (such as musical beats), the program should be reset by pressing *r* in time with the beat.

The program continues indefinitely until the CTRL and BREAK keys are jointly pressed. Exit from BASIC in the normal way (ALT, F, X).

There you are, kind Caller – an answer for *free*. But even the enhanced electronic version is not going to set your wallet back very much, about 25 quid (for the benefit of overseas devotees, a *quid* is English slang for one pound Sterling – what diversities you learn through *EPE*!).

(Which reminds the author of a time when he was in Egypt: the "driver" of a horse-drawn cab he had hired believed that the term *lubbly-jubbly* was English for *money* – what cruel Dell-boy tourist had taught him that?)

(Perhaps we should explain that Dell-boy was a lovable rogue who frequently used the term in a long-running British TV comedy series. Ed.)

However, we digress – on with the story ... the design for a more sophisticated bit of electronics counting gadgetry.

COUNTER CIRCUIT

In Fig.1 is shown the complete circuit diagram for the PIC Event Counter. Some of you regular readers may now be puzzled – *haven't we seen that same circuit before somewhere?*

Quite right – you have (almost), as part of the *PIC Tape Measure* in *EPE* November '98. Unashamedly, it is almost identical. And why not? The functions of both designs are very similar – amplify sound pulses, calculate delays between them and display the results on an l.c.d. screen.

The previously required ultrasonic transmitter has been dropped, of course, the software has been modified and a few components have been changed, but otherwise the circuits are twins. So much so, in fact, that the same printed circuit board is used for both circuits. Here's a classic example of how designers can benefit from PIC microcontrollers.

An electret microphone (MIC1) is used to detect audio signals, such as the ticks of a clock, or the snap of fingers, or other intermittent sound events. It is biased to the +5V power line via resistor R7 and panel-mounted potentiometer VR3. The latter is used (somewhat unconventionally) as a simple input signal amplitude control (its configuration here saved making significant changes to the existing p.c.b. for a more conventional level control to be placed somewhere within the following amplifier chain).

Between them, op.amps IC1a and IC1b amplify the input signal that enters capacitor C3. Capacitor C6 across IC1a restricts upper frequencies to minimise general background noise picked up by the microphone. (It is a component not used in the *Tape Measure*.)

INDIVIDUAL EVENTS

The aim has been to allow lower amplitude and lower frequency *transient* audio signals to be picked up and detected as individual events. *Constant* lower frequencies (e.g. 50Hz) are attenuated by using a low-ish value for capacitor C5.

From IC1b, the amplified signal is rectified by diode D1 and fed into capacitor C9. These two components replace capacitor C6 and resistor R7 that were in the same positions in the *Tape Measure*.

Because C9 replaces R7, it is connected to the positive rail, rather than more conventionally to the 0V rail; the effect is the same – allowing the rectified multiple pulses from IC1b to be "combined" into a longer pulse. This allows, for example, a brief audio "pip" (a short burst of an audio frequency) to be converted to a single voltage change on C9.

Preset potentiometer VR1 feeds the voltage across C9 to transistor TR1. Nominally, the quiescent (stand-by/no-signal) output from IC1b is about 2·5V (half the supply line voltage). VR1 sets the initial bias provided by this voltage to the base (b) of TR1 to about 0·55V. Signal voltages across C9 that cause the bias to rise to about 0·6V turn on TR1 and cause its collector (c) to fall from the normal condition of +5V to 0V.

Pin RB7 of the PIC microcontroller, IC2, is connected to the collector of TR1 and the software has been written to respond to and count the 5V/0V changes in voltage, using the count values for subsequent calculations.

The results of calculations are output to the alphanumeric l.c.d. module, X2. This is used in 4-bit mode (see several previous *EPE* articles, including the *EPE PIC Tutorial* Part 3 of May '98). Preset VR2 is used to set to the l.c.d. contrast.

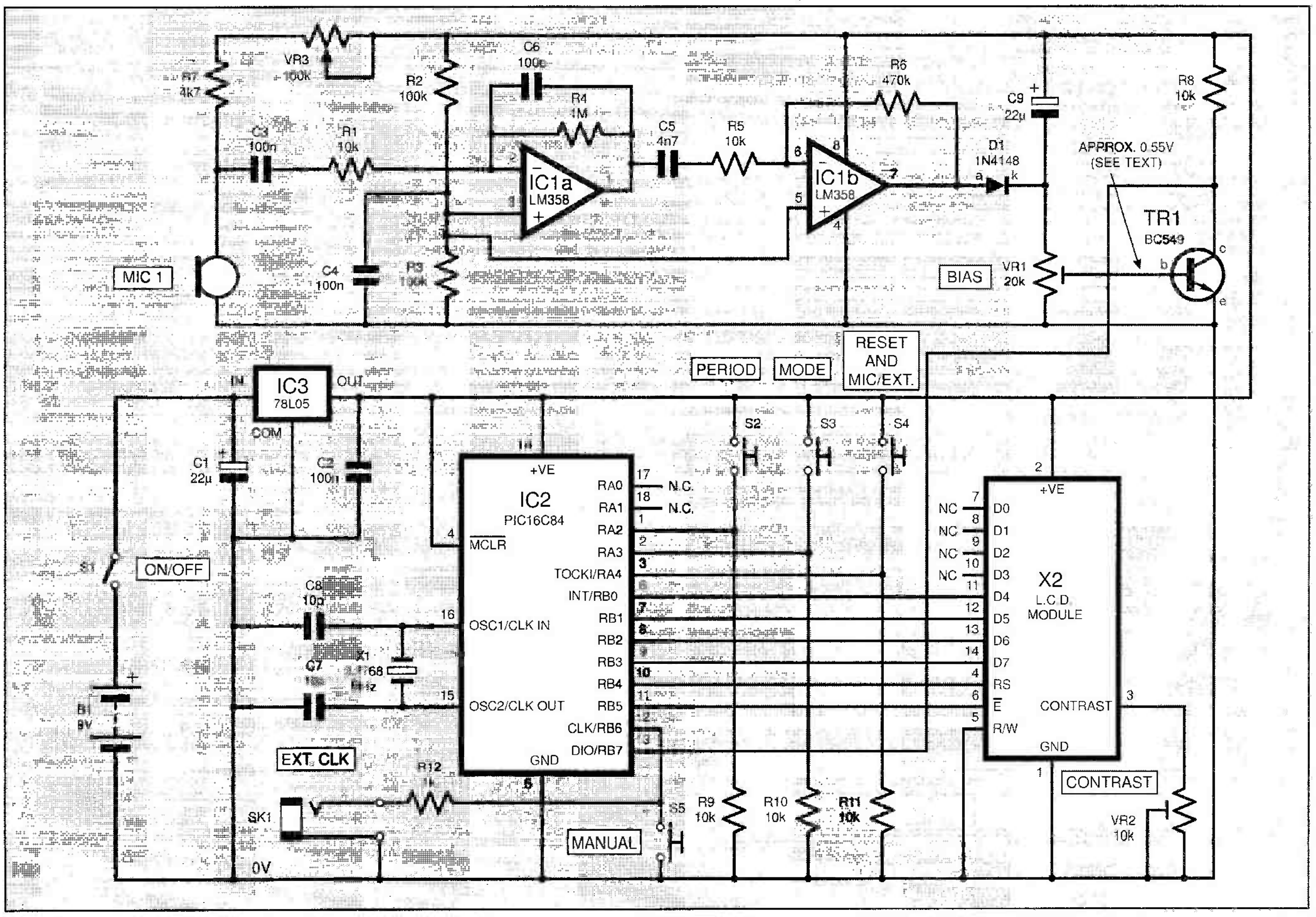
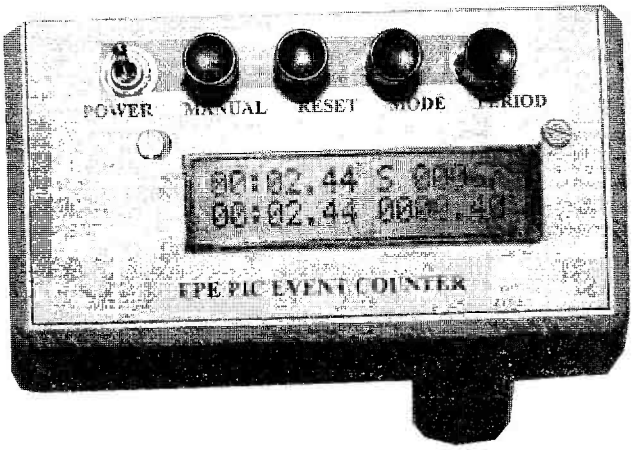


Fig.1. Complete circuit diagram for the Versatile Event Counter.

Power is supplied by a 9V PP3 battery, B1, and is switched on by S1. Regulator IC3 reduces and stabilises the voltage to +5V (the maximum that the l.c.d. can accept). Current consumption is about 7mA.

The PIC is operated at 3.2768MHz, as set by crystal X1 in conjunction with capacitors C7 and C8.

Switches S2 to S4 have several functions which are activated by the software when they are pressed. In Mode 1 (see earlier), switch S2 (Period) steps the display through the three counting periods (CPS, CPM and CPH), on a 3-step repeating cycle. In this mode, S4 (Reset) resets the count and timing start values to zero.



Front panel display window and function buttons; Mode 1 shown.

Switch S3 (Mode), on a 4-step repeating cycle, steps the program through Modes 1 to 4. The latter offers microphone use (MIC) or external signal input (EXT/S5). "External" means that signal pulses can be input from an external signal generator via socket SK1 and resistor R12, or they can be triggered manually by switch S5.

The MIC and External signals are routed to different pins of the PIC and it is the software that selects which pin is to be taken as the signal source – this avoids having to use a changeover switch to select the source.

When the MIC/External option is offered (Mode 4), pressing the Reset switch (S4) alternates between the two options.

SOFTWARE

The program for the PIC microcontroller has been written in TASM. The software (including that for the BASIC program in Listing 1) is available via the *EPE* web site and on 3.5in disk from the Editorial office. Pre-programmed PICs are available. For further details see this month's *Shop Talk* page.

The software is too long (around 960 commands) and complex to discuss in this article, but a lot of comments are included in the source code listing that will help PIC-programming readers understand some of what it does.

Essentially, the Mode 1 routine of the PIC software performs the same operation as the BASIC program in Listing 1, but *far* more commands are required.

Of passing interest may be the fact that this program was not written from scratch. It is heavily based on (lifted from!) the author's software for *PIC-Agoras* (Bike Computer, *EPE* April/May '97). Many of those routines, which include such functions as timing, multiplication, division, binary-to-decimal conversion and l.c.d. display, required little modification to make them usable for this Event Counter.

CONSTRUCTION

Details of the printed circuit board component and track layouts are shown in Fig.2. This board is available from the *EPE PCB Service*, code 207. As stated earlier, this p.c.b. is identical to that for the *PIC Tape Measure*

Note, though, that a track cut is needed on the p.c.b., as shown in Fig.2. Because the resistor feeding to MIC1 (R7) is a component which was not required with the *Tape Measure*, a place on the p.c.b. had to be found for it (without redesigning the p.c.b.). The logical position is that shown, making use of two existing pads. However, one of the pads was previously used for connection of one side of the ultrasonic transmitter to the PIC. It is this connection that needs to be cut as shown.

Even though the PIC pin involved can be set in software to high impedance, it was felt that there might be a small amount noise emanating from the pin which would be adversely amplified via the microphone routing. Hence the pin's isolation by a track cut.

It is suggested that assembly of the components is pursued in order of size upwards. Sockets should be used for both IC1 and IC2 (note that a wire link sits under the socket for IC2 – make it first!).

Capacitor C6 (another component not required for the *Tape Measure*) has to be soldered on the trackside of the p.c.b. across the pads for resistor R4.

Connections to the l.c.d. can be either via short stranded wires (insulated) or by rigid (uninsulated) solid wires. In either case, note that the l.c.d. and the p.c.b. are mounted back-to-back "double-decker" fashion, with the l.c.d. screen and the p.c.b. component side facing outwards in opposite directions.

If using rigid connections, use wire of about 1mm diameter (resistor cut-offs might be OK if they are long enough). Solder one end of each wire into the l.c.d. terminal pads, with the long end protruding below the l.c.d. Trim all the long ends to the same length and then *patiently* and with the aid of a small screwdriver or thin-nosed pliers, push each wire into the respective p.c.b. holes – *from the track side*.

It will help if one outer wire is soldered first, then the outer wire at the other end, ensuring that the spacing between the l.c.d. and the p.c.b. is even, at about 12mm or so. Then solder the intermediate wires.

It is advisable to insert a length of card between the l.c.d. and the p.c.b. (taping it in position) to prevent contact between both items. Also cover the switch tags with insulating tape to prevent them connecting with the p.c.b. tracks.

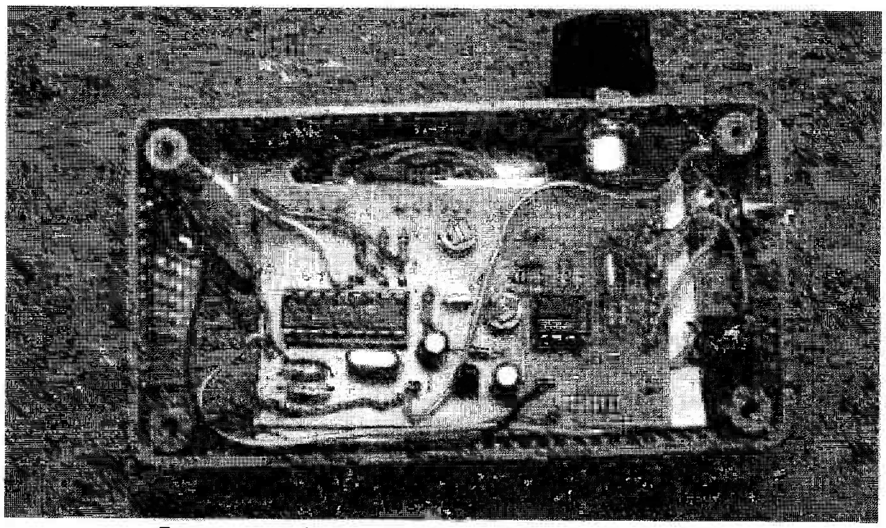
Do double-check your complete assembly for correctness before connecting power.

ENCLOSURE

Fitting all the components into the suggested plastic case is a bit of an exercise in compactness. But as you can see from the photos, it can be done and with a bit to spare.

You will see that it is into the *base* of the case that the l.c.d. is mounted and that the switches are mounted alongside it. The precise positioning will depend of the size of the l.c.d. module, a factor that seems to vary between manufacturers and availability from the suppliers.

You must also ensure that you leave room for the PP3-size battery at one end and the potentiometer in the side of the box. There is plenty of space, however, for mounting the jack socket in the other end of the box, but you must allow space for the microphone to poke through a hole in the same end.



Prototype p.c.b. mounted "below" the display module.

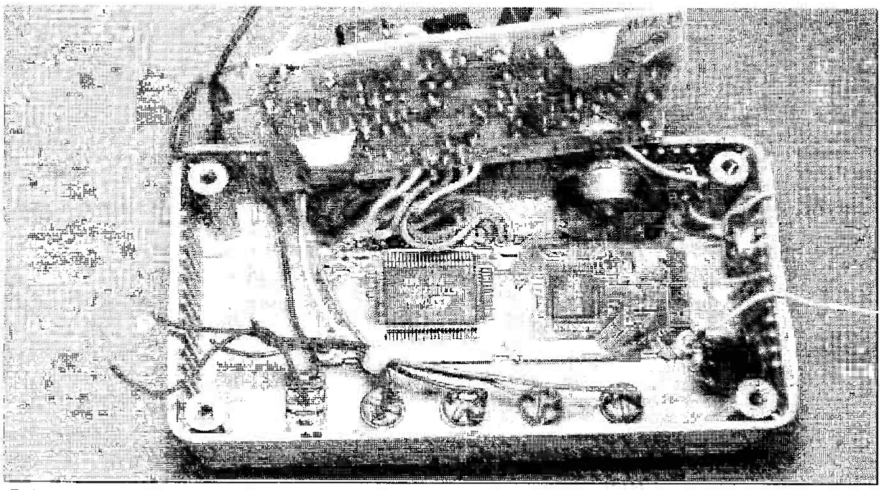
Study the photographs, measure your components, plan and mark out their positions, and then drill the necessary holes. The slot for the l.c.d. is also achieved by drilling – making a perimeter of holes within the proposed slot area and then filing down the rough edges until smooth and to the correct dimensions.

Bolt the l.c.d. into its slot (the author just used two bolts rather than the four allowed by the l.c.d. module). Then wire up the remaining components as shown in Fig.2. Note that resistor R12 is mounted on the tags of socket SK1 – this done purely for physical convenience as there is no provision for the resistor to be mounted on the p.c.b.

With IC1 and IC2 omitted, switch on the power and check that there is $-5V$ (within a few per cent) on the output of IC3. If there is not then there is either a short circuit on the board (0V output) or IC3 is incorrectly inserted (much greater than 5V output) – provided that the connections back to the battery are correct, of course!

Assuming all's well, switch off and insert IC1 and IC2. Switch on again and observe the l.c.d.

At first you may not see anything on the l.c.d. – adjust the contrast control VR2 until a display similar to that in the second photo is seen. This is the default screen that will always appear when first powering up.



Printed circuit board folded back to reveal the l.c.d. module bolted behind the display window. (Wires disconnected for photography.)

Turn the exterior potentiometer (VR3) fully anti-clockwise (minimum signal gain). Now, with a meter (preferably digital) set to read about 5V d.c., monitor the voltage at the base of TR1 and adjust preset VR1 until the reading is about 0·55V, which is typically just below the turn-on point for a small-signal silicon transistor such as the BC549 used here.

This bias voltage sets the sensitivity of TR1 to signals arriving from IC1b and may be adjusted slightly later in the light of experience (individual transistors may exhibit slightly different characteristics).

COMPONENTS

See SHOP TALK Page

Resistors

R1, R5, R8 to R11	10k (6 off)
R2, R3	100k (2 off)
R4	1M
R6	470k
R7	4k7
R12	1k

All 0.25W 5% carbon film or better.

Potentiometers

VR1	20k min. cermet preset, round
VR2	10k min. cermet preset, round
VR3	100k rotary, lin.

Capacitors

C1, C9	22µ radial elect. 16V (2 off)
C2 to C4	100n ceramic disc, 0·2in spacing (3 off)
C5	4n7 polystyrene
C6	100p polystyrene
C7, C8	10p polystyrene (2 off)

Semiconductors

D1	1N4148 signal diode
TR1	BC549 *npn* transistor
IC1	LM358 dual op.amp
IC2	PIC16C84 (or PIC16F84) pre-programmed microcontroller – see text
IC3	78L05 +5V 100mA voltage regulator

Miscellaneous

S1	min. s.p.s.t. toggle switch
S2 to S5	min. push-to-make switch (4 off)
SK1	plastic 3.5mm jack socket, mono
MIC1	min. electret microphone
X1	3.2768MHz crystal
X2	16-character 2-line alphanumeric l.c.d.
B1	9V PP3 battery and clip

Printed circuit board, available from the *EPE PCB Service*, code 207; plastic case, 120mm × 64mm × 40mm; 8-pin d.i.l. socket; 18-pin d.i.l. socket; nuts and bolts, M3 × 12mm (to suit l.c.d. mounting) (2 off); knob; connecting wire; solder, etc.

Approx Cost Guidance Only £25

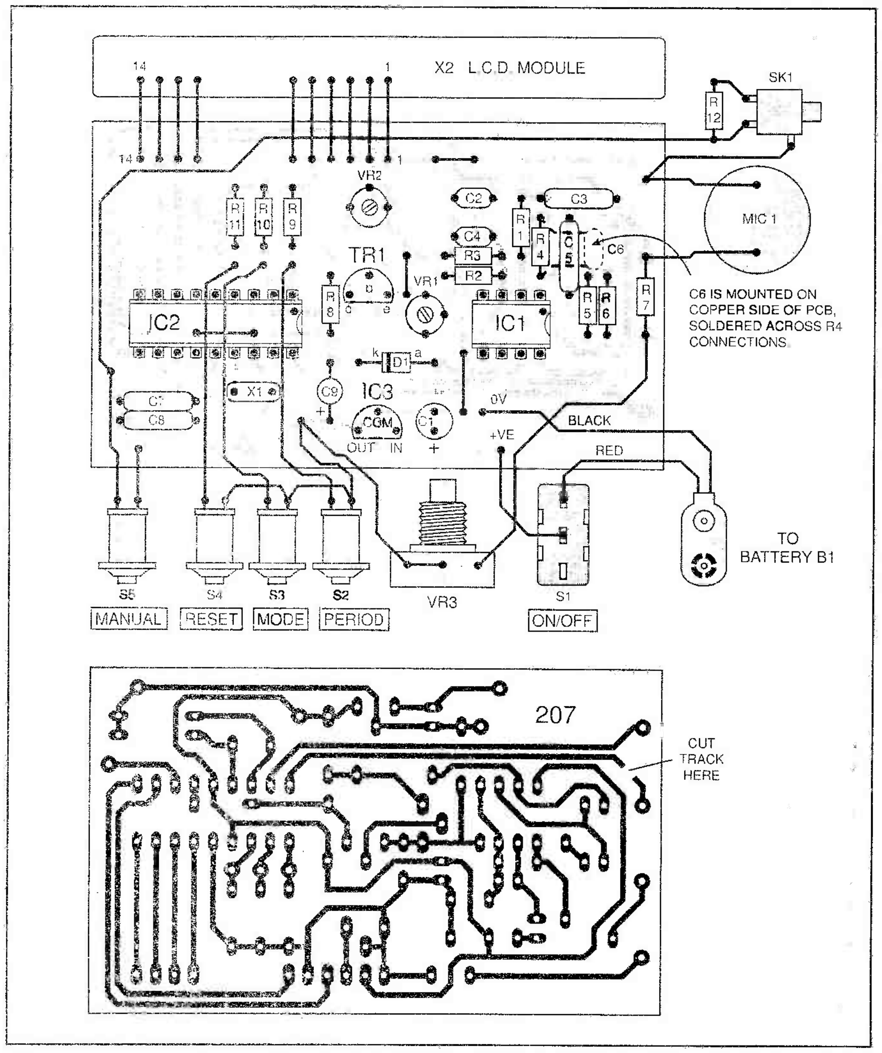
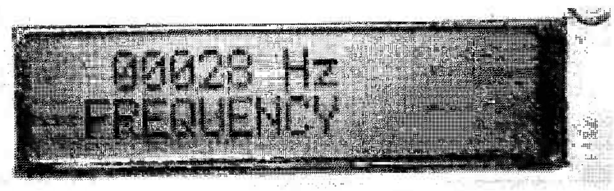


Fig.2. Printed circuit board component layout, interwiring and full size copper foil master for the Versatile Event Counter.

Let's now step you through what's what of the unit's full workings.



Typical screen display in Mode 2.

OPERATION

There are five groups of information shown on the screen you should be looking at immediately after switching on (as already shown in the second photo). At this time the unit is in Mode 1 and by default it is the microphone signal routing that is being monitored.

At the top left is shown the time elapsed following the unit's response to the first signal pulse received. It is formatted as HH:MM.SS (hours, minutes, seconds). Make some noise near the microphone (click your fingers or something!) and you should see this display start counting (use VR3 to increase the signal level if necessary).

The bottom left display shows the time (also as HH:MM.SS) at which the last detected pulse was received – intermittently click again a few times and it should change its reading accordingly.

The top right display shows the number of pulses that have been received so far (to five digits).

At the bottom right, the display shows the average number of pulses that have been occurring in each second since you started the unit counting, to the nearest two places of decimals.

Sandwiched between the top left and top right values will be seen the single letter S. This indicates that the unit is set for the counts per second range.

Briefly press switch S2 (Period) and observe that the S changes to M, indicating counts per minute, again to two decimal places. A further press of S2 will show H for counts per hour, this time as an integer value (no decimal places). Pressing S2 again will return the display to S for seconds. Note that S2 will only be responded to after the first count pulse following reset has been received.

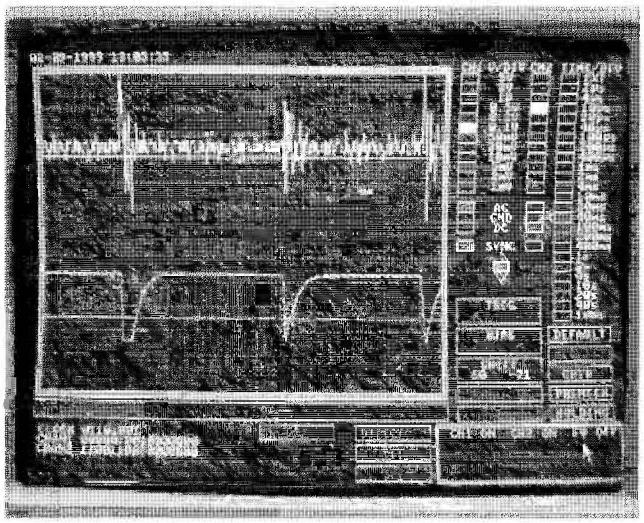
Periodically click your fingers while observing the count period displays.

Having returned to S, briefly press switch S4 (Reset) and remain silent – all values should be seen to read as zero. Click again to start it all off again.

MODE 2

To enter Mode 2 from Mode 1 (and it can only be entered from Mode 1), press switch S3 (Mode). The screen should change to show "00000 Hz" on the top line and "FREQUENCY" on the bottom line. This is the frequency counting mode and is intended principally for use when an external square wave signal is being fed in via SK1 (see later). You may get it to respond to finger clicks and other noises but the values displayed will not be meaningful.

In Mode 2, the status of the PIC's chosen input pin (RB6 or RB7) is repeatedly monitored for periods of one second. At the end of each period, the number of pulses counted during that time is displayed on the top line.

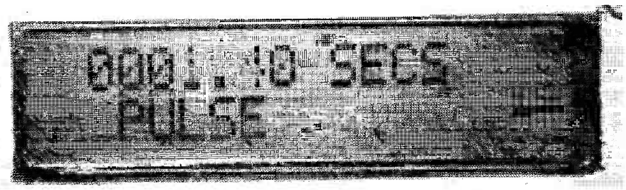


EPE Virtual Scope *display showing 3Hz clock ticks and TR1 response.*

When set for External input, the maximum rate of meaningful input is about 20kHz. Frequencies much greater than 20kHz can be input but, because of the limits imposed by the rate at which signal level changes can be responded to by the software, the displayed answers will be incorrect. They could well be subharmonic rates since one or more pulses arriving may be overlooked during sampling. There is no way for the software to detect what it has missed!

MODE 3

When in Mode 2, pressing S3 (Mode) sets the program and display into Mode 3. All that is seen on screen when first entered is "0000.00 SECS" on the first line, and "PULSE" on the second. Click fingers in front of the microphone – the display will now show the number of seconds, to two decimal places (hundredths of a second), between entering Mode 3 and your finger click. Click again and the period between your first and second clicks will be shown.



Typical screen display in Mode 3.

The rate at which you can observe changes of count is the determining factor in this mode – you will probably find that around five events a second is about the maximum your eyes/brain will register clearly.

The slowest rate at which two events can be timed and correctly shown is 9999.99 seconds.

MODE 4

From Mode 3, Mode 4 is entered by again pressing S3 (Mode). It is from this mode that the signal route is selected – either microphone or external.

At this moment you should see the words "SOURCE MIC" displayed. Press S4 (Reset) to display "SOURCE EXT/S5". Repeated pressing of S4 cycles the routing message between the two options. End up now with the EXT/S5 message shown.

Having set the signal routing from this mode, the routing will be applied for each of Modes 1 to 3. Mode 4 is exited by pressing S3 (Mode) again. Press it now.

This action will return you to Mode 1. You now have two options for triggering the unit, either by an external signal via SK1, or by pressing switch S2. The microphone routing is now inactive, and you can be as noisy as you like (family/neighbours permitting!).

Repeatedly pressing switch S5 (Manual) causes the unit's counting and display to respond as they did when you finger-clicked in MIC mode. This is useful for counting such events as the beat rate of music, the idea which prompted the design of this Event Counter.

The rate of switch response is limited by the rate at which you can push it (although a software limit of 100Hz applies in Mode 1 – helping to prevent switch bounce problems).

As with the MIC routing, Mode 1 offers selection of the same three periods by use of S2 (CPS, CPM and CPH).

To check the response to signals fed in via SK1, plug in a signal generator. It should be set for 0V/5V square wave output at about 2Hz or so (though it's not critical – just lets you observe a bit better than a fast rate would).

Note that resistor R12, which is in series with the external signal and the PIC, allows signals a bit greater than +5V to be input. It's probably best though to keep them below about +15V to avoid possible distress to the PIC. (In this application, the voltage *actually reaching* pin RB6 of the PIC must not exceed +5V.) **Negative voltage signals must NOT be input.**

You are likely to find that the PIC will respond to signal pulse levels down to a minimum of about 3·5V.

While the signal generator is plugged in, also check out the unit's response to it from Mode 2 and Mode 3.

Should you press S5 (Manual) while an external signal is connected, no damage can occur because of the presence of R12 (but the PIC's response to the conflicting signal sources will suffer, of course). Note that the act of changing modes (S3) resets all timing/event counters to zero.

IN USE

The prototype Event Counter has been found to be extremely responsive to some astonishingly low level audio (via MIC) signal sources. Such sources have included the once-per-second (1Hz) *ticks* of a small "carriage" clock, and the three-per-second (3Hz) *tick-tocks* of Editor Mike Kenward's period mantel clock (nicely wooden and 1930's – ish). The 10 metres distant sound of Wife's "Dinner – NOW!" war-cry has also been "observed" (undesirably during timing tests, as it happens!).

Typical screen display in Mode 4. Software has been amended to show "EXT/S5".

ED'S CLOCK

The 3Hz clock proved an interesting subject. Originally, Mode 1 and Mode 2 were programmed for sampling at a rate of 25Hz (the rate the author normally uses for PICs performing HH:MM.SS counting), while Mode 3 was set for 100Hz (to readily obtain the 1/100ths of a second accuracy required).

It was a pre-requisite of this design that it should respond to Mike's 3Hz clock. "How useful", he'd said, "if it could have helped in setting the clock's timing accuracy when newly acquired". (By *newly* is meant Christmas present time a couple of years ago – we staff shall deny it had any connection with Wimborne Market!)

Anyway, first tests of Event Counter and 3Hz Clock showed that a correct response was observed in Mode 3 but not in Mode 1. Quick thinking on author's part and a few minutes of reprogramming for everything to be sampled at 100Hz cured the problem – up to a point. The point was raised by the *tick-tock*: the *tocks* were louder than the *ticks* (see photo of computer screen display).

The answer now was in the setting of level control VR3, carefully adjusting the level to be enough for the *ticks* to be responded to correctly without the amplification being saturated by the *tocks*. Success was achieved (and the author's honour remained untarnished!).

Be aware that in the early minutes of obtaining repetitive pulse averages with something such as a clock, the averages may appear to change a bit erratically. This is due to the limitations of the multiplying and dividing routines in the software which have only one byte in which to store fractions. The averages will "settle down" as the minutes and count values progress.

EVENT HORIZON

There must be innumerable situations in which *you* could find use for this design ("subject only to your imagination" is the usual – if overworked – expression when a really versatile design is published).

One option that comes to mind is using two or more external sensors (e.g. pressure pads or opto-transmitter/receivers) interfaced to the unit via an OR gate – race timing, for example.

So, it's over to you now, to beat the clock and get your components purchase order in the post before this evening's collection! Or are you doing things the "modern" way, via the Net? It offers 24-hour shopping and has *very high* security – for a start, you can order the p.c.b. right now via the *EPE* web site: **http://www.epemag.wimborne.co.uk**. Through the same address you can also get to our FTP site and download (*free*) the software.

Do make sure you read this month's *Shop Talk* page where we tell you more about component sourcing (including where to get the pre-programmed PIC microcontroller).

VIDEOS ON ELECTRONICS

A range of videos selected by EPE and designed to provide instruction on electronics theory. Each video gives a sound introduction and grounding in a specialised area of the subject. The tapes make learning both easier and more enjoyable than pure textbook or magazine study. They have proved particularly useful in schools, colleges, training departments and electronics clubs as well as to general hobbyists and those following distance learning courses etc.

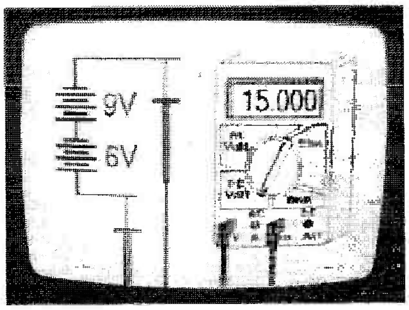
BASICS

VT201 to VT206 is a basic electronics course and is designed to be used as a complete series, if required.

VT201 54 minutes. Part One; **D.C. Circuits.** This video is an absolute must for the beginner. Series circuits, parallel circuits, Ohms law, how to use the digital multimeter and much more. **Order Code VT201**

VT202 62 minutes. Part Two; **A.C. Circuits.** This is your next step in understanding the basics of electronics. You will learn about how coils, transformers, capacitors, etc are used in common circuits. **Order Code VT202**

VT203 57 minutes. Part Three; **Semiconductors.** Gives you an exciting look into the world of semiconductors. With basic semiconductor theory. Plus 15 different semiconductor devices explained. **Order Code VT203**



VT204 56 minutes. Part Four; **Power Supplies.** Guides you step-by-step through different sections of a power supply. **Order Code VT204**

VT205 57 minutes. Part Five; **Amplifiers.** Shows you how amplifiers work as you have never seen them before. Class A, class B, class C, op.amps. etc. **Order Code VT205**

VT206 54 minutes. Part Six; **Oscillators.** Oscillators are found in both linear and digital circuits. Gives a good basic background in oscillator circuits. **Order Code VT206**

£34·95 each
inc. VAT & postage
Order 8 or more get one extra FREE
Order 16 get two extra FREE

VCR MAINTENANCE

VT102 84 minutes: Introduction to VCR Repair. Warning, not for the beginner. Through the use of block diagrams this video will take you through the various circuits found in the NTSC VHS system. You will follow the signal from the input to the audio/video heads then from the heads back to the output. **Order Code VT102**

VT103 35 minutes: A step-by-step easy to follow procedure for professionally cleaning the tape path and replacing many of the belts in most VHS VCR's. The viewer will also become familiar with the various parts found in the tape path. **Order Code VT103**

DIGITAL

Now for the digital series of six videos. This series is designed to provide a good grounding in digital and computer technology.

VT301 54 minutes. Digital One; **Gates** begins with the basics as you learn about seven of the most common gates which are used in almost every digital circuit, plus Binary notation. **Order Code VT301**

VT302 55 minutes. Digital Two; **Flip Flops** will further enhance your knowledge of digital basics. You will learn about Octal and Hexadecimal notation groups, flip-flops, counters, etc. **Order Code VT302**

VT303 54 minutes. Digital Three; **Registers and Displays** is your next step in obtaining a solid understanding of the basic circuits found in today's digital designs. Gets into multiplexers, registers, display devices, etc. **Order Code VT303**

VT304 59 minutes. Digital Four; **DAC and ADC** shows you how the computer is able to communicate with the real world. You will learn about digital-to-analogue and analogue-to-digital converter circuits. **Order Code VT304**

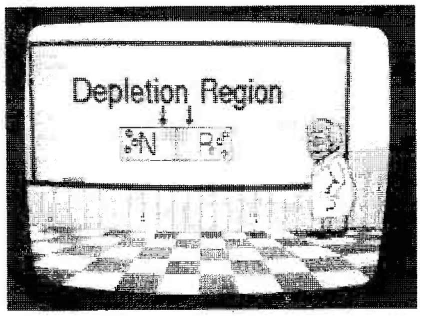
VT305 56 minutes. Digital Five; **Memory Devices** introduces you to the technology used in many of today's memory devices. You will learn all about ROM devices and then proceed into PROM, EPROM, EEPROM, SRAM, DRAM, and MBM devices. **Order Code VT305**

VT306 56 minutes. Digital Six; **The CPU** gives you a thorough understanding in the basics of the central processing unit and the input/output circuits used to make the system work. **Order Code VT306**

RADIO

VT401 61 minutes. **A.M. Radio Theory.** The most complete video ever produced on a.m. radio. Begins with the basics of a.m. transmission and proceeds to the five major stages of a.m. reception. Learn how the signal is detected, converted and reproduced. Also covers the Motorola C-QUAM a.m. stereo system. **Order Code VT401**

VT402 58 minutes. **F.M. Radio Part 1.** F.M. basics including the functional blocks of a receiver. Plus r.f. amplifier, mixer oscillator, i.f. amplifier, limiter and f.m. decoder stages of a typical f.m. receiver. **Order Code VT402**

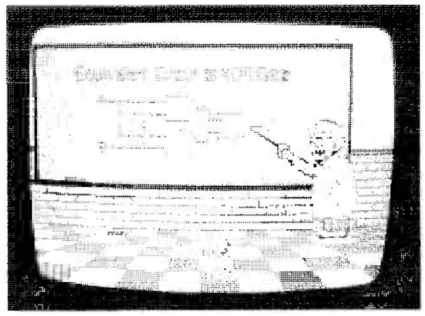


VT403 58 minutes. **F.M. Radio Part 2.** A continuation of f.m. technology from Part 1. Begins with the detector stage output, proceeds to the 19kHz amplifier, frequency doubler, stereo demultiplexer and audio amplifier stages. Also covers RDS digital data encoding and decoding. **Order Code VT403**

MISCELLANEOUS

VT501 58 minutes. **Fibre Optics.** From the fundamentals of fibre optic technology through cable manufacture to connectors, transmitters and receivers. **Order Code VT501**

VT502 57 minutes. **Laser Technology** A basic introduction covering some of the common uses of laser devices, plus the operation of the Ruby Rod laser, HeNe laser, CO_2 gas laser and semiconductor laser devices. Also covers the basics of CD and bar code scanning. **Order Code VT502**



Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes are imported by us and originate from VCR Educational Products Co, an American supplier. (All videos are to the UK PAL standard on VHS tapes)

ORDERING: Price includes postage to anywhere in the world.
OVERSEAS ORDERS: We use the VAT portion of the price to pay for *airmail* postage and packing, wherever you live in the world. Just send £34.95 per tape. All payments in £ sterling only (send cheque or money order drawn on a UK bank).

