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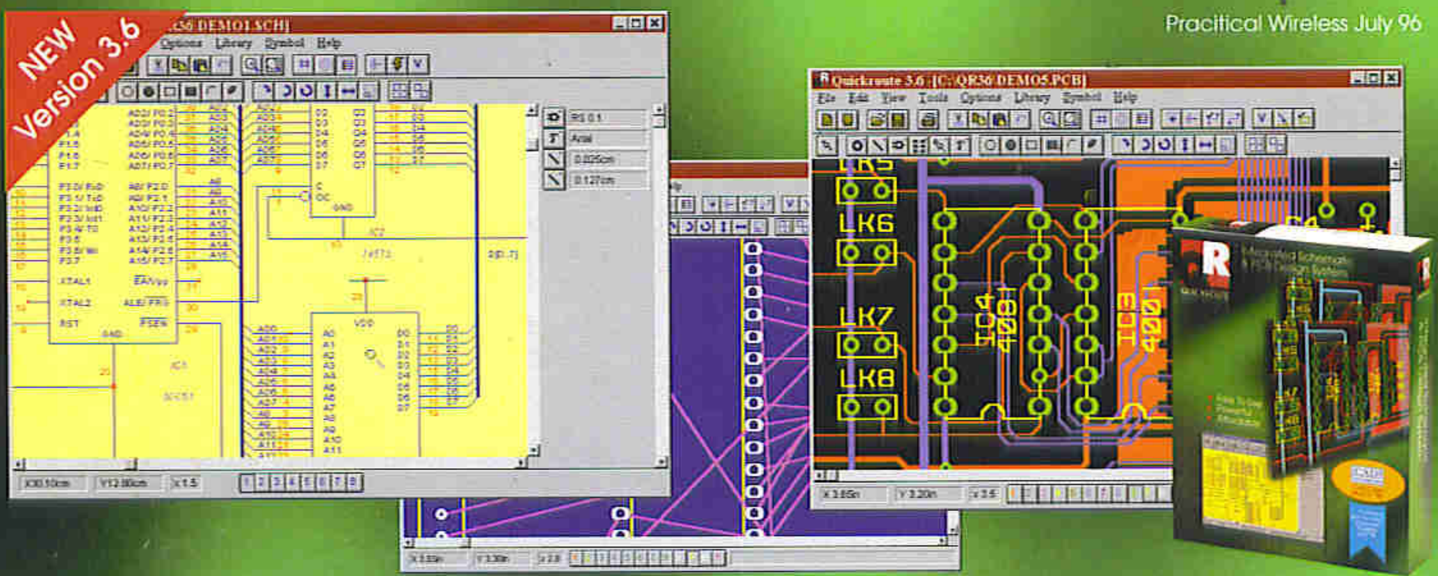
QUICKROUTE

"extremely good value for money for such a comprehensive package"

Practical Wireless July 96



Schematic capture, Autorouting & Design Checking for just £149*

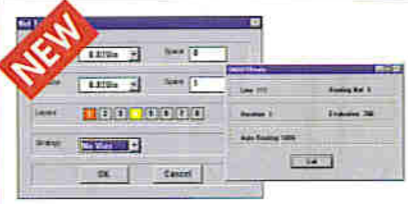
NEW QR 3.6 Designer £149*

Take a look at Quickroute 3.6 Designer and you might be surprised! For just £149* you get easy to use schematic design (automatic junction placement, parts-bin, etc), "one click" schematic capture, autorouting on 1 or 2 layers, design rule & connectivity checking and a starter pack of over 260 symbols.

NEW QR 3.6 PRO+ £399*

For those needing more power & more features there is Quickroute 3.6 PRO+. For just £399 you get multi-sheet schematic capture, 1 to 8 layer autorouting, net-list import/export, links to simulators, CAD/CAM file export, Gerber import/viewing, DXF WMF & SPICE file export, copper fill, advanced connectivity checking with automatic updating of a PCB from a schematic, the basic set of over 260 symbols and library pack 1 which includes a further 184 symbols. More symbols are available in additional library packs available separately

NEW PLUG IN AUTOROUTER



SMART ROUTE

SMARTRoute is a new 32-bit autorouter from Quickroute Systems rated in ' category A' by Electronics World (Nov 96). SMARTRoute plugs straight into Quickroute 3.6, automatically updating Quickroute' s menus with new features and tools.

SMARTRoute 1.0 uses an iterative goal seeking algorithm which works hard to find the best route even on single sided PCB' s. SMARTRoute allows you to assign different algorithms, design rules, track & via sizes, layers used, etc to groups of nets for total flexibility. SMARTRoute 1.0 costs just £149*.

Prices are Quickroute 3.6 Designer £149, Quickroute 3.6 PRO+ £399, SMARTRoute 1.0 £149.00, Library Packs £39 each. *Post & Packing per item is £6 (UK), £8 (Europe) and £12 (World). V.A.T must be added to the total.

CAD CAM RECOMMENDED

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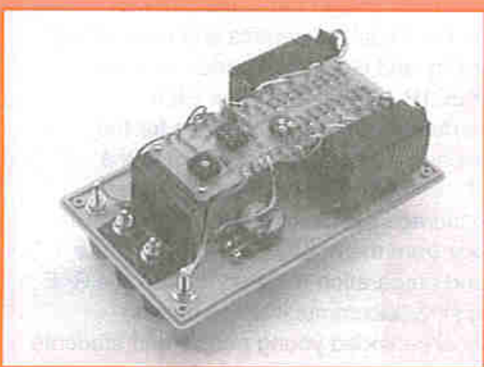
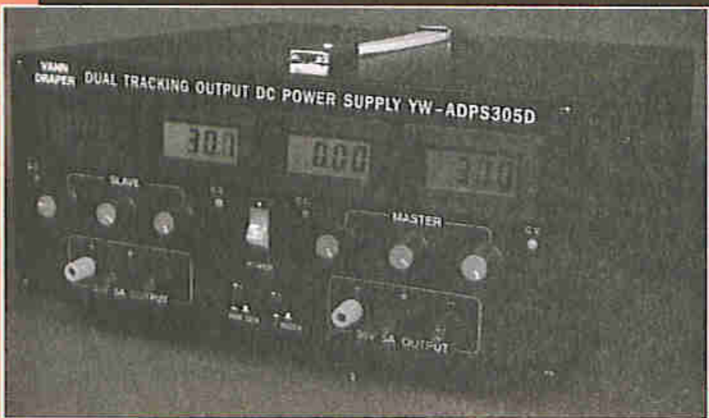


Regulars

ETI ELECTRONICS TODAY INTERNATIONAL News...

High-powered, modern supply at a good price



Van Draper have brought out a new dual output power supply with full current-foldback overload and short circuit protection and a solid range of features.

The ADPS305 is a dual-output 0 - 30 volt, 0 - 5 amp regulated DC linear bench power supply, capable of operating in constant voltage and constant current modes, with isolated, serial or parallel operation switchable from the front panel: 0 - 30 volts/0 - 5 amps, 0 - 30 volts/0 - 10 amps or dual 0 - 30 volts/0 to 5 amps can be selected. In serial or parallel modes, the unit operates as a master/slave.

Output voltages can be tuned by both coarse and fine controls, with output voltage and current monitored by four 3.5-digit LCDs. Load regulation is better than 0.2 percent, and ripple is less than 5 mV. The steel-cased 350 x 320 x 150 mm unit is priced at £289.

For further information please contact Van Draper Electronics Ltd., Unit 5, Premier Works, Canal Street, South Wigston, Leicester LE18 2PL. Tel: 0116 277 1400 Fax: 0116 277 3945.

Radio Amateurs Exam: lower costs and quicker results from May 1998

The RA has proposed to simplify the format of the Radio Amateurs' Examination (RAE) so that results can be released more speedily and fees reduced. The RAE currently costs £19.40 per paper for each of two parts. Following an appeal from the Radio Society of Great Britain, the two papers will be amalgamated into one paper of 80 questions at a single cost of £26 from May 1998.

Candidates who already have a pass in one part of the RAE will be able to carry over that pass until May 1998, when they will need to re-sit for full new examination. Other changes agreed are a reduction in the one-off centre approval fee from £250 to £200 for centres running the examination.

The RA and the RSGB hope that these rationalisations will encourage more people to take up amateur radio.

An RAE pass is required to obtain a Class B amateur radio licence, while a further pass in Morse Code at 12 words per minute is required to obtain a Class A licence. The RAE is held in examination centres around the country in May and December each year. For details of centres and examination procedures, contact City and Guilds of London Institute, 1 Giltspur St., London EC1B 1JP. Tel 0171 294 2468.

The decline in the number of new candidates for the amateur radio licence has been causing concern to the RSGB and other radio authorities for a number of years, despite efforts to encourage people to enter by stages with Novice licences. Aside from the hobby benefit of amateur radio, the practice and preparation required to pass the RAE is a valuable training in radiocommunications basics, particularly for practically-minded young people and students hoping to go into engineering and IT.

80-channel CB sets fair

The Radiocommunications Agency has announced that 80-channel Citizens' Band sets will soon be available for UK users. This is in response to a questionnaire sent out to all CB licence-holders in 1995 and to meetings held by the RA for CB user groups- a demand for sets that would cover both UK and the European CEPT services was clearly indicated.

The UK CB type approval Specification (MPT 1382) has been revised to allow both these services in one set.

Manufacturers will still be able to produce sets incorporating any combination of the UK or CEPT channels, however, the Agency stresses that such sets may only be used in the UK.

The UK only service is in the 27.60215 - 27.99125 MHz band and the CEPT service in the 26.965 - 27.405 MHz band. A UK service between 934.0125 - 934.9625 MHz will be withdrawn on 31 December 1998. The Specification for that service was withdrawn in 1998.

Public enquiry line in the UK: 0171 211 0211.

Don't chew do it

Things Electronics Hasn't Fixed Yet - Don't try this at home! Apparently an electrician in Australia turned to his work to help take his mind off a ban on smoking on site - in (to say the least) a somewhat unusual way - we hope. Troubled by internal pains, he was taken to hospital, where tests showed that he had three times the standard safety level of lead in his bloodstream. You will be glad to hear that this was not the result of working in too-close proximity to gently curling solder fumes, much though ingestion of the Constructor's Best Friend should be avoided - this was more solid fare. The dedicated worker had been chewing nearly a yard (1m for the youngsters) of cable a day during his stints on building sites where smoking was not allowed - for 10 years.

Wind up

Britain's wind farms produced a record 505,000,000 units of electricity in 1996, a 49 percent rise over 1995, and bringing the total output over the last five years to over a (UK) billion units. Figures released in February show that the 34 wind farms now operating in the UK are outputting sufficient to meet the average power demand of around 120,000 households.

Underneath the lamplight ...

A couple promenading in the streets of Paris were shocked when their normally mild-mannered dog suddenly leapt into air, bit her owner, and ran off howling into the darkness. The unfortunate dog had received a far worse shock - investigation showed that electricity escaping from a damaged street lamp in the damp street had put a several thousand volts onto a metal pavement grille. At the time of reporting, she was still missing. It's tough when you can't go for a breath of air without strapping on rubber boots and a multimeter.

Fish in power sauce?

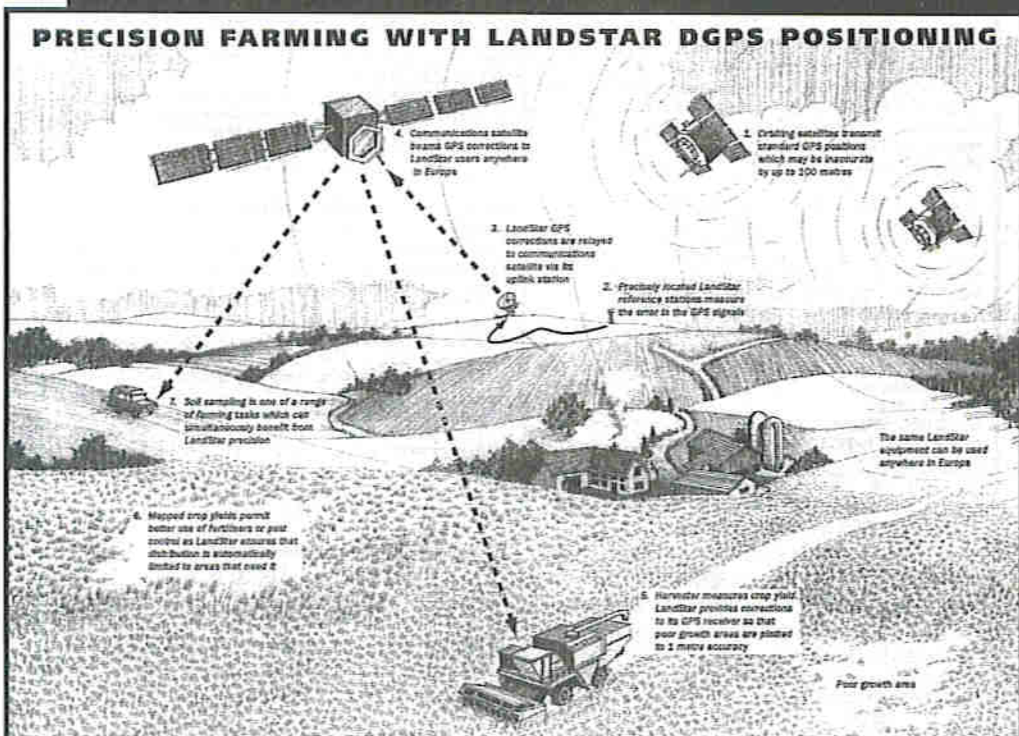
US explorer John Lundberg of the University of Arizona and a team of Brazilian researchers have been surveying fish in the rivers of the Amazon basin for the last four years and have come up with a number of new species - including a new genus of electric fish, now called Magosternarchus. These will not be gracing the shack fishtank, nor, we calculate, will the blind, pink electric Orthosterarchus tamandua - much better that they should stay rarely seen in their riverine habitats. But as pharmacists trawl the rainforests for new medicines and wonder drugs, how long before battery scientists start showing more than a culinary interest in fish?

Web-page authoring software

Users of the industry-wide page-design and publishing software QuarkXPress(tm) can now move onto the Internet with QuarkImmedia(tm), the new comprehensive Internet and multimedia authoring and viewing application from Quark Inc. For use in conjunction with QuarkXPress or QuarkXPress Passport(tm) 3.32 or later, combines the power, ease of use and typographic control for which Quark is famous with the interactive requirements of multimedia, and can be obtained for Danish, Dutch, French, German, Italian, Norwegian, Spanish and Swedish as well as International English. Both components - the QuarkImmedia design software and QuarkImmedia Viewer, are now available for Macintosh and Power Macintosh computers. A Windows version is planned for a later date. QuarkImmedia Viewer is a stand-alone multimedia delivery applications that allows users who don't own QuarkXPress or QuarkImmedia view and interact with QuarkImmedia projects

For more information, contact Adriaan Roosen, Quark Media House BV, tel Netherlands +31 318 693300 or the Quark Internet home page at http://www.quark.com.

Crop planning with precision GPS



Following the launch of the Italsat F2 comms satellite, Racal Survey has introduced a high-accuracy positioning service for precision farming techniques.

The Racal Landstar Europe differential GPS can now provide farmers and agricultural contractors with positioning accurate to 1 metre anywhere in Europe 24 hours a day in any weather conditions. The new service removes the need for local reference stations and comms links which some users had found impractical and unreliable. The LandStar will provide a precise location anywhere from the Western Atlantic to east of Moscow, and from the Straits of Gibralter to Scaninavia. A 24-hour monitoring station at Aberdeen maintains the quality and accuracy of the differential GPS corrections continuously.

There is some more background to differential GPS in "What a difference a 'd' makes" in our leading feature this month.

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

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

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

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

DIVINING RODS £3.99 a pair! ref EF111

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

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

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

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

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

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

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

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

GPS SATELLITE NAVIGATION SYSTEM Made by Garmin, the GPS38 is hand held, pocket sized, 255g, position, altitude, graphic compass, map builder etc £179 ref GPS1.

CCTV CAMERA MODULES 46X70X29mm, 30 grams, 12v 100mA, auto electronic shutter, 3.6mm F2 lens, CCIR, 512x492 pixels, video output is 1v p-p (75 ohm). Works directly into a scart or video input on a tv or video. IR sensitive. £79.95 ref EF137.

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

INFRA RED POWERBEAM Handheld battery powered lamp, 4 inch reflector, krypton bulb, gives out powerful infrared light! 4 D cells required. £29 ref PB1.

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

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

9 WATT CHIEFTAN TANK LASERS

Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for alignement. 7 mile range, no circuit diagrams due to MOD, new price £50,000? us? £199. Each unit has two gallium Arsenide injection lasers, 1 x 9 watt, 1 x 3 watt, 900nm wavelength, 28vdc, 600hz pulse frequency. The units also contain an electronic receiver to detect reflected signals from targets. £199 for one. Ref LOT4.

TWO WAY MIRROR KIT Includes special adhesive film to make two way mirror(s) up to 60"x20". (glass not included) includes full instructions. £12 ref TW1.

NEW LOW PRICED COMPUTER/WORKSHOP/HI-FI RCB UNITS Complete protection from faulty equipment for everybody! Inline unit fits in standard IEC lead (extends it by 750mm), fitted in less than 10 seconds, reset/test button, 10A rating. £6.99 each ref LOT5. Or a pack of 10 at £49.90 ref LOT6. If you want a box of 100 you can have one for £250!

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

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

THOUSANDS AVAILABLE RING/FAX FOR DETAILS!

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

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

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

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

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

NIGHTSIGHTS Model TZS4 with infra red illuminator, views up to 75 metres in full darkness in infrared mode, 150m range, 45mm lens, 13 deg angle of view, focussing range 1.5m to infinity. 2 AA batteries required. 950g weight. £199 ref BAR61. 1 years warranty

LIQUID CRYSTAL DISPLAYS Bargain prices,
16 character 2 line, 99x24mm £2.99 ref SM1623A
20 character 2 line, 83x19mm £3.99 ref SM2020A
16 character 4 line, 62x25mm £5.99 ref SMC1640A

TAL-1, 110MM NEWTONIAN REFLECTOR TELESCOPE Russian. Superb astronomical 'scope, everything you need for some serious star gazing! up to 169x magnification. Send or fax for further information ref TAL-1, £249

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

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

WOLVERHAMPTON ELECTRONICS STORE NOW OPEN IN WORCESTER ST TEL 01902 22039

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

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

PERFECT FOR SURVEILLANCE, INTERNET,VIDEOCONFERENCING, SECURITY, DOMESTIC VIDEO

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

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

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

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

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

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http://www.pavilion.co.uk/bull-electrical

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

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

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

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

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

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

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

PC PAL VGA TO TV CONVERTER Converts a colour TV into a basic VGA screen. Complete with built in psu, lead and s/ware.. Ideal for laptops or a cheap upgrade. Supplied in kit form for home assembly. **SALE PRICE £25** REF SA34

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

ELECTRIC CAR WINDOW DE-ICERS Complete with cable, plug etc **SALE PRICE JUST £4.99** REF SA28

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

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

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

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

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

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

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

MEGA POWER BINOCULARS Made by Helios, 20 x magnification, precision ground fully coated optics, 60mm objectives, shock resistant caged prisms, case and neck strap. £89 ref HPH1

GIANT HOT AIR BALLOON KIT Build a 4.5m circumfrence, 1.8m high fully functioning balloon, can be launched with home made burner etc. Reusable (until you loose it!) £12.50 ref HA1

AIR RIFLES .22 As used by the Chinese army for training puposes, so there is a lot about! £39.95 Ref EF78. 500 pellets £4.50 ref EF80.

VIDEO SENDER UNIT. Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 100' range! (tune TV to a spare channel) 12v DC op. Price is £25 **REF: MAG15** 12v psu is £5 extra **REF: MAG5P2**

***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range up to 2 km in open country. Units measure 22x52x155mm. Including cases and earp'ces. 2xPP3 req'd. £37.00 pr **REF: MAG30**

***FM TRANSMITTER KIT** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £18 REF: EF62 (kit) Transmits to any FM radio. Built and tested version now available of the above unit at £45 ref EXM34

***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14

GAT AIR PISTOL PACK Complete with pistol, darts and pellets £14.95 Ref EF82B extra pellets (500) £4.50 ref EF80.

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

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

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

4X28 TELESCOPIC SIGHTS Suitable for all air rifles, ground lenses, good light gathering properties. £24.95 ref R/7.

GYROSCOPES Remember these? well we have found a company that still manufactures these popular scientific toys, perfect gift or for educational use etc. £6 ref EP70

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

NICAD CHARGERS AND BATTERIES Standard universal mains operated charger, takes 4 batts + 1 PP3, £10 ref PO11D. Nicads- AA size (4 pack) £4 ref 4P44, C size (2 pack) £4 ref 4P73, D size (4 pack) £9 ref 9P12.

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

RECHARGE ORDINARY BATTERIES UP TO 10 TIMES! With the Battery Wizard! Uses the latest pulse wave charge system to charge all popular brands of ordinary batteries AAA, AA, C, D, four at a time! Led system shows when batteries are charged, automatically rejects unsuitable cells, complete with mains adaptor. BS approved. Price is £21.95 ref EP31.

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

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

PHOTOGRAPHIC RADAR TRAPS CAN COST YOU YOUR LICENCE! The new multiband 2000 radar detector can prevent even the most responsible of drivers from losing their licence! Adjustable audible alarm with 8 flashing leds gives instant warning of radar zones. Detects X, K, and Ka bands, 3 mile range, 'over the hill' 'around bends' and 'rear trap facilities. micro size just 4.25"x2.5"x.75". Can pay for itself in just one day! £89 ref EP3.

3" DISCS As used on older Amstrad machines, Spectrum plus3's etc £3 each ref BAR400.

STEREO MICROSOPES BACK IN STOCK Russian, 200x complete with lenses, lights, filters etc etc very comprehensive microscope that would normally be around the £700 mark, our price is just £299 (full money back guarantee) full details in catalogue.

SECOND GENERATION NIGHT SIGHTS FROM £748

RETRON Russian night sight, 1.8x, infra red lamp, 10m-inf, standard M42 lens, 1.1kg. £349 ref RET1

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

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ETI News...

SHORTS

A study by market research consultancy Frost & Sullivan has predicted that the European printed circuit board industry will stabilise and grow steadily, rather than swiftly, in the years leading up to 2002. Badly hit during the recession, the industry lost around 1600 manufacturers since the early 1990s. As with many industries, the trend during the recession has been towards fewer and larger companies, still under "extreme pressure" on profit margins, despite increased sales overall. Put simply, this means that companies are being forced to sell greater amounts for lower prices pro rata. Structural trends for the future include greater use of surface mount technology, use of even larger scale integration on chips, and higher wiring densities, including multi-layer boards of more than 12 layers, with buried vias. Telecommunications looks set to be the biggest market for the most advanced boards

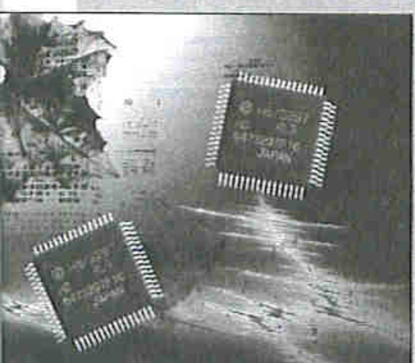
National Semiconductor have produced a low-voltage CD-quality 'Boomer' audio amplifier chip, the LM4863, designed mainly with laptop and desktop computers in mind, but also suitable for powered loudspeakers and portable video games. The device can alternately power stereo headphones or stereo speakers, at up to 1.5W per channel as a speaker-driver. This is a single-chip solution replacing two mono power amps, a headphone amp, and load switching circuitry between headphone and speaker modes, reducing board space, design time and cost. The device comes in 16-pin small surface mount or 16-pin dual in line packaging ...

Northrop Grumman Naval Systems, developing advanced thermal batteries for the US Navy and McDonnell Douglas, has joined forces with specialist ceramics manufacturer ART to work on commercialising energy cells based on lithium-metal sulphide (LiMS) technology and aluminium nitride battery separators. LiMS is one of the technologies involved in high temperature battery research over the last two decades. The developers believe that the use of AlN separators, while costing more per unit than current magnesium oxide separator powder, will give a "much higher" battery cycle life, reducing costs overall. Electrically powered vehicles are one of the likely commercial applications in the fullness of time ...

In Washington, USA, an Internet International Ad Hoc Committee (IAHC) has been named to resolve issues arising from a proposal to establish further global registries and international Top Level Domains (iTLDs). New iTLDs would add to the current three-letter tags (.com, .net, .org and so on) that end many Internet e-mail and World Wide Web addresses. The committee will, among other things, be charged with looking at issues including trademark and infringement, administration of registry operations, fees, etc. and may report in January 1997. The web site http://www/iahc.org will carry documents for public comment.

Fast microcontroller development kits

The Hitachi H8/300 have been announced as the world's fastest microcontrollers yet. The H8/3297 series of 8/16-bit microcontrollers gives a minimum instruction cycle time of 125ns within a powerful general register architecture, memory options up to 69 Kbytes of rom and 2 kbytes of ram in mask rom and one-time programmable eprom. The device has 51 I/Os and includes 64-pin Shrink dip packaging.



The microcontrollers are supported by a number of development tools, including a low-cost evaluation kit EVB3334Y including the H8/300 evaluation board and compiler, and the PCE3297 in-circuit emulator. The EVB3334Y also includes an evaluation copy of IAR's C compiler and C-Spy source level debugger, and all documentation and cables. The PCE emulator provides a debugging tool with multi-level break point logic, providing program execution and data value breaks as well as a pass counter. It also has a real-time trace facility.

Hitachi also supply CIDE, a Windows 3.1-based C source level debugger, allowing real time debugging of C code in a point and click screen environment, with single step at C level, breakpoints on C statements, C level real-time trace, monitoring and modifying of complex C structures and variables within a watch window, access to all the features of the emulated device, and I/O and memory-dump windows. The aim is to provide an efficient solution for engineers developing embedded applications in C, including automative airbags, air conditioning, cordless phones and process control applications. The S5 PCE emulator package includes the emulator, IAR C compiler and CIDE source level debugger.

For information contact Mr. Vince Pitt, Hitachi Europe Ltd., Whitebrook Road, Lower Cookham Road, Maidenhead, Berks SL6 8YA. Tel 01628 585163 Fax 01628 585160.

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PCB Shake'n'Etch ETI February 1997

If you are unable to obtain the LM 3911 temperature controller ic, please write to ETI Shake'n'Etch Worksheet (address on page 74) for an alternative. The LM 3911 has apparently been withdrawn.

Overseas Readers

To call UK telephone numbers, replace the initial 0 with your local overseas access code plus the digits 44.

Way to go, Car!

Carin is part of the new generation of GPS-based in-car get-you-to-your-destination aids. Now the car really does know the way ... Graham Whyte reports.

What do you get when you cross a Wheatstone bridge with a sidereal satellite, with a CD-I, with the highways department? Only so far ... but add a fluxgate compass and several layers of digital mapping, and you arrive at Carin, the new in-car navigation and information system from Philips. The system is controlled from a "Man-Machine Interface" (MMI) front-end, though calling Carin a 'machine' is an impressive understatement.

Conceived early in the 1980s, Carin is one of several in-car navigation systems to reach the public in mainland Europe and America in recent years. In the UK, however, it appears to have stolen the march, at least inside the M25 "London bypass", where I suspect it has been fully operational for longer than Philips have yet admitted - like most new, complicated digital systems, it has not been without its share of teething troubles. But the £3,000 after-market (retro-fit) price-tag will not remain exclusively "capital" expenditure - by the end of 1997 most major conurbations should be looking at the sky to find out where on earth they are - and motorway guidance will provide the missing links for the bits in between.

Why do we need this technology? What's wrong with using the good old A-Z? Quite a bit, if you're driving a car - until someone comes up with a way to convert an entire map-book into a head-up display, stopping to look is the only safe option. And what do you do when you don't know quite where you are - and then you find your destination is on the page join?

Ever since the ancient mariners' race for a positional fix inspired the Harrison chronometers, man has had a passion (a fixation?) to know his exact whereabouts. When all you had to do was find the New World, near enough was often good enough, but nowadays, when we want to get to B to A, we don't mean A+ or A-. If you know the approximate bearing, most scouts could get you to B from A with nothing much more than a watch (even a digital one), as long as the sun is out (and how often is that?). But how do you find your way when you (a) don't know the distance and bearing to your destination, and (b) are enclosed in a dynamic environment constantly re-positioning itself in time and space - like a car?

Take one passenger, add one disc

When Martin Thoone addressed the topic in the *Philips Technical Review*, December 1987, he pointed out that the most reliable in-car navigational aid available at that time was called a "passenger". Note that he said "in-car" - electronic and radio nav has been around in boats since Decca first criss-crossed the English Channel when Marconi was a brand-leader. By the mid-1980s avionics navigation was taken for granted. But none of this spawned an electronic automotive guidance system that needed neither specialised training or a massive support infrastructure such as range-finding beacons.

And - significantly - there was no low-cost means of storing the huge amounts of data in a detailed electronic map of even the smallest town.

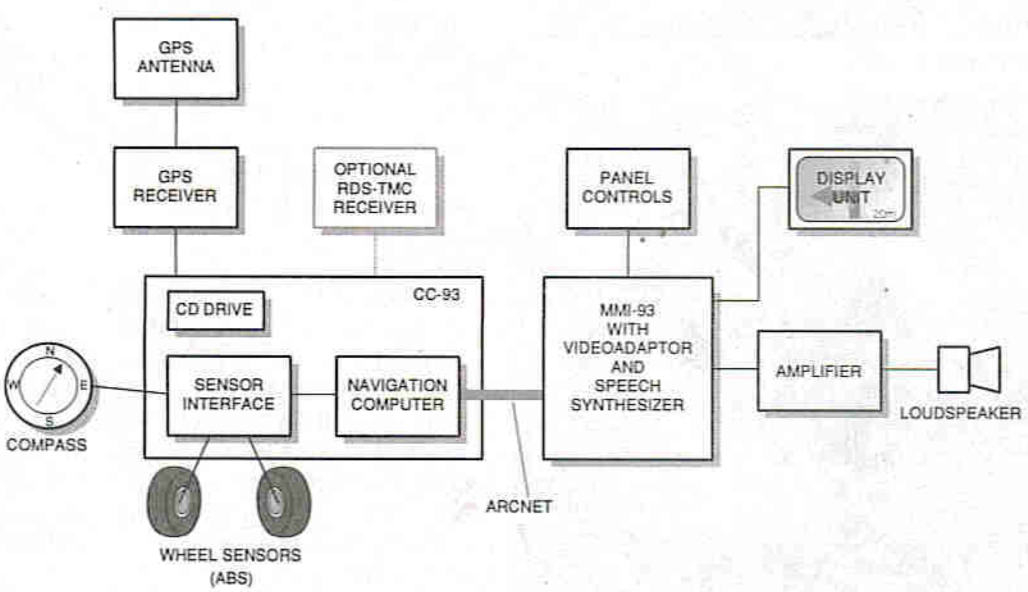

Figure 1: the Carin system schematic

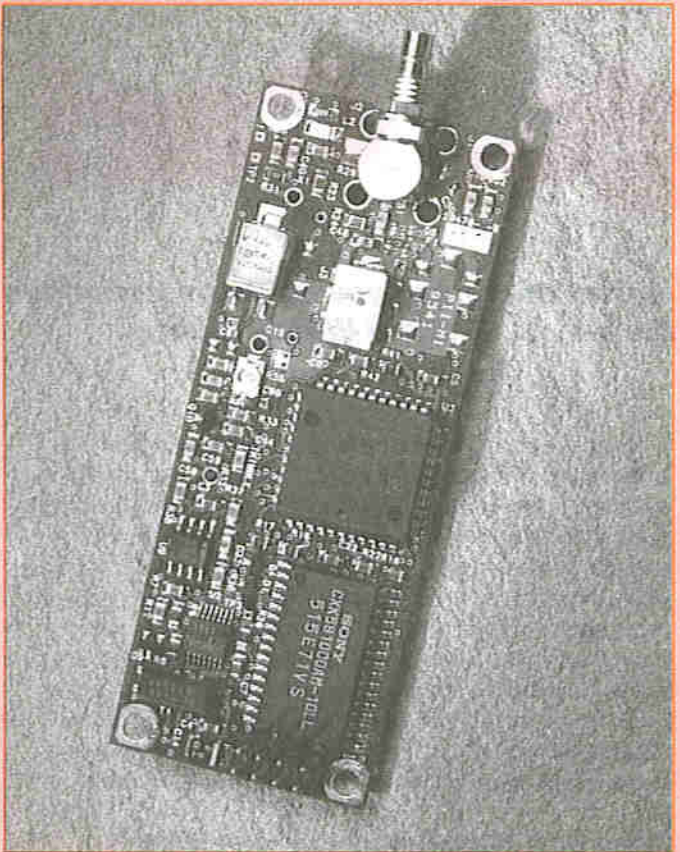

Figure 2: a Trimble GPS engine high integration circuit board
Trimble engine: photograph courtesy of Trimble.

