EVERYDAY PRACTICAL ELECTRONICS

NOVEMBER 1996

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EPE Elysian Midi Theremin

Part 1 – A full specification Theremin plus the

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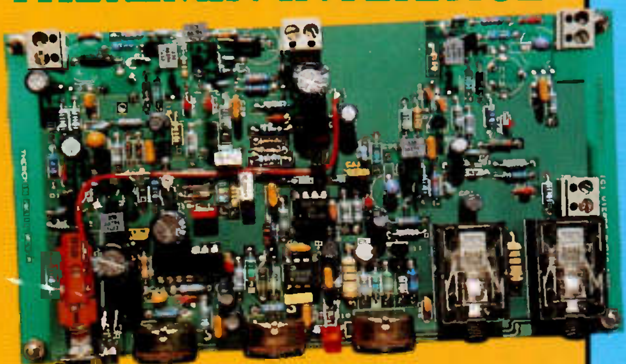

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The No. 1 Magazine For Electronics Technology & Computer Projects

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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. £15 ref MS1

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.

SINCLAIR C5 MOTORS We have a new ones available without gearboxes at £50 ref LOT25

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

GALLIUM ARSENIDE FISHEYE PHOTO DIODES Complete with suggested circuits for long range communications\switching £12 complete.

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!)

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! £5.99 ref EF138.

REMOTE CONTROLTANDATA TD1400 MODEM/VIEWDATA Complete system comprising 1200/75 modem, auto dialler, infra red remote keyboard, (could be adapted for PC use?) psu, UHF and RGB output, phone lead, RS232 output, composite output. Absolute bargain for parts alone! £9.95 ref BAR33.

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, full circuit diagrams, new price £50,000? us? £349. 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. five or more units £299 ea. £349 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!

RADIO CONTROLLED CARS FROM £6 EACH!!!!

All returns from famous manufacturer, 3 types available, 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

PANORAMIC CAMERA OFFER Takes double width photographs using standard 35mm film. Use in horizontal or vertical mode. Complete with strap £7.99 ref BAR1

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

PLASMA SCREENS 222x310mm, no data hence £4.99 ref BAR67

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

WOLVERHAMPTON BRANCH NOW OPEN AT WORCESTER ST W'HAMPTON TEL 01902 22039

details £249 ref TAL-1

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, Dbase, disc editor, over 40 viewers, remote computing, password protection, encryption, comprehensive manual supplied etc £25 ref lot 97 3.5" disks.

GOT AN EXPENSIVE BIKE? You need one of our bottle alarms, they look like a standard water bottle, but open the top, insert a key to activate a motion sensor alarm built inside. Fits all standard bottle carriers, supplied with two keys. **SALE PRICE £7.99 REF SA32.**

GOT AN EXPENSIVE ANYTHING? You need one of our cased vibration alarms, keyswitch operated, fully cased just fit it to anything from videos to caravans, provides a years protection from 1 PP3 battery, UK made. **SALE PRICE £4.99 REF SA33.**

DAMAGED ANSWER PHONES These are probably beyond repair so just £4.99 each. BT response 200 machines. REF SA30.

COMPUTER DISC CLEAROUT We are left with a lot of software packs that need cleaning so we are selling at disc value only! 50 discs for £4, thats just 8p each!!(our choice of discs) **£4** ref EP66

IBM PS2 MODEL 160Z CASE AND POWER SUPPLY Complete with fan etc and 200 watt power supply. **£9.95** ref EP67

DELL PC POWER SUPPLIES 145 watt, +5,-5,+12,-12, 150x150x85mm complete with switch, flyleads and IEC socket. **SALE PRICE £9.99** ref EP55

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

DELL PC POWER SUPPLIES (Customer returns) Standard PC psu's complete with fly leads, case and fan. +12v,-12v,+5v,-5v **SALE PRICE £1.99 EACH** worth it for the bits alone! ref DL1. **TRADE PACK OF 20 £29.95** Ref DL2.

GAS HOBS AND OVENS Brand new gas appliances, perfect for small flats etc. Basic 3 burner hob **SALE PRICE £24.99** ref EP72. Basic small built in oven **SALE PRICE £79** ref EP73

RED EYE SECURITY PROTECTOR 1,000 watt outdoor PIR switch **SALE PRICE £6.99** ref EP57

ENERGY BANK KIT 100 6"x6" 6v 100mA panels, 100 diodes, connection details etc. £69.95 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!) Current retail price **is £129, SALE PRICE** £9.95 ref SA12. SAVE £120!!!

COMPLETE PC 200 WATT UPS SYSTEM Top of the range UPS system providing protection for your computer system and valuable software against mains power fluctuations and cuts. New and boxed, UK made Provides up to 5 mins running time in the event of complete power failure to allow you to run your system down correctly. **LAST FEW TO CLEAR AT £49 SAVE £30** ref LOT61

BIG BROTHER PSU Cased PSU, 6v 2A output, 2m o/p lead, 1.5m input lead, UK made, 220v. **SALE PRICE £4.99** REF EP7

Check out our WEB SITE

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

RACAL MODEM BONANZA! 1 Racal MPS1223 1200/75 modem, telephone lead, mains lead, manual and comms software, the cheapest way onto the net! all this for just £13 ref DEC13.

4.5mw LASER POINTER. BRAND NEW MODEL NOW IN STOCK!, supplied in fully built form (looks like a nice pen) complete with handy pocket clip (which also acts as the on/off switch.) About 50 metres range! Runs on 2 AAA batteries. Produces thin red beam ideal for levels, gun sights, experiments etc. just £39.95 ref DEC49 TRADE PRICE £28 MIN 10 PIECES

BULL TENS UNIT Fully built and tested TENS (Transcutaneous Electrical Nerve Stimulation) unit, complete with electrodes and full instructions. TENS is used for the relief of pain etc in up to 70% of sufferers. Drug free pain relief, safe and easy to use, can be used in conjunction with analgesics etc. £49 Ref TEN/1

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**

EMERGENCY LIGHTING UNIT Complete unit with 2 double bulb floodlights, built in charger and auto switch. Fully cased. 6v 8AH lead acid req'd. (secondhand) £4 ref MAG4P11

YUASHA SEALED LEAD ACID BATTERIES Two sizes currently available this month. 12v 15AH at £18 ref LOT8 and 6v 10AH (suitable for emergency lights above) 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. **£8.99** REF SA25.

MICRODRIVE STRIPPERS Small cased tape drives ideal for stripping, lots of useful goodies including a smart case, and lots of components. **SALE PRICE JUST £4.99 FOR FIVE REF SA26**

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

RGB/CGA/EGA/TTL COLOUR MONITORS 12" in good condition. Back anodised metal case. **SALE PRICE £49 REF SA16B**

PLUG IN ACORN PSU 19v AC 14w, £2.99 REF MAG3P10

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**

PHONE CABLE AND COMPUTER COMMUNICATIONS PACK Kit contains 100m of 6 core cable, 100 cable clips, 2 line drivers with RS232 interfaces and all connectors etc. Ideal low cost method of communicating between PC's over a long distance utilizing the serial ports. Complete kit £8.99. Ref comp1.

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**

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.

PLUG IN POWER SUPPLY SALE FROM £1.50 Plugs in to 13A socket with output lead, three types available, 9vdc 150mA £1.50 ref SA19, 9vdc 200mA £2.00 ref SA20, 6.5vdc 500mA £2 ref SA21.

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 2km in open country. Units measure 22x52x155mm. Including cases and earp'ces. 2xPP3 req'd. £30.00 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 £15 REF: EF62 (kit) Transmits to any FM radio.

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

TALKING COINBOX STRIPPER COMPLETE WITH COINSLOT MECHANISMS originally made to retail at £79 each, these units are designed to convert an ordinary phone into a payphone. The units have the locks missing and sometimes broken hinges. However they can be adapted for their original use or used for something else?? **SALE PRICE JUST £2.50 REF SA23**

GAT AIR PISTOL PACK Complete with pistol, darts and pellets £12.95 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. £19.95 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.

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.

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! £79.95 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.

***SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK**

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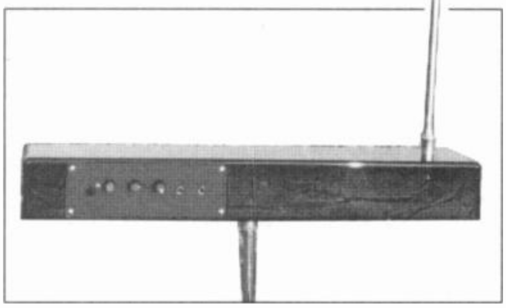
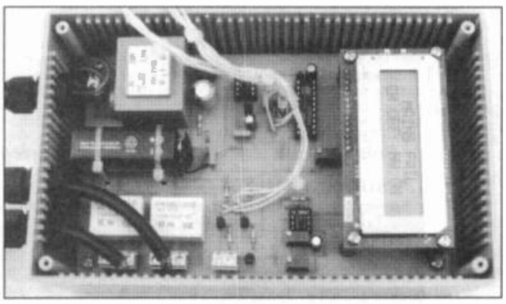
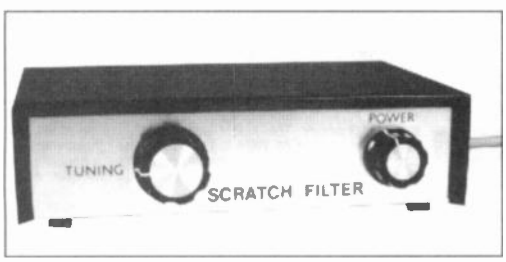
VOL. 25 No. 11 NOVEMBER '96

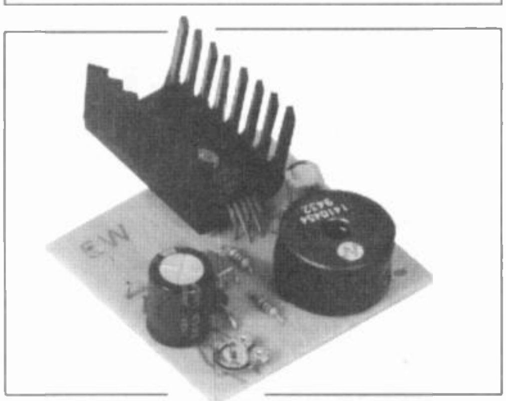
EVERYDAY PRACTICAL ELECTRONICS

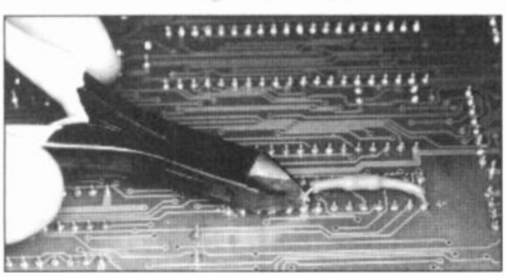
The No. 1 Magazine for Electronics, Technology and Computer Projects











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Our December '96 issue will be published on Friday, 1 November 1996. See page 859 for details.

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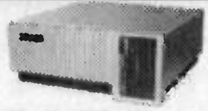
SPECIAL BUY
'AT 286'
40Mb HD + 3Mb Ram



LIMITED QUANTITY only of these **12Mhz HI GRADE 286** systems Made in the USA to an industrial specification, the system was designed for *total reliability*. The **compact case** houses the mother-board, PSU and EGA video card with single 5¼" **1.2 Mb** floppy disk drive & **integral 40Mb hard disk drive** to the front. Real time clock with battery backup is provided as standard. Supplied in good used condition complete with **enhanced keyboard, 640k + 2Mb RAM, DOS 4.01** and **90 DAY** Full Guarantee. *Ready to Run !*
Order as HIGRADE 286 ***ONLY £129.00*** (E)

Optional Fitted extras: VGA graphics card	£29.00
1.4Mb 3½" floppy disk drive (instead of 1.2 Mb)	£19.95
Wordperfect 6.0 for Dos - when 3½" FDD option ordered	£22.50
NE2000 Ethernet (thick, thin or twisted) network card	£29.00

LOW COST 486DX-33 SYSTEM

Limited quantity of this 2nd user, supurb small size desktop unit. Fully featured with standard simm connectors 30 & 72 pin. Supplied with keyboard, 4 Mb of RAM, SVGA monitor output, 256k cache and integral 120 Mb IDE drive with single 1.44 Mb 3.5" floppy disk drive. Fully tested and guaranteed. *Fully expandable*
Many other options avaiable - call for details. Only **£399.00** (E)

FLOPPY DISK DRIVES 3½" - 8"

5¼" or 3½" from only £18.95 !

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

3½" **Panasonic** JU363/4 720K or equivalent RFE	£24.95(B)
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3½" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop	£18.95(B)
5¼" **Teac** FD-55GFR 1.2 Meg (for IBM pc's) RFE	£18.95(B)
5¼" **Teac** FD-55F-03-U 720K 40/80 (for BBC's etc) RFE	£29.95(B)
5¼" **BRAND NEW Mitsubishi** MF501B 360K	£22.95(B)
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8" **Shugart** 800/801 8" SS refurbished & tested	£195.00(E)
8" **Shugart** 810 8" SS HH *Brand New*	£195.00(E)
8" **Shugart** 851 8" double sided refurbished & tested	£250.00(E)
Mitsubishi M2894-63 8" double sided *NEW*	£275.00(E)
Mitsubishi M2896-63-02U 8" DS slimline *NEW*	£285.00(E)
Dual 8" cased drives with integral power supply 2 Mb	£499.00(E)

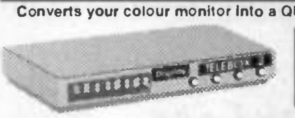
HARD DISK DRIVES

End of line purchase scoop! *Brand new* **NEC D2246** 8" 85 Mbyte drive with **industry standard SMD interface**, replaces Fujitsu equivalent model. Full manual. Only **£299.00** or **2** for **£525.00** (E)

3½" **FUJI** FK-309-26 20mb MFM I/F RFE	£59.95(C)
3½" **CONNER** CP3024 20 mb IDE I/F (or equiv)RFE	£59.95(C)
3½" **CONNER** CP3044 40mb IDE I/F (or equiv.)RFE	£69.00(C)
3½" **RODIME** RO3057S 45mb SCSI I/F (Mac & Acorn)	£69.00(C)
3½" **WESTERN DIGITAL** 850mb IDE I/F *Brand New*	£185.00(C)
5¼" **MINISCRIBE** 3425 20mb MFM I/F (or equiv.) RFE	£49.95(C)
5¼" **SEAGATE** ST-238R 30 mb RLL I/F Refurb	£69.95(C)
5¼" **CDC** 94205-51 40mb HH MFM I/F RFE tested	£69.95(C)
5¼" **HP** 9754B 850 Mb SCSI RFE tested	£89.00(C)
5¼" **HP** C3010 2 Gbyte SCSI *differential* RFE tested	£195.00(C)
8" **FUJITSU** M2322K 160Mb SMD I/F RFE tested	£195.00(E)
Hard disc controllers for MFM, IDE, SCSI, RLL etc. from	£16.95

THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER
*CABLE COMPATIBLE **

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

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

For overseas PAL versions state 5.5 or 6 mHz sound specification.
*For cable / hyperband reception Telebox MB should be connected to a cable type service. Shipping code on all Telebox's is (B)

DC POWER SUPPLIES

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

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For *MAJOR* SAVINGS - CALL FOR SEMICONDUCTOR HOTLIST

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

Mitsubishi FA3415ETKL 14" SVGA Multisync colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including **IBM PC's** in CGA, EGA, VGA & SVGA modes, **BBC, COMMODORE** (including Amiga 1200), **ARCHIMEDES** and **APPLE**. Many features: Etched faceplate, text switching and **LOW RADIATION MPR** specification. Fully guaranteed, supplied in EXCELLENT little used condition.
Tilt & Swivel Base £4.75 **Only £119** (E) Order as **MITS-SVGA**
VGA cable for IBM PC included.
External cables for other types of computers CALL

As New - Used on film set for 1 week only!!
15" 0.28 SVGA 1024 x 768 res. colour monitors.
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Just In - Microvitec 20" VGA (800 x 600 res.) colour monitors. Good SH condition - from £299 - CALL for info

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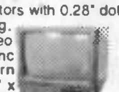

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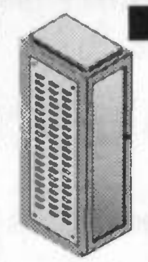

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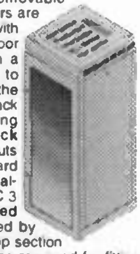

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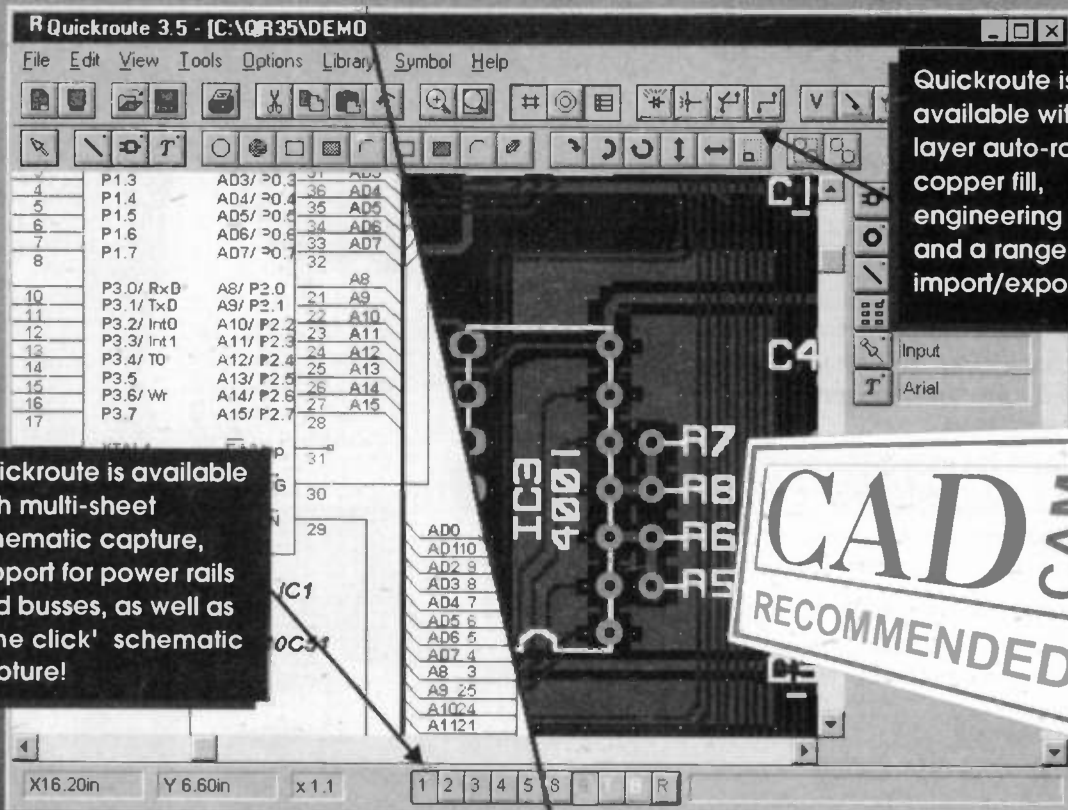

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Auto router			•	•
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Individual Transmitter DLTX........ £19.95
Individual Receiver DLRX........ £37.95

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QLX180 Crystal Controlled Telephone Transmitter
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QSX180 Line Powered Crystal Controlled Phone Transmitter
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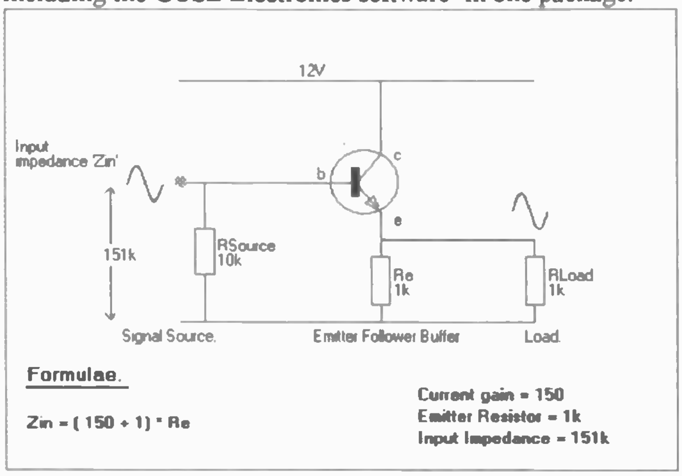
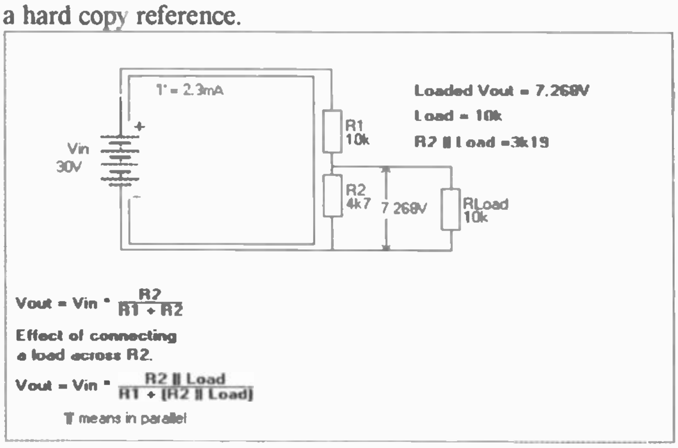


• The software is completely self-contained, explanatory text and calculations are laid out in additional Windows, enabling you to see the effect of changing component values, one-at-a-time within the formulae. Graphics, text and calculations can be 'pasted', in colour into text documents for a hard copy reference.