Visa and **Mastercard** orders accepted – please give card number, card expiry date and cardholder's address if different from the delivery address.

Orders are normally sent within seven days but please allow a maximum of 28 days – longer for overseas orders.

Send your order to: Direct Book Service, 33 Gravel Hill, Merley, Wimborne, Dorset BH21 1RW (Mail Order Only)

Direct Book Service is a division of Wimborne Publishing Ltd., Publishers of *EPE*

Tel: 01202 881749. Fax: 01202 841692

Due to the cost we cannot reply to overseas orders or queries by Fax.

E-mail: editorial@epemag.wimborne.co.uk

Special Feature

MAX761 D.C. TO D.C. CONVERTER

ANDY FLIND

Squeezing the most out of your batteries could not be easier if you use the MAX761 step-up voltage converter.

CONSIDER the following design problem. A circuit is to be battery powered, preferably from a 9V source. It will drive six ultra-bright l.e.d.s, connected in series on the end of a two-core connecting lead.

To be sure of overcoming their collective forward voltage drop a supply of at least six volts is required, plus an additional three volts as "overhead" for their operating circuit since brilliance is to be accurately controlled. This rules out direct supply from a 9V battery as these normally deteriorate to about 6V before replacement.

As the l.e.d.s are to be operated with a maximum current of 40mA a charge-pump step-up converter is not practical, which leaves just two possibilities. Either a switch-mode converter is employed, or the battery supply must be increased to 12V.

SWITCHED-ON I.C.

Not so long ago the design of switch-mode converter circuits was considered to be something of a black art, usually avoided by hobbyists. The introduction of simple, integrated circuit, switch-mode regulators is rapidly changing this however, and the Maxim MAX761 is a fine example of these i.c.s.

It can provide an output voltage between 5V and 16·5V from an input extending to below 3V, and output currents in excess of 150mA are possible. High speed switching allows the use of small inductors and decoupling capacitors. It can operate from as little as 100µA of quiescent current and also contains a low supply voltage detecting circuit which makes it ideal for battery-powered applications.

Although advertised as a 12V device, the output voltage can in fact be adjusted to any value between 5V and 16·5V with just two external resistors. The design of step-up converters using this i.c. is very simple and anyone designing their own circuits, especially where battery power is intended, would benefit from an understanding of its capabilities.

IN BRIEF

The operation of the switch-mode step-up converter has been covered previously in the pages of *EPE* so only a brief description will be given here.

In simple terms, an electronic switch is used to connect the supply voltage across an inductor so that a rapidly rising current flows through it. When this current reaches a suitable value the switch is opened. Current in an inductor has a tendency to keep flowing and will generate a high voltage in order to do so, as demonstrated by the sparks produced when mechanical contacts are used to break current flowing in an inductive circuit.

In the case of a switch-mode converter this current is diverted through a diode into a reservoir capacitor, and repeated operation of the electronic switch can produce an output voltage which is higher than that of the input. A control circuit is normally provided to ensure that current flow in the inductor does not rise to a value high enough to damage the switch, and to adjust switch frequency and "on" times to achieve the desired output voltage over a range of input voltages and output load currents.

INSIDE DATA

Although switch-mode circuits are complex, most of the design work is covered by the internal circuit of the MAX761. The best way to understand the operation of this device is probably through some practical examples.

The data sheet refers frequently to two "modes" of operation, "*bootstrapped*" and "*non-bootstrapped*". In practice, all

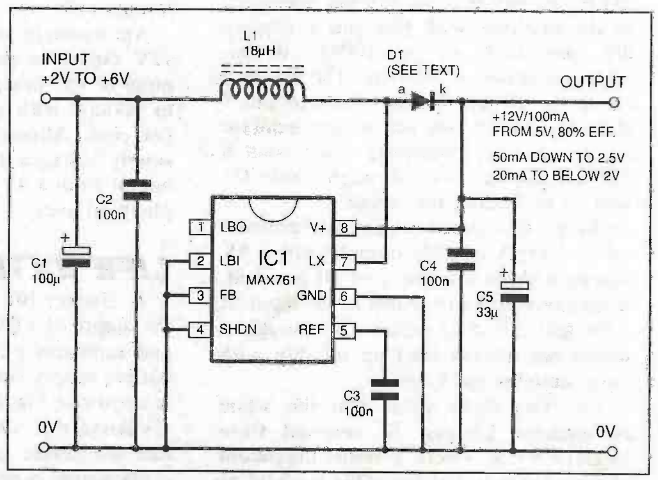


Fig.1. Pin connection details and basic bootstrapped operation for the Maxim MAX761 step-up voltage converter.

this means is that in bootstrapped mode the i.c. takes its internal power from the circuit output, whilst in non-bootstrapped operation power is taken in the conventional manner from the positive supply input.

There are two advantages to bootstrapped use. One is that the internal power switch, a MOSFET device, receives a higher gate drive voltage and can therefore switch more rapidly, improving efficiency with low supply voltages and high output currents.

The other is that in this mode the voltage-setting feedback input can be simply connected to $-V$ supply for a fixed 12V output, eliminating the two voltage-setting resistors. This option is not possible in the non-bootstrapped mode. An alternative version of the device, the MAX762, produces a 15V output in this configuration.

The data sheet recommends the use of bootstrapped operation for supply voltages below 4V and up to 6V for higher output currents. At higher supply voltages non-bootstrapped operation can marginally improve efficiency, although the simple fixed 12V output option may make bootstrapping preferable.

OPERATION BOOTSTRAPS

The basic bootstrapped circuit is shown in Fig.1, which also shows the pin arrangement for the MAX761 d.c./d.c. converter i.c. Positive supply for pin 8 is taken from the output. The "low battery" (LB) and "shutdown" (SHDN) inputs, pin 2 and pin 4, are not used and are disabled by connection to ground (–V). The voltage sensing feedback (FB) connection at pin 3 is also grounded, causing the internal sensing circuit to take its reference from pin 8 and generate a fixed 12V output.

Decoupling capacitors are provided at input and output. The data sheet suggests 33µF at both input and output, but in practice some improvement was obtained from the use of 100µF for C1 at the input. Some designs might also benefit from the use of a larger value of C5 at the output. For simplicity these capacitors are only shown in this example, though they should be included in *all* circuits using this device.

The internal reference voltage is nominally 1·5V and appears at pin 5 (REF), though it is usually not necessary to do anything with this pin excepting the provision of a 100nF decoupling capacitor as shown. The internal electronic switch operates through pin 7 (LX) to connect one end of the inductor L1 to ground, following each switch turn-off current flows through diode D1 into C5 to produce the output.

On test this circuit managed to produce up to 100mA of 12V output from a 5V supply with an efficiency of 80 per cent. It maintained 50mA down to an input of 2·5V and 20mA to below 2V, though it would not always start up reliably with these supplies and loads.

The data sheet states that the value of inductor L1 can be selected from L(µH) = 5 × V, where V is the maximum expected supply voltage. This is about as simple as inductor selection for a switch-mode circuit can get, and since the i.c. also shows an amazing tolerance for incorrect values, design is very easy even when a wide range of supply voltage and output current is expected.

Diode D1 *MUST* be a *high speed* type due to the switching frequency of the circuit. "1N400**X**" series types will NOT work with the 761. The data sheet suggests a Schottky device, the 1N5817. Testing for this article was carried out using a UF4002, which is a high-speed version of the 1N4002.

A bootstrapped circuit using external feedback resistors R1 and R2 to set the output to 9V is given in Fig.2. Apart from the use of these resistors the circuit is the same as that of Fig.1. (Input and output decoupling capacitors not shown.)

The resistors are calculated from the simple formula $R2 = R1 \times ((V_{out}/V_{ref}) - 1)$ remembering that V_{ref} has a nominal value of 1·5V. The value of resistor R2 can be anywhere between 10k (kilohms) and 250k, bearing in mind that the higher the values of these two resistors, the lower the current loss through them.

With a supply of 6V, this circuit produced up to 150mA with an efficiency of 87 per cent, whilst 100mA was available with a 4·5V input. This would allow three or four AA cells to become a cost-effective alternative to the ubiquitous PP3. A current of 30mA was maintained to below 2V, suggesting the possibility of low-power 9V circuitry operating from just two cells or a single lithium cell.

An example of a non-bootstrapped 12V circuit is shown in Fig.3. With an input of 9V, this generated 12V out at up to 200mA with an efficiency around 90 per cent. Although designed for higher supply voltages it still managed 50mA of output from a 4V supply, so it could find plenty of uses.

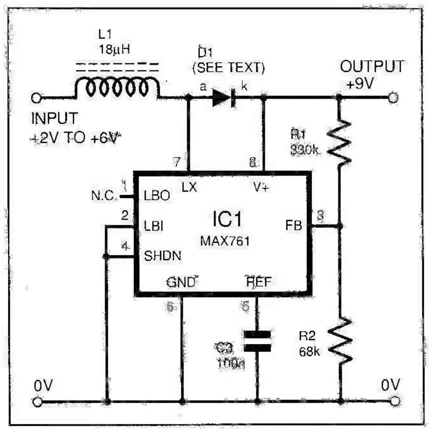


Fig.2. Bootstrapped operation with a 9V output.

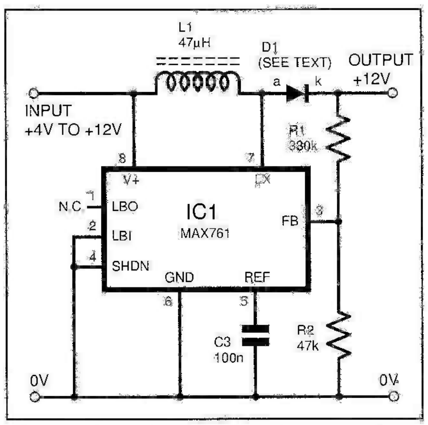


Fig.3. Non-bootstrapped operation, 12V output from 9V input.

LIFE EXTENDER

A Battery-life Extender which takes the output of a 9V battery, such as a PP3, and maintains a constant 9V as the actual battery supply voltage gradually drops off is shown in Fig.4. There are two reasons for doing this, one being that the battery can deteriorate further than usual before replacement is necessary, whilst the other is that the circuit receives full supply for the entire life of the battery.

Low battery indication is provided in this example by feeding part of the supply voltage to LB1 (pin 2) through the potential dividing resistors R1 and R2, for comparison with the 1·5V internal reference. Resistor R2 can be anywhere from 10k up to 500k, whilst R1 can be calculated from the formula shown in the diagram, again remembering that Vref is 1·5V.

The values shown cause l.e.d. D1 to light at about 6V. The input LB1 has a built-in hysteresis of 20mV to help prevent jitter.

The output of the low battery detector, LB0 (pin 1), is an open-drain capable of sinking 5mA so it can be used for directly driving a low-power l.e.d. as shown in Fig.4. If it is to be used to control a logic input a pull-up resistor from LB0 to positive supply may be required.

SHUTDOWN

No mention of the shutdown (SHDN) input, pin 4, has been made so far. Quite simply, if this input is low (–Ve) the 761 operates normally, whilst if it is high

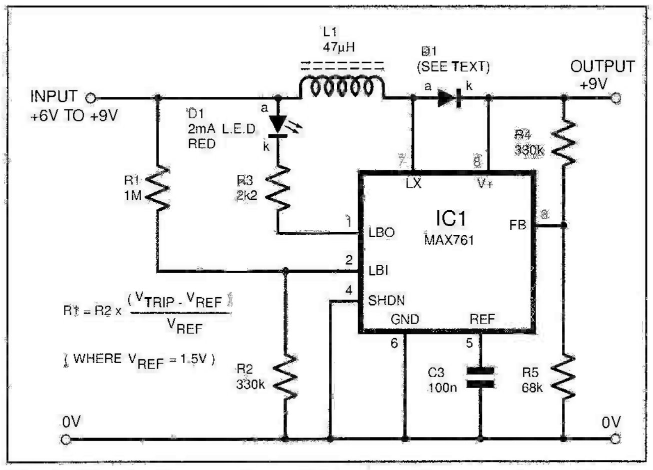


Fig.4. Circuit diagram for a 9V battery life extender, with low battery warning.

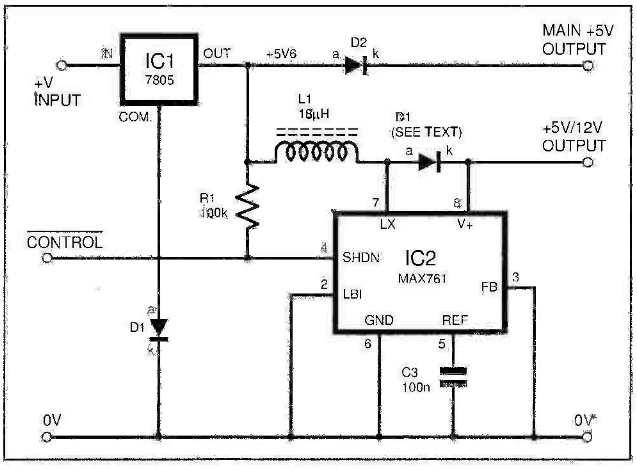


Fig.5. Circuit diagram for a 5V/12V switchable supply from a 5V input.

(+ Ve) operation ceases. In the shutdown state the MAX761 i.c. is stated to draw about 5μA of quiescent current, and the supply voltage will, of course, continue to appear at the output, less the forward drop of diode D1.

A possible use for this feature is shown in outline by Fig.5, a 5V/12V switchable supply circuit. Here a regulated supply of 5·6V is produced by placing a diode in the "ground" (common) path of the 5V regulator IC1. The forward voltage drop of diode D2 compensates to provide a main logic supply rail of +5V.

Meanwhile, resistor R1 holds the SHDN input of IC2 high so IC2 does not operate, and the forward voltage drop of D3 results in an auxiliary supply of +5V. If the "control" input is now grounded however, IC2 will begin to operate and the auxiliary supply will rise to almost 12V.

Some decoupling capacitors are, of course, required in a practical circuit, but this easily controlled dual-voltage supply can be created with very few components and a single low-voltage supply, and could prove useful in the design of logic circuits which require a switchable 5V/12V supply for programming purposes.

IN CONCLUSION

The circuits shown here were all bench-tested by the author to obtain practical data on the MAX761's performance. The i.c. appears to be commendably robust, as the usual untidy breadboard construction, poor handling procedures and occasional incorrect connection caused no damage.

Internal switching appears very efficient as, despite input currents up to 500mA, it never became noticeably warm. Under heavily loaded conditions it sometimes failed to start, and when overloading causes it to drop out of regulation drastic reduction of the load is sometimes necessary to bring it back in. When forced out of regulation in this manner it can generate a lot of r.f. noise, right into the v.h.f. spectrum.

It should be remembered that switch mode circuits are fairly noisy in this respect anyway, so their main use is in logic circuits, anything to do with radio reception is probably not a good idea. To minimise radiation a toroidal or pot-core inductor could be used, though testing for this article was carried out with miniature ferrite bobbin-type inductors.

With these notes in mind, the MAX761 d.c./d.c. voltage converter will hopefully become a useful device in the workshop of many amateur designers.

SOURCE

The MAX761 5V to 12V d.c./d.c. converter chip should now be widely stocked by advertisers and will be priced around £4 each. The author obtained his from Maplin (Tel: 01702 554000), code NR61R.

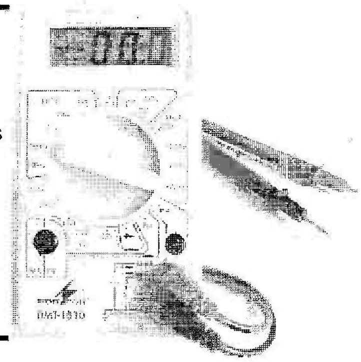
READOUT

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

The DMT-1010 is a 3½ 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 DMT-1010 Digital Multimeter to the author of the best *Readout* letter.



APPLE PRESS

Dear EPE,

I must take exception to some of the remarks in the Jan '99 *Net Work* column concerning the Apple iMac. There are things I think need to be said, and the press should be saying them.

I am an electronics technician in California, and an avid computer hobbyist, building my own PCs from parts. I too would advocate avoiding the iMac for those who like to tinker with their systems. However, my reasoning is very different. I would also tell these same people to avoid Compaqs, Packard Bells, and any number of other PC brands.

Why? Because they, like the iMac, are designed to be taken home, plugged in, and left alone. Despite the fact that these are PC compatible, that compatibility is primarily operational. These machines frequently contain proprietary components that make upgrading or adding on peripherals a nightmare. For those who want a simple "plug-n-play" solution, the iMac is nearly ideal.

As for the compatibility problems, I feel you have grossly overstated them. While transferring files from Mac to PC can be problematic, anyone who has worked in a (supposedly) homogeneous PC environment will have experienced the problems that come with the numerous incompatible versions of Microsoft software.

The standard practice is to forgive any problems caused by Microsoft's software, and suggest buying a new version to fix problems that shouldn't have been in the old version. Also ignored is the fact that the new versions always have at least as many problems as the old ones; they're just different problems.

It's been my experience that 90 per cent of "hardware" problems go away when you switch to a non-Microsoft operating system. Apple's current hardware is better than anything available in the PC world.

A technically oriented magazine such as yours should not be advocating staying with the status quo for convenience reasons. The situation would be much better if those in the press were more willing to explore those alternatives and less prone to dismiss them out of hand for problems that often amount to "urban myths".

Alan Ratcliff,
Livermore, California, USA,
via the Net

The above and the following reply have been heavily edited from their original lengths for space reasons. Net Work *being Alan Winstanley's pet addiction, it's he who replies:*

If I had the time, I could write many pages of views comparing the practicalities of Wintel and Macintosh ownership and I also know how defensive and loyal Macintosh owners are concerning their choice of computer equipment.

Like many users stuck on a perpetual upgrade treadmill, I hardly have a wonderful time relying for a living on hardware and applications from Apple's competitors, though if nothing else I am totally spoilt for choice of plentiful and cheap upgrades and accessories for my PC system. (I run a Macintosh Powerbook too, by the way.)

I have just spent several hours talking to Apple's representative about the iMac and also playing around with an iMac 233, and I can tell you that if I had the office space I would probably buy one today. I think it is a brilliantly executed piece of (consumer) electronics which oozes design flair and it deserves to be an enormous success. Apart from my biggest gripes (the lack of removable diskette, the mouse ergonomics and the lack of tilt/swivel monitor), I think that the reliance on the Internet for file transmission is a brave move but is one which is slightly ahead of its time.

My *Net Work* article (which was not aimed at gurus) related to the launch of an Internet-dependent machine which was targeted specifically for home use, with the added attraction that it was said to be easy to use (and implying it would appeal to beginners or inexperienced users). I felt it was important that people should be aware of some of the practical differences between the two platforms before they buy into either path.

Without wishing to spoil Apple's fun, ultimately I outlined some of the drawbacks but I did leave it to the reader to decide. The problems are hardly insurmountable to an experienced user/buyer but are pretty fundamental to the beginner looking for an easy to use home machine.

Rather than the situation being caused by the technical press forever "pushing" PCs, I think Apple has only itself to blame for the disparity in the market penetration of its products, though I am the first to acknowledge that the Mac easily reigns supreme in professional markets including page make-up and pre-press, graphics and web creation, as reflected by the highly specialist software available for the Mac OS.

Alan Winstanley

LADDERS

Dear EPE,

With reference to Carle Wilde's request in *Readout* Feb '98 for a Ladder Logic article, I would like to refer him to *ETI* Dec '98. This is great article which gives the reader a chance to experiment.

Tom Mullan,
Woking Surrey

Thanks Tom, as we now own ETI *we can quite happily pass on your recommendation! We have copies of this issue for resale – see* Back Issues *page.*

Continued over . . .

★ LETTER OF THE MONTH ★

PIC TOOLKIT AND WINDOWS I/O

The first part of this letter is specific to Windows 98, but the remainder will be of interest to Windows 95 and 3.1 users as well.

Dear EPE,

Having just changed my operating system to Window 98, I found that I could not send signals to the *PIC Toolkit* board (*EPE* July 98) in a DOS box under Windows. I have now been doing some work on the Windows 98 I/O port accessibility problem.

I have found that if I disable LPT1, then Windows 98 keeps trying to reinstall it and there seems to be some disagreement between the BIOS and Windows. I've given up trying to sort out what is happening and instead have come up with a solution that works all the time.

I have two parallel ports, the first of which came with the PC and is known as LPT1. The second is one that I later added myself at a cost of a few pounds and is LPT2. I installed this as normal and tested it on my printer.

The trick now is to navigate from My Computer to the Properties – General tag for LPT2, then tick the box to "Remove from this hardware profile". This frees the port from Windows, which then ignores it no matter how many times I reboot. I've not looked into hardware profiles!

Using the now free LPT2 port connected to either the *PIC Toolkit* board or the *EPE PIC Tutorial* board, I find that I can access and run the software from the desktop in a DOS box.

This has brought to light another problem. My LPT2 port has some sort of internal pull-up on its pin 10 which is so strong that the drive from the PIC in Verify Mode can't drive logic 0 below about 2V, which gives verify errors of course.

To get over this I have added a 7404 chip on a small piece of Veroboard and wired two of its inverters in series to give a non-inverting drive between the PIC pin 13/4053 pin 15 junction and pin 10 of the Centronics connector. I didn't need to cut the track but just removed two jumper links from the board and wired accordingly.

As seen by my oscilloscope, the voltage at connector pin 10 goes from 0·1V to 5V and so far I have not had a single Verify error.

I really can't thank you enough for the knowledge and experience gained from your two projects and I can only guess at the number of man-weeks of effort invested on your part.

Colin Birtwistle, Swanley, Kent

Colin, I am most grateful to you for this information, as will be a number readers – there have been quite a few who have contacted me about their computer's inability to correctly read the data on connector pin 10.

In this context, it has surprised me how many readers have not fully read my comments about setting the program variable VERIFY% = 0 if the computer cannot read the pin (it's near the head of the program and normally set to VERIFY% = 1, which tells the computer that it should try to verify/disassemble).

As result, a common resulting problem is that some of these readers have thought their PIC was not being programmed at all because the computer was reporting vast quantities of errors found, probably as many as the number of bytes sent! In all cases, it is highly likely (provided everything else is being/has been done correctly), that the PIC will have accepted the data, and it's just the computer that erroneously reports otherwise, simply because it cannot read pin 10.

To summarise the possible reasons why the PIC might appear to be inaccurately programmed by Toolkit, *they are:*

- PIC omitted/incorrectly inserted (should be notch down)/wrong type (16C84 and 16F84 only)
- Power to the board not present or not to the voltage required
- Printer cable not plugged in
- Incorrect Port address selected on computer (re-read my text – there are three possible addresses, hex 378, 278, 3BC)
- Computer cannot read printer port as an input – (see Colin's letter above for possible solution and my above comment about disabling the verifying routine, setting VERIFY% = 0)
- P.C.B. and/or components faulty in some way
- A few genuine errors exist – try again (I've never experienced it)
- PIC has not first been configured as required for application (Menu Option 1 not run)
- Failure to disassemble may be because PIC has previously been Code Protected

I have long suspected that some computers might need a buffering chip between their printer port and the PIC, and have been suggesting such to some readers who have phoned me. It is an option which is well worth exploring if your computer seems unable to verify/disassemble. With Toolkit Mk2 *which I am currently preparing (and which is intended for the PICx84 and the new '87x family), I have included a buffer as part of the circuit.*

WINDOWS 98 PORTS

Dear EPE,

In *Readout* Feb '98 (*High Language*), you ask about accessing Windows 98 ports, in the context of Ken Brown's enquiry about using Windows programming languages for *EPE* parallel port projects.

Windows 95 and 98 are not nearly so different as Windows 3.1 and 95 are. Information about using MS-DOS/Windows computer's parallel port for *EPE* type projects is on my web site at: **www.arunet.co.uk/tkboyd/ele1pp.htm.**

Ken Brown's points address what you are "supposed" to do in Windows programming. For the purpose of *EPE* type projects, I do not believe that there would be significant problems with the "cheats" inherent in my "quick and dirty" method.

Please consider publishing an E-mail address for *Readout* as part of its main page heading.

Lastly, congratulations on absorbing *ETI.*

Tom Boyd, via the Net

You have an interesting web site, Tom, with some very useful links. I spent a couple of hours browsing through the links. There's a lot of port-related material. Readers are recommended to take their own look.

Curiously, though, I didn't spot anything relating to why lap-top computers seem less willing than desk-tops to allow their printer ports to be used for purposes other than driving printers.

We periodically get calls from readers who cannot get their lap-tops to work with some projects that are known to work correctly with desk-tops. Could the lap-top output voltages be lower than those expected from desk-tops? Could pull-up/down resistors provide a solution? Can anyone provide some answers from their own experience with lap-tops?

Readout *does not have its own E-mail address, the general Editorial address should be used (as given at the top right of each month's Editorial page), i.e.* **editorial@epemag.wimborne.co.uk**.

FUEL FOR THOUGHT

Dear EPE,

I have just changed my motorbike (from an R110RS to a Cruiser). All my previous bikes had fuel gauges yet this new model from BMW surprisingly lacks one (except for a low-warning light which is useless as you may not be able to find a garage with the range left).

Not to be put off, I removed the tank and plate expecting to find a float and rheostat inside (as is the case with their other models, even though a gauge might not be actually fitted to the display panel. There is only a small float switch used by the warning lamp. There appears to be no float/rheostat assembly available which can be fitted inside this particular model's tank.

Do you, or any reader, know of a way of measuring fuel quantity in a metal tank using a transducer from outside (so as not to have to drill a hole through the tank which would present sealing problems), e.g. by pinging the tank with a sound wave. The measurement does not have to be linear as this could be accomplished using a PIC.

Any suggestions would be welcomed as I do not want to run out of fuel miles from anywhere again!

Stephen H. Alsop JP, via the Net

Again? – therein lies a tale (and a trail) I guess! Stephen's E-mail was addressed to Alan Winstanley, who offers the following:

From my industrial experience it can be extremely hard to obtain reliable results, depending on the nature of the fluid being measured. Methods include ultrasonic or laser detection, checking the image reflected from the top of the fluid. But with a motorcycle there will obviously too much turbulence for such a system to work properly.

The old ways are best and I think that a float would be the only feasible way of damping down the movement inside the tank. There are several float sensors available from RS or Farnell, but I really wouldn't like to offer a circuit due to the hazards involved. As for trying to detect the fluid content from outside, I really cannot think of any reliable method.

I find it incredible that no gauge is fitted to your machine. (I'll stick to a mountain bike!)

Alan Winstanley

As a thought from me, could you perhaps put a flow monitor into the fuel line? Knowing the rate of flow and the pipe diameter, the PIC should be able to calculate the quantity used. Providing you know how much fuel you put into your tank each time (perhaps entering the value into the PIC) you should be able to keep track of the minimum quantity remaining.

RS do a range of flow sensors, at least one of which is for use in automotive fuel line applications (part no 256-225, about £70). Let us know how you eventually solve the problem.

PIC84 EEPROM DATA

Dear EPE,

How can I program the PIC16x84's internal EEPROM data memory with a message *before* the program itself is loaded? I understand some PIC programmers can do it, but your TASM Send does not seem able to.

Daniel Hicks, via the Net

Yes, TASM Send cannot do this. However – my new Toolkit MK2 that is in preparation can! It will both program any message (or other codes) of one's choosing into the PIC's EEPROM data memory and (with computers that can read their printer ports) can also read them back to disk. Toolkit Mk2, *is for programming PIC16x84 and the new PIC16F87x microcontrollers and is scheduled for the May issue. And, incidentally, the inclusion of this facility was prompted by your query (and half a weekend to spare)!*

ONLINE DILEMMA

Dear EPE,

Now that EPE is available OnLine via the Net and I can readily access it, should I now cancel my printed edition of the mag and adopt the Internet version?

Also, I have noticed that *EPE* has been criticised through *Readout* for becoming computer orientated. Electronics is purely a hobby for me, but as part of my science course in the early '60s I had to learn the characteristics of thermionic valves and transistors and how to build a better amplifier. I did not find this particularly interesting or challenging.

However, in my opinion, I believe that with the advent of the computer and microelectronics all this has changed. I believe that *EPE* should have a bit of everything whilst remaining at the cutting edge of technology and innovation.

Colin Watkin, via the Net

EPE Online *provides an excellent way for readers all around the world to gain fast access to the magazine and to the articles in past issues (*EPE Online *started with the November '98 issue). The Online web site also houses a shopping mall which carries books, CD-ROMs etc., in addition to this various other information in the form of back up material is available free of charge. Online represents an exciting leap forward for* EPE *and an extra facility for all readers. However, readers should be aware that the on-line edition appears about ten days after publication of the printed version and, at present, carries no advertising.*

If you just want access to the articles and are not worried about the adverts then Online is cheaper than the printed version. We suggest you "suck it and see", a free issue (Nov '98) is available so you can get the feel of it and see if it suits you.

The Net version is prepared and put online in America by our friends Max and Alvin (of PhizzyB infamy!). They are sent our files only when the printed edition layouts have been finalised and sent to our UK printers. M&A then edit the files so that the Net edition is tailored to Web presentation and an international market. In this process some contents may be slightly changed, and even some articles may be switched between editions.

Whilst we are aware that some readers would prefer us not to be involved with computers, the majority do seem to welcome the fact that in their various forms computers and allied devices such as microcontrollers have become an integral part of electronics design and construction. I for one would be totally lost now without a computer – I use one in my workshop much more than I ever use a multimeter.

ENTITLING

Dear EPE,

In your Feb '99 Editorial you asked for title suggestions to suit the integration with *ETI*. I beg you not use an amorphous initial-lettered title. Such a pseudo name may identify the magazine to those who are familiar with it – or it may confuse even them – but it would mean nothing to the unacquainted whom you would wish to attract.

The fatuous use of corporation names comprised of initials has become fashionable; but apart from a very few such designations, as of the BBC, they convey nothing to the majority of the people.

Besides, historically your amalgamated publication will be derived from more than only *PE*, *EE* and *ETI* (*Hobby Electronics*, for example?).

I suggest that you need a title which would associate the magazine with its aspirations and achievements. Try *Functional Electronics*.

J. H. Eastaugh, Chesham, Bucks

I have to agree that initials-only titles can be confusing to those who are not already in the know. Although we refer to ourselves as EPE *within the body of the magazine, it would be imprudent of us to substitute those letters for the full title on the front cover. Even as an independent magazine,* ETI *still spelt out their full title underneath the logo.*

Personally, I think it's dangerous for any magazine to change its name in any significant way without a really good reason – readers become used to looking for their favourite magazine by its cover style. If changes are to be made they should be done gradually. Our incorporation of the ETI *logo has, we hope, made* EPE *and* ETI *readers still feel they have a familiar image to draw their attention to the cover.*

You are almost right on the historical aspect – Hobby Electronics *was started by Argus Press as a "little sister" to* ETI*, in the same way that IPC Magazines had previously started* EE *as a "little sister" to* PE*. This was in the great hey-day of electronics hobbyist activity (1970s-80s) with several publishers offering comparable magazines to meet market demand.*

However, as I understood it when it was happening, Hobby Electronics (HE) *began to decline in popularity and its name was changed to* Electronics Monthly (EM) *in an attempt to gain more readers. It failed in this and the title was bought by* Everyday Electronics *and incorporated on the* EE *cover. In fact, the title of* Hobby Electronics *was also bought by* EE*. Consequently, our parent company, Wimborne Publishing, owns six electronics magazine titles, abbreviated to:* EE, PE, EPE, HE, EM *and* ETI *(not to mention the two massive electronics manuals and their on-going quarterly supplements:* Electronics Service Manual (ESM) *and* The Modern Electronics Manual (MEM).

HAPPY FAMILIES

Dear EPE,

A wee suggestion for your title – I know you are trying to keep loyal to all the readers of *EE*, *PE* and *ETI*, but why not take a simple and practical approach? Your magazine is about electronics so why not have a clear and obvious title that anyone looking for an electronics magazine can spot on the crowded newsagent shelves – why not call it *Electronics*? It may be a bit simple but it tells the onlooker what is inside! Maybe have a picture of the world under the title to show that it is an international magazine, but what ever you do, keep it simple.

I would also like to thank Alan Winstanley for his *Home Page* on the Internet. If you have not seen it yet, look it up. Being a father of seven children I know where he is coming from.

Lee Elvin, via the Net

Thanks for the observations Elvin – simplicity has a lot to be said for it. But I'll bet that simplicity is not always a keyword with a septet in tow! And, yes, Alan's probably a father-figure to many treading the path towards electronics knowledge.

ROM Vs CAT

Dear EPE,

I fancied a CD-ROM catalogue from Maplin. I had just added a CD-ROM drive to my computer set-up and was anxious to try it out. Cheque sent. Eventually (!) a disk arrived, but the set-up stalled trying to open a non-existent file. Sent disk back with note of the problem.

They send another CD-ROM. Same problem, so wrote to HQ who had no knowledge of my previous correspondence. Sent copies. Eventually got a strange letter, very difficult to understand but setting out instructions using the enclosed disk – only they never sent the disk! Where's the disk?, I asked. This came some days later with a scribbled compliments slip.

It took a long time running following their instructions using the floppy disk containing a file omitted(?) from the CD-ROM. However, I got a little window which said it had all been successfully installed. Play "Freecell" and all would be well. Which I did, but there is no sign of the catalogue anywhere. I wonder where it went?

I then had to re-install Windows because I couldn't access it at all. The re-installed Windows didn't work either. So I had to format the hard drive, so everything went.

Re-installed DOS and Windows and all is well, except I lost my letter files so I don't have a copy of my *EPE* Prize Winning Letter (Dec '98), and there wasn't a copy of *EPE* to be had in Newcastle.

I don't know why I bother, but I suppose my generation always did. I will just have to use the paper catalogue.

Peter McBeath, Morpeth, Northumberland

A somewhat longer Comedy of Errors detailed in Peter's letter has been edited!

We knew Maplin's first CD-ROM had been causing problems for a lot of our readers, indeed our own copy gave us problems too. However, I have loaded their latest CD onto two machines without problems and am using it (them) regularly.

We feel sure that a company of Maplin's size, and usually good reputation for the variety, quantity and quality of its products, will take heed of any feedback they receive about their CD-ROM and rectify any problems before the next edition. It must be said, though, that it is concerning that someone should have lost data through loading it.

Peter also asks:

"How can I do a drawing on the drawing board which will put it straight on the computer screen – a fine pointer instead of a mouse? And how can I program a timer and clock to produce 'ship's' bells?"

Well, readers, have you any suggestions?

BASIC

Dear EPE,

Referring to the letter from Joseph Zammit (Dec '98), I would like to suggest *EPE* continues to use BASIC as the main programming language for two reasons: almost everyone knows BASIC and if someone wants to use other programming languages they can easily translate the program. Secondly, QBASIC.EXE is free.

On the other hand, you mentioned Visual Basic in your reply letter – I think it is a good idea since many people are using Windows and writing Windows-based programs will become more popular.

Charles Law, Hong Kong, via the Net

Thanks Charles.

YETI BOUND?

Dear EPE,

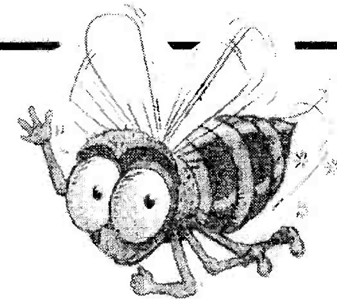
There was a letter published in *Readout* Oct '98 which suggested that a serial link between two PICs increased the number of available I/O lines. I would like to know how this was done as I have a requirement where two PICs are being used and linked serially.

Also, re the letter in *Readout* March '99 regarding the "mistake" of changing *Electronics Today International* to *ETI* and that *EPE* is not easily pronounced: how difficult is it to reel off *eepy*? Akin to *ETI* being pronounced like *yeti* or *yehti* without the *y*.

Chris Neale, via the Net

Hi again Chris. I've not done double-PICing yet and can't answer you, but suggest you ask via our Internet Chat Zone – lots of knowledgeable readers out there!

Ah yes, the Yeti – the abominable snowman, and still being looked for I believe. But you don't have to look far for us – on any good newsagent's shelves, or on your door mat if you're on subscription, or on the Net if you're Webbed.



PhizzyB COMPUTERS

Part 6: PhizzyBot – Collision Detection

Clive "Max" Maxfield and Alvin Brown

HI THERE. As you will recall, last month in a crescendo of excitement we created a simple d.c. motor controller output device. Next we mounted the PhizzyB on a base with two d.c. motors, thereby taking a first step towards a simple robot, the PhizzyBot.