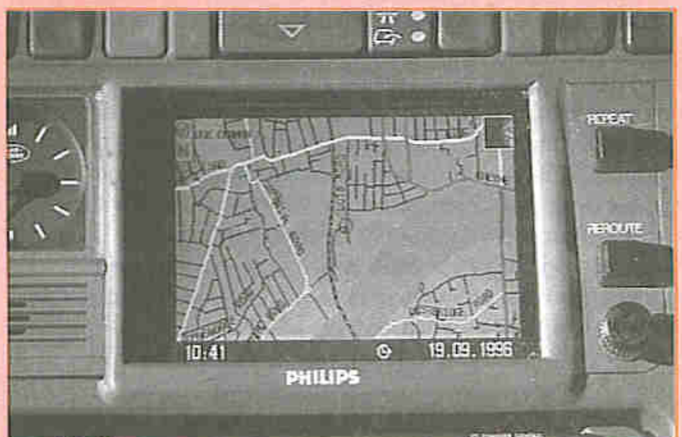

Figure 3: the LCD panel *in situ*

Figure 4: the selection keypad

That was in 1987 - but enter a technological revolution that allowed manufacturers to put Carin and its rivals on the map: CD-I (Compact Disc Interactive), easily portable and able to store up to 700 Mbytes of data, the perfect medium for storing the digitised map data that interacts with Carin's sense of direction. To put it into perspective, the whole of Germany now fits onto one disc.

Clearly, CD-I is only part of the story (figure 1). Long before the digitised map is consulted, the CC-93 navigation computer system gathers positional information from three other sources: wheel sensors, compass and a GPS engine, currently supplied by Trimble (figure 2). The processed data is delivered to the driver via a full-colour LCD panel (figure 3) mounted on or in the vehicle fascia, and a speech synthesiser. Designated the MMI-93, this unit has a small, separate key pad (figure 4) that allows the driver to select command options from multiple-choice displays.

Billed as "the car of the not-too-distant future", the prototype British vehicle fitted with the forerunner of the present system (and a full qwerty keyboard) was designed by I.A.D (Industrial Automotive Design) of Worthing. The CD-I unit and CC-93 computer share a DIN enclosure accessible for changing discs. An Arcnet local area bus on coaxial cable hooks the CC-93 to the MMI-93.

Vehicle Location Probability Area (VLPA) is the Holy Grail of vehicle guidance system designers: we've all heard about the diminutive African tribe whose misfortune was to dwell in a land where the grass was taller than they were - well, the same sort of agonising goes on inside CC-93, as the components of the location system track the vehicle's VLPA. It uses three sources to contribute to a dead-reckoned position at any given moment (strictly speaking, at any given stretch of road within a few metres).

The first of these sources is a pair of sensors that measure the revolutions of the non-driven wheels and the distance each has travelled. As the differential action of their common axle will cause the wheels to travel at different speeds through bends and corners, so the two wheels will also travel different distances. This constantly-changing relationship provides the processor with enough data to calculate changes of direction as well as distance travelled.

Here comes the U.S. ... Navy

The second source is a fairly straightforward fluxgate compass that monitors the vehicle's bearing in relation to the earth's magnetic field. For a while, these two were considered sufficient to give reliable dead-reckoning - which is just as well, because that's all that they had. Then along came the US Navy with around 24 navigation satellites in sidereal orbit, to which they sold the key of the door. (The side door, anyway - only the Top Guns get to play with the real McCoy.)

Suddenly, Philips were able to add (sky)hooks to their belt and braces, and from 11,000 miles away Global Positioning System (GPS) satellites uprated the reliability (if not the accuracy) of the VLPA, and Carin came of age. Yet despite these detailed computations, all the system could know *for sure* was that the vehicle had travelled a certain distance, performed n changes of direction, was on some particular bearing, and that the GPS was indicating that the vehicle was either at a given point on the earth's surface (or somewhere in space ...)

So we have arrived at a point (if you'll excuse the pun) where the system can predict with almost cast-iron certainty

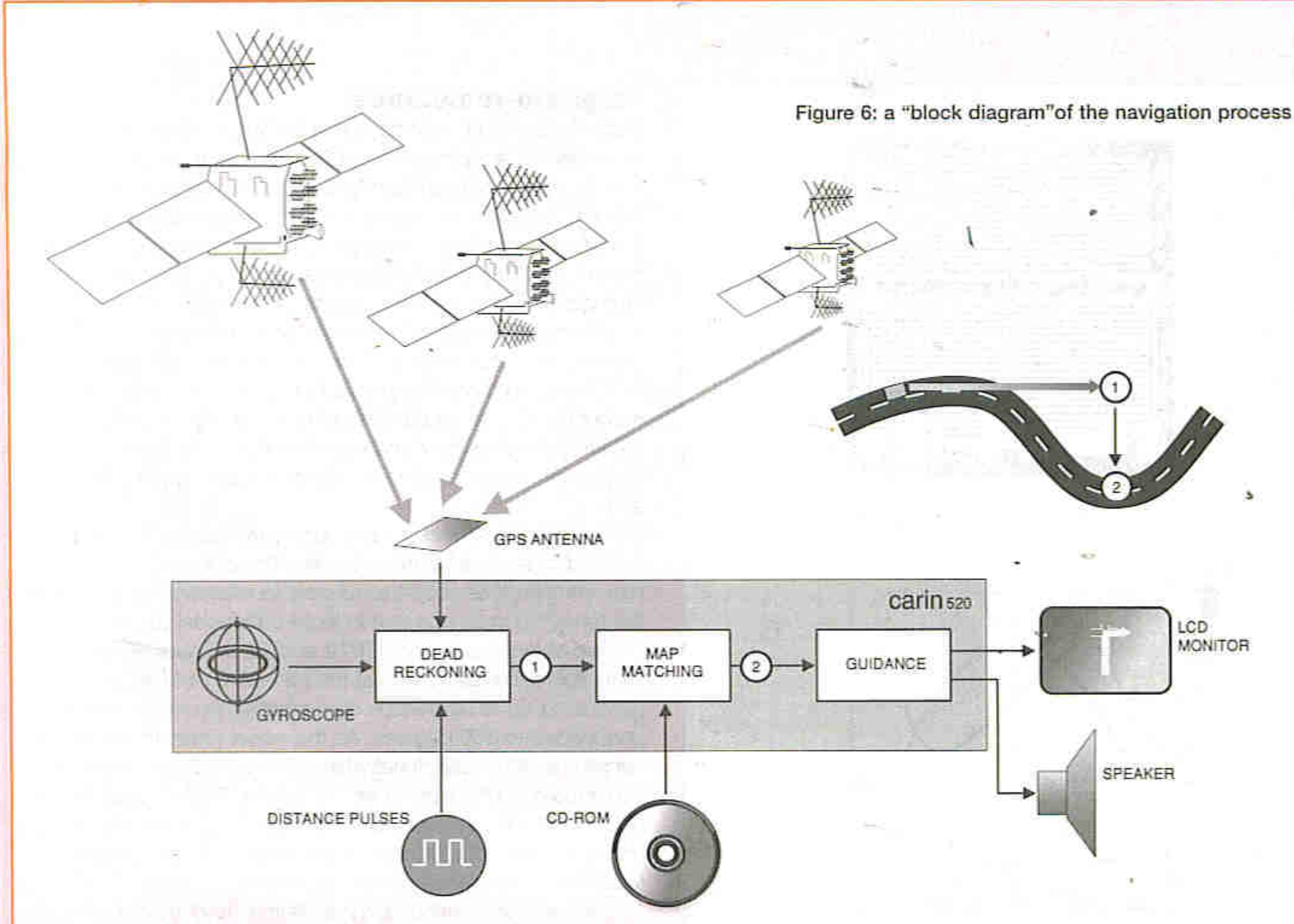

Figure 6: a "block diagram"of the navigation process

a VLPA within 50 metres or so either way. To turn all this relativity into facts, Carin uses the CC-93 processor to compare the VLPA with the topographical data retrieved from the CD-I, to generate a fix - that appears at last as a street name at the bottom of the MMI screen (figure 5).

But this is not just a location system: its ultimate function is to guide you to your chosen destination. It might be enlightening to discover you are at The Barbican, but suppose you really want to be in Holborn Viaduct?

The clever bit is the dynamic guidance system that updates itself as the vehicle heads towards your destination. You know the one about the driver who asked for directions and was told "you don't want to start from here, mate." Well, Carin follows that advice. Imagine an invisible fishing line, with the hook attached to your car and the rod located at your destination. In principle, that's Carin. It pin-points your destination, works backwards to your current position, and then reels you in with audio\visual directions generated via the MMI. We can use figure 6, which is a schematic of the Series 2 positioning and guidance process, as a block diagram to examine the functions and system components (figure 7) in more detail.

On the left of the diagram is the dead-reckoning function: the wheel sensors and compass have gone, replaced by a gyroscope and "distance pulses". The former combination is still used in some of the "original equipment" arrays factory-fitted by vehicle manufactures such as BMW. On the after-market Series 2 version, Philips have discarded the wheel sensors and compass in favour of a pcb-mounted piezo-electrical vibration gyroscope, which functions as an angular rate sensor, with a feed from the vehicle's own electronic speedometer to provide a linear distance input. Although marginally less accurate, the gyroscope is easier to fit and requires no specialist calibration.

Figure 5: the Carin MMI display

Figure 7: the external hardware of the Carin system

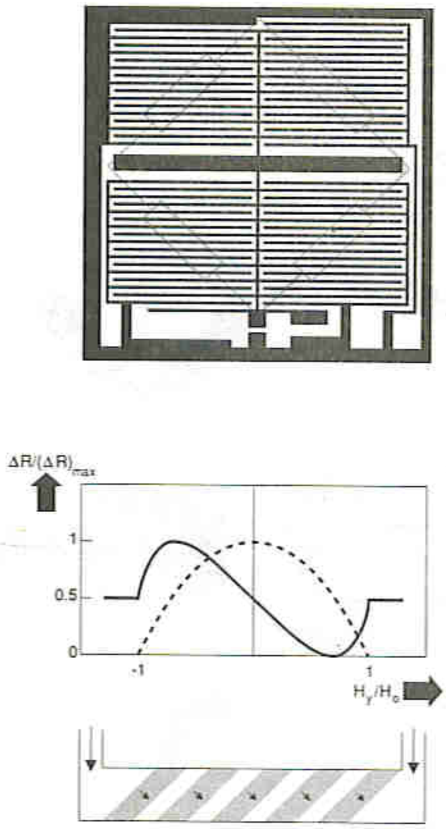

Figure 8: (a) (Top): Inside a KMZ10 magnetic transducer: the transducer is composed of ferromagnetic strips connected to form a Wheatstone bridge, and uses the magneto-resistance effect to measure magnetic fields. (b) shows the prinicple of a magneto-resistive transducer

Magneto-resistance

Both the electronic compass and the wheel sensors, which in later vehicles are part of the ABS mechanism, employ transducers to convert a magnetic flux into voltage, utilising the magneto-resistance effect in which the resistance of certain materials depends on the angle between the direction of the current and that of the magnetisation. Because the effect is strongest in ferromagnetic material, the transducer is made from multiple strips of a nickel-iron alloy. These strips are connected in four groups to form a Wheatstone bridge (figure 8). When the external magnetic field is zero, the direction of magnetisation will be parallel to the x axis. The angle between the direction of current and magnetisation, and hence the resistance, changes when a magnetic field is applied in the y axis.

The maximum sensitivity of such a transducer is about 0.1mV per ampere/metre at 5 volts. The electronic compass may contain three such transducers to measure the strength of the terrestrial magnetic field in three orthogonal directions.

Two similar transducers (Tr12 and Tr2 in figure 9) are used to measure the revolutions of the non-driven wheels by generating up to 50 periods of magnetisation which together correspond to 360 degrees. As the wheel turns, the transducer supplies a sinusoidal signal which is amplified and converted into square-wave voltages which, in turn, are converted into a pulse train. Binary numbers are also generated to indicate separately the angular rotation of the left and right wheels relative to the previous dead-reckoned fix.

Several calibrations follow installation. To begin with, the vehicle is driven around a closed loop to enable the compass to be calibrated (after which the effect of the car's magnetic field can be largely eliminated), and the wheel-sensor transducers matched to each other by comparing their output with a computer-generated regression circle. The odometric function is calibrated by driving the vehicle in a straight line along a measured distance and comparing the output with the known distance.

The remaining, non-correctable, errors are collectively treated as random, the magnitude of which can be estimated, since their standard deviation can be calculated with a fair probability from repeated measurements. These standard deviations of the random errors in the measurement of heading and distance can be obtained from comparing a large sample of dead-reckoning fixes with correct, map-matched fixes. The magnitude of the random errors contributes to the size of the VLPA which is, in theory, bounded by an ellipse whose area is determined by rules for the propagation of random errors.

Both the compass and wheel sensors provide a quantifiable heading, in the former case an absolute heading, and in the latter relative to an initial value.

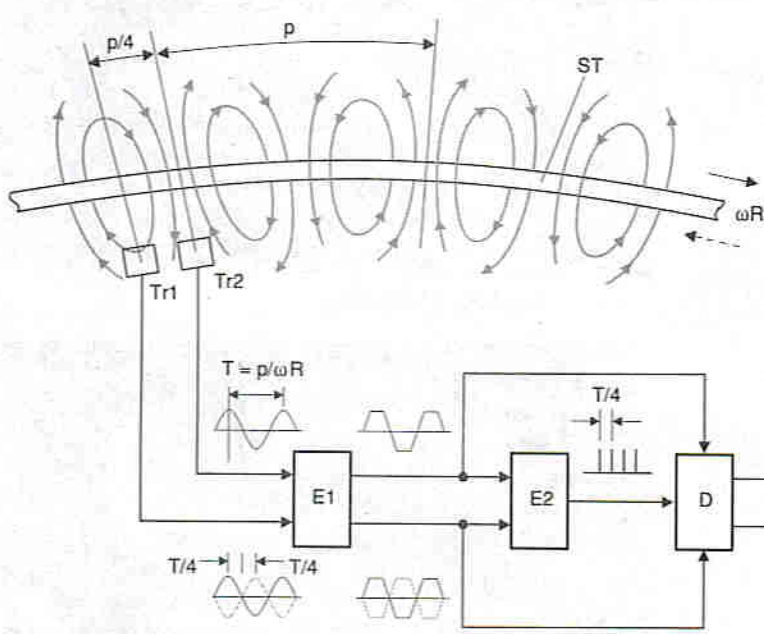

Figure 9: the principle of a wheel sensor. ST is a permanently magnetised strip; p is the period of the radial magnetisation; ωR is the peripheral velocity of the strip where ω is the angular velocity and R is the radius; Tr1 and Tr2 and magnetic transducers. The output signal is approximately sinusoidal with a period T = p/ωR.

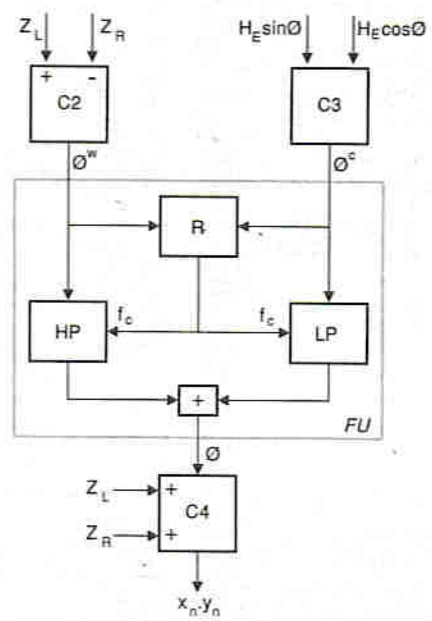

Figure 10: the reconciliation schematic: processing the signals ZL and ZR from the wheel sensors and HEsin∅ and HEcos∅ from the electronic compass. C2,C3,C4 are computing units; FU is the filter unit. In C2 the signals ZL and ZR are converted into a signal ∅W for the heading. In C3 the compass signals are converted into a signal ∅C comparable with ∅W. HP is a highpass filter; LP a lowpass filter; fc the cutoff frequency of the two filters; R is the control unit that continuously controls the magnitude of fx by measuring the rms value of the interfering components in ∅W and ∅C. After addition, the resultant signal ∅ is periodically converted into values xn and Yn for the coordinates of position, with the aid of the sum signal from the wheel sensors.

They are both subject to interference because of the signal source: the wheel sensors are subject to slow drift due to changes in tyre pressure, tyre wear, and so on, while the compass is subject to very fast fluctuations caused by the magnetic fields of other vehicles, steel bridges and other masses along the road. And, of course, there is a small but constant error due to the magnetic field generated by the host vehicle.

These disparate signals must be reconciled and corrected. A schematic and description of this process is given in figure 10.

Getting it right

Having ironed out as many of the disturbances as possible, a complex dead-reckoning algorithm factors in the random errors and calculates the instantaneous VLPA. But despite the cleaning-up process, random errors will always remain within the VLPA which will, in consequence, grow continuously. Under difficult circumstances the VLPA can grow very quickly, and this is where the addition of a GPS fix will limit that growth and so improve the reliability of the positioning system. *(A description of how GPS functions appeared in ETI August 1994.)*

Of course, we know that VLPA positioning, even at the point of update, serves little real purpose unless it can be expressed in terms of a street location. Knowing your whereabouts to a six-figure fix is great if you normally navigate your way round London with a Pathfinder map ...

At this point it is only the GPS element that is providing anything like a navigational fix - the rest is a length of electronic string that has charted the course but not the position. To find your precise whereabouts in the real world, turn to the NavTech digitised map on the CD-I. The dead-reckoning process generates a pattern of calculated positions which are compared the topographical map. A match fixes the part of the road network where the car is, and resets the VLPA at that instant in time and space to its smallest, or most accurate, area - which immediately begins to grow again as the car continues to move. Whenever a dead-reckoning is made, the computer detects the segments of the digitised map contained in the VLPA rectangle and holds them in memory as 'trees' of possible routes. If a segment is found to lie beyond the VLPA in the next dead-reckoning, it is discarded from the tree. A position correction takes place if the computer can decide with a good degree of certainty which of the possible routes has been followed.

Dead-reckoning, map matching, VLPA update, VLPA growth continue in a merry-go-round of estimate, correction and counter-correction repeated every five metres or so with sufficient accuracy for the system to know, and tell the driver via a message on the MMI, the exact location of the vehicle at any moment. As the name of the road changes, so does the display. It is immediate and, in my experience, always correct and quite uncanny.

The digital map

So far we have looked only at the positioning part of the system; the so-called PVH components - position, velocity and heading relative to polar north. On input of a destination via the MMI, using the keypad to highlight and select the required function on the display screen, Carin starts planning a route. But before that, it is worth considering how the map has been created, bearing in mind that it is much more than an electronic road atlas.

The digital map is divided into a large number of uniform areas, each containing several levels or networks, all covering the same area but with more or less detail. For example, the area that covers part of Wandsworth (in south London) may contain on its highest level only the South Circular and A3 - major routes between, say, Southwark and Kingston. The next layer down would include both these roads plus a number of secondary through routes, and would be used by the system on a more localised journey, say, from Fulham to Clapham Junction. The lowest level would contain all the information on its two superior networks, plus the entire tertiary network of local residential roads as on a printed town plan, and would be used for local journeys, such as might be made by doctors or delivery drivers and, of course, visitors whose destination was in that immediate area.

NavTech, and their only serious rival Tele Atlas (aka Etak), use OSCAR (Ordnance Survey Centre-line Alignment of Roads), which details every public driveable road and most private roads in a digitised format using the vector method, in which the axes of the roads are closely approximated by straight-line segments. This requires less memory than the alternative raster scanning method, and has proved entirely adequate for all the pan-European and American databases already in use. Figure 11 shows how a road network is translated into a series of points each connected by straight lines - the sharper the bend, the shorter the lines. The position of each point can be expressed as either an *xy* co-ordinate on a conventional grid system, or as a geodetic co-ordinate. NavTech manipulate this geometry to meet the required specification for in-car systems and, as an example of the end result, figure 12 shows how the area around Greenwich Observatory appears on one of NavTech's computers.

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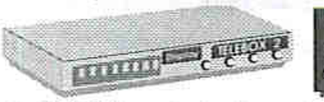

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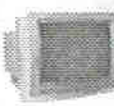

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PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with **both RGB and standard composite 15.625 Khz video inputs** via **SCART socket** and separate phono jacks. Integral audio **power amp and speaker** for **all audio visual 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
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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)

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Virtually New, Ultra Smart
Less than Half Price!

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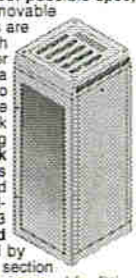
32U - High Quality - All steel RakCab



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)

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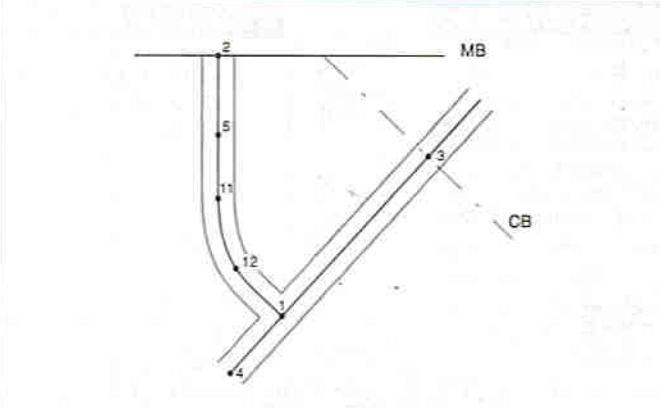

Figure 11: digitisation of the road layout with nodes

Points may be either a node or a shape point. In figure 11, points 1, 2, 3 and 4 are all nodes (where more than one component exists); points 11 and 12, used to plot curvature, are typical shape points. Point 5 marks a change in road name and is therefore upgraded to a node. A succession of points that starts and ends with a node is called a chain, or links. To this skeleton can be added navigable attributes such as directions of one-way streets, restricted turns, road dividers, timed road closures and so on.

Sorting the parcels

At this point NavTech "massage" the data so that it corresponds with drivers' perceptions of junctions "on the ground", rather than being simply a strict geometric interpretation that could occasionally give misleading guidance. NavTech say that the secret of their success is the application of "art, not science". Using County Council (or London Borough) Transport Policies and Programmes (TPP) strategic networks as a starting point, NavTech define the so-called "arterial network" which determines the "weighting" applied to routes, the first steps to which are distinctly hands-on (figure 13). This process is very much qualitative, and includes systematic behind-the-wheel driving of the roads by NavTech's own surveyors, as well as consultation with highway authorities and other interested organisations. This is an ongoing process that has to take account of changes to road layouts and so on, and must include "temporary" long-term road closures (such as Hammersmith Bridge). Regular updates are issued as replacement discs which can be ordered by subscription.

All the information is divided into parcels, stored as discrete blocks on the CD-I and distributed over a number of sectors. The CD also contains addresses of the first sector where each block is stored, its size in blocks, and the co-ordinates of the lines that delineate the corresponding map parcel. Access can be kept to a minimum if the parcels are not too large and are stored logically to minimise pick-up movement. The first requirement dictates that each parcel should contain a similar data value, so that its blocks do not occupy too much space in the RAM. Conversely, there should not be so many blocks that the address directory becomes unwieldy.

The second requirement demands that adjacent parcels on the map should correspond to blocks close to each other on the disc. To achieve similar block characteristics, the map data for each parcel must likewise be similar. From this it follows that parcels in rural areas will be larger than those in towns. The partitioning algorithm is known as the "region quad tree", in which the map is successively subdivided into four rectangles until the data content per parcel is less than a preset value (figure 14).

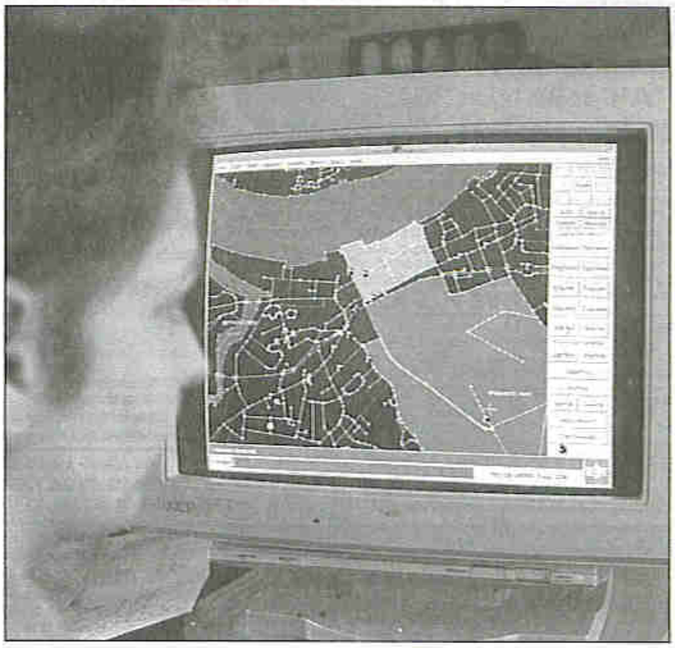

Figure 12: a digitised map of a NavTech computer

Figure 13: the hands-on approach to weighting

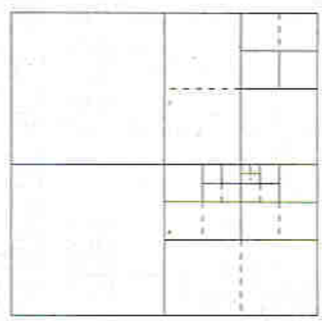

Figure 14: map partitioning with the "region quad tree" algorithm.

Occasionally adjacent parcels are joined again, provided the combined data value barely exceeds the preset. Logical arrangement of the data blocks for accessibility is achieved by the application of Peano space-filling curves, where the curve passes through each point in a given space once only.

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PRICE £64.35 + £4.00 P&P

OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 330 x 175 x 100mm.
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OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
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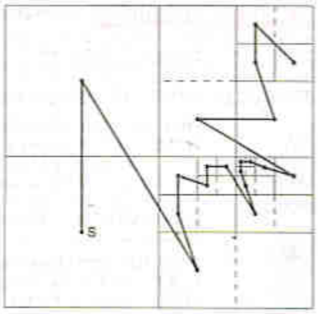

Figure 15: The Peano N-curve that connects the parcels of figure 14 and starts at S. In the case of a parcel formed from a summation, the centre of the first original parcel is taken: the other parcel is then ignored.

A Peano curve is particularly suitable for arranging the parcels generated by region quad tree partitioning. It can be seen from figure 15 that the smaller the parcel, the shorter the Peano curve that joins it to its neighbour. Think of the curves as expressing the physical proximity of one CD sector to another, and it's easy to see how the curve can represent relative pick-up movements.

Because the destination is fixed and the vehicle dynamic, Carin performs the route-planning backwards, based on the algorithms of Dijkstra and Dial. Starting at the destination, many possible routes, all in the general direction of the vehicle, are simultaneously assembled and investigated. The driver will have indicated via the MMI a preference for major or minor roads and whether time or distance is of the essence. To distinguish the optimum route, Carin introduces a "cost" element that reflects the physical characteristics of the route, and also takes account of the "weighting" of particular routes as preferred by the relevant Local Authority. The latter caused some teething problems for NavTech who, by diplomacy as much as technology, were obliged to overcome "edge mapping" problems associated with adjacent authorities preferring different routes.

To the cost function is added a heuristic routine (trial and error) which estimates the cost of the route to the current position of the car. Together, the cost and heuristic functions generate an optimum selection and reject the remainder. Planning time is critical and, as CD-I access times are conventionally too slow, an algorithm has been developed to improve access times by anticipating the map areas and consequent disc sectors likely to be needed and loading them into the system RAM. Expressed in the form of a histogram, typical planning times for the German database are shown in figure 16.

SOCRATES - A philosophy for the future

Within a few years, "getting there" will be even easier as navigational systems begin to interact with traffic status networks via GSM up- and down-links. Philips, in conjunction with a number of other European partners including Volvo and British Telecom, is participating in the so-called SOCRATES programme which will integrate road and traffic information using the cellular network.

In this system, vehicles act as information-sources as well as recipients via the down-link. In the test areas of Gothenburg (Germany) and Eindhoven (the Netherlands) only a few percent of cars are fitted with interactive Carin, yet the system computers are able to detect traffic hold-ups and accidents and relay this information back down to vehicles in the area. It is obvious that Carin will soon be automatically generating its own detours in response to such inputs. SOCRATES will also provide information on available parking spaces, and drivers may reserve places via the system. According to the Transport and Road Research Laboratory, if SOCRATES were to be fully operational in London savings, of up to 100 million pounds per year could be achieved - and no doubt the atmosphere would be a lot more breathable. As the evaluation of the Gothenburg trials are coming to a close, larger trials are planned for Frankfurt and London with 100 and 200 cars respectively.

As the SOCRATES tests continue we can also look forward to RDSTMC, the snappy title for Radio Data System Traffic Message Channel. RDS we already know and hate, particularly when the aliens from Grunt FM interrupt the non-RDS Radio 4 with news of a snar-lup at the War Memorial. Lurking on the sub-carrier of Classic FM (amongst others), RDS is also used to carry the differential correction signals for dGPS - the ultra-accurate GPS system used by farmers and surveyors (see 'What a difference a d makes'). But the Carin-integrated RDS will make it possible to store the transmissions and replay them selectively. Pilot schemes are already operating in the Dutch Rhine-Corridor project and the Paris Ile de France project. As with SOCRATES, RDSTMC also offers the possibility of intelligent re-routing via the Carin guidance system, but only if the computer calculates that the obstruction will still be there when the Carin-equipped vehicle reaches the locality.