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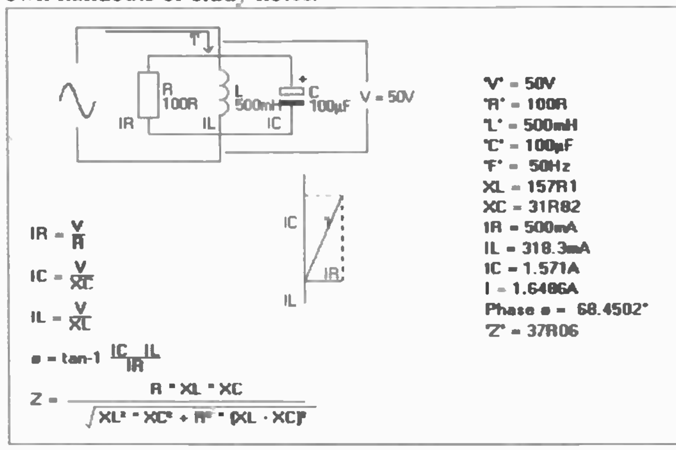

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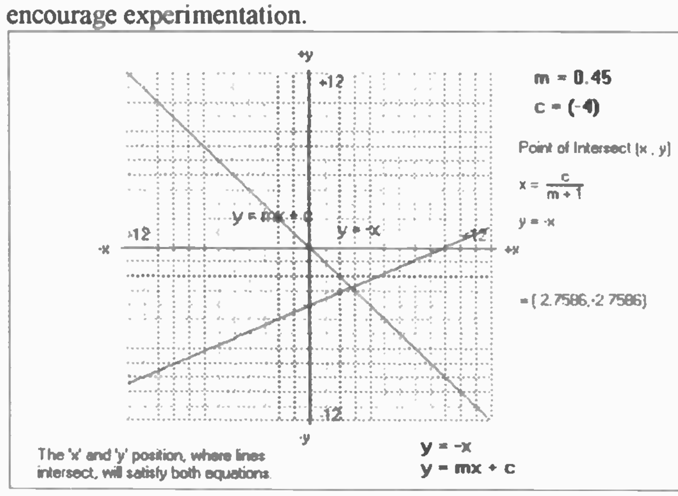

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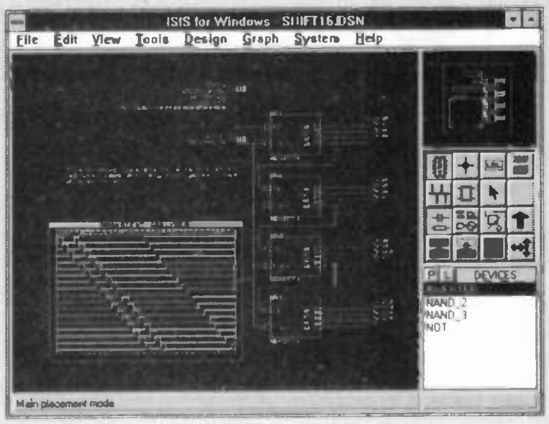

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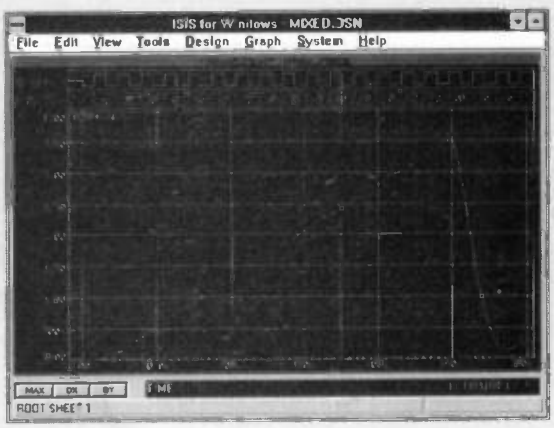

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- Event driven Digital Simulation with modelling language.
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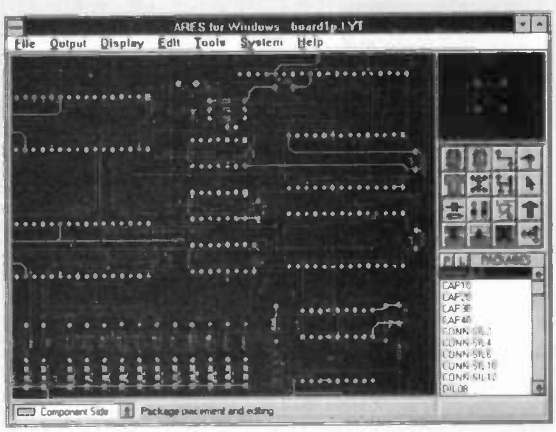
- Graphs displayed directly on the schematic.



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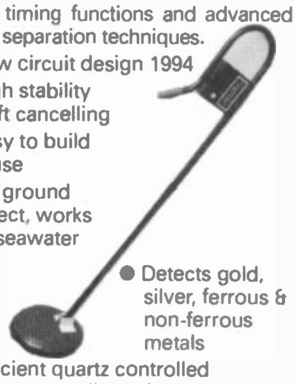
EPE MICROCONTROLLER P.I. TREASURE HUNTER

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



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

KIT 847....................£63.95

DIGITAL LCD THERMOSTAT

A versatile thermostat using a thermistor probe and having an l.c.d. display. MIN/MAX memories, −10 to 110 degrees celsius, or can be set to read in Fahrenheit. Individually settable upper and lower switching temperatures allow close control, or alternatively allow a wide 'dead band' to be set which can result in substantial energy savings when used with domestic hot water systems. Ideal for greenhouse ventilation or heating control, aquaria, home brewing, etc. Mains powered, 10A SPCO relay output. Punched and printed case.

KIT 841........................£29.95

PORTABLE ULTRASONIC PEsT SCARER

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

KIT 842.......................£22.56

DIGITAL CAPACITANCE METER

A really professional looking project. Kit is supplied with a punched and printed front panel, case, p.c.b. and all components. Quartz controlled accuracy of 1%. Large clear 5 digit display and high speed operation. Ideal for beginners – as the µF, hF and pF ranges give clear unambiguous read out of marked and unmarked capacitors from a few pF up to thousands of µF.

KIT 493.......................£39.95

ACOUSTIC PROBE

A very popular project which picks up vibrations by means of a contact probe and passes them on to a pair of headphones or an amplifier. Sounds from engines, watches, and speech travelling through walls can be amplified and heard clearly. Useful for mechanics, instrument engineers, and nosey parkers!.

KIT 740.......................£19.98

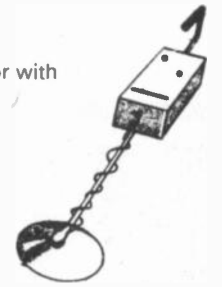
WINDICATOR

A novel wind speed indicator with LED read-out. Kit comes complete with sensor cups, and weatherproof sensing head. Mainspower unit £5.99 extra.

KIT 856..£28.00

BUCCANEER I.B. METAL DETECTOR

An Induction Balance (I.B.) detector with audible output. Providing good sensititivy and easy construction.
COMPLETE KIT – INCLUDES ALL HARDWARE, HANDLE, SEARCH HEAD, PCB etc.
CIRCUIT REJECTS IRON WHILST PICKING UP GOLD, SILVER, COPPER etc.
A SOLID RELIABLE DESIGN.



KIT 719..£54.99

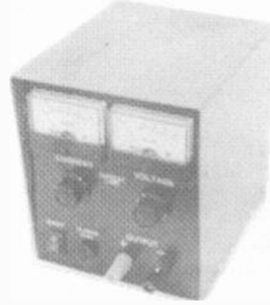
1000V & 500V INSULATION TESTER

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

KIT 848..................£32.95

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

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



KIT 845..............£64.95

ULTRASONIC PEsT SCARER

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

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

KIT 812..£14.81

SPACEWRITER

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

KIT 849......................£16.99

12V EPROM ERASER

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

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

MOSFET 25V 2.5A POWER SUPPLY

High performance design has made this one of our classic kits. Two panel meters indicate Volts and Amps. Variable from 0-25 Volts and current limit control from 0-2·5A. Rugged power MOSFET output stage. Toroidal mains transformer.

KIT 769........................£56.82

INSULATION TESTER

A reliable and neat electronic tester which checks insulation resistance of wiring and appliances etc., at 500 Volts. The unit is battery powered, simple and safe to operate. Leakage resistance of up to 100 Megohms can be read easily. A very popular college project.

KIT 444........................£22.37

DIGITAL COMBINATION LOCK

Digital lock with 12 key keypad. Entering a four digit code operates a 250V 16A relay. A special anti-tamper circuit permits the relay board to be mounted remotely. Ideal car immobiliser, operates from 12V. Drilled case, brushed aluminium keypad.

KIT 840...........................£19.86

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

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

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

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

DOLBY PRO-LOGIC DECODER

DOLBY SURROUND PRO • LOGIC

Experience the delight of SURROUND SOUND in your own home. This project brings full Genuine PRO-LOGIC surround sound to you at a fantastic price. The circuit meets all *Dolby specifications, with "Stereo", "3-Stereo" and "Surround Sound" selections. Exactly as described in this booklet.

For minimum cost the "Short Form Kit" is ideal. This is complete except for the case and power transformer. It includes the switches, sockets, and pots, and is ideal for building into a custom set-up with pre-amp and power-amp modules, where power is available.

The alternative "Full Kit" gives the best value option. With a printed front panel, punched rear panel, power transformer and mains lead and black brushed aluminium knobs. This kit produces a complete stand-alone decoder that can be used with any audio.

Short Form KIT, Kit Ref: 858 £99.00
Kit with case and transformer, Kit Ref: 869 £124.99

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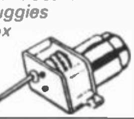
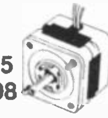
Our Popular and Versatile DC motor/Gearbox sets. Ideal for Models, Robots, Buggies etc. 1·5 to 4·5V Multi ratio gearbox gives wide range of speeds.



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

Stepping Motors



MD38...Mini 48 step...£8.65
MD35...Std 48 step...£12.98
MD200...200 step...£16.80
MD24...Large 200 step...£22.95

SIMPLE PIC PROGRAMMER

INCREDIBLE LOW **PRICE!**

Kit 857 **£12.99**

INCLUDES 1-PIC16C84 CHIP SOFTWARE DISK, LEAD CONNECTOR, PROFESSIONAL PC BOARD & INSTRUCTIONS

Power Supply £3.99

EXTRA CHIPS: PIC 16C84 £7.36

Based on the design in February '96 EPE Article Magenta have made a proper PCB and kit for this project. PCB has 'reset' switch, Program switch, 5V regulator and test L.E.D.s. There are also extra connection points for access to all A and B port pins.

PIC16C84 LCD DISPLAY DRIVER

INCLUDES 1-PIC16C84 WITH DEMO PROGRAM SOFTWARE DISK, PCB, INSTRUCTIONS AND 16 CHARACTER 2 LINE **LCD DISPLAY**

Kit 860 **£17.99**

Power Supply £3.99

FULL PROGRAM SOURCE CODE SUPPLIED – DEVELOP YOUR OWN APPLICATION!

Another super PIC project from Magenta. Supplied with PCB, industry standard 2 LINE x 16 character display, data, all components, and software to include in your own programs. Ideal develpment base for meters, terminals, calculators, counters, timers – Just waiting for your application!

★ Chip is pre-programmed with demo display ★

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Kit 862 **£29.99**

Power Supply £3.99

PIC STEPPING MOTOR DRIVER

NEW!

INCLUDES: PCB, PIC16C84 WITH DEMO PROGRAM, SOFTWARE DISK, INSTRUCTIONS AND MOTOR.

Kit 863 **£18.99**

FULL SOURCE CODE SUPPLIED. ALSO USE FOR DRIVING OTHER POWER DEVICES e.g. SOLENOIDS.

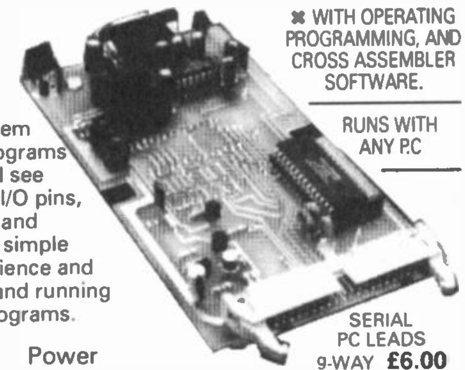
Another NEW Magenta PIC project. Drives any 4 phase unipolar motor – up to 24V and 1 amp. Kit includes all components and 48 step motor. Chip is pre-programmed with demo software, then write your own, and re-program the same chip! Circuit accepts inputs from switches etc and drives motor in response. Also runs standard demo sequence from memory.

PIC16C5x

DEVELOPMENT AND TRAINING SYSTEM

- IN-CIRCUIT SIMULATOR
- POWERFUL ON-LINE MONITOR
- SINGLE STEP, DISPLAY REGISTERS, MEMORY, AND I/O, READ & PROGRAM
- SUPPORTS PIC16C54, 55, 56, & 57.
- FULL SOFTWARE & DATA SUPPLIED
- THE IDEAL SYSTEM FOR EDUCATIONAL USERS

The easiest way to get started with PIC Microchips. This system allows you to test programs one line at a time and see what happens to the I/O pins, the internal registers and memory. From these simple steps you gain experience and soon will be writing and running longer and longer programs.



✖ WITH OPERATING PROGRAMMING, AND CROSS ASSEMBLER SOFTWARE.

RUNS WITH ANY P.C

Kit 853 **£99.00** Power Supply £8.99

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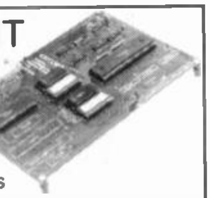
68000 DEVELOPMENT AND TRAINING SYSTEM KIT



Never before at this price! Our own 68000 board kit. Used all over the world in schools and universities. Double Eurocard PCB with RAM, ROM, and I/O. Full featured MONITOR and LINE BY LINE ASSEMBLER ON BOARD. Just needs power, and a serial link to your PC. Supplied with full data and applications course. Use to learn, or as a stand-alone computer board.

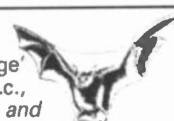
POWER SUPPLY +5V, +12V, −12V: £12.99

INCLUDES SOFTWARE

£55.00! Kit Ref 601

SUPER BAT DETECTOR

NEW!



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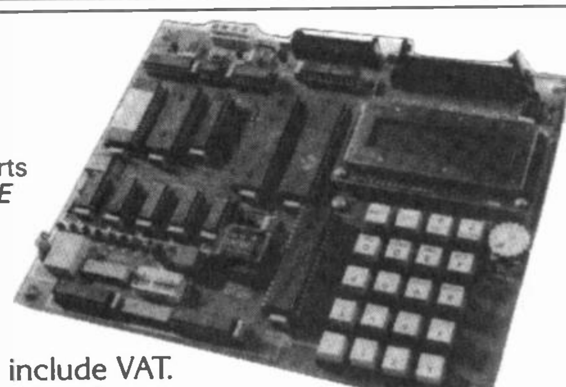
A new circuit using a 'full bridge' audio amplifier i.c., internal speaker, *and* headphone/tape socket. The latest sensitive transducer, and 'double balanced mixer' give a stable, high peformance superheterodyne design.

KIT 861....**£24.99**

Mini-Lab & Micro Lab
Electronics Teach-In 7



As featured in *EPE* and now published as Teach-In 7. All parts are supplied by Magenta. *Teach-In 7* is £3.95 from us or *EPE*

Full Mini Lab Kit – £119.95 – Power supply extra – £22.55

Full Micro Lab Kit – £155.95 Built Micro Lab – £189.95

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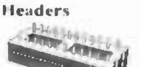

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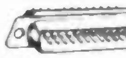
D Type Connectors



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9 Way Male Plug £0.29
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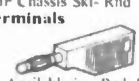
UHF Plug 5mm Cable £0.72
UHF Plug 11mm Cable £0.66
UHF Chassis Skt- Sqr £0.45
UHF Chassis Skt- Rnd £0.58
Terminals



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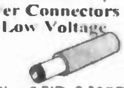

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DC Chassis Skt 2.1mm £0.46
DC Chassis Skt 2.5mm £0.46
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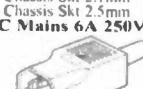

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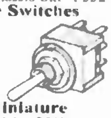

Sub-Miniature
3A 125V 1A 250V
5mm Ø Mounting Hole
SPST 5 x 10mm £0.58
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SPDT C/Off 5 x 10mm £0.86
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SPDT C/Off 8 x 13mm £0.64
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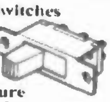

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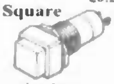

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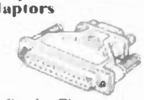

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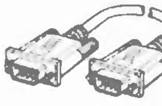

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AMAZING

Amazing, isn't it, that an unusual musical instrunent invented in the 1920s is still fascinating and is still exercising the inventiveness of design engineers. One would think that modern technology would easily be able to reproduce the physical and aural intricacies of a seventy year old instrument.

However, Jake Rothman's Theremin article looks briefly at the various designs and the methods used for overcoming the problems. It seems that valves were quite good in some circuits! Of course, they are still the only device used for high power transmitters, etc.

The *EPE Elysian Theremin*, plus its MIDI Interface, represent the top end of our constructional projects in terms of cost and complexity but, because these designs are unique, the circuitry interesting in its own right and we believe, as far as the MIDI Interface is concerned, also represent a world first, then we feel fully justified in providing in-depth details on these designs. They are not for the beginner to electronics construction but should not prove too difficult to build for those with a reasonable level of experience.

FIRST TIME

If you are a relative newcomer to the world of electronics we hope our new *Build Your Own Projects* series will help you take the first steps towards project construction. The series will also provide many hints and tips which will also be of interest to the more experienced reader. We believe it will be highly regarded by everyone involved in electronics.

HELP PLEASE

Finally, I hope you have discovered our Readership Survey question sheet tucked into this issue. Please help us to continue the development of *EPE* by letting us know of your interests, etc. There are also two £75 prizes to be won – see the Survey sheet for details.

Your answers will be *confidential* and only used to help us bring you the magazine you want. Your help would be appreciated.

Mike Kenward

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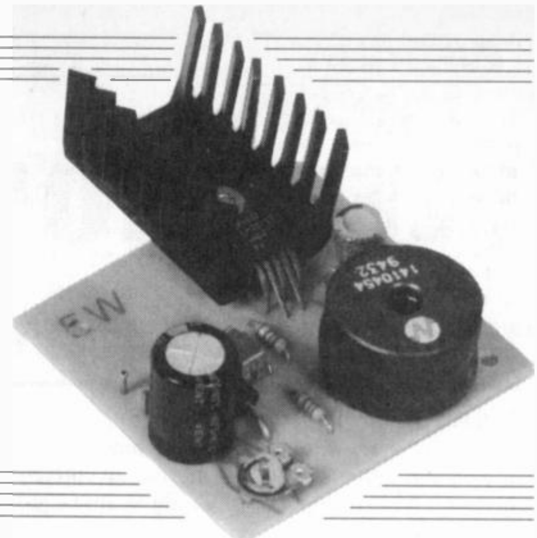


D.C.-TO-D.C. CONVERTERS

ROBERT PENFOLD

Using modern chips it is no longer difficult to build switch mode power supplies.

TRADITIONALLY, each supply voltage required for a circuit has been provided by what is essentially a separate supply circuit. Some components might be common to more than one supply circuit, such as a tapped mains transformer used to provide two or three output voltages, but there is generally limited scope for this type of thing unless suitable custom components can be produced. For the home constructor this is not usually a practical proposition.

Matters are rather different these days, with switch mode power supplies offering an alternative approach to multi-voltage supplies. There are numerous types of switch mode supply, but the type we are concerned with here are the d.c.-to-d.c. converters.

This kind of supply is a sort of d.c. equivalent to a transformer. Supply voltages can be stepped up or down with an efficiency that is often around 80 to 90 per cent.

CURRENT AFFAIRS

An ordinary series regulator can, of course, provide a voltage step-down, but not with good efficiency. For example, a 5V output is easily produced from a 15V input, but the input current will be slightly higher than the output current. This results in less than a third of the input power reaching the output, and an efficiency of only about 30 per cent.

Using a switch mode step-down circuit, the input current can be much less than the output current, but, like a transformer, the input power is always more than the output power. With our 15V to 5V example the input current would be one third of the output current with a 100 per cent efficient circuit.