Then we performed some simple experiments to test our ability to control the PhizzyBot's motors. This included the creation of a timing subroutine that allowed us to execute actions for fixed durations specified in tenths of a second. Cool! And there's more . . .

IN THIS month's constructional article, Alan Winstanley describes how to add a number of microswitches around the periphery of the PhizzyBot. For our part in this tutorial, we are going to discuss how to program the PhizzyBot to use these microswitches to detect collisions (say with a wall or a household pet) and perform whatever actions we deem to be appropriate. (Note that vaporizing hamster-type obstructions with industrial-strength lasers is NOT an appropriate response!).

As part of this, we'll be employing some rather cunning programming tricks that will make you squeal with delight (so don't read this article in a public place, because we cannot be held responsible for the outcome)!

ADDING SWITCHES

Note that we are going to be using the interrupt-driven input switch device we created in Part 4 of this series (Feb '99), and that this device will be connected to the PhizzyB's input port at address $F012. Now, as discussed in Alan's constructional article, we are going to physically mount six microswitches to the PhizzyBot as shown in Fig.1.

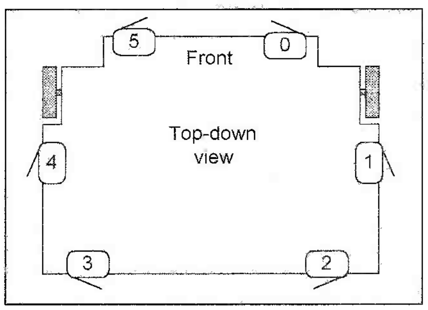


Fig.1. Locations of the microswitches.

For reasons that are a bit involved to go into here, computer guys and gals often start numbering things from zero, and our microswitches are no exception. (The reasons for numbering things in this manner are discussed in excruciating detail in our book *Bebop BYTES Back*.)

These switches are going to be connected to the 16-pin header on the interrupt-driven switch device, such that Switch 0 ultimately drives bit IP0 of the input port, Switch 1 drives bit IP1, and so forth.

One point you might be pondering is why did we use only six microswitches? After all, the input port could support eight switches if we so desired. If you've been conditioned to assume that everything to do with computers is complex, the answer to our poser should prove to be refreshingly simple, because there is no reason whatsoever.

We could indeed have used eight microswitches, but we decided that six would do the job (plus we only had six microswitches in our treasure chest of parts and it was raining and neither of us wished to trek out to the local electronics store).

SKELETON PROGRAM

OK, as for last month, the first thing we're going to do is to create a skeleton (framework) program, which we'll develop as we go along. Invoke your PhizzyB Simulator, activate the assembler, and enter the program shown in Listing 1.

Before you do anything else, save this skeleton program as **eeexp1.asm**. Now consider the Constant Declarations section at the beginning of the program. The **SWITCHES** label will be used to associate our interrupt-driven switch device (which is now wired to the microswitches) with the input port at address $F012.

As per last month, we're going to use the PhizzyB's on-board 8-bit l.e.d. bargraph display to indicate the value we're driving to the motors. Thus, we equate the **MGRAPH** label to the address of this output port, which is $F030.

Similarly, we're going to connect the 8-bit l.e.d. bargraph display we created in Part 2 (Dec '98) to the output port at address $F031, and then use this to display the current value in the timer. Thus, we equate the **TGRAPH** label to the address of this output port.

Next we're going to connect our motor controller board from Part 5 (Mar '99) to the output port at address $F032. Hence the **MCONTROL** declaration.

Moving on, the **DELCONST** label is assigned a value of $0C (12 in decimal), which is used to persuade our timing subroutine to loop around for 1/10 of a second (we determined the value of **DELCONST** by trial and error as we discussed in last month's tutorial).

Finally, the way in which we use the **FOREVER**, **NOMORE**, **GOGOGO**, and **EEEKSTOP** labels will become apparent

Listing 1

```
### Start of Constant Declarations
SWITCHES: .EQU $F012        # Switch input device
MGRAPH:   .EQU $F030        # Motor bargraph display
TGRAPH:   .EQU $F031        # Timer bargraph display
MCONTROL: .EQU $F032        # Motor controller board
                            #
DELCONST: .EQU $0C          # Delay constant value
FOREVER:  .EQU $00          # Do it forever code
NOMORE:   .EQU $FF          # End-of-sequence code
GOGOGO:   .EQU $01          # "Let's go" code
EEEKSTOP: .EQU $00          # "Let's stop" code
### End of Constant Declarations

### Start of Main Program Body
          .ORG $4000        # Start of program
### End of Main Program Body

### Start of Interrupt Service Routines
### End of Interrupt Service Routines

### Start of Subroutines
### End of Subroutines

### Start of Temp Locations and Data Values
GOFLAG:   .BYTE               # Flag (0=stop, 1=go)
TVALUE:   .BYTE               # Main timer temp value
TEMPSW:   .BYTE               # Copy of switches
TEMPX:    .2BYTE $0000        # Temp index register
### End of Temp Locations and End of Program
          .END
```

as we proceed (although their names should be somewhat suggestive of their function).

At the end of the program we reserve three 1-byte memory locations called **GOFLAG**, **TVALUE**, and **TEMPSW**, plus a 2-byte value called **TEMPX**. This 2-byte value is of particular interest in that we assign it an initial value of $0000. The way in which this initialization works is discussed in more detail in Chapter 12 of *Bebop BYTES Back* and also in Appendix D of *The Official Bebopuler Microprocessor Databook*.

INDIVIDUAL MOTOR CONTROL CONSTANTS

What! More constants? Well yes, we're afraid so, but these little rascals are going to make our lives one heck of a lot easier, let me tell you. For example, a binary value of 00001010 doesn't immediately convey a lot of information to the casual reader, whilst a constant label called **FORWARD** (which we can associate with the 00001010 value) gives us a pretty good clue as to what's going on.

From last month's article we know that output port bits OP1 and OP0 are used to control the PhizzyBot's left-hand motor, whilst bits OP3 and OP2 are used to control the right-hand motor (Table 1). (Remember that, in this context, the terms "left" and "right" refer to your perspective if you were to shrink yourself down and position yourself atop of the PhizzyBot looking towards its front end.)

Note that if the control bits associated with a motor are at both at 1, this will also cause that motor to stop, but we aren't particularly concerned with this. We only need one stop condition per motor, and we've chosen to use the case where both control bits are 0. Based on this, we need to add six more constant declarations to our program as shown in Listing 2a (append these to the bottom of the existing declarations).

COMBINED MOTOR CONTROL CONSTANTS

If we only account for one stop condition for each motor as discussed above, then each motor has three possible states it can be in. As we have two motors, this gives us a total of 3 × 3 = 9 different possibilities. Four of these cover the cases where both motors are active simultaneously (Fig.2).

The next four cases to consider are those in which only a single motor is active (Fig.3). In this case the PhizzyBot can turn left or right, and also reverse to the left or right.

The final case, of course, is where both motors are inactive (we won't bother illustrating). We can add these nine cases to our constant declarations as shown in Listing 2b.

The vertical bar character ("|") in the centre of the listing is used to indicate a logical OR operation. We haven't seen this sort of thing before, but in fact constant declarations can employ simple logical and arithmetic operations between numerical values and/or previously declared constant declarations.

For example, we previously assigned the labels **RREVERSE** and **LFORWARD** with values of 00000100 and 00000010, respectively. The logical operator in the constant declarations behaves in a similar manner to the PhizzyB's OR instruction (which was introduced in Part 2). Thus, our new **SPIN_CW** (spin clockwise) label will end up being assigned a value of 00000100 ORed with 00000010, which will be resolved as 00000110.

There are several points to note here. First, constant declarations are only used by the assembler to perform its machinations. These declarations don't affect the size of the final machine-code program, so there's no overhead involved in using them.

Obviously we could have simply used a **SPIN_CW .EQU %00000110** statement to assign a value to our **SPIN_CW** label directly (and similarly for our other labels). However, this would have obliged us to perform the OR operations manually, which would be a pain and prone to error. Given a choice, we always prefer to make the assembler do the bulk of the "grunt work", thereby leaving us free to do the conceptual thinking.

One very important point is that these new labels MUST appear AFTER our other labels, because an expression forming part of a constant declaration can only make use of constant labels that have already been declared. Otherwise, it would be possible to generate expressions in which label "A" was used to define label "B", which was in turn used to define label "A", which would result in no end of confusion. (This is discussed in more detail in Chapter 12 of *Bebop BYTES Back* and in Appendix D of *The Official Bebopuler Databook.*)

ACTION SEQUENCES

Now let's pause for a moment to ponder exactly what we want to be able to do. If the PhizzyBot wanders into something causing one of its microswitches to be activated, then we want to be able to cause the PhizzyBot to execute a specific sequence of

Table 1: The bits used to control the motors

Left Motor			Right Motor		
OP1	OP0	Label	OP3	OP2	Label
0	0	LSTOP	0	0	RSTOP
0	1	LREVERSE	0	1	RREVERSE
1	0	LFORWARD	1	0	RFORWARD
1	1	–	1	1	–

Listing 2a

```
LSTOP:     .EQU %00000000    # Left motor stop code
LREVERSE:  .EQU %00000001    # Left motor reverse code
LFORWARD:  .EQU %00000010    # Left motor forward code
RSTOP:     .EQU %00000000    # Right motor stop code
RREVERSE:  .EQU %00000100    # Right motor reverse code
RFORWARD:  .EQU %00001000    # Right motor forward code
```

Listing 2b

```
STOP:      .EQU LSTOP    | RSTOP    # All stop
FORWARD:   .EQU LFORWARD | RFORWARD # Go forward
REVERSE:   .EQU LREVERSE | RREVERSE # Reverse
SPIN_CW:   .EQU LFORWARD | RREVERSE # Spin clockwise
SPIN_ACW:  .EQU LREVERSE | RFORWARD # Spin anticlockwise
TURN_L:    .EQU LSTOP    | RFORWARD # Turn left
TURN_R:    .EQU LFORWARD | RSTOP    # Turn right
BACK_L:    .EQU LSTOP    | RREVERSE # Reverse left
BACK_R:    .EQU LREVERSE | RSTOP    # Reverse right
```

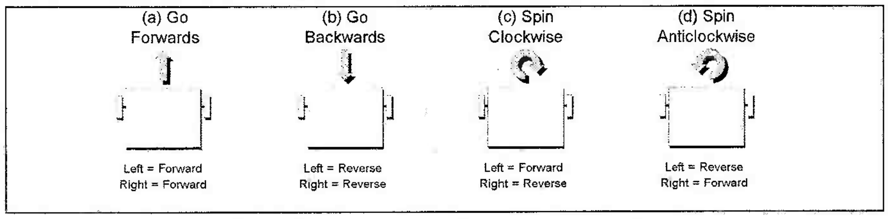


Fig.2: Cases where both motors are active

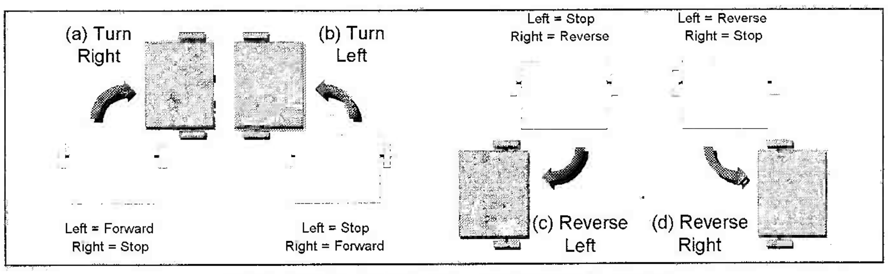


Fig.3: Cases where only one motor is active

Listing 3

```
ACTSW0: .BYTE STOP,      5 # Stop for 5/10 sec
        .BYTE REVERSE, 10 # Reverse for 1 sec
        .BYTE SPIN_ACW, 7 # Spin ACW for 7/10
        .BYTE FORWARD, FOREVER
ACTSW1: .BYTE NOMORE      # No actions
ACTSW2: .BYTE NOMORE      # No actions
ACTSW3: .BYTE NOMORE      # No actions
ACTSW4: .BYTE NOMORE      # No actions
ACTSW5: .BYTE STOP,      5 # Stop for 5/10 sec
        .BYTE REVERSE, 10 # Reverse for 1 sec
        .BYTE SPIN_CW,   7 # Spin CW for 7/10
        .BYTE FORWARD, FOREVER
ASTART: .BYTE FORWARD, FOREVER
```

actions (for example, "Stop, reverse, turn right, go forward again . . .").

In order to do this we require a method by which we can specify such a sequence of actions in our PhizzyBot control program. Furthermore, remembering that there could well be a different sequence associated with each microswitch, we want this method to be easy to read and modify, thereby facilitating our ability to experiment with different sequences.

The absolute worst case would be for us to have to specify such a sequence as a collection of binary values. For example: 00000000 (stop), 00000101 (wait for 0·5 seconds), 00000101 (reverse), 00001010 (for 1·0 second), 00001001 (spin anticlockwise), 00000111 (for 0·7 seconds), 00001010 (go forward), and so forth.

Note that, as per our discussions from last month, we're assuming that the delays are specified in tenths of a second. For example, 00000101 = 5, which means 5 times 0·1 seconds = 0·5 seconds.)

At the other end of the spectrum, it would be great to be able to actually specify a command sequence as a string of characters in natural language format, such as "Stop and pause for 0·5 seconds, then reverse for one second, then spin anticlockwise for 0·7 seconds, then start to go forward again".

Unfortunately, natural languages contain ambiguities and logical inadequacies, so we'll need to use something a little more formalized. However, we might be able to get quite close to our ideal case with relatively little effort.

Consider the statements shown in Listing 3 (and while you're considering them, insert them into your program just after the temporary locations at the bottom of the program).

The syntax we've decided to use is to commence each sequence of actions with a label. For example, the label **ACTSW0** stands for "The actions associated with Switch 0". This label is then followed by a series of bytes, which are organized as pairs consisting of an action followed by a delay (specified in tenths of a second). The assembler will of course replace the action code labels like **STOP**, **REVERSE**, and **SPIN_ACW** with their binary equivalents 00000000, 00000101, 00001001, respectively.

As we will soon discover, we're going to organize the main body of the program such that an action code of 11111111 causes the PhizzyBot to stop and wait for another interrupt to occur (for example, a pet to bump into one of the switches).

Furthermore, we're going to write the program such that specifying a delay of 0 actually means "do this action forever" (or at least until the PhizzyBot bumps into something causing a new interrupt to occur). This explains the two constant labels **NOMORE** and **FOREVER**, which we declared in our skeleton program, and which we see appearing in Listing 3.

Note the ASTART label at the end of the action sequences. We're going to use this to define what the PhizzyBot will do when the program first starts running. As you can see, our example program simply instructs the PhizzyBot to start rolling forward, and to keep on doing so until it bumps into something.

However, once you've got this first version of the program working, you could easily modify this sequence to do something more interesting, such as spinning round three times before heading off into the great unknown.

Also note that we've only assigned actions to the two switches on the front of the PhizzyBot (Switch 0 and Switch 5). This assumes that the PhizzyBot will roll forward until it bumps into something, at which point it will reverse, spin one way or the other, and start going forward again. If any of the other switches are triggered, the PhizzyBot will stop dead in its tracks ... unless you assign your own action sequences to these switches of course ...

A CUNNING PLOY

One thing we're going to need to know is the start address of each of the action sequences we just created above. But these start addresses are fairly fluid. For example, if we insert additional actions into the **ACTSW0** sequence (or delete some actions), then this will change the start addresses of all of the other action sequences.

What's needed is a cunning ploy, and we are nothing if not masters of the cunning ploy! To illustrate what we mean, peruse the statements in Listing 4 (while you're adding them to the program just after the action sequences).

DON'T PANIC if this doesn't appear immediately obvious on a first viewing. Consider label **ADRSW0**, which is used to reserve a 2-byte value in the PhizzyB's memory. As we discussed earlier (in the context of the **TEMPX** label), it is possible to instruct the assembler to initialize the contents of memory locations reserved in this way. In this case, we're assigning the label **ACTSW0** to our 2-byte value. Our cunning ploy is that the assembler will automatically replace this assignment with the actual address of **ACTSW0**.

The end result is that we know that the 2-byte value we've called **ADRSW0** will contain the start address of action sequence **ACTSW0**. Similarly, the 2-byte value we've called **ADRSW1** will contain the start address of action sequence **ACTSW1**, and so forth.

Listing 4

```
ADRSW0:  .2BYTE ACTSW0 # Address of SW0 actions
ADRSW1:  .2BYTE ACTSW1 # Address of SW1 actions
ADRSW2:  .2BYTE ACTSW2 # Address of SW2 actions
ADRSW3:  .2BYTE ACTSW3 # Address of SW3 actions
ADRSW4:  .2BYTE ACTSW4 # Address of SW4 actions
ADRSW5:  .2BYTE ACTSW5 # Address of SW5 actions
ADRSTR:  .2BYTE ASTART # Address of initial acts
```

Listing 5

```
#== Start of "Main Timer" Routine
TIMER:     STA   [TVALUE]     # Store original count
TLOOPA:    JSR   [ONETENTH]   # Call 1/10 Sec loop
           LDA   [GOFLAG]     # Load flag
           JZ    [TRETURN]    # Jump if flag=0
           LDA   [TVALUE]     # Load count value
           DECA               # Decrement it
           STA   [TVALUE]     # Store it
           STA   [TGRAPH]     # Store it to LEDs
           JNZ   [TLOOPA]     # Loop again if !=0
TRETURN:   RTS                # Exit subroutine
#== End of "Main Timer" Routine

#== Start of "1/10 Second" Routine
ONETENTH:  LDA    DELCONST    # Load count value
OTLOOPA:   DECA               # Decrement it
           JNZ   [OTLOOPA]    # Loop again if !=0
OTRETURN:  RTS                # Exit subroutine
#== End of "1/10 Second" Routine
```

The clever bit is that whenever we modify anything, the values associated with all of the labels will automatically be updated when we re-assemble the program.

DELAY SUBROUTINES

OK, we're almost ready to create the main body of our program, but before we do we need to create a couple of utility routines. First we need to add the timer routines shown in Listing 5 (add these just after the "start of subroutines" comment in the skeleton program).

These two routines are almost identical to the ones we developed last month, so we won't spend too much time on them here. Suffice it to say that we can load the accumulator with the required delay (specified in tenths of a second) and then call the **TIMER** routine. In turn, this routine will repeatedly call the **ONETENTH** routine, which is designed to take one tenth of a second to execute.

Every time it goes around the loop, the **TIMER** routine will display the current count on the 8-bit l.e.d. display connected to the output port at address $F031. This routine will terminate when it has "timed-out" or if it discovers that the contents of the **GOFLAG** location have been set to zero. As we discussed last month, the contents of **GOFLAG** are modified by an interrupt service routine as shown in the next section.

INTERRUPT ROUTINE

Now we need to add the **GETSW** interrupt service routine shown in Listing 6 (add this just after the "start of interrupt service routines" comment in the skeleton program).

As we will see in the main body of the program, this routine is called when one of the PhizzyB's microswitches is triggered. The first thing this routine does is to use a **PUSHA** (push accumulator) instruction to copy whatever is currently in the accumulator onto the stack.

Next we load the value from the input port connected to the microswitches. As we know from Parts 4 and 5, the way this input device is constructed means that a closed (activated) switch returns a logic 0, while all of the other switches return logic 1s. However, we'd prefer this to be the other way around, so we use an **XOR $FF** statement to invert all of the bits in the accumulator (swap the 0s for 1s and vice versa), then we store this value into our **TEMPSW** location (which stands for "temporary switch").

As soon as we've safely squirreled the value from the switches away, we load the accumulator with the **EEEKSTOP** code (which we previously assigned a value of zero) and store this into our **GOFLAG** location (this will be used to terminate the **TIMER** subroutine).

Last but not least, we use a **POPA** (pop accumulator) instruction to retrieve our original accumulator value from the stack, then we return to wherever we were in the program when this interrupt service routine was called.

THIS ISN'T COMPLICATED!

Take a deep breath, count to ten slowly, and breath out. This really isn't as complicated as you might think. Although we seem to have covered a lot of ground, our program thus far is really rather simple. In fact all it actually contains at this stage is two timer subroutines (14 instructions) and one interrupt service routine (eight instructions). The rest of the program consists of constant declarations (a lot of labels) and the action sequences (lists of labels). All we have to do now is to create the main program.

Listing 6

```
#== Start of "Get Switch" Routine
GETSW:      PUSHA                  # Copy ACC to stack
            LDA    [SWITCHES]      # Read value on switches
            XOR    $FF             # Invert 0s to 1s etc.
            STA    [TEMPSW]        # Store to temp location
            LDA    EEEKSTOP        # Load ACC with stopcode
            STA    [GOFLAG]        # Set flag to stop
            POPA                   # Copy ACC from stack
            RTI                    # Exit routine
#== End of "Get Switch" Routine
```

MAIN PROGRAM BODY

The main program body is shown in listing 7 (enter this just after the "start of main program body" comment in your skeleton program). As we'll see, this is where all of the really cunning stuff takes place.

The easiest way to understand what's happening is to "walk through" the code one instruction at a time. First we use a **BLDSP** to load the stack pointer with an address of $4FFF, then we use a **BLDIV** to load the interrupt vector with the start address of our **GETSW** interrupt service routine (remember that the assembler will automatically substitute the **GETSW** label with its corresponding address in the PhizzyB's memory).

Listing 7

```
            .ORG   $4000           # Set program origin
            BLDSP  $4FFF           # Load stack pointer
            BLDIV  GETSW           # Load interrupt vector
            SETIM                  # Enable interrupts
            LDA    %01000000       # Load ACC with dummy switch
            STA    [TEMPSW]        # Store to temp location
#== Work out which microswitch was activated
GETSEQ:     BLDX   $0000           # Load index register = 0
            LDA    [TEMPSW]        # Retrieve value on switches
GSLOOP:     RORC                   # Rotate right 1 bit
            JC     [GSCONT]        # Jump if carry flag = 1
            INCX                   # Else increment X reg
            JMP    [GSLOOP]        # Jump back and repeat
#== Get start address of appropriate action sequence
GSCONT:     BSTX   [TEMPX]         # Store index register
            LDA    [TEMPX+1]       # Load LS temp index A
            SHL                    # Shift left (x2)
            STA    [TEMPX+1]       # Store it again
GETACT:     BLDX   [TEMPX]         # Load X reg with addr of addr
            LDA    [ADRSW0,X]      # Load MS addr of 1st action
            STA    [TEMPX]         # Store it to MS of temp X
            LDA    [ADRSW0+1,X]    # Load LS addr of 1st action
            STA    [TEMPX+1]       # Store it to LS of temp X
            BLDX   [TEMPX]         # Load X reg with addr of data
GOOD2GO:    LDA    GOGOGO          # Load ACC with go code
            STA    [GOFLAG]        # Store it to Flag
#== Get the next action in the sequence
NEXTACT:    LDA    [0,X]           # Get next action
            JN     [ALLSTOP]       # If N=1 then stop
            STA    [MGRAPH]        # Store action to LEDS
            STA    [MCONTROL]      # Store to motor controller
            INCX                   # Increment index register
            LDA    [0,X]           # Get delay value
            JZ     [JUSTDOIT]      # If 0 then do it forever
            INCX                   # Increment index register
            JSR    [TIMER]         # Call timer subroutine
            LDA    [GOFLAG]        # Load go flag
            JNZ    [NEXTACT]       # If !=0 get next action
            JMP    [GETSEQ]        # ... else get new sequence
ALLSTOP:    LDA    STOP            # Load ACC with stop code
            STA    [MGRAPH]        # Store action to LEDS
            STA    [MCONTROL]      # Store to motor controller
JUSTDOIT:   HALT                   # Wait for an interrupt
            JMP    [GETSEQ]        # Get new sequence
```

We want the PhizzyBot to start off by performing whatever action sequence it finds at the **ASTART** label, but we really don't want to do a lot of work creating any special "start up" code. To get around this we use a trick, which is based on the fact that we know the PhizzyBot only has six microswitches (numbered 0 to 5). What we do is to load the accumulator with a binary value of 01000000, which corresponds to a seventh, dummy microswitch, and then store this value away into our **TEMPSW** location. (Remember that **TEMPSW** is where our **GETSW** interrupt service routine stores the value from the input switch device.)

WHICH SWITCH?

Now we arrive at the **GETSEQ** label (short for "get sequence"), which is where the main program loop really starts. In the future this will be the point in the program where we'll end up after a microswitch has just been activated. Thus, as far as the program is concerned, it needs to work out which switch was triggered and it has no clue that we've pre-loaded the **TEMPSW** location with a dummy value.

The first instruction at **GETSEQ** is a **BLDX**, which is used to load the index register v 'th zero. Next we load the accumulator with the contents of **TEMPSW**, which our program assumes is the value from the input switch device. Now we enter a subloop, in which we use a **RORC** (rotate right through carry) to rotate the contents of the accumulator one bit to the right, thereby causing the least-significant (LS) bit to "fall off the end" into the carry flag.

The JC (jump if carry) instruction is used to test the contents of the carry flag. If this flag contains 1 we've found the microswitch that was activated and we jump to label **GSCONT**, otherwise we use an **INCX** to increment the index register and then jump back to the **GSLOOP** label.

The end result of this loop is that by the time we reach the **GSCONT** label, the index register contains a number corresponding to the decimal value of the microswitch that was activated (Table 2).

The first thing we do at **GSCONT** is to use a **BSTX** instruction to store the contents of the index register into our 2-byte temporary location **TEMPX**. In a moment we're going to use this value to point to one of our **ADRSW0**, **ADRSW1**, **ADRSW2** . . . labels.

The problem is that each of these fields occupies two bytes, so we really want to multiply whatever value is in **TEMPX** by two. In order to do this we load the accumulator with the least-significant byte of this value, shift it one bit to the left, and store it away again. (The fact that shifting a binary value one bit left is equivalent to multiplying it by two was discussed in the bonus article accompanying Part 3 of this series.)

WHAT ADDRESS?

So we now find ourselves at the **GETACT** label, at which point we use a **BLDX** to reload the index register with the new value in **TEMPX**. Remember that we originally loaded the **TEMPSW** location with a binary value of 01000000. From Table 2 we know that this will have been converted into a value of $0006 in the index register (6 in decimal), and we've just multiplied this by 2, so the index register now contains $000C (12 in decimal).

Table 2. Evaluating the number of the triggered switch.

Switch	Switch value	Index register
0	00000001	$0000 (0)
1	00000010	$0001 (1)
2	00000100	$0002 (2)
3	00001000	$0003 (3)
4	00010000	$0004 (4)
5	00100000	$0005 (5)
Dummy	01000000	$0006 (6)

Now consider the **LDA [ADRSW0,X]** statement, which loads the accumulator using the indexed addressing mode. What this means is that the contents of the index register ($000C in this case) are added to the address of the **ADRSW0** label, and the accumulator is loaded with the contents of the memory location at the resulting address.

By some strange quirk of fate, this resulting address is that of the **ADRSTR** label, which itself contains the start address of the **ASTART** action sequence . . . Phew!

So the accumulator now contains the most-significant (MS) byte of the address of the **ASTART** action sequence, which we immediately store in the MS byte of the 2-byte temporary value **TEMPX**. Now we use a second indexed-mode **LDA** to load the accumulator with the LS byte of the address of the **ASTART** action sequence, and store this to the LS byte of **TEMPX**.

Next we use a **BLDX** instruction to load the value in **TEMPX** into the index register. We know that this is a little convoluted, but the end result is that the index register ends up containing the address of the **ASTART** label, which is the first byte in our startup action sequence.

A TAP-DANCING FOOL

Let's quickly summarize what we've done to make sure that we're all still tap-dancing to the same drumbeat. First of all we arranged for the index register to contain a value corresponding to whichever switch was loaded (0 = switch 0, 1 = switch 1, and so forth).

We then saved this value to **TEMPX**, multiplied it by two, and reloaded it into the index register. Next we used the contents of the index register to provide an offset from the base address of the **ADRSW0** label (in the case of our dummy switch, this offset allowed us to locate the address of the **ADRSTR** label). We next loaded the two bytes at **ADRSTR** into **TEMPX** and then loaded this value back into the index register, which leaves the index register containing the address of the **ASTART** action sequence.

PERFORM THE ACTIONS

So now we're at the **GOOD2GO** label, at which point we load the accumulator with the **GOGOGO** code, save it to the **GOFLAG** location, and proceed to the **NEXTACT** label to start executing the action sequence.

The first thing we do at **NEXTACT** is to load the accumulator with the first action in the sequence. Once again we're using the indexed addressing mode. However, this time we know that the index register contains the full address of the first action, so we use an **LDA [0,X]** instruction, which will add the contents of the index register to 0 to give us the target address.

The **JN** (jump if negative) instruction tests to see if the most significant bit of this action is 1 (corresponding to a **NOMORE** code). In this case we would jump to the **ALLSTOP** label and stop the motors. Otherwise we store this action to the l.e.d. bargraph display at address $F030 and also to the motor controller.

Now we use an **INCX** to increment the contents of the index register, then we load the accumulator with the delay value associated with this action. The **JZ** (jump if zero) instruction is used to test if the delay value is zero (corresponding to a **FOREVER** code).

In this case we would jump to the **JUSTDOIT** label, which contains a **HALT** instruction. This means that the PhizzyBot will continue to perform this last action until the universe ends or until a microswitch is activated thereby triggering an interrupt (whichever comes first).

Alternatively, if the delay value is non-zero, we use an **INCX** to increment the index register to point to the next action, then we call our timer subroutine to wait for the required delay. When we return from the timer subroutine we check the status of the **GOFLAG**.

A non-zero value means that we're still in **GOGOGO** mode, in which case we jump back to **NEXTACT** to get the next action. Otherwise we know that an interrupt must have occurred, in which case we jump to **GETSEQ** to find out which switch was activated and do the whole thing all over again.

LET'S GO!

OK, let's be honest and admit that the main body of this program is non-trivial, and it requires a bit of "lateral thinking" to wrap our brains around its cunning machinations. But if you read through it a few times you should be able to see what's happening. Also, don't forget that all of the instructions and addressing modes are discussed in excruciating detail in Appendix A of *The Official Beboputer Microprocessor Databook*.

Once you've entered the entire program, assemble it to generate the corresponding **eeexp1.ram** file. Before we load this program into the PhizzyBot, it's worth taking the time to test it on the PhizzyB Simulator. Power up the simulator and use the **Memory – > Load** RAM command to load **eeexp1.ram** file into its memory.

Click the simulator's Run button and note that both the onboard l.e.d. bargraph display at address $F030 and the external output device at address $F032 (corresponding to the motor controller device) show values of 00001010, which equates to both motors driving forward (this is what we specified in our **ASTART** sequence).

Now enter a value of 11111110 into the binary field of the input device at address $F011 and click the Set button to present this value to the input port (this value corresponds to microswitch 0 being activated). Next click the simulator's **IRQ** (interrupt request) button, and observe the resulting **ACTSW0** sequence being executed (note especially the output device at address

$F031 reflecting the current value in the timer subroutine).

When you're ready, use the PBLink utility to download the program to the PhizzyBot and set it running. The Bot should start rolling forwards until one of its front microswitches hits something, at which point it should perform the appropriate action sequence (stop, reverse, spin) and start rolling forwards again.

FINE TUNING

As fate would have it, the delays in our action sequences were arrived at in a fairly arbitrary manner. This is because your PhizzyBot may have different sized wheels and be geared different to ours. Thus, you are going to have to modify the delays associated with the action sequences to ensure that your PhizzyBot does what you want. For example, if you want the Bot to spin 90 degrees, you are going to have to fine-tune the delay associated with the spin action until your PhizzyBot performs as required.

Also, don't forget that you can modify the start-up sequence to do something more interesting, like spinning around three times before heading off into the great unknown.

Finally, remember that we only specified useful action sequences for microswitches 0 and 5. If any of the other switches are triggered, their action sequences cause the PhizzyBot to stop and wait for you to do something. Of course there's nothing to stop you from modifying these action sequences to do something more interesting. . . .

NEXT MONTH

Next month we'll show you a trick that will allow you to replace delay values with units like inches and degrees. This will allow us to specify action sequences along the lines of "Go forward for 10 inches and then spin clockwise for 45 degrees. . . ."

And, we'll be adding a light sensor to the PhizzyBot, to let us tailor its behaviour to be that of a "RoachBot" (avoids the light) or a "MothBot" (loves the light).

PhizzyB SMORGASBORD – Useful Tools

DON'T forget that the PhizzyB Simulator comes equipped with a smorgasbord of tools, which can be incredibly useful when you are debugging a program or simply trying to understand exactly what your code is doing.

First of all, when you assemble a program you can use the assembler's **Window –> View Listing File** command to show the contents of the list file, which you can subsequently print out.

The list file contains your original source code alongside the resulting machine code (including the addresses of the memory locations containing each byte of machine code). The list file is invaluable when used in conjunction with the other tools referenced below.

CPU REGISTER DISPLAY

Use the simulator's **Display – > CPU Registers** command to invoke the CPU Register display (Fig.A).

This display shows the current contents of the PhizzyB's internal registers whilst you are stepping through a program one instruction at a time. (Note that the contents of the status register are displayed as five individual I, O, N, Z, and C flags.)

MEMORY WALKER DISPLAY

Use the **Display – > Memory Walker** command to invoke the simulator's "Memory Walker" display (Fig.B).

The Memory Walker display can be used to examine (and edit!) the contents of the PhizzyB's memory locations. Amongst other things, the toolbar icons at the top of this display allow you to quickly bounce around between the RAM, ROM, and input/output ports.

Whilst stepping through a program, two chevron characters appear in the "Step" column to indicate the address you are currently at. (Note that the address of the

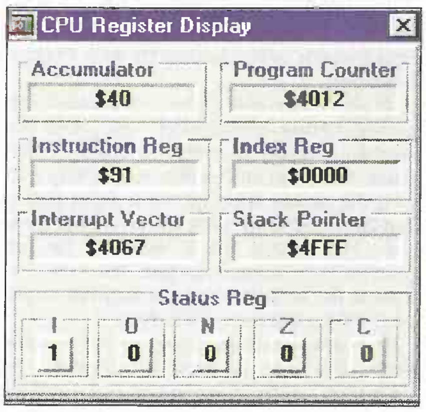


Fig. A. The CPU Register display

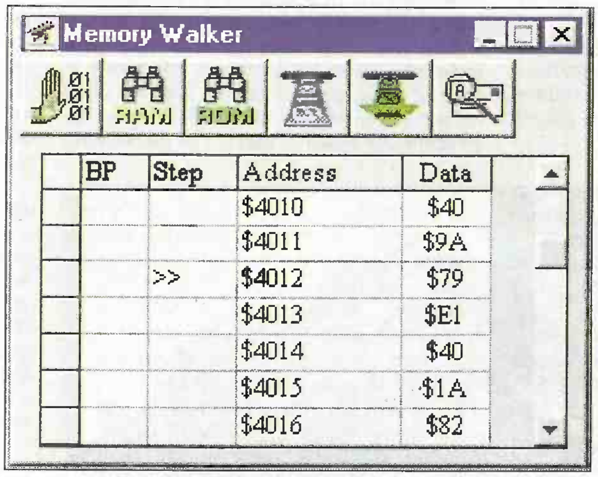


Fig.B. The Memory Walker display

chevrons in Fig.B. reflects the value of the Program Counter shown in Fig.A.)

More importantly, you can use the breakpoint toolbar icon (the one with the hand) to specify one or more "breakpoints", which will appear in the BP column. When you click the simulator's Run button, it will race through the program until it reaches the next breakpoint, at which time it will automatically return the simulator into its Step mode. This allows you to quickly and easily run through uninteresting portions of a program (such as a timing loop) so as to focus on specific areas of interest.

MESSAGING SUBSYSTEM

Use the simulator's **Display – > Message System** command to invoke the simulator's messaging subsystem.

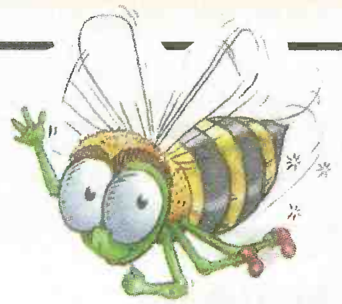
If this display is active, then whenever you click the simulator's Step button to step through an instruction, the messaging subsystem will display all of the micro-actions comprising that instruction. The left-most text describes the main actions (Get Opcode, Decode Opcode, Execute Opcode, and so forth).

Messages indented one level to the right indicate sub-actions, such as incrementing the contents of the program counter. Finally, messages indented two levels to the right offer additional comments and explanations.

ALL FOR ONE AND ONE FOR ALL

Each of the tools described here can be used in isolation, but they are most effective when used in conjunction with each other. For example, you can use the Memory Walker to set a breakpoint and run to it. Then you can use both the Memory Walker to examine the contents of the PhizzyB's memory and the CPU Register display to examine the PhizzyB's registers as you step through the program. And when you reach an area where you need yet more information about what's going on, you can activate the messaging subsystem.

The authors use all three of these tools regularly, as will you once you come to appreciate just how useful they can be. Note that all three of these displays are documented in the simulator's online help. Also note that the Memory Walker and CPU register displays (and the use of the list file) are discussed in the *PhizzyB User Manual Volume 1*.



PhizzyB COMPUTERS

Construction – PhizzyBot Feelers

Alan Winstanley

Wheelie feelies give PhizzyBot a sense of touch (and a sense of humour?)