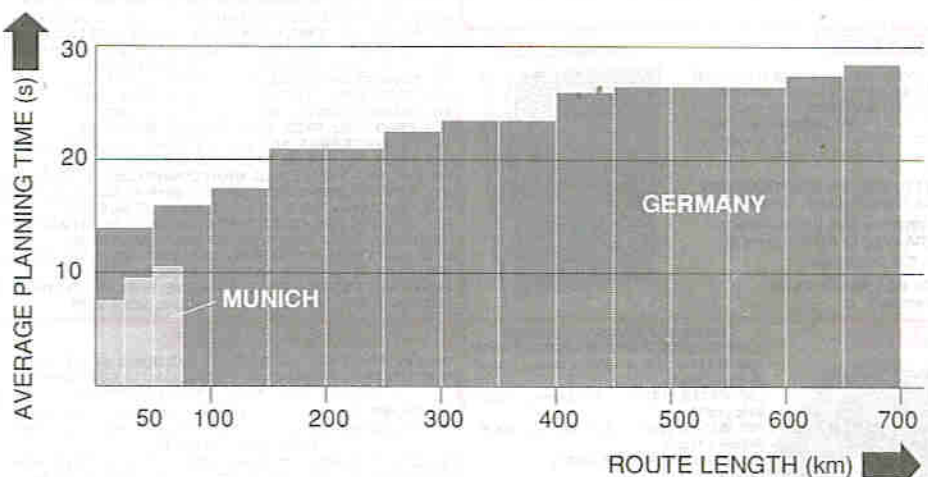

Figure 16: the histogram for Germany

Figure 17: Carin in a Mitsubishi Shogun

Figure 18: a pictogram in operation

Figure 19: a scaleable map display

What a difference a d makes

When Uncle Sam launched all that military, sorry, communications hardware that made GPS possible, he introduced something called "selective availability" to ensure that no hostile force could turn it round on him. SA introduces "noise" into the atomic clocks, which reduces their accuracy. The military authorities also feed the satellites slightly erroneous orbital data, transmitted back to earth as a slight wobble which, of course, reduces the accuracy in navigational functions. If a time-period plot of the position solutions of a stationery GPS receiver is taken, the fix can be seen to wander around with a 100-metre circle to a surprising degree. Military receivers have a decrypting key that tells them what errors have been introduced, so that they can be removed and accuracies in the order of 15 metres can be achieved.

Differential GPS receivers are able to improve the accuracy to around 1 metre or less. dGPS not only takes care of SA, it also filters out most of the inaccuracies caused by atmospheric distortion and multipath errors caused by signal reflections (as in TV ghosting).

So how do they do that? Normal GPS navigation is dynamic in the sense that the receiver is usually on the move, and so the fix is dependent upon the inherent trigonometry of the system. dGPS, however, introduces a second receiver which is situated on a point that has been very carefully surveyed. This reference receiver detects errors transmitted from the satellites and applies a correction based on its fixed parameters. A commercial differential correction service is available on subscription from companies like Focus FM, who use the Classic FM sub-carrier, and Racal who have recently launched LandStar Europe differential correction for farmers.

The corrections are transmitted to the mobile GPS receiver which, is relatively close at hand, so the incoming signals from the satellite and the reference receiver are effectively simultaneous. The reference receiver measures the incoming errors using its known position (and therefore distance) to calculate timing discrepancies - the reverse of the mobile receiver, which uses timing to calculate distance.

Having measured and corrected any timing errors for all satellites above the horizon, the reference receiver encodes the information into a standard format and transmits it to the mobiles, which decode and use only those bits of information applying to satellites "visible" to them.

There are a couple of variations which have no need for a continuous radio link. In "post processing", for example, in surveying, the mobile receiver records the time it made each measurement; the correction data can later be downloaded from the reference receiver to clean up raw real-time data. "Inverted" dGPS is sometimes used in vehicle tracking applications: a base station collects location information and applies differential correction. The driver's display may show he's up and down the City Road, but the dispatcher will know when he's in and out' the Eagle.

See me, hear me

Everything we have so far encountered, apart from the street name displayed at the base of the screen, occurs without any visual indication to the driver. What makes Carin effective is its public face, the guidance system. The Carin guidance system is of course audible as well as visual, but I will deal with the latter first.

The LCD screen (figure 17) is built into the fascia on some factory-fitted versions, or attached to the top or front of the fascia in aftermarket versions. It offers two modes - junction schematics (pictograms) (figure 18) or a scaleable map (figure 19), which can be viewed head-up or north-up, on which the vehicle's position is tracked. With practice it is possible to

Figure 20: the set-up screens in multiple-choice format

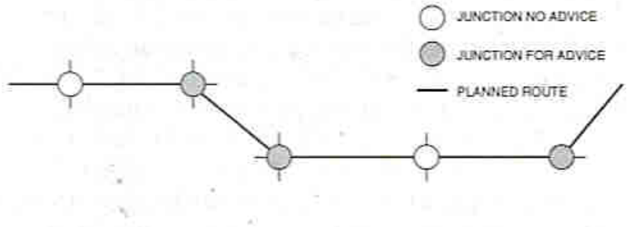

Figure 21: advice and non-advice junctions

toggle deftly between the two, but I have found it much safer and easier to use the pictograms, as they can be understood at a glance and correspond with the spoken guide.
As well as the pictogram, the screen shows date and time, distance to destination and the approximate heading (indicated by means of a small rotating arrow-head). The set-up screens (figure 20) offer multiple-choice options in a straightforward text format.

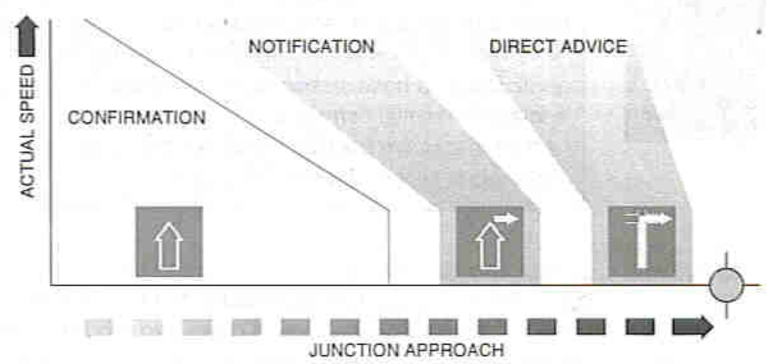

Figure 22: advice - broken down into three windows

Having selected a destination, the driver can set off and within 15-20 seconds the screen fills and voice guidance begins. If, at a simple intersection, no change of direction is required the schematic arrow of the pictogram simply indicates straight ahead, and no audio guidance is provided. Examples of advice and non-advice junctions are shown in figure 21. The approach to junctions where advice will be given is broken down into three windows (figure 22). The first, or confirmation, window is visual only and means "continue straight ahead". This is the same display that would be seen for non-advice junctions. The actual distance to the next 'advice' junction is counted down in metres on the screen display. When the vehicle reaches a point prior to the junction, determined by speed, a visual and audible warning is given of the approaching junction. This is called the notification window. The final instructions occur in the final advice window, in both media, at a point dependent on the vehicle approach speed. The voice messages are divided into three groups: prefix advice, such as 'At the next junction'; main messages such as 'Turn right'; and suffix advice such as 'To join the motorway' - which together offer up to 10,000 possible permutations.
If the driver decides to deviate from the route, Carin will detect the new route, re-calculate from the destination back to the new position, and provide guidance either to return to the original route or for a new route. Philips do not claim that Carin will always take the route that a human with local knowledge would choose, but they are quite bullish that it will always get you to where you want to go, which, in fairness, was the objective.
When you reach your destination, which may be a street or a point of local interest like the British Museum, a dot appears above the confirmation arrow on the pictogram and a butler-like voice announces *"You have arrived"*.

Technical diagrams by kind permission of Philips Car Systems.

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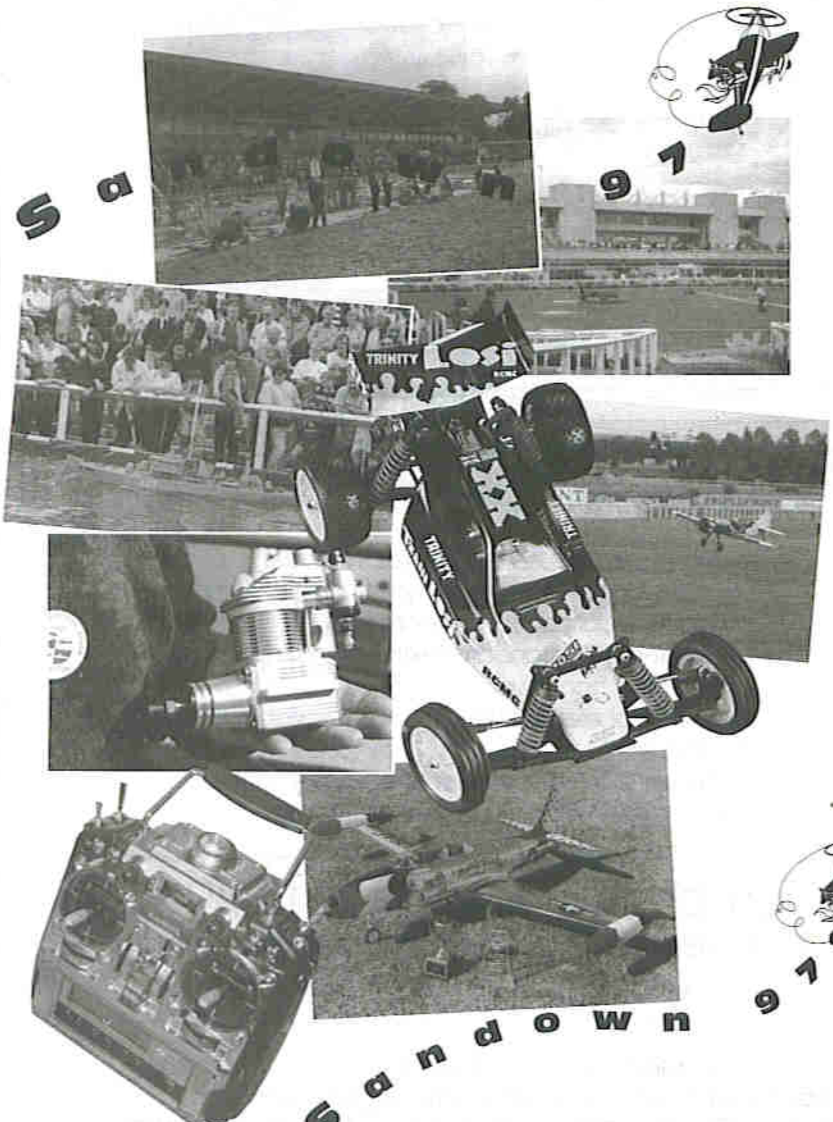

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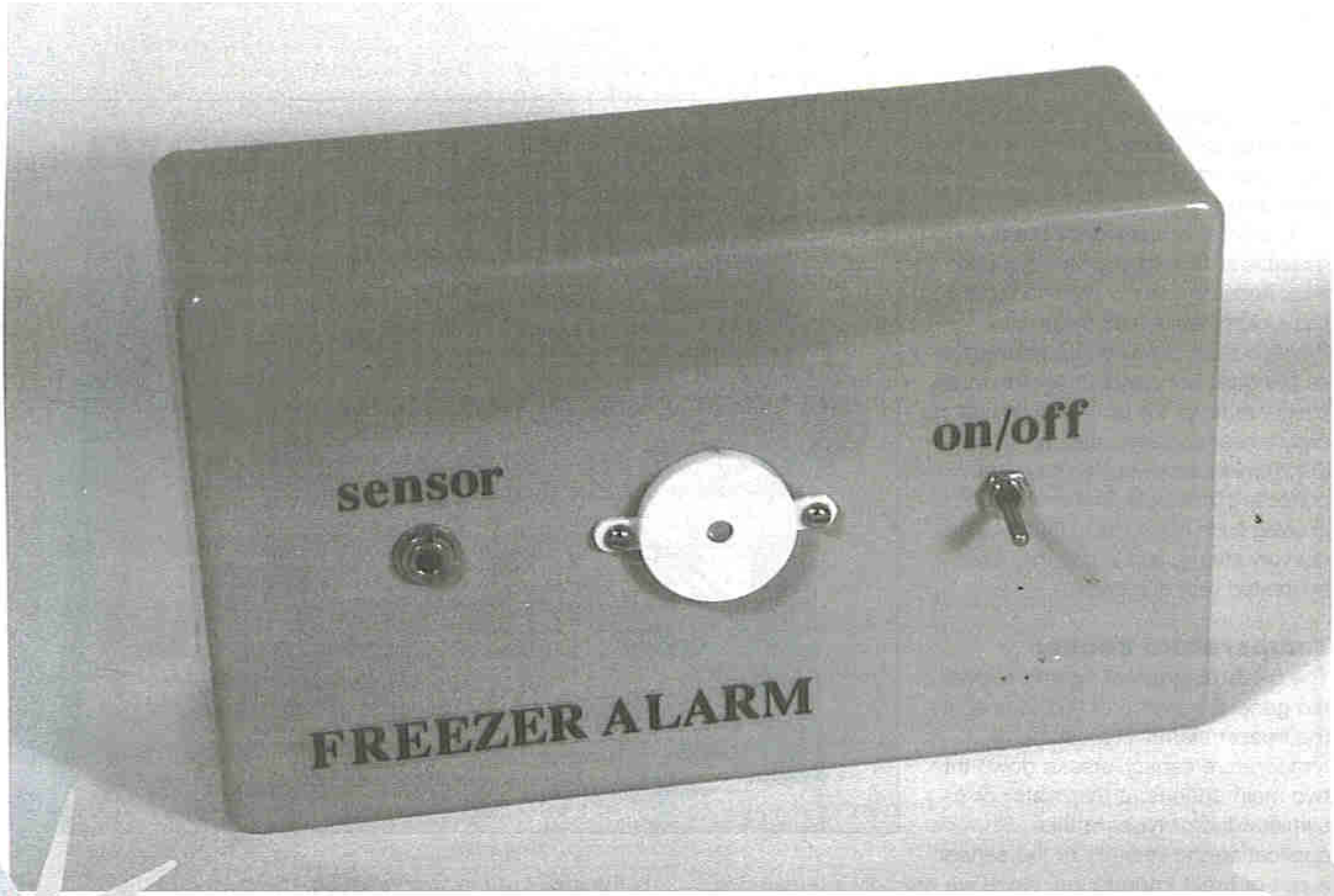


ETI Freezer Alarm

The kitchen is flooding, your heart is sinking, supper's off - the freezer has gone down again! Time to reach for Robert Penfold's freezer defrost alarm.

I am sure I'm not the only person to have had that sinking feeling on discovering that the freezer door has been left slightly open. The usual cause is a freezer over-stuffed with the latest supermarket bargains, making the door reluctant to close properly - because of the flexible rubber seal, the door can be left so slightly ajar that it appears to have closed.

It is the ease with which the door opens the next time you visit the freezer that alerts you. The thick layer of frost on everything inside the freezer also gives you a clue!

Having to defrost the freezer prematurely is inconvenient, but there is also the question of whether or not the food in the freezer is fit to eat. The food may not have actually defrosted (unless you have had one of those "someone pulled the wrong plug out when they plugged the electric drill in" events that make a certain editorial team shiver ...) but it is unlikely to have been kept at a suitably low temperature either. Many people prefer to take the safe option and throw it all away "just in case."

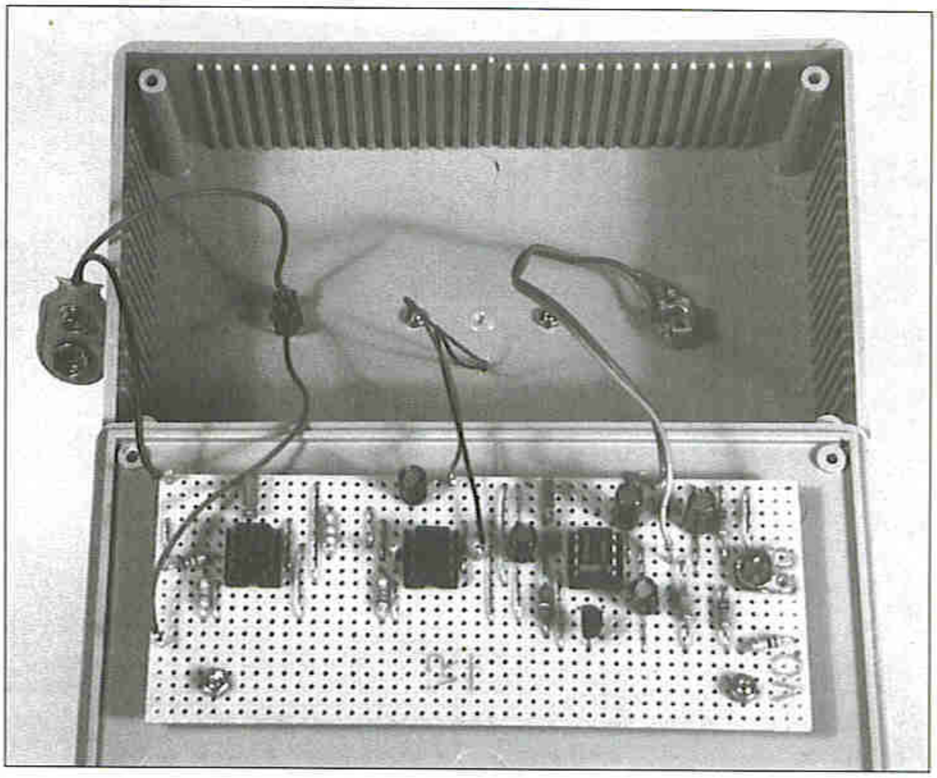
Either way, it is the kind of waste and inconvenience - not to mention potential flood - that we would all like to avoid.

One way of providing an electronic alarm to guard against the dreaded defrost is to use a micro-switch to operate an indicator light or a simple audio alarm generator when the door is not fully closed - in other words, an arrangement much like an ordinary refrigerator light, but with the light on the outside. However, it is difficult to add this type of thing to an existing piece of equipment.

The obvious alternative is to use a temperature-operated alarm. This method has the advantage of detecting any problem that causes the temperature inside the freezer to rise above its normal level. Whether the door has been left slightly ajar, the freezer has developed a fault, or the mains supply has failed, the alarm will detect the temperature rise and be activated. This method is also problematic, since the sensor must be inside the freezer with the rest of the unit on the outside. Drilling holes through the side of the freezer is obviously not an option!

The only alternative is to use very fine wires that can be taken out through the door seal without rendering it ineffective.

The finest insulated wire readily available is 44 swg enamelled copper wire. According to my data book, this has a diameter of 0.08 millimetres. Practical tests showed that wire as thin as this does not significantly reduce the effectiveness of the door seal. In fact, a slightly heavier gauge such as 40 swg (0.125 millimetre) wire seems to be perfectly acceptable. The only problem in using such fine wires is that they are not very strong, and in use they must be treated with due care.



Temperature sensor

The block diagram of figure1 shows the general scheme of things used in the freezer alarm. The choice of temperature sensor breaks down into two main options: a thermistor or a semiconductor type. In this application the linearity of the sensor is not of great importance, since we are only interested in detecting a particular threshold temperature. A thermistor is therefore perfectly adequate. The temperature inside a freezer is well below zero, at around -18 to -20 degrees Celsius. This is outside the scope of some semiconductor temperature sensors, but most of the thermistors currently available will work perfectly well down to about -40 degrees Celsius. A thermistor was therefore selected as the temperature sensor.

A thermistor is effectively a resistor with very poor temperature stability. Normal thermistors have a negative temperature coefficient, which means the component's resistance falls as its temperature is increased. The thermistor is used in a simple potential divider circuit connected across the supply rails. If the temperature of the thermistor rises, its resistance falls, and the output voltage from the potential divider circuit falls as well.

The output from the potential divider is compared with a reference voltage by a voltage comparator circuit. If the output potential from the potential divider is higher than the reference level, the output of the comparator goes high. Conversely, if the output voltage from the potential divider is the lower of the two voltages, the output of the comparator goes low. In practice the reference voltage is set at a level which results in the output from the potential divider normally being the higher of the two voltages. Under standby conditions the output of the comparator is therefore high. If the thermistor is taken above its normal temperature, its resistance decreases, and the output potential from the potential divider decreases. If the temperature rise is high enough, the output voltage from the potential divider will go below the reference voltage, and the output of the comparator will then go low.

The output of the comparator drives an electronic switch, and this controls the supply to the other stages of the unit. These stages generate a simple frequency modulated alarm sound. The switch and alarm generator are switched off under standby conditions when the output of the comparator is high. When the output of the comparator goes low, it turns on the electronic switch, which in turn supplies power to the alarm generator circuit. The basic alarm sound is produced by a vco (voltage controlled oscillator) which has a centre frequency of around 4kHz or so.

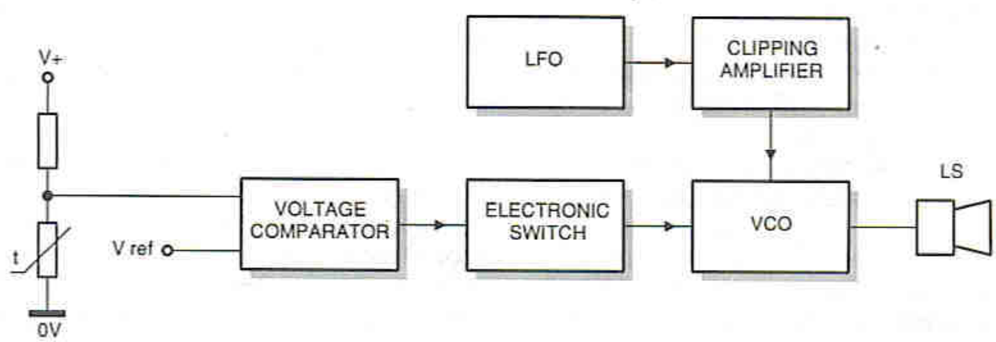


Figure 1: The block diagram of the freezer alarm

An lfo (low frequency oscillator) provides the control signal to the vco, and the roughly squarewave output from the vco would normally result in the vco being switched between two tones. In this case a lowpass filter is used between the lfo and the vco, and this attenuates the harmonics in the squarewave signal to produces a roughly triangular modulation signal. This varies the vco between two frequencies, rather than switching it between the two. The result is an excellent and highly effective alarm sound.

Circuit Operation

The circuit diagram for the freezer alarm appears in figure 2. IC1 is an operational amplifier, but it operates here as the voltage comparator. VR1 provides an adjustable reference voltage to IC1's inverting input, and the potential divider circuit which contains the thermistor (Th1) drives the non-inverting input of IC1. This gives what is really just a basic bridge circuit. An advantage of this simple arrangement is that it does not require a stable supply voltage. If the supply voltage changes, so will the output potential from R3 and Th1. However, the output potential from VR1 will change as well. The temperature at which two sides of the bridge provide the same voltage, and the alarm is activated, is always the same, regardless of the supply voltage.

Th1 is a "47k bead" thermistor, but the value of 47k refers to its resistance at 25 degrees Celsius. Its typical resistance is 155.6k at 0 degrees Celsius, and around 220k at the typical operating temperature in this application. VR1 is therefore adjusted for an output potential of about half the supply voltage. A variable reference voltage is needed so that it can be adjusted to compensate for component tolerances, and the exact threshold temperature required.

C2 and C3 filter out any "hum" or other noise picked up in the wiring at the inputs to IC1. The circuit lacks any hysteresis, and in theory it is possible for the output of IC1 to go to an intermediate voltage. In reality, the gain of the circuit is so high that this does not seem to happen, although there might be a small amount of "jitter" as the alarm switches on. In practice it seems to be better to tolerate this than to add triggering, which could impair the circuit's ability to respond to small temperature changes.

TR1 is the electronic switch, and this is a simple pnp common emitter switching stage. When the output of IC1 goes low, TR1 is switched on and it connects the battery supply through to the alarm generator. The vco uses IC2 in what is basically just a standard 555 astable (oscillator) circuit. The output of IC2 directly drives IC2, which is a ceramic resonator and not a moving coil loudspeaker. The circuit might operate properly using a high impedance (40 ohm or more) loudspeaker, but a ceramic resonator requires a far lower drive current and is a safer option. The output frequency range of IC2 is quite high, but it is a frequencies of a few kilohertz that a ceramic resonator provides peak efficiency.

The low frequency modulation signal is generated by IC3, which is another 555 astable. The higher timing component values give it a low operating frequency of around 3Hz. IC3's output is coupled to the lowpass filter, which is a simple passive type (R8 - C6). The modulation is applied to pin 5 of IC2. Without the modulation, C5 is first charged to two thirds of the supply potential via R6 and R7, and then discharged to one third of the supply voltage via R7 and an internal switching transistor of IC2. The circuit oscillates indefinitely, with C5 being repeatedly charged and discharged in this manner. The output at pin 3 goes high while C5 is being charged, and low while it is being discharged.

It is possible to vary the upper threshold voltage by applying a voltage pin 5 of IC2. Pulling the threshold voltage higher increases the charge and discharge times of C5, and reduces the output frequency. Taking the threshold voltage lower reduces the charge and discharge times, giving a higher output frequency. This gives a rather crude form of frequency modulation, but it gives good results in an undemanding application of this type.

It is important that the circuit has a very low standby current, so that it can operate continuously for months without exhausting the battery. The high values used in the bridge circuit help in this respect, and the current is further reduced by using a low power device for IC1. The current consumption of the alarm generator circuit is not important, as it is switched off under standby conditions. A leakage current will flow through TR1, but this is too low to be of any significance.

Under quiescent conditions the prototype had a measured current consumption of 120 microamps. The capacity of a PP3 size battery is typically about 0.35 to 0.55 amp/hours, but is effectively higher with the minute current drain involved here. This gives a battery life which is typically about six months to one year. The current consumption is about 12 milliamps when the alarm generator is switched on.

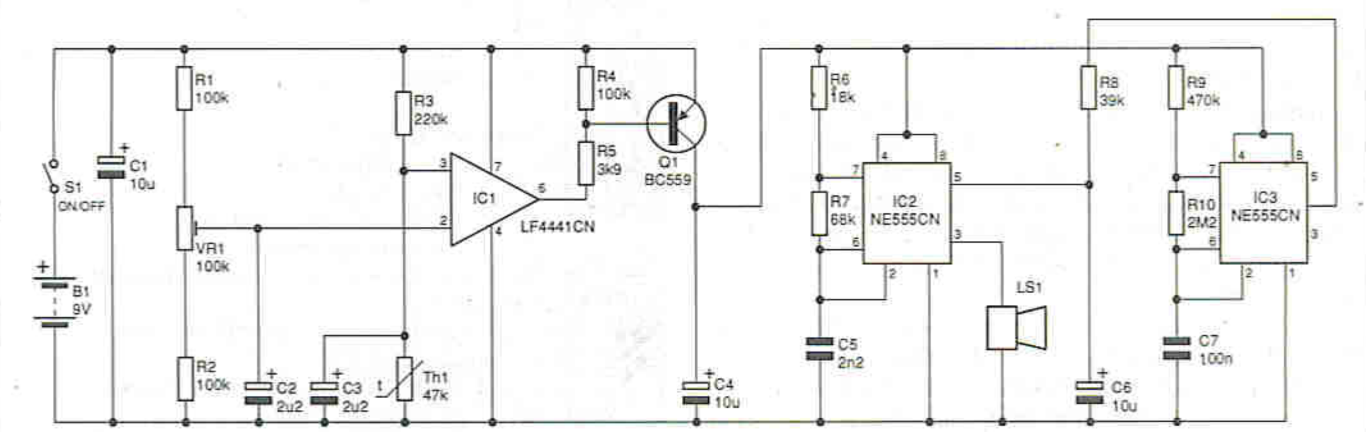
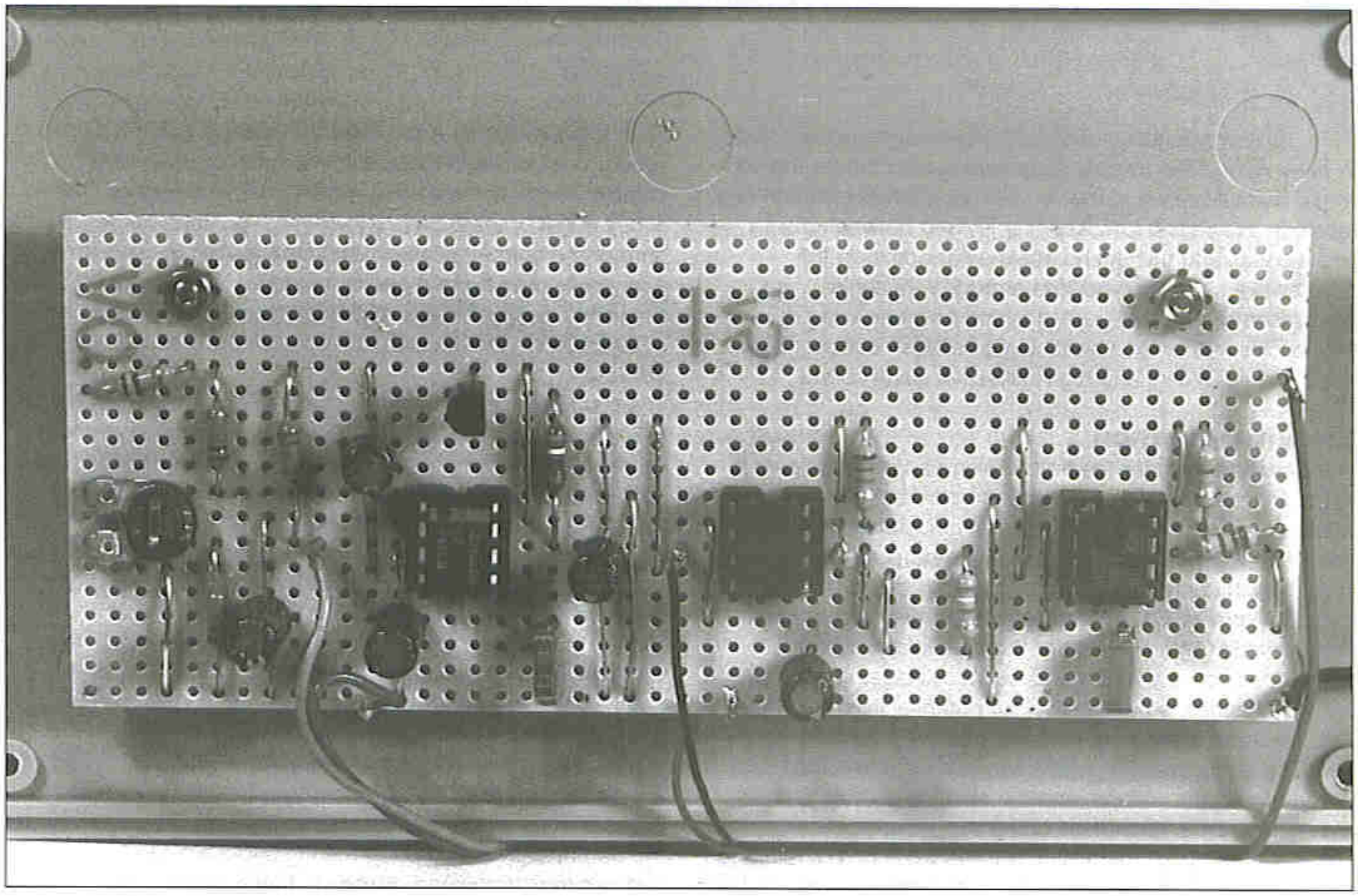


Figure 2: the circuit of the freezer alarm



Construction

The circuit is assembled on a 0.1 inch pitch stripboard panel which measures 47 holes by 19 copper strips, using the component layout shown in figure 3. The underside view of the board appears in figure 4. Start by trimming a board to the correct size using a hacksaw, and then drill the two 3.2 millimetre diameter mounting holes. To complete the preparation of the board make the breaks in the copper strips. A special strip cutting tool is available, but a hand held twist drill bit of about five millimetres in diameter also does the job quite well. Modern stripboard is quite thin and brittle, so try not to cut any deeper into the board than is really necessary in order to fully break each strip. Cutting too deeply can seriously weaken the board.