In practice, the input current would probably be closer to half the output current, but this obviously represents a reasonably efficient means of handling things, and a switch mode step-down circuit is far more efficient than a simple series regulator.

A switch mode supply can also provide a voltage step-up, which is something that is not possible using conventional supply circuitry. This begs the question, "is it better to use a low voltage main supply and a step-up circuit, or a high voltage main supply and a step-down circuit?".

The answer depends on the relative output currents of the two supplies. A step-up circuit would normally be used where a high current supply at a low voltage is needed, plus a lower current supply at a higher voltage.

If the lower voltage supply must provide currents that are similar to, or less than, the currents supplied by the higher voltage supply, it is better to use a normal supply to provide the higher voltage, plus a step-down regulator to provide the lower output potential. In some cases the output currents will be such that either method will work perfectly well. If in doubt, it is probably best to opt for a the step-down approach.

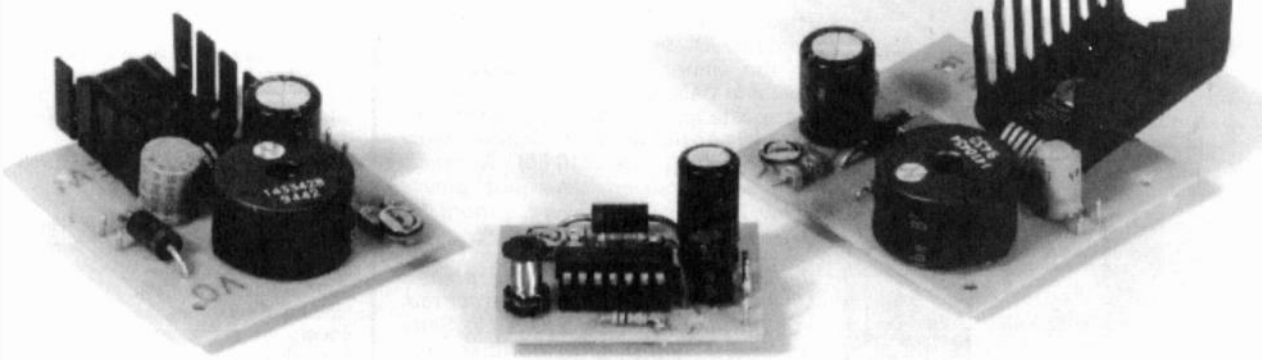
With a step-up regulator, the input current will always be higher than the output current. If we invert our previous 15V to 5V example, a step-up from 5V to 15V is a three-fold increase in voltage. The input current must therefore be at least three times higher than output current, and in practice it would probably be closer to four times as much.

It is essential to bear this in mind when working out the maximum load current on the main supply circuit, particularly when using a large step-up. It is this relatively high input current that makes a voltage step-up generally inappropriate where a high output current is required.

POSITIVELY NEGATIVE

Switch mode power supplies can be used to generate a negative supply from a positive type. Circuits of this type are sometimes referred to as "inverters". In general, this approach is only used where fairly modest output currents are required. The efficiency of practical negative supply

Line-up of low cost, switch-mode, D.C.-to-D.C. Converters. Left to right: Step-Down Regulator (+7V to 40V input, +1·2V to 12V output); Negative Supply Generator (+5V in, −5V out); Step-Up Regulator (+5V in, +12V out).



generators tends to be rather less than that of step-up and step-down circuits. In fact it is often under 50 per cent.

This lack of efficiency is not of great importance if output powers of up to a Watt or two are involved, but it makes negative supply generators a less attractive proposition when higher powers are involved. It is not essential for this type of circuit to provide an output voltage that matches the input voltage. A voltage step-up or step-down can be provided as well.

Of course, switch mode circuits are not restricted to use in multi-voltage mains power supply units, and they have many uses in battery powered equipment. For example, a large 5V logic circuit could be powered from a 12V vehicle battery via a simple series regulator, but a step-down regulator could provide the same function with only about half the battery drain.

If it was necessary to power a 24V circuit from a 12V vehicle battery, a step-up regulator would probably be a more practical solution than using an additional battery to provide the boosted supply voltage. An inverter could be used in a project that required dual balanced supplies, so that one rather than two batteries would be needed.

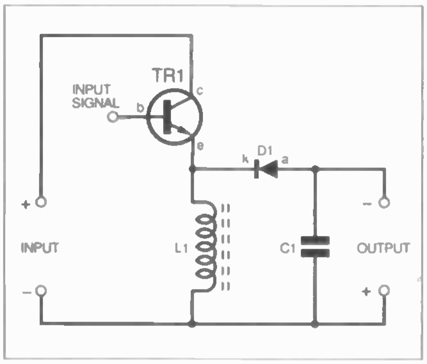


Fig. 1. Circuit diagram for an "inverter" output stage.

SWITCH MODES

All three types of switch mode regulator have an output stage that includes a rectifier, an inductor and a switching transistor. Each form of switch mode power supply uses these in a different configuration. In all three modes the switching transistor is pulsed at what is normally a high audio frequency (about 10 to 20kHz), but which can be a much higher frequency of about 100kHz.

Shown in Fig. 1 is the configuration used in a negative supply generator output stage. The switching transistor TR1 is used in the emitter follower mode, and its load is the inductor L1.

When TR1 is switched on, a current flows through L1 and a magnetic field builds up around it. The magnetic field rapidly collapses when TR1 switches off, and this produces a high reverse voltage across L1.

Due to the speed at which the field collapses, the voltage produced is quite high. In fact, it is likely to be more than ten times the input voltage, but it is at a relatively high impedance. It is this factor that enables a voltage step-up as well as an inversion to be provided.

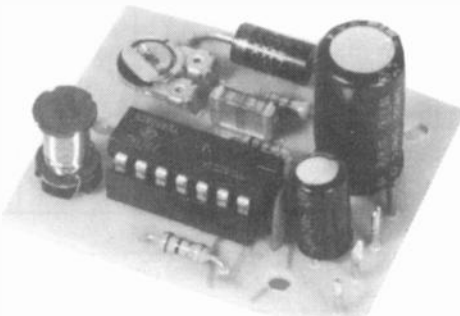
Diode D1 enables the reverse voltage spikes across L1 to reach the smoothing capacitor, C1, at the output of the circuit. It blocks any flow of current from C1 back to L1, which would otherwise interfere with the operation of L1 and TR1.

STEPPING-UP

The configuration for a step-up output stage is shown in Fig. 2. This is really just a slightly revamped version of the inverter configuration, with transistor TR1 operating as a common emitter switch that drives the inductor L1.

As before, a high reverse voltage is developed across L1 when TR1 switches off. This means that the top end of L1 is negative, and the bottom end is positive. This results in the voltage across L1 being added to the input voltage, and being fed to smoothing capacitor C1. Note that the polarity of diode D1 has been altered so that it enables this positive voltage to flow to the output, but blocks it from flowing back into TR1 when the transistor is switched on.

Once again, the voltage developed across inductor L1 can be many times higher than the input voltage. This configuration can therefore provide a large voltage boost, and it is not restricted to voltage doubling.


Printed circuit board module for a negative supply or "inverter" generator.

STEPPING DOWN

The configuration for a step-down output stage is shown in Fig. 3. When transistor TR1 is switched on it subjects inductor L1 to a voltage that is virtually equal to the difference between the input and output voltages. Therefore, while TR1 is switched on, a steadily increasing current flows through L1 and into smoothing capacitor C1.

A charge is stored in L1 while TR1 is switched on, and this charge is released when TR1 switches off. The charge is released as the magnetic field around L1 collapses, giving a signal of the opposite polarity to the original signal. In other words, the left hand terminal of L1 is negative, and the right hand terminal is positive.

Diode D1 completes the circuit, and couples the signal from L1 to C1 and any load connected across the output.

The important point here is that the voltage dropped across L1 when TR1 is switched on is not wasted, but is held as a charge which is given up when TR1 is switched off. With an ordinary series regulator, the voltage drop from the input to the output is pure wastage, giving a relatively low level of efficiency. An input current only flows when TR1 is switched on, but a current flows into the output whether it is switched on or off. This factor gives a relatively low input current, and a sort of transformer effect.

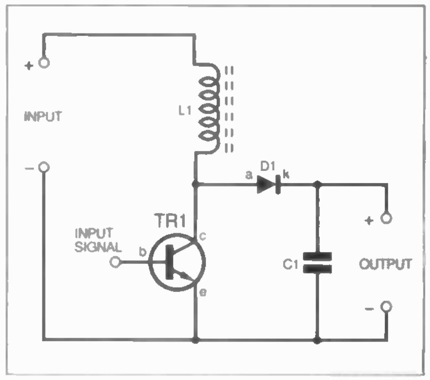


Fig. 2. Basic circuit configuration for a step-up output stage.

A SWITCH IN TIME

There is a problem with a basic switch mode power supply in that the output voltage is not well defined. It is usually necessary to convert from one voltage to another with a fair degree of precision, rather than simply accepting whatever loaded output voltage the circuit happens to produce. It would obviously be possible to use a standard series regulator at the output of a switch mode power supply in order to provide a stable output at the required potential. However, this would greatly reduce the efficiency of the circuit, and is not the normal way that output regulation is tackled.

The more usual approach is to control the output voltage via the switching circuit. This is normally achieved using some form of pulse width modulator (p.w.m.) circuit. A conventional p.w.m. simply consists of a voltage comparator and a clock oscillator, as shown in Fig. 4.

It is essential to the operation of the circuit that the clock oscillator has a reasonably linear triangular output signal. The output of the comparator goes high when the input voltage is greater than the clock voltage, and low when the clock voltage is the higher of the two voltages.

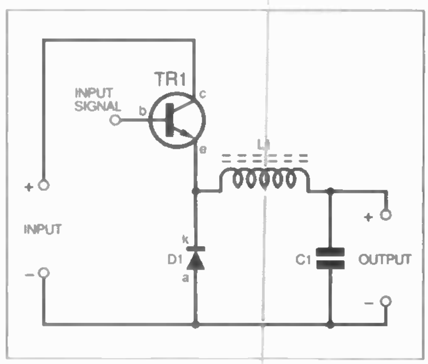


Fig. 3. Basic step-down output circuit.

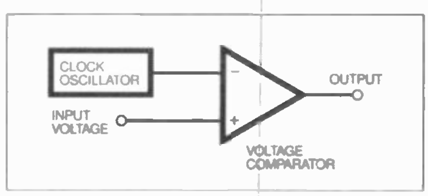


Fig. 4. A p.w.m. can consist of a clock oscillator and voltage comparator.

P.W.M. PROCESS

The waveform diagrams of Fig. 5 help to explain the way in which the pulse width modulation process operates. In each pair of waveforms the upper waveform is the clock signal plus the d.c. input voltage, and the lower waveform is the output from the comparator.

In Fig. 5a the input voltage is half way between the peak positive and negative levels of the clock signal. This gives a squarewave output having a 1-to-1 mark-space ratio. The average output voltage of the comparator is therefore equal to half the supply voltage.

The input voltage has been increased in Fig. 5b, resulting in the input voltage being higher than the clock voltage for the majority of the time. This gives longer output pulses from the comparator, and a higher average output voltage.

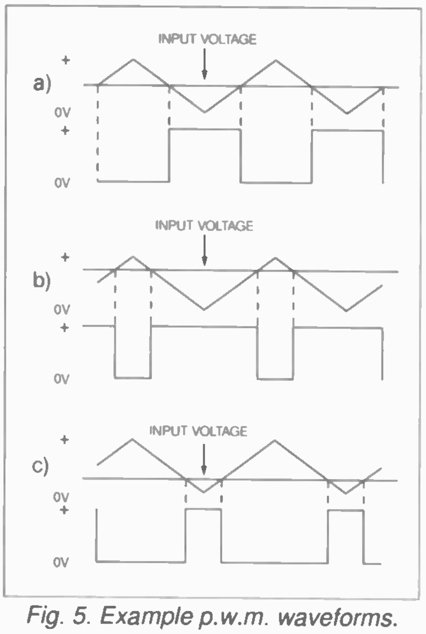


Fig. 5. Example p.w.m. waveforms.

In Fig. 5c the input voltage is quite low, resulting in the clock signal being at the higher voltage for the majority of the time. This gives brief output pulses from the comparator, and a low average output potential.

It should be apparent from this that the average output voltage from the modulator varies in sympathy with changes to the d.c. input level. A d.c. output voltage equal to the average output potential of the modulator can be obtained by feeding the pulsed output signal through a lowpass filter. With this type of modulator the output frequency is fixed, and the output voltage is altered by changing the pulse width of the output signal.

There is an alternative approach which uses a monostable to provide output pulses of fixed duration. The output voltage is controlled by altering the clock frequency. Infrequent triggering of the monostable gives output pulses that are few and far between, and a low average output voltage. Frequent triggering results in the output pulses being bunched close together, which gives a high average output voltage.

The point of controlling the output voltage using pulse width modulation is that it is very efficient. The series transistor that chops the output signal is either switched fully on or fully off. In either case it consumes very little power. There will be some voltage drop through the transistor when it is switched on, but the voltage drop and resultant power wastage should be quite small. In most cases the regulator and switch mode output stage are combined, which further aids good efficiency.

SWITCH-MODE REGULATOR

In Fig. 6 is shown the simplified block diagram for a practical switch mode regulator. This has obvious similarities to a conventional series regulator, with a differential "error" amplifier, reference generator, and feedback from the output via a potential divider. The circuit is basically just an operational amplifier non-inverting mode amplifier circuit.

The reference generator provides a highly stable voltage to the amplifier's non-inverting input. The potential divider sets the output voltage at X-times the reference level, and a normal negative feedback action accurately stabilises the output at this voltage. Within reason, the output potential can be any voltage greater than the reference level.

A switch-mode power supply differs from a conventional series regulator in that the output buffer stage is replaced by a pulse width modulator, plus an output stage that provides the required action (step-up, step-down, or inversion). In most practical regulators, the modulator stage also includes a fair amount of control logic which handles such things as current

NEGATIVE SUPPLY GENERATOR

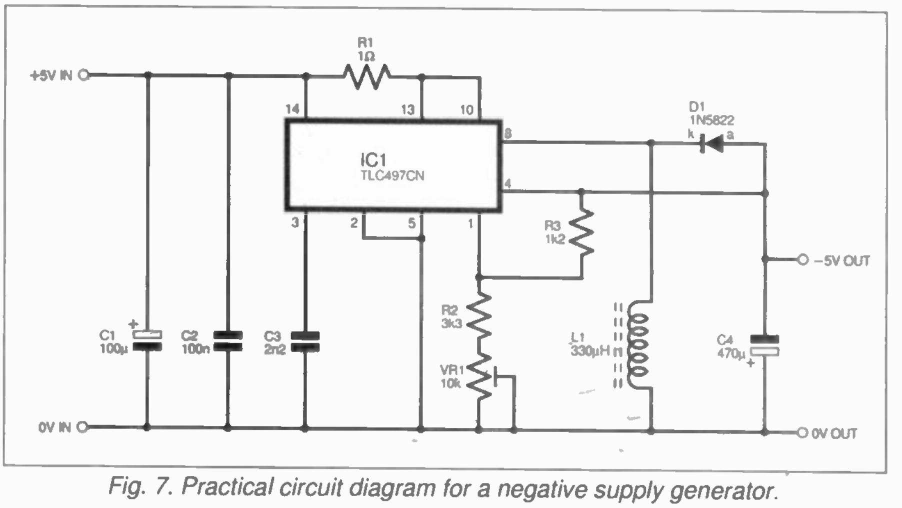


Fig. 7. Practical circuit diagram for a negative supply generator.

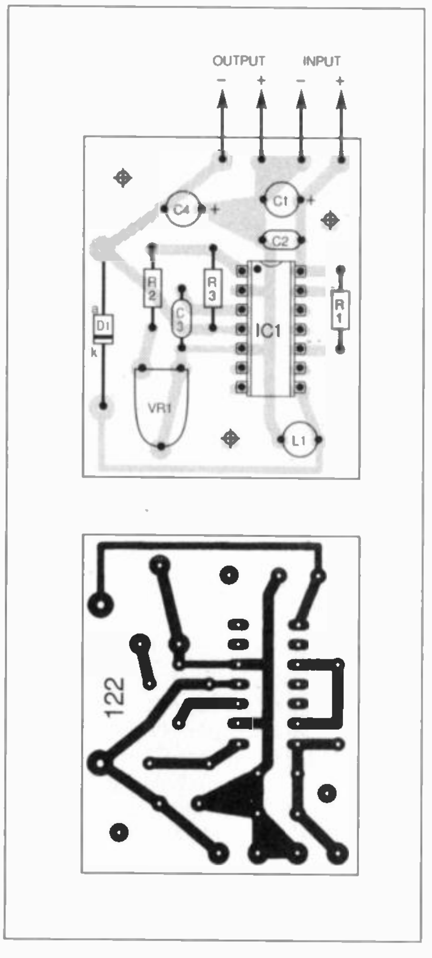


Fig. 8 (left). Inverter module component layout and full size foil master.

COMPONENTS

NEGATIVE SUPPLY GENERATOR

Resistors — See **TALK** Page

R1	1Ω
R2	3k3
R3	1k2

All 0·25W 5% carbon film

Potentiometer

VR1 — 10k min. preset, horiz

Capacitors

C1	100µ radial elect. 10V
C2	100n ceramic disc
C3	2n2 polyester
C4	470µ radial elect. 10V

Semiconductors

D1	1N5822 Schottky rectifier diode
IC1	TL497CN switch mode p.s.u.

Miscellaneous

L1 — 330µH inductor (see text)

Printed circuit board, available from the *EPE PCB Service*, code 122; 14-pin d.i.l. socket; single-sided solder pins; connecting wire; solder, etc.

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limiting and protection against excessive operating temperatures.

Although switch-mode power supplies offer neat solutions in many situations where awkward supply requirements must be met, they are not without one or two drawbacks. One problem is simply that the chips for use in switch-mode supplies are far more expensive than ordinary series regulator chips. Consequently, they provide neat but not necessarily cheap solutions.

Another point to bear in mind is that circuits of this type oscillate strongly at what is mostly a fairly high audio frequency. This makes them a poor choice for use with many audio circuits, radio circuits, sensitive test gear, or any circuit where stray pickup of the switching signal could be a problem.

PRACTICAL INVERTER

The TL497CN is not exactly the latest thing in switch-mode power supply chips, but it is very useful for applications that do not involve high output currents. In particular, it provides a cost effective means of providing a negative supply of up to about 150 milliamps. A circuit diagram for an Inverter based on this device is shown in Fig. 7.

The efficiency of the circuit is typically a little over 50 per cent with an input potential of 10V, but is significantly under 50 per cent with an input supply of 5V. This is not bad for a simple negative supply generator.

Capacitors C1 and C2 are simply supply decoupling components on the input supply. Resistor R1 is the series resistance in the current limiting circuit at the input to IC1. This is an essential safety feature since the circuit will often be fed from a high current supply that could almost instantly "fry" IC1 in the event of an overload on the device's output.

Capacitor C3 is the timing component in the oscillator section of the p.w.m. The TL497CN uses a fixed pulse width and a variable clock frequency to control the average output voltage.

Many switch-mode supply chips are either unsuitable for use in inverter circuits, or require the use of a discrete switching transistor and other components. The TL497CN works quite well in this mode if its substrate terminal (pin 4) is connected to the negative output rail. The only problem is that its internal diode cannot be used. Accordingly, discrete Schottky rectifier D1 is used instead.

The circuit will actually work using an ordinary rectifier such as a 1N4002, but the lower voltage drop and faster switching speed of a Schottky type result in significantly better efficiency. The circuit's output stage inductor is L1, and capacitor C4 provides output voltage smoothing.

The output voltage is determined by the feedback network which is comprised of preset VR1 plus resistors R2 and R3. The input and output voltages are nominally plus and minus 5V, but the circuit can handle input and output voltages of up to 12V. For input or output voltages of more than 10V, capacitors C1 and (or) C4 should have a voltage rating of 16V rather than the 10V specified in the components list.