In last month's article we introduced the concept of the PhizzyBot, which is a very simple motorised platform that transforms a PhizzyB into a simple buggy. This month we show how easy it is to add a series of detector "feelers" to the PhizzyBot platform, plus the interrupt-driven switch module of Feb '99. This means that, along with a suitable program (described in the tutorial feature), the PhizzyBot is now empowered with movement, obstacle avoidance and collision detection routines.

GETTING SWITCHED ON

This penultimate constructional article describes the addition of six microswitches to the PhizzyBot motorised platform. The switches are used as simple mechanical collision detectors. As explained in the tutorial, it is possible to use up to eight microswitches and alter the program accordingly, but the authors felt that six were enough, and besides, it was raining at the time and they didn't fancy a trip to their parts store!

The PhizzyBot hardware consists of two d.c. gearmotors and a simple relay driver board that controls the direction of each motor. By driving, reversing or stopping either motor, the PhizzyBot can be made to advance, reverse, turn or spin in either direction.

However, since there is no "feedback" in the system at this stage, your average fearless PhizzyBot will travel blindly until it collides with something, after which it will be forced to a standstill.

The system to be described now is intended to demonstrate further principles of computer control, in this instance using microswitches as limit detectors in conjunction with a computer program that forces a suitable response from the motors when a collision is sensed.

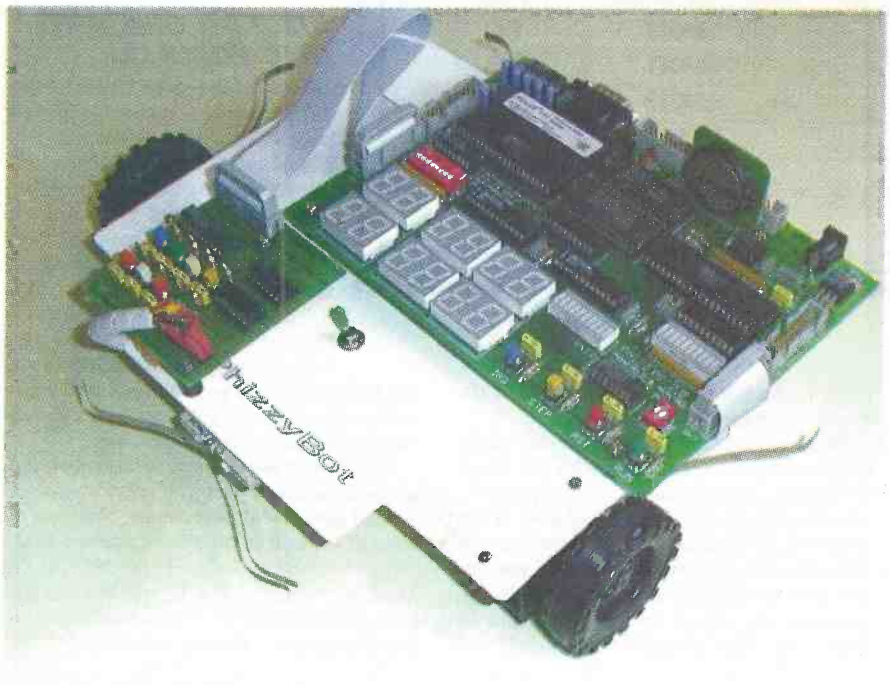
The simplest way of incorporating collision detection is simply to add an array of microswitches around the periphery of the chassis. These are hooked to an interface board which connects directly to a PhizzyB input port.

If the PhizzyBot strikes an obstacle, the corresponding microswitch will close and send an interrupt signal to the PhizzyB computer. The program can then respond by stopping the motors (perhaps for a timed period) and then reverse or move off in another direction. The tutorial article describes the programming technique in full, but now let's look at the hardware aspects required to give your PhizzyBot some "whiskers"!

It is the interrupt-driven switch module (Feb '99) that is used to interface the "whiskers" to the PhizzyB computer, and this will be connected to input port $F012 by a ribbon cable. The output port $F032 is used to control the d.c. gearmotors via a simple driver board, as described last month.

You will recall that the interrupt board includes a 16-pin header which, effectively, is a set of solder pins in parallel with the eight keypad push-switches S0 to S7. The microswitches are added in parallel to the existing keypad using the 16-pin header, to which their connections are soldered.

The prototype system used microswitches which had 2·5in (60mm) steel levers that could easily be bent to shape as required. Because they have a very low mass, it proved quite simple to stick the switches around the edge of the PhizzyBot platform merely by using double-sided adhesive foam pads. The steel levers were then bent outwards so that they would protrude and act as "antennae".



ASSEMBLY DETAILS

Construction is very easy but there are one or two mechanical points to bear in mind. Assuming that you have built the PhizzyBot platform successfully last month, the interrupt-driven board should now be located on the platform where it can "reach" input port $F012 using a 20-way ribbon cable folded as required.

Unless you decide to make up a new IDC lead, the length of any made-up cable which you have available will determine where the interrupt-driven board can be fitted, so check this carefully. Then fix the input board to the platform using p.c.b. stand-off hardware (see photos).

Take care not to damage the wiring on the underside of the expansion board – over time the author sprayed several generous coats of aerosol lacquer onto it in order to help secure it and protect the wiring from harm. The switchboard was mounted at the front of the PhizzyBot in the prototype by using 10mm threaded pillars with M3 panhead screws.

The next stage is to solder a pair of leads to each of the six microswitches. The two rear switches (numbered 2 and 3) will require a connecting lead up to 12in (300mm) long, the wires for the remaining switches should be of corresponding length. It is far better to use six different coloured wires in order to colour-code the microswitches, which will help with the interwiring enormously. Be quite generous with the lengths of wire at this stage and don't be afraid to waste a little.

An example of a typical microswitch is

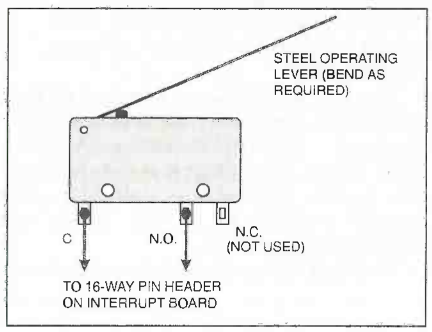


Fig.1. A typical microswitch.

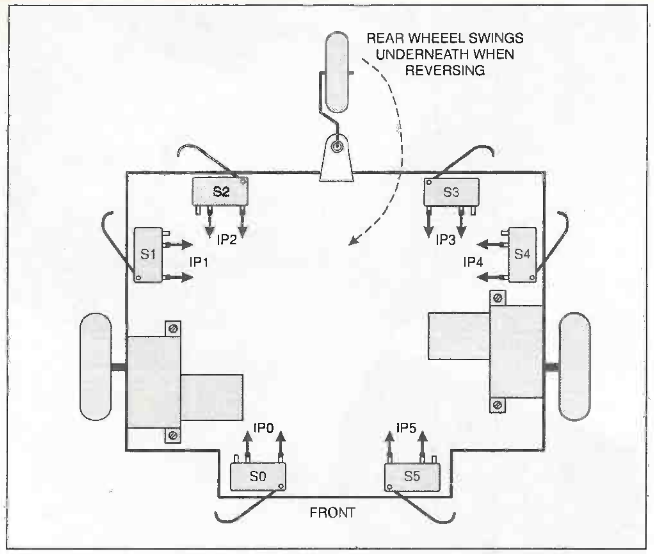
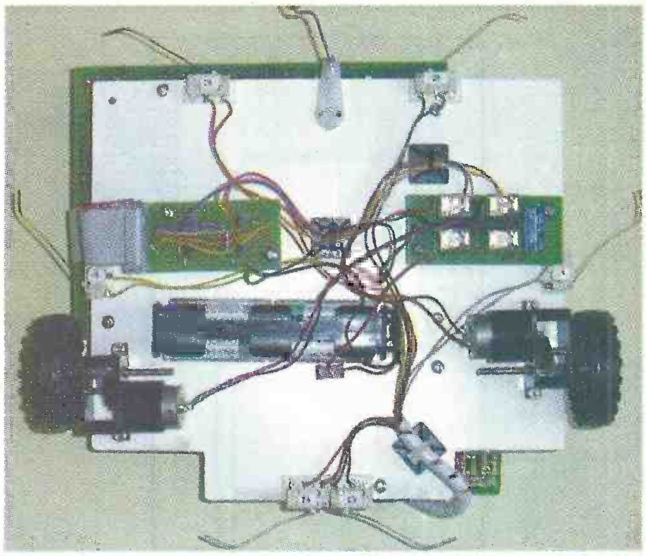


Fig.2. Layout and orientation of the six microswitches on the underside of the PhizzyB platform.



Rear view of the platform showing microswitches positioned in relation to other components.

illustrated in Fig.1. They have three terminals, usually marked "n.o." (normally open), "n.c." (normally closed) and "C" (common).

You may need an ohmmeter or continuity buzzer to determine which terminal is which, we are interested in the common and normally-open terminals (which will therefore close together when the PhizzyBot hits an obstacle). Check the types used in your particular case, then solder suitable lengths of general-purpose hook-up wire to them, and then proceed to stick them around the edge of the platform.

No circuit diagram was considered necessary this month, so Fig.2 shows how the switches were organised on the prototype, noting that the hinges of the levers were positioned as depicted in the diagram.

In fact the switches were located where it was thought they would best act as "feelers", enabling the PhizzyBot to detect an obstruction at the front or rear. Since the prototype's wheels protrude from the sides, the levers of these microswitches (numbered 1 and 4) were bent outwards so that they would be tripped by "passing" objects. The feelers were also curved to help prevent them snagging on any obstructions (though this didn't always quite work).

It should be pointed out that the design also relies on the fact that the rear wheel (of the model aircraft type specified in the PhizzyBot's constructional details) will swing back underneath the PhizzyBot as soon as the platform reverses, which means that the rear wheel is then tucked neatly out of the way. This leaves the rear switches S2 and S3 clear to detect collisions when the PhizzyBot reverses.

Be prepared for some trial and error, and you might also consider adding "feeler" wires to the microswitches to extend the levers even further, noting that the object is simply to demonstrate the principles and there is plenty of scope for you to improvise and experiment.

At this stage it is worth double-checking before proceeding any further, to ensure that each pair of wires does short together when the corresponding microswitch is closed: use your ohmmeter to confirm this.

ONWARDS

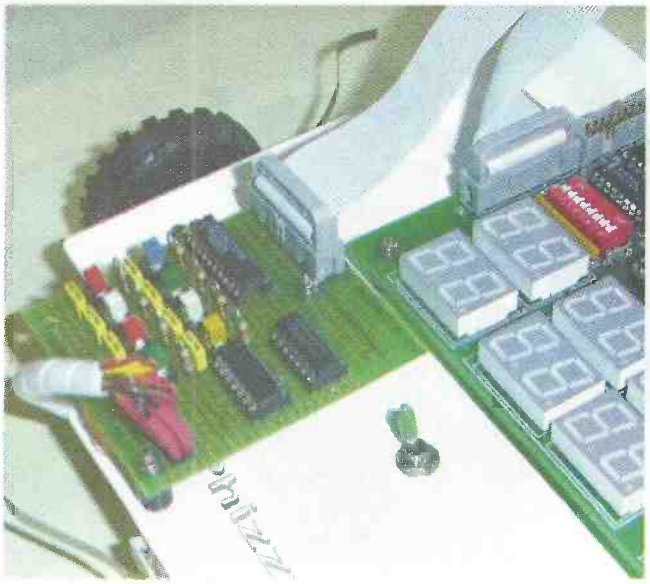
The six pairs of microswitch wires can now be soldered to the 16-way pin header. Each switch should be hooked to the corresponding pins (see Fig.4 of February's constructional article for further details), so switch S0 should be wired to IP0, S1 to IP1 and so forth (and you will now see why colour coding the wiring is a good idea!).

Since the pins on the header are quite tightly packed, then rather than wrap the wires around them, it was found best to employ a "re-flow" soldering technique – each pin should be generously tinned with the soldering iron, and the bared end of the hook-up wire should be tinned as well. Then simply touch the hook-up wire to the pin and melt the solder together to form a joint.

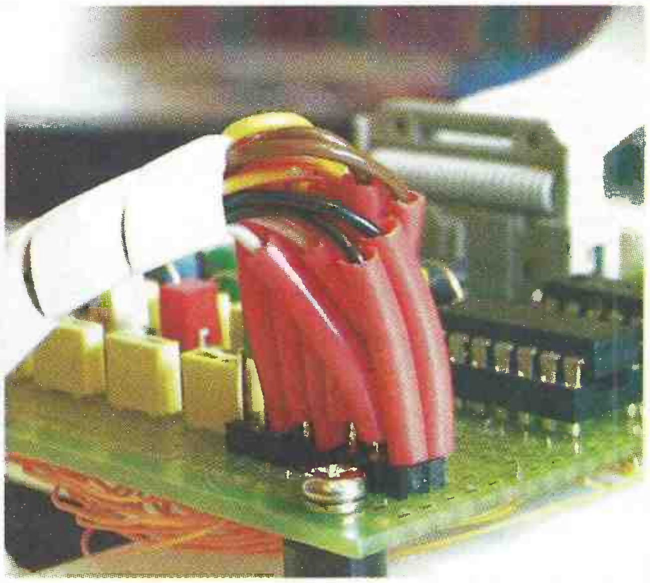
It is also an extremely good idea to use short lengths of PVC sleeving to eliminate the possibility of short circuits: a 1in (25mm) length should be placed over the wire before soldering the joint and slid back over the solder when all joints are complete. The result will be a loom of 12 wires, which on the prototype were contained in an offcut of poly spiral wrapping.

Adhesive tie-wrap bases help to route the wiring on the underside of the PhizzyBot platform. This should be routed to avoid impeding the movement of any microswitch levers. With all the interwiring complete, connect the interrupt-driven board to the PhizzyB using an IDC lead.

The prototype PhizzyBot was entirely self-propelled by using a 9V Nickel-Cadmium battery to power the PhizzyB at the d.c. inlet socket (see photos), giving 20 to 30 minutes of operation (the twelve 7-segment displays when illuminated form a major drain on the battery!).



Interrupt-driven module connected to the PhizzyB input port.



Microswitch leads connected to the interface board.

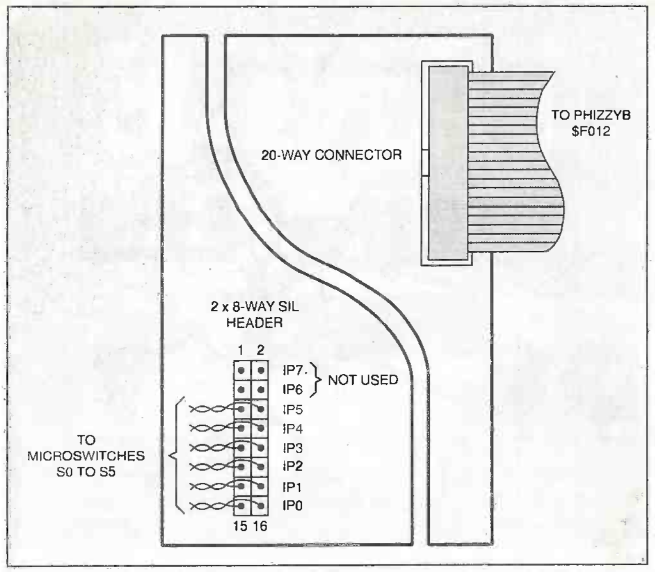
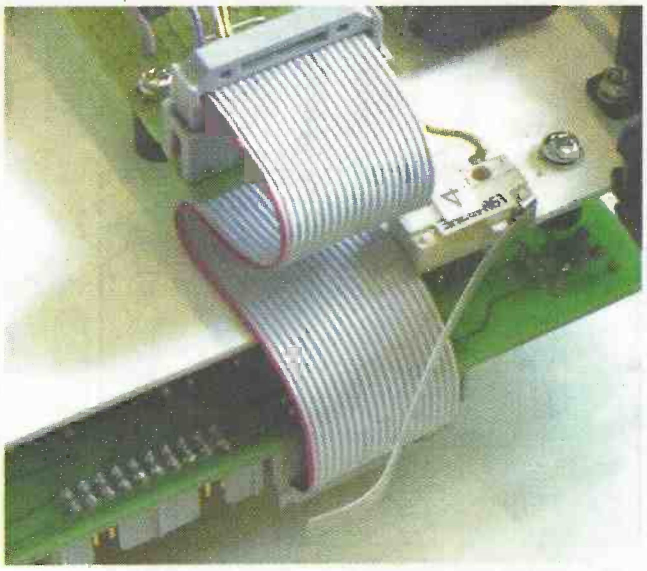


Fig.3. Interconnections to the interrupt driven switch module.



The ribbon cable for the motor controller needs folding to prevent it interfering with the microswitch.

You may prefer simply to test the design using the mains adaptor, but the PhizzyBot is quite a hyperactive little fellow and when scampering around the floor it will do a passable impression of a double reef knot in the power supply cable in no time at all! (Fortunately at times like this the on-board memory back-up battery will prevent loss of the program when the main power is temporarily interrupted.)

BEFORE SWITCHING ON

Ensure that the d.c. motor controller and interrupt boards are both hooked up to the main PhizzyB with ribbon cables, and switch the d.c. motor supply off (to save your ears from the noise as much as anything!).

Then download the main PhizzyBot program from your PhizzyB Simulator and press the Run key. Various segments in the l.e.d. bargraph on $F030 will illuminate to reflect the state of the motor controller and by clicking various microswitches this will cause the bargraph display to update, which corresponds to a change in direction of the PhizzyBot platform.

A blank bargraph indicates that the PhizzyBot is stationary at that time but, because of some built-in time delay routines, the PhizzyBot may erupt into life without warning several seconds later. It is worth waiting to see what happens! (Don't worry, it's all part of Max's sense of humour.)

The final stage is a road test – so clear the decks, switch on the separate on-board motor supply and prepare to be dazzled! The PhizzyBot will gladly gallivant around on the floor and upon bumping into an obstruction it will behave in a number of ways, sometimes seeming to stop and think about it before zooming off in another direction or spinning around at quite a dizzying speed!

As explained in the main article, it may be necessary for you to adjust the timing of the delays in the action sequences to meet individual preferences.

The system should operate quite reliably and if the interrupt driven board is known to function successfully then hopefully there is little possibility of users experiencing any problems. If any malfunction is perceived, try resetting the power supply or using the RST key, then run the program again.

Unfortunately, d.c. electric motors and relay coils are probably the worst imaginable electrical loads in terms of noise and spikes, and if readers notice any signs of misbehaviour or erratic operation, try to isolate the cause. Does the PhizzyBot respond correctly if, say, the relays are powered but the d.c. motors are disconnected?

The problem could perhaps be electrical interference from the motors, and since the design is unscreened, it may be worth re-routing any "noisy" wiring away from sensitive signal wires. Also it may perhaps help to add further suppressors in the form of 100nF polyester capacitors soldered directly across the motors.

COMPONENTS

Miscellaneous

S0 to S5 long-lever micro switch with solder terminals (6 off)

General purpose multi-stranded hookup wire in six colours; PVC sleeving; p.c.b. standoffs; adhesive; tiewraps; solder, etc.

Optional – 9V Ni-Cad rechargeable battery with connector clip; lead to power the PhizzyB (standalone mode only)

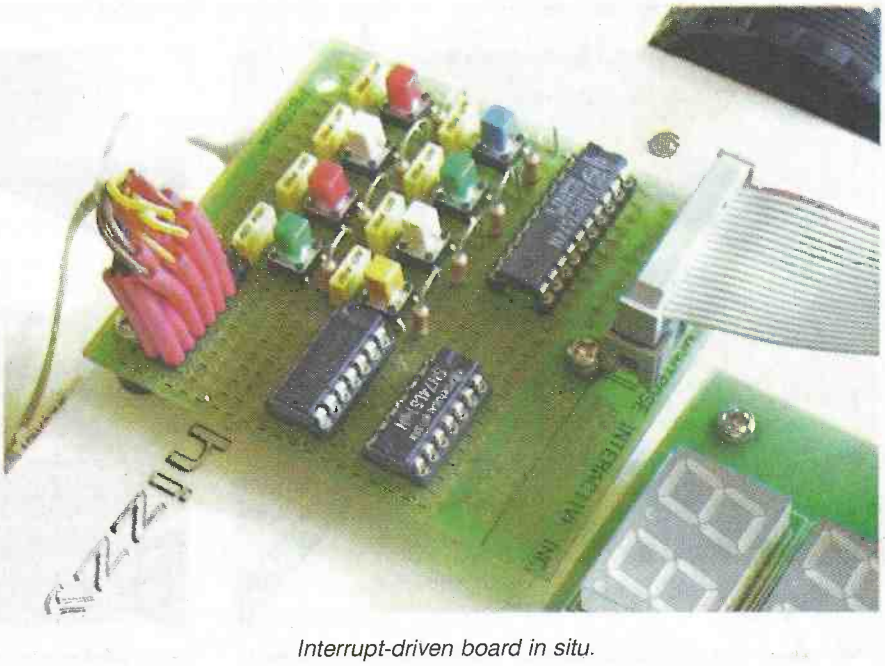
Approx Cost Guidance Only £8 *excluding batteries*

NEXT MONTH

In next month's article, we wrap up the practical aspects of the PhizzyB hardware construction by incorporating a series of light-dependent resistors on the input port, so that our friendly PhizzyBot can be attracted to light (hence the "MothBot") or indeed repelled by it (the "RoachBot").

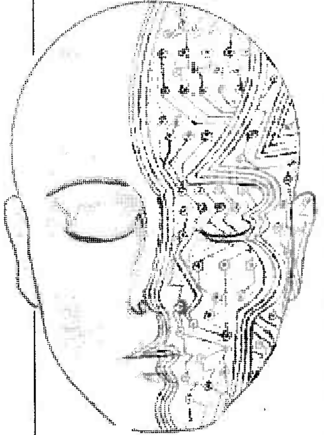
Max and Alvin will thereafter outline further ideas which will hopefully encourage PhizzyB owners to develop more practical applications for themselves – perhaps using the PhizzyBot to follow a white line or a buried metallic stripe for example, as the PhizzyB hardware is quite capable of being incorporated into complex operations including robotics or mechatronics, for example.

But remember that the PhizzyBot is designed to demonstrate principles and you are all encouraged to improvise and experiment for yourselves.



Interrupt-driven board in situ.

INGENUITY UNLIMITED



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

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

Audio Limiter -

A CIRCUIT was required to limit the level of audio applied to an f.m. radio transmitter. The circuit diagram of Fig. 1 meets these requirements and it could be used in many areas besides the intended one, particularly in limiting the signal applied to an audio power amplifier, protecting those valuable tweeters!

The design is based around an LM13700 Operational Transconductance Amplifier (OTA) IC1. These devices are unlike conventional op.amps in that they are current driven and have a bias input which can be used to control the gain. The two transistors shown in the circuit diagram are internal to the LM13700 package.

Under normal operating conditions the output of IC2d will be sitting at the positive rail, biasing IC1 (OTA) via resistor R5. IC2a and IC2b form a peak detector which stores the peak value of the audio for a short time based around the time constant of R9/C4. When the peak level of the audio exceeds a particular level D2 will be forward biased.

With IC2d having a gain of 100 its output quickly swings negative reducing the bias to the OTA thereby reducing its gain and holding the audio at the desired level. IC2c is a simple comparator used to show when limiting is occurring.

To set up the circuit, apply the maximum input signal, then with a voltmeter on the output of IC2d adjust VR1 until the voltage just hits the positive rail (around 13·8V).

Duncan Boyd,
Blackburn,
West Lothian.

I.R. Remote Control Tester -

THE SIMPLE circuit of Fig. 2 is designed to test common handheld remote controls as used in televisions, stereo systems and other equipment, and is based around a photo-sensitive transistor switch (TR1). The infra-red emitter on the remote control is pointed directly towards TR1 from a distance of about 5cms.

Each button on the remote control can then be pressed in turn; the ultra-bright l.e.d. D1 should light to indicate correct operation. If each of the buttons on the remote control appears to be working properly, then the fault (if any) may lie in the equipment set itself.

Mark McGuinness,
Clondalkin, Dublin.

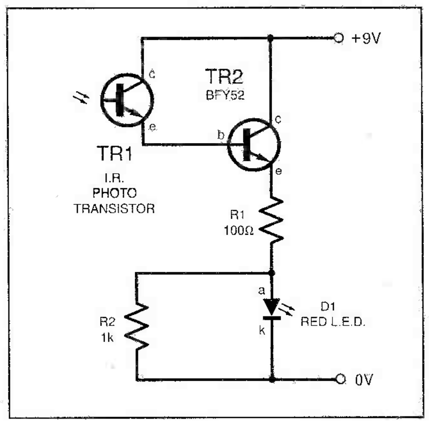


Fig.2. I.R. Remote Control Checker circuit.

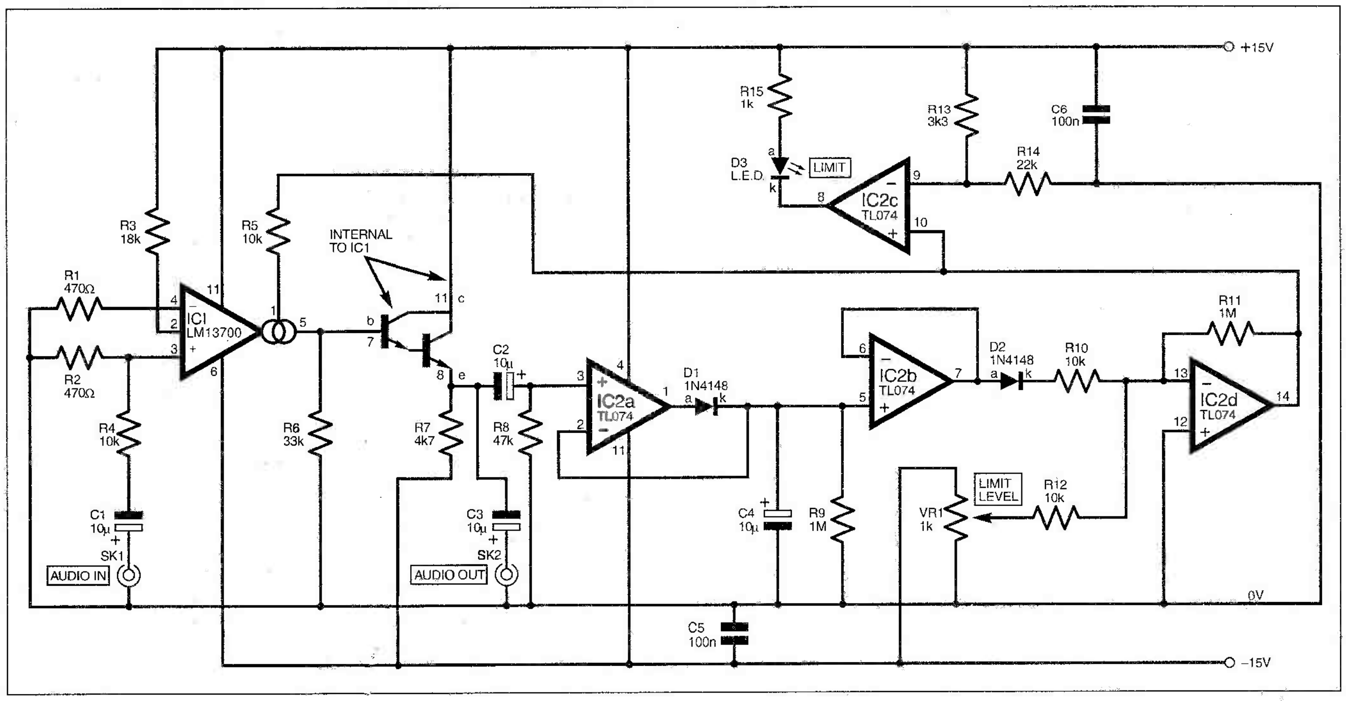


Fig.1. Circuit diagram for the Audio Limiter. Note the "split" power supply.

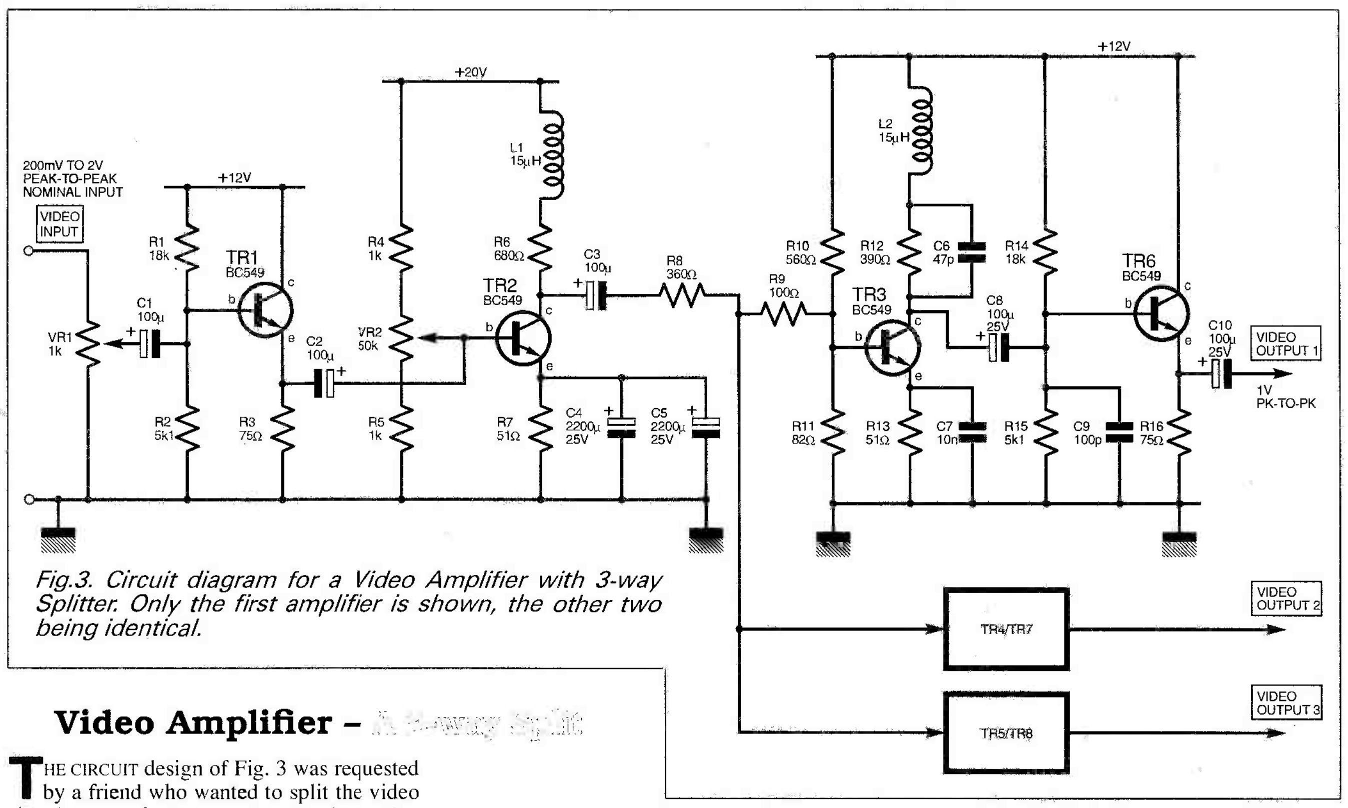


Fig.3. Circuit diagram for a Video Amplifier with 3-way Splitter. Only the first amplifier is shown, the other two being identical.

Video Amplifier – A 3-way Split

THE CIRCUIT design of Fig. 3 was requested by a friend who wanted to split the video signal output from a games console so that when he and his friends played multi-player games, they could use more than one monitor. The circuit accepts a standard 1V peak-to-peak into 75 ohm composite video signal input (200mV to 2V max.), which it then amplifies and splits three ways to produce 1V pk-pk on each of three outputs.

The console video signal is applied across control potentiometer VR1 and fed into the circuit via transistor TR1 which acts as an emitter follower. Control VR2 is used to set the base voltage to 1·55V on transistor TR2 and the video signal is then pre-amplified by TR2 to give a voltage of 2·7V pk-pk at the junction of capacitor C3 and resistor R8. This is then attenuated by R8 to produce 380mV pk-pk.

The resulting signal is split three ways so that 160mV is supplied to the bases of transistors TR3 to TR5, each amplifier having an input impedance of 75 ohms. The signals are then amplified up to 1V pk-pk, and fed to the video outputs via TR6, TR7 and TR8, each acting as emitter followers. *(Only the first amplifier circuit (TR3/TR6) is shown in full, the other two are completely identical.)*

The inductors L1 to L4 improve the gain of the amplifiers at high frequencies, using the "Shunt peaking coil" technique. This helps to amplify the colour information contained in the video waveform, which would otherwise tend to be attenuated.

Capacitors C6 and C9 and corresponding devices help to remove spikes which appear in the front porch and peak white area of the waveform. Users may well find that they need to either increase or decrease the values shown when finally testing the circuit.

A +12V/+20V mains power supply is suggested separately (see Fig. 4) although it is possible to construct a 12V only version of this circuit. It will then be necessary to delete components C5, R8 and VR2 from the present circuit. Then change R4 to 47k and R5 to 8k2, and finally change R6 to 390 ohms.

The value of capcitor C4 should be a minimum of 1,000µF, although the circuit will function well without C4 or L1. However, the minimum input voltage will then be reduced to approximately 500mV. Ensure that electrolytic capacitors all have adequate voltage ratings.

Laurence Curnow,
Cuxton, Rochester, Kent.

INGENUITY UNLIMITED

BE INTERACTIVE

IU is *your* forum where you can offer other readers the benefit of your Ingenuity. Share those ideas and earn some cash and possibly a prize!

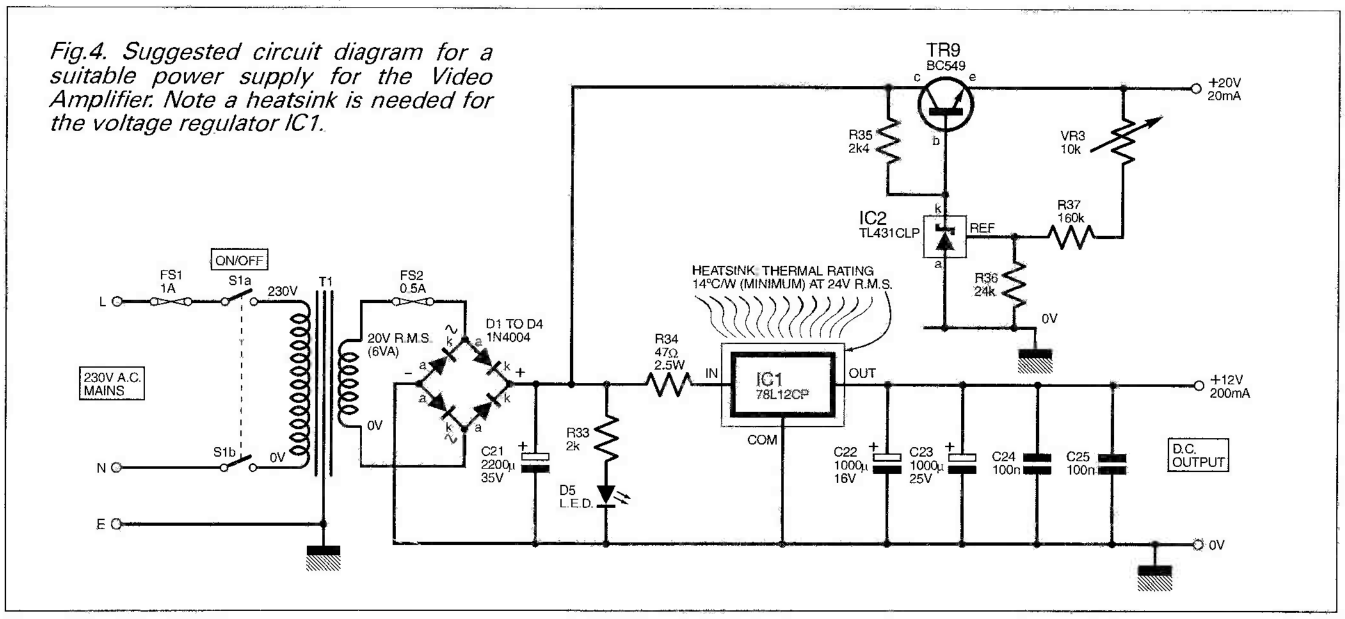
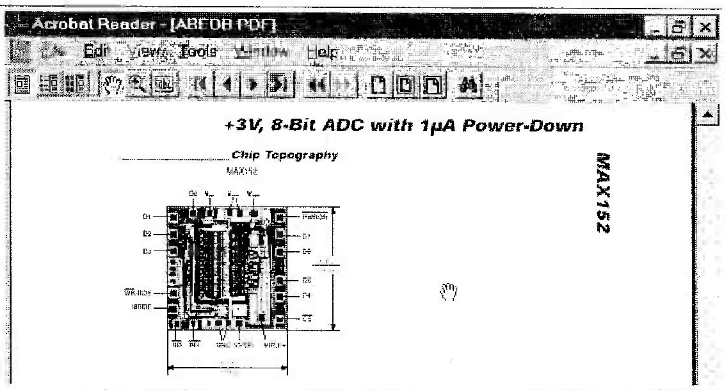


Fig.4. Suggested circuit diagram for a suitable power supply for the Video Amplifier. Note a heatsink is needed for the voltage regulator IC1.