Next the components and link-wires are added. None of the integrated circuits are static sensitive, but I would still recommend using holders for all three. The link-wires can be made from tinned copper wire of about 0.56 millimetres in diameter (24 swg), or the trimmings from the resistor and capacitor lead-out wires might suffice. C5 and C7 must be printed circuit mounting types having 7.5 millimetre (0.3 inch) lead spacing if they are to fit neatly into this layout. Fit single-sided solder-pins at the points where connections to Th1, LS1, etc. will be made.

This project will fit into practically any small to medium size plastic box. The removable lid becomes the rear panel, and the circuit board is mounted on this panel. In general, plastic stand-offs do not seem to work very reliable with stripboard, and it is probably best to use 6BA or metric M3 nuts and screws to fix the board in place. On/off switch S1 and LS1 are mounted on the front panel.

Cased ceramic resonators normally have provision for two small (8BA or M2) mounting bolts. The easiest way of mounting LS1 is to bolt it in place on the front surface of the panel. A small hole must then be drilled at the appropriate point in the panel to permit the two "flying" leads to pass through to the interior of the case.

PARTS LIST for the Freezer Alarm

Resistors (all 0.25 watt 5% carbon film)

R1,2,4	100k (3 off)
R3	220k
R5	3k9
R6	18k
R7	68k
R8	39k
R9	470k
R10	2M2

Potentiometer

VR1	220k min hor preset

Capacitors

C1,4,6	10u 25V radial elect (3 off)
C2,3	2u2 50V radial elect (2 off)
C5	2n2 polyester (7.5mm lead spacing)
C7	100n polyester (7.5mm lead spacing)

Semiconductors

IC1	LF441CN
IC2,3	NE555CN (2 off)
Q1	BC559

Miscellaneous

S1	spst toggle switch
B1	9 volt (PP3 size)
LS1	cased ceramic resonator
Th1	47k bead thermistor

Plastic box, 0.1 inch pitch stripboard measuring 47 holes by 19
copper strips, 8-pin dil holder (3 off), battery connector,
40 swg enamelled copper wire, multi-strand connecting wire,
solder, etc.

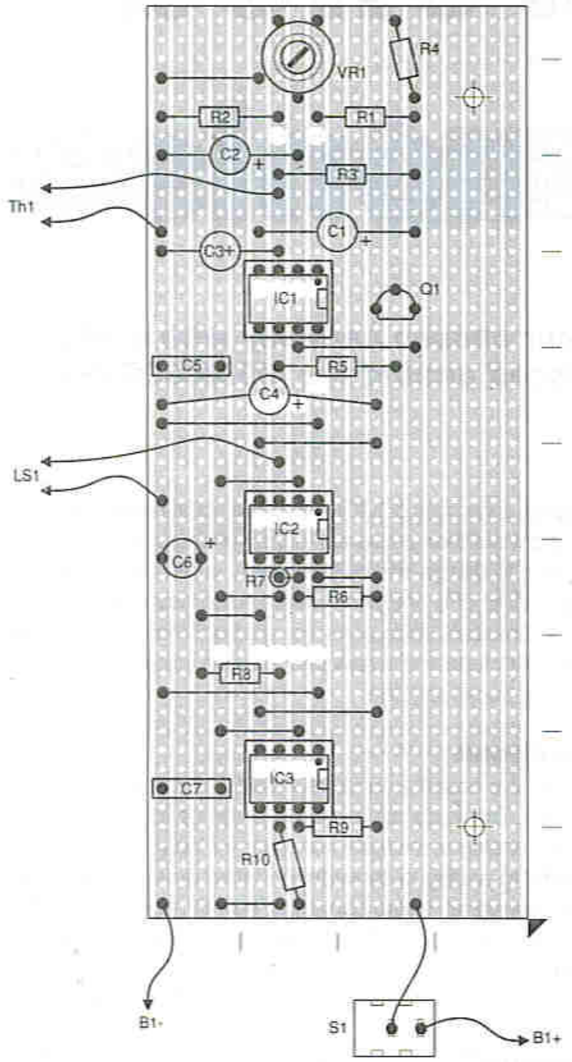


Figure 3: the stripboard layout and wiring

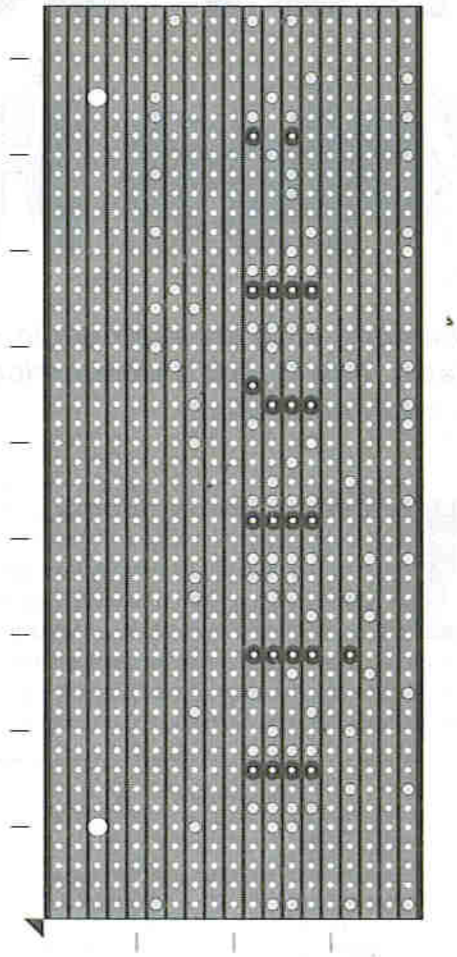


Figure 4: the underside of the stripboard panel

The alternative is to mount LS1 on the rear surface of the panel. A large cutout will then be needed to accommodate the main body of the component. Most ceramic resonators seem to have one black lead and one red one. This is presumably to indicate the phasing, since these components are not polarised, and can be connected either way round.

Th1 can be wired direct to the circuit board, and a small entrance hole for the two leads must then be drilled somewhere in the case. On the prototype Th1 is connected to the circuit board via a 3.5 millimetre jack socket mounted on the front panel, and a matching jack plug fitted to the extension wires from Th1. The enamel insulation is easily removed from the connecting wires using the blade of a penknife, but go very gently or the wire may be damaged and have a tendency to break. Use pvc sleeving over the leads of the thermistor to prevent any accidental short circuits. The connecting wires can be a few metres long if necessary.

In Use

It is best if the thermistor is positioned near the front of the freezer, where it will respond rapidly if the door is not closed properly. The exact positioning will have to be chosen to suit your particular freezer, but it will probably be necessary to tape the extension leads to the outside of the freezer to help keep everything in place. These leads are very thin and easily broken, so the alarm must be positioned somewhere that enables the leads to be tucked away out of harms way.

Give the thermistor a couple of minutes or so to adjust to the temperature inside the freezer before switching on the alarm and testing it. By adjusting VR1 it should be possible to switch the alarm generator on and off. The optimum adjustment for VR1 is the most counter-clockwise setting that does not result in the alarm sounding. Having given VR1 a suitable setting, try touching the thermistor to warm it up. If all is well, this should result in the alarm being activated within a few seconds. In use the alarm might tend to sound when new food is stored in the freezer, or possibly even if the door is opened for more than a few seconds. Fractionally backing off VR1 in a clockwise direction will make the unit a little less sensitive, and should avoid false alarms.

MIDI Controlled Voice Harmoniser

Stay on song with yourself while controlling your chosen harmony with a MIDI interface. Tom Scarff's economical design is based around the MSM6322 real-time audio pitch controller.

All the health and exercise pundits tell us that the ideal is to be in perfect harmony with yourself. Well, let's concentrate on perfect harmony from a singing point of view: this is the kind of unit allows you to achieve that goal. A voice harmoniser converts the pitch of your voice into another musically related pitch, so that when the two voices are combined they produce perfect vocal harmony (assuming your input voice was 'perfect' in the first place!).

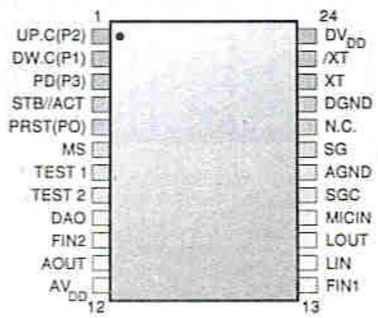


Figure 1: the pin-out of the MSM6322

There are a number of MIDI-controlled vocal harmonisers available at present but their prices are in the hundreds of pounds range, so I decided to design and build my own. While this unit has the limitation that only one pitch-shifted voice harmony appears at the output, if multiple voice parts are required, then each part can be recorded to tape and a new pitch-shifted voice can be added by bouncing tracks together.

The circuit

The circuit is based around the MSM6322 real time audio pitch controller. This ic contains a fourth-order low pass filter with an eight-bit analogue to digital converter for input signals, and a nine-bit digital to analogue converter and third order low pass filter for the output signal. It also contains a built-in microphone and line preamplifier. The block diagram and associated pinouts of IC3 are shown in figures 1 and 2 and Table 1.

The pitch-conversion table shows that there are sixteen different musical pitch combinations available, are selected by the applied binary code. The maximum range, relative to the applied voice, is plus or minus one octave. However, the output is limited to the sixteen semitones shown in the table.

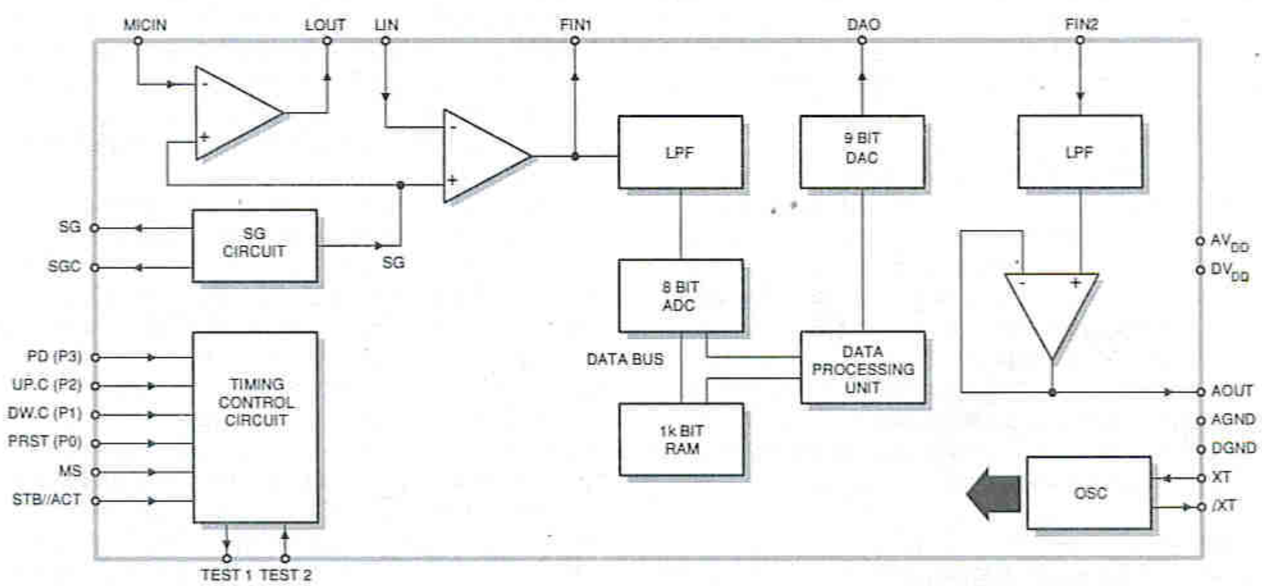


Figure 2: the block diagram of the ic

The circuit is set to operate in binary mode by connecting the mode select (MS) pin to the supply voltage. This enables the ic to be controlled by the binary code that is fed to input pins 5,2,1 and 3, according to the pitch conversion table in Table 2. From the table, it can be seen that both the sampling frequency and the low pass filters are variable relative to the pitch changes - this reduces the chances of aliasing occurring.

The binary code presented to the voice harmoniser IC3 is derived from the output of IC2, a PIC microcontroller which takes the MIDI note-on data, via opto-coupler IC1, and converts it into the required 4-bit binary number to operate the pitch controller IC3. Since no pitch change occurs with the binary input equal to 1000, this is output to the I/O port for the notes that have no corresponding pitch change available. The eight selections from 0000 to 0111 produce corresponding downward pitch changes, whereas a binary output ranging from 1000 up to 1111 produces upward pitch changes.

Analogue section

The microphone input is fed to two pre-amplifiers - one contained in IC3 whose mid-band gain is set by R2/R1, and a direct feed based around IC5A whose mid-band gain is set by (1+R3/R4) - and used in the non-inverting mode to allow in-phase mixing of the direct and effect voices. A summing amplifier IC5B combines three inputs, direct voice, effect voice and external source and feeds them to the line output.

In order to improve the signal-to-noise ratio, the audio signal is routed through a compander consisting of compression via IC4B and expansion via IC4A. The mic amplifier output from IC3 is fed to the compressor IC4B and then to a line amplifier in IC3 whose mid-band gain is set by R14/R13. The analogue output, Aout, from IC3 is fed via expander IC4A to the summing amplifier IC5B.

Compression involves reducing the dynamic range of the input signal being processed so that with a 2:1 compression ratio if the input increases by 12dB then the output increases by only 6dB.

Conversely, *expansion* increases the dynamic range, so when the input to the expander increases by 6dB the output will increase by 12dBwhich is a 1:2 expansion ratio, or alternatively, if the input falls by 6dB, the output drops 12dB. At the same time the noise introduced in the system will be reduced on expansion, since it was not subject to the initial compression treatment and is therefore expanded downwards below the lowest dynamics of the audio signal. This process is illustrated in figure 3.

Software operation

The software initialises port A to be inputs and port B to be outputs. On power-up, the switches SW1-4 are read through port pins RA0 to RA3 and decide the MIDI channel which the harmoniser will operate on, from binary 0000 (0) to 1111 (15). The software then waits to detect a note-on in the range mid C (60) to B (71) above it. Outside this range a note-on is ignored. This decides the musical key in which the harmoniser will operate. This allows relative pitch shifting in any key. So in the key of C, the note E would be four semitones up. Whereas in the key of D, the note F# would be four semitones up.

The software then checks for MIDI status and correct channel and, when these match, checks for note-on or note-off and carries out these routines if selected. Both routines allow for MIDI running status. Also, the harmoniser can be switched off if a correct note-off or a note-on with a velocity of zero are received. When a note-on is received, it is checked to see if it is in the correct range relative to the musical key previously selected, plus or minus an octave. Notes outside this range are ignored.

So when a song is being sung, the harmony at the output can be changed by the MIDI keyboard selection at any part in the song. However, since there are only 16 possible pitch changes, not every semitone of the keyboard is operational. The pitch changes that are available are shown in Table 2.

The harmoniser can be controlled in real-time via a MIDI keyboard, or the MIDI data can be recorded onto a track of a MIDI sequencer allowing automatic changing of harmonies as a song progresses. The relative levels of the direct and harmonised voices can be controlled via the built in mixer controls VR2 and VR3. Also the external input, controlled via VR1, can be fed from a previously recorded mix of voices thus allowing the building of multi-part harmonies.

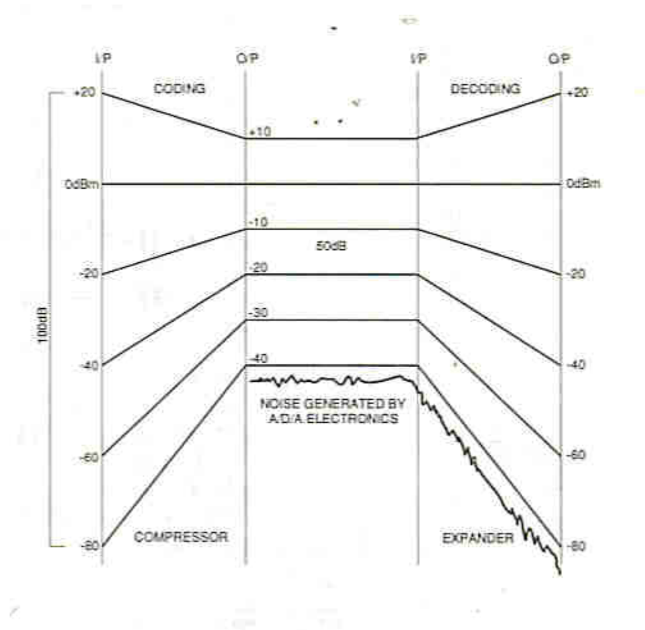


Figure 3: operation of a compression/expansion system

PIN NAME	PIN NUMBER	DI/AI/AO	FUNCTION
MICIN	16	AI	INPUT TO MIC. PREAMP MUST BE CAPACITIVELY COUPLED
LOUT	15	AO	OUTPUT OF MIC PREAMP
LIN	14	AI	INPUT TO LINE AMP. MUST BE CAPACITIVELY COUPLED TO EITHER LOUT OR THE LINE OUT SIGNAL FROM AUDIO SOURCES
FIN1	13	AO	SETS THE INPUT AUDIO SIGNAL AMPLITUDE IN COMBINATION WITH THE LIN PIN
STB/$\overline{ACT}$	4	DI	CHIP SELECT PIN. THE PROCESSING IS INTERRUPTED BY STOPPING CLOCKS OTHER THAN THE OSCILLATOR WHEN THE CHIP SELECT PIN IS AT THE H LEVEL
TEST 1	7	DI	MANUFACTURERS TEST PINS
TEST 2	8		MUST BE CONNECTED TO 0V
XT,$\overline{XT}$	22,23		EXTERNAL CAPACITORS ARE CONNECTED HERE TO STABILISE THE INTERNAL ANALOGUE VOLTAGE REFERENCES OF ½ AV_{DD}
DAO	9	AO	OUTPUT FROM THE DIGITAL TO ANALOGUE CONVERTER
FIN2	10	AI	INPUT PIN FOR INTERNAL LOW PASS FILTER (FOR OUTPUT)
AOUT	11	AO	OUTPUT OF LOW PASS FILTER (FOR OUTPUT)
D_{GND}	21		DIGITAL POWER SUPPLY PINS
DV_{DD}	24		
A_{GND}	18		ANALOGUE POWER SUPPLY PINS
AV_{DD}	12		
			NOTE: DI DIGITAL INPUT AI ANALOGUE INPUT AO ANALOGUE OUTPUT

Table 1: Pin functions

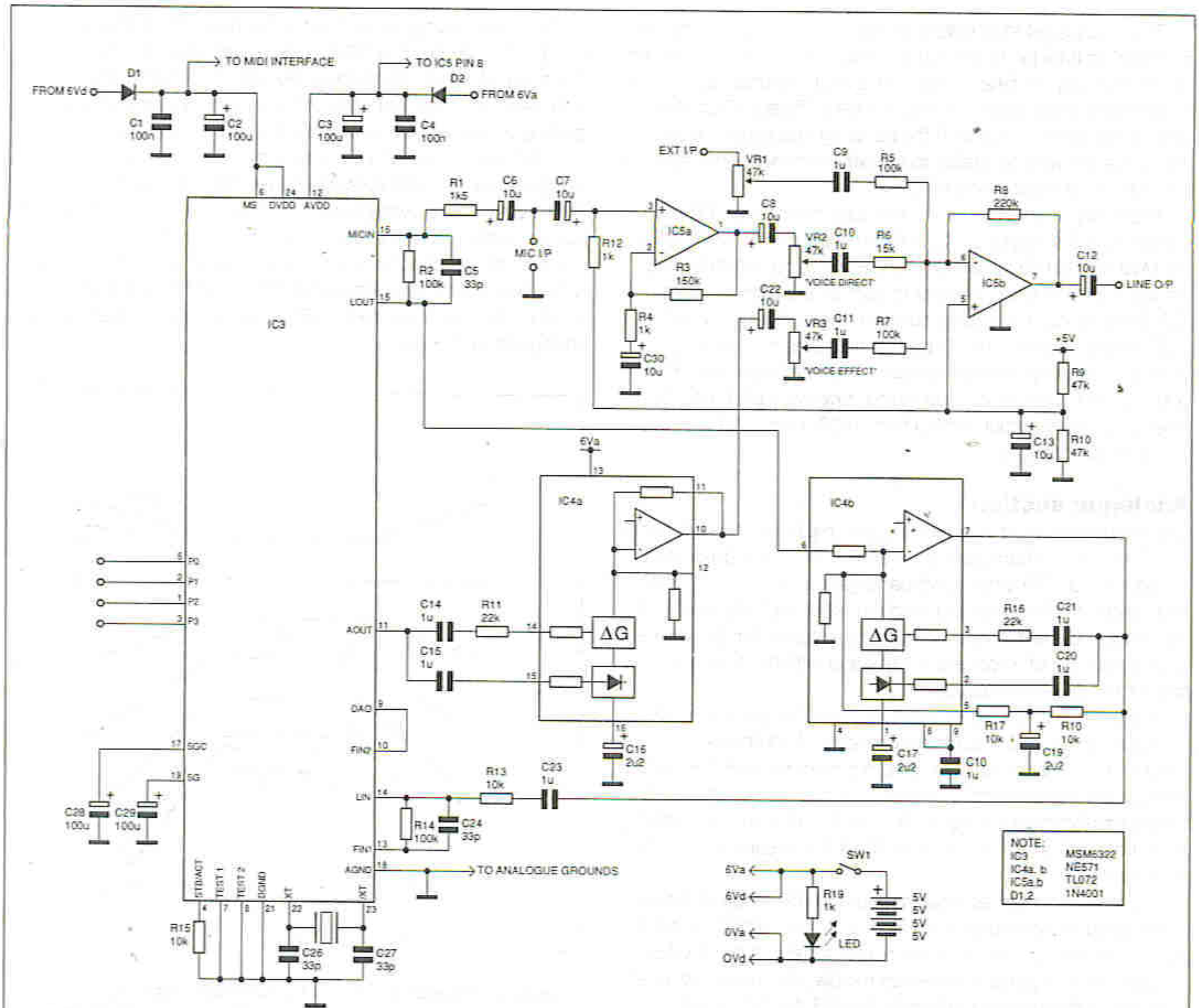


Figure 4: the circuit of the Voice Harmoniser

BIN MODE SETTINGS P3 P2 P1 P0	SCALE STAGE	DA SAMPLING CYCLE (uS) FREQUENCY (kHz)	LPF CUT-OFF FREQUENCY (kHz)	PITCH CHANGE
NOT AVAILABLE	16	60/16.6	7.6	1 octave up
1 1 1 1	15	71/14.0	7.6	9 semitones up
1 1 1 0	14	76/13.1	5.7	8 semitones up
1 1 0 1	13	80/12.5	5.7	7 semitones up
1 1 0 0	12	90/11.1	5.7	5 semitones up
1 0 1 1	11	95/10.5	5.7	4 semitones up
1 0 1 0	10	101/9.9	4.56	3 semitones up
1 0 0 1	9	113/8.84	4.56	1 semitone up
1 0 0 0	8	120/8.33	3.8	no pitch change
0 1 1 1	7	127/7.87	3.8	1 semitone down
0 1 1 0	6	143/6.99	3.26	3 semitones down
0 1 0 1	5	151/6.22	3.26	4 semitones down
0 1 0 0	4	160/6.25	3.26	5 semitones down
0 0 1 1	3	180/5.55	2.85	7 semitones down
0 0 1 0	2	190/5.26	2.53	8 semitones down
0 0 0 1	1	202/4.95	2.53	9 semitines down
0 0 0 0	0	227/4.4	2.07	1 octave down

Table 2: Pitch conversion table

The power supply

The circuit is designed for battery operation using four 1.5V type AA batteries and the current consumption is 20mA.

The analogue and digital power supplies need to be kept isolated to reduce the chance of digital noise introducing itself into the analogue signal path. So the 6 volts from the batteries is fed via D1 to the digital supply inputs of IC1, IC2, IC3, and via D2 to the audio dc supply input of IC3, IC4 and IC5. The diodes prevent damage to the ics if the batteries are fitted incorrectly. The pcb earth tracks for the digital and audio circuits are kept separate, and joined only at the battery terminals.

Construction

The components should be mounted in the following order: links, resistors, diodes, dil ic sockets, capacitors and finally electrolytic capacitors. You will need to check your leds in circuit to see which way round your type needs to be mounted. The 4MHz

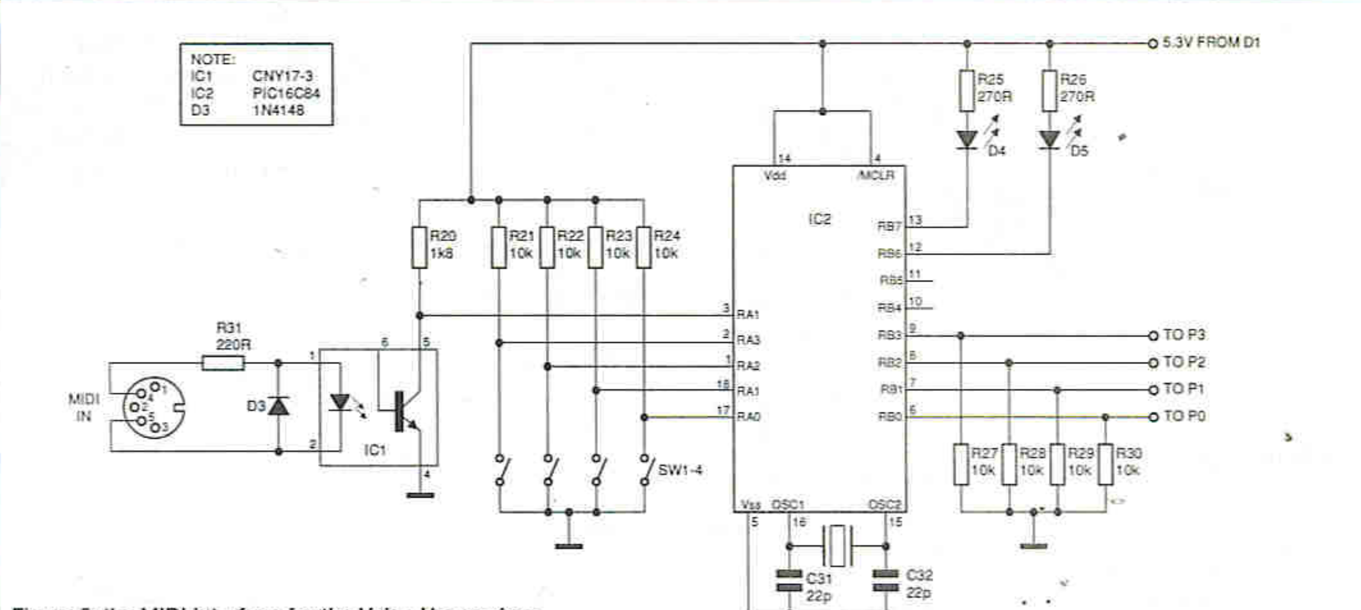


Figure 5: the MIDI interface for the Voice Harmoniser

crystal should be mounted flat on the pcb with its legs connected at 90 degrees into the pcb. The microphone input should be connected to the jack-socket via screened cable to reduce the chances of noise and hum pickup.

The MSM6322 IC3 is a surface mounted device and is soldered to the underside of the pcb. When mounting this component, the smallest possible size soldering bit should be used (less than 1mm), with 22 swg solder. Place the ic squarely on all 24 pins, and solder the opposite diagonal pins first, then solder the remaining pins allowing several seconds between each joint to allow the ic to cool down. The other ics are mounted in dil sockets to allow ease of changing for test or fault-finding purposes. Also, the correct orientation of IC3 is achieved by noting pin 1 being marked on the pcb.

Finally the connectors and controls need to be wired to the PCBs, and the pcbs connected together. Inspection of the pcb overly diagrams shows the off-board connections, whose names are, for the most part, self explanatory.

Control connections P0, P1, P2, P3 run between the boards and you should take care to connect them in the right order. The midi interface pcb is powered from the pitch shift pcb where there are diodes to protect against reverse polarity. Note that it is powered from the digital supply. The 0V connection for the interface is from the battery.

Make sure to connect the midi connector the right way round, by checking the schematic against the pcb overlay.

The microphone input should be connected using screened cable, unless a metal case is used and the connection is only about an inch long.

On the interface board, switches 1 to 4 are each connected to opposite pairs of pads - with a separate ground connection being available for each one.

The potentiometer connections to the main board should be kept as short as practical, though the signal levels here are greater than microphone level. Pot wires should not be run next to the other wiring to avoid introducing noise. Note that the wiper connection for the voice effect pot is separated from its other two connections. Again, it is necessary to check the layout connections against the schematic to ensure that the pots are connected correctly.

A case has not been specified for this project. The choice of case is left to the reader.

Operation

It is difficult to sing in tune while listening to a pitch-shifted harmony of your own voice, so it is easier to just listen to your input voice while recording the mixture of voices onto tape. One of the limitations of the circuit is the fact that the digital converters in IC3 are only 8-bit, which reduces the quality of the overall sound.