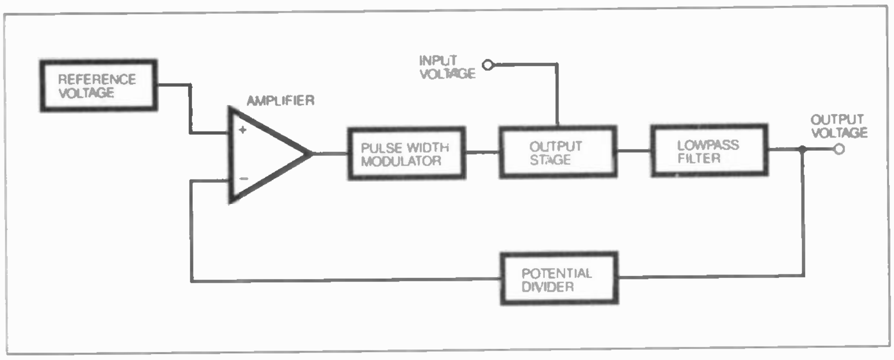
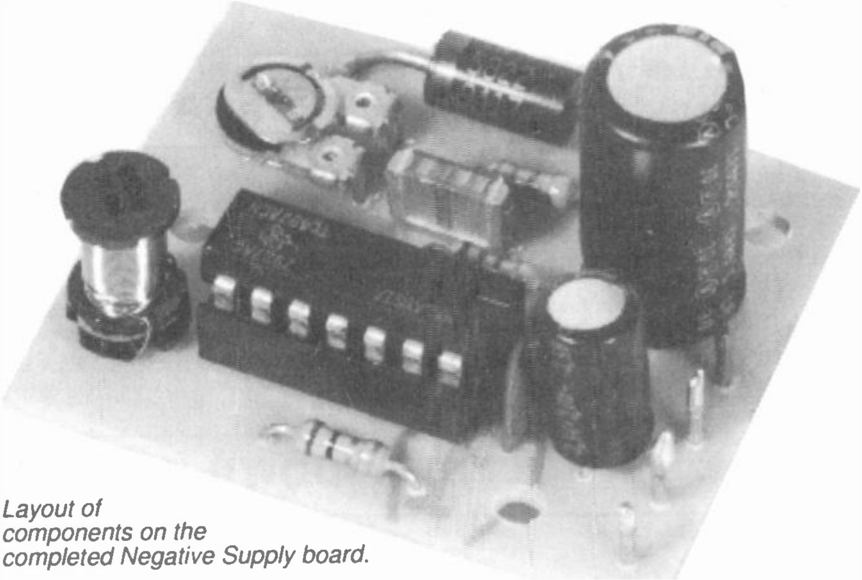


Fig. 6. Simplified block diagram for a switch-mode regulator.



Layout of components on the completed Negative Supply board.

The input and output voltages do not have to be the same, and the circuit can provide a voltage step-up or a step-down. Just use the appropriate supply voltage of between 5V and 12V, and set VR1 for the required output voltage. Of course, the maximum output current is reduced if a voltage step-up is produced. For example, a maximum output current of about 50 milliamps is available with a step-up from +5V to −12V.

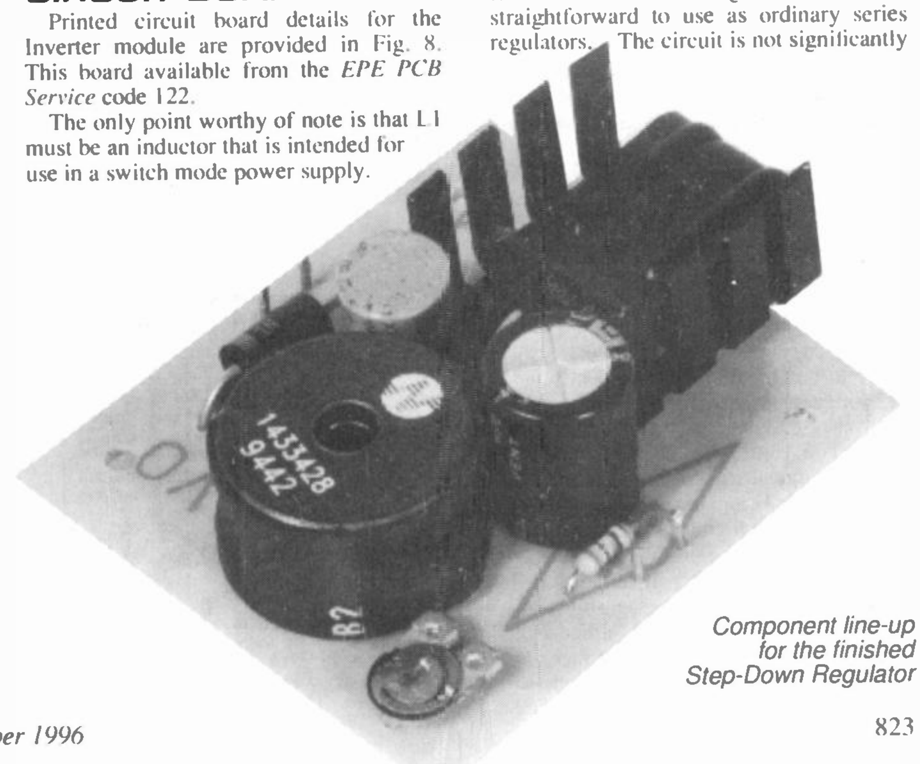
CIRCUIT BOARD

Printed circuit board details for the Inverter module are provided in Fig. 8. This board available from the *EPE PCB Service* code 122.

The only point worthy of note is that L1 must be an inductor that is intended for use in a switch mode power supply. An ordinary r.f. choke will not work properly in this circuit. It must also be a miniature type having 5mm (0·2 inch) lead spacing if it is to fit onto the board properly. The RS type 228-523 is suitable.

STEP-DOWN CIRCUIT

A Step-Down Regulator circuit is shown in Fig. 9. It is based on a LM2575T-ADJ, which is a modern device that is intended to make switch-mode regulators almost as straightforward to use as ordinary series regulators. The circuit is not significantly



Component line-up for the finished Step-Down Regulator more complex than one based on a conventional three or four terminal adjustable regulator.

Capacitor C1 provides supply decoupling at the input of IC1. Pin 5 is a TTL compatible input that is taken high in order to place IC1 in a low current standby mode. In most applications this serves no useful purpose, and pin 5 is connected to "earth" (0V) to hold IC1 in its normal operating mode. Diode D1, inductor L1 and capacitor C2 are a normal step-down mode output stage. Again, a Schottky rectifier is used for the diode, because its lower voltage drop and high operating speed provide much improved efficiency.

REGULATOR

There are several versions of the LM2575T. Some are fixed voltage devices which have a built-in potentiometer at pin 4. Pin 4 is simply connected to the output supply in order to obtain an output potential of 5V, 12V or 15V (depending on the particular version used).

The device used here has an "ADJ" suffix which indicates that it has an adjustable output voltage. Pin 4 connects to the inverting input of the internal error amplifier. This amplifier's non-inverting input is fed from a 1·2V reference source. A discrete potentiometer connected across the output and feeding into pin 4 therefore enables the output voltage to be set at any realistic figure above 1·2V.

In this case the potentiometer is formed by VR1 in series with resistor R1. The adjustment range provided by VR1 is from 1·2V to a little over 16V. Higher output voltages can be accommodated by making R1 lower in value, but a circuit of this type is mainly used where there is a large voltage difference between the input and the output. Consequently, it is unlikely to be used with output voltages of more than about 16V.

The absolute maximum input voltage is 40V. The step-down circuit would normally be fed from the unregulated side of the main supply, rather than via the main regulator circuit. This avoids having the step-down circuit increase the loading on the main regulator. The only normal exception is where the unregulated supply might exceed the 40V limit for this step-down circuit. The same basic premise applies to the other regulator circuits, incidentally. The maximum output current for the LM2575T-ADJ is one amp.

CONSTRUCTION

The printed circuit board component layout and actual size foil track master for the step-down regulator module are shown in Fig. 10. This board is available from the *EPE PCB Service*, code 123.

As supplied, IC1 has straight leads. They must be carefully bent through right angles and into the appropriate staggered configuration in order to fit IC1 onto the board properly.

The inductor used in the L1 position must be a type intended for operation in switch mode power supplies, and it must also be capable of handling currents of up to 1A. Small radial inductors and r.f. chokes are not suitable. The Maplin 330µH "Bobbin Type Inductor" and the virtually identical RS 330µH "High Current Inductor Type A" were both found to work well in this circuit.

The RS version has long leadout wires. These must be trimmed short, and then the enamel insulation must be scraped away from the remaining leadouts so that the inductor can be fitted to the board in standard printed circuit mounting fashion.

The efficiency of the circuit is surprisingly high, and seems to be not far short of 90 per cent. With an input potential of 25V, the output set at 5V and a load current of 1A, the input current was only about 225 milliamps.

Due to this high efficiency there is very little power dissipated in the regulator chip. A small clip-on heatsink should be sufficient to ensure that IC1 does not overheat, and in most applications it will not be essential to use a heatsink at all.

STEP-DOWN REGULATOR

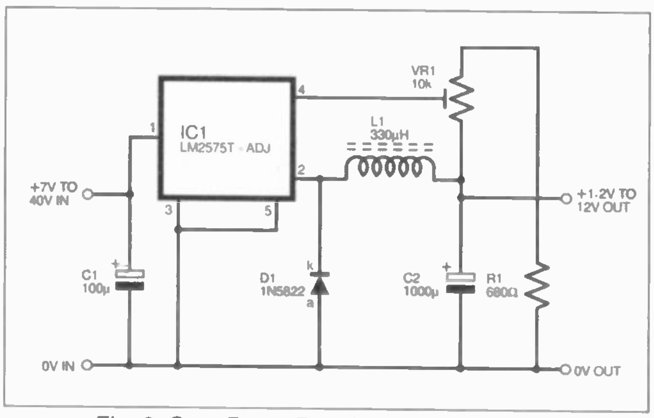


Fig. 9. Step-Down Regulator circuit diagram.

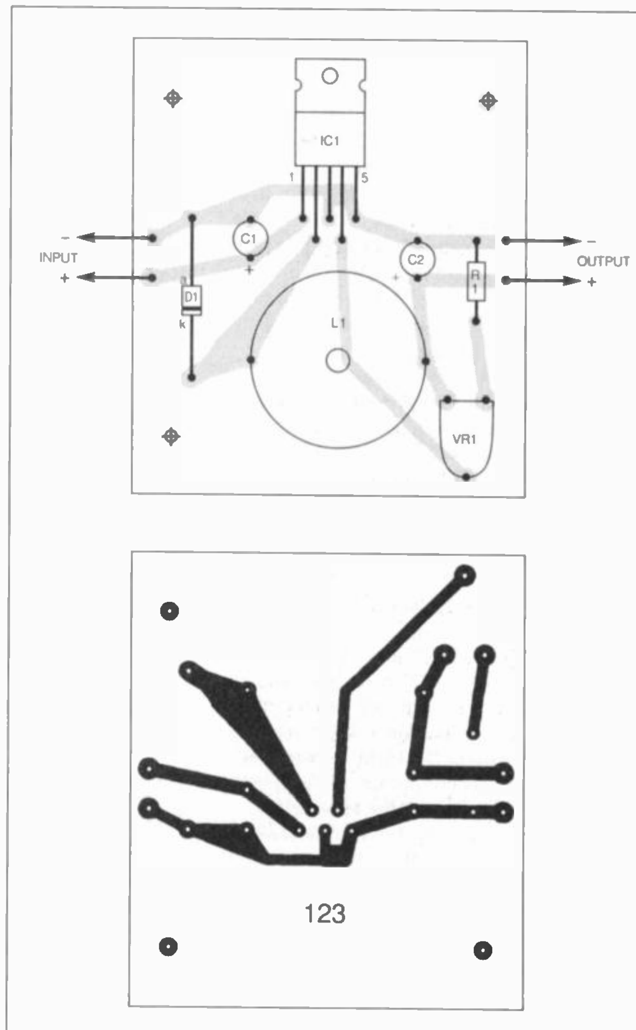


Fig. 10. P.C.B. component layout and foil master.

COMPONENTS

STEP-DOWN REGULATOR

Resistor
R1 680Ω 0·25W 5% carbon film

Potentiometer
VR1 10k min. preset, horiz

Capacitors
C1 100µ radial elect. 40V
C2 1000µ radial elect. 16V

Semiconductors
D1 1N5822 Schottky rectifier diode
IC1 LM2575T-ADJ step-down regulator

Miscellaneous
L1 330µH inductor (see text)
Printed circuit board, available from the *EPE PCB Service*, code 123; clip-on TO220 heatsink; single-sided solder pins; connecting wire; solder, etc.

See **TALK** Page

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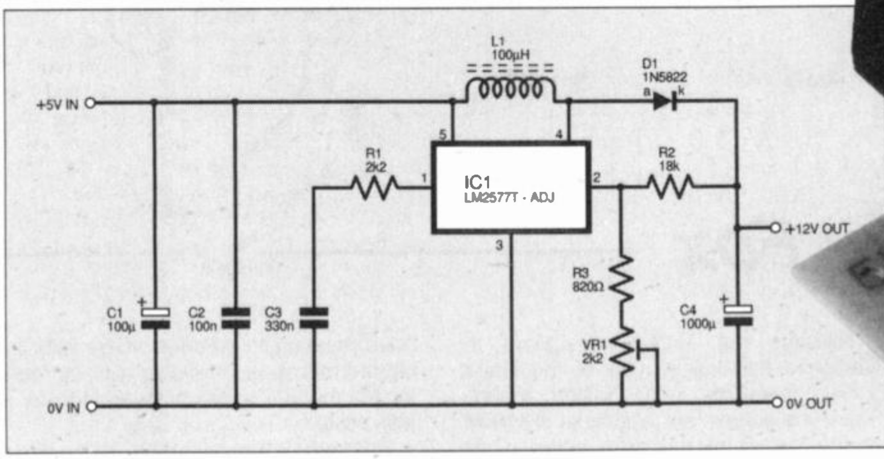
STEP-UP REGULATOR



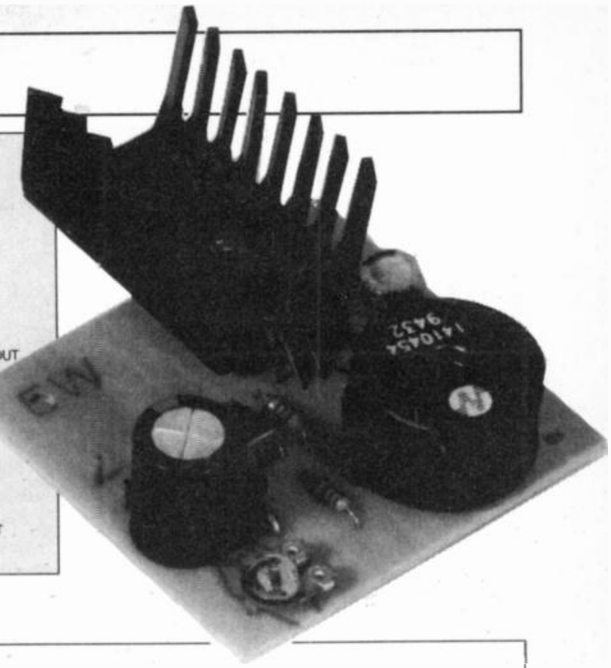


Fig. 11. Complete circuit diagram for the Step-Up Regulator.

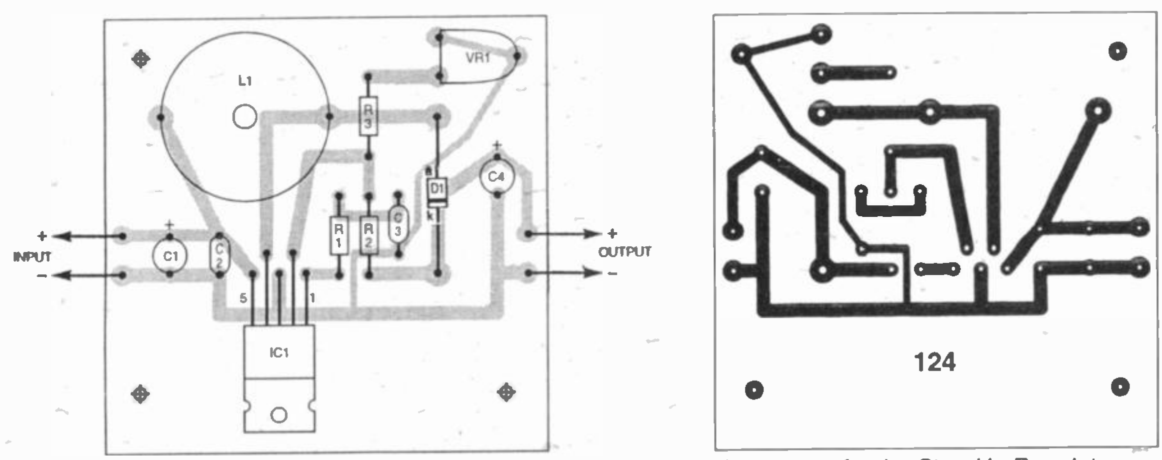


Fig. 12. Printed circuit board component layout and full size master for the Step-Up Regulator.

STEPPING UP

Refer to Fig. 11 for the circuit diagram of the Step-Up Regulator. This circuit is based on an LM2577T-ADJ, which is another chip designed to give a combination of high performance and stark simplicity.

It can provide output currents of up to 3A, and has both over-current and thermal protection circuits built-in. It requires a minimum input potential of 3·5V, and it shuts down automatically if the input voltage is inadequate. The maximum input voltage is 40V.

Capacitors C1 and C2 provide supply decoupling at the input, and C3 plus resistor R1 provide frequency compensation. Inductor L1, diode D1 and an internal switching transistor of IC1 form a standard step-up output stage, with output smoothing provided by capacitor C4. Resistors R2, R3 and preset VR1 form a potential divider that controls the output voltage.

IC1 has an internal 1·2V reference generator and the voltage at pin 2 is therefore stabilised at this figure. With the specified values in the potential divider circuit, the output voltage range is therefore around 9·5V to 25V.

CONSTRUCTION

The printed circuit board details for the Step-Up Regulator appear in Fig. 12. This board is available from the *EPE PCB Service*, code 124.

Inductor L1 can be either a Maplin 100µH "Bobbin Type Inductor", or an RS "High Current Radial Inductor Type A". In the case of the latter the leadouts must be pruned short and have the insulation scraped away before they are connected to the board.

Like the step-down regulator, this circuit achieves a high level of efficiency. The LM2577T has a specified efficiency of 80 per cent, but my tests suggest that a somewhat higher level of efficiency can be achieved. With a 5V to 15V step-up and 400mA drawn from the output, the measured input current was only a fraction over 1.4A. An input current of 1·44A would represent an efficiency of 80 per cent.

Due to this high efficiency, it is not necessary to fit IC1 with a large heatsink. Even when used at high output currents one of the larger bolt-on heatsinks should be perfectly adequate.

FINALLY

Switch mode power supplies have not been particularly popular with home constructors in the past. One probable reason for this is the relative complexity of many switch mode supply circuits. Also, suitable inductors and high speed rectifiers were difficult or impossible to obtain. Using modern devices it is possible to produce simple but efficient switch mode circuits using "off the shelf" components. □

COMPONENTS

STEP-UP REGULATOR

See SHOP TALK Page

Resistors

R1	2k2
R2	18k
R3	820Ω

All 0·25W 5% carbon film

Potentiometer

VR1	2k2 min. preset, horiz

Capacitors

C1	100µ radial elect. 10V
C2	100n ceramic disc
C3	330n polyester
C4	1000µ radial elect. 16V

Semiconductors

D1	1N5822 Schottky rectifier diode
IC1	LM2577T-ADJ step-up regulator

Miscellaneous

L1	100µH inductor (see text)

Printed circuit board, available from *EPE PCB Service*, code 124; bolt-on TO220 heatsink; single-sided solder pins; connecting wire; solder, etc.

Approx Cost Guidance Only £17

REPORT

by Barry Fox

Acrimonious Logic

Technology runs on acronyms, snappy little words made up from the first letter of a string of jargon words. Without acronyms, articles would be twice as long. They are also a boon for bluffers who use them to disguise ignorance.

America's TV sets use the NTSC standard, after the "National Television System Committee" that wrote the specification. Many people who have seen North American TV pictures prefer *Never Twice the Same Colour.*

Digital telephone lines use ISDN. Wags say it stands for an *Innovation Subscribers Don't Need*, not the "Integrated Services Digital Network".

RAM is "Random Access Memory" in which users store data. ROM is "Read Only Memory", in which users cannot store data. But a PROM is a "Programmable ROM" which stores data.

An EPROM is an "Eraseable PROM" from which the stored data is removed with ultraviolet light. An EEPROM is an "Electrically Eraseable PROM" from which the stored data is removed by electricity, much like a RAM.

Rather more logically, WYSIWG describes modern software which lets you print out exactly what is on screen so that "What You See Is What You Get".

Rather less neatly, PITO, the "Police Information Technology Organisation", is now working with NSPIS, the "National Strategy for Police Information Systems", to give bobbies PSRCP, "Public Safety Radio Communication Project", walkie-talkies. Thanks to PITO and NSPIS, cops will also get NAFIS, the "National Automated Fingerprint Identification Service".

In case you are confused, PITO used to be HOSTG, the old "Home Office Science and Technology Group".

Tongue In Cheek

The good news is that some companies now have their tongues in their cheeks.

Apple recently proposed an SVS encryption system for DVD, the new Digital Video Disc. It works on the Something Very Simple principle.

Computer scanners and digital cameras are now usually labelled TWAIN-compatible. This means that TWAIN-compatible software can Acquire image data from the device. TWAIN is a Terminal Which Aquires InformatioN. It really does stand for a Tool Without An Interesting Name.

Perhaps the TWAIN designers in California had visited one of the Napa Valley vineyards near Silicon Valley. There the guides talk proudly of the VBM in the corner of the wine cellar. Only those who ask are let into the trade secret that VBM stands for a "Very Big Machine".