Special Review

DATA-NET REVIEW



ROBERT PENFOLD

A ten CD-ROM library with a vast repertoire of useful data is put to the test.

WHILE it would be an exaggeration to say that the days of conventional semiconductor data books "are numbered", computerised versions seem to be steadily taking over.

Computerised data is available from two main sources, which are the Internet and CD-ROMs. I do not know if the Internet contains data sheets for every available semiconductor, but data for most devices seems to be available if you search long and hard enough.

The CD-ROM approach is potentially much quicker and easier, and many component manufacturers now make their data available in this form. Also, some of the major component retailers supply data sheets on CD-ROM for the main semiconductors that they have available. No doubt many readers will have tried the offerings from Farnell, RS and Maplin.

GIGA-DATA

I suppose that the ideal data source would consist of a set of CD-ROMs containing all the semiconductor data available on the Internet. This is, more or less, what the DATA-NET package sets out to be. It consists of 10 CD-ROMs and a single floppy disk.

There is no proper manual supplied in the package, just a single-sided A4 sheet. However, this software is quite easy to set up and use, so the minimalist documentation is perfectly adequate. The usual "readme" file on one of the CD-ROMs augments it.

... includes data for many minor semiconductors such as transistors and diodes ...

Two programs are needed in order to access the data, and these are to be found on disk number 10. The first program is a database of all the devices for which data is available and a search engine to make it easy to find the data you require. The second program is Adobe Acrobat Reader, which is needed to view the data sheets that are all in Adobe PDF format.

This now seems to be the accepted format for electronic component data sheets. Of course, if you already have Adobe Acrobat Reader installed on your PC, and provided it is a reasonably up-to-date version, only the database program has to be loaded.

The Data-Net 10 CD-ROM and "floppy" disk collection.

Installation is basically just a matter of finding the appropriate Setup programs on the CD-ROM and then going through the usual Windows-style installation processes. The service pack on the single floppy disk is then installed, and this brings everything completely up-to-date.

With what is presumably in excess of six gigabytes of data on the CD-ROMs there is no question of installing the data on to the hard disk drive of the PC. You find the data sheet you require using the database and search engine, and then read it from the appropriate CD-ROM using the Adobe Acrobat reader program.

SEARCH ENGINE

The search engine is very simple to use, and it is just a matter of providing it with a text string. This can be either a complete type number, or just part of one. The recommended approach is to supply only the basic part number, omitting any manufacturers prefix, or any suffix.

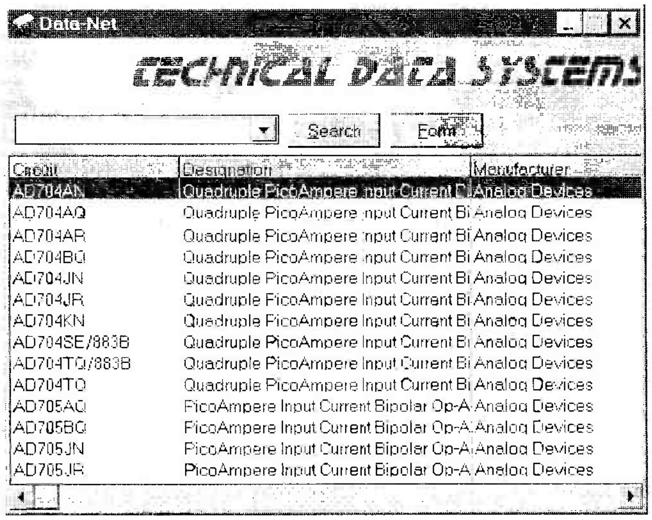
By using this method you are supplied with a list of all the available data sheets for the device you are interested in. This might not provide you with any additional data, but some manufacturer's data is more informative than others, and this maximises your chances of finding the required information.

One slight snag with this approach is that any device numbers that contain a given search string will be included, which can sometimes produce a long list of devices, most of which are of no relevance. For example, using "109" as the search string will not just produce a listing for the BC109 transistor, but will also throw up other devices that have "109" in their type number, such as the CMOS 40109B level shifter.

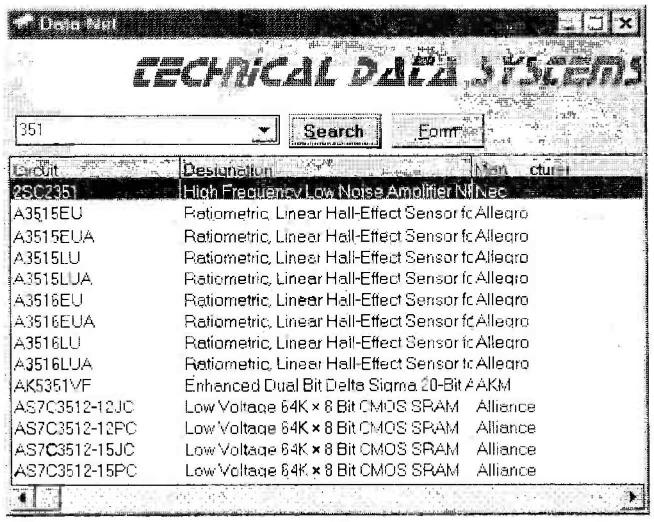
... provides the user with a vast amount of data for the money ...

This is not usually a major problem and "741" for example, only produces a list of 741 operational amplifiers. Occasionally though, it is necessary to refine the search with an additional prefix or suffix in order keep things manageable. Entering "351" for the LF351N for example, brings up a long list of devices which have "351" in their type number.

This shows up a minor flaw in the search engine, which is simply the small size of the window in which it operates. The type numbers have to be scrolled out of sight in order to bring the vertical scrollbar into the visible part of the window. This can result in a lot of juggling with the two scrollbars in order to find the device you require. A larger and resizeable window would be better.



The initial screen of the search engine. A type number (or part of one) is entered in the box, and clicking the Search button then produces a list of matches. Selecting an entry and clicking on the Form button brings up a request for the appropriate CD-ROM, after which Adobe Acrobat Reader is run automatically and the data sheet is displayed.



Using partial type numbers will sometimes bring up a large list of matches. In this case there are too many to display at once, but it is necessary to use the horizontal scrollbar in order to access the vertical scrollbar (which is out of the display area to the right).

IN PRACTICE

It is fine having a search engine and CD-ROMs full of data, but do the two work together efficiently? Obviously it is not possible to check that everything listed by the search engine carries through to the correct data sheet, but in my tests everything went smoothly.

You just double click on the entry for which data is required, insert the requested CD-ROM into the CD-ROM drive, and then wait while Adobe Acrobat Reader runs and the appropriate data sheet is displayed. If your PC has more than one CD-ROM drive you can select the drive that is used by DATA-NET.

Most PC screens are incapable of displaying full pages of data with adequate clarity, but Adobe Acrobat Reader makes it easy to zoom in and scroll around the selected page. The quality is usually very good, but this is obviously dependent on the system being fed with a good scan of the original data sheet.

Provided your PC is equipped with a suitable printer, high quality hard copy can be produced. In fact with a suitable laser or inkjet printer the quality of most printed-out data sheets is remarkably good.

The amount of data varies from one data sheet to another, but all the information made available by the manufacturer seems to be included. As a few examples, there are nine pages for the CD40109B, seven for the BC109, and eight for the LF351N operational amplifier. The data is mostly facts, figures, and graphs, but there are applications circuits for some components, especially for the more specialised integrated circuits.

CONCLUSION

On the face of it, DATA-NET has little to offer that is not available on the CD-ROMs available from some of the major electronic component retailers. It does have a definite advantage though, which is that it is far more comprehensive, and it includes data for many minor semiconductors such as transistors and diodes, which are not included in many other data sources.

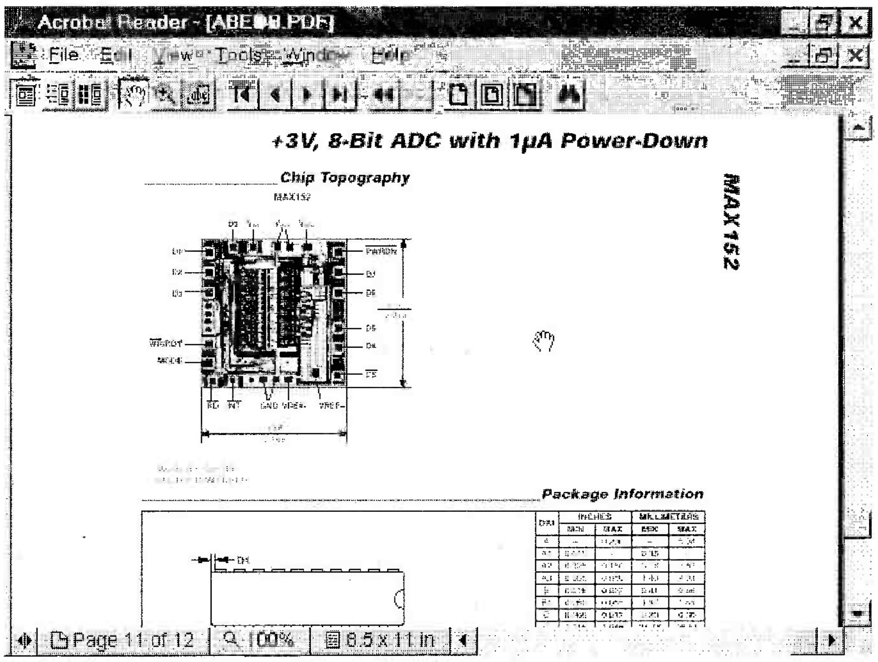
It also includes a far wider range of integrated circuits, although non-professional users should bear in mind that they may find it impossible to obtain many of these. There do seem to be some omissions from the data, and the entire Holtek range seems to be absent for example.

. . . It is easy to search for data if you already have a type number . . .

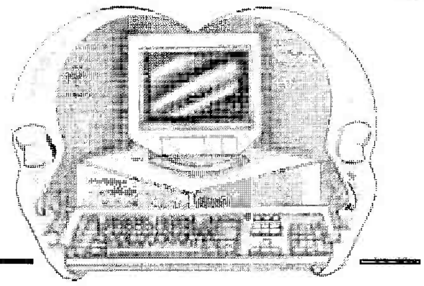
Obsolete devices are not included, which will not worry circuit designers, but it makes the package less useful to service engineers. It is easy to search for data if you already have a type number, but the search facilities do not let you search for devices of a particular type, such as wide bandwidth operational amplifiers or analogue multipliers.

Although DATA-NET has a few limitations, it still provides the user with a vast amount of data for the money, and it is easy to track down the data sheet for any device in its "repertoire". It is supplied with 16 and 32-bit versions of Adobe Acrobat Reader, and it should therefore work with practically any PC running Windows 3.1 or later. Of course, the PC must be equipped with a CD-ROM drive and a hard disk drive. Only 10 megabytes of hard disk space are required.

DATA-NET is handled in the UK by *Dannell Electronics Ltd, Unit 15, Enterprise Court, Lake Road, Braintree, Essex, CM7 3QS (Tel 01376 347415, Fax 01376 550019, E-mail **sales@dannell.co.uk**)*. It should also be available for purchase on-line at **http://www.dannell.co.uk**. The cost is £39.00 including postage and VAT. Updates consisting of five CDs should be available for less than £20 at approximately six-month intervals.



The Adobe Acrobat Reader program uses PDF files that can handle high quality graphics as well as text. A good display is needed in order to make the best use of them, or they will produce high quality hard copy via a suitable printer.



Robert Penfold

AD8300 SERIAL DIGITAL TO ANALOGUE CONVERTER

IN RECENT years a lot of "old favourites" have disappeared from the semiconductor market. Many of the popular analogue to digital and digital to analogue converters from Ferranti are recent additions to this growing list. Several circuits in this series over the years have featured Ferranti chips, and their converters often represent the simplest solution to a problem. On the other hand, they require a parallel interface, which can make life difficult where several converters are required.

The use of serial analogue to digital converters has been covered in several previous *Interface* articles, and but so far we have not considered the subject of serial digital to analogue converters. Whereas a device such as the Ferranti ZN426E requires an eight-line interface and offers only eight-bit resolution, a serial converter typically requires just three connecting wires and provides 12 or even 16-bit resolution.

The main drawback of serial converters is that the software side of things becomes much more convoluted. Something that requires just a single line of BASIC or machine code when using a parallel converter often requires dozens of program lines when using a serial chip. Overall though, serial converters represent a genuine step forward rather than just an enforced replacement for "golden oldie" chips that are no longer available.

The AD8300

The circuit of Fig.1 is for a simple 12-bit digital to analogue converter that utilizes the Analogue Devices AD8300 serial converter chip, and connects to a PC printer port. The AD8300 is actually the only component used in the circuit! This chip will operate over a supply voltage range of 2·7 to 5·5 volts, but it must be operated from a standard 5-volt supply if compatibility with standard 5-volt logic circuits is required, as it is in this case. The current consumption is only about two milliamps.

The PC printer ports do not have a supply output, but ways of obtaining a +5 volt supply from a PC have been covered in several previous *Interface* articles. A highly stable voltage reference is included in the AD8300, and this ensures accurate operation despite any changes in the supply voltage. It also permits operation over a wide temperature range of −40 to +65 decrees Celsius. The output voltage is 0·5 millivolts per bit, giving a maximum output potential of 2·0475 volts.

There are five control inputs on the AD8300, but in normal operation only three of these are required. The Clear (CLR) input at pin 6 is a sort of reset input that is pulsed low to reset the DAC register to zero. If this facility is not required the Clear input is simply tied to the +5 volt supply rail. The Chip select ($\overline{CS}$) input at pin 2 disables shift register operation when it is taken high. This input is normally taken to the 0V rail so that the shift register is permanently enabled.

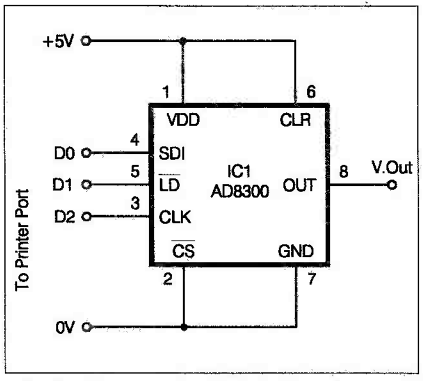


Fig.1. The circuit diagram for the serial DAC. The output potential is 0·5mV per bit.

The other three inputs are used to clock data into the chip, bit-by-bit, and then load it into the DAC register. The clocking process is quite simple, and it is just a matter of placing the data on pin 4 and then producing a pulse on pin 3. Data is latched into the shift register on the positive going edge of the clock pulse.

This process must be repeated for all 12 bits, starting with the most significant bit and working through to the least significant bit. Note that most serial interfaces operate the opposite way round with the least significant bit being transmitted first. Once all 12 bits have been latched into the serial register, a low pulse on pin 5 loads this data into the DAC register and the appropriate output voltage is generated by the chip.

Details of the connections to the PC printer port are provided in Fig.2. These connections are made via a 25-way male D-connector. The converter is driven from the least significant data outputs, but with appropriate software the circuit should be usable with any three latching outputs. Although a form of serial interfacing is used here, an ordinary parallel port provides the control lines. Consequently the connecting cable should be no more

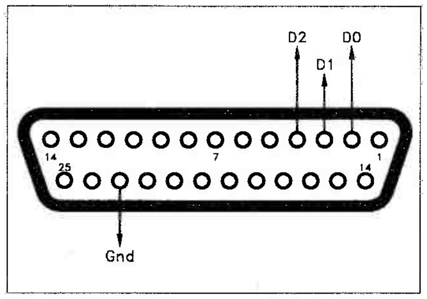


Fig.2. Connection details for the PC printer port.

Listing 1

```
10 REM SERIAL DAC PROGRAM (12-BIT)
20 PORT=&H278
30 C=2
40 D=6
50 INPUT A
60 OUT PORT,6
70 B=A AND 2048
80 IF B=2048 THEN E=C+1 ELSE E=C
90 IF B=2048 THEN F=D+1 ELSE F=D
100 OUT PORT,E
110 OUT PORT,F
120 B=A AND 1024
130 IF B=1024 THEN E=C+1 ELSE E=C
140 IF B=1024 THEN F=D+1 ELSE F=D
150 OUT PORT,E
160 OUT PORT,F
170 B=A AND 512
180 IF B=512 THEN E=C+1 ELSE E=C
190 IF B=512 THEN F=D+1 ELSE F=D
200 OUT PORT,E
210 OUT PORT,F
220 B=A AND 256
230 IF B=256 THEN E=C+1 ELSE E=C
240 IF B=256 THEN F=D+1 ELSE F=D
250 OUT PORT,E
260 OUT PORT,F
270 B=A AND 128
280 IF B=128 THEN E=C+1 ELSE E=C
290 IF B=128 THEN F=D+1 ELSE F=D
300 OUT PORT,E
310 OUT PORT,F
320 B=A AND 64
330 IF B=64 THEN E=C+1 ELSE E=C
340 IF B=64 THEN F=D+1 ELSE F=D
350 OUT PORT,E
360 OUT PORT,F
370 B=A AND 32
380 IF B=32 THEN E=C+1 ELSE E=C
390 IF B=32 THEN F=D+1 ELSE F=D
400 OUT PORT,E
410 OUT PORT,F
420 B=A AND 16
430 IF B=16 THEN E=C+1 ELSE E=C
440 IF B=16 THEN F=D+1 ELSE F=D
450 OUT PORT,E
460 OUT PORT,F
470 B=A AND 8
480 IF B=8 THEN E=C+1 ELSE E=C
490 IF B=8 THEN F=D+1 ELSE F=D
500 OUT PORT,E
510 OUT PORT,F
520 B=A AND 4
530 IF B=4 THEN E=C+1 ELSE E=C
540 IF B=4 THEN F=D+1 ELSE F=D
550 OUT PORT,E
560 OUT PORT,F
570 B=A AND 2
580 IF B=2 THEN E=C+1 ELSE E=C
590 IF B=2 THEN F=D+1 ELSE F=D
600 OUT PORT,E
610 OUT PORT,F
620 B=A AND 1
630 IF B=1 THEN E=C+1 ELSE E=C
640 IF B=1 THEN F=D+1 ELSE F=D
650 OUT PORT,E
660 OUT PORT,F
670 OUT PORT,4
680 OUT PORT,6
690 GOTO 50
```

than a few metres long. The AD8300 is a MOS device and it therefore requires the normal anti-static handling precautions.

Software

The first GW BASIC program in Listing 1 demonstrates the writing of 12-bit data to the converter. An integer from 0 to 4095 is entered at the prompt, and the program then outputs this value to the converter. At line 20 the base address of the printer port is assigned to the variable called "PORT". This is the address used to write data to the printer port, and it is normally &H378 for port 1 (LPT1), or &H278 for port 2 (LPT2). It can sometimes be &H3BC, and if necessary trial and error must be used to find the right address.

The value to be written to the converter is input at line 50. Next the program must generate a clock pulse on data line D2, having first set output D0 to one if appropriate. Bitwise ANDing is used to set variable "B" to 1 or 0, depending on the state of the most significant bit. If B is at 1, 1 is added to variables E and F, which are then written, in turn, to the printer port. This generates the clock pulse with D0 being set to 1 where appropriate.

The same general process is repeated for the other 11 bits, and then a pulse is generated on output D1 at lines 670 and 680. The purpose of this pulse is to latch the data into the converter's DAC register, and the appropriate output voltage should then appear at its output. The program then loops back to the beginning so that a new value can be entered if desired. Use the normal Control-Break combination of keys to break out of the program.

The same program can be used if only eight-bit operation is required, but the maximum output voltage will be a mere 127·5 millivolts. It is better if the eight bits of data are shifted into the most significant bits of the DAC register, and this is achieved using the program in Listing 2. This operates much as before, but only on eight bits of data. Four dummy bits set at zero are then written to the converter, moving the original eight bits of data into bits four to 11 of the DAC register. This gives an output voltage of eight millivolts per bit and a maximum output potential of 2·04 volts.

Clearly the software needed to drive serial DACs is relatively cumbersome, but the fact that they can operate with just three control lines is a great asset when trying to make the most of a PC printer port. This also makes them attractive for use with PIC processors. The software side of things is actually somewhat simpler with PICs as they have bit level instructions that make it easier to generate the correct control signals.

Listing 2

```
10 REM SERIAL DAC PROGRAM (8-BIT)
20 PORT=&H278
30 C=2
40 D=6
50 INPUT A
60 OUT PORT,6
70 B=A AND 128
80 IF B=128 THEN E=C+1 ELSE E=C
90 IF B=128 THEN F=D+1 ELSE F=D
100 OUT PORT,E
110 OUT PORT,F
120 B=A AND 64
130 IF B=64 THEN E=C+1 ELSE E=C
140 IF B=64 THEN F=D+1 ELSE F=D
150 OUT PORT,E
160 OUT PORT,F
170 B=A AND 32
180 IF B=32 THEN E=C+1 ELSE E=C
190 IF B=32 THEN F=D+1 ELSE F=D
200 OUT PORT,E
210 OUT PORT,F
220 B=A AND 16
230 IF B=16 THEN E=C+1 ELSE E=C
240 IF B=16 THEN F=D+1 ELSE F=D
250 OUT PORT,E
260 OUT PORT,F
270 B=A AND 8
280 IF B=8 THEN E=C+1 ELSE E=C
290 IF B=8 THEN F=D+1 ELSE F=D
300 OUT PORT,E
310 OUT PORT,F
320 B=A AND 4
330 IF B=4 THEN E=C+1 ELSE E=C
340 IF B=4 THEN F=D+1 ELSE F=D
350 OUT PORT,E
360 OUT PORT,F
370 B=A AND 2
380 IF B=2 THEN E=C+1 ELSE E=C
390 IF B=2 THEN F=D+1 ELSE F=D
400 OUT PORT,E
410 OUT PORT,F
420 B=A AND 1
430 IF B=1 THEN E=C+1 ELSE E=C
440 IF B=1 THEN F=D+1 ELSE F=D
450 OUT PORT,E
460 OUT PORT,F
470 GOSUB 540
480 GOSUB 540
490 GOSUB 540
500 GOSUB 540
510 OUT PORT,4
520 OUT PORT,6
530 GOTO 50
540 OUT PORT,2
550 OUT PORT,6
560 RETURN
```

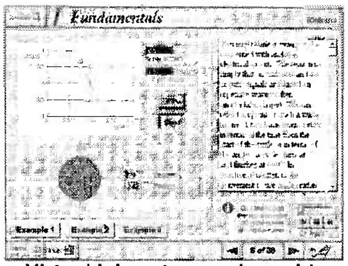
Everyday Practical Electronics are pleased to be able to offer all readers these

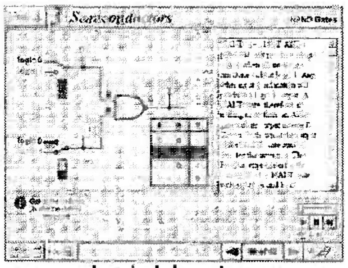
TWO APPLICATIONS ON ONE CD-ROM

ELECTRONIC CIRCUITS & COMPONENTS + THE PARTS GALLERY
by Mike Tooley

ELECTRONIC CIRCUITS & COMPONENTS

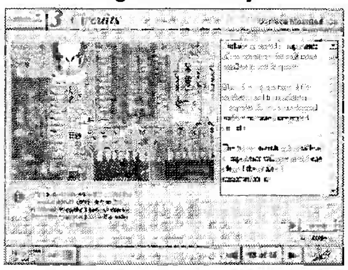
Electronic Circuits & Components provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment 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


Virtual laboratory – sinusoids


Logic laboratory

THE PARTS GALLERY

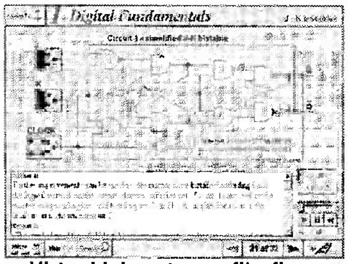
Many students have a good understanding of electronic theory but still have difficulty in recognising the vast number of different types of electronic components and symbols, *The Parts Gallery* helps overcome this problem; it will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.
Selections on the disk include:
Components
Components Quiz
Symbols
Symbols Quiz
Circuit Technology

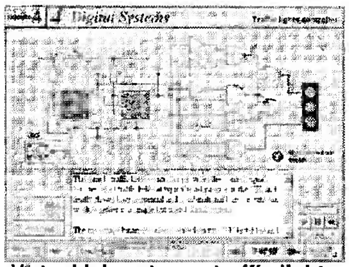

Circuit technology screen

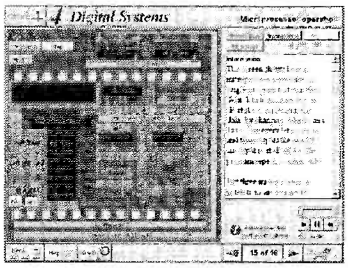
Hobbyist/Student .... £34 inc VAT
Institutional (Schools/HE/FE/Industry) ....£89 *plus* VAT
Institutional 10 user (Network Licence) .... £169 *plus* VAT

DIGITAL ELECTRONICS
by Mike Tooley

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components,* 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 unit.

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.

Hobbyist/Student .... £45 inc VAT
Institutional (Schools/HE/FE Industry) ....£99 *plus* VAT
Institutional 10 user (Network Licence) .... £199 *plus* VAT

NEW

MODULAR CIRCUIT DESIGN *by Max Horsey* and *Philip Clayton*

This CD-ROM has been developed from Max Horsey's *Teach-In* series *A Guide to Modular Circuit Design* (*EPE* Nov '95 to Aug '96). This highly acclaimed series presented a range of tried and tested analogue and digital circuit modules, together with the knowledge to use and interface them. Thus allowing anyone with a basic understanding of circuit symbols to design and build their own projects.

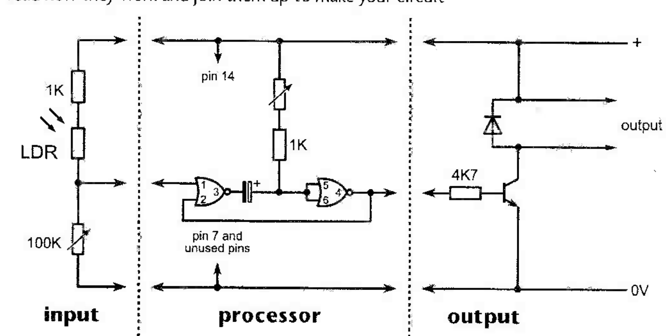
Essential information for anyone undertaking GCSE or "A" level electronics or technology and for hobbists who want to get to grips with project design.

Over seventy different Input, Processor and Output modules are illustrated and fully described together with detailed information on construction, fault finding and components, including circuit symbols, pinouts, power supplies, decoupling etc. A full contents list and alphabetical index are provided and, at every stage, alternative modules are offered.

Written by a highly experienced author and teacher (Max is Head of Electronics at Radley College), this CD brings it all together for all students of electronics.

Single User Version £19.95 inc. VAT
Multiple User Version £34 *plus* VAT

designing your circuit
simply select your modules from the wide choice available, read how they work and join them up to make your circuit



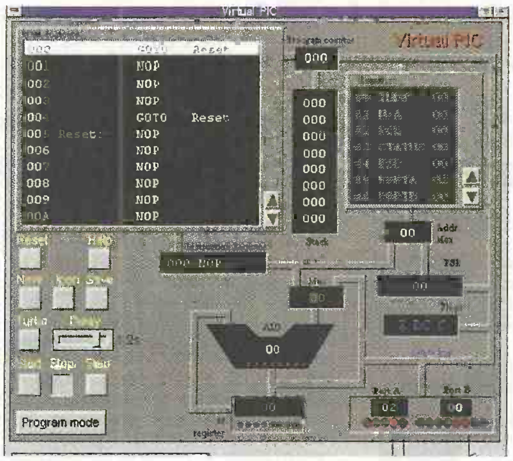
"I found that I could design a circuit without my teacher's help. And it worked! Everything was to hand - which chips to use - and which pins did what."
Andrew Preston (GCSE student)

A Web Browser is required for Modular Circuit Design – one is provided on the *EPE CD-ROM No.1* (see opposite) but most modern computers are supplied with one.

Interested in programming PIC microcontrollers?

PICtutor *by John Becker*

NEW



The Virtual PIC

Developed from our famous and incredibly popular *EPE PIC Tutorial* series by John Becker (*EPE* March to May '98) this CD-ROM, together with the PICtutor experimental and development board, will teach you how to use PIC microcontrollers with special emphasis on the PICx84 devices. The board will also act as a development test bed and programmer for future projects as your programming skills develop.

This interactive presentation uses the specially developed Virtual PIC simulator to show exactly what is happening as you run, or step through, a program. In this way the CD brings the *EPE PIC Tutorial* series to life and provides the easiest and best ever introduction to the subject.

Nearly 40 tutorials cover almost every aspect of PIC programming in an easy to follow logical sequence.

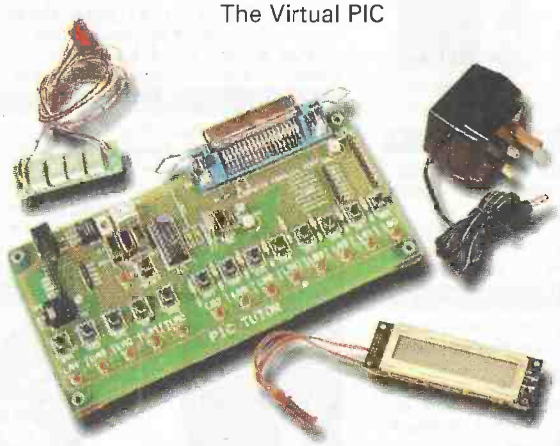
HARDWARE

Whilst the CD-ROM can be used on its own, the physical demonstration provided by the PICtutor Development Kit, plus the ability to program and test your own PIC16x84s, really reinforces the lessons learned. The hardware will also be an invaluable development and programming tool for future work once you have mastered PIC software writing.

Two levels of PICtutor hardware are available – Standard and Deluxe. The Standard unit comes with a battery holder, a reduced number of switches and no displays. This version will allow users to complete 25 of the 39 Tutorials – it can be upgraded to Deluxe at a later date, by adding components, if required.

The Deluxe Development Kit is supplied with a plug-top power supply (the Export Version has a battery holder), all switches for both PIC ports plus l.c.d. and 4-digit 7-segment l.e.d. displays. It allows users to program and control all functions and both ports of the PIC and to follow the 39 tutorials on the CD-ROM.

All hardware is supplied **fully built and tested** and includes a PIC16F84 electrically erasable programmable microcontroller.



Deluxe PICtutor Hardware

CD-ROM

Hobbyist/Student .... **£45 inc. VAT**
Institutional (Schools/HE/FE Industry) .... **£99 *plus* VAT**
Institutional 10 user (Network Licence) .... **£199 *plus* VAT**

HARDWARE

Standard PICtutor Development Kit...................... **£47 inc. VAT**
Deluxe PICtutor Development Kit......................... **£99 *plus* VAT**
Deluxe Export Version .... **£96 *plus* VAT**

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

Minimum system requirements for these CD-ROMs: PC with 486/33MHz, VGA+256 colours, CD-ROM drive, 8MB RAM, 8MB hard disk space. Windows 3.1/95/98/NT, mouse, sound card (not required for PICtutor or Modular Circuit Design).

CD-ROM ORDER FORM

Please send me:

- ☐ **Electronic Circuits & Components + The Parts Gallery**
- ☐ **Digital Electronics**
- ☐ **PICtutor**

Version required:

- ☐ **Hobbyist/Student**
- ☐ **Institutional**
- ☐ **Institutional 10 user**

- ☐ **PICtutor Development Kit – Standard**
- ☐ **PICtutor Development Kit – Deluxe** ☐ **Deluxe Export**

- ☐ **Modular Circuit Design – Single User**
- ☐ **Modular Circuit Design – Multiple User**

Full name:..

Address:..

....

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

Signature:...

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

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

Card No:..

Please supply name and address of card holder if different to the delivery address.

ORDERING

ALL PRICES INCLUDE UK POSTAGE

Student/Single User/Standard Version – price includes postage to most countries in the world
EU residents outside the UK add £5 for airmail postage per order

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

Send your order to:
Direct Book Service
33 Gravel Hill, Merley Wimborne
Dorset BH21 1RW
(Mail Order Only)

Direct Book Service is a division of Wimborne Publishing Ltd. To order by phone ring

01202 881749. Fax: 01202 841692

We cannot reply to overseas orders by Fax
Goods are normally sent within seven days

Demos (not Modular Circuit Design) available on the ***EPE CD-ROM No.1*** (Free with the November '98 issue) – send £2 for this CD-ROM if you require the demos. For Modular Circuit Design demo send £6.95 for cut down version (£5 refunded if you buy full version). **Minimum order** for credit card payment is £5.

EVERYDAY PRACTICAL ELECTRONICS

BACK ISSUES

ETI ELECTRONICS TODAY INTERNATIONAL

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

DID YOU MISS THESE?

NOV '97

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

DEC '97

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

JAN '98

PROJECTS • Disco Lights Flasher • Simple M.W. Radio • EPE Virtual Scope–1 • Surface Thermometer.
FEATURES • TEACH-IN '98 – An Introduction to Digital Electronics–3 • Circuit Surgery • Ingenuity Unlimited • Alternative and Future Technologies–2 • Net Work – The Internet • *Free* – Giant PIC Data Chart.

FEB '98

PROJECTS • Water Wizard • Kissometer • Waa-Waa Effects Pedal • EPE Virtual Scope – 2.
FEATURES • TEACH-IN '98 – 4 • Ingenuity Unlimited • Techniques–Actually Doing It • Circuit Surgery • Net Work – The Internet • Chip Special – HT7630 PIR Controller.

MAR '98 Photostats Only

PROJECTS • Lighting-Up Reminder • The Handy Thing • Switch-Activated Burglar Alarm • Audio System Remote Controller.
FEATURES • TEACH-IN '98 – 5 • Ingenuity Unlimited • Interface • Stripboard Magic Review • Circuit Surgery • Net Work • *EPE* PIC Tutorial Supplement 1

APRIL '98 Photostats Only

PROJECTS • Simple Metal Detector • Single or Dual Tracking Power Supply • Experimental Piezo-Cable Projects – Distributed Microphone – Vibration Alarm • RC-Meter.
FEATURES • Ingenuity Unlimited • Patent Your Invention • TEACH-IN '98 – 6 • Circuit Surgery • Net Work • Techniques – Actually Doing It • *EPE* PIC Tutorial Supplement 2

MAY '98

PROJECTS • Dice Lott • Security Auto-Light • Stereo Tone Control plus 20W Stereo Amplifier • Improved Infra-Red Remote Repeater.
FEATURES • TEACH-IN '98 – 7 • Net Work • *EPE* PIC Tutorial Supplement 3

JUNE '98

PROJECTS • EPE Mood Changer • Simple SW Receiver • Atmel AT89C2051/1051 Programmer • Reaction Timer.
FEATURES • 8051-based EEPROM Microcontrollers • TEACH-IN '98 – An Introduction to Digital Electronics – 8 • Circuit Surgery • Techniques – Actually Doing It • Ingenuity Unlimited

JULY '98

PROJECTS • PIC16x84 Toolkit • Noise Cancelling Unit • Low Battery Indicator • Greenhouse Computer – 1.
FEATURES • Using the L200CV Voltage Regulator • TEACH-IN '98 – 9 • Ingenuity Unlimited • Circuit Surgery • Net Work.

AUG '98

PROJECTS • Lightbulb Saver • Float Charger • PC Transistor Tester • Greenhouse Computer – 2 • Time Machine Update.
FEATURES • TEACH-IN '98 – 10 • Circuit Surgery • Techniques – Actually Doing It • Ingenuity Unlimited • New Technology Update • Net Work • IVEX PCB Cad Review.

SEPT '98

PROJECTS • Mains Socket Tester • Personal Stereo Amplifier • Greenhouse Radio Link • PIC Altimeter.
FEATURES • TEACH-IN '98 – 11 • Ingenuity Unlimited • Circuit Surgery • Interface • Net Work • Crocodile Clips Review.

OCT '98

PROJECTS • Voice Processor • Digiserv R/C Channel Expander • Reliable Infra-Red Remote Control • PC Capacitance Meter.
FEATURES • Easy PCB Making • Using LM335 and LM35 Temperature Sensors • Circuit Surgery • Ingenuity Unlimited • Net Work • Electronics Principles 5.0 Review.

NOV '98

PROJECTS • PIC Tape Measure • T-Stat Electronic Thermostat – 1 • PhizzyB Computers – 1 • 15-way Infra-Red Remote Control.
FEATURES • Circuit Surgery • Ingenuity Unlimited • New Technology Update • Net Work – The Internet • Easy PC for Windows 95 Review • *FREE* EPE CD-ROM No.1.

DEC '98

PROJECTS • EPE Mind PICkler–1 • Fading Christmas Lights • Handheld Function Generator • Damp Stat Electronic Thermostat • PhizzyB Computers–2.
FEATURES • PhizzyB Computers–2 Understanding Computers • Circuit Surgery • Ingenuity Unlimited • Interface • Net Work – The Internet • 1998 Index • *FREE* 48-page Understanding Passive Components booklet.

JAN '99

PROJECTS • Alternative Courtesy Light Controller • Twinkle Twinkle Reaction Game • Volume Compressor • PhizzyB Computers–3 • EPE Mind PICkler–2.
FEATURES • New Technology Update • From Russia With Love • Circuit Surgery • PhizzyB Computers–3 • Net Work.