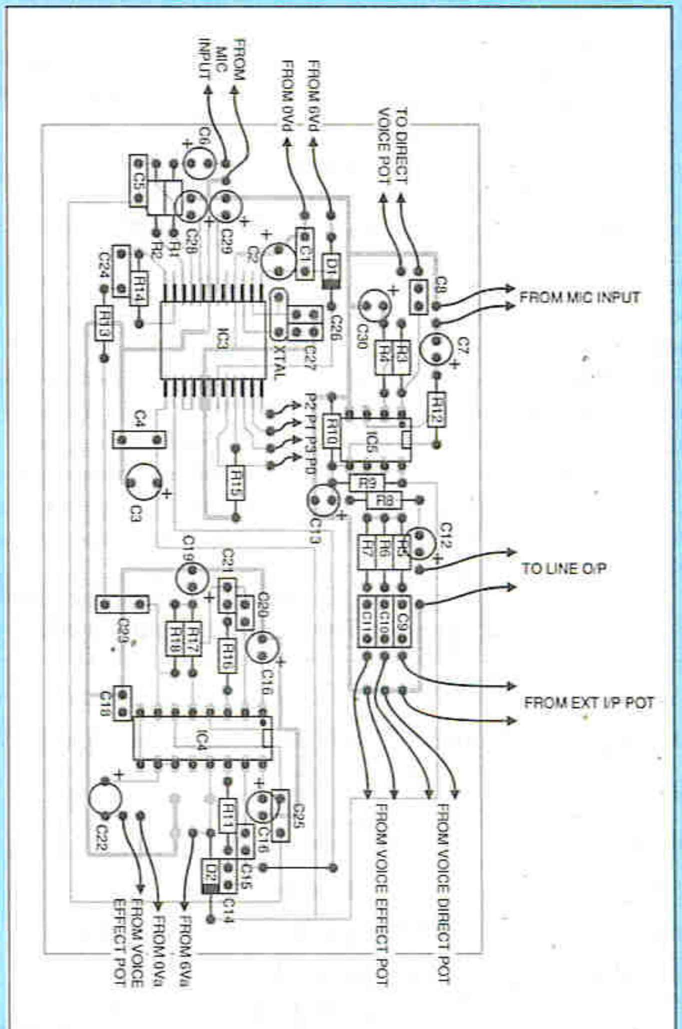


Figure 6: the flowchart of the MIDI controlled Voice Harmoniser

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Computer Compatibility

To run the program you will need:

- Windows 3.x, Win95 or Win NT,
- a min. 386 processor
- 8mb of RAM • CD-ROM Drive

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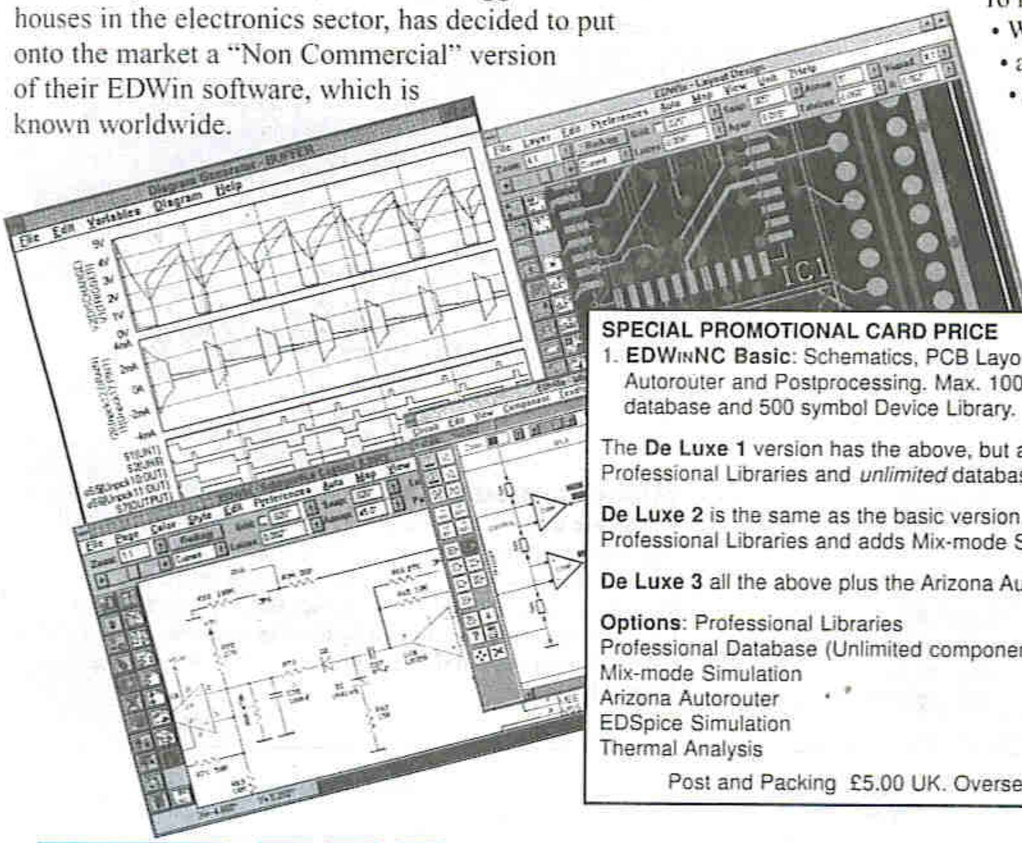

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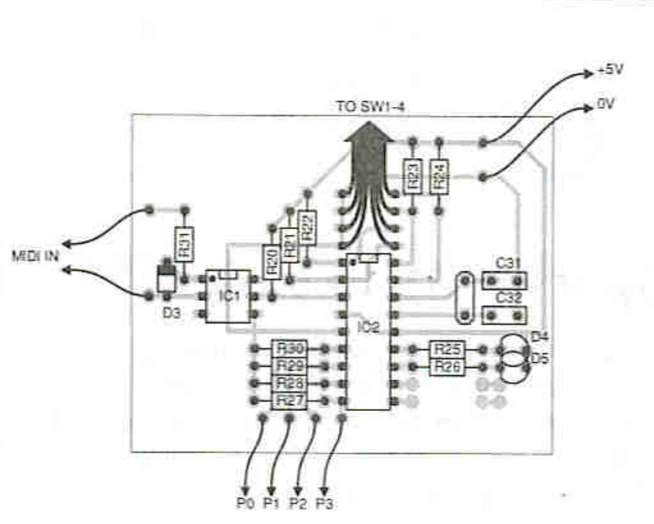


Figure 7: the component layout for the MIDI interface

Further development

To allow further development, the MIDI keyboard decoder and voice harmonizer are built on separate pcbs. More than one pitch controller could then be used to produce up to four or five-part harmonies, controlled via the output ports of a microcontroller.

The pads on the MIDI interface board next to R25 and 26 and D4 and 5 (leds) are empty.

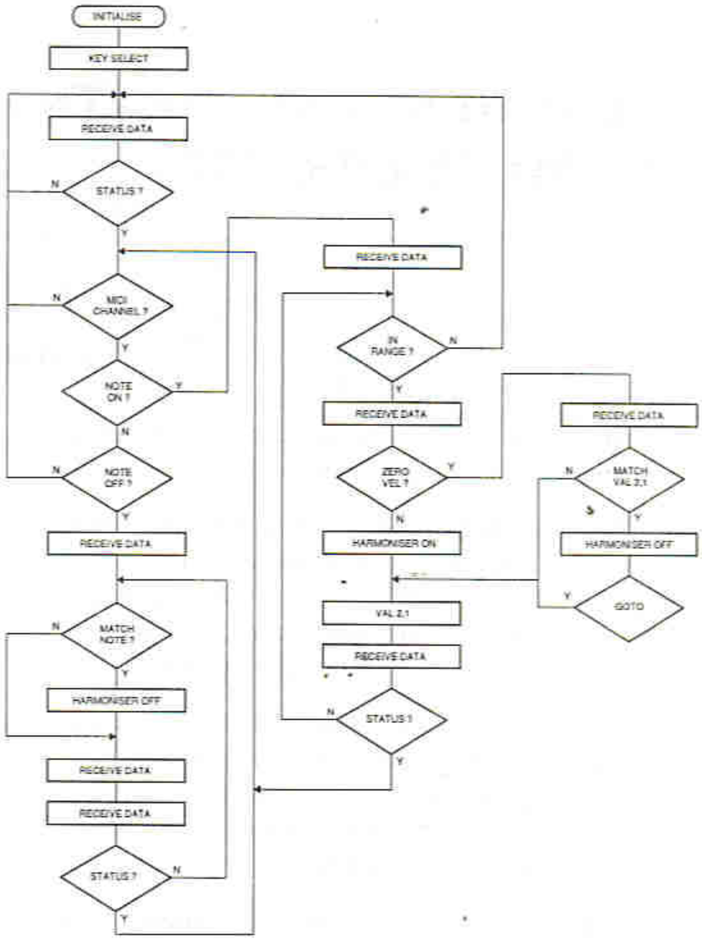


Figure 8: the component layout for the Voice Harmoniser

PARTS LIST for the MIDI Voice Harmoniser

Resistors:

(All 0.25W metal film)

R1	1k5
R2,5,7,14	100k (4 off)
R6	15k
R3	150k
R8	220k
R9,10	47k
R11,16	22k
R13,15,17,18,19	10k (5 off)
R21 to R24, R27 to R30	10k
R4,19,12	1k
R31	220R
R20	1k8
R25,26	270R
VR1,2,3	47k Log.

Capacitors

C1,4	100nF 16V mini disc
C2,3	220uF 10V min elect.
C28,29	100uF 10V min elect.
C5,24,26,27	33pF ceramic
C6,7,8,12,13,22,30	10uF 16V min elect
C9,10,11,14,15,18,20,21 ... 23,25	1uF (non-electrolytic)
C16,17,19	2u2F 16V min elect.
C31,32	22pF ceramic

Semiconductors

IC1	CNY17-3
IC2	PIC16C84
IC3	MSM6322
IC4A,B	NE571
IC5A,B	TL072
D1,2	IN4001
D3	IN4148
D4,5	Leds

Miscellaneous

IC holders 6-pin (1 off), 8-pin (1 off), 16-pin (1 off), 18-pin (1 off), crystals 4MHz and 10MHz, SPST switch, leds, 6mm jack sockets (3 off), 4 x 1.5V battery holder and enclosure of suitable size. A pre-programmed PIC 16C84 is available for £15.00. The program software by itself is available on disk for £4.00 from the author at, 1 Martello Court, Portmarnock, Dublin, Ireland.

```
 list P=PIC16C84

;Program to RX. MIDI data
with 10Mhz clock
;MIDI controlled voice
harmoniser
;Filename: Harmid1.asm
;Date: 23/01/1997

;*************************
; Variable Assignment Addresses
;*************************
dlyregequ       0C
```

```
rcount equ      0D
rcvregequ       0E
offsetreg       equ     0F
noteval1        equ     10
noteval2        equ     11
midichequ       12
note            equ     13

;*************************
;       Constant Assignments
;*************************
CARRY           equ     00
MSB             equ     07
```

```
BORROWequ       00
LED             equ     07
W               equ     00
F               equ     01
Z               equ     02
C               equ     00
dx              equ     05

;*************************
;       Port Assignments
;*************************
PCL             equ     02
STATUS          equ     03
```

```
PORTA       equ     05
PORTB       equ     06

;**************************
;     PROGRAMME Reset Point
;**************************
          org       0
          goto      INIT

;**************************
;     Subroutines
;**************************

delay1  movlw .27
        movwf dlyreg
dly1    nop
        decfsz dlyreg
        goto dly1
        nop
        return

delay2  movlw .17
        movwf dlyreg
dly2    nop
        decfsz dlyreg
        goto dly2
        nop
        return

rxdata  btfsc PORTA,4
        goto rxdata
        movlw .8
        movwf rcount
        clrf rcvreg
        call delay1

rnext   bcf STATUS,CARRY
        rrf rcvreg
        btfsc PORTA,4
        bsf rcvreg,MSB
        call delay2
        decfsz rcount
        goto rnext
        return

keysel  call rxdata
        movf rcvreg,W
        andlw #$F0
        sublw #$90
        btfss STATUS,Z
        goto keysel
        call rxdata
        movlw .184
        addwf rcvreg,W
        btfsc STATUS,CARRY
        goto keysel
        movlw .60
        subwf rcvreg,W
        btfss STATUS,BORROW
        goto keysel
        movwf offsetreg

        bcf PORTB,LED
        return

;**************************
;     Initialise Software
;**************************
INIT    clrf  PORTB
        movlw 00H
        TRIS  PORTB ;MAKE
PORTB ALL O/Ps
```

```
            movlw #$F8
            movwf PORTB

            clrf PORTA
            movlw 0FFH
            TRIS  PORTA ;make
PORTA all I/Ps

            clrf  noteval1
            clrf  noteval2

            movf PORTA,W ;read
midich switches
            andlw #$0F
            movwf midich

;**************************
;   Main Program Start
;**************************

main      call keysel

start     call rxdata ;is it
status?
            movf rcvreg,W
            andlw #$80
            sublw #$80
            btfss STATUS,Z
            goto start

midich? movf rcvreg,W ;cor
rect MIDI Ch?
            andlw #$0F
            subwf midich,W
            btfss STATUS,Z
            goto start

noteon? movf rcvreg,W
            andlw #$F0
            sublw #$90
            btfsc STATUS,Z
            goto noteon
            movf rcvreg,W
            andlw #$F0
            sublw #$80
            btfsc STATUS,Z
            goto noteoff

            goto start

noteon    call rxdata ;check
note range
nrange    movf rcvreg,W
            movwf noteval2
            movf offsetreg,W
            sublw .184
            addwf noteval2,W
            btfsc STATUS,C
            goto start
            movf offsetreg,W
            addlw .48
            subwf noteval2,W
            btfss STATUS,BOR
ROW
            goto start
            movwf note

vel       call rxdata
            movf rcvreg,F
            btfsc STATUS,Z
            goto zerovel
            movf note,W
            call convert
            movwf PORTB
```

```
val2tol movf noteval2,W
          movwf noteval1

          call rxdata ;sta
tus or note?
          movf rcvreg,W
          andlw #$80
          sublw #$80
          btfss STATUS,Z
          goto nrange
          goto midich?

zerovel movf noteval2,W
          subwf noteval1,F
          btfss STATUS,Z
          goto val2tol
          movlw #$08 ; harm
off
          movwf PORTB
          goto val2tol

noteoff call rxdata ; note
value?
match   movf rcvreg,W
          subwf noteval2,W
          btfss STATUS,Z
          goto offvel

          movlw #$08 ; harm
off
          movwf PORTB

offvel  call rxdata ;vel-off
value

          call rxdata ;stat
us or note-off
          movf rcvreg,W
          andlw #$80
          sublw #$80
          btfss STATUS,Z
          goto match
          goto midich?

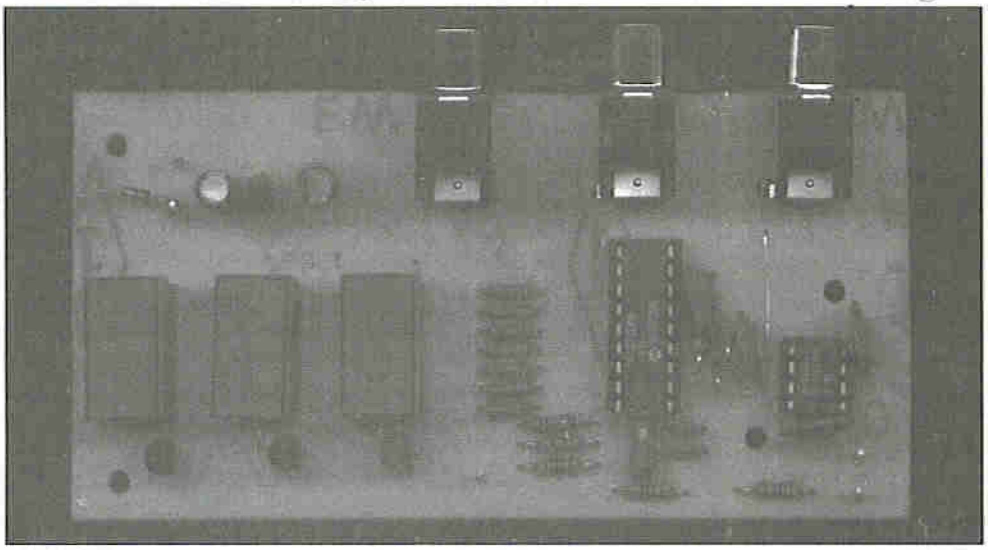
convert addwf PCL
          retlw 00
          retlw #$08
          retlw #$08
          retlw #$01
          retlw #$02
          retlw #$03
          retlw #$08
          retlw #$04
          retlw #$05
          retlw #$06
          retlw #$08
          retlw #$07
          retlw #$08
          retlw #$09
          retlw #$08
          retlw #$0A
          retlw #$0B
          retlw #$0C
          retlw #$08
          retlw #$0D
          retlw #$0E
          retlw #$0F
          retlw #$08
          retlw #$08
          retlw #$08
           end
```

Experimenting with Video

PART 4

A Video Line Trigger

For the experimenter or developer of video projects, Robin Abbott's video line trigger allows the examination of a specific line in the video frame.



Over the last couple of months we have looked at the structure of the video signal, and built a sync separator which was used for a video mixer/fader. In the next two articles we will have a look at building test equipment of use for the experimenter or developer of video projects.

This month's project is a video line trigger suitable for an oscilloscope.

An oscilloscope is virtually essential for serious work with video signals, and it is very useful to be able to look a specific line in the video frame. Although it is possible to trigger the oscilloscope from the frame signal, and then use the delay facility to examine a specific line, it is not easy to identify a specific line in each frame. This project allows the user to select a line, and it then produces a trigger signal suitable for the external trigger input of an oscilloscope. This enables a specific line to be examined in each frame, considerably simplifying circuit debugging.

This circuit makes use of a cheap PIC microcontroller to implement a video line trigger device which is considerably less complex and less expensive than commercially available units.

Operation

In operation the line trigger consists of a small unit with a three-digit, seven-segment display, and two pushbuttons for up and down. The unit is powered from an external 9 to 30V supply rail. The video signal is supplied to the unit on a standard phono socket, and provides a phono output, so that the unit can be placed in line with a video signal under test. There is also an output on a phono socket for the trigger signal of the oscilloscope. The push buttons select the line which is to be examined. If one is pressed briefly, then the line count increases or decreases by one. If one is held down, then the count runs more rapidly. If the unit is left powered up, and the line selection is not changed for more than five minutes, then the unit automatically writes the current line into internal eeprom, and will use this value next time the unit is powered up. This makes the unit considerably easier to use on a day by day basis on a project.

The display will flash, and the unit will not allow keypresses when there is no video signal present.

The output of the unit is a single low-going pulse of about 4us, which is approximately coincident with the colour burst on the selected line. This may be connected directly to the external trigger input of the 'scope.

In practice it is probably better to trigger from the line immediately prior to the required line. The first synchronisation pulse shown on the 'scope will be at the start of the required line.

The circuit

Figure 1 shows the circuit diagram. The main work of the unit is performed using a PIC - a 16C84 in this case. The 16C84 is used because it has an internal eeprom data store, which is employed to store the line set by the user and ensure that, on power-up, the same line is displayed as was previously used.

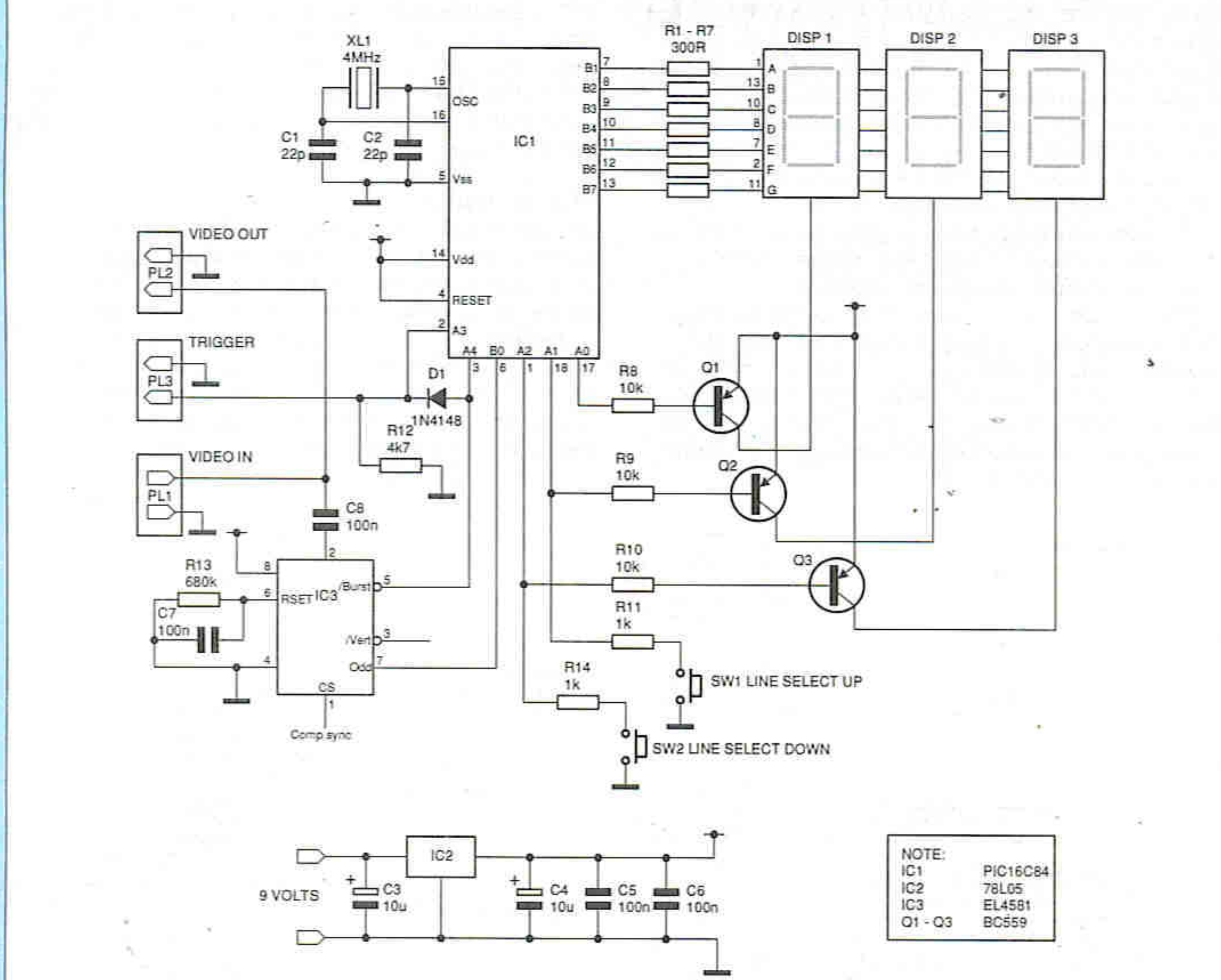


Figure 1: The circuit of the Video Line Trigger

The incoming video signal is not terminated, as the unit is expected to be used in line with other equipment. However it will operate successfully without requiring connection to other equipment with termination.

The video signal is supplied to the EL4581 sync separator. This ic provides detection of the frame signals in the incoming video signal. It also provides a colour burst output - a short pulse following the horizontal synchronisation pulse, which is approximately coincident with the colour burst in the line. The odd/even frame output is a signal which is high during the first field of the frame (the odd field), and is low during the second field of the frame (the even field).

The odd/even frame output is used to drive the interrupt input of the PIC, and causes an interrupt at the start of the first field.

The colour burst output is used to drive the counter input of the PIC, and it is this signal which is used to count the lines internally to the PIC.

The trigger output of the PIC (on pin RA3) must be re-timed with the video signal. This is because the PIC has a resolution of 1us per internal instruction, and a latency of 3 or 4us to respond to an interrupt. This results in an error of up to 2us in the position of the trigger pulse output, which results in jittering of the oscilloscope trace.

Traditionally retiming would be achieved with D-type latch, such as an HC74; however, to simply the circuit, the trigger signal from the PIC is wire OR'd with the colour burst signal. During normal operation the output of the PIC is driven high holding the trigger output high. Approximately 25us before the start of the desired line, the PIC places its output into a high impedance state. The trigger signal is then held high by the

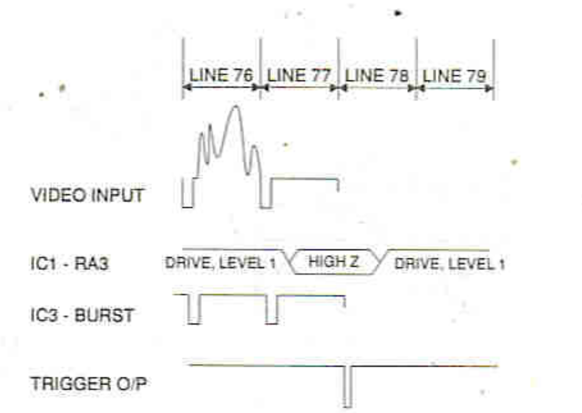


Figure 2: signals in the circuit around the trigger point when line 78 is selected

colour burst output. During the colour burst signal of the desired line the colour burst output also goes low, and the trigger output is pulled low by resistor R12. About 20us after this, the PIC trigger output returns to driving a high level signal. This results in a trigger output which is synchronous with the video frame signals, and avoids jitter due to software operation. This is illustrated in figure 2.

The display is driven in a multiplexed fashion. The PIC has sufficient drive capability on its output port pins to drive small (0.3in) 7 segment displays directly, however, the common anode of the displays is driven through a PNP drive transistor. The displays are driven on a 5ms multiplexing cycle.

The push buttons are connected to the base of the display drive transistors using 1k resistors, as shown in the circuit. This is necessary due to the lack of I/O pins on the PIC. Normally the PIC drives the transistor bases through the 10k base resistor and drives them high or low, overriding the push buttons. When the PIC reads the push buttons, it sets the display outputs all high which disconnects the seven-segment displays, and tri-states the PNP transistor base drive signals. Now the push button inputs are pulled high by the 10k resistors though the transistors base/emitter junction. However, if the push button is pressed then it will pull the input to around 0.5V, which is well below the PIC's low level input threshold, and the PIC will read a low logic level from the pin.

The software

The software operation of the unit is straightforward, but is of interest to other constructors of real time systems operating using microcontrollers. Figure 3 shows a block diagram of the main modules of the software, and the way in which they are called.

The main loop checks to see if a frame interrupt has occurred, and whether it is time to call the multiplexing routine to shift on to the next display digit. The main loop also maintains a counter which checks the time since the count was last changed. After about 5 minutes the value is written to the eeprom.

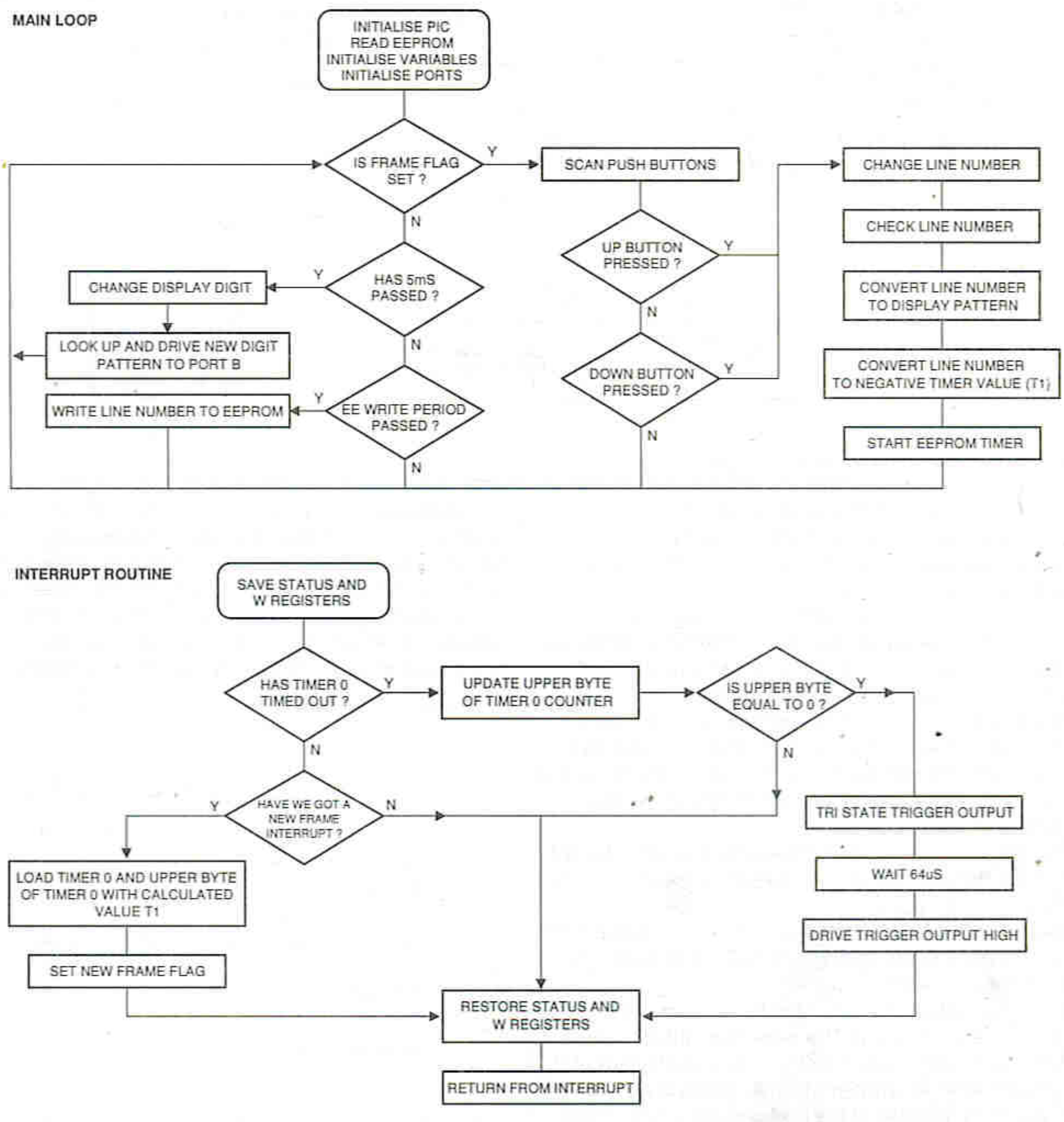


Figure 3: the software flow diagram

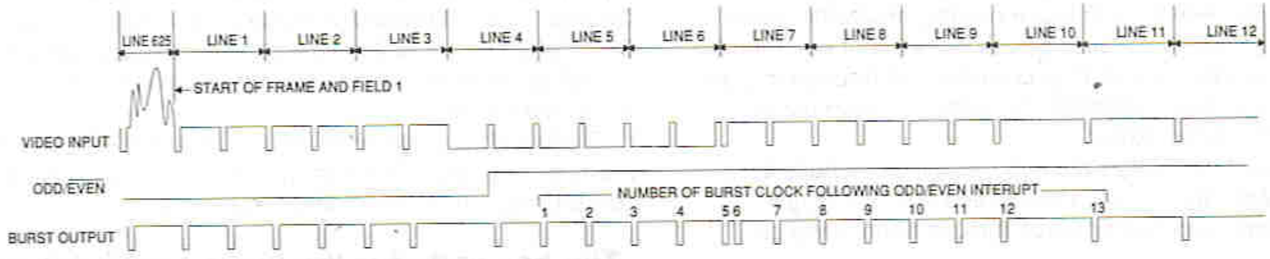


Figure 4: the burst count at the start of field 1 following Odd/Even frame interrupt

The user-selected line number is converted into a negative number, and the lower 8 bits are loaded into the internal (8-bit) timer. The internal timer increases its count on every colour burst signal. When it overflows it causes an interrupt. This is used to increment an internal register which keeps count of the upper 8 bits of the line counter. When the 16 bit line counter reaches 0, the required line has been reached, and the trigger output is generated.

Figure 4 shows a timing diagram of the signals produced by the EL4581. Note that the equalising pulses which occur during the vertical frame interval are detected by the chip and cause colour burst signals to be generated at twice the normal frequency during the vertical frame interval.

The frame interrupt occurs half way through line 4 of field 1, and is clocked out by the colour burst signal produced by the equalising pulse in the middle of line 4. To avoid problems with this late signal then the first line which may be selected as a trigger is line 10 of the field. Note (from figure 4) that to trigger on line 10 of the field requires the PIC to tri-state the trigger output (RA3) during line 9, and that this is the twelfth colour burst pulse of the signal following the odd/even frame change. Therefore a count of 2 is added internally to the user-selected count.