The police, who breed acronyms like rabbits, may even be developing a sense of humour, too. Their catchy names come from the National Strategy for Police Information Systems, otherwise known as NSPIS.

In The Red

Some consumer electronics companies have resorted to labelling VCRs with the big red message "If all else fails, try reading the manual". The computer industry is less polite.

Internet surfers will often encounter a list of FAQs, answers to the most "Frequently Asked Questions" on technical problems. Anyone who asks a question without bothering to read the FAQs, or looking at the maker's instruction book, can expect the snappy retort RTFM, Read The F***ing Manual.

Now that computer companies are cutting costs by providing no printed manuals, just On-Line helP, idle enquirers can expect a new acronym. RTFOLP!

Frank Confession

Dr Frank Carrubba, Executive Vice-President of Philips, visited the Philips Labs at Redhill in June, to mark fifty years of research in the UK.

He kicked off with a talk on the "Social Trend and Implications of Technology", and showed a video predicting a future full of videophones, video payphones, video cellphones and video answerphones. But do people really need, or want, callers to see whether they have shaved or made up?

The only real consumer use I could see was a kid going to a video payphone and saying "Is this the one you want Mum?" Presumably he was then arrested for shoplifting, having taken the thingy out of the shop to the phone before spending his mother's money.

Carrubba was gloriously frank when asked questions. He admitted that DCC (Digital Compact Cassette) had been a "great product" that failed. "We couldn't get the cost curve down", said Carrubba.

"We listened to the music industry when they said that people wanted to go on using tapes, but with CD quality, and that people would upgrade if the equipment was compatible. We spent a Helluva lot of money and time on making a compatible sytem with CD quality sound. But the music companies didn't move fast enough."

Now there is a question mark over DVD, the high density Digital Video Disc which Toshiba, Thomson and Panasonic have promised to launch this year. Industry observers believe there is no way it can be ready. So does Carrubba.

"DVD is tricky technology. The format is standardized, that's been put to bed. But now we are battling with the film and music industries. It's very difficult to protect copyright and their lawyers are screaming.

"People are saying they will launch this year. Don't believe it. There will not be a product this year. I'll tell you that. There are too many issues and problems still to be solved.".

Sticky Digits

The DVD Consortium and the Hollywood movie studios are trying to agree on a digital encryption system that will stop people copying movie discs and will stop people playing movies discs in countries for which they are not intended (for example, movies are released in the USA ahead of Europe).

The encryption system must be tough enough to resist hackers but not so tough as to fall under an import/export ban because the US government then classifies it as munitions.

Personally, I am more interested in the robustness of the disc. With around seven times the packing density of an ordinary CD, it relies on accurate readout of very small pits.

Although publicists hold the discs aloft in sticky fingers, they never play those discs. The only discs played are very carefully handled, at the extreme edges, by engineers.

The general public has sticky fingers.

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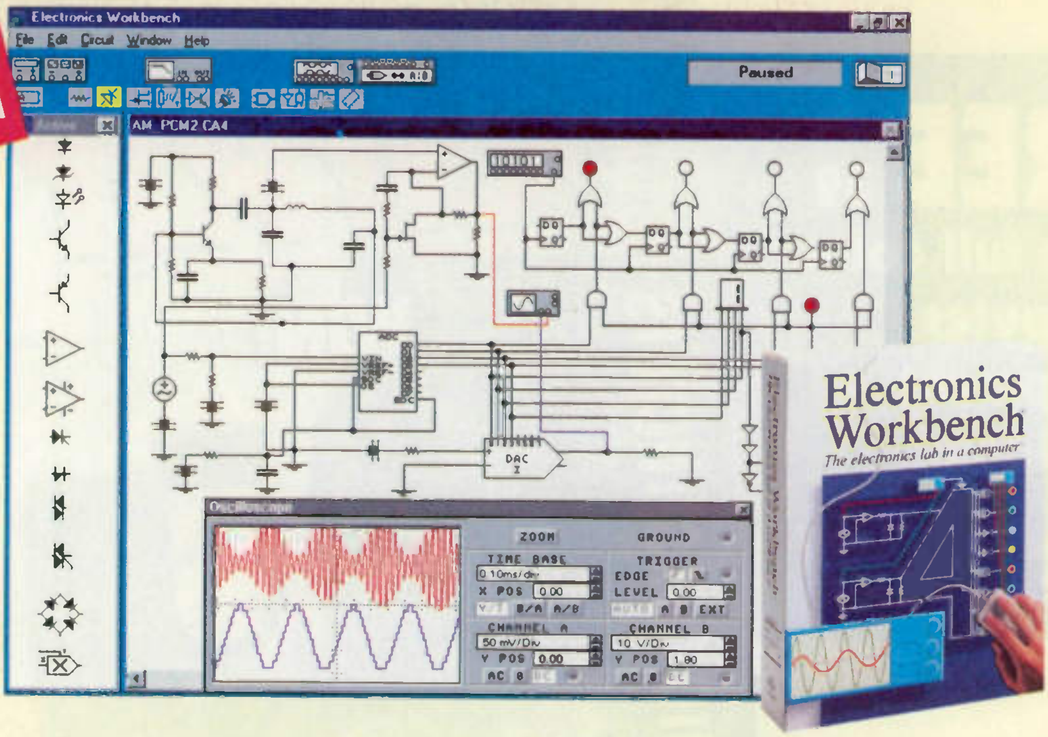

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INTERACTIVE

SWATCH WATCHES COME UP WITH A WINNER

– by Hazel Cavendish

ONE of the best electronically-inspired ideas of the year comes from Switzerland's Swatch watch company – a product which has already made billions internationally by marketing a timepiece of simple reliability and utility at a bargain price which has fitted admirably with today's casual dress codes. Now Swatch is moving upmarket into a more significant role.

The Company has an admirable philosophy of simplifying life for busy people, and it saw its chance by challenging the SMART card. Rightly reckoning that the public is heartily tired of carrying round a wallet or handbag stuffed with plastic cards, it has produced a Swatch Access wristwatch which not only tells you the time but contains a V4050 read-write EPROM chip capable of storing one kilobyte data, working at a low clock rate of 125kHz with a data length of 32 bits and a communication rate of 204kHz. This watch should save people a great deal of time and effort in the future, as the Company develops various applications.

SKI WATCH

Not unnaturally in a country which takes to the ski slopes for its recreation at the first heavy fall of snow in winter, the watch was first designed for the ski slopes, christened the Swatch Access Ski Watch and costed at only £28 in sterling.

Credit points are downloaded into the watch, and all the skier queuing at the ski lift needs to do is flash his watch at the gate. The transponder sends out signals constantly, while a sensor coil encircling the watch provides the antennae. Everything needed is integrated in the chip which is able to work without a microprossesor. Once up the mountain the skier can use his watch to obtain his hot chocolate and for any other facilities offered in the course of a day's ski-ing.

It is also possible to buy time related to points, so that an athlete could pay a set sum for, say, five days, and the watch would be primed for those dates in which all ski trips (or other athletic events) were covered.

The ski watch has been an enormous success, and is used at 280 ski resorts and is registered in 13 countries including America and Canada as well as most of Europe.

Now the Swatch is being introduced for the tourist trade, and was trialled in Salzburg, Austria this autumn. The Ski Access watch is compatible with this use as the "Debit Value Solution" is contained in the EPROM chip. The potential for this new application is impressive.

Company spokesman Ruud Krabbe says, "This use of the Swatch watch is not only more comfortable for the tourist but it is actually far less expensive than operating a Smart card.

"A tourist arriving in Slazburg can now apply for an all-inclusive package in which his hotel, meal expenses in a wide range of the city's restaurants, tourist attractions such as visits to castles and including the Casino, will all be integrated.

"We do not load money on the watch; instead we load credit points for everything.

"We are also working on other more sophisticate chip solutions for the use of Credit Cards, which we recognise involves a need for more security."

MARIN CHIP

He explains that the reason his company has been able to offer the watch at such an economic price is because the large watch group to which Swatch belongs (which includes most of the famous Swiss watch companies) has its own semi-conductor company, Electronic Marin, which specialises in low voltage and low power applications and produces chips for products as diverse as items for the motor industry and animal identification items for pigeons requiring small read-only chips fixed to their feet.

TRANSPORT

Mr Kabbe says another Swatch watch using a more powerful chip solution will soon be introduced for international transport fares. Watches can be used to pay fares on busses, metro systems and trains, similar to a system which has been in place in Hong Kong for some time, and negotiations to sell the system to two large Asian cities is in the pipeline and is expected to be announced shortly.

"In many parts of Asia people lack any sort of infrastructure and are prepared to jump directly on to new technology, giving them an advantage over older countries and fulfilling many needs," he said. "Such a process is very slow in America, because of their innumerable Labour regulations, and there is low penetration of our new technology in France because most of the ski regions are State owned and controlled by electricity companies, so we met some resistance there."

UK MARKET

His company is in final negotiation with a major British company at present, and is planning a marketing programme which will concentrate on the English market. Interest has already been shown by British amusement parks and it is expected that large department stores wishing to offer their customers 'loyalty bonuses' in the American manner may use the system to give people a convenient way to shop.

Swatch, which provided much of the timing at the Atlanta Olympics, is already in discussion with the Australian organisers of the next Olympics planned for Sydney, and hopes for a much larger role than they played in America, where they were hampered by the fact that their technology was not compatible with some of the established US systems.

DIG THAT PICTURE!

DIGITAL photographs that can be downloaded to your PC can be easily achieved with Sanyo's first digital camera, the VPC-G1 "Image PC". This compact camera uses a CCD sensor instead of film and stores pictures in its built-in memory.

The camera can then be coupled to a PC via the RS-232C serial port. Pictures can then be brought up on screen and even manipulated to be used in documents and other similar applications. Up to 32 images can be taken using normal resolution (320 x 240), or 16 in high resolution mode (640 x 480). Optional 2MB and 4MB memory expansions are available allowing up to 128 shots to be taken.

Retailing at £579.99, the VPC-G1 is designed to look and handle like a conventional film camera. It is supplied with "Chelsea" photo-enhancement software and is Microsoft Windows compatible.

For information ask your local camera dealer, or contact Sanyo UK Sales Ltd, Dept EPE, Sanyo House, Otterspool Way, Watford, Herts WD2 8JX.

NET CLEANING

SCIENCE and Technology Minister Ian Taylor recently challenged the Internet industry to co-operate to help parents and schools control children's access to undesirable material on the Internet.

He urged that software which can screen out unwanted and undesirable material should be made widely available. At the same time, he welcomed the inclusion of screening standards in the new version of Microsoft's Internet browser. The Platform for Internet Content Selection (PICS), can be implemented on any PC platform to allow Internet users and parents to be censorial.

Ian Taylor went on to say that "Government will face increasingly strong calls for legislation to regulate all aspects of the Internet, unless service providers are seen wholeheartedly to embrace responsible self-regulation."

Whilst most people will share his concerns about "undesirable" Net material, many will undoubtedly feel unease about Government intervention on the Net; such intervention by governments more aggressive than ours in the UK could suppress aspects of the "freedom of speech" which it is supposed that the Internet offers to the world-wide community.

BRIDGE TOO FAR?

INCREDULITY is likely to be the reaction of those who do not play Bridge to BT's announcement that it has introduced software which allows the game to be played via a computer/telephone link.

The software is part of BT's new interactive computer games network, Wireplay. BT is working with the English Bridge Union (EBU) to recruit members to test the system which will be fully launched in Spring 1997.

The uninitiated might be excused for thinking that Bridge is a game that requires socially interactive partnerships around the same table, not across the distances of remote telecoms. Cynics, however, could suggest that Bridge's reputation for breaking up relationships might decline if gameplay is not at close-quarters!

PATENTLY MORE INVENTIVE

IS it possible that in the UK we are becoming more inventive? The Patent Office has recently commented that "after many years of decline, the demands for patents appears to have stabilised. The increase in demand for registration of designs has continued and the demand for trade marks reached a further record level."

Let's hope that, contrary to past experience, we are also learning how to capitalise on our inventions to benefit the UK, not foreign businesses.

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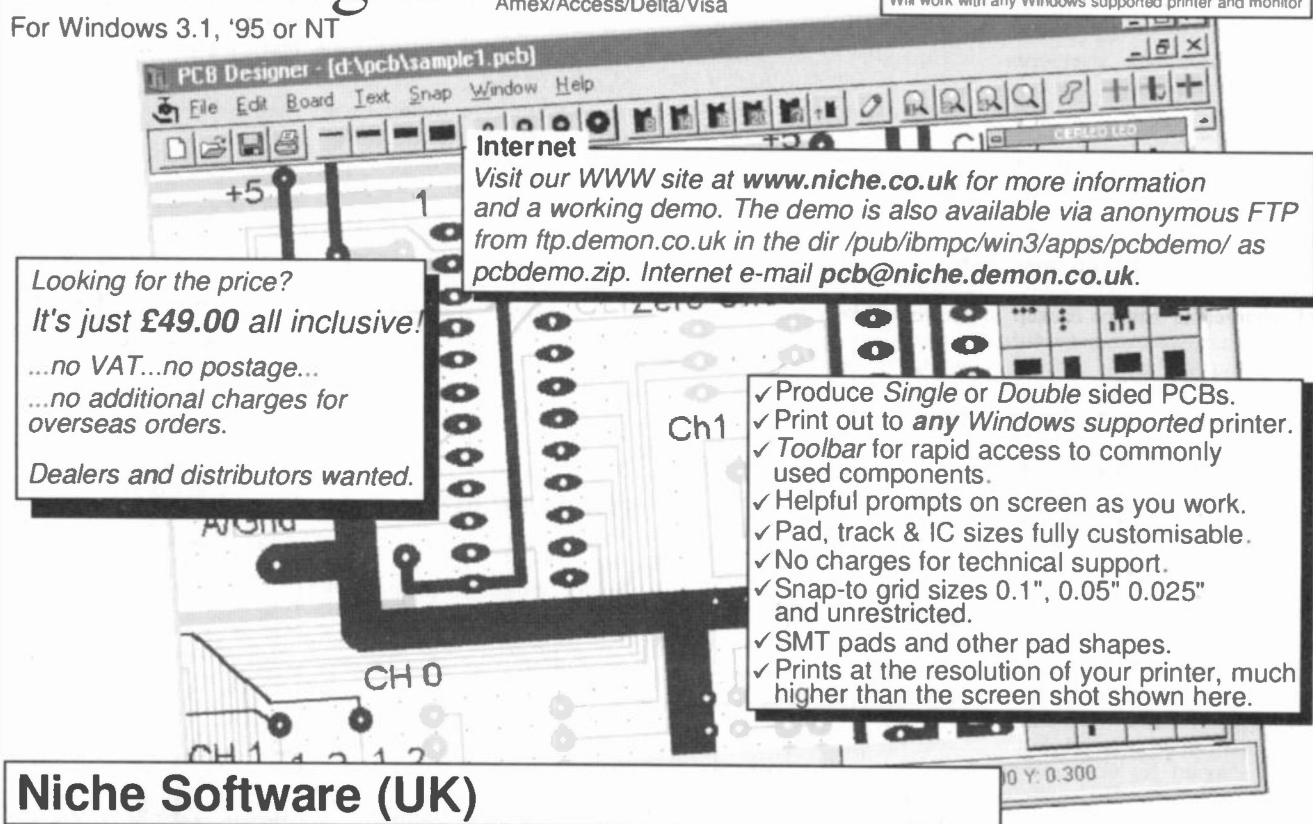

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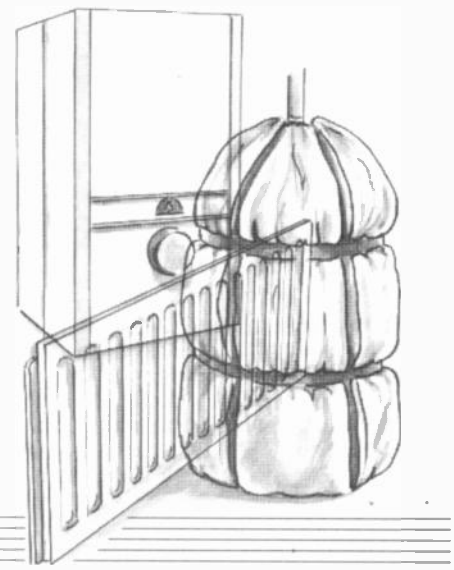


CENTRAL HEATING CONTROLLER

RICHARD STONE

Achieve the benefits of a sophisticated central heating system with this 7-day programmable controller.

THIS ARTICLE describes the design, construction and use of a microcontroller-based central heating controller similar in specification and performance to typical commercial units. The unit has been designed to be easy to use and reliable, and offers the following features:

- Independent switching of both central heating and domestic hot water
- Switching capacity of 5A at 240V a.c.
- Separate programs for each of seven days
- Once or twice per day switching cycles
- Thermostat capability using integral or external temperature sensor
- 2-line 16-character l.c.d. display
- Continuous display of temperature and time
- Rechargeable battery backup to protect program in event of mains failure
- Outputs configurable to be permanently on or off if required
- Indication by l.e.d. of relay operation

DESIGN OVERVIEW

A simplified block diagram of the Central Heating Controller is given in Fig. 1. The system is based around an 8051-series microcontroller (the Atmel AT89C2051). The microcontroller reads program instructions contained in its ROM (Read Only Memory) and then executes them to perform the functions of the Central Heating Controller in conjunction with a minimum of additional electronic circuitry.

User input is via four pushbutton switches which are continually scanned for a keypress by the microcontroller, which accordingly takes appropriate action as dictated by its control program.

Output to the user is via a 2-line 16-character alphanumeric l.c.d. display module. The module is capable of displaying the full ASCII character set so user messages and prompts appear in plain English.

The unit monitors temperature by means of an analogue sensor whose output has to be converted to a digital format so that it can be processed by the microcontroller. This function is performed by means of an analogue-to-digital converter (ADC).

Relays are used to interface the microcontroller outputs to the mains voltages which are required to be switched by the Control Unit.

The Central Heating Controller may be powered by either a mains derived supply or a standby battery. Under normal circumstances, the mains derived supply will be used but, in the event of mains failure being detected, the standby battery supply is switched in to ensure that the time and program information is not lost.

MICROCONTROLLER

The full circuit diagram of the Central Heating Controller is given in Fig. 2.

The Atmel AT89C2051 microcontroller is shown as IC3. This device is compatible with the industry-standard 8051 series of microcontrollers, although, as it is intended as a low cost device, some of the standard 8051 features are missing. The features included are as follows:

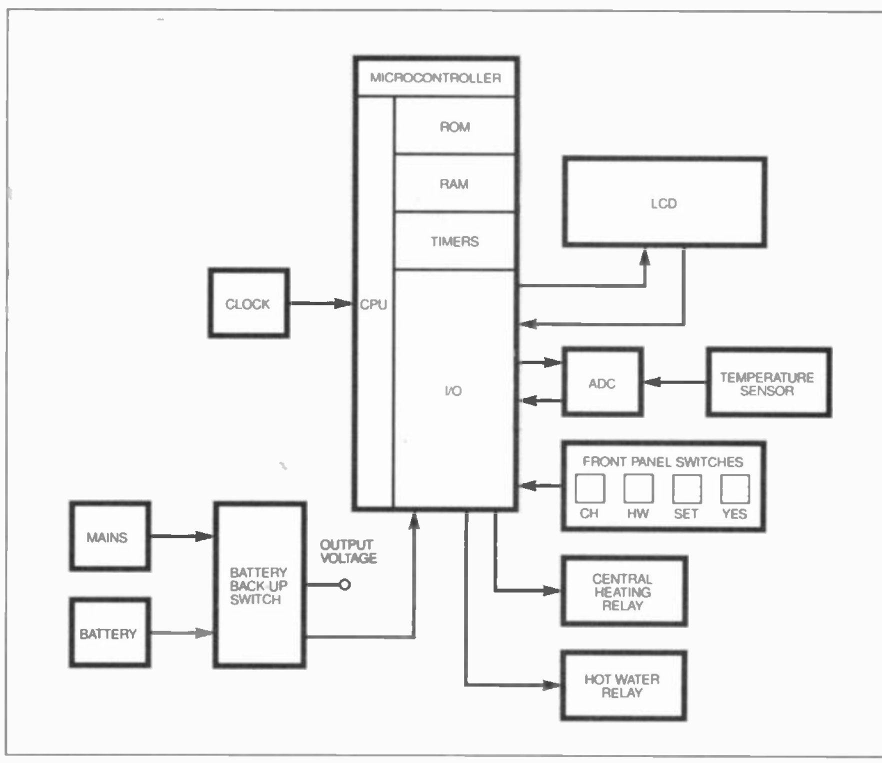


Fig. 1. Block diagram of the Central Heating Controller.

- 2048 bytes of "flash" ROM
- 128 bytes of RAM (Random Access Memory)
- Two 16-bit timer/counters
- 15 programmable I/O (Input/Output) lines
- On-chip oscillator circuitry

Although some microcontrollers have ADC circuitry included in them, this is not a feature of the AT89C2051. However, the ADC is the only additional major data processing circuit required in this design. This illustrates the major benefit of using a microcontroller for this design as the component count is very much reduced compared to a design based around a conventional microprocessor and peripherals.