FEB '99

PROJECTS • PIC MIDI Sustain Pedal • Light Alarm • Wireless Monitoring System–1 • PhizzyB Computers–4.
FEATURES • Ingenuity Unlimited • Scolar Project • PhizzyB Computers–4.

MAR '99

PROJECTS • Smoke Absorber • Auto Cupboard Light • PhizzyB Computers–5 • Time and Date Generator • Wireless Monitoring System–2.
FEATURES • Ingenuity Unlimited • I/ITSEC Show Report • PhizzyB Computers–5 • Practically Speaking • Circuit Surgery • Net Work.

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

We can also supply issues from earlier years: 1992 (**except** March, April, June to Sept. and Dec.), 1993 (**except** Jan. to March, May, Aug., Dec.), 1994 (**except** April, May, June, Nov.), 1995 (**except** Jan., May to Sept., Nov., Dec.), 1996 (**except** Feb., April, May, July, Aug., Nov.), 1997.
We can also supply back issues of *ETI* (prior to the merger of the two magazines) for 1998/9 – Vol. 27 Nos 1 to 13 and Vol. 28 No. 1. We are not able to supply any material from *ETI* prior to 1998. Please put *ETI* clearly on your order form if you require *ETI* issues.
Where we do not have an issue a photostat of any ***one article*** or ***one part*** of a series can be provided at the same price.

ORDER FORM – BACK ISSUES – PHOTOSTATS – INDEXES

☐ Send back issues dated ....

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

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

Name ....

Address ....

....

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

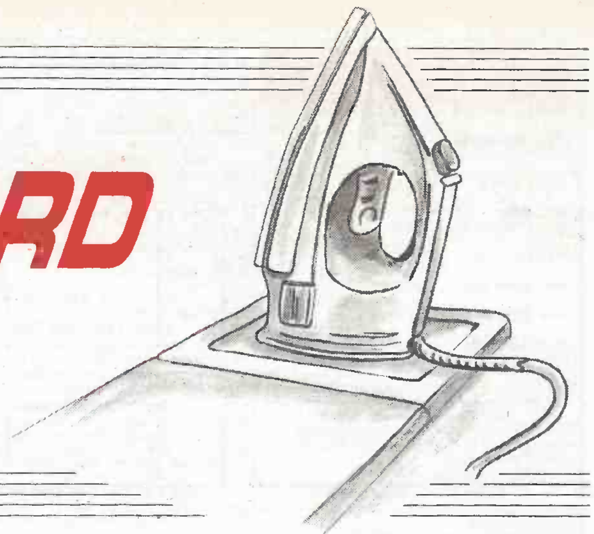
☐ Please charge my Visa/Mastercard £..............................

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

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

M4/99

Constructional Project



IRONING BOARD SAVER

ROBERT HUNT

Save energy with this environmentally friendly ironing board add-on.

OVER-CONSUMPTION of power and damage to the environment are two concerns of great interest to many people today. To those not so involved with "green" efforts, the following project will appeal on safety aspects.

The author has noted from discussions with many of his friends who do the majority of the clothes ironing in their households that at some time everyone accidentally leaves the iron on, seemingly no matter what presence of mind they normally enjoy. For instance, a mother may suddenly have to leave what she is doing to investigate an unexplained noise.

This Ironing Board Saver project was envisioned to prevent clothes irons being left on accidentally, thus saving electricity and reducing the risk of a possible fire.

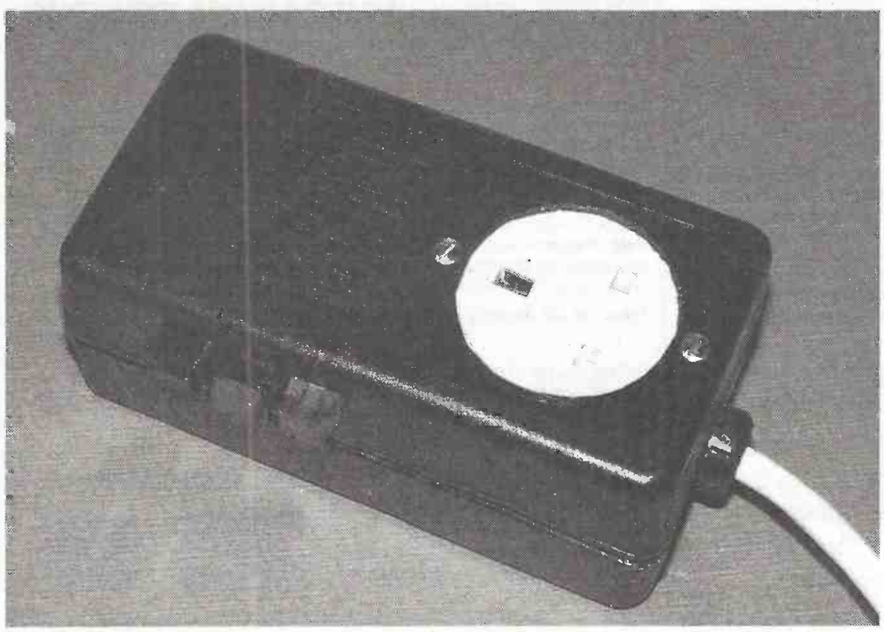
HOW IT WORKS

The original design concept is for a device which may be attached to an ironing board, into which the clothes iron is plugged, and which senses the use of the iron by vibration. An added benefit is that you now have an ironing board with a built-in extension lead!

The idea could be adapted to control any mains powered device which creates some form of vibration when in use.

When the clothes iron is to be put to use, the unit's On button is pressed and the iron stays on for around 1·5 minutes or as long as vibration is detected on the ironing board. When the time-out period arrives, before disconnecting the power, the "Saver" unit emits a beep tone to warn the user, or reassure him or her, that the iron has been disconnected should he or she have forgotten to switch it off after use.

The purpose of the beep tone is to prevent the user trying to work with a cold iron, which would obviously become a nuisance, thus preventing the unit from being "approved" by the user, and thus defeat the purpose of its construction. At any time a "Mains On" neon will indicate whether power is on or off.



CIRCUIT DESCRIPTION

The full circuit diagram for the Ironing Board Saver is shown in Fig.1. The circuit power supply and mains relay contact switching arrangement is also included.

The particular type of inverting buffer, IC1, used here is a special type called a Schmitt trigger. This means that the device has a built in hysteresis range of input voltages so that it switches over at, say 70 per cent of supply rail but switches back at say 30 per cent.

This can best be understood with the illustration of a thermostat in an electric fire, when it reaches the required temperature, say, 20°C, and switches off it doesn't come on again until the room temperature has dropped to, say, 17°C. This 3°C "loop" is called hysteresis.

Hysteresis is used in this project to enable the reliable use of varying voltages connected to logic gates, as logic gates do not work well with poorly defined input levels unless designed to handle them, such as the Schmitt trigger. Otherwise, oscillation around the switch-over point occurs which makes the output spend time halfway between logical states, which can cause failure of the gate due to power developed at the junction at switchover.

BUZZER

While on the subject of these gates, we'll start with the warning buzzer part of the circuit formed by IC1e/IC1f, R8 and piezoelectric transducer WD1. The piezo buzzer circuit can best be understood if you look at Fig.2.

Imagine point *A* is *low*, causing point *B* to be *high*, which causes point *C* to be *low* too. However, resistor R8 passes current from point *B* (high) to one side of the piezo crystal WD1 whose other side is low (point *C*). As piezo crystals are basically 20nF capacitors, gradually the crystal charges, causing the voltage at point *A* to rise.

At a certain point the first inverter will switch over, so point *B* becomes low, point *C* thus becomes high, causing WD1 to gradually discharge through R8 to point *B* (low). When WD1 has sufficiently discharged it begins to charge in the opposite direction and eventually the voltage at point *A* becomes low again, switching *B* to high and *C* to low and so the whole cycle repeats itself.

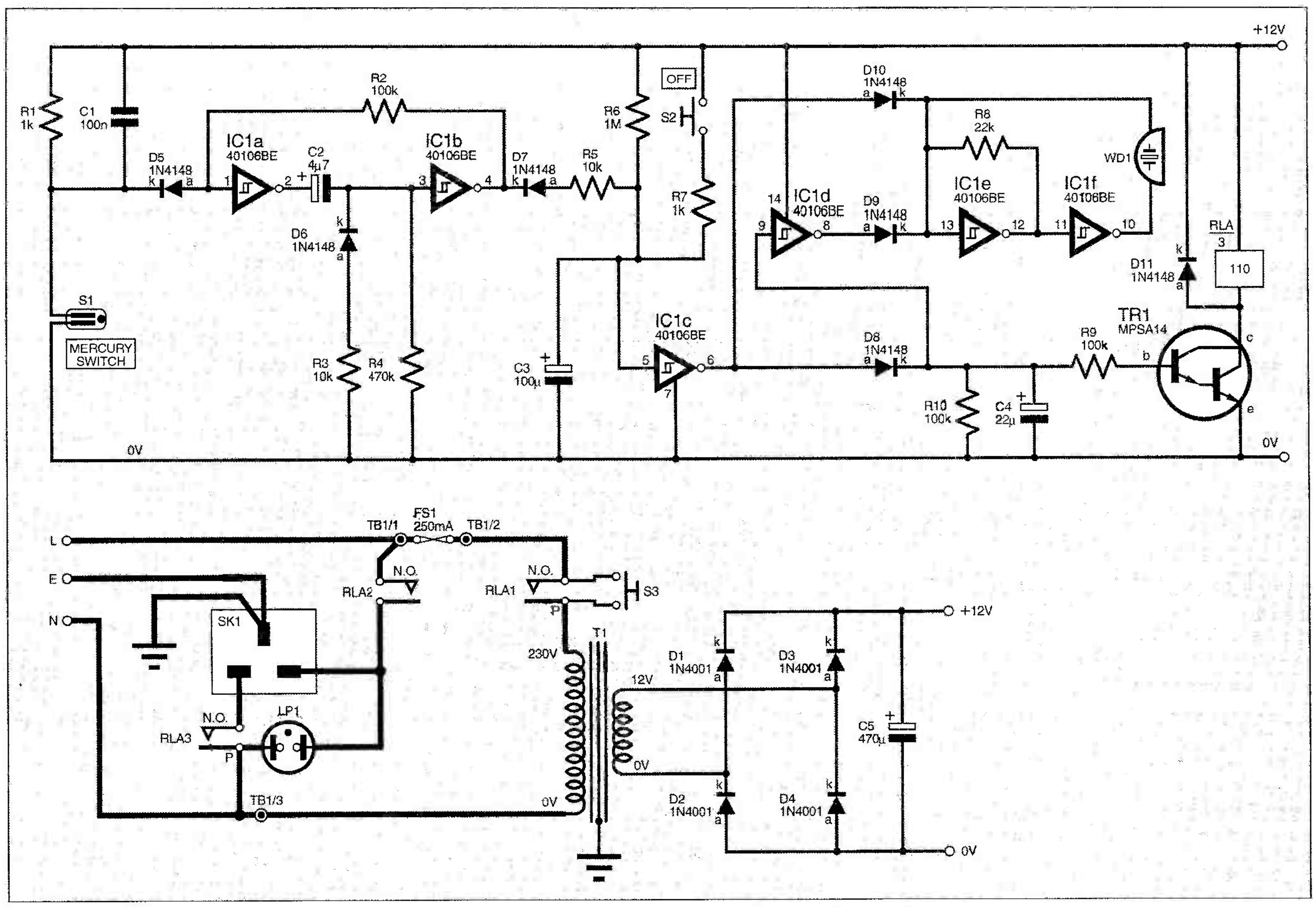


Fig.1. Complete circuit diagram of the Ironing Board Saver.

If you wish, you could alter the frequency of the tone by altering the value of resistor R8.

The frequency can be roughly calculated by working out the time constant of R8 and WD1, multiplying this by two, and dividing one by the result.

$$\text{Frequency} = \frac{0{\cdot}5}{R8 \times WD1}\ \text{Hz}$$

POWER CONTROL

Turning now to the power supply/relay stage of the circuit, the relay, RLA, controls both the current to the appliance being controlled, and the power to the circuit itself. However, the push-to-make switch S3 momentarily supplies power to the circuit when pressed, and the circuit subsequently operates the relay.

To avoid passing appliance current through switch S3 (which would have to be 13A rated if this were the case) the relay alone connects power to the output socket SK1. Hence the relay must have three normally open (n.o.) contacts. This is so that both poles of the mains supply are disconnected from the socket when it is switched off by RLA2 and RLA3, and the third contact (RLA1) is for power to the electronics.

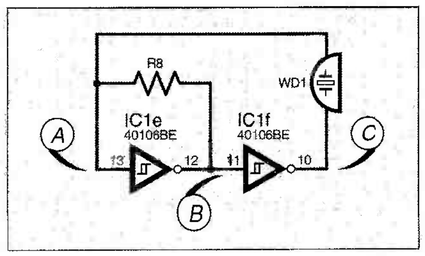


Fig.2. Simplified piezo buzzer oscillator circuit.

Fuse FS1 is rated at 250mA quick blow and supplies current to the control circuit *only*, the mains socket SK1 is fused via the fuse in the mains plug.

POWER TIMER

Once power has been applied to the circuit, the timer formed by resistor R6, capacitor C3, and IC1c operates the relay via diode D8, resistor R9 and Darlington transistor TR1. Once C3 has become charged to around two thirds of the supply voltage (around one minute) IC1c switches over, no longer operating TR1 directly. (TR1 is still held "on" at this point by capacitor C4 – see later.) From this point the piezo buzzer WD1 starts to sound due to the oscillator no longer being blocked off by diode D10.

After about a further three seconds, the charge in capacitor C4 decays to a point which no longer holds the output of IC1d low, so it blocks off the oscillator via diode D9 and hence the warning sound ceases. After another couple of seconds the charge in C4 decays to a point where TR1 no longer holds the relay RLA on, so power is finally disconnected.

You may wonder how it is that capacitor C4 can discharge to a point which switches over IC1d and yet still holds transistor TR1 on. Well, IC1d will switch over at a voltage equivalent to two thirds of the supply voltage, but TR1 will switch off only when the gain of the transistor does not amplify the current enough to hold the relay on any longer.

As relays demand much more current to switch on than they need to stay on, then resistor R9 needs to pass much less current after the relay is engaged. Therefore, it will stay on for a few seconds after IC1d has switched over.

If you wish to alter the time it takes for the power to disconnect after the time expires, reduce the value of resistor R10 to discharge capacitor C4 more rapidly. To alter the main time period, adjust the value of C3. The time will be around 1·5 minutes per 100µF.

Pushswitch S2 operates via resistor R7 as an "Off" button. Pressing S2 charges up C3 within half a second, thus causing time expiry, and so the unit switches off.

VIBRATION SENSOR

The vibration sensor switch S1 is supplied basically as a metal can of approximately 9·5mm length and 8·2mm diameter. Only one connection is already provided, you have to solder another lead onto the can (see Fig.3). Its predicted life is in the order of millions of operations, especially if used in low current situations like this.

The timer circuit, IC1a/IC1b, is constantly being reset by signals from the vibration sensor, S1. Capacitor C1 serves to absorb any very short signals and the circuit around IC1a/IC1b is again simplified to aid explanation, see Fig.4.

This stage of the circuit basically serves as a pulse stretcher so that momentary signals from the vibration switch S1 are lengthened to a time long enough to discharge the timing capacitor C3, via resistor R5 and diode D7. IC1a and IC1b are connected in a monostable fashion with an on time of around half a second.

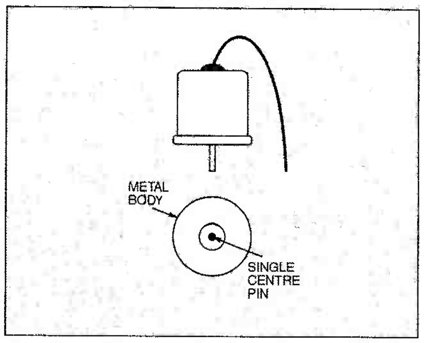


Fig.3. Wiring of S1, the vibration sensor.

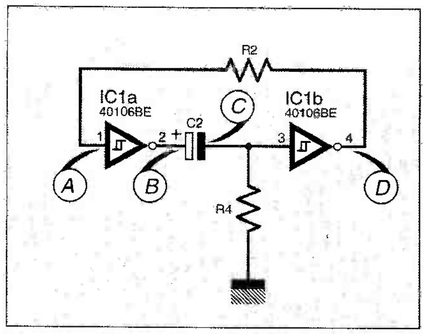


Fig.4. Simplified monostable timer circuit.

Referring to Fig.4, once a negative going pulse from S1 arrives at point *A*, point *B* goes high, initially putting point *C* high (via capacitor C2) causing point *D* to go low. As C2 charges, the voltage at point *C* drops via resistor R4 until IC1b output goes high again, bringing point *A* high via resistor R2 which puts point *B* low, discharging C2.

In the actual circuit two additional components, resistor R3 and diode D6, enable capacitor C2 to discharge far more rapidly than it charges, ensuring that the next trigger pulse at point *A* results in just as long an output pulse from the circuit.

POWER SUPPLY

The power supply circuit after mains transformer T1 is a conventional full-wave rectifier formed by D1 to D4 with smoothing by C5. Neon lamp LP1 serves to indicate to the user that power is on.

There are no requirements for regulation as the circuit does not draw a widely varying current, and it is insensitive to minor fluctuations in supply rail voltage.

CONSTRUCTION

Most of the components for the Ironing Board Saver are mounted on a small printed circuit board (p.c.b.). The exceptions being the mains transformer, relay, switches and output socket. This board is available from the *EPE PCB Service*, code 224.

The board component layout and full-size copper foil master are shown in Fig.5. Assembly of the p.c.b. is straightforward, but IC1 is static sensitive so take the usual precautions when handling it. Note that the buffered version of the 40106 must be used (suffix BE *not* UBE).

The only difficult component to fit is the vibration sensor, which must have a wire lead soldered to its metal body. Be careful not to apply heat any longer than necessary.

After mounting and soldering all components in positon, attach flying wires to the p.c.b. for the relay coil, piezo buzzer and switch S2. Attach the two outer wires from the transformer secondary, which will output 12V between them (if the transformer is 6V-0V-6V the centre tap wire should be clipped short and be fully insulated) and fit the p.c.b. into the case.

Flying leads from the p.c.b. can now be fitted to the relay, buzzer and S2. When attaching leads to the piezo element, you can solder wires directly to the element if required but you must be careful to apply as little heat as possible so as not to destroy the junction between the two plates. The piezo element can be glued to the case, away from all mains wiring.

MAINS WIRING

For connecting mains wiring, carefully follow the interwiring diagram Fig.6, double-checking as you go along. Also, make sure you keep to the following safety notes below.

Safety Aspects

When wiring the unit it is necessary to fuse the mains transformer separately from the supply to the output socket SK1. **All**

COMPONENTS

Resistors

R1, R7	1k (2 off)	R4	470k
R2, R9, R10	5100k (3 off)	R6	1M
R3, R5	10k (2 off)	R8	22k
		All 0·25W 5% carbon film	

Capacitors

C1	100n disc, ceramic	C4	22μ radial elect 25V
C2	4μ7 radial elect. 25V	C5	470 radial elect. 25V
C3	100μ radial elect. 25V		

Semiconductors

D1 to D4	1N4001 1A 50V rectifier diode (4 off)
D5 to D11	1N4148 signal diode (7 off)
TR1	MPSA14 *npn* Darlington transistor
IC1	40106BE Hex Schmitt trigger inverter

Miscellaneous

S1	mercury vibration sensor
S2	mains rated push-to-make switch, red
S3	push-to-make switch, black
T1	230V mains transformer, with 0V-12V (or 6V-0V-6V) 250mA secondary
LP1	mains neon indicator, panel mounting
WD1	3V to 30V wire-ended piezoelectric sounder
RLA	3-pole mains relay, with 12V d.c. 110 ohm coil and 13A 230V a.c. contacts (normally open)
TB1	3-way mains terminal block, with fuseholder
FS1	230V 250mA 20mm glass fuse, quick blow

Printed circuit board available from the *EPE PCB Service*, code 224; case, size and style to choice; 14-pin d.i.l. socket; multistrand connecting wire; 13A mains rated cable; mains lead, with fused plug; strain relief grommet for cable entry; crimp terminals for relay; plastic sleeving; tie wraps; nuts and bolts; solder etc.
37

Approx Cost Guidance Only £37 excluding case

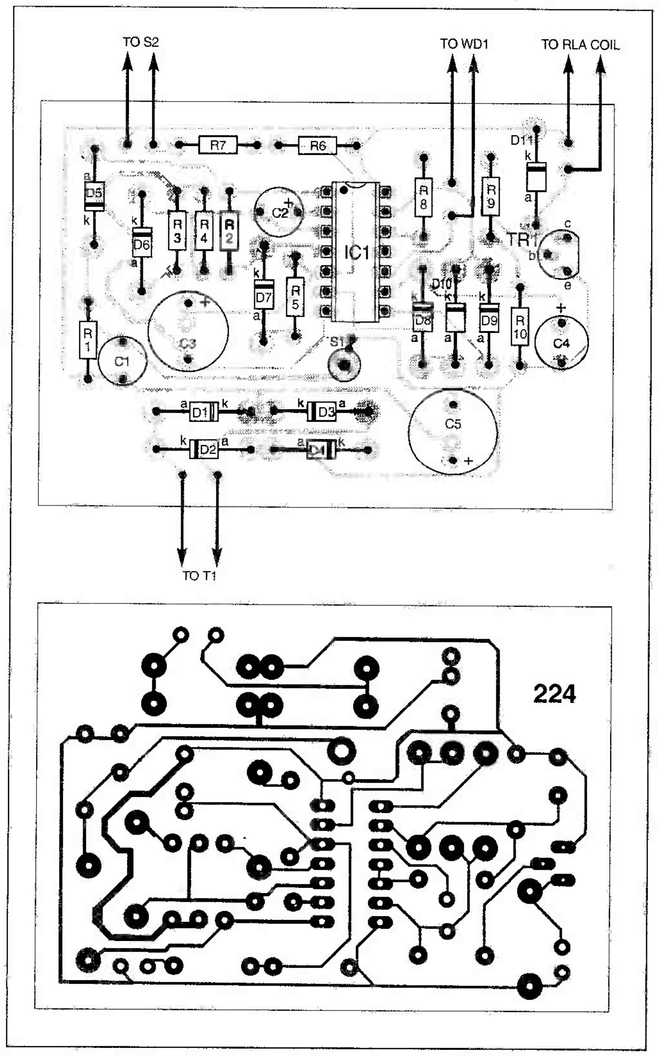


Fig.5. Full size p.c.b. layout for the Ironing Board Saver.

wiring which carries the current to the output socket via the relay must be 13A rated, including the earth wiring, so that no overheating could be experienced should a unit taking this much current be used.

Ensure that all exposed metal (e.g. bolts etc.) is earth bonded, and that the cable exiting from the enclosure is ***firmly*** gripped by a strain relief grommet. It is necessary to ***sleeve or insulate all mains connections*** even though they are enclosed within the box.

In the prototype rubber covers were fitted over the connections to neon LP1 and S3, and the relay terminals were terminated with insulated crimps. Take care also that all mains wiring (whether high current or not) is mains rated. If this is not the case then the insulation could in time break down and cause serious problems.

If there is any danger of the iron touching the mains flex leading out of the unit, you should use heat resistant cable, or cotton covered if you can clamp it securely in the case.

A safety note on earth bonding – do not effect this in a "daisy chain fashion" – one fault in the chain and the earthing fails at every subsequent point. It would also introduce hazardous potentials in the event of a fault current, as the length of the chain would generate a certain amount of voltage drop.

Instead of this, wire all earth conductors back to a common point excepting the continuity conductor between the input cable and output socket. **Remember, this conductor MUST be rated at or above the capacity of the mains incoming lead.**

Note that mains wiring to the relay should not have any exposed metal showing so sleeve all connections or use all-insulated crimp terminals. It is most important that the terminal block TB1, if used, ***must*** be a mains rated one, preferably an approved type. Different poles of the mains should always be separated by a certain creepage and clearance gap of 3mm as well as a standoff from the base of 3mm – normal terminal blocks do not always satisfy this requirement. The terminal block used in the prototype also provides a fuse (FS1) for the live connection. Note that the piezo element must be mains isolated from earth.

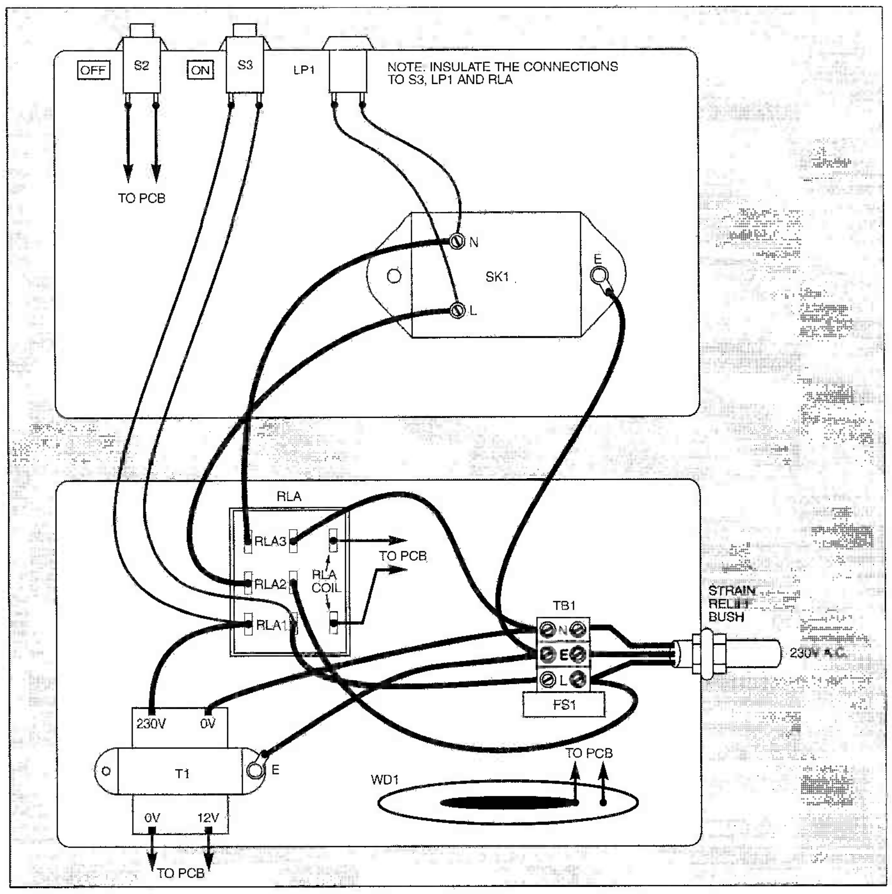


Fig.6. Interwiring of the p.c.b. to all other components. All earth leads must connect back to TB1.

RELAY

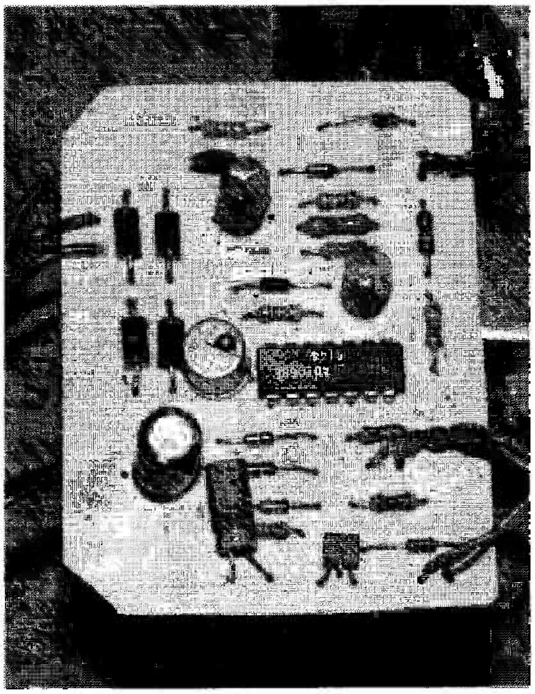
When selecting the relay, as well as ensuring the contacts can switch 13A at 230V a.c., ensure that the coil is well insulated from the contacts and that the contact gap is 3mm or greater. These are requirements for disconnecting mains current.

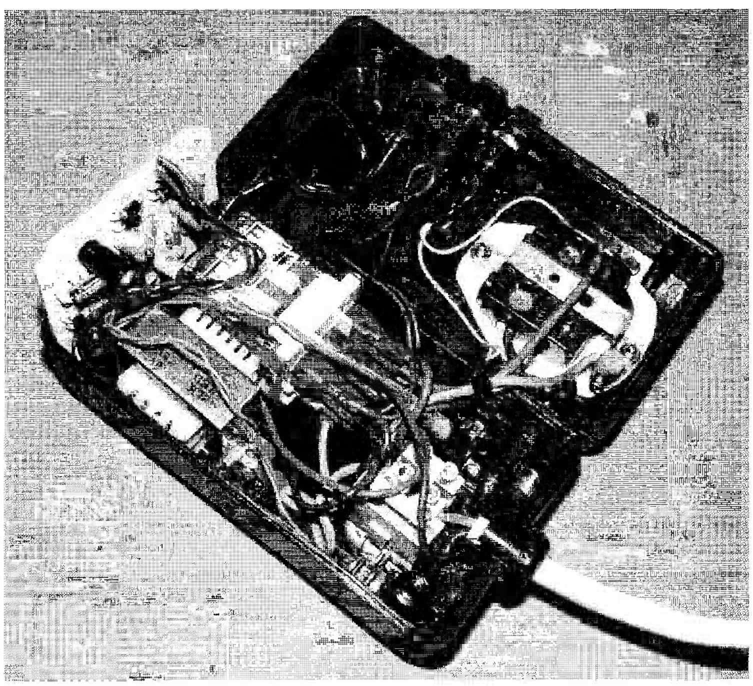
The relay should have a coil resistance of at least 100 ohms at 12V d.c. This is to limit the amount of current drawn by the whole circuit as the relay is the major consumer of current!

Note that the operate and release times are totally unimportant in this application – you won't need to specify a more expensive relay simply for the sake of speed of operation. If sourcing a three-pole relay becomes difficult, you could use two separate relays so long as the coil resistance of the two combined does not draw more than 120mA or so altogether.

INSTALLATION AND OPERATION

Various methods of attaching the box to the ironing board include the use of adhesive TY-wrap bases (as in the





prototype) or pipe clips so that it can be detached when desired.

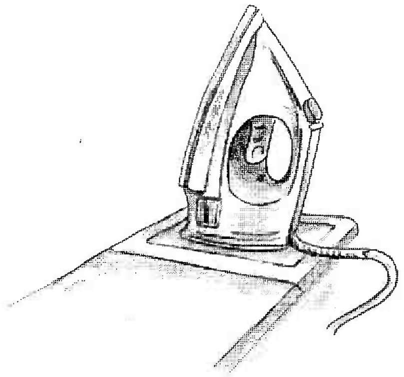
Mount the unit as close as reasonable to the part of the board where the iron is often laid to rest. Orientation does not matter as far as the vibration sensor is concerned, but the switches should be accessible.

Instructing the user of the ironing board (once he or she is happy with it being attached!) is very straightforward. Simply plug the unit into the wall, and the clothes iron into the unit. Press the On button and wait as usual until the iron is hot.

If you hear a beep, it means the unit will soon go off unless you tap it or use the iron. Observe the neon lamp to see if the iron is still on. To switch off, press and hold the Off button until the lamp goes out.

After the unit has been in use for some time, you may find that the timing settings are not quite to the satisfaction of the user. Remember that you can alter the component values!

Happy ironing!



SHOP TALK

with David Barrington

Voice Record/Playback Module

Only the ID1416P ChipCorder "natural voice" integrated circuit chip, used in the Voice Record/Playback module, will take some finding locally.

To date, the only outlet we have found for readers is from **Maplin** (☎***http://www.maplin.co.uk***), code NM47B. At the time of writing they tell us that stocks are low, but more are on order. They also supply a suitable electret microphone insert, type EM-10B (code QY62S) or type EM-60B (code FS43W).

The small printed circuit board is available from the *EPE PCB Service*, code 225 (see page 308). As for the loudspeaker (which must be 16 ohms or more), you may have to opt for a 64 ohm impedance version if you are looking for one less than 76mm (3in.) diameter (Maplin Hi-Z range); depending, of course, on the size of case used. You may even be contemplating putting the project into your favourite soft toy – your very own Furbie!

Versatile Event Counter

There should be no problems finding a suitable electret microphone insert for the *Versatile Event Counter* as many of our advertisers, including Maplin (FS43W), seem to stock them.

These omni-directional electret "condenser" microphones are usually listed as ultra or sub-miniature types and either will do in this circuit. Likewise, the small plastic box, or one with almost identical (larger) measurements should be readily available.

The vast majority of 2-line 16-character l.c.d. modules appear to use the same chipset line-up and interwiring arrangement (but check when purchasing), so they should not give any sourcing troubles. You could try **Greenweld** (***http://www.greenweld.co.uk***), who occasionally give discounts on these devices. The one in the model originally came from **Magenta** (***http://magenta2000.co.uk***) and they still have stocks.

The printed circuit board for this project is the same one that was used for the *PIC Tape Measure* published in the November '98 issue of *EPE*. This board is available from the *EPE PCB Service*, code 207. Readers will have to make their own minor corrections to the p.c.b. to adapt it for the *Versatile Events Counter.*

For those readers who do not have the facilities to program their own PIC chips, a ready-programmed PIC16C84 microcontroller is available from **Magenta Electronics** (☎ ***01283 565435*** for the all inclusive sum of £5.90 (overseas readers add £1 for postage).

If you do intend to do your own programming, the software listing is available from the Editorial Offices on a 3·5in. PC-compatible disk, see *EPE PCB Service* page. There is a nominal admin charge of £2.75 each (UK), the actual software is *Free*. For overseas readers, the charge is £3.35 surface mail and £4.35 airmail. If you are an Internet user, it can be downloaded *Free* from our FTP site: **ftp://ftp.epemag.wimborne.co.uk/pub/PICS/eventcounter.**

Ironing Board Saver

A number of components needed to construct the *Ironing Board Saver* come into the category of being "special" and may be difficult to locate. But first we must endorse all the comments about the dangers of working with mains voltages and advise readers to take extra care when building this project.

For the mains transformer, the author suggests readers use one of the 250mA miniature, wire-ended, types from **Maplin**. He suggests the 6V-0V-6V version (not using the centre-tap) code VN14Q.

All the semiconductors, including the 40106BE Schmitt inverter i.c., should be widely stocked. When ordering the i.c., stress that it must be the "buffered" version; suffix BE.

The biggest problem will be in finding a 3-pole mains rated relay that meets all the design requirements. The only one we can recommend is manufactured by Finder (62 series) and stocked by **Farnell** (☎ ***0113 263 6311*** or ***http://www.farnell.com***), code 606-625. This 3-pole relay has a 12V 110 ohm coil, "normal open" contacts rated at 16A, and has a 3mm gap between the open contacts. If possible, use nylon nuts and bolts to fix the relay in the case.

All the switches and neon indicator used in the prototype model came from Maplin, codes FF96E (square push, black), FF98G (square push, red) and RX82 for the panel mounting neon. The metal cased, single pin, mercury vibration sensor switch carries the code UK57.

This just leaves us with the mains socket panel, 3-way fused mains terminal block and the printed circuit board. The circular, panel mounting mains socket came from Farnell, code 107-721 and the terminal block from Maplin, code GU72P.

The single-sided printed circuit board is available from the *EPE PCB Service*, code 224 (see page 308 for price).

Mechanical Radio

To save some possible problems regarding component sourcing, a kit of components consisting of the motor, 1 Farad capacitor, 2mm spindle and gears is available *(mail order only)* from the author at £7.50 including postage (add £2 extra for overseas orders). Send cheque/postal order/bank draft to: **B. Trepak, 20 The Avenue, London W13 8PH.**

An excellent range of low-voltage motors, gears and gear wheels are also stocked by **Squires** (☎ ***01243 842424***) and **Magenta** (☎***012283 565435***). For the ferrite rod aerial, try **Bull Electrical** (☎***01273 203500***), **J&N Factors** (☎ ***011444 881965***), or **ESR Electronic Components** (☎ ***0191 251 4363***).

You may need to cut down the ferrite rod to the required size (50mm x 10mm dia.), if you use a small case. Be extra careful here as ferrite is very brittle! The author suggests that some suppliers list ready-wound ferrite aerials and matching tuning capacitors – we have yet to locate one. The small 10pF to 260pF tuning capacitor is usually found listed as a "transistor radio tuning capacitor" in catalogues.

The printed circuit board is available from the *EPE PCB Service*, code 226 (A and B).

PhizzyBot

The microswitches for this part were bought by the author from Farnell, part number 624-688. Nothing else deserves special note.

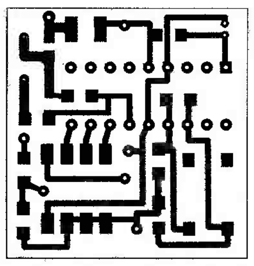
PLEASE TAKE NOTE

Wireless Monitoring System *(Feb '99)*

Fig.4 and Fig.6. The author informs us there is an error on the circuit for the Transmitter, for which he apologises. On the circuit diagram, capacitor C3 should be connected on the other side of resistor R5 nearest the PIC.