During the entire frame, there will be another field synchronisation pulse between field 1 and field 2. During this field the colour burst signals will again be at double the correct rate. To correct for this the software in the PIC adds 2 to the count for each line during the field synchronisation pulse, and adds a total of seven extra pulses to the count for any line in the second field of the frame.

The frame interrupt routine causes the negative value for the line counter to be loaded into the internal counter, and into the upper 8-bit counter register. This is achieved within 20us of the frame interrupt - plenty of time for the first colour burst signal following the frame interrupt. The frame interrupt routine also sets a flag which is used by the main loop to scan the push buttons.

The push button scanning routine checks to see if the push button is pressed. If so the count is moved up or down appropriately. If the button remains pressed then no action is taken until approximately 250ms passes. Then the count is changed by five on each frame interrupt, while the button remains pressed.

On each change of the count the following actions are undertaken :

The count is checked to make sure that it is in range (from 10 to 620).

The count is converted into decimal, into a 3-digit BCD form to be used by the multiplexing routine for the display.

The count is converted into the correct negative number for loading into the counter registers. This involves checking the range of the count, adding on the appropriate offset to compensate for the equalising pulses, and then negating the count. This result is stored for immediate use by the frame interrupt routine.

Finally when the counter overflows to 0, the trigger output is placed in a high impedance state for 60us.

The code

The hex code for the program can be manually entered into a text file. As the file is checksummed, errors should be easy to find. Save the file with the name "LINETRIG.HEX"; most programmers accept this hex file format. The PIC should be programmed with the Watchdog disabled, and Power Up timer enabled. The XT fuse type should be selected. Alternatively, ready-programmed 16C84 devices are available (see the end of the article).

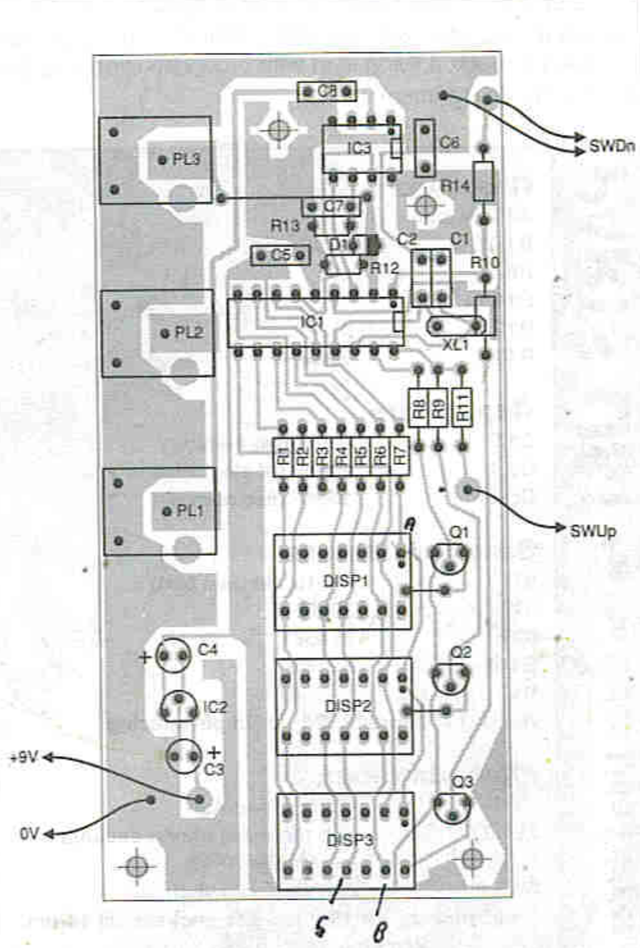


Figure 5: the component layout

Construction and testing

The circuit is built on a single small pcb. The overlay is shown in figure 5. Note that a ceramic resonator should be used for the PIC because it uses the smallest board profile (they are also cheaper than crystals). The displays may be any 0.3 in, seven-segment, CA types, as they nearly all have the correct pinout.

The phono sockets are pcb-mounting components. There are three in total: video in and out, and trigger out. The power supply is provided through flexible wire on Veropins.

The board has three wire links which should be fitted first. Horizontally mounted resistors should be fitted next. The displays and both dil ics should be mounted in sockets. Finish construction with the capacitors and phono sockets. It may be worthwhile connecting a diode in series with the input positive power supply pin to protect against wrong polarity connection.

Initially do not fit the ics or the displays. Apply a power supply of 9V or greater, and check that the power pins of IC1 and IC3 are at +5V. If you wish to check the operation of the displays then insert them now and use short wire links on the socket of IC1 to short each digit driver transistor to ground and then each segment.

Finally, power down, fit ics and displays, and then power up again. The display should show "010" and will be flashing if there is no video signal. Connect a video signal and then check the operation of the push buttons. Connect the trigger output to an oscilloscope and check that the expected line is correctly displayed (trigger at the start of field 2 - line 310 onwards - to see the even field synchronisation pulse).

The prototype was fitted into a small plastic box. The displays are covered with red filter material, and the power is applied through a flying lead with crocodile clips to allow use in a lab environment.

PARTS LIST for the Video Line Trigger

Resistors

All 1 percent, 0.25 watt

R1-7	300R
R8-10	10k
R11,14	1k
R12	4k7
R13	680k

Capacitors

C1,2	22pF disc ceramic
C3,4	10uF 10V electrolytic radial
C5-8	100nF disc ceramic

Semiconductors

IC1	PIC16C84 (See text)
IC2	78L05
IC3	EL4581 468 MPS 389 RS
Q1-3	BC559
D1	1N4148
Disp1-3	7-segment, CA , 0.3in pin spacing

Miscellaneous

XL1	4MHz resonator
PL1,2,3	pcb mounted phono sockets (eg Maplin HF99)
SW1,2	pushbutton switch

1 x ic sockets, dil 18-pin, 3 x ic sockets, dil 14-pin; pcb; case; Veropins.

Obtaining components

A pre-programmed 16C84 is available from Forest Electronic Developments (10 Holmhurst Avenue, Christchurch, Dorset, BH23 5PQ) for £12.00. Please enclose a cheque payable to "Forest Electronic Developments", and a stamped, self addressed envelope.

The EL4581 is available from Maplin, as are the PCB mounted phono sockets used in the prototype. All other components are standard and can be obtained from most suppliers.