The clock signal is provided by connecting a crystal (X1) and two capacitors (C5, C6) around the AT89C2051 on-chip oscillator circuitry, which is brought out to pins 4 and 5 of the microcontroller. Although the AT89C2051 can be clocked at up to 24MHz, in this application a clock frequency of 6MHz is used, which translates to a typical execution time of 2µs per machine code instruction.

This is more than fast enough to process the software used to perform the functions of the Central Heating Controller. Using a higher clock frequency would only serve to increase the amount of unwanted electrical noise and emissions generated by the microcontroller.

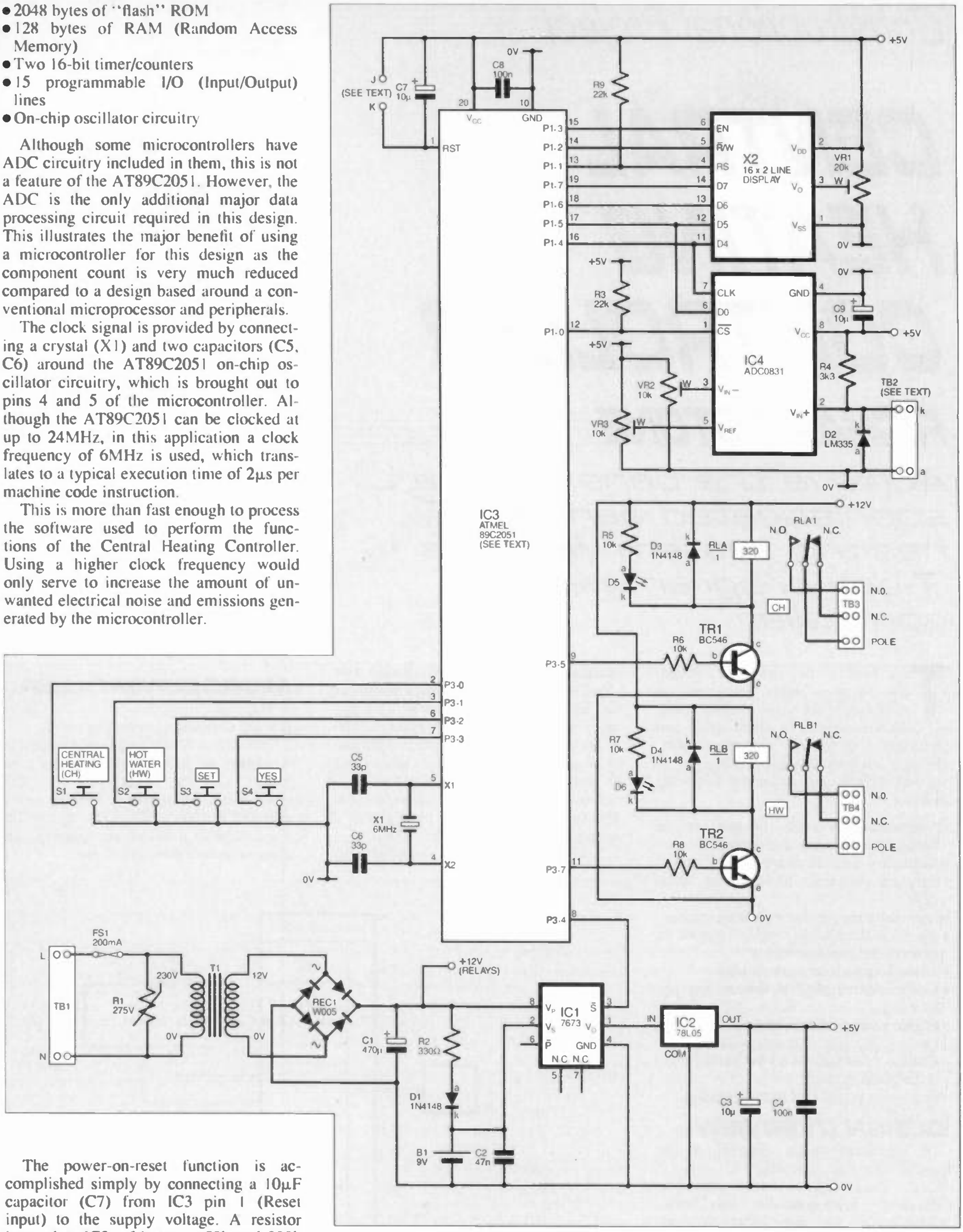


Fig. 2. Complete circuit diagram for the Central Heating Controller.

The power-on-reset function is accomplished simply by connecting a 10µF capacitor (C7) from IC3 pin 1 (Reset input) to the supply voltage. A resistor internal to IC3, of between 50k and 300k ohms, connects pin 1 to ground. The microcontroller is reset when pin 1 is taken to the supply voltage and C7 accomplishes this by holding pin 1 at the supply voltage until it discharges via the internal resistance.

A jumper connection is provided across C7 (points J and K) which allows a manual reset facility by momentarily shorting across these two points – it is a facility which is unlikely to be required.

POWER SUPPLY

The unit is designed to be mains operated but also has the added feature of battery backup, to retain programme settings in the event of mains failure.

The design of the power supply is entirely conventional, using a step-down transformer (T1) and a bridge rectifier (REC1) to provide an unsmoothed d.c. supply from the a.c. mains. Fuse FS1 is provided in the "live" line to protect the unit and the installation from drawing excessive current in the event of a fault. The recommended fuse is an automatic resetting type that requires no manual intervention once the cause of the trip has been removed.

A metal oxide varistor (R1) is connected across the mains supply, after the fuse, to afford the unit some protection from high voltage transients and spikes which are sometimes present on the mains supply. Under normal conditions, the varistor presents a very high impedance to the supply, but as soon as the supply voltage exceeds a predetermined level, e.g. due to a voltage transient, the device's impedance rapidly falls, which has the effect of clamping the transient voltage at a protective level. In this particular case the clamping level is 275V a.c.

The step-down transformer (T1) has two 6V secondary windings which are connected in series to give a 12V a.c. output. This is rectified by REC1 to give a full wave rectified d.c. output with a peak voltage of around 17V. This is smoothed by a large value electrolytic capacitor (C1) to give a steady d.c. output voltage.

BATTERY BACKUP

The battery backup feature is provided by a rechargeable NiCad battery (B1). This is a PP3 equivalent and is trickle charged via resistor R2 and diode D1. Resistor R2 sets the trickle charge current to approximately 10mA.

IC1 is an ICL7673 automatic battery backup switch integrated circuit which performs the switching function between the primary supply (mains derived) and the secondary supply (battery derived). IC1 determines which of the two input voltage sources is greatest and automatically switches this to its output at pin 1.

In normal operation, the primary voltage (around 12V to 16V) will be higher than the secondary voltage (around 9V) and so the primary supply will be switched through to the output pin. However, in the event of mains failure, then obviously the battery supply will be highest and so this will be connected through to the output.

The switchover from one input source to the other occurs in less than 50µs, which means that the changeover s transparent to the rest of the circuitry.

The ICL7673 provides two open-drain transistor outputs (pins 3 and 5) to indicate which supply is currently connected. One of these, pin 3, is connected to the microprocessor's I/O line P3.4 which is configured as an input. This I/O line has an internal pull-up resistor to the microcontroller's supply voltage. When IC1 switches from primary to secondary supply, the voltage on this line will go from logic 1 (high) to logic 0 (low). The state of line P3.4 is read by the controlling program to detect if the mains has failed and take the appropriate action.

The voltage output from IC1 is fed to the regulator IC2, the output of which supplies the regulated +5V required to power the rest of the circuit. This output is decoupled by capacitors C3 and C4, although additional decoupling is used in various other parts of the circuit.

The 78L05 device used for IC2 has a maximum output current of 100mA, which is more than sufficient to power the entire Central Heating Controller circuit with the exception of the output relays. The latter are powered directly from the unregulated d.c. supply. This means that if the mains supply fails and the unit is running from the battery supply then the relays will be de-energised and both outputs will be off.

INPUT SWITCHES

There are four push-to-make switches, S1 to S4 (labelled CH, HW, SET and YES) which allow the user to programme and configure the unit for the desired mode of operation. These switches have one side connected to ground and the other to the microcontroller's I/O lines P3.0 to P3.3 (pins 2, 3, 6 and 7) which are configured as inputs.

These I/O lines also have internal pull-up resistors to the supply voltage and hence operation of a switch will cause the corresponding I/O line to go from logic 1 to logic 0. The programmed software can therefore detect if a switch has been pressed and respond accordingly. The

COMPONENTS

Resistors

R1	varistor, 275V a.c.
R2	330Ω
R3, R9	22k (2 off)
R4	3k3
R5, R7, R6, R8	10k (4 off)

All 0·25W 5% carbon film except R1.

See SHOP TALK Page

Potentiometers

VR1	20k multiturn preset
VR2, VR3	10k multiturn preset (2 off)

Capacitors

C1	470µ radial elect. 25V
C2	47n ceramic
C3, C7, C9	10µ radial elect. 16V (3 off)
C4, C8	100n ceramic (2 off)
C5, C6	33p ceramic (2 off)

Semiconductors

D1, D3, D4	1N4148 signal diode (3 off)
D2	LM335 temperature sensor diode
D5, D6	red l.e.d., 3mm (2 off)
REC1	W005 1.5A 50V bridge rectifier
TR1, TR2	BC546 *npn* transistor (2 off)
IC1	ICL7673 battery backup switch
IC2	78L05 +5V regulator
IC3	AT89C2051 pre-programmed microcontroller (see text)
IC4	ADC0831 A-to-D converter

Miscellaneous

B1	9V NiCad battery, PP3 equivalent
FS1	200mA resettable fuse, p.c.b. mounting
RLA, RLB	12V relay, s.p.c.o. contacts rated 10A 240V a.c. (2 off)
S1 to S4	push-to-make switch, panel mounting (4 off)
T1	mains transformer, 12V secondary, 1·2VA
TB1, TB2	2-way terminal block (2 off)
TB3, TB4	3-way terminal block (2 off)
X1	6MHz crystal
X2	2-line 16-character l.c.d. display module

Printed circuit board, available from the *EPE PCB Service*, code 120; plastic case, 184mm × 115mm × 163mm; clear display bezel; 30mm p.c.b. mounting pillar (4 off); 15mm p.c.b. mounting pillar (4 off); PP3 battery clip; cable ties; l.e.d. mounting clip (2 off); cable grommets, clamping (3 off); 8-pin d.i.l. socket (2 off); 20-pin d.i.l. socket; connecting wire; solder, etc.

Approx Cost Guidance Only £65

problem of contact bounce, which is inherent to all mechanical switches, is taken care of by the software. This is done by performing successive reads of the input pins, separating each read by a delay which is greater than the expected contact bounce time (typically 10ms to 20ms).

DISPLAY MODULE

The system imparts information to the user via an Hitachi LM016XMBL l.c.d. display module (X2) which is capable of displaying two lines of 16 alphanumeric characters. This module consists of both the l.c.d. display itself and a driver and display controller chip (the HD44780) which provides the interface to the outside world.

In simple terms, the HD44780 appears as a series of byte-wide registers and memory locations which can be accessed as appropriate in order to display the required characters on the l.c.d. The HD44780 is normally accessed via a byte-wide data bus (lines D0 to D7) and three control Inputs, Register Select (RS), Read/Write ($\overline{R}$/W) and Enable (EN).

The EN input must be high in order to allow a data transfer to take place. The other two inputs, RS and $\overline{R}$/W, are used to select the required register (either data or control) and to determine whether a read or write access is required.

The HD44780 also allows data transfer to take place as two consecutive 4-bit wide transfers using the upper four data bus lines (D4 to D7) and this is the approach used in this design in order to cut down on the number of I/O pins required.

Microcontroller I/O lines P1.4 to P1.7 are used as the data bus and connect to lines D4 to D7, respectively, of the HD44780. Lines P1.1, P1.2 and P1.3 are used as EN, $\overline{R}$/W and RS, respectively. Line P1.1 requires an external pull-up resistor to the supply voltage and this is provided by R9.

Display contrast can be adjusted by means of preset potentiometer VR1, whose wiper sets the voltage applied to the module's control pin 3.

RELAY CONTROL

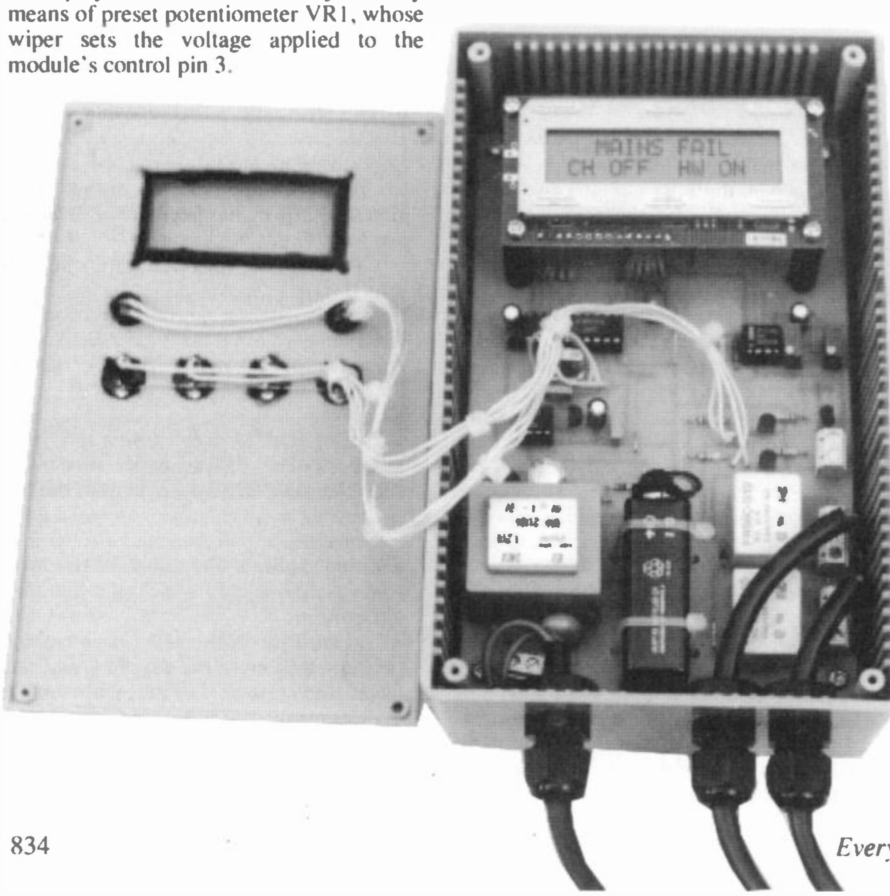
The Central Heating Controller has two switchable outputs which are intended to switch the central heating and the water heating on or off in accordance with how the unit is programmed. Both these outputs are electrically identical and so only the central heating output is described here.

A relay is used in order to meet the rated voltage and current requirements of the equipment to be switched. However, the output current drive available from the microcontroller's I/O lines is insufficient to directly power the coil of the specified relay (RLA). Consequently, the coil is driven by a transistor (TR1) operating as a simple switch.

When microcontroller I/O line P3.5 is set to output logic 1 the transistor is driven into saturation due to the current flowing into its base (b) via resistor R6. This effectively connects the relay coil to ground and hence the coil is energised and operates the contacts. Diode D3 protects the transistor against the inductive voltage generated across the coil at the moment that the transistor is switched off.

An l.e.d. (D5) is also controlled by TR1 and an appropriate current limiting resistor (R5) in order to give an external indication of the relay operation. The relay contacts are brought out to a terminal block (TB3) in order to allow easy connection to the external wiring.

The relays used are 12V types and operate directly off the unregulated supply available at the output of REC1. The reason for this was to reduce the amount of current required to be sourced via IC2. Using relays with 5V coils would have required an extra 100mA or so to be sourced via IC2, which would have necessitated using a larger regulator and also resulting in a lot of wasted energy dissipated as heat across the regulator. It would also impose an undue strain on the battery during a mains power failure.



TEMPERATURE SENSING

One of the features of the Central Heating Controller is the ability to measure and display temperature. In order to do this, some form of electronic temperature sensing device is required, the output of which is required to be in a format that can be interpreted by the microcontroller software.

The sensing device used in this design is the LM335 precision temperature sensor (D2) which basically operates as a two terminal Zener diode. When biased via a resistor from a suitable voltage source, this device has a breakdown voltage which is directly proportional to absolute temperature (i.e. temperature measured in degrees Kelvin). Therefore, at a temperature of 0° Celsius (273° Kelvin), the breakdown voltage of the device will be 2·73V, and at 25° Celsius, the breakdown voltage will be 2·98V.

Digital computing devices, such as a microcontroller, cannot directly interpret analogue voltages until they are converted into a digital format. This function is undertaken here by an ADC0831 analogue-to-digital converter, IC4. This device is capable of 8-bit resolution, which means that the analogue input voltage can be digitized into 256 (2^8) discrete digital values.

The ADC0831 also features a differential amplifier input stage, which allows the analogue zero input voltage to be offset from ground, and an adjustable voltage reference input, which allows a smaller analogue voltage span to be encoded to the full eight bits of resolution. These features are very useful in this design due to the fact that, at the temperature range of interest, the output of the LM335 consists of a relatively small changing voltage superimposed on a large offset voltage.

TEMPERATURE RANGE

The temperature range chosen to be displayed is from −20°C to +43·75°C, corresponding to LM335 nominal output voltages of 2·53V to 3·1675V. In order to configure the ADC0831 to accept this input voltage range, all that is required is to set the appropriate voltage levels at the inverting amplifier and reference voltage inputs.

Adjustment is achieved by using preset potentiometers VR2 and VR3 connected between the supply voltage and ground. VR2 is adjusted to set the offset voltage at the inverting amplifier input (pin 2) to 2·53V. VR3 sets the input reference voltage and should be adjusted to give a voltage at this input (pin 3) of 0·6375V.

Using these settings of VR2 and VR3, the voltage resolution is 0·25V per digital unit, which is equivalent to 0·25°C, although the system software only deals with temperatures to the nearest integer value. Also, it should be noted that the output voltages quoted are for a "perfect" LM335 and a calibration process, detailed later, can be performed if the best possible accuracy is required.

The LM335 is connected to the non-inverting input of the ADC0831 and is biased from the +5V supply via resistor R4. Provision is made in the design to

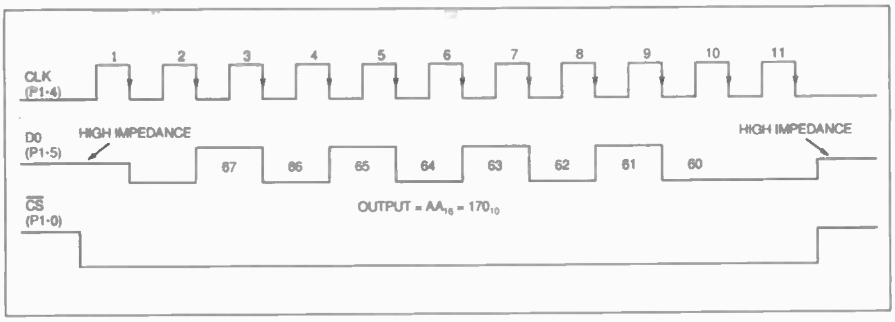


Fig. 3. Timing diagram for the ADC0831 ADC.

mount the LM335 either on the printed circuit board or remotely via connector TB2. Capacitor C9 provides a supply voltage decoupling function.

The ADC0831 features a 2-wire serial interface, comprising a clock input (CLK) and a data output (D0). An active low chip-select input (CS) is also provided. These pins are connected to microprocessor I/O lines P1.4, P1.5 and P1.0. It will be seen that I/O lines P1.4 and P1.5 are also connected to the l.c.d. display module.

This is allowable as the module's data bus takes on a high impedance state when its EN input is low, and the same can be said of the ADC0831's D0 output if its CS line is high. Therefore, as long as the software does not attempt to access both devices simultaneously, there will be no conflict.

Microcontroller I/O line P1.0 requires an external pull-up resistor to the supply voltage and this is the function of R3.

In order to perform an analogue-to-digital conversion using the ADC0831, it is necessary to drive its CS line to a logic 0 level and then, while CS is low, generate a series of eleven clock pulses (high to low logic level transitions) at the CLK input. The conversion result is output, most significant bit first, via line D0 on the falling edge of clock pulses two to nine. After the eleventh clock pulse, the conversion is ended by bringing CS back to a high logic level.

This process can best be illustrated by reference to the timing diagram given in Fig. 3. The controlling software manipulates the relevant microcontroller I/O pins in such a way as to generate the necessary sequence of logic levels. The output data present on D0 is read by the software when the CLK level is high on clock pulses three to ten. It can then be processed at will by the microcontroller software.