Regarding the p.c.b. Carefully cut the copper track (component side) connecting C3, L1 and R5 at the C3 contact **BEFORE** the junction with the track to resistor R5. Next, solder a small wire link from the "free end" of C3 to R5 at IC1 pin 13 end. As a precaution, remove the PIC from its socket during this operation.

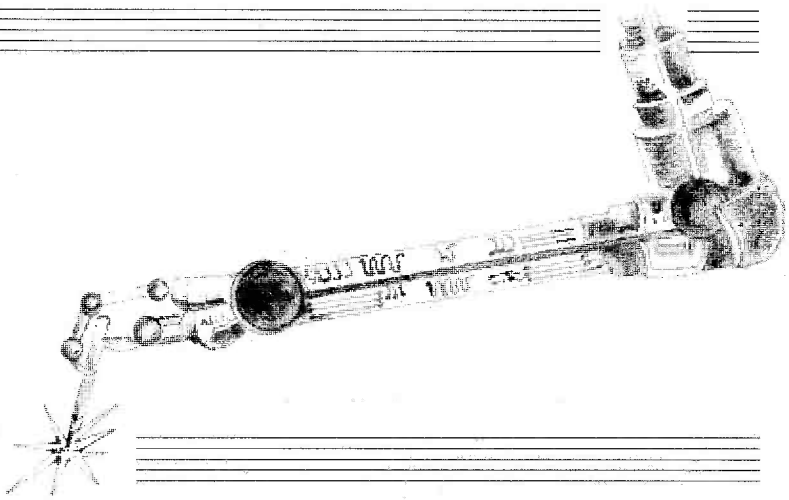
We have corrected the component side foil master pattern diagram below:



FULL SIZE – COMPONENT SIDE

Regular Clinic

CIRCUIT SURGERY



ALAN WINSTANLEY

Our monthly round-up of readers' queries and comments starts with an in-depth examination of solid-state relays, plus d.c. motor control, electret microphone f.e.t.s and more!

Solid state relays

One reader is building a powerful model boat but has a few problems deciding the best way to control the two motors:

I have to power a model boat that will use two motors rated as 6V 10A. The electronic speed control is no problem since I've already made several types of controller all suitable for the model. However, I need a double-pole relay for each motor.

I can find relays suitable for a 6V supply but no more than 8A current rating. I've found some relays which could cope with up to 15A but they are all physically too big and, what is worse, they require no less than 12V d.c. to operate! I've heard that so called "solid state relays" can deal with heavy currents but I don't know how to use them or how to insert such components in a circuit. Could you help with a solution?

Many thanks from **Fernando Bentes de Jesus**, *Portugal.*

I thumbed through some heavyweight catalogues and the nearest I managed was a single pole 6V 10A p.c.b. relay (Maplin JM66W) but most "power relays" are designed for 12V automotive or 24V process control use. Relay ratings were described in the December '98 edition of *Circuit Surgery*.

Alternatives to ordinary electromagnetic relays include solid-state relays (SSRs) which are all-electronic switching devices that incorporate an opto-isolator or other device for safety: the idea is to keep the sensitive signal well away from the load. Your requirement for double-pole operation could be a problem though, because SSRs don't exactly come cheap and they are inherently "single-pole" devices. Some types include zero-voltage switching for a.c. power control circuits to eliminate noise on the a.c. supply (they only switch on at zero volts or off at zero current). Manufacturers of SSRs include Crydom (**www.crydom.com**) and International Rectifier (**www.irf.com**).

Solid-state relays are especially useful where control signals (e.g. digital outputs

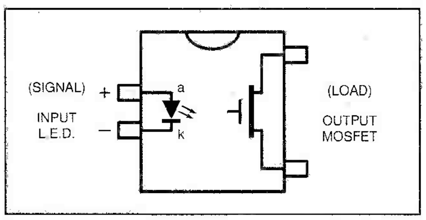


Fig. 1. A photovoltaic MOSFET-type of solid-state relay in a dual-in-line package.

from a microcontroller) are to be interfaced with external heavy a.c. or d.c. loads. They start with small dual-in-line types capable of handling a hundred milliamps, all the way up to large chassis-mounting devices which will carry 125A! They usually use an opto-emitter in place of a relay "coil" and a MOSFET or thyristor for the relay "contacts".

The most common specifications to look for include load voltage (equivalent to the "relay contact voltage"), since the output is switched by a semiconductor power device, this rating states the maximum load voltage permitted. An SSR may either be current or voltage-controlled, depending on its type. A control voltage ("relay coil voltage") can be anything from 3V to 15V or so, whilst a typical control current will be 2-5mA, say.

Also of interest, of course, is the load current: a tiny d.i.l. SSR will handle maybe 70-100mA but large chassis-mounting versions will cope with 25-100A or more. Instead of a relay contact resistance, an "on-state" resistance of a few tens of ohms might be typical. Just for interest, the dielectric strength (also called the isolation rating) indicates how effective such devices really are at separating the load from the signal before the device fails. A value of 2,500V to 5,000V is typical, which is the maximum input/output potential of the solid state relay. The insulation resistance indicates the same thing, only expressed in ohms (say 10^9 ohms).

These devices offer many advantages over ordinary electromechanical relays: they have no moving parts, so there are no contacts to arc or "soot" or generate interference, they are smaller than a comparable relay, and are more power efficient as well. Problems of back-e.m.f. in the relay coil are also eliminated, although some SSRs may need e.m.f. protection on their output instead, to protect them from inductive loads.

Photovoltaic relays

So a solid state relay sounds ideal for the job – but there are still a few more considerations (not least of which is cost). There are several types of SSR – one is a photovoltaic relay which has a MOSFET output. They start at £4-£5 each, and the "photovoltaic" label comes from the fact that they have a light-sensitive voltage source inside (a series of on-chip photovoltaic cells) which produces a voltage when light shines on it (the Photovoltaic Effect). The light is emitted by a separate input l.e.d. (Fig.1), hence the opto-isolation. The photo-voltage generates a control signal which turns on the output transistors and completes the circuit to the load, which can be anything from d.c. to r.f.

Catalogues sometimes highlight this type of SSR by calling them Photovoltaic MOSFET solid-state relays. They can usually be used for a.c. or d.c. loads but they may already include protection diodes on the output so check the data first. In some of their photovoltaic relays, the manufacturer International Rectifier uses a single-chip power i.c. dubbed a BOSFET (a bi-directional MOSFET) for the output drivers, which enables both a.c. and d.c. loads to be switched by the solid state relay.

MOSFET-type solid-state relays in a dual-in line style are restricted to a lower power level (say from 100mA to a few amps). Larger ones are panel-mounted in a bolt-down package which can carry much higher currents.

A second type of SSR uses a thyristor (SCR) or a triac to switch a.c. power loads. These may include extra functions such as zero-crossing switching and dv/dt transient protection. If you don't see "MOSFET" mentioned in the description, the device is probably this latter thyristor variety. I

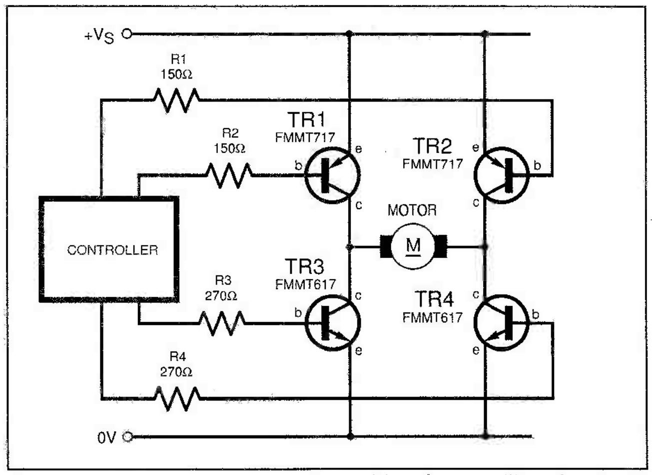


Fig.2. 'H' bridge motor driver capable of controlling the direction of the d.c. motor (2·5A maximum) – courtesy Zetex.

hesitate to speculate on the effects of using such a device on a continuous d.c. load instead, though.

I did indeed manage to locate a MOSFET type solid state relay which will technically fit the bill but the price may rule it out. The International Rectifier 1-DC Series are d.c. output relays with MOSFET outputs. The D1D12 (e.g. Farnell Part No. 280-276) is rated at 12A d.c. They are provided in bolt-down packages, and data sheets are available from the IR web site (look for Series 1DC data). However, this type works in a slightly different way: they are actually transformer-coupled internally, so the input signal powers a 50kHz oscillator which is current limited and functions over a range of 3·5V-32V d.c. at 1.6mA-28mA.

I am afraid the really bad news is the price – they are some £35 each + VAT, but there is probably no neater self-contained alternative to a relay. There are some useful "H-bridge" motor controller chips available (e.g. Allegro's 2953 is a complete pulse-width modulation motor controller) but I am not sure that the need for 10A will be met with a fully integrated device, as the largest of these tend only to handle a couple of amps. Fig.2 shows how an H-bridge is configured: the motor can be made to reverse simply by switching over diagonally-opposed transistors, which swaps the polarity of the motor voltage.

The best compromise is probably a motor driver chip coupled to external power transistors. You could try using say the SGS-Thomson L292 (Farnell 407-550), which is a 2A controller, and add external power transistors to supply higher currents. An application circuit is shown in Fig.3 which gives the general idea but has not been proven by us, and the maker's device notes must be consulted for more information. It is suggested that the circuit could deliver up to 8A or so with the 15A 125W TO-3 power transistors shown.

Electret microphones – the plot thickens...

In the February '99 issue I described the basic construction of an electret microphone, showing how a typical miniature capsule consists of a metallised disc "diaphragm" which forms one side of an air-spaced capacitor of a few picofarads in value. The other capacitor "plate" was welded directly to the terminal of a mysterious JFET transistor and trying to track down the actual "K596" type used in my example was somewhat of a marathon. After some detective work on the Internet, I was still not much wiser about the identity of that "K596" transistor but I found likely-looking alternatives suggested by semiconductor web sites.

Last month, aided by regular reader/contributor ***Barry Taylor***, we concluded that the transistor must be a 2SK596 though its data eluded us still. I am extremely grateful to ***Bob Schoomaker*** of Woodside, New York, USA whom I know is an avid reader of *EPE*. He E-mailed me with further interesting background information as follows, which will be of interest especially to those who deal with Asian transistors:

I was just reading your Feb '99 Circuit Surgery *column, and dug out my "spares" box, as I remembered cannibalising several old electret mics from both Panasonic and Murata. All had the same construction as shown in your Fig.2 (page 135), minus what appears to be a resistor on the p.c.b., although they all used the 2SK50 JFET which is listed in the* Towers' International MOS Power and Other FET Selector Update Number 1, 1994.

The convention for labelling most Asian semiconductors using the EIAJ system (Electronic Industry Association of Japan) is to drop the 2S, and mark the part with only K50 (K = N-channel, J = P-channel). Unfortunately, the 2SK596 was not listed in Towers'. However, it was listed in a Japanese publication similar to the Towers' book, whose only English cover lettering says: '95 The FET Manual No. 4 – *CQ Publishing (ISBN4-7898-4324-6), available in the USA from MCM Electronics* (**www.mcmelectronics.com**) *and there is also a standard BJT version, part number 81-1205, same price (ISBN 4-7898-4321-1). Both are very handy in an area where in my view Towers' is weak.*

The 2SK596 depletion mode JFET is listed in the "Use" column specifically for use as a "C-mic" (condenser microphone). Other specs are as follows:

(V_{ds} = 5V): V_{gd} = −20V; P_d = 100mW; I_{dss} = 0·1mA min/0·8mA max; V_{gs} off = −1·5V max for 1µA; G_m = 0·4mS min/1·2mS max; C_{iss} = 3·5pf typ; C_{rss} = 0·65pf typ.

With regard to the availability of the 2SK596, I could find only one distributor with stock; a company in Russell, Pennsylvania called B&D Enterprises

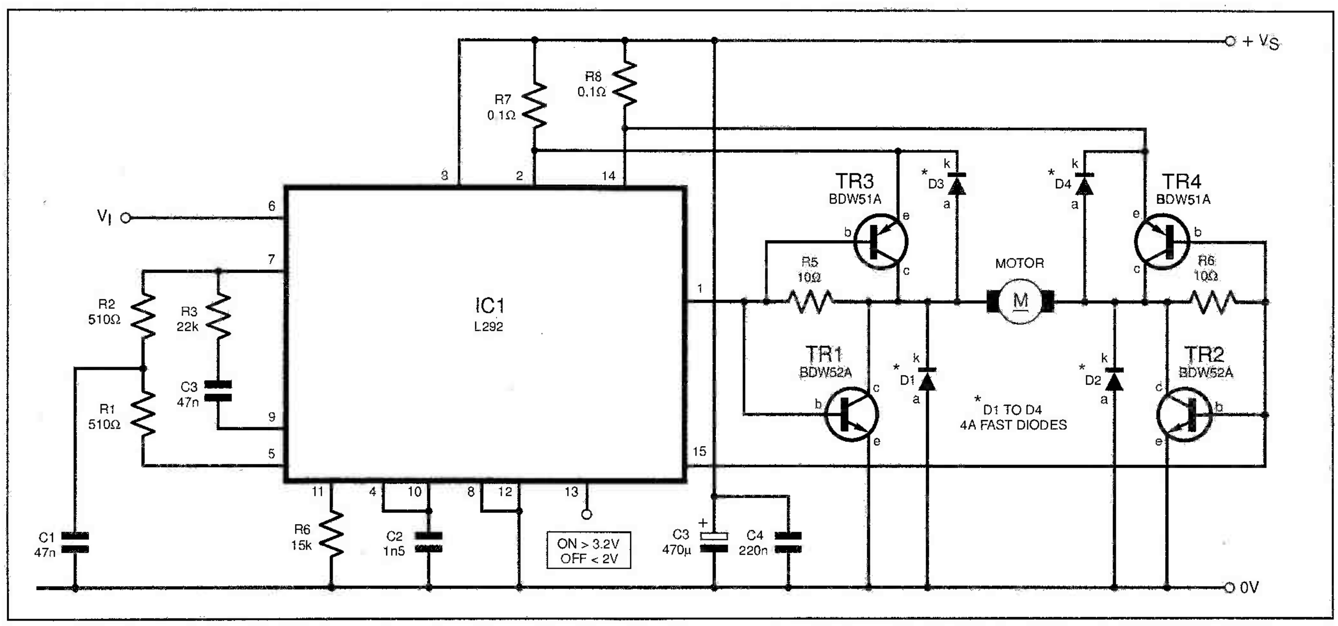


Fig.3. A high power motor controller suitable for 8A d.c. motors, with external power transistor bridge – courtesy SGS-Thomson.

*International (***www.bdent.com***), which is the credit card/mail order arm of Ten-Four Ltd, a major Asian semiconductor importer and distributor in the US. I called B&D who said the 2SK596 was a proprietary Sanyo part discontinued in 1991. This was confirmed by Sanyo Corporation in the US, adding that before the 2SK596 was discontinued, it had been supplanted by the newer 2SK1578, which is a direct replacement with improved noise and other specs. It will remain a current production part for the foreseeable future. Data for all current-production Sanyo devices is available at:*
www.semic.sanyo.co.jp/english/index-e.html.

After further examination of The FET Manual, *it seems that the 2SK595 and 2SK597 both have identical specs to the 2SK596. The only difference is the pin-out – which for the 2SK595 is GSD; for the 2SK596 is DGS; and for the 2SK597 is GDS.*

*Just thumbing through the manual, I was surprised by the number of devices specifically listed for use as "C-mic" (23 additional). I suspect any of them will work quite satisfactorily, as all have very close parameters. More importantly, while at another Radio Shack (*Tandy stores in the UK, which were recently sold off to Carphone Warehouse – ARW*), I spotted some blister-pack styles for the electret capsules. Upon examination I noticed to my surprise that they had the 2SK596 JFET you encountered, but without the resistor, just as I found in the mics containing the 2SK50.*

Bob Schoomaker confirms something which many readers may not be aware of, namely the practice of omitting the "2S" in Asian device type markings, although this can sometimes create even more confusion: for instance I have a bag full of (European) BC548C transistors which are marked as "C548C". Only with experience are you likely to know whether a device type number commences with a "B" or whether it's likely to be an Asian "2S" type.

The microphone manufacturer probably picked the 2SK596 because it had the desired pinouts, so that the transistor could be orientated inside the capsule in a particular direction. The example of the elusive f.e.t. also proves the value of having access to appropriate data books, and again with experience you will soon know where to look on the World Wide Web for information. My *Net Work A-Z* index contains every URL that I have linked to ever since that column began, and is a good starting point for Internet users embarking on some electronics-related research. Once again, my thanks to our readers for providing the extra input.

Endangered Species

The Internet is also useful for tracking down any pockets of odd, obsolete devices, or at least finding out the current status of an obscure semiconductor chip, as prompted by this enquiry:

I was wondering whether you could find out whether or not the General Instrument SPO256-AL2 speech synthesis i.c. is available anywhere or even still in production. It is mentioned in an old robotics book (published in 1987) I bought from a car boot sale – I was intrigued by this particular circuit because it allows a PC or C64 to talk! Also, the SPO256-AL2's sister i.c., the CTS256-AL2, converts ASCII into speech. Many thanks for anything you can do. **Joseph Birr-Pixton**.

Some research on Usenet and Web sites revealed that the SP0256-AL was produced by General Instruments very many years ago, but I gather that GI sold off their chip manufacturing division to Arizona Microchip and the SP0256 has long since bitten the dust. An attractive range of voice synthesis chips is manufactured by Information Storage Devices Inc (ISD) and is retailed by Maplin and others. Try **www.isd.com** for details.

The question of obsolete chips is quite a pertinent one, and sudden chip deletions cause at lot of headaches for ourselves as well as our readers. If a chip is listed in a catalogue and possibly included on a catalogue CD then it seems reasonable to assume that it should be readily available from that supplier. Savvy designers know only too well, though, that catalogues cannot always be relied on and they may try to seek confirmation from the manufacturer to determine the likely availability.

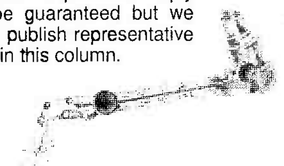
To be fair, catalogues themselves have a long shelf life and it is quite common to find that devices have been withdrawn (overnight, sometimes, when remaining stocks just vanish) after a catalogue has gone to press. I have found it to be unrealistic to expect that just because a chip is listed in a catalogue, it is always still available in a reasonable quantity. It may have been delisted, or there may only be a handful left, and a direct substitution may not be possible.

I noticed that National Semiconductor list devices on their web site which they have discontinued or which are likely to be discontinued in the future: look for the Obsolete Products Listing at **www.national.com**. It's a 400K text file which some engineers and buyers may find handy. (Some hobbyists will be dismayed to learn that National finally drowned the useful LM1830N fluid level detector in December 1998; remember the fun LM3909 l.e.d. flasher/oscillator and the handy LM3911 temperature controller? They were both ditched as far back as April 1995. I hope the indispensable LM3914N bargraph driver doesn't suffer the same fate.)

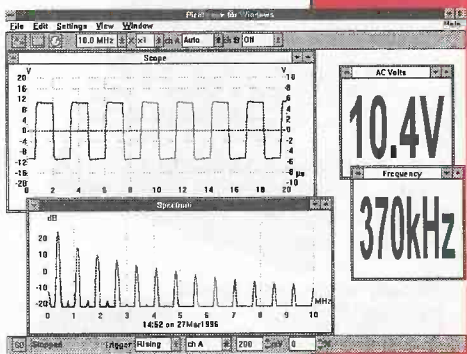
One final point Joseph, I know you are a regular contributor to the *EPE Chat Zone* on our Internet site, so here's a "thank you" from us all for helping to keep our Internet message board system running in the spirit in which it is intended.

CIRCUIT THERAPY

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



Transform your PC.... Into an oscilloscope, spectrum analyser and multimeter...



The ADC-200 range of PC based oscilloscopes offer performance only previously available on the most expensive `benchtop' scopes. By intergrating several instruments into one unit, the ADC-200 is both flexible and cost effective.

Connection to a PC gives the ADC-200 the edge over traditional oscilloscopes: the ability to print and save waveforms is just one example. Units are supplied with PicoScope for Windows which is powerful, yet simple to use, with comprehensive on line help.

Applications

- Video
- Automotive
- Electronics design
- Production line tests
- Fault finding
- Education

All units are supplied with software, cables and power supply. Prices exclude VAT.

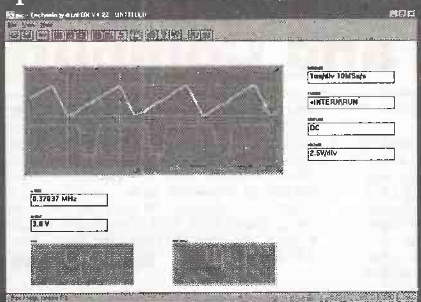
Features

- A fraction of the cost of comparable benchtop oscilloscopes
- Up to 100 MS/s sampling
- Advanced tigger modes- capture one off events.
- Up to 50 MHz spectrum analyser
- Large buffer memory

ADC-200/100	£499
ADC-200/50	£399
ADC-200/20	£299

A scope at your fingertips......

Once oscilloscopes were heavy and clumsy to handle, but over the years they have become smaller and smaller. The latest development in this field has just arrived: a digital storage oscilloscope in a handy slim housing, scarcely longer than a pencil and about as thick as your thumb. Despite its small size, its performance can match that of a service oscilloscope.



ONLY £80

Applications

- On-the-spot measurements
- Hobby electronics
- Measurements in amplifiers
- Production line tests

- Can use PC display
- Sample rates from 50ns to 1ms
- Up to 20 MS/s

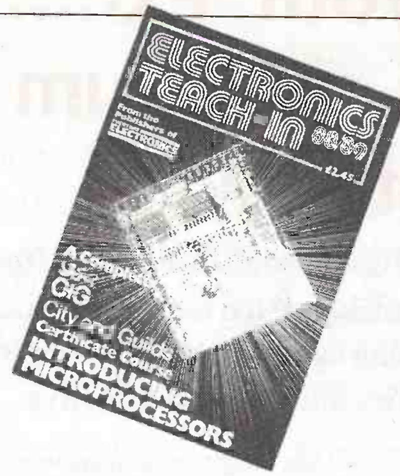
Prices exclude VAT

Call for a FREE software demonstration disk or visit our web site

Fax: +44 (0)1954 211880 Tel: +44 (0)1954 211716
E-mail: post@picotech.co.uk Web: www.picotech.com

pico® Technology Limited

Everyday Practical Electronics Books



TEACH-IN No. 7 plus FREE Software
ANALOGUE AND DIGITAL ELECTRONIC COURSE
FREE SOFTWARE
(Published by *Everyday Practical Electronics*)
Alan Winstanley and Keith Dye B.Eng(Tech)AMIEE

The highly acclaimed *Teach-In* series, which included the construction and use of the *Mini Lab* and *Micro Lab* test and development units, has been put together in book form. Additionally EPT Educational Software have developed a GCSE Electronics software program to compliment the course and a FREE DISC covering the first two parts of the course is included with the book.

An interesting and thorough tutorial series aimed specifically at the novice or complete beginner in electronics. The series is designed to support those undertaking either GCSE Electronics or GCE Advanced Levels, and starts with fundamental principles.

If you are taking electronics or technology at school or college, this book is for you. If you just want to learn the basics of electronics then this is for you. If you are teaching electronics or technology you must make sure you see it. *Teach-In No. 7* will be invaluable if you are considering a career in electronics or even if you are already training in one. The Mini Lab and software enable the construction and testing of both demonstration and development circuits. These learning aids bring electronics to life in an enjoyable and interesting way: you will both see and hear the electron in action! The Micro Lab microprocessor add-on system will appeal to higher level students and those developing microprocessor projects.

152 pages **Order code TI7** **£3.95**

ELECTRONICS TEACH-IN 88/89 – INTRODUCING MICROPROCESSORS
Mike Tooley BA (published by *Everyday Practical Electronics*)

A complete course that can lead successful readers to the award of a City and Guilds Certificate in Introductory Microprocessors (726/303). The book contains everything you need to know including full details on registering for assessment, etc. Starting with basic terminology, integrated circuits, logic families and numbering systems the text builds in stages, with revision and assessments built in, up to programming, languages, flow charts, etc. The course is ideal for the newcomer to the subject.

80 pages (A4 size) **Order code TI-88/89** **£2.45**

DIRECT BOOK SERVICE

The books listed have been selected by Everyday Practical Electronics editorial staff as being of special interest to everyone involved in electronics and computing. Books are supplied by mail order direct to your door. Full ordering details are given on the last book page.

For another selection of books see the next two issues of EPE.

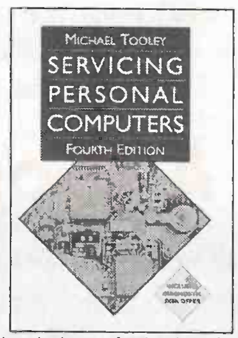
Testing and Test Gear

HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT
R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers, and crystal calibrators.

104 pages **Order code BP267** **£3.50**

SERVICING PERSONAL COMPUTERS – 4th EDITION
Mike Tooley BA



The revised and enlarged forth edition has been completely re-written to cover the latest technology, such as 32-bit microprocessors and serial communications servicing. It includes a diagnostic disk offer. Essential for anyone concerned with the maintenance of personal computer equipment or peripherals, whether professional service technician, student or enthusiast.

387 pages Hardback **Order code NE15** **£30**

Radio, TV, Satellite

BASIC RADIO PRINCIPLES AND TECHNOLOGY **NEW**
Ian Poole

Radio technology is becoming increasingly important in today's high technology society. There are the traditional uses of radio which include broadcasting and point to point radio as well as the new technologies of satellites and cellular phones. All of these developments mean there is a growing need for radio engineers at all levels.

Assuming a basic knowledge of electronics, this book provides an easy to understand grounding in the topic.

Chapters in the book: Radio Today, Yesterday, and Tomorrow; Radio Waves and Propagation; Capacitors, Inductors, and Filters; Modulation; Receivers; Transmitters; Antenna Systems; Broadcasting; Satellites; Personal Communications; Appendix – Basic Calculations.

263 pages **Order code NE30** **£14.99**

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold

This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.

92 pages **Order code BP304** **£3.95**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century.

This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages **Order code BP257** **£4.99**

SIMPLE SHORT WAVE RECEIVER CONSTRUCTION
R. A. Penfold

Short wave radio is a fascinating hobby, but one that seems to be regarded by many as an expensive pastime these days. In fact it is possible to pursue this hobby for a minimal monetary outlay if you are prepared to undertake a bit of d.i.y., and the receivers described in this book can all be built at low cost. All the sets are easy to costruct, full wiring diagrams etc. are provided, and they are suitable for complete beginners. The receivers only require simple aerials, and do not need any complex alignment or other difficult setting up procedures.

The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.

Contains everything you need to know in order to get started in this absorbing hobby.

88 pages **Order code BP275** **£3.95**

Computers and Computing

MULTIMEDIA ON THE PC
Ian R. Sinclair

In this book, you'll find out what a CD ROM is, how it works, and why it is such a perfect add-on for a PC, allowing you to buy programmes, text, graphics and sound on a CD. It also describes the installation of a CD ROM drive and a sound card, pointing out the common problems that arise, and then shows how to use them to create a complete multimedia presentation that contains text, photos, a soundtrack with your own voice recorded as a commentary, even animation and edited video footage.

184 pages **Order code PC112** **£11.95**

UNDERSTANDING PC SPECIFICATIONS
R. A. Penfold (Revised Edition)

If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.

This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!

128 pages **Order code BP282** **£4.95**

Our postage is the same no matter how many books you buy – just £1.50 in the UK.

Theory and Reference

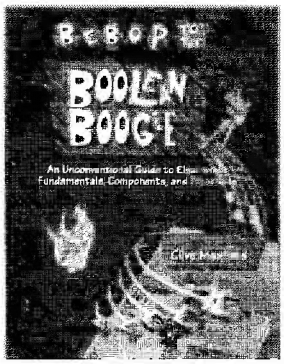
Bebop To The Boolean Boogie

By Clive (call me Max) Maxfield

ORDER CODE BEB1

£24.95

470 pages. Large format



Specially imported by EPE – Excellent value

An Unconventional Guide to Electronics Fundamentals, Components and Processes

This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean algebra and Karnaugh maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more (including a recipe for a truly great seafood gumbo!). Hundreds of carefully drawn illustrations clearly show the important points of each topic. The author's tongue-in-cheek British humor makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. A great reference for your own shelf, and also an ideal gift for a friend or family member who wants to understand what it is you do all day....

DIGITAL ELECTRONICS – A PRACTICAL APPROACH **FREE SOFTWARE**
With FREE Software: Number One Systems – EASY-PC Professional XM and Pulsar (Limited Functionality)
Richard Monk

Covers binary arithmetic, Boolean algebra and logic gates, combination logic, sequential logic including the design and construction of asynchronous and synchronous circuits and register circuits. Together with a considerable practical content plus the additional attraction of its close association with computer aided design including the FREE software.

There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.

Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.

250 pages **Order code NE28** **£16.99**

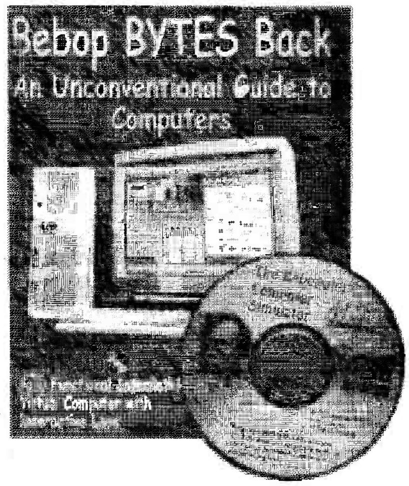
Bebop Bytes Back **FREE CD-ROM**

By Clive "Max" Maxfield and Alvin Brown

ORDER CODE BEB2

£29.95

Over 500 pages. Large format



Specially imported by EPE – Excellent value

An Unconventional Guide To Computers

Plus **FREE CD-ROM** which includes: Fully Functional Internet-Ready Virtual Computer with Interactive Labs

This follow-on to Bebop to the Boolean Boogie is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the accompanying CD-ROM (for Windows 95 machines only) contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the book contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this one!

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages **Order code PC106** **£8.95**

Audio and Music

AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN
V. Capel

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him – or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.

148 pages **Order code BP256** **£3.99**

ACOUSTIC FEEDBACK – HOW TO AVOID IT
V. Capel

Feedback is the bane of all public address systems. While feedback cannot be completely eliminated, many things can be done to reduce it to a level at which it is no longer a problem.

Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving acoustics. Some microphones are prone to feedback while others are not. Certain loudspeaker systems are much better than others, and the way the units are positioned can produce a reduced feedback. All these matters are fully explored as well as electronic aids such as equalizers, frequency-shifters and notch filters.

The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

Also included is the circuit and layout of an inexpensive but highly successful twin-notch filter, and how to operate it.

92 pages **Order code BP310** **£4.99**

PREAMPLIFIER AND FILTER CIRCUITS
R. A. Penfold

This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases). The preamplifier circuits featured include: Microphone preamplifiers (low impedance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A. equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier (for use with compact cassette systems).

Other circuits include: Audio limiter to prevent overloading of power amplifiers. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Audio mixers. Volume and balance controls.

92 pages **Order code BP309** **£4.99**

COMPUTERS AND MUSIC – AN INTRODUCTION
R. A. Penfold

Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully

174 pages **Order code PC107** **£8.95**

ELECTRONIC PROJECTS FOR GUITAR
R. A. Penfold

This book contains a collection of guitar effects and some general purpose effects units, many of which are suitable for beginners to project building. An introductory chapter gives guidance on construction.

Each project has an introduction, an explanation of how it works, a circuit diagram, complete instructions on stripboard layout and assembly, as well as notes on setting up and using the units. Contents include: Guitar tuner; Guitar preamplifier; Guitar headphone amplifier; Soft distortion unit; Compressor; Envelope waa waa; Phaser; Dual tracking effects unit; Noise gate/expander; Treble booster; Dynamic treble booster; Envelope modifier; Tremelo unit; DI box.

110 pages **Temporarily out of print**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold

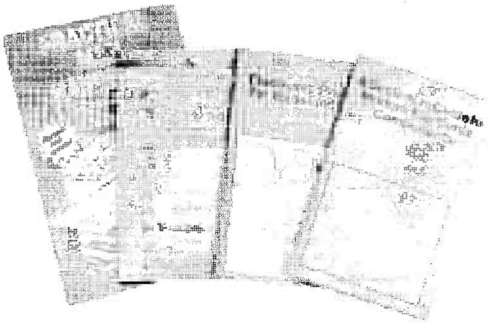
Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.

96 pages **Order code BP277** **£3.99**

Circuits, Data and Design

PRACTICAL ELECTRONIC FILTERS
Owen Bishop
This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.
The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.
Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.
88 pages **Order code BP299** **£4.99**

ELECTRONIC HOBBYISTS DATA BOOK
R. A. Penfold
This book should tell you everything you are ever likely to want to know about hobby electronics, but did not know where to ask or refer. Comprehensive contents pages makes it easy to quickly locate the data you require.
The subjects covered include: Common circuits, and related data (including helpful graphs and tables of values); Colour codes for resistors, capacitors and inductors; Pinout details for a wide range of CMOS and TTL devices, plus basic data on the various logic families; Pinout details and basic data for a wide range of operational amplifiers; Data and leadout information for a wide range of transistors, FETs, power FETs, triacs, thyristors, diodes, etc; General data including MIDI message coding, radio data, ASCII/Baudot coding, decibel ratios, etc.
242 pages **Order code BP396** **£5.95**



50 SIMPLE LED CIRCUITS
R. N. Soar
Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components – the light-emitting diode (LED). Also includes circuits for the 707 common anode display.
64 pages **Order code BP42** **£2.99**

BOOK 2 50 more l.e.d. circuits.
50 pages **Order code BP87** **£2.99**

CIRCUIT SOURCE BOOK 1
A. Penfold
Written to help you create and experiment with your own electronic designs by combining and using the various standard "building block" circuits provided. Where applicable, advice on how to alter the circuit parameters is given.
The circuits covered in this book are mainly concerned with analogue signal processing and include: Audio amplifiers (op.amp and bipolar transistors); audio power amplifiers; d.c. amplifiers; highpass, lowpass, bandpass and notch filters; tone controls; voltage controlled amplifiers and filters; triggers and voltage comparators; gates and electronic switching; bargraphs; mixers; phase shifters, current mirrors, hold circuits, etc.
Over 150 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
182 pages **Order code BP321** **£4.99**

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold
This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world"
142 pages **Order code BP332** **£4.95**

HOW TO USE OP.AMPS
E. A. Parr
This book has been written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.
160 pages **Order code BP88** **£3.99**

CIRCUIT SOURCE BOOK 2
R. A. Penfold
This book will help you to create and experiment with your own electronic designs by combining and using the various standard "building blocks" circuits provided. Where applicable, advice on how to alter the circuit parameters is provided.
The circuits covered are mainly concerned with signal generation, power supplies, and digital electronics.
The topics covered in this book include: 555 oscillators; sinewave oscillators; function generators; CMOS oscillators; voltage controlled oscillators; radio frequency oscillators; 555 monostables; CMOS monostables; TTL monostables; precision long timers; power supply and regulator circuits; negative supply generators and voltage boosters; digital dividers; decoders, etc; counters and display drivers; D/A and A/D converters; opto-isolators, flip/flops, noise generators, tone decoders, etc.
Over 170 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
192 pages **Order code BP322** **£4.99**

Project Building

ANDROIDS, ROBOTS AND ANIMATRONS
John Lovine
Build your own working robot or android using both off-the-shelf and workshop constructed materials and devices. Computer control gives these robots and androids two types of artificial intelligence (an expert system and a neural network). A lifelike android hand can be built and programmed to function doing repetitive tasks. A fully animated robot or android can also be built and programmed to perform a wide variety of functions.
The contents include an Overview of State-of-the-Art Robots; Robotic Locomotion; Motors and Power Controllers; All Types of Sensors; Tilt; Bump; Road and Wall Detection; Light; Speech and Sound Recognition; Robotic Intelligence (Expert Type) Using a Single-Board Computer Programmed in BASIC; Robotic Intelligence (Neutral Type) Using Simple Neural Networks (Insect Intelligence); Making a Lifelike Android Hand; A Computer-Controlled Robotic Insect Programmed in BASIC; Telepresence Robots With Actual Arcade and Virtual Reality Applications; A Computer-Controlled Robotic Arm; Animated Robots and Androids; Real-World Robotic Applications.
224 pages **Order code MGH1** **£19.99**

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold
Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.
The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infrared "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.
138 pages **Order code BP371** **£4.95**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold
While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.
The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.
All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.
132 pages **Order code BP374** **£4.95**

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold
This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:
Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.
In fact everything you need to know in order to get started in this absorbing and creative hobby.
135 pages **Order code BP392** **£4.95**

A BEGINNER'S GUIDE TO MODERN ELECTRONIC COMPONENTS
R. A. Penfold
The purpose of this book is to provide practical information to help the reader sort out the bewildering array of components currently on offer. An advanced knowledge of the theory of electronics is not needed, and this book is not intended to be a course in electronic theory. The main aim is to explain the differences between components of the same basic type (e.g. carbon, carbon film, metal film, and wire-wound resistors) so that the right component for a given application can be selected. A wide range of components are included, with the emphasis firmly on those components that are used a great deal in projects for the home constructor.
166 pages **Order code BP285** **£4.99**

BOOK ORDERING DETAILS

Our postage price is the same no matter how many books you order, just add **£1.50** to your *total* order for postage and packing (overseas readers **add £3** for countries in the EEC, or **add £6** for all countries outside the EEC, surface mail postage) and send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or credit card details, Visa or Mastercard – minimum credit card order is £5 – to: **DIRECT BOOK SERVICE, 33 GRAVEL HILL, MERLEY, WIMBORNE, DORSET BH21 1RW** *(mail order only).*
Books are normally sent within seven days of receipt of order, but please allow 28 days for delivery (more for overseas orders). *Please check price and availability (see latest issue of* Everyday Practical Electronics) *before ordering from old lists.*
For a further selection of books see the next two issues of EPE.
DIRECT BOOK SERVICE IS A DIVISION OF WIMBORNE PUBLISHING LTD. Tel 01202 881749
Fax 01202 841692. Due to the cost we cannot reply to overseas orders or queries by Fax.
E-mail:dbs@epemag.wimborne.co.uk

BOOK ORDER FORM

Full name: ....