The hex code for the Video Line Trigger

```
:020000000528D1
:1000080003C29A8208316F830810010308500013083
:10001800860083125A21B4200A21D02008308500096
:10002800FF30860006308E00B0308B000A30970013
:1000380010169018362822F208F0B1D282521A50A69
:10004800A40BA503A508031D1D28101A1D28901E22
:100058001D286D211D2803309A009A0B31280800AD
:10006800133030280608A3000508A2009010831654
:100078000073085048312FF3086004C208B178316C7
:10008800F8308505831222088500230886001D287C
:10009800851C5528051D6928F33090050A309700FE
:1000A8000008008B130130101D5F28970803195E287C
:1000B8009703080005306220101570289A008D0AE4
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:10012800031010180314840308001010 1A0880071D
:1001380084 0A031CA328013080070318 10141B0825
:100148008007031810149428223 08C000E308D007C
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:100168008D08031DBE280C08093C031C08000A3032
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:100198008C0002308D00080037309C0001309D0033
:1001A8003D309E0001309F000730A000EA20023059
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:100218000D089D009B0164309A001A2191000A3054
:100228009A001A2192001C0893000800FF309E00D3
:100238001C30840086209E0A031C1E2999201E0853
:1002480008000730850403148E0D0E080739073C93
:1002580 0031D2F290E1011088E1C12080E1D1308DD
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:10027800980 0030E990083128B184F290B194529F2
:10028800 55290B11940F552985158316851534208A
:100298008511831255298B1015088100160894 00C2
:1002A8009014190E8300980E180E0900890168 2110
:1002B8008C00890A68218D000D0A031D08000A3088
:1002C8008C0000308D0008 0083160814831208087B
:1002D80008 0089010C087621890A0D087621101674
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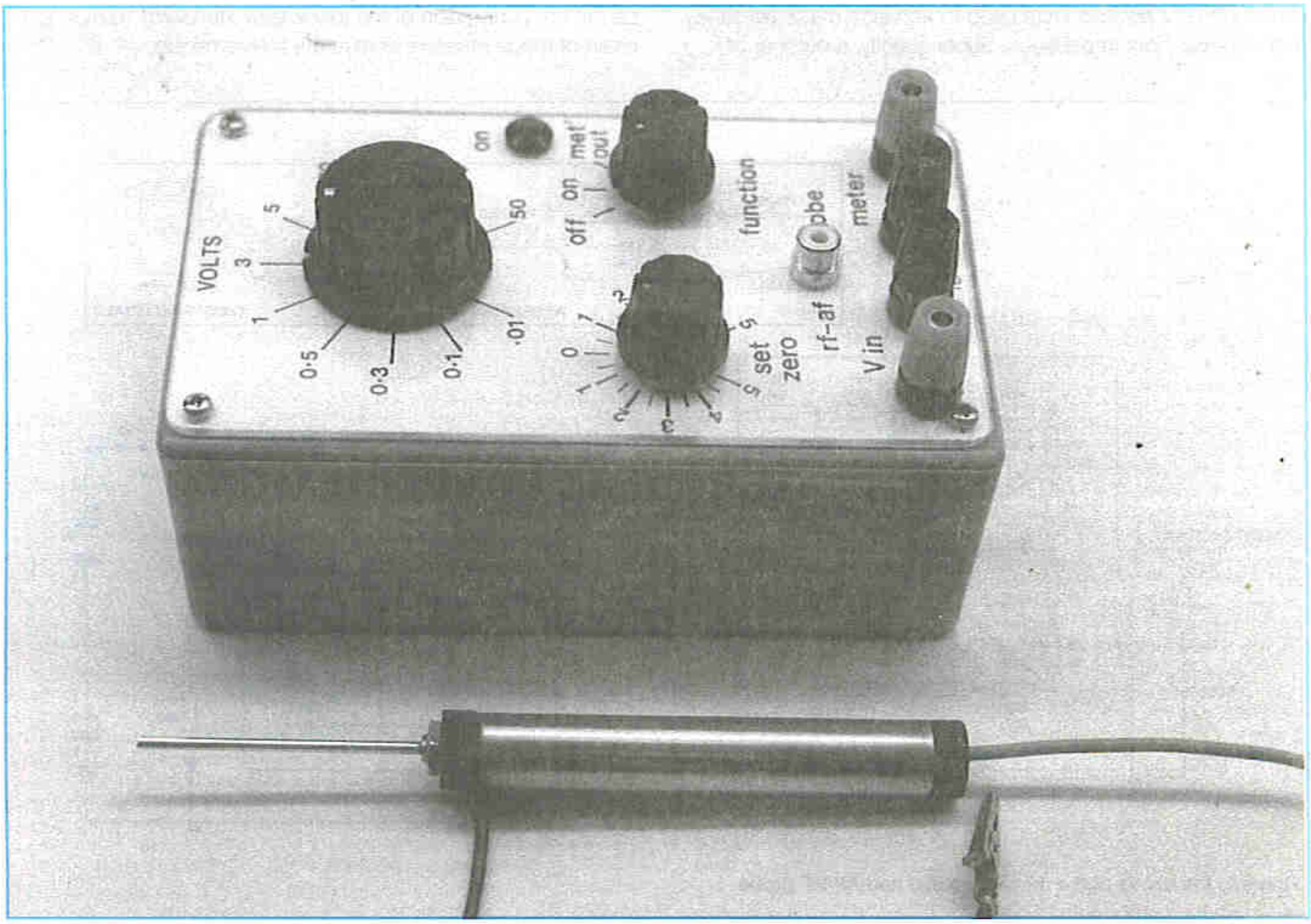
High Impedance Multimeter Amplifier and AF/RF Probe

An inexpensive multimeter accessory to give you more accuracy on high impedance and signal measurements. By Raymond Haigh.

This simple and inexpensive unit will greatly enhance the performance of moving-coil multimeters by permitting the measurement of low DC and signal voltages with a minimum of disturbance to the circuit under test.

Many constructors rely on moving-coil multimeters to check voltage levels in equipment under development or repair. However, even the best meters present a comparatively low resistance to the circuit under test, especially when small DC voltages are being measured, and this can cause inaccuracies.



The situation is even worse when a meter of this kind is used to measure AC voltages. The impedance on these ranges is even lower, and sensitivity falls off rapidly above a few hundred Hertz.

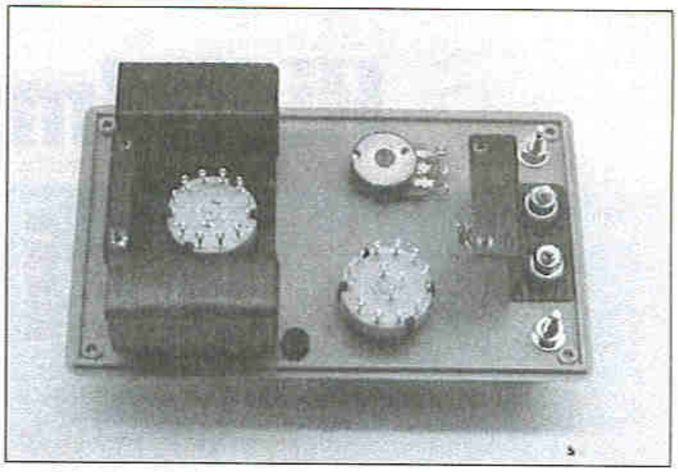
Warning: Mains project - constructors without experience of safe mains handling should seek the assistance of someone more experienced.

Digital multimeters present a much higher impedance on both AC and DC ranges, and low voltage readings taken with these instruments can be relied upon. Again, however, the accurate measurement of AC voltages is restricted to the lower audio frequencies, and most manufacturers indicate reliable AC readings only within a frequency range of 50 to 500Hz.

The inexpensive unit described here will greatly increase the sensitivity of a moving-coil multimeter, and give it an input resistance of 10 megohms when DC voltages are being checked, even on the lowest (0.01V or 10mV) range. A simple probe enables low AC voltages to be measured, from 20Hz to around 200MHz. This last facility can be particularly useful as a signal tracing aid. Voltage ranges have been chosen to accommodate the scale calibrations of most moving-coil multimeters. Constructors who prefer stand-alone equipment could install the amplifier unit along with its own moving-coil meter into a larger case.

The circuit

No originality is claimed for the basic design, which has been around in one form or another since the invention of the triode valve. With the development of the transistor, discrete semiconductor devices were used to enhance meter sensitivity and increase input impedance. Subsequently, a number of



meter amplifier designs based on the ubiquitous 741 op-amp were published. These represented an improvement on many of the circuits incorporating bipolar transistors, but the one megohm input resistance of the 741 meant that performance still fell short of earlier laboratory instruments. It was the introduction of the field-effect transistor (fet) that made possible the achievement, with solid-state devices, of standards of performance formerly associated only with valves. The incorporation of fets into op-amps, and the availability of close-tolerance resistors at low cost, has since made the construction of high-performance meter amplifiers a comparatively simple and inexpensive matter.

The meter amplifier

The unit is designed around the widely available CA3140E fet-input op-amp. This device has an input resistance of 1T5 ohms (yes - 1.5 million, million ohms), more than high enough to permit the connection of the (once fairly standard) 10 megohm chain of range resistors across the test terminals.

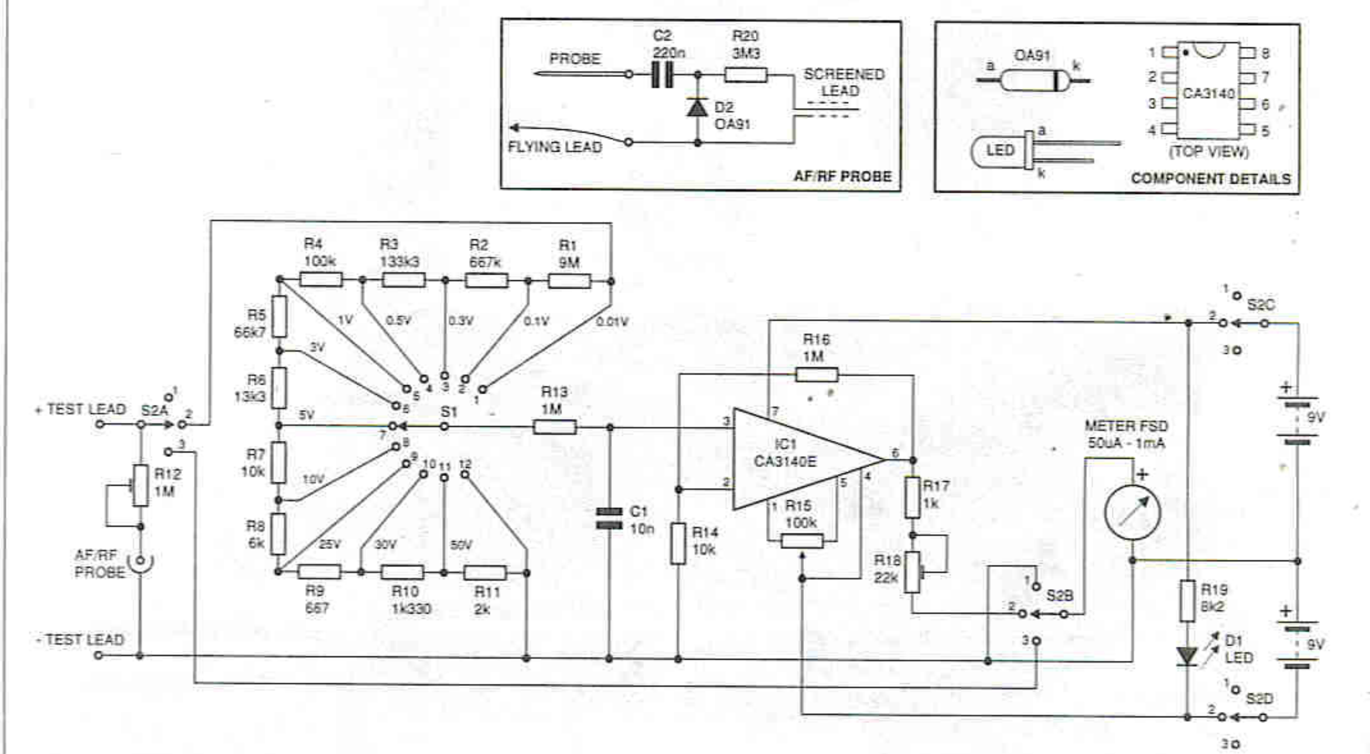


Figure 1: the circuit of the meter amplifier and AF/RF probe

The full circuit of the unit is given in figure 1, where the CA3140E op-amp is connected in the non-inverting mode with feedback resistors, R14 and R16, setting the gain of device at x 100. An input of 10mV will, therefore, produce an output of 1V. Potentiometer R15 is connected to the amplifier's offset-nulling circuitry, and functions as a set-zero control for the meter. R17, and pre-set potentiometer R18, set the meter to read 1V FSD. The non-inverting input of the op-amp (pin 3) is connected by range switch, S1, to the appropriate point on the potential divider chain formed by R1 to R11. The resistor values have been chosen to accommodate classic British multimeters with 0-10 and 0-30 ranges (the AVO meters, for example), and imported instruments with scales calibrated in multiples of 0-10, 0-25, and 0-50. The full chain of resistors is presented to the circuit under test, and the input resistance of the unit is, therefore, 10 megohms on all ranges.

R13 and C1 filter the input to the op-amp and ensure the stability of the circuit. The value of R13 may, at first sight, seem a little high, but it has a negligible effect on DC voltage levels because of the extremely high input resistance of the device. If, despite this measure, random movements of the meter pointer are encountered (no problems of this kind have been displayed by several prototypes), fit 100nF ceramic capacitors close to pins 4 and 7 of the op-amp in order to decouple the supply lines.

When the amplifier unit is connected to the workshop multimeter, it is sometimes necessary to switch the meter directly into the circuit under test in order to measure current and resistance, and S2a and S2b facilitate this. Always remember to set the multimeter to an appropriate range before switching it through, or damage may result. The unit is powered by two PP3 batteries, connected into circuit by S2c and S2d. Equipment of this kind is often inadvertently left switched on. The low current led, D1, gives a visual indication that the amplifier is drawing current, and helps to prevent this.

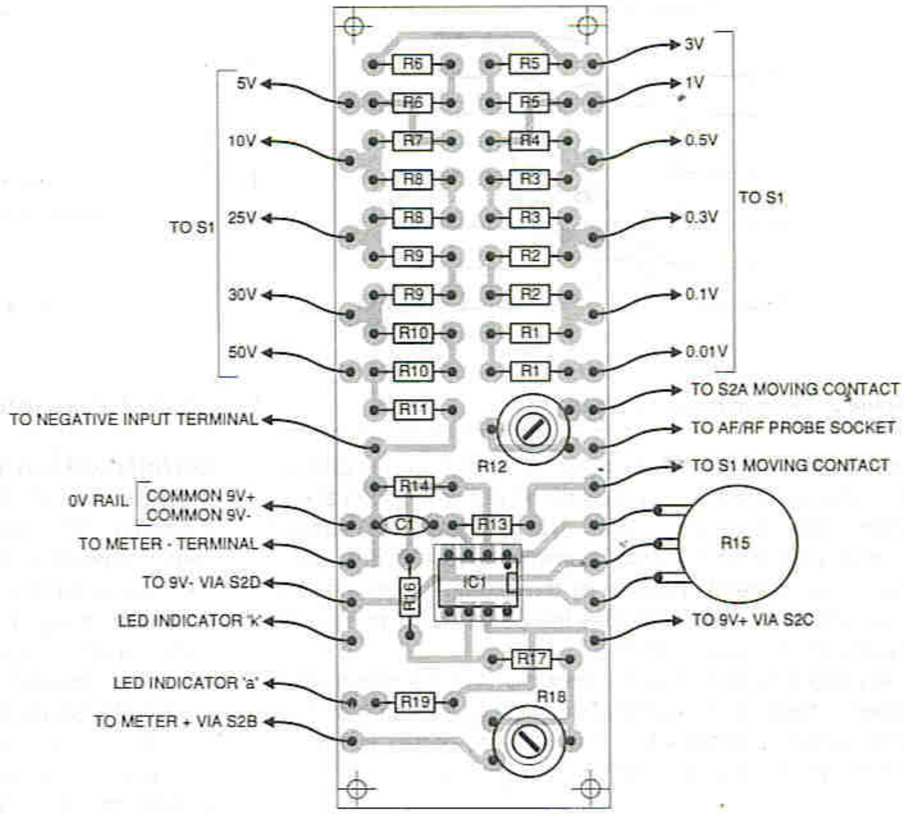


Figure 2: the component layout

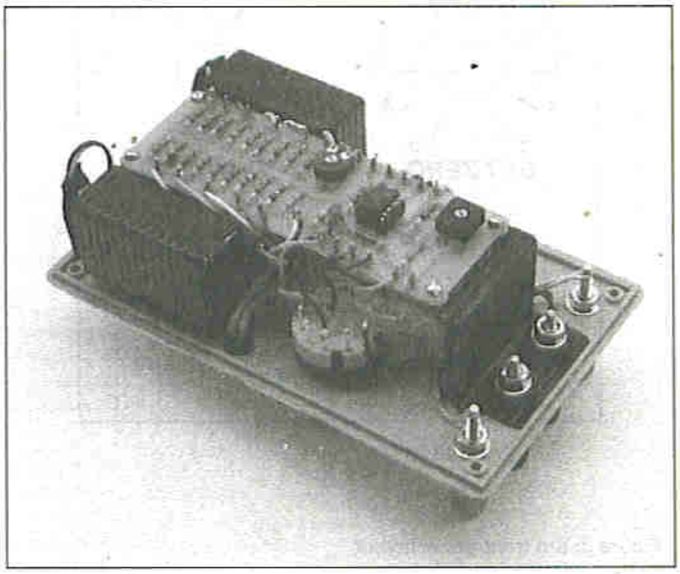
The AF/RF probe

The AF/RF probe could hardly be simpler. It comprises a DC blocking capacitor, C2, which couples the voltage being measured to rectifier diode D2. Resistor R20 isolates the probe tip from the connecting cable and, together with pre-set resistor R12, sets the probe output to a true RMS value.

The diode has to be connected shunt fashion across the circuit under test. If it were to be series connected the load resistance of 14 megohms or so would greatly exceed its own reverse resistance, and the rectifying action would be disastrously impaired. The arrangement is, of course, the same as the DC restorer circuit used in TV receivers to shift the level of the vision signal, and a little less than twice the peak value of the applied AC voltage appears across the diode. More is said about the implications of this later.

Constructing the amplifier

Most of the components for the meter amplifier are mounted on a small pcb. Details of the component layout and the off-board wiring are shown in figure 2. The switch connections are given in figures 3 and 4. The use of a holder for the ic facilitates substitution-checking of the device, and Vero pins, inserted at the lead-out points, simplify the task of off-board wiring. Provision is made on the pcb for the recommended chain of close-tolerance resistors (see the Parts List), but it should be possible to adapt the layout, and use the land areas, for other resistor combinations in order to produce a different set of voltage ranges, should this be desired. Thw photographs show the switches, terminals, battery holders



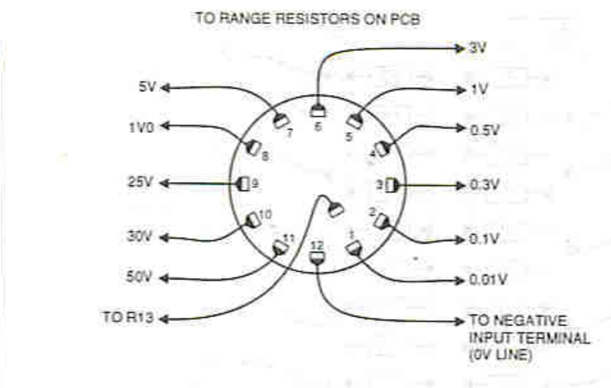


Figure 3: wiring to range switch S1

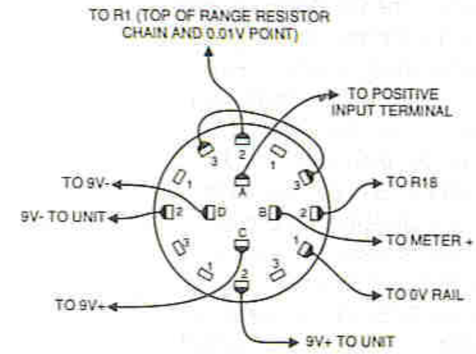


Figure 4: wiring to function switch S2

and pcb mounting brackets mounted on the lid of a plastic box, and the completed unit, with the pcb in position and wired to the other components. The brackets which support the pcb are formed from thin aluminium sheet. The smaller bracket is secured in position by the negative terminals. The larger assembly, which includes the battery holders, is held in place by the range switch.

A suggested layout for the front panel of the instument is shown in figure 6. The original was simply marked out on white card and protected by a small piece of thin acrylic sheet of the kind sold for DIY double-glazing.

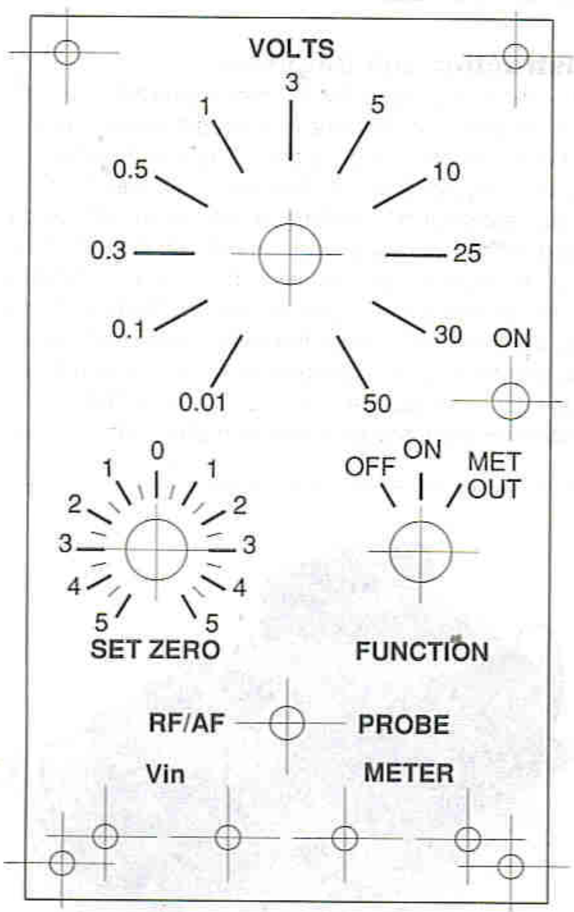


Figure 5: the front panel layout

Construction of the probe

A section through the probe unit is given in figure 6. The case is formed from a short length of brass tubing (copper central heating piping would do just as well), and some scrap plastic terminals which are a tight push fit into the tube ends. Most constructors will have something suitable for the end pieces in their spares boxes but, if all else fails, they can be made from hard, dry wood. If wood is used, it is a good idea to insulate the probe tip where it passes through the plug.

Keep the leads of capacitor C2, diode D2 and resistor R20 as short as possible. These components are self supporting: just soldered together, to the probe tip, and to the thin strip of brass which connects the probe to the 0V rail via the cable screen. It is a wise precaution to use a small crocodile clip as a heat shunt when soldering the diode into circuit after its leads have been cropped in this way. The connecting cable is retained by the brass strip, which is held in place by sandwiching it between the probe tube and the end plug. Terminate the flying test lead with a small crocodile clip, and solder it to the projecting end of the brass strip. Screened audio cable and a phono plug can be used to connect the probe to the amplifier unit. See the photographs for the show the completed probe.

Components

No difficulty should be encountered in obtaining any of the components. Low cost, close-tolerance resistors, in a wide range of values, are retailed by Maplin. (Some suppliers stock a more restricted range and they may not be able to supply some of the values quoted in the Parts List). Lower tolerance resistors can, of course, be used if a reduced standard of accuracy is acceptable.

Inexpensive, plastic-cased, Lorlin rotary switches are one type that is suitable for S1 and S2, and low-current 2mA leds are available from Maplin. If a standard led is fitted, the value of R19 should be reduced to 1k5 (the current drawn by the indicator will then be of the order of 10mA, which exceeds the 8mA drawn by the meter amplifier). Brass tube and strip, in a wide range of sizes, is available from most model shops. Constructors who would prefer to combine meter and amplifier in a stand-alone unit will require a moving coil meter with a full-scale deflection of between 50uA and 1mA. A larger case will, of course, be also required.

Setting up and testing

Check the pcb for poor soldered joints and bridged copper tracks, and check the off-board wiring and connections. Check the orientation of the ic and diodes and, if

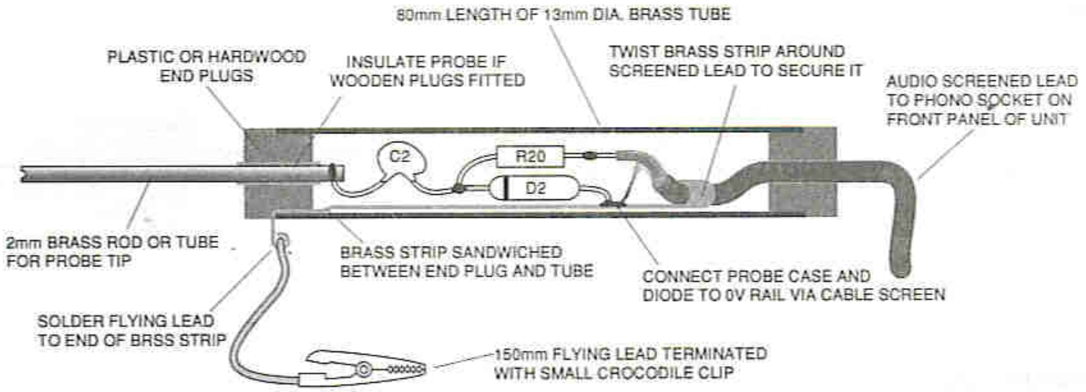


Figure 6: details of the AF/RF probe assembly

everything is in order, connect up the PP3 batteries and switch on. The current in each supply rail should be of the order of 4mA.

Set R15 to mid travel, set R18 to maximum resistance, switch the multimeter to its 3mA or 5mA current range, and connect it to the amplifier unit. Operating R15 should swing the meter pointer either side of zero. Switch the multimeter to a current range of 1mA or less, and, if necessary, refine the adjustment of R15 to bring the pointer back to zero. If the multimeter does not have a sufficiently low current range but has a voltage range of less than 1V (unusual but not unknown) this can be used instead.

Calibration

Switch the meter amplifier to the 10V range, apply its test leads to a fresh PP3 or similar battery, and set R18 so that the meter reads the correct voltage. (Check the battery voltage by direct measurement with the multimeter.) Switch the meter amplifier through the higher voltage ranges to check for consistency and the accuracy of the input divider chain. The correct voltage should continue to be displayed on the multimeter (very slight variations will probably be due to non-linearity in the meter movement as the pointer has to traverse less and less of the scale). The DC calibration of the instrument is now complete.

Connect a power transformer, with a secondary in the 5-10V range, to the mains supply, and check the output voltage by direct measurement with the multimeter.

Readers who have no experience of constructing mains-powered equipment should note that the voltages involved are LETHAL and should seek the help of someone with the necessary experience, particularly if the wiring or terminals at the mains primary side of the transformer are exposed.

Reconnect the multimeter to the amplifier unit (remember to reset it to the low current range), plug in the probe, and set the amplifier to 0-10V. Apply the probe and its flying lead to the mains transformer secondary, and adjust R12 until the reading coincides with the one given directly by the multimeter. The AC calibration of the instrument is now complete. The quoted component values are best suited to meters with FSDs in the uA range. If a less sensitive meter with a 1mA FSD is used with the amplifier, calibration adjustments will be easier if the current limiting resistor R17 is shorted out and the value of pre-set R18 is reduced to 1k.

Use and limitations: DC measurements

The basic accuracy of the unit will, of course, only be as great as the accuracy of the multimeter used to check the calibration voltages. However, with a constant input resistance of 10 megohms on all ranges, disturbance of the circuit under test is minimal, and this will result in the more accurate measurement of voltages in high impedance circuits. The amplifier greatly increases meter sensitivity, and potentials below 1mV can be measured, still with the very high instrument resistance of 10 megohms. Although there is seldom need to measure DC voltages as low as this, the facility can be useful for checking dubious earth returns and switch contacts. The maximum voltage range is 50V, and this should accommodate the needs of most constructors who work with transistorised equipment. At voltages greater than this, even fairly inexpensive multimeters present a reasonably high resistance to the circuit under test, and there is not so much to be gained by using the meter amplifier. Constructors who have decided to build a stand-alone unit may, however, wish to incorporate higher voltage ranges, and this can be done by sub-dividing R11 (the range resistor at the bottom of the chain). Those who wish to do this, or to modify the range switching in some other way, may find figure 7 useful. From that diagram:

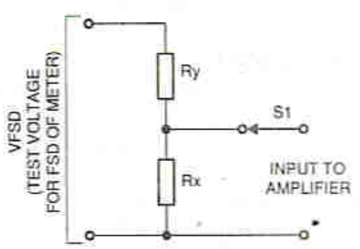


Figure 7: sub-dividing R11 to incorporate higher voltage ranges

$Rx = (0.01 \times 10^7) / VFSD$

and:

$Ry = 10^7 - Rx$

(The total value of the chain is maintained at 10 megohms)

For a 100V range:

$Rx = (0.01 \times 10^7) / 100 = 1k$

So R11 would have to be sub-divided into two 1k resistors, and connecting the amplifier input to their junction would give a 100V range.

Random meter pointer fluctuations have not been experienced with any of the amplifiers constructed to this design, and the set-zero control, R15, is smooth and easy to operate. Some readjustment may be necessary after the first reading has been taken (this is commonplace with op-amp designs of this kind), but otherwise the zero setting will be found to be completely stable. R15 can be used to set the pointer at centre scale, and this facility is useful for some test work.

AC measurements

From 0.5V upwards, and from 20Hz to 20kHz, the probe will enable AC voltages to be measured accurately. (The readings should, of course, be taken from the multimeter's DC scales: its AC scale is modified to suit its own rectifier circuitry). Below 0.5V and, more particularly, below the knee of the diode characteristic (around 0.3V for a germanium diode), deteriorating rectifier performance results in progressively low readings. At 0.1V (100mV), the reading is approximately 25% low, and around 0.05V (50mV) the readings should be doubled to give a more accurate RMS value.

PARTS LIST for the Multimeter Amplifier

Resistors

(All 0.25 Watt, 1% tolerance unless otherwise stated.)

R1	9M (6M8 and 2M2)
R2	667k (620k and 47k)
R3	133k3 (130k and 3k3)
R4	100k
R5	66k7 (62k and 4k7)
R6	13k3 (10k and 3k3)
R7	10k
R8	6k (3k3 and 2k7)
R9	667 (620R and 47R)
R10	1k330 (1k and 330R)
R11	2k
R12	1M pre-set variable
R13	1M 5% tolerance
R14	10k
R15	100k linear potentiometer
R16	1M
R17	1k 5% tolerance
R18	22k pre-set potentiometer (see text)
R19	8k2 5% (see text)
R20	3M3 5% tolerance

Capacitors

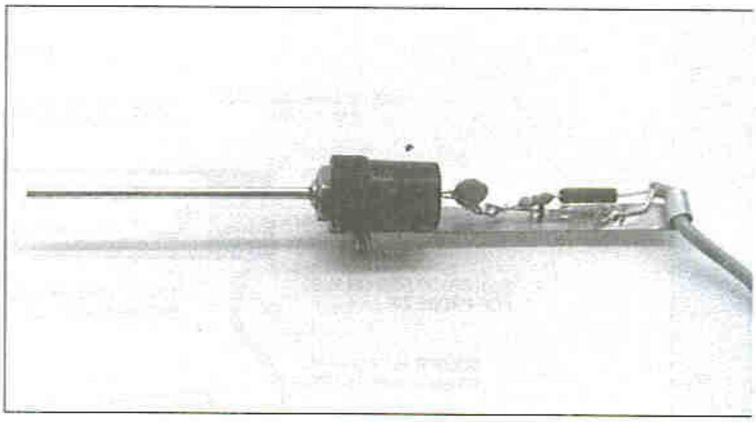
C1	10nF (.01uF) ceramic
C2	220nF (.22uF) ceramic, 100V working (see text)

Semiconductors

IC1	CA3140E FET input op-amp
D1	Low current, 2mA LED
D2	0A91 germanium diode

Miscellaneous

S1 1 pole, 12 way switch; S2 4 poles, 3 way switch; PCB making materials, Vero pins and ic holder; hook-up wire, audio screened lead and flexible test-meter leads; one large and two small control knobs and 5mm led holder; battery connectors, two red and two black terminals, phono plug and socket, and one red and one black test probe; scrap aluminium sheet for brackets and battery holders; brass tube and strip for AC probe; nuts, bolts and washers; thin acetate sheet to protect panel markings; plastic box, 90 x 150 x 52mm externally; PP3 batteries.



The voltage developed across the probe diode is a little less than twice the peak value of the AC voltage being measured, that is, almost 2.82 times the RMS value. Different manufacturers quote PIV ratings of between 100 and 115 volts for the OA91 diode, and the probe should not, therefore, be used to measure RMS voltages in excess of 30V. This ceiling could be extended by using a silicon diode with a higher PIV rating, or by using germanium diodes in series (voltage equalising resistors would have to be placed in parallel with the diodes). This would, however, detract from the performance of the probe at low voltages and at RF, and the arrangement suggested here is probably the best compromise.

The value of the blocking capacitor C2 is given as 220nF in order to ensure a uniform response down to 20Hz. This can be reduced to 100nF, or even 10nF, if an extended LF response is not required. Probe impedance is, of course, frequency dependent, and designers of probes of this kind have quoted impedances of the order of 6kohms shunted by around 2pF at 200MHz.

A rough check on the impedance presented by this probe was carried out by progressively increasing a resistance placed in series with its tip until the meter reading was halved. The value of the resistance was then taken as an approximation of the impedance of the probe. This revealed that, from 20Hz to 20kHz, (ie the entire AF range) the impedance presented by the probe is approximately 0.5 megohms. At 1MHz this falls to 25k, at 10MHz 2k5, until, at 40MHz, the impedance is of the order of 700 ohms. As frequency increases, probe impedance becomes increasingly dependent upon its capacitance. Constructors wishing to maximise performance at RF should, therefore, take care with this aspect of the design. A larger diameter probe case, a shorter probe tip, ceramic or other high performance insulation, lowering the value of C2 to 10 or even 1nF in order to reduce its physical size, will all help to keep capacitance low and impedance as high as possible.

Notwithstanding the limitations outlined above, the performance of the unit at audio and radio frequencies is very acceptable, and should meet the needs of most experimenters and hobbyists. The RMS values of sine waves can be measured with reasonable accuracy throughout the AF spectrum, and the probe will provide an indication of AF and RF signal levels down into the low mV region.

Fast Fivers

Adaptable, affordable - handy circuits for around £5. By Owen Bishop.
1. Warbling Door Alert

This is the first of a series of simple low-cost, quick-to-build projects that will be useful around the home or in the workshop. Each project has at least one interesting point about the circuit that will help you discover a little more about electronics. The target cost of the circuit is £5, including VAT. Suppliers' prices vary and you may sometimes need to shop around for the more expensive items when the budget is tight. The loudspeaker in this month's project is an example, for some suppliers charge about 50% more than others for virtually the same thing. Or you can get one free from an old radio set.

There are numerous electronic buzzers on the market but most of them produce either a rather dreary sound or one that is too aggressive for many domestic situations. Like the more expensive telephones, this one produces a more relaxed warbling note. Better still, you can program the warble over a wide range of pitch and warble-rate. If you need more than one alert in your home you can tune each one to give a distinctive tone.

How it works

The circuit in figure 1 is based on two voltage controlled oscillators, one to make the basic tone and the other to produce the warbling effect. The VCOs (voltage controlled oscillators) are provided by a pair of cmos 4046 ics. In the catalogues the 4046 is described as a Phase Locked Loop, which it certainly is. A PLL is a circuit that locks on to a signal of given frequency, even when the signal is faint against a lot of background noise. The 4046 contains all the parts necessary to build a PLL, among them a VCO. It needs so few extra components that a 4046 is an inexpensive and easy way to build a VCO, and we can (with a clear conscience) just forget about the other bits of the ic that we do not use.

The basic tone is provided by IC2. Its output is a square wave from pin 4, driving a loudspeaker by way of a mosfet to produce a sound amply loud to rouse the average household. The central frequency (fc) of the tone is decided by the values of capacitor C2 and resistor R2, where:

$$fc = 1/(R2 \times C2)$$

With the values shown in figure 1, fc is about 15kHz. This is the frequency when the control voltage at pin 9 of IC2 is at half the supply voltage (4.5V in this circuit). As the control voltage is reduced below 4.5V, the frequency gradually falls to zero. As the voltage is increased, the frequency rises to 2fc, about 30kHz. So the tone frequency can be set anywhere in the audio range simply by adjusting VR2.

The warbling effect is provided by IC1. This VCO has a central frequency of 1/(R1 x C1) = 37Hz and can be varied from zero up to 74Hz by adjusting VR1. When the push-button at the front door (S1) is pressed, both ics begin to oscillate. The oscillations of IC1 provide a pulsed control voltage to IC2 so that its basic tone is frequency-modulated, and gives the warbling effect. By adjusting VR1 and VR2 you can produce an almost unlimited variety of sounds, some harsh, some urgent, and some pleasantly restful.

Construction

The power supply is intended to be a 9V PP3 battery. Since current is supplied only when the button is pressed, the battery lasts a long time. The circuit is built on a piece of 0.1in-matrix stripboard, 16 (or only 14) strips wide and 35 holes long. First use a spot face cutter to cut the strips beneath the board at C10 to K10, C17 to K17, C23 to K23, J29, K 29 and P13. When you solder in the ic sockets, solder blobs beneath the board join points B12 to C12, B25 to C25, K9 to L9 and K22 to L22.

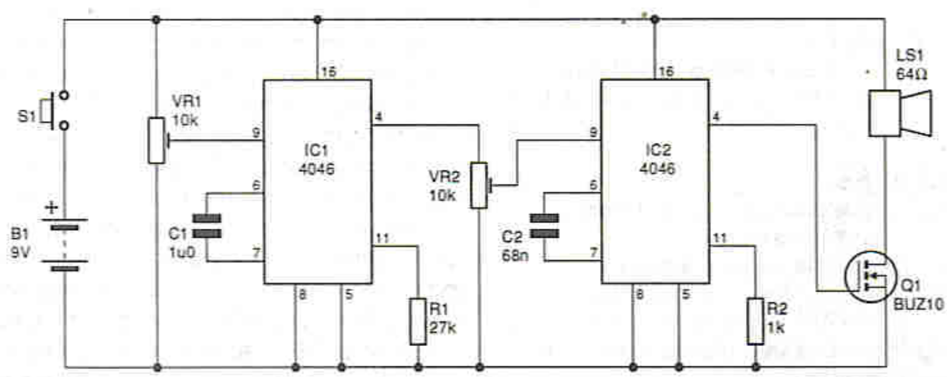


Figure 1: the circuit of the Warbling Door Alert

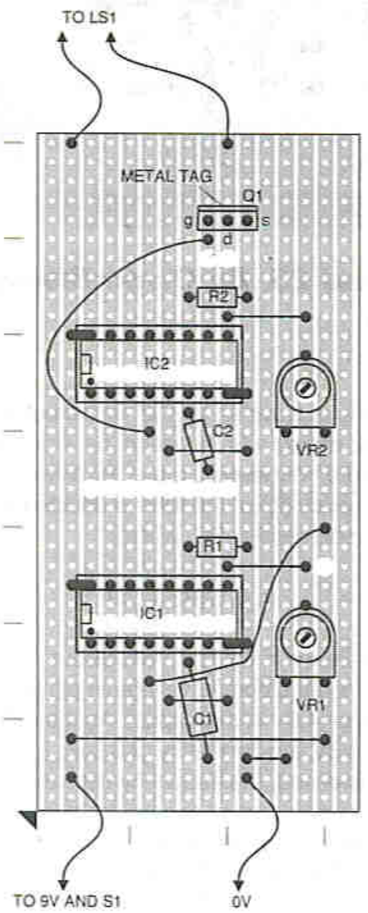


Figure 2: the stripboard layout

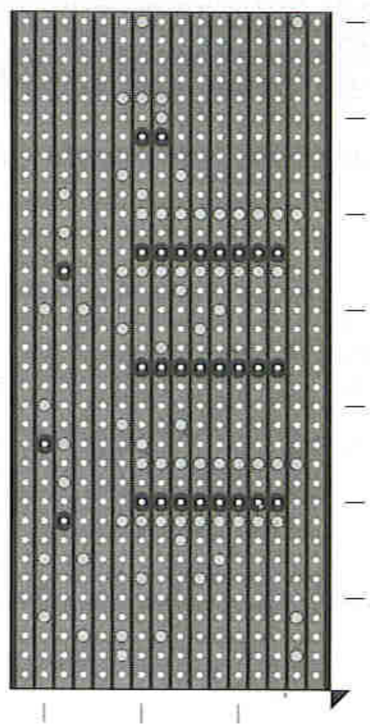


Figure 3: the underside of the stripboard layout

PARTS LIST for the Warbling Door Alert

(Capacitor and fixed resistor values can be amended to suit your requirements)

Resistors (5% tolerance or better)

R1	27kW
R2	1kW
VR1, VR2	Miniature horizontal preset potentiometer, 10kW

Capacitors (polyester layer)

C1	1uF
C2	68nF

Semiconductors

IC1, IC2	4046 cmos phase locked loop
Q1	BUZ10 n-channel enhancement power mosfet

Miscellaneous

S1	push-switch (door-bell type)
LS1	64W loudspeaker

Clip for PP3 battery; 0.1in stripboard approx 40mm (16 strips) wide by 80mm (35 holes) long, 1mm terminal pins (4 off), 16-pin dil sockets for the ics (2 off), connecting wire, including twin lead from door to site of alert.

Assemble the whole circuit before testing it. At this stage, the loudspeaker need not be mounted in its enclosure; just connect it temporarily. Before testing compare the circuit with figure 2 to make sure that all components and particularly the wire links go to the correct holes. Check beneath the board (use a hand-lens) to make sure that all tracks have actually been cut where required and also that there are no unwanted solder bridges between adjacent tracks. Set VR1 and VR2 to about half way along their tracks and press S1. When all is working properly, adjust VR1 and VR2 to obtain the sound you prefer.

The £5 costing in this series does not include a case. Often a project will run just as usefully without one. But a loudspeaker really needs an enclosure if full volume and tone quality is to be obtained. You may have a small wooden or plastic box that can be adapted for this purpose, otherwise, the cheapest solution is to buy an ABS project box. You do not need a box with slots for mounting the circuit-board; use a lump of Blu-tack or a piece of double-sided tape to fix it to the bottom of the box. Cut a circular aperture in the lid of the box for the speaker and glue it in place. Of course, if you happen to have a spare speaker with enclosure from an old radio set, tape player, or stereo system, you can use this: strip out the old circuit board, and mount the project circuit-board inside the case. Figure 1 shows a 64R speaker being used, but the BUZ10 can take up to 20A, so an 8R speaker can be used instead. You may want to reduce volume by wiring a 2 watt (or more) wire-wound resistor of a few ohms in series with the speaker.

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Battery Quick-Check

Terry Balbirnie's battery "health-checker" will tell you instantly whether those loose AA cells and PP3s are still in service, or ready for the bin.

The modern home is filled with battery-operated devices. These include toys, photographic equipment, TV remote controls, Walkman-type personal stereos, games and radios. Batteries are also used as back-up supplies for clocks and videos. Most of these batteries fall into two categories: the 9V PP3 type and the 1.5V "AA" (HP7) size cell. Note that, strictly speaking, a *cell* is a single unit and a *battery* consists of several cells connected in series. However, the word 'battery' is often used for single cells and this is how it will be used here.

All mixed up