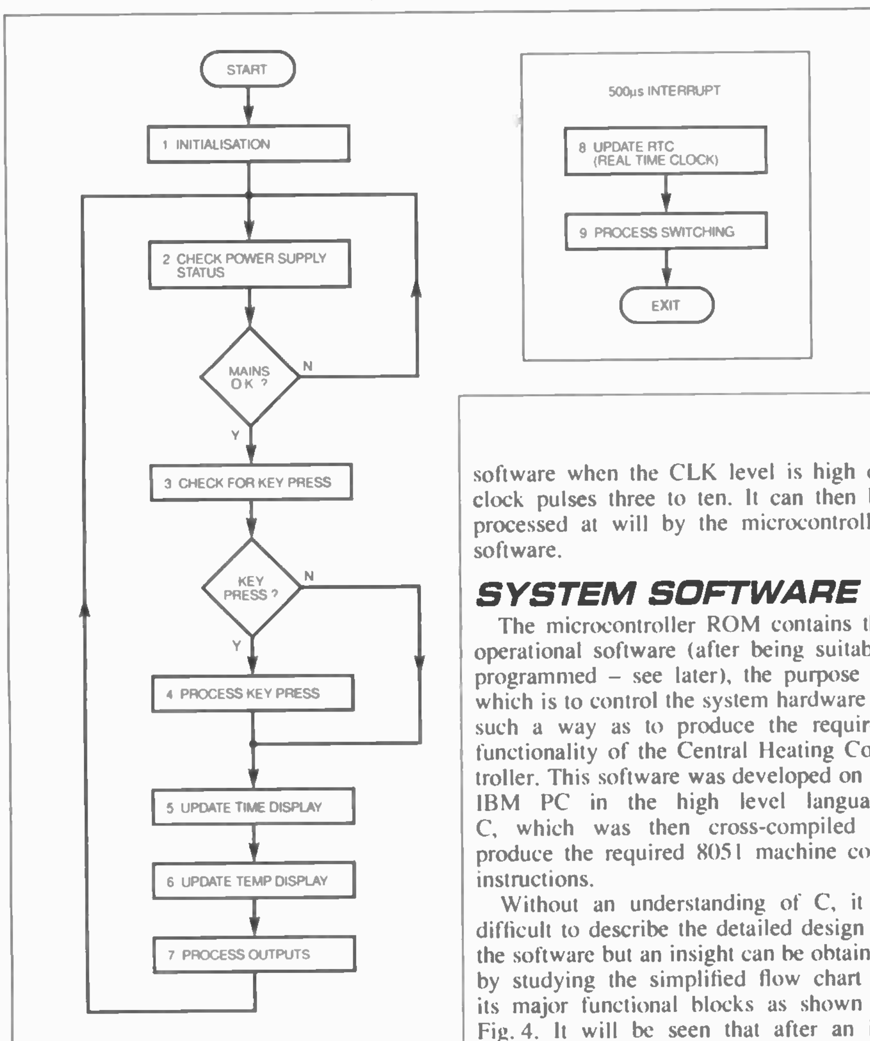


Fig. 4. Simplified flow chart of system software.

SYSTEM SOFTWARE

The microcontroller ROM contains the operational software (after being suitably programmed – see later), the purpose of which is to control the system hardware in such a way as to produce the required functionality of the Central Heating Controller. This software was developed on an IBM PC in the high level language C, which was then cross-compiled to produce the required 8051 machine code instructions.

Without an understanding of C, it is difficult to describe the detailed design of the software but an insight can be obtained by studying the simplified flow chart of its major functional blocks as shown in Fig. 4. It will be seen that after an initialisation process has taken place, the main body of the program is basically a continuous loop of repeated operations.

In addition to this continuous loop, another sequence of operations is being executed in the background on a periodic basis, the main function of which is to drive a software-based real time clock. Each operation is numbered and explained in greater detail in the following text.

MAIN PROGRAM LOOP

Operation 1 is the first sequence of instructions executed after a microcontroller reset, the main purpose being to initialise the program variables and the various sections of the microcontroller hardware. One of the functions undertaken here is to configure one of the microcontroller's internal timers to produce a periodic interrupt every 500 microseconds, which is used as an accurate timing signal for the real time clock (RTC).

After the initialisation sequence is complete, the software enters a continuous loop of operations.

Operation 2 is the first operation in this continuous loop and consists of a check upon the mains power supply status, which is determined by reading the state of line P3.4. If the mains supply is present, then the software jumps to Operation 3. However, if the state of line P3.4 indicates that the unit is being powered from the battery, then the software shows "MAINS FAIL" on the top line of the l.c.d. display and disregards any front panel switch operations until the mains power is restored.

It should be noted that the periodic timer-driven background functions continue to execute during this period so the time information is not lost, even though the time is no longer being displayed on the l.c.d. When it is determined that the mains power has been restored, the software begins the next operation.

Operation 3 is to check if the user has pressed a front panel switch. The software which reads and debounces front panel keypresses runs as a periodic background task. If it is determined that a keypress has occurred, a "flag" is set within the microcontroller RAM. This flag is read during Operation 3 and if it is determined that a keypress has occurred, then this keypress and any subsequent keypresses are processed appropriately within Operation 4. If no key has been pressed, then the software jumps to Operation 5.

Operation 4 processes the keypress which was detected in Operation 3 and, depending on subsequent keypresses, allows the user to set the operating mode of the unit or to program it with the current time, switching information and the thermostat trip point.

During this stage, the time and temperature are not displayed and the unit instead uses the l.c.d. display to prompt the user and allow switched entry of the required information. Once the user has finished entering the data, the software begins the next operation.

Operation 5 obtains the current time information from the real time clock and displays this on the l.c.d. The real time clock information is contained in the microcontroller RAM and the program simply reads this information, formats it, and then writes it to the appropriate area of the display. The software also flashes the colon which separates hours and minutes at a 1Hz rate, to give a visual indication that the clock is operating.

During the period that this operation is accessing the real time clock information, the periodic interrupt is disabled to ensure that the clock data does not change as it is being accessed, which could result in erroneous data being displayed on the l.c.d.

Operation 6 simply obtains the current temperature information by reading the analogue-to-digital converter. It converts this digital value to a degrees Celsius format and displays it on the l.c.d. This operation is only undertaken once every

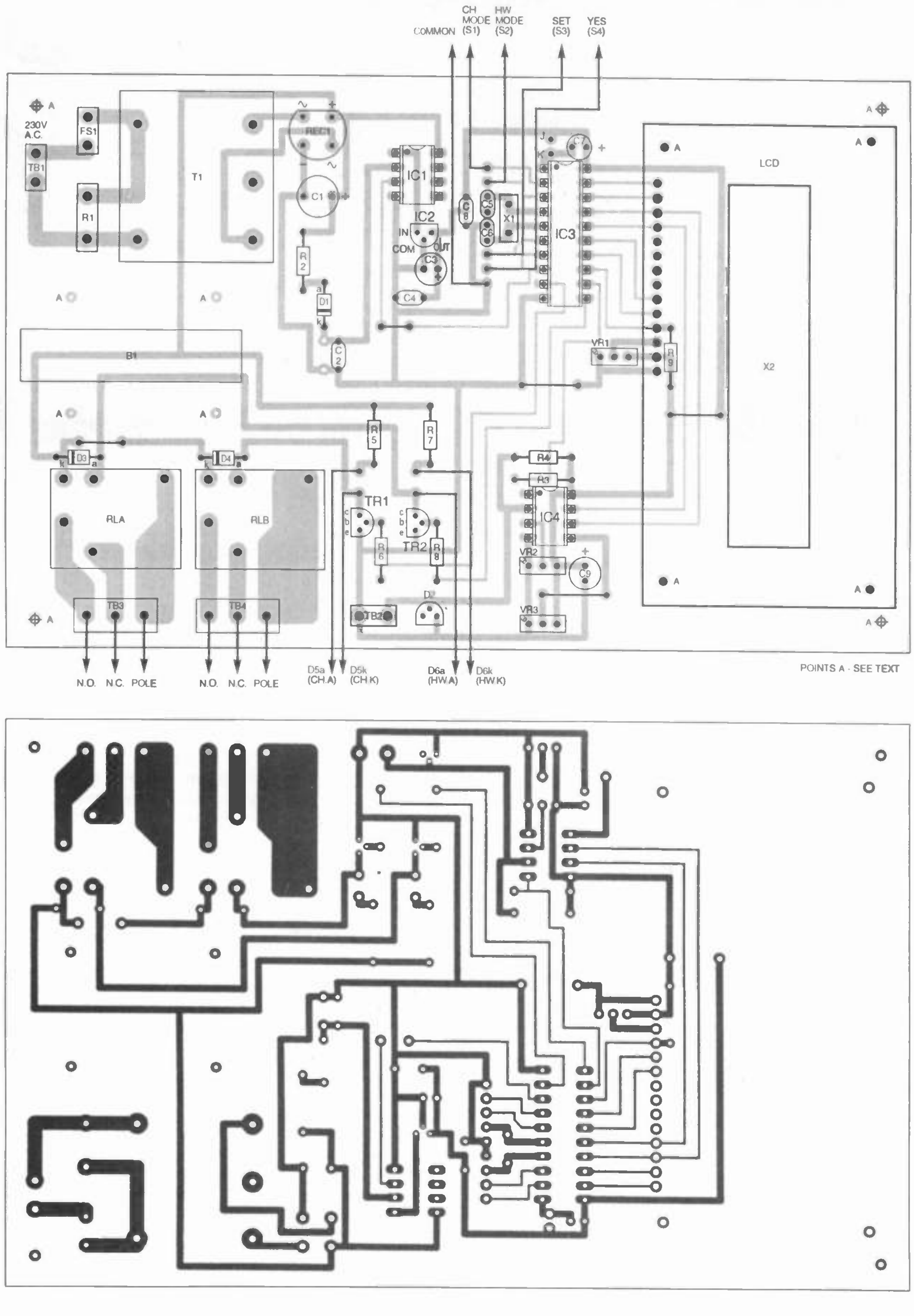
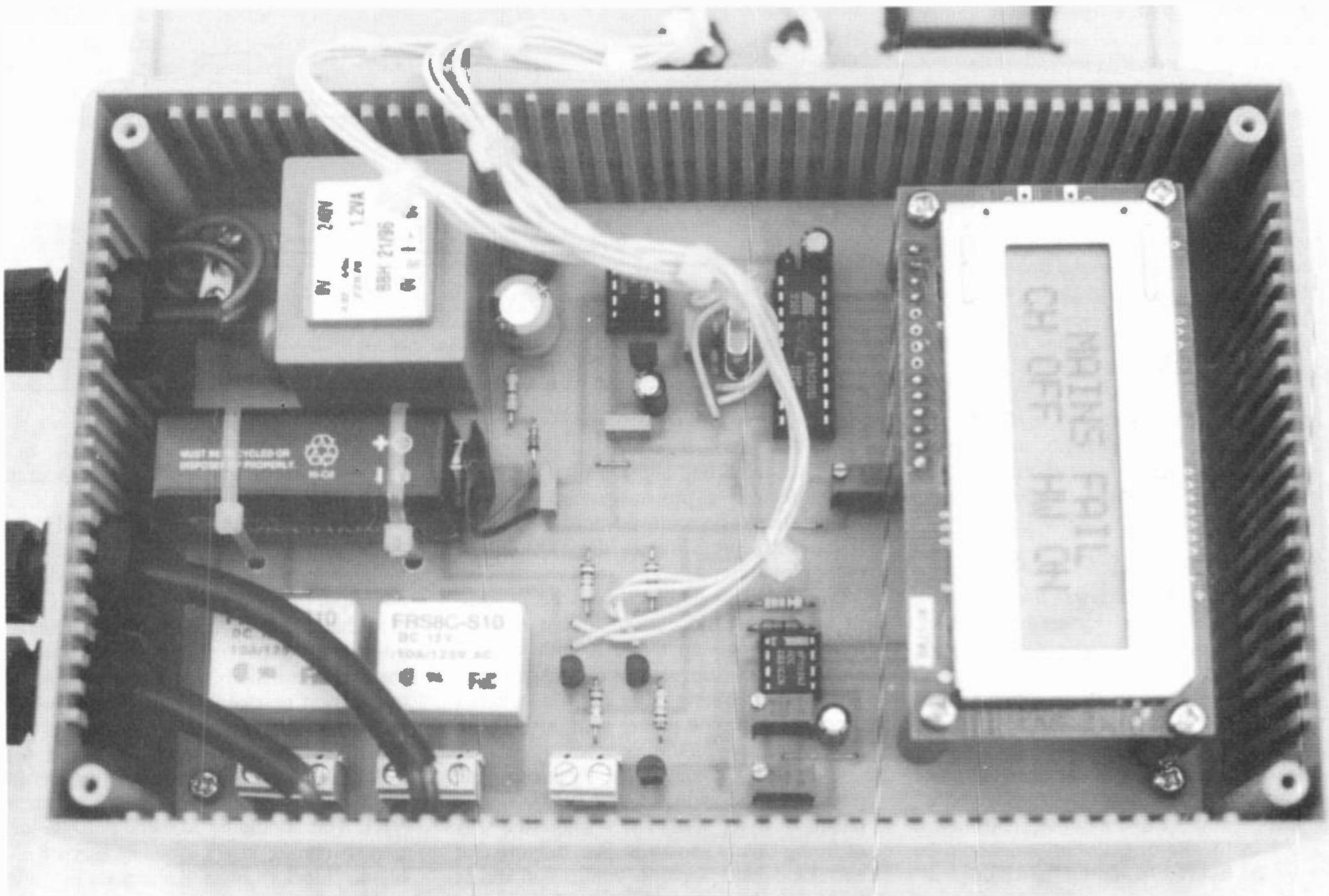


Fig. 5. Printed circuit board component layout and full size underside copper foil track master pattern.



Even when the mains power is off, the battery keeps the controller functioning.

second, determined from the real time clock information, in order to prevent the display flickering as the temperature changes from one integer value to another.

Operation 7 determines whether the two relay outputs should be switched on or off, according to the data previously keyed into the program via the switches.

In the case of the central heating control (but not the hot water), the current temperature and the thermostat setting must also be taken into account. The software also incorporates a hysteresis mechanism on the Central Heating output to ensure that the output does not rapidly change on and off if the temperature is borderline between two integer values.

After Operation 7 has been completed, the program loops back to Operation 2 and the whole process repeats.

PERIODIC OPERATIONS

Operation 8 consists of implementing the software driven real time clock. This basically comprises a dividing chain which converts the 2·0kHz input frequency (equivalent to 500µs periodic interrupt) to days, hours, minutes and seconds.

The 2·0kHz frequency is derived from the microcontroller crystal via one of the hardware timers and therefore the real time clock has the potential to be very accurate. All of the real time clock data variables are stored in the microcontroller RAM and therefore can be easily accessed by other areas of the program.

Operation 9 is concerned with reading the state of the input switches, via lines P3.0 to P3.3, and determining if a valid keypress has occurred. This operation is executed periodically every 20ms (determined from the real time clock) and uses this 20ms interval as a "debounce" period during switch closure and release. The software is coded in such a way that a key will not be acted upon until the key is released, and also to ignore rapid multiple keypresses.

CONSTRUCTION

The Central Heating Controller was designed to be a self-contained unit requiring only the addition of a suitable mains supply and appropriate wiring to the user's central heating system in order to operate.

All components, with the exception of the four front panel switches, S1 to S4, and the two l.e.d.s, D5 and D6, are mounted on a single printed circuit board (p.c.b.) which in turn is mounted in an ABS box. Details of this board are shown in Fig. 5. It is available from the *EPE PCB Service*, code 120.

The l.c.d. module is mounted on the p.c.b. using stand-off pillars to ensure that the display is at the correct height to be clearly visible through a bezel fitted in the lid of the box.

Connections to all components which are not directly mounted on the p.c.b. are made via flying leads. It should be noted that the p.c.b. assembly can be mounted into any suitable enclosure and that it is not necessary to use the specified box.

Assembly of components onto the p.c.b. is relatively straightforward, but it is recommended that the following sequence is adhered to:

First, before beginning assembly, the p.c.b. should be checked to ensure that all the holes are drilled and clear. There are twelve holes on the board, marked as "A" in Fig. 5, which are used for mounting pillars and to attach tie wraps to fasten the battery. These are only drilled as pilot holes in order to allow the constructor to drill them out to suit the actual mounting hardware used. On the prototype unit, they were all drilled out to 3mm diameter.

The four wire links should now be fitted using tinned copper wire of an appropriate gauge, or resistor cut-off leads. Resistors R2 to R9, and diodes D1, D3 and D4 can now be fitted. The diodes must be fitted the correct way round; the cathode (k) is usually indicated by a band on the component body.

The next stage is to fit the i.c. sockets, and it is strongly recommended that they *are* used. Capacitors C1 to C9 and crystal X1 can now be fitted. Ensure correct orientation of the electrolytic capacitors, C1, C3, C7 and C9.

Next fit the two transistors, TR1 and TR2, and the voltage regulator, IC2, again observing correct orientation in accordance with Fig. 5. If the temperature sensor, D4, is required to be internally mounted, it can also be fitted at this stage. With all these devices, it may be necessary to carefully preform (bend) the leads to suit the hole layout on the p.c.b.

All the remaining components should now be soldered to the p.c.b. The bridge rectifier, REC1, is the only other component whose polarity needs to be observed.

The l.c.d. display module is mounted on the p.c.b. using 30mm stand-off pillars and this should be fitted next. The mounting holes on the module are only 2·5mm in diameter and these may need opening out slightly, depending on the type of mounting pillars used.

Electrical connection between the l.c.d. module and the p.c.b. is made by ribbon cable. This should be carefully cut to length and appropriately stripped and tinned before being connected.

The PP3 battery is fastened to the p.c.b. using nylon tie wraps. These should be fastened as tightly as possible so that the battery is firmly held on the board. Electrical connection may be made by soldering a PP3 battery connector lead direct to the p.c.b. However, at this stage, the battery should remain disconnected.

Switches S1 to S4 and l.e.d.s D5 and D6, which are mounted on the box lid, are connected back to the p.c.b. using flying leads. These connections, though, should be made after the respective components have been mounted in the box lid.

CONTROLLER CASE

An ABS plastic case was used to house the prototype Central Heating Controller. Any other similarly sized enclosure could be used instead. However, if a metal box is used, the box should be suitably earthed in order to minimise any electrical shock hazard.

The drilling details for the box will depend on the choice of display bezel, switches and l.e.d. mounting clips used. The area for the display cut-out should be removed by a combination of chain drilling and filing.

The lower portion of the box should have four holes drilled in it to secure the p.c.b. mounting pillars and should be countersunk if a flush finish is desired. If wall mounting of the unit is required, two "keyhole" slots should also be drilled and filed out.

You will also need to drill holes for the mains cable, switched outputs and external temperature sensor (if fitted). Appropriate glands or grommets should be used with all cable holes. On the prototype unit, an external temperature sensor was not fitted and all other cable entry/exit points were on the lower face of the box.

The box lid can be suitably labelled using rub down transfers or similar to indicate the function of the switches and l.e.d.s.

FINAL ASSEMBLY

Before the unit is assembled, it is necessary to fit the display bezel, the front panel switches and the l.e.d.s to the lid of the case. The display bezel is supplied with

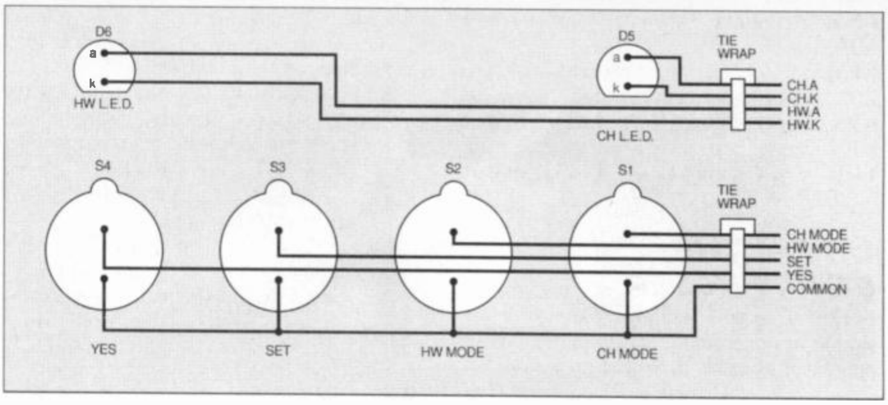


Fig. 6. Wiring connections to lid-mounted components.

the outer moulding and the filter separate. The filter has a protective film covering which should be removed before the filter is carefully pressed into the slots in the outer moulding.

The bezel assembly should be a push-fit in the case lid cut-out, but it may be found necessary to retain it with a small amount of plastic glue applied sparingly. The l.e.d. mounting clips and the switches used in the prototype are also push-fits in their respective mounting holes.

Electrical connections between the p.c.b. and the switches and l.e.d.s are by means of flying leads and a suggested way of doing this is shown in Fig. 6. Note that each l.e.d. has a separate connection and as these are polarity sensitive, care should be taken to ensure that the connections are made correctly.

When connecting up the flying leads, it is useful to allow sufficient length so that the box lid can be removed and laid to one side to allow access to the internal connections. Once the leads have been soldered up, nylon tie wraps should be used to neatly loom the individual cables together.

Once construction of the Central Heating Controller is complete, it is strongly recommended that you follow the advice concerning testing before applying power.