Address: ....

....

.... Post code: .... Telephone No: ....

Signature: ....

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

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

Card Number ....

Please send book order codes: ....

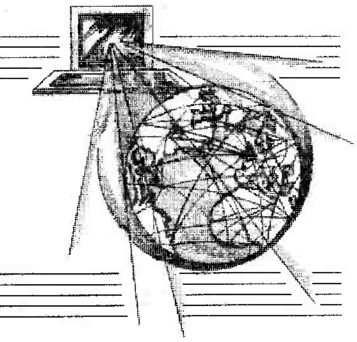
....

Please continue on separate sheet of paper if necessary

2a

SURFING THE INTERNET

NET WORK



ALAN WINSTANLEY

NET WORK is our monthly column written for readers having Internet access. We maintain our own web site at **http://www.epemag.wimborne.co.uk**, and our FTP site (**ftp://ftp.epemag.wimborne.co.uk**) contains files related to our constructional projects and more besides. Type either URL into your browser to access these sites, or better still, use an FTP client to retain full control over FTP file transfers.

FREESERVE SUPPORT COSTS LESS

Barely a day goes by without the name "Freeserve" being mentioned (**www.freeserve.com**), and this attractive free Internet access operation is now set to be hived off into a separate company. Many existing users would argue that Freeserve is every bit as good as their existing ISP, and about one million users are said to have signed up in just a few months. (If Internet access statistics are to be believed, there are now over six million Internet users in the UK alone.)

Judging by your E-mails, most Freeserve users appear to be completely happy although there have been a number of others who reportedly suffered difficulties in trying to sign up using the Freeserve CD. Problems include unwelcome alterations to software configurations which irked some experienced users, conflicts with other software or system crashes during the registration process. Another bone of contention was the price of support calls at £1 a minute, but these have recently been slashed to 50p which is welcome news.

FREESERVE SANS CD

The Freeserve FAQ Page advises that it is not possible to sign up to their service without using the Freeserve CD-ROM, although nothing which prohibits trying to do this is mentioned in Freeserve's Acceptable Use Policy (AUP), and Freeserve are also investigating whether on-line sign-up can be accommodated for the future. If you want to sign up the E-mail client on your Apple Mac incidentally, you have to use a Windows PC and then transfer the login details over. Freeserve users must access the service every 30 days to maintain their account, but dormant accounts are easily re-activated by their users.

In the February issue I pointed to an independent web site which published details of how to obtain a Freeserve account without the need to use the Freeserve CD. Unfortunately the web site in question was temporarily withdrawn soon after publication of the last Net Work column. The co-maintainers of the web site tell me that their popular instructions for connecting to Freeserve without the use of the CD have now been relocated to a more appropriate URL, and its authors have decided to generalise their previously Turnpike-specific instructions so that people using software other than Turnpike can connect to Freeserve without destroying their local setups. (Turnpike is an E-mail and newsgroup client marketed by Demon Internet which also supports other UK ISPs including Freeserve). The new URL is **www.seesaw.freeserve.co.uk/fs/fs-sans-cd.htm**. My thanks to Wm and Colin Price for keeping me posted.

BT CLICK GOES FREE

If you have a Windows 95/98 PC and all you seek is web browser access plus E-mail, then British Telecom's new "Click-Free" (**www.btclickfree.co.uk**) might be the simple way of getting off the ground. It appears to have none of the potential sign-up problems reported by a number of Freeserve users, and interestingly BT claims it is the UK's only free service which doesn't require registration. It looks to be an excellent starting point for beginners. BT Clickfree has also linked with Value Direct, which aims to offer cut-price electrical goods for Internet shoppers.

Unfortunately the launch of BT's original "Click+" (**www.btclick.com**) Internet access service coincided with that of Freeserve. BT Click charged local call rates plus 1p. per minute which, compared against Freeserve, appeared to be doomed from the start. I have now tried BT's latest offering, BT ClickFree which is a new free access service for which you only pay for the local rate phone call. The idea is that users can fire up a web browser simply at the click of a discrete desktop icon. Telephone support costs 50p per minute.

If you do not already have an existing Internet connection then a CD ROM is available (Freefone 0800 731 7887). BT Clickfree also offers the user "free-mail" (Talk21) which is currently an on-line mailbox service allied to Excite mail (the Clickfree portal site is hosted by Excite UK). Presently E-mails must be composed when connected to the web-based Talk21 mail server but a POP3 upgrade is promised, which means that offline mail composition and reading will be possible. (Excite.com has already done the same.) The BT Clickfree mail service also makes it simple to attach files to E-mails. Don't forget that you can put your modem phone number on a "BT Friends & Family" list to attract further discount.

So how good is it? I found the BT Clickfree sign-up was very smooth and extremely rapid, in the sense that the download is a tiny 70kB "setup.exe" file which can be fetched from the web site provided that you have an existing connection. This quickly installed to create an icon that launches your own pre-installed browser. During set-up, I tried to jump from the Clickfree page to create an E-mail address but this was very problematic, with lengthy delays that I eventually circumvented by hopping over direct to the Talk21 web site (**www.talk21.com**). It was soon set up, though. A single icon on the desktop is double clicked and this dials in and launches the browser, and you can access other online services too.

CHECKING OUT AT TESCO

Talking of shopping, Britain's largest supermarket chain has commissioned BT to produce TescoNet (**www.tesco.net**), a free Internet access whose primary requirement is the ownership of a Tesco loyalty Clubcard. This necessitates a visit to your nearest Tesco store, and if you don't already have an existing connection to sign up, then a TescoNet CD-ROM was scheduled to launch on February 22nd. This is another free access service with 50p. per minute telephone support. It runs on Windows 95/98 and Tesco say that Windows 3.1 and Mac are supported too, along with single channel ISDN. Customers' own homepages (10MB) are provided and TescoNet supports up to five POP3 mailboxes, permitting off-line E-mail composition. POP3 mail allows you to usually fetch mail even if you have dialled in using another Internet provider, or you have moved location (e.g. you may be at work rather than at home, noting that commercial use of TescoNet is prohibited).

Registration is performed by logging on to **http://register.tesco.net** and answering a few minor questions (have your Clubcard ready). Browsing around TescoNet's new web site, I was impressed by the amount of material which is aimed at Internet beginners, and overall presentation was clear and concise. Although it wasn't possible to try TescoNet's CD-ROM or custom software, it was quite feasible to access TescoNet using another dialler. Setup was straightforward and involved configuring the right addresses and passwords, and the system then ran trouble-free. The necessary setup information is found in the TescoNet FAQ which should be printed off via their web site.

As always, I have gathered together a number of links which I think will be of interest to *Net Work* readers and these are published on the *Net Work* page of the *EPE* web site. I welcome pointers from readers for electronics or Internet-related links. These can be sent by E-mail to **alan@epemag.demon.co.uk**, and all contributions are acknowledged.

PCBs FROM PAST ISSUES OF ETI

(prior to the merger of EPE and ETI in March 99). See below for ordering details.

Name and issue of project	Unit code	Price
ETI PCB Service Issue 1 1999		
Stress and Skin Temperature Meter	E/0199/1	£14.55
'Short Cut' Continuity Tester	E/0199/2	£5.09
R.F. Probe	E/0199/3	£5.09
Switch Volt PSU	E/0199/4	£5.09
ETI PCB Service Issue 13 1998		
Programmable Logic Microcontroller Board	E/1398/1	£7.32
Programmable Logic Simulator Board	E/1398/2	£5.09
Regulated Battery PSU	E/1398/3	£5.09
Audio Power Meter	E/1398/4	£7.32
Car Vigilante	E/1398/5	£5.64
Millivolt Meter	E/1398/6	£6.77
Wobbulator	E/1398/7	£6.22
ETI PCB Service Issue 12 1998		
Beerstat	E/1298/1	£5.09
Fishbiter	E/1298/2	£5.09
Smooth Fuzz	E/1298/3	£5.09
ETI PCB Service Issue 11 1998		
Loop Alarm	E/1198/1	£5.09
Ricky Sound (Music Lovers)	E/1198/2	£5.09
ETI PCB Service Issue 10 1998		
Ionisation Chamber	E/1098/1	£5.09
Ionisation Chamber (SMD)	E/1098/2	£5.09
PIC Development Board: see also issue 6 below	E/698/1	£5.50
ETI PCB Service Issue 9 1998		
Q Meter	E/998/2	£5.09
Bath Duck	E/998/3	£5.09
ETI PCB Service Issue 8 1998		
PIC Electronics Security Switch	E/898/1	£5.09
PIC Multiplexed LED Display	E/898/2	£5.09
PIC Non-multiplexed LED Dispay	E/898/3	£5.09
Easy Parker	E/898/4	£6.77
Tiny Traffic Lights	E/898/5	£5.09
Q Meter	E/898/6	£5.09
Bath Duck	E/898/7	£5.50
ETI PCB Service Issue 7 1998		
PIC 16C74 Development Board	E/798/1	£5.09
Surface Mount Diagnostic Interface	E/798/2	£5.09
Surface Mount Logic probe	E/798/3	£5.09
Mains Monitor	E/798/4	£12.33
Aquaprobe	E/798/5	£5.50
ETI PCB Service Issue 6 1998		
PIC Development Board	E/698/1	£5.50
Signal Generator	E/698/2	£8.99
Headlight Delay Unit	E/698/3	£5.50
6-Interval Games Timer	E/698/4	£5.09
ETI PCB Service Issue 5 1998		
UHF Transmitter (DS)	E/598/1	£5.07
UHF Transmitter Encoder	E/598/2	£5.09
UHF Receiver Front End (DS)	E/598/3	£5.07
UHF Receiver I.F. stage (DS)	E/598/4	£5.07
Fridge Thermometer	E/598/5	£5.50
AVR Controller	E/598/6	£5.50
27C16 Eprom Programmer	E/598/7	£7.87
Guardian Light	E/598/9	£6.22
ETI PCB Service Issue 4 1998		
LED Voltmeter	E/498/1	£5.64
BB Ranger Control Board	E/498/2	£6.22
BB Ranger Score Board	E/498/3	£22.89
Line-Up Oscillator with Glitch	E/498/4	£8.99
Tic-Tac-Toe	E/498/5	£8.44
ETI PCB Service Issue 3 1998		
Medium Wave Loop	E/398/1	£5.64
AA Cell Eliminator	E/398/2	£7.32
PIC Based Double Bass Tuner	E/398/3	£5.64
5-range Capacitor Meter	E/398/4	£6.77
MIDI Drum Pads	E/398/5	£5.64
ETI PCB Service Issue 2 1998		
Smartcam main board	E/298/1	£5.09
Smartcam opto-sensor board	E/298/2	£5.09
Both smartcam boards	E/298/1&2	£7.00
Switched Mode Internal Power Supply	E/298/5	£7.87
Auto Cupboard light	E/298/3	£5.64
ETI PCB Service Issue 1 1998		
Control Centre Desk-Top unit	E/198/1	£8.99
Control Centre Main Section	E/198/2	£7.87

PCB SERVICE

Printed circuit boards for certain EPE constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics,* Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749; Fax 01202 841692 (NOTE, we cannot reply to orders or queries by Fax); E-mail: orders@epemag.wimborne.co.uk** . Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**

NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photostats of articles are available if required – see the *Back Issues* page for details.

Please check price and availability in the latest issue.

Boards can only be supplied on a payment with order basis.

Special KNOCK DOWN SALE of PCBs.

We have a few p.c.b.s left from past projects these are being offered at the knock down price of **£2.00** each – *no matter what size they are* **(some of these boards are worth over £15.00 each)** while stocks last. This price includes VAT and UK post – overseas orders please add 50p postage (or £1 per board for airmail postage).

£2.00 EACH inc. VAT and p&p

1W Stereo Amplifier, 851; Visual Doorbell, 863; EPE SounDAC PC Sound Board, 868; Microprocessor Smartswitch, 881; Print Timer, 874; Stereo HiFi Controller – Power Supply, 886 – Main Board, 887 – Expansion/Display Boards, (pair) 888; Power Controller, 905; 1000V/500V Insulation Tester, 906; Active Guitar Tone Control, 907; TV Off-er (pair), 908/909; Video Modules – 1 Simple Fader, 910; Video Enhancer, 912; Rodent Repeller, 913; Spacewriter Wand, 921; Video Modules – 3 Dynamic Noise Limiter, 919 – System Mains Power Supply, 920; The Ultimate Screen Saver, 927; 12V 35W PA Amplifier, 930; ★National Lottery Predictor, 935; MIDI Pedal, 938; Club Vote Totaliser, 939; EPE HiFi Valve Amplifier – Phase splitter, 941; PIC-DATS 4-channel Light Chaser, 942; HV Capacitor Reformer, 943; Ramp Generator – Logic Board (double-sided p.t.h.), 944 – Analogue board, 945; Microcontrolled 3-Digit Timer, 933; Low-Range Ohmmeter Adaptor, 926; Vandata – Boot Control Unit, 953 – Display Unit, 954.

Any of the above for just £2 each inc. VAT and p&p.

Back numbers or photostats of articles are available see the *Back Issues* page for details.

PROJECT TITLE		Order Code	Cost
Simple Theremin	SEPT'95	952	£6.68
Sound Switch	OCT'95	915	£6.55
Capacitor Check		955	£5.76
Ginormous VU Meter		956	£9.31
Multiple Project PCB	NOV'95	932	£3.00
Video Enhancer – Current Tracer – Distortion Effects Unit			
Digital Delay Line		958	£8.04
50Hz Field Meter		959	£8.32
Temperature Warning Alarm (Teach-In '96)		960	£6.15
Stereo "Cordless" Headphones	DEC'95		
Transmitter		961	£8.04
Receiver		962	£7.66
★EPE Met Office – Sensor/Rainfall/Vane		963/965	£11.33
Spiral transparency free with above p.c.b.			
Light-Operated Switch		966	£6.37
Modular Alarm System (Teach-In '96)		967a/b	£7.12
★EPE Met Office –	JAN'96		
Computer Interface (double-sided)		964	£7.69
Audio Signal Generator		969	£6.58
Mains Signalling Unit, Transmitter and Receiver		970/971 (pr)	£9.09
Automatic Camera Panning (Teach-In '96)		972	£6.63
Printer Sharer		973	£9.93
Vari-Speed Dice (Teach-In '96)	FEB'96	974	£5.69
Mains Signalling Unit – 2 12V Capacitive PSU		975	£6.07
Multi-Purpose Mini Amplifier	MAR'96	976	£6.12
High Current Stabilised Power Supply		979	£6.62
Mind Machine Mk III – Sound and Lights		980	£7.39
Infra-Zapper Transmitter/Receiver (Teach-In '96)		981/982 (pr)	£8.01
Bat Band Converter/B.F.O.	APR'96	984a/b	£5.80
Hearing Tester		985	£6.87
Event Counter (Teach-In '96)		986	£8.39
B.F.O. and Bat Band Converter	MAY'96	984a/b	£5.80
Versatile PIR Detector Alarm		988	£6.76
Mind machine Mk III – Tape Controller		989	£6.70
Midi Analyser		992	£6.74
Countdown Timer (Teach-In '96)		993	£9.44
Sarah's Light	JUNE'96	996	£7.17
Home Telephone Link		997 (pr)	£10.72
★PulStar		998	£6.60
VU Display and Alarm		999	£7.02
Ultra-Fast Frequency Generator and Counter – Oscillator/L.C.D. Driver	JULY'96	994/995 (pr)	£12.72
Timed NiCad Charger		100	£6.99
Single-Station Radio 4 Tuner		101	£7.02
Twin-Beam Infra-Red Alarm – Transmitter/Receiver		102/103 (pr)	£10.50
★Games Compendium		104	£6.09

PROJECT TITLE		Order Code	Cost
Mono "Cordless" Headphones	AUG'96		
– Transmitter/Receiver		990/991 (pr)	£10.16
Component Analyser (double-sided p.t.h.)		105	£12.18
Garden Mole-Ester		106	£6.07
Mobile Miser		107	£6.36
Bike Speedo		108	£6.61
★PIC-Tock Pendulum Clock	SEPT'96	109	£6.31
Power Check		110	£6.42
Analogue Delay/Flanger		111	£7.95
Draught Detector		112	£6.22
Simple Exposure Timer		113	£6.63
Video Fade-to-White	OCT'96	114	£6.98
Direct Conversion 80m Receiver		116	£7.52
Vehicle Alert		117	£6.55
10MHz Function Generator– Main Board		118	£7.33
– PSU		119	£5.39
Tuneable Scratch Filter	NOV'96	115	£7.83
★Central Heating Controller		120	£7.85
D.C. to D.C. Converters – Negative Supply Generator		122	£5.96
– Step-Down Regulator		123	£6.01
– Step-Up Regulator		124	£6.12
★PIC Digital/Analogue Tachometer	DEC'96	127	£7.23
Stereo Cassette Recorder			
Playback/PSU		128	£7.94
Record/Erase		129	£9.04
★Earth Resistivity Meter	JAN'97		
Current Gen. – Amp/Rect.		131/132 (pr)	£12.70
Theremin MIDI/CV Interface (double-sided p.t.h.)		130 (set)	£40.00
Mains Failure Warning		126	£6.77
Pacific Waves	FEB'97	136	£9.00
PsiCom Experimental Controller		137	£6.78
Oil Check Reminder	MAR'97	125	£7.16
Video Negative Viewer		135	£6.75
Tri-Colour NiCad Checker		138	£6.45
Dual-Output TENS Unit (plus Free TENS info.)		139	£7.20
★PIC-Agoras – Wheelie Meter	APRIL'97	141	£6.90
418MHz Remote Control – Transmitter		142	£5.36
– Receiver		143	£6.04
Puppy Puddle Probe		145	£6.10
MIDI Matrix – PSU		147	£5.42
– Interface		148	£5.91
Quasi-Bell Door Alert	MAY'97	133	£6.59
2M F.M. Receiver		144	£7.69
★PIC-A-Tuner		149	£7.83
Window Closer – Trigger		150	£4.91
– Closer		151	£4.47
Child Minder Protection Zone	JUN'97		
– Transmitter		153	£6.58
– Receiver		154	£6.42
Pyrotechnic Controller		155	£6.93
★PIC Digilogue Clock		156	£7.39
Narrow Range Thermometer		158	£6.37
Micropower PIR Detector – 1	JULY'97	152	£6.69
Infra-Red Remote Control Repeater			
(Multi-project P.C.B.)		932	£3.00
Karaoke Echo Unit – Echo Board		159	£6.40
– Mixer Board		160	£6.75
Computer Dual User Interface		161	£6.70
★PEsT Scarer		162	£6.60
Variable Bench Power Supply	AUG'97	932	£3.00
Universal Input Amplifier		146	£6.55
Micropower PIR Detector – 2 Controller		163	£6.72
★PIC-OLO		164	£7.02
Active Receiving Antenna	SEPT'97	140	£6.59
Soldering Iron Controller		157	£6.63
★PIC Noughts & Crosses Game		165	£7.82
Micropower PIR Detector – 3			
Alarm Disarm/Reset Switch		166	£5.72
Ironing Safety Device		167	£5.12
Remote Control Finder	OCT'97	168	£6.32
Rechargeable Handlamp		169	£6.23
★PIC Water Descaler		170	£6.90
★EPE Time Machine	NOV'97	171	£8.34
Auto-Dim Bedlight		172	£6.63
Portable 12V PSU/Charger		173	£6.61
Car Immobiliser	DEC'97	175	£7.00
Safe and Sound (Security Bleeper)		179	£7.32
Surface Thermometer	JAN'98	174	£7.64
Disco Lights Flasher		178	£8.30
Waa-Waa Pedal (Multi-project PCB)	FEB'98	932	£3.00
★Virtual Scope – Digital Board		176	£14.49
Analogue Board (per board)		177	£7.34
★Water Wizard		180	£7.69
Kissometer		181	£7.67
★EPE PIC Tutorial	MAR'98	182	£7.99
The Handy Thing (Double-Sided)		183	£6.58
Lighting-Up Reminder		184	£5.90
★Audio System Remote Controller – PSU		185	£7.05
Main Board		186	£8.29
Simple Metal Detector	APR'98		
(Multi-project PCB)		932	£3.00
Single or Dual-Tracking Power Supply		187	£7.90
★RC-Meter		188	£7.66
Security Auto-Light	MAY'98	189	£8.10
Stereo Tone Control plus 20W Stereo Amplifier			
Tone Control		190	£7.78
20W Amplifier		191	£8.58
★Dice Lott		192	£8.05

PROJECT TITLE		Order Code	Cost
EPE Mood Changer	JUNE'98	193	£7.75
★AT89C2051/1051 Programmer			
Main Board		194	£8.50
Test Board		195	£8.69
★Reaction Timer **Software only**		–	–
★PIC16x84 Toolkit	JULY'98	196	£6.96
★Greenhouse Computer			
Control Board		197	£9.08
PSU Board		198	£8.10
Float Charger	AUG'98	199	£6.59
Lightbulb Saver		202	£3.00
Personal Stereo Amplifier	SEPT'98	932	£3.00
(Multi-project PCB)			
★Greenhouse Radio Link		200	£8.32
★PIC Altimeter		201	£8.15
Voice Processor	OCT'98	203	£7.18
★Digiserv R/C Expander		204	£7.69
IR Remote Control			
Transmitter		205	£3.00
Receiver		206	£3.50
★PIC Tape Measure	NOV'98	207	£6.82
Electronic Thermostat			
T-Stat		208	£4.00
PhizzyB			£14.95
A–PCB **B**–CD-ROM **C**–Prog. Microcontroller		Bee (A)(B)(C)	**each**
15-Way IR Remote Control			
Switch Matrix		211	£3.00
15-Way Rec/Decoder		212	£4.00
Damp Stat	DEC'98	209	£4.50
Handheld Function Generator		213	£4.00
★Fading Christmas Lights		215	£5.16
PhizzyB I/O Board (4-section)		216	£3.95
Twinkle Twinkle Reaction Game	JAN'99	210	£7.55
★EPE Mind PICkler		214	£6.30
PhizzyB I/O Board (4-section)		216	£3.95
Alternative Courtesy Light Controller		217	£6.72
Light Alarm	FEB'99	218	£6.78
★Wireless Monitoring System – Transmitter		219+a	£9.92
Receiver		220+a	£8.56
★PIC MIDI Sustain Pedal **Software only**		–	–
★Wireless Monitoring System–2	MAR'99		See
F.M. Trans/Rec Adaptors		219a/220a	Feb'99
★Time and Date Generator		221	£7.37
Auto Cupboard Light		222	£6.36
Smoke Absorber		223	£5.94
Ironing Board Saver	APR'99	224	£5.15
Voice Record/Playback Module		225	£5.12
Mechanical Radio (pair)		226A&B	£7.40 pr.
★Versatile Event Counter		207	£6.82

EPE SOFTWARE

Software programs for *EPE* projects marked with an asterisk ★ are available on 3.5 inch PC-compatible disks or *free* from our Internet site. Three disks are available: **PIC Tutorial** (Mar-May '98 issues); **PIC Disk 1** (all other software Apr '95–Dec '98 issues); **EPE Disk 2** (Jan '99 issue to current cover date). The disks are obtainable from the *EPE PCB Service* at £2.75 each (UK) to cover our admin costs (the software itself is *free*). Overseas (each): £3.35 surface mail, £4.35 each airmail. All files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk.**

EPE PRINTED CIRCUIT BOARD SERVICE

Order Code **Project** **Quantity** **Price**

....

Name...

Address..

....

I enclose payment of £..............................(cheque/PO in **£ sterling only**) to:

Everyday Practical Electronics

Access (MasterCard) or Visa No.
Minimum order for credit cards £5

EUROCARD

Signature..Card Exp. Date......................

Please supply name and address of cardholder if different from the address shown

NOTE: You can order p.c.b.s via our Internet site on a *secure* server: **http://www.epemag.wimborne.co.uk**

EVERYDAY PRACTICAL ELECTRONICS CLASSIFIED

ETI ELECTRONICS TODAY INTERNATIONAL

Everyday Practical Electronics/ETI reaches twice as many UK readers as any other independent monthly hobby electronics magazine, our audited sales figures prove it. We have been the leading independent monthly magazine in this market for the last fourteen years.

If you want your advertisements to be seen by the largest readership at the most economical price our classified and semi-display pages offer the best value. The prepaid rate for semi-display space is £8 (+VAT) per single column centimetre (minimum 2·5cm). The prepaid rate for classified adverts is 30p (+VAT) per word (minimum 12 words).

All cheques, postal orders, etc., to be made payable to Everyday Practical Electronics. **VAT must be added.** Advertisements, together with remittance, should be sent to Everyday Practical Electronics/ETI Advertisements, Mill Lodge, Mill Lane, Thorpe-le-Soken, Essex CO16 0ED. Phone/Fax (01255) 861161.

For rates and information on display and classified advertising please contact our Advertisement Manager, Peter Mew as above.

RCS VARIABLE VOLTAGE D.C. BENCH POWER SUPPLY

Up to 20 volts d.c. at 1 amp continous, 1·5 amps peak, fully variable from 1 to 20 volts. Twin Voltage and Current meters for easy read-out. 240 volt a.c. input. Fully smoothed, size 23cmx14cmx8cm.

£45 inc. VAT Post £4

RADIO COMPONENT SPECIALISTS

337 WHITEHORSE ROAD, CROYDON SURREY, CR0 2HS. Tel: 0181-684 1665

Lots of transformers, high volt caps, valves, output transformers, speakers, in stock. Phone or send your wants list for quote.

ELECTRONIC KITS

- 88-108MHz FM transmitters from **under £5**
- Many educational and hobby electronic kits covering all technical abilities, from beginners' circuits to MCU/MPU designs
- Low cost PCB services and equipment
- Send 4x1st class stamps for catalogue

DTE MICROSYSTEMS, 112 SHOBNALL ROAD, BURTON-ON-TRENT, STAFFS DE14 2BB PHONE or FAX: 01283 542229 http://www.btinternet.com/~dtemicrosystems

Z88 NOW AVAILABLE WITH 128K AND 512K + O24

BRAND NEW SINCLAIR SPECTRUM & QL PARTS

ZX MICRODRIVES £15, INTERFACE ONE £20, CARTRIDGES 10 FOR £15, 50 FOR £50.

QL BOARDS 5, 6 &7, POPULATED WITH JS ROMS, £30; UNPOPULATED, £12; MICRODRIVES £10 EACH. TOP & BOTTOM CASES £15, MEMBRANES £15.

THE P.C., MAC and QL's "Little Friend" MAC LINK £10 - P.C. LINK £25 - QL LINK £12

CAMBRIDGE Z88 A4 NOTEBOOK COMPUTER AVAILABLE AGAIN £99, RECONDITIONED £60

ONLY 1" THICK, 4xAA BATTS. 20 HOURS WORK. LCD SCREEN, 72 Crs, 6 LINES, 32K RAM, EXTRA RAMS & EPROMS, 9 pin D SERIAL PORT, ROM HAS BBC BASIC, W/PROCESSOR, SPREADSHEET, DATA BASE, IMP/EXPORT TO PC etc, V52 TERMINAL.

W.N. RICHARDSON & CO.
PHONE/FAX 01494 871319
6 RAVENSMEAD, CHALFONT ST PETER, BUCKS, SL9 0NB.

BTEC ELECTRONICS TECHNICIAN TRAINING

GNVQ ADVANCED ENGINEERING (ELECTRONIC) – PART-TIME
HND ELECTRONICS – FULL-TIME
B.Eng FOUNDATION – FULL-TIME

Next course commences
Monday 13th September 1999
FULL PROSPECTUS FROM

LONDON ELECTRONICS COLLEGE (Dept EPE) 20 PENYWERN ROAD EARLS COURT, LONDON SW5 9SU TEL: 0171-373 8721

THE BRITISH AMATEUR ELECTRONICS CLUB

exists to help electronics enthusiasts by personal contact and through a quarterly Newsletter.
For membership details, write to the Secretary:

Mr. M. P. Moses, 5 Park View, Cwmaman, Aberdare CF44 6PP

Space donated by Everyday Practical Electronics

Miscellaneous

X-10® Home Automation We put *you* in control™

An extensive range of 230V X-10 products and starter kits available.
Uses proven Power Line Carrier technology, no wires required.
Products Catalogue available online.
Worldwide delivery.

Laser Business Systems Ltd.
E-Mail: info@laser.com
http://www.io.com/~lbs/
Tel: (0181) 441 9788
Fax: (0181) 449 0430

ATTENTION ALL AUDIO CASSETTE USERS

Tight spools cause slow running, tape bunching and spillage and loss of treasured recordings.
TAPE DROPS has been specially developed to cure/prevent this. Easy home treatment for up to 100 cassettes £4.95 incl. p&p. Chq/PO/CC details to: Ref EPE, Premier Elmech, 65 High Town Road, Luton LU2 0BW. 01582 611991

One telephone number?

How would you like people to be able to reach you on just one number? With a Personal Number you can! For a "one off" payment of just ten pounds for life, with no ongoing charges or credit checks, it's now possible to choose which phone you take all your calls on, and when it suits you! You can even forward calls to your mobile phone.
For further information call Ashley on

07050 202510

FOR RESTORATION: 1915 Bergmann electric wagon, rolling chassis with brakes and steering, motor, switchgear and 44 unused 2V cells, 920 amp/hr dry not charged, round plate traction type, £2,750 or any offers. 01162 712576.

EPROM PROGRAMMING SERVICE. Also microcontrollers, FLASH, EEPROMS, FPGAs, etc. Same day service from £15 inclusive of postage and VAT. RFT Electronics. Phone 01276 686889, fax 01276 686244.

G.C.S.E. ELECTRONIC KITS, at pocket money prices. S.A.E. for FREE catalogue. SIR-KIT Electronics, 52 Severn Road, Clacton, CO15 3RB.

PROTOTYPE PRINTED CIRCUIT BOARDS one offs and quantities, for details send s.a.e. to B. M. Ansbro, 38 Poynings Drive, Hove, Sussex BN3 8GR, or phone Brighton 883871, fax 01273 706670.

VALVE ENTHUSIASTS: Capacitors and other parts in stock. For free advice/lists please ring, Geoff Davies (Radio), Tel. 01788 574774.

PRINTED CIRCUIT BOARDS – QUICK SERVICE. Prototype and Production. Artwork raised from magazines or draft designs at low cost. PCBs also designed from schematics. Production assembly also undertaken. For details send to P. Agar, Unit 5, East Belfast Enterprise Park, 308 Albertbridge Road, Belfast, BT5 4GX, or phone/fax 01232 738897.

NEW AND USED COMPUTERS, spares, etc. at keenest prices. e.g.: 386 min 2MB RAM, 20MB HDD, desktop case, keyboard and cables, 12in. VGA mono monitor, £55. 486 DX33 min. 8MB RAM, 120MB HDD, desk top case, keyboard and cables, 14in. VGA colour monitor, £165. Many other systems available. Whatever you need, Phone/Fax 0181 853 3374 for prices.

HUNDREDS OF UNUSUAL ITEMS, CHEAP! Send £1 coin for interesting samples and list. Grimsby Electronics, Lambert Road, Grimsby.

COMPUTER BOARDS – TM990 RANGE: SBC (Teaching and application), I/O, DSP, speech, development, chassis, PSUs, mostly brand new, for professional or amateur. Also 20in. NEC Multisync monitor. Take best offers. Call 01628 533054.

100 WATT AMPLIFIER MODULES, £8.95! Glass p.c.b. 3, heatsink ±50V d.c. ex. equipment and directions. K.I.A., 1 Regent Road, Ilkley, LS29 9EA. Lists and samples 26p s.a.e.

CHEAP ELECTRONIC COMPONENTS and Built Kits – about half catalogue prices. P&P only 50p for any UK order. Visit website at http://members.tripod.com/~baec/complist

EPE NET ADDRESSES

EPE FTP site: **ftp://ftp.epemag.wimborne.co.uk**

Access the FTP site by typing the above into your web browser, or by setting up an FTP session using appropriate FTP software, then go into quoted sub-directories:

PIC-project source code files: **/pub/PICS**

PIC projects each have their own folder; navigate to the correct folder and open it, then fetch all the files contained within. *Do not try to download the folder itself!*

EPE text files: **/pub/docs**
Basic Soldering Guide: **solder.txt**
EPE TENS Unit user advice: **tens.doc** and **tens.txt**
Ingenuity Unlimited submission guidance: **ing_unlt.txt**
New readers and subscribers info: **epe_info.txt**
Newsgroups or Usenet users advice: **usenet.txt**
Ni-Cad discussion: **nicadfaq.zip** and **nicad2.zip**
UK Sources FAQ: **uksource.zip**
Writing for *EPE* advice: **write4us.txt**

Ensure you set your FTP software to ASCII transfer when fetching text files, or they may be unreadable.

Note that any file which ends in **.zip** needs unzipping before use. Unzip utilities can be downloaded from:
http://www.winzip.com or
http://www.pkware.com

On-line readers! Try the new EPE *Chat Zone* – a virtually real-time Internet "discussion board" in a simple to use web-based forum!
http://www.epemag.wimborne.co.uk/wwwboard
Or buy *EPE Online:* www.epemag.com

ADVERTISERS INDEX

A.L. ELECTRONICS 312
ASA MICROS 256
A.S.A 311
N. R. BARDWELL 311
B.K. ELECTRONICS .... Cover (iii)
BRIAN J. REED 312
BULL ELECTRICAL .... Cover (ii)
CHEVET SUPPLIES LTD 312
CONFIDENTIAL COMMUNICATIONS 293
COOKE INTERNATIONAL 311
CROWNHILL ASSOCIATES 228
DANNELL ELECTRONICS 267
DISPLAY ELECTRONICS 226
ELECTROMAIL 256
EPT EDUCATIONAL SOFTWARE 246
ESR ELECTRONIC COMPONENTS 232
FML ELECTRONICS .... 31[illegible]
FOREST ELECTRONIC DEVELOPMENTS 293
GREENWELD 228
ICS 311
J&N FACTORS 230
JPG ELECTRONICS 289
LABCENTER ELECTRONICS 255
MAGENTA ELECTRONICS 234/235
MAPLIN ELECTRONICS .... Cover (iv)
MILFORD INSTRUMENTS 299
NATIONAL COLLEGE OF TECH 299
PICO TECHNOLOGY 303
QUASAR ELECTRONICS 299
QUICKROUTE SYSTEMS 245
RADIO-TECH 231
SEETRAX CAE 265
SERVICE TRADING CO 293
SHERWOOD ELECTRONICS 312
SQUIRES 231
STEWART OF READING 231
SUMA DESIGNS 283
TECHNOLOGY EDUCATION INDEX 269
TELNET 229
VANN DRAPER ELECTRONICS 267
VERONICA FM 268
VERONICA KITS 311

ADVERTISEMENT MANAGER: PETER J. MEW
ADVERTISEMENT OFFICES:
EVERYDAY PRACTICAL ELECTRONICS, ADVERTISEMENTS,
MILL LODGE, MILL LANE, THORPE-LE-SOKEN,
ESSEX CO16 0ED.
Phone/Fax: (01255) 861161

For Editorial address and phone numbers see page 233.

Published on approximately the first Friday of each month by Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Printed in England by Wiltshire (Bristol) Printers Ltd., Bristol, BS20 9XP. Distributed by Seymour, 86 Newman St., London W1P 3LD. Subscriptions INLAND £26.50 and OVERSEAS £32.50 standard air service (£50 express airmail) payable to "Everyday Practical Electronics", Subs Dept, Allen House, East Borough, Wimborne, Dorset BH21 1PF. E-mail: subs@epemag.wimborne.co.uk. EVERYDAY PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.


MAPLIN
ELECTRONICS
Order your catalogue now on 01702 554000 or visit and collect from one of our 48 stores nationwide. You can also purchase your catalogue from your local Maplin store, WH Smith and John Menzies.
CATALOGUE
• Over 1,000 new products
• Includes over £50 worth of discount vouchers
• Order code CA18
DOUBLE CD
• Includes FREE datasheet CD-Rom
• FREE McAfee anti-virus software
• FREE 30 day Demon Internet trial
• Order code CQ02
THE NEW CATALOGUE OUT NOW
£3.99
MAPLIN ELECTRONICS
electronics & beyond
Sept 98-Feb 99
17,000 NEW products
Price reductions on over 2,000 products
visit our Web Site http://www.maplin.co.uk
Companion CD
£1.95
catalogue
the key to better selection and service
Telephone 01702 554000 with your enquiry