It often happens that batteries are left lying around the house, or new ones get mixed up with the old. It is then necessary to test them to find out which are fit for use, which may be used for some other purpose and which should be thrown away. Sometimes a cell that shows up as unsuitable for the most demanding purposes may be used to operate a clock or other very low-current device for a few months. *Note, however, that smoke detectors must always be fitted with new batteries.*

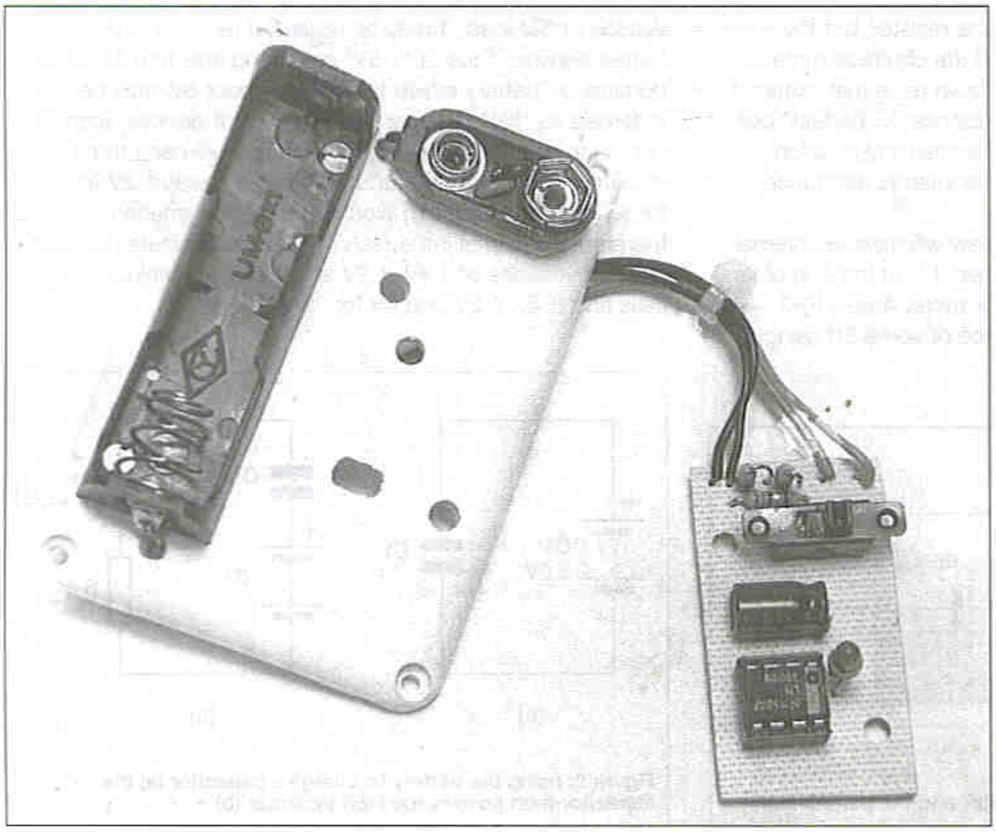
This tester circuit will give a good indication of the "state of health" of the types of battery mentioned above. It is very simple to use, making it ideal where children or the non-technically minded are involved.

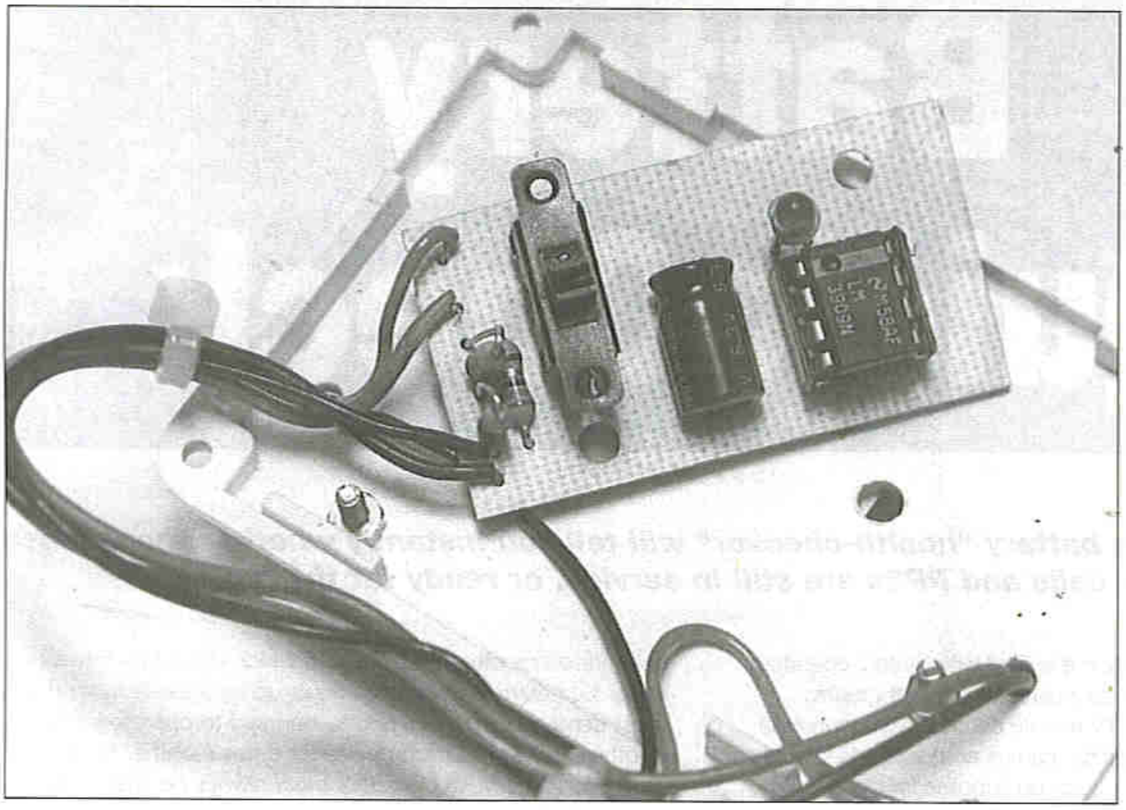
Fit for service

The unit is housed in a small plastic box which has an "AA" size cell holder and a PP3 connector mounted on top. There is also a small slide switch and an LED. To make the test, the slide switch is set to "9V" or "1.5V" as appropriate; the battery is then connected and the LED observed. If there are bright flashes given about once every second, the battery is in good condition and fit for further service. If the flashes are somewhat dimmer and the rate is markedly slower, the battery may be suitable for use in a low-current appliance such as a clock. If the LED remains off or flashes very feebly and slowly, the battery is "flat" and should be discarded.

If a battery is connected to the tester with incorrect polarity, no harm will result but, of course, the circuit will not work and the LED will remain off.

Note that the LED is powered by the battery being tested, so there is no problem caused by having a battery in the checking circuit itself (how do you check the battery that checks the battery?).





When current flows through the internal resistance, a voltage is developed across it (as Ohm's Law dictates). This voltage is "lost" as far as the external circuit is concerned. To take a practical example, suppose a bulb is connected to a battery. The same current flowing through the lamp's filament also passes through the internal resistance. The greater the voltage developed across the internal resistance, the less will appear across the bulb. To put it another way, the bulb loses out and becomes dimmer as the battery ages.

A bit of theory

To test a battery, it is necessary to use a circuit which responds to the voltage between the terminals. This voltage tends to fall as the battery ages. Some inexpensive units perform the test with the battery off-load (that is, while not delivering significant current). This is not very satisfactory, because the voltage does not fall very much under such circumstances. In use, the battery will be delivering current, and it is then that the reduction in terminal voltage is more pronounced. This is due to the voltage drop which occurs when current flows through the internal resistance of the cell. The internal resistance is not a physical resistor, but the undesirable effect of the resistance of the chemical material inside. It may be imagined as, and drawn as, a real external resistor connected in series with a supposedly "perfect" cell (see figure 1). As the battery ages, the chemical reaction taking place within it clogs up, and the internal resistance rises.

A typical "AA" alkaline cell when new will have an internal resistance of less than 0.5 ohms. When it is at the end of its useful life, it may have risen to 10R or more. A new PP3 battery may have an internal resistance of some 3R rising to 60R or thereabouts when "flat".

Under working conditions, a brand new "1.5V" cell may develop some 1.45V across the load. A 9V PP3 type battery operating, say, a small radio may develop some 8.6V. Appliances always allow for some voltage drop, so that they will continue to work properly (up to a point) as the battery ages. The rated voltage of a cycle light bulb, for example, may be 2.4V when the supply is derived from two cells (nominally 3V). When the battery is new, the bulb may be somewhat overloaded. However, for most of the time it will operate correctly or with only slight dimming.

When a battery provides less than 66% of its nominal voltage under load, it may be regarded as unsuitable for further service. Thus, a "1.5V" cell giving less that 1V, or a nominal 9V battery which falls below about 6V, may be regarded as "flat". To operate high-current devices such as certain toys and flashguns, the batteries will need to be discarded long before that, and in those cases 1.2V (or 7.2V for a nominal 9V battery) would be a better criterion. It would therefore be helpful if the tester could discriminate between on-load voltages of 1.4V, 1.2V and 1.0V for nominal "1.5V" cells and 8.4V, 7.2V and 6V for "9V" batteries.

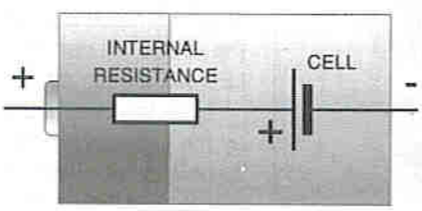


Figure 1: in theory: the "external resistor and the perfect cell"

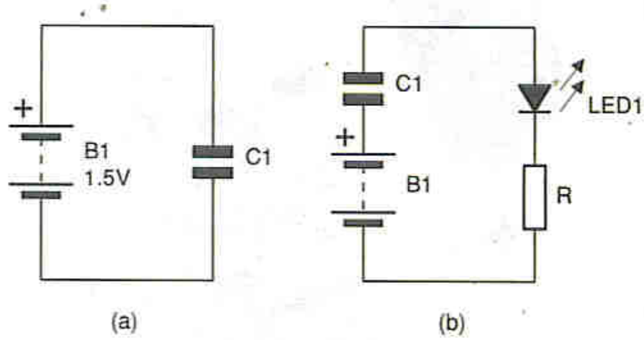


Figure 2: using the battery to charge a capacitor (a) the capacitor then powers the PED indicator (b)

Cheap and easy

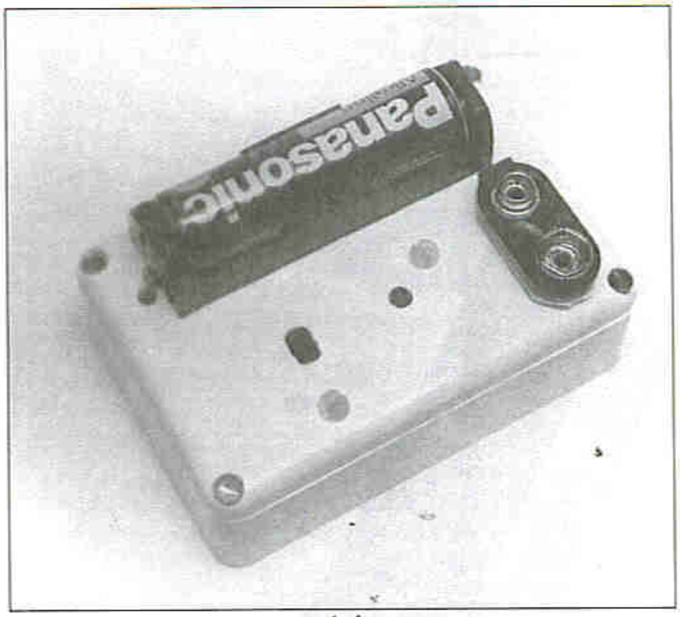
In this circuit, an LED is used to indicate, by its brightness and rate of flashing, a good idea of the terminal voltage. However, there is a problem. An LED needs approximately 2V before it will operate. A single cell, even when new, would therefore not be sufficient.

One way of overcoming this would be to use the cell, B1, to charge a capacitor, C1 (see figure 2a). After a short while, a voltage equal to that of the cell would appear across its ends. If the capacitor were now connected in series with the cell (figure 2b), the voltage across the pair would be about 3V (that is, there would be a doubling of the voltage) and it would then be sufficient to operate the LED. Resistor R limits the current flowing to prevent damage to the LED. The LED would give a burst of light until the capacitor discharged to a voltage less than about 0.5V (that is, until the total falls below 2V). If this whole process were repeated quickly, the LED would emit a series of flashes. The repeated action could be carried out automatically. To design and construct such a circuit would not be difficult, but it would involve several components that would raise the cost above that which seemed reasonable for a device of this type.

Fortunately, there is an inexpensive ic that does the work with very few external components. It is designed to flash an LED brightly with a supply of 1.5 to 1.4V. Tests show that it will flash the LED less brightly and more slowly between 1.4V and 1.2V. At 0.9V approximately, the flashing stops altogether. This makes it ideal for the present purpose. The internal structure of this ic is fairly complex and will not be explained in detail here. However, it works in a similar way to the process shown in figure 2. A capacitor connected externally gives the voltage doubling effect; there is an internal oscillator (a pulse generator to provide the "repeating" aspect of the circuit) and this also needs a capacitor to make it work. Here, the two functions are combined so that one capacitor does both jobs. With the value specified, and with a 1.5V supply, there will be one pulse per second approximately. At 1.2V it will be much dimmer and the flash rate will be roughly once every 1.2 seconds. At 1V, the LED will be very dim and it will flash every 1.5 seconds approximately.

How it works

Figure 3 shows the circuit of the Battery Quick-Check. IC1 is the integrated circuit LED flasher. C1 (referred to above) is connected to pins 1 and 8 on one hand and pin 2 on the other. The LED is connected between pin 6 (anode) and pins 1 and 8 (cathode). Note that no conventional series resistor is



needed for the LED, because current control takes place on the chip. The nominal 1.5V input is made to pin 5. The two-way switch, S1, selects between the 1.5V cell or 9V battery to be tested. For the 9V battery, the voltage will need to be scaled down to make it appear like a 1.5V supply to the circuit so that the ic will respond correctly.

For the 1.5V cell, R3 is connected directly across its terminals, and provides the load. With the value specified, and with the battery in average condition, the current drain will be about 100mA on average. It will be somewhat higher with a new battery and less when it is nearly flat. When a 9V battery is being tested, resistors R1 and R2 connected in series provide the load. By using comparatively low values, there will be a moderate current flowing through the pair - some 40mA - with a battery in average condition. This is a suitable load for the PP3 type. The resistors also form a potential divider which scales down the voltage. The value of R1 is five times greater than R2. The effect is that the voltage appearing across R2 is one sixth of that across the pair (since the resistance of R2 is one sixth of the total). Thus, when the "9V" battery is connected across R1 and R2 a nominal 1.5V appears across resistor R2. The result is then applied to IC1 pin 5 via the "9V" switch contacts.

(Figure 3b is a little extra for experimenters from the Office - configuring the circuit this way means that no switch is necessary - but you will have to adapt the pcb layout, and test to make sure the circuit still works as the author describes it.)

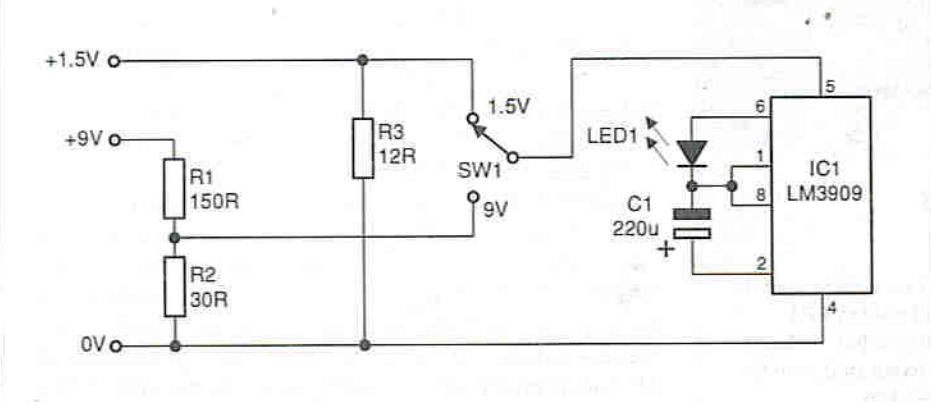
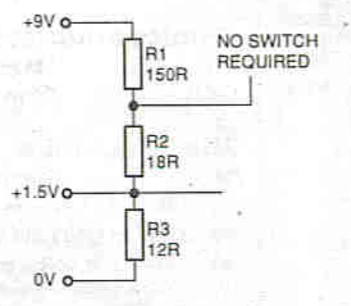
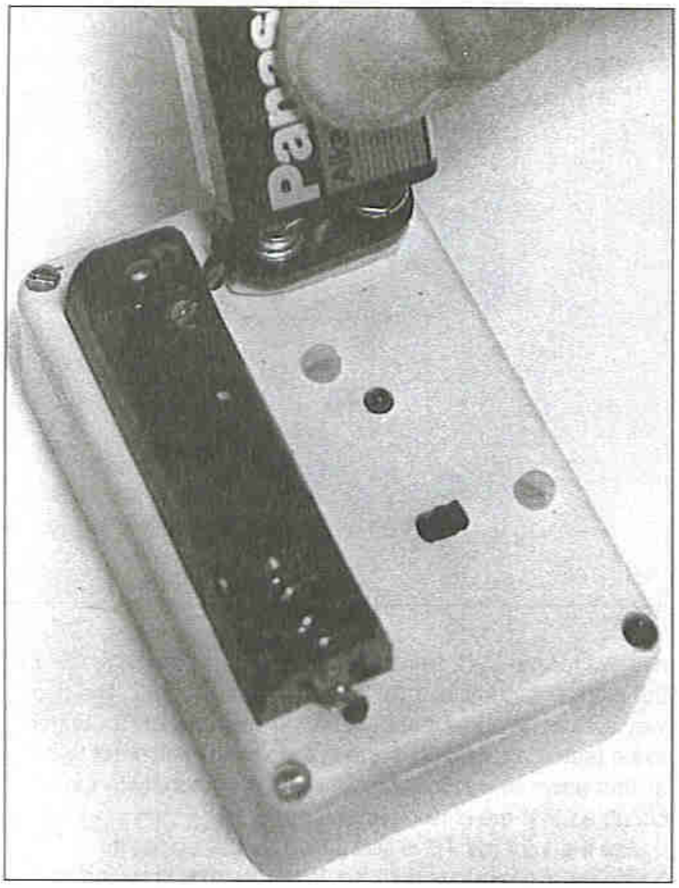


Figure 3a: the circuit of the Battery Quick-Check

Figure 3b: experimenter's circuit: adding a extra resistor to the potential divider chain is a way of removing the need for a switch .





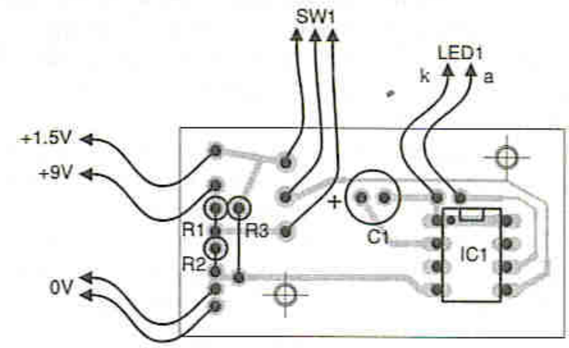


Figure 4: the component layout for the Battery Quick Check

Construction

Figure 4 shows the topside pcb layout of the circuit. Drill the two mounting holes, and solder S1 in position. Use the minimum length of tags pushed through the holes (about 1mm) to make good soldered joints - do not push the body right down on to the surface of the pcb. The switch should stand clear of the pcb by about 2mm. Solder the ic socket in place, and then the other components, noting the polarity of the capacitor. Bend the capacitor's end leads so that it flat against the pcb. Solder the LED so that it stands with its tip about 12mm above the circuit panel - the slightly shorter end lead is the negative (k) one. Solder 10cm pieces of light-duty stranded wire to the point labelled "+1.5V" and one of the "0V" pads.

PARTS LIST

Resistors

All 0.6W 1%

R1	150R
R2	30R
R3	12R

Capacitor

C1	220µ 6V radial electrolytic

Semiconductors

IC1	LM3909N
LED1	3mm red LED

Miscellaneous

S1	Sub-miniature spdt slide switch

8-pin dil socket. Single "AA" cell holder, PP3 battery snap (the rigid type having a flat surface). Small nuts and bolts, adhesive fixing pad, plastic stand-off insulators, small plastic box.

Carefully measure the position of the switch and LED on the pcb, and make holes in the lid to correspond. Mount the pcb temporarily, using 6mm long plastic stand-off insulators on the bolt shanks. This should allow the tang of the switch to protrude through its hole sufficiently to operate it. Check that the switch can be used easily and make any adjustments as necessary. Remove the pcb again.

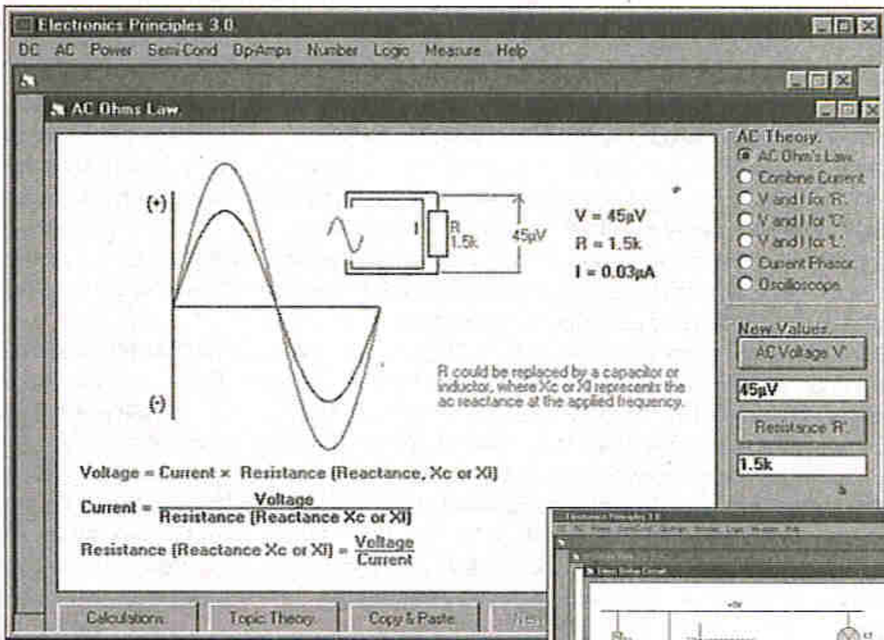
Place the cell holder on the lid and mark the positions of the mounting holes. Drill these through and attach it. Drill a small hole near each end for the wires passing through the lid from the pcb. Attach the PP3-type connector using an adhesive fixing pad (the type available from stationer's shops), and make a small hole nearby for the wires. Note that the rigid type of connector with a flat surface can be attached much more securely than the soft variety. Pass the connecting wires through the hole. Solder the red and black to the "+9V" and unused "0V" pad respectively on the circuit panel. Attach the pcb. Pass the 1.5V cell wires already soldered to the pcb through their holes and solder them to the cell holder tags taking care over the polarity. All the wires may be grouped together and held neatly using small cable ties.

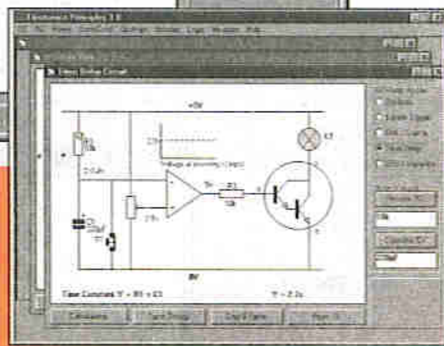
Testing

Testing is simply a matter of checking for correct operation. Find a few "AA" cells in various states from new to practically "flat". Set the switch to "1.5V" and place them one by one in the holder taking care to put them in the right way round. With a fresh cell, the LED should flash brightly at about once per second. Compare the effect of cells in poor condition. It should be found easy to distinguish between them. Set the switch to "9V" and conduct a similar test using some PP3 batteries. If all is well, the unit may be put into service. Note that a PP3 battery should be simply *touched* on the connector (see photograph). Engaging it properly will probably detach the fixing pad when it is removed.

When making a test, observe the LED over a period of ten seconds or so. This will distinguish between batteries which really are in good condition and those which have simply "picked up" temporarily - this often happens when a battery has been left standing for a while. However, do not leave a battery connected for longer than necessary, as it is still being drained by the load resistor in the unit while it is on test.

REVIEW





Electronics Principles* from EPT Educational Software has been around for several years, gradually expanding and being updated in response feedback from users, particularly teachers. The current version, V3.0 for Windows on the PC, appeared for the first time in 1996. (The DOS version 2.1 is still available.) Installation into Windows should be straightforward so long as other applications are closed down first, but if there is any problem, EPT will give telephone support, always an advantage of the smaller independent company.

Electronics Principles 3.0

For Windows 3.1, '95 or NT

As the name suggests, *Electronics Principles* concentrates on explaining and demonstrating principles, in a modular form, rather than specific advice about building circuits. Starting with the atomic structure of many of the materials used in electronics (carbon, silicon, copper, germanium), it explains the relationship between the structure and the function of the material, and works through a variety of components and demonstration circuits up to the basic circuits of a Wheatstone bridge and an analogue multimeter. Progress is quite literally from top to bottom and left to right through the pull-down Windows menus.

The current version has 284 topics in 64 windows, many of which can be opened at the same time so that the user can switch between them quickly. If too many windows are open, users may encounter resource low warnings - but as there are only so many topics that a serious student can work with at one time, this may be an advantage rather than a restriction, by providing a motivation to be organised.

Principled

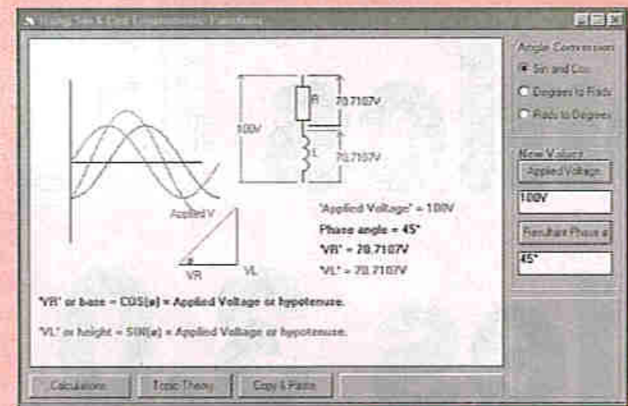
The major attraction of *Electronics Principles* is the demonstration circuits into which you can enter any values, and in most cases see how these affect the outcome of the calculation directly on the circuit diagram, while others have a calculations box that must be opened separately after the component values have been changed. The actions performed under the screens are adjusted to the subject being demonstrated.

Here is a quick round-up of the Menu headings and some of the topics under them: DC, AC, Power, Semicond(uctors), Op-Amps, Number, Logic, Measure, Help - topics covered include Ohms Law, power supplied, transistor configurations, sum and difference amplifiers, complex numbers and logic interfacing.

All the screens have the important details picked out in different colours, which has the effect of drawing the user's eye to the important areas. The colours also provide a cross-reference with tables on the screen - for instance, in the Voltage Divider screen, all values relating to Vin and Vout are in brown, all values relating to I are in blue, and all values relating to R are in green. The colours are not universal to the whole program, but this is not necessary, and there is enough consistency to be helpful.

The Topic Theory screens, and later in the program the Calculations screens, must be opened separately from the interactive circuit screens, and although this does allow operation from the minimum 8.5 x 6 in window, this is not a great advantage (see below) whereas if everything was displayed on one screen, the window could then be resized just to show the interactive area if desired. Also, returning to the interactive buttons automatically switches off the Calculation and Topic Theory screens, which I found rather annoying, as the Calculation screen is often the primary display of the changes.

Some circuits - for instance the Timer Delay, in the Op-amp Applications section under the Op-Amps menu - have a "switch" button that runs a waveform display of the voltage at the inverting input when it is operated, plus a numerical display of the changes as they take place. Some circuits may compel you to pay particular attention. For instance, the Schmitt Trigger (under the same menu) only accepts changes up to 12 volts. This should be self-evident from the +12V rail, but if you enter a higher number you do not get an error message - the screen simply sits and waits unblinkingly for you to work out what you have done wrong. The Calculation and Topic Theory screens switch themselves off once you have begun to work with the New Value boxes, as previously remarked, so there are no clues there unless you manually switch them on again, and again you must think through the implications of what they are telling you.



Buttons

Other examples of the variety of screen displays are the windows showing the different logic gates, which have "Input A" and "Input B" buttons that change the logic levels back and forth within the circuit, as well as an interactive truth table alongside that also displays the changes. Some screen do not have user-definable values, but simply display changes for a series of set values when the right button is pushed - perhaps accompanied by a diagram of a buzzer sounding, switches operating or a relay opening and closing. The only individual chip demonstrated is the 555 timer, "probably the most useful chip available to the hobbyist", according to the Topic Theory, shown in three separate screens.

In terms of versatility and availability, the 555 and its family are indeed old friends, although this does reinforce the fact that EP 3.0 is aimed at a basic level, rather than industry training. One helpful idea is the Resistor Value Test screen under the DC menu, where random four-band patterns are produced and you must work out the value from the colour key given.

I would have liked it if there was some indication which main menu topic each window was operating under - sometimes it took some guesswork to re-locate a window that had been closed among the menu sub-topics if I was not paying attention to which aspect of the demonstration I was supposed to be studying. But I find that this is a shortcoming with many Windows programs, although it would not be difficult to rectify.

As it is designed to be self-explanatory, *Electronics Principles* comes with very little paperwork other than the loading instructions, so you must get used to how it works by trying it out. A minor vexation is that to enter the new values for any screen, you must click on a "New Values" button, and then move to a completely separate box that opens up to type in your values and Enter them. This may be partly for reasons of space in the box, as you may need to select, for instance, volts, microvolts, or millivolts from another menu once you have entered a basic value. The division of the dialogue box into "actual value" and "formatted value" seems puzzling at first, but you soon get used to the program adjusting your entries to the appropriate number of decimal places and adding scientific notation. Entering simple values is quite quick as you can select from the New Values box with the mouse and the Actual Value box straight from the keyboard. But you must return to New Values for each value change you make in the circuit.

Concentration

Certainly, using the screens and boxes requires a fair amount of concentration to follow and understand everything that is there in the box, but the advantage is that it is all there, and you can change it to see how it works. The Topic Theory boxes tend to be short and to the point.

Once or twice, challenging the boxes to accept odd values, or change quickly, I found that the program got its combinations in a slight twist and refused to accept certain values, or to change the notation. I would not even bother to mention this if this were not an entry-level program, as nearly all software behaves in this way given half a chance. Good practice is to make sure you step through the instructions as intended, and give the program "time to work", and it will not let you down. Also, it is easy to reset screens "back to start" by closing and re-opening, which is not true of all software.

On opening, I found that the main Window occupied the entire screen, but if the main window is reduced using the middle top right icon, you can work with the smaller window, and resize it manually to a minimum practical display of just over 8.5 in wide by 6in deep to be useable with the control panels. In fact, as you open more windows and "cascade" them (from the Help menu) they take up more space. Non-Windows users will see that Windows users quickly become spoiled by being able to run several programs at once and moan about the window sizing! With this in mind, screens from *Electronics Principles* can be easily cut and pasted into a Windows wordprocessor for use in your own documents, which is also useful for teaching staff who wish to make up worksheets or overhead projector slides, as EPT point out.

The level, clearly indicated by the favoured 555 timer and the four-band resistor test, is hobbyist and entry-level educational rather than industrial, although the practice available from a program like this could be helpful to higher levels of study. Indeed, although EPT stress that they are aiming at the hobby market, many of the features of EP 3.0 are described as useful to teachers. EPT also produce a version 4.0 of *Electronics Principles*, which is essentially built on the same lines, but with an extended - roughly doubled - range of screens and topics, and priced at £99.95. On a sheerly practical note, EPT also recommend two low-cost paperbacks, Teach-in No 6 "Design your own circuits" by Mike Tooley (£3.45) and Teach-in No 7 "A complete electronics course" by Alan Winstanley and Keith Dye (£3.95) (Books are VAT-free. Post and packing add £1.50 each or £2.50 for both books) as useful partners to *Electronics Principles*. Software has many virtues, but well-written paperbacks are a great source of information.

EPT also market *Mathematics Principles* at £49.95 and *Electronics Toolbox* formula software at £19.95 (all prices ex VAT - please add VAT plus £2 for UK post and packing). They have a Web page at http://www.octacon.co.uk/ext/ept/software.htm or Tel. 01376 514008.

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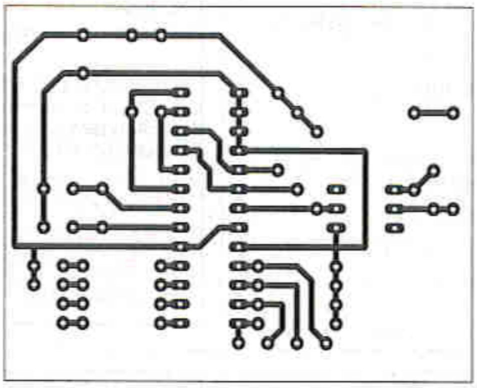

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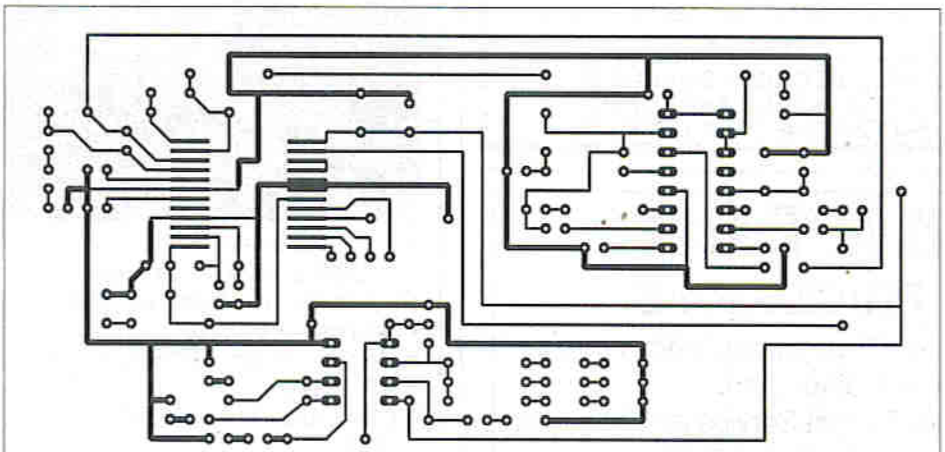

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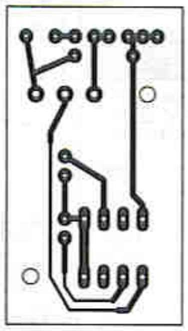

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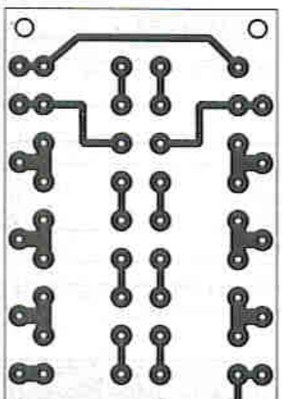

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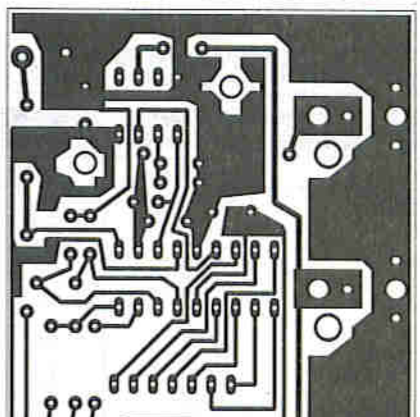

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Around the Corner

With all the concentration on software, the Internet, computing power at our fingertips, CAD, CAE, simulations, networking, so on ad infinitum, one sometimes overlooks the advances in other areas of electronics. For example, last year mosfets (metal oxide field effect transistors) with an improved structure were introduced, and they may soon reach the level of availability that hobbyists and other people who work with electronics in quantities under 10,000 units a time may be able to buy them and build them into their own designs.

The basic improvement is that the gate is buried in the channel, and current flows around it. The capacitance is increased a little, compared with the same gate area on the surface, and the ON-resistance drops by a much larger percentage.

This is significant, because one of the limitations on switching FETs fast is that the gate capacitance must be charged and discharged, which requires significant current to do quickly. In a switched mode power supply, a major part of the dissipation in the power mosfet usually occurs during the switching, because when the device is in an intermediate state its dissipation can be enormous. A moderate power offline switcher might be switching off a mosfet passing a current of 3A. When it is switched half way off, the current will not have declined much by the time that the voltage across the device reaches 200V, which means that the dissipation at this instant is 600W! Clearly you do not want that situation to continue for long.

With the improved FET topology you can switch faster for a given gate drive current and on resistance, or have lower on resistance and therefore less dissipation during conduction for the same switching speed.

Gate drive power can be significant in some circuits, such as micropower dc-to-dc converters (as in next month's free pcb project). The battery power used in charging and discharging the mosfet gate capacitance in a low power dc-dc converter can noticeably reduce the battery life.

What you will notice on the consumer side is that your lump-in-a-lead switching power supply delivers more watts for the same size, and doesn't even get warm. You'll just have to ask the family for thicker socks next winter. And a couple of extra cups of coffee from the boss.

Another change which has happened quietly has been in television set design. In the old stone age, the IF (intermediate frequency) stages used tuned transformers to give selectivity, separate the sound subcarrier from the video, and so on. Surface acoustic wave devices have been used for this purpose for a long time, resulting in cheaper televisions (because factory adjustment was reduced), and better sound and pictures.

Modern television ics available from Philips have taken the next step - to DSP (digital signal processing). Intermediate frequency bandpass filtering, separation of sound and video, separation of colour subcarrier, all is done digitally. The only tuned circuits in sight are in the UHF tuner.

With lower cost memory, look for average-priced televisions with a frame store to do comb filtering, so that the horizontal resolution can be increased by a factor of perhaps 50% without the moire type patterns which result from crosstalk between luminance and chrominance. Then wide-screen will then not look quite so blurred.

Perhaps you remember the Challenge concerning hifi loudspeakers a few months back? Well, it looks as if the people at Nxt have gone quite a distance towards answering this one (they have been working on the project for years. You may have seen the *Tomorrow's World* feature a few weeks back). Look out for an in-depth review soon.

The Challenge - *Things that electronics hasn't fixed yet*

Given that NXT have invented a flat loudspeaker, what we want now is a good flat video display with lots of resolution, with a fast update, but without hundreds of wires to carry signals to each crosspoint. Is this just StarTrek technology?

Send your suggestions to the Editor at the address on the right.

Next Month...

Volume 26 no.5 of Electronics Today International will be in your newsagent on 25th April 1997, with a FREE pcb on the cover - look out for the Little Red Reading Torch - a long-life torch for reading and walking at night, based on red LEDs ... an ingenious multi-function PIC-controlled Lottery and Games Console - plus how to interface to an LCD, and adapt the basic design for other applications ... Don't get caught in the dark - build a car-headlight switch-on warning if you are forgetful (or know someone who is) ... Are power cables an unseen danger? Douglas Clarkeson reports on the safety angle of electro-magnetic radiation around us ... on test: a new system to make your own pcbs at home ... Spiced Circuits ... all the news, and more ...

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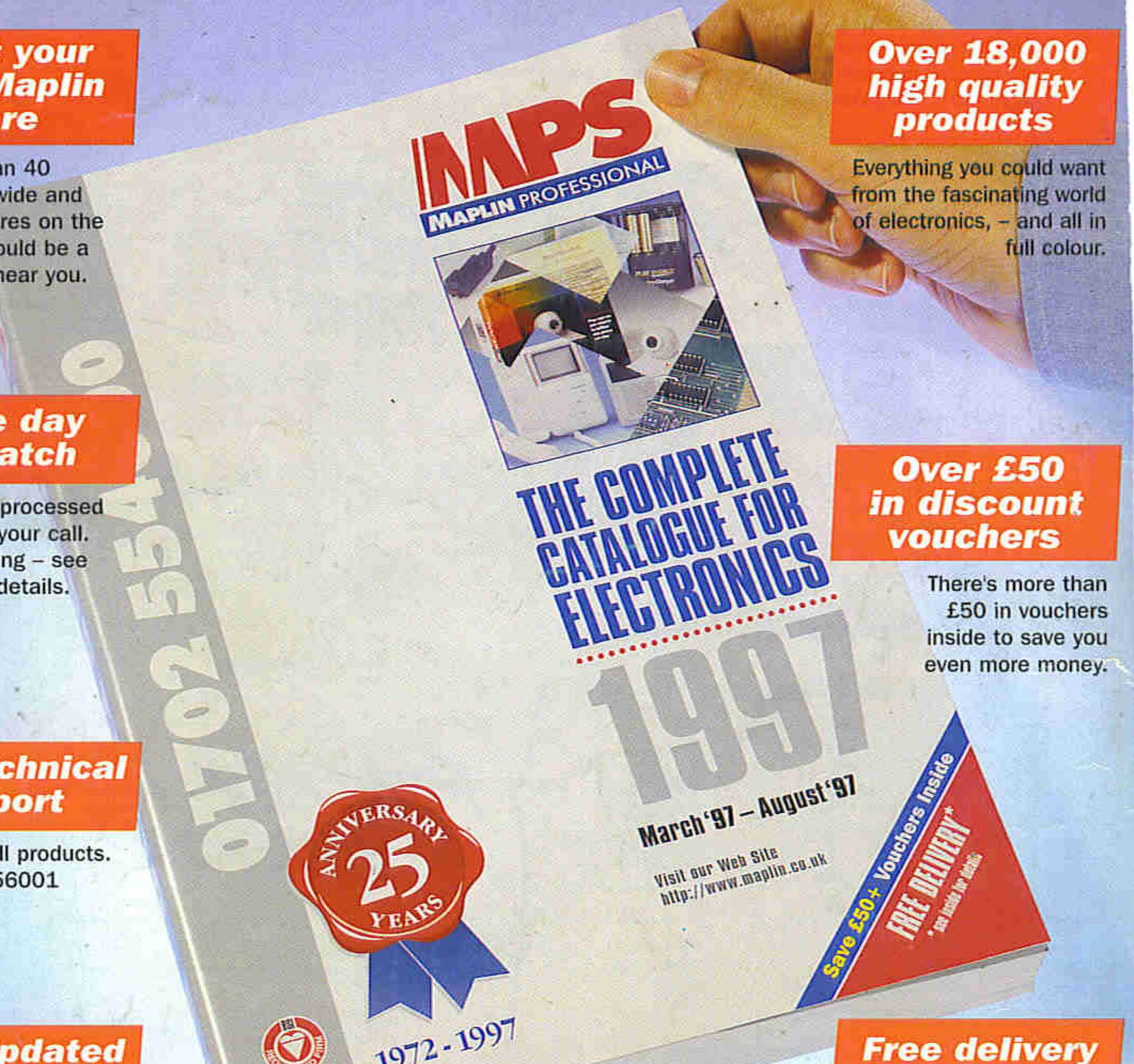

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