TESTING

When power is applied to the unit it should be borne in mind that several areas of the printed circuit board are at mains potential and therefore great care should be exercised. If you are in doubt about the mains electrical wiring, consult a qualified electrician.

The first test of the assembled p.c.b. should be a visual one to check for any soldering defects and for the correct orientation of polarised components. If all appears to be satisfactory, the battery can be connected and the unit carefully wired up to the mains supply. This should be done with all of the socketed i.c.s. removed as a precaution to avoid damage if there is a problem.

If the mains power supply circuitry is working correctly, then approximately 17V d.c. should be present across pins 8 and 4 of the socket for IC1. The precise voltage will depend on the transformer used and the load it is supplying. The battery voltage of approximately 9V d.c. should also be present across pins 2 and 4 of the same socket.

If all is in order, the unit should be powered down by removing the mains *and* battery supplies, after which IC1 can be inserted and both power sources re-applied.

A voltage of about 17V d.c. should now be present between pins 1 and 4 of IC1. Voltage regulator IC2 should be producing an output of 5V d.c. (±0.25V d.c.). Check also that 5V is present at all the relevant points on the p.c.b. If this is not the case then the most likely cause is a poor solder connection or open circuit on one of the p.c.b. tracks.

If all appears to be in order, the next task is to adjust the contrast setting on the l.c.d. display module by means of preset VR1. This should be adjusted until the display becomes just visible as a series of blank "blocks" in each character position.

The two output relays can be tested by temporarily "patching" a lead from pin 20 (5V) on the socket for IC3 to pins 9 and 11 in turn on the same socket. As the +5V is applied to each pin, the relevant relay should be heard to operate and the corresponding l.e.d. should illuminate.

This is about the extent of testing that can reasonably be performed so the next operation is to adjust presets VR2 and VR3 so that the analogue-to-digital converter (IC4) is correctly configured. This can either be done using the "default" settings described earlier in the text, or using the more accurate calibration procedure which is given in the following section.

The unit should now be powered down and the remaining integrated circuits (IC3 and IC4) inserted in their respective sockets.

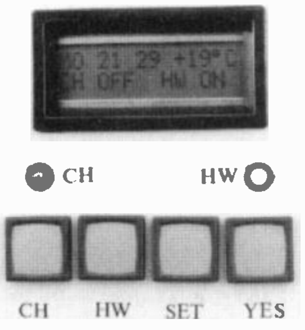
Microcontroller IC3 should, of course, already be pre-programmed with the controlling software – see later.

Both power sources can now be reapplied and if all is well, the unit should display an initial time and temperature on the upper line of the l.c.d. and the status of the "CH" and "HW" outputs on the lower line.

TEMPERATURE CALIBRATION

As mentioned earlier, the nominal output of the LM335 temperature sensor is 10mV/°K, although this may differ slightly between devices. The only thing that can be guaranteed is that at a temperature of absolute zero (−273°C) the output of the device will be 0V. *(Don't try to check this assertion! Ed.)* To compensate for slight differences, the settings of VR2 and VR3 can be optimised as follows:

- Measure the voltage at IC4 pin 2



- Note the ambient (room) temperature in °C
- LM335 output = measured voltage/ (measured temperature + 273)
- VR2 wiper setting (V) = LM335 output ×253
- VR3 wiper setting (V) = LM335 output ×63.75

USING THE CONTROLLER

The Central Heating Controller is simple to use in that each switched output only has four basic modes of operation:

- OFF Output off all the time
- ON Output on all the time
- T2 Output on for two periods each day
- T1 Output on for one period each day

The desired output mode is set by means of the *CH* and *HW* front panel switches. Pressing these will cycle through the available options with the user choice being displayed on the lower line of the l.c.d.

PROGRAMMING THE CONTROLLER

Before the Controller can be used, it is necessary to program the current day of the week and the current time into its memory. If the following preset switching times are not satisfactory, these may also be reprogrammed

• Central heating ON	(Period 1)	06:30
• Central heating OFF	(Period 1)	08:30
• Central heating ON	(Period 2)	16:30
• Central heating OFF	(Period 2)	21:30
• Hot water ON	(Period 1)	06:30
• Hot water OFF	(Period 1)	08:30
• Hot water ON	(Period 2)	16:30
• Hot water OFF	(Period 2)	21:30

It should be noted that when the unit is in T1 mode, i.e. one On period per day, the On time is given by the appropriate Period 1 On time and the Off time by the appropriate Period 2 Off time.

TIME SETTING

The current day and time is set as follows:

1. Press SET. The upper line of the display will go blank and the lower line will prompt you with "TIME ?"
2. Press YES. The upper line of the display will show the first two letters of the day of the week, e.g. "MO" for Monday
3. Increment the day to the correct setting by repeatedly pressing CH
4. Press SET to confirm the day setting. The upper line of the display will now also show the time in the form of "hh:mm" where "hh" is hours and "mm" is minutes
5. Increment the hours to the correct value by repeatedly pressing CH
6. Increment the minutes to the correct value by repeatedly pressing HW
7. Press SET to confirm these settings and return to the main display. Note that as SET is pressed, seconds are set to zero so the clock can be synchronised to an external time source if required.

SETTING FUNCTION TIMES

Setting the program function times follows a similar procedure:

1. Press SET. The upper line of the display will go blank and the lower line will prompt you with "TIME ?"
2. Press SET again. The lower line of the display will prompt with "PROG ?"
3. Press YES. The lower line of the display will show "MO" for Monday
4. Increment the day to the correct setting by repeatedly pressing CH
5. Press YES when the correct day for which you wish to set the program times is shown. The upper line of the display will show "CH 1 ON hh:mm", where "hh:mm" is the currently set time in hours and minutes
6. The time setting can be changed by means of CH and HW as described earlier, although it should be noted that the program times can only be incremented in 10 minute steps
7. Press SET when the correct time is showing. The display will now show "CH 1 OFF hh:mm". This time can also be altered as explained above
8. Step 7 can be repeated until all the program times have been programmed. After "HW 2 OFF" has been programmed, pressing SET will return you to step 4 with the next day showing, e.g. "TU"
9. You now have a choice of repeating steps 5 to 8 for the day shown, or returning to the main display by repeatedly pressing CH until Sunday (SU) has been and gone!

Note that it is not possible to "escape" from a sequence once you are in it, it must be completed, though this can be done by repeatedly pressing SET without having to change other settings.

Also, be aware that the unit does not have the capability to check if the times you have entered are valid times, and to avoid erroneous operation you should adhere to the following rules:

- All On and Off times should be programmed in a single 24 hour period i.e. between 00:00 and 23:50
- On times for a particular period should be before the corresponding Off time
- Period 1 Off times should occur before the Period 2 On time

THERMOSTAT SETTING

To set the thermostat temperature, follow this procedure:

1. Press SET. The upper line of the display will go blank and the lower line will prompt you with "TIME ?"
2. Press SET again. The lower line of the display will prompt with "PROG ?"
3. Press SET again. The lower line of the display will prompt with "TEMP ?"
4. Press YES. The upper line of the display will show "+xx°C", where "xx" is the currently set thermostat temperature in degrees Celcius.
5. The temperature setting can be changed by means of the CH key. It only counts upwards; to set a lower temperature than that shown, CH must be repeatedly pressed until the start of the cycle at −20°C appears following +43°C
6. When the desired temperature is displayed, press SET to return to the main display

If you do not require the thermostat facility on the Central Heating output, then setting the thermostat to the maximum (normally unattainable!) temperature of +43°C will to all intents and purposes achieve this.

INSTALLATION

Installation of the Central Heating Controller should be straightforward but will to a great degree depend on the nature of the rest of the central heating and domestic hot water system. It should be noted that if the central heating system does not allow heating to be on without hot water i.e. gravity fed, then care should be taken to ensure that the unit is programmed correctly to reflect this.

As an added precaution for mains powered solenoid valves, the CH output should be wired through the HW output as shown in Fig. 7. If there is any doubt at all about how the Central Heating Controller should be installed, then it is recommended that a qualified central heating engineer should be consulted.

As mentioned earlier, the temperature sensor, D2, can be remotely mounted and if this option is used then twisted cable should be used with a maximum cable length of five metres. The sensor can be insulated by using adhesive filled heat shrink tubing.

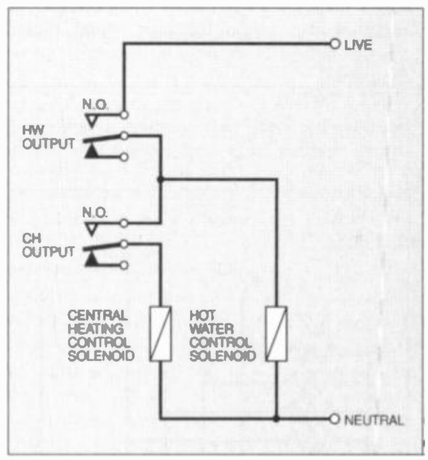


Fig. 7. Safety interlock wiring example.

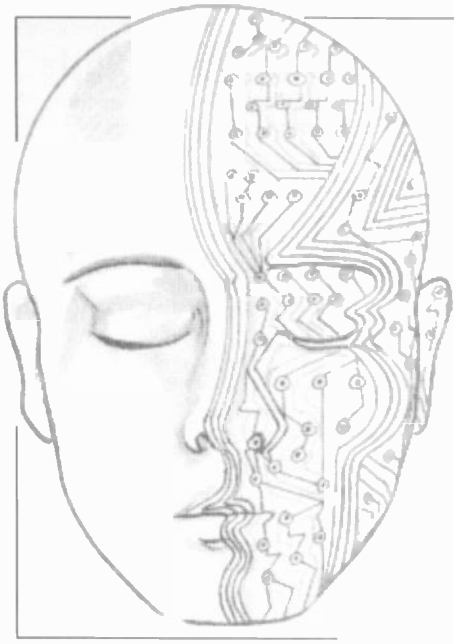
SOFTWARE

Pre-programmed microcontrollers for this design are available direct from the author for £20 all inclusive, see *Shoptalk* page.

The software is also available on a 3.5 inch disk from the *EPE* Editorial office for £2·50 to cover admin costs (the software itself is *free*). This disk also includes software for other recent *EPE* projects – see *EPE PCB Service* page for details.

Alternatively, Internet users can download the software *free* from our ftp site: **ftp://ftp.epemag.wimborne.co.uk**. There are five files, totalling just under 20K bytes, held in the directory named "Heating" – you need all five.

Note that the software has been written in "C" and that in order to program the microcontroller, you need a programmer which is intended for use with the Atmel 89C2051 microcontroller (the PIC programmers recently published in *EPE* are *not* suitable).



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8-bit Binary-to-Decimal Converter

– handy test project

THE design illustrated in Fig. 1 is one which I created to help me when testing a number of digital projects using 8-bit data buses. The decimal value of the eight input lines is displayed on three 7-segment displays. Whilst chips exist to perform this function for single displays, none include the possibility of displaying numbers greater than nine.

No EPROM is necessary in this design. It operates by using two counters synchronised to one another, one which generates an 8-bit binary output and a second counter which drives the display. If the display is only updated when the binary counter is at the same value as the input, then the display will show the decimal value of the input.

IC4 is the binary counter and IC6 to IC8 form the display/counter section. IC5a and IC5b form the astable which clocks both counters at some 5kHz. The minimum display refresh rate is therefore 20 times per second. IC1 and IC2 are two 4-bit comparators, ganged to form an 8-bit comparator. This compares the output of the binary counter IC4 with the binary input taken from the circuit under test. Resistors R1 to R8 pull down the input lines to prevent them floating when no input is connected.

When the comparator inputs are equal, pin 6 of IC2 goes high, triggering the monostable IC3ab which outputs a brief pulse. This latches the value of the display counters IC6 to IC8 to the display. When IC4 reaches a value of 256, the link between pins 11 and 12 resets the chip, and this resets the display counter also.

Tom Baldwin,
Romsey, Hants.

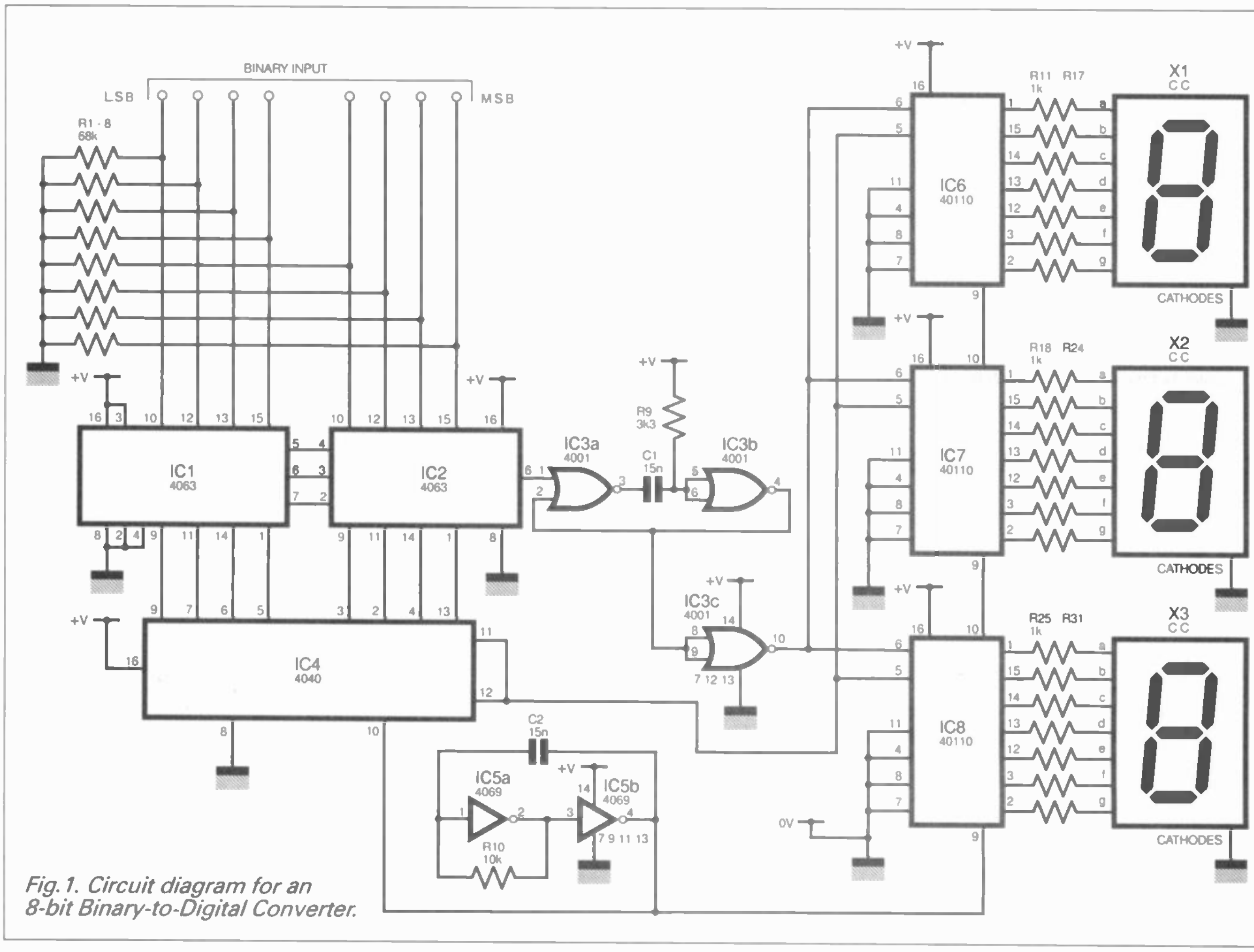

Fig. 1. Circuit diagram for an 8-bit Binary-to-Digital Converter.

L.E.D. Quick Test – check in a flash

My idea for a handy unit to quickly check l.e.d.s. is shown in Fig.2. The circuit was intended as a simple one to enable it to be used at Radio Rallies for spot testing of bulk surplus l.e.d.s. A flashing l.e.d. is used (D1) with a 9V battery, and is connected to a coaxial socket.

By placing a test l.e.d. across the socket (anode to the inner conductor), both the flashing l.e.d. and the test l.e.d. will flash. No on-off switch is necessary.

Mark McGuinness,
Clondalkin, Dublin, Ireland.

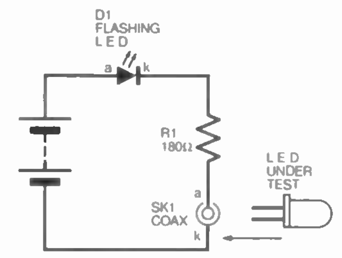

Fig.2. L.E.D. Quick Test circuit.

Model Railway Level Crossing Lights

The small circuit of Fig. 3 is for use on model railway layouts and approximates the flashing light signals used at level crossings. It is operated by a reed switch (S1) embedded in the track, which is closed by a magnet on the underside of a passing train. This triggers the monostable timer IC1, which powers a Darlington transistor pair TR1 and TR2.

Diodes D1 and D2 (orange) illuminate and also TR3 and TR4, connected as an astable, cause the red l.e.d.s D3 to D6 to flash alternately for about six seconds, enough for the train to pass. One set of l.e.d.s is used on each side of the level crossing, for added realism. 3mm l.e.d.s are best for "00" scale.

Peter Gent (14),
Sutton, Surrey.

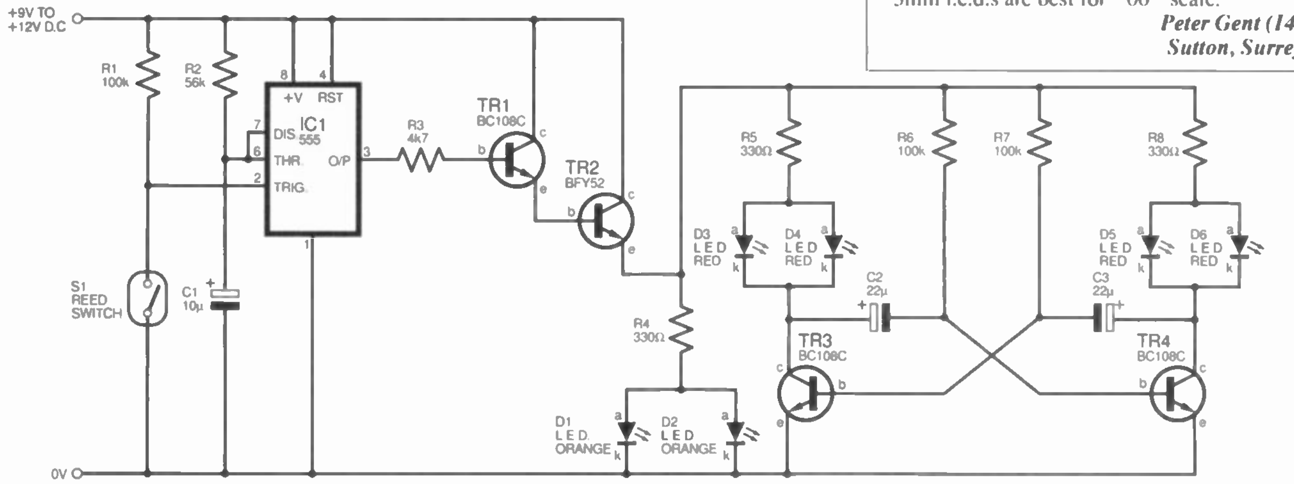

Fig.3. Circuit diagram for replica Model Railway Level Crossing Lights.

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Jake Rothman

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Some assembled and tested boards available:-
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New Technology Update

Reliability becomes one of the key words with the introduction of a special range of "lead frame base" modules – reports Ian Poole

CIRCUIT modules can be used in a number of niche applications. They are usually manufactured by placing surface mount components (s.m.d.s.) onto a substrate which is then encapsulated to provide protection. Often the packages are costly and cannot be repaired if they fail, although this is no different to an i.c.

One example of an area where modules are widely found is for crystal oscillators which are used in a wide variety of applications where accurate signals are needed. Often they are manufactured as small modules which can be sold separately and mounted directly onto boards. Another area is for d.c.-to-d.c. converters.

Whilst this approach enables items like these to be bought in by equipment manufacturers, they have two main drawbacks. These mainly arise because the techniques used in manufacturing do not lend themselves to automatic assembly. The first is cost, and the second is equally important, and is the reliability.

Reliability

Reliability is a particularly important factor in today's electronics industry. Fortunately, the quality of electrical goods is improving all the time. Television sets are a very good example. In the days of valve sets, it was not uncommon to have the repair man visit two or three times a year.

The introduction of semiconductors brought about an improvement, but even then a large number of repairs were required. After the Japanese manufacturers entered the market with very high quality goods, this forced other manufacturers to follow suit. Nowadays it is not uncommon to have a TV set work for ten years or more without the need for repair.

The reliability of a product is obviously dependent upon the workmanship whilst it is being built. However, it is far more dependent upon the design and methods used in production. Poor design may over stress a component which fails after a while. Alternatively, a poor production process will leave many latent faults in the equipment which may appear at any time.

It is for this reason that any new method used in manufacturing modules needed to be carefully designed and *appraised* before being introduced to the production line.

Lead frame base

In view of the problems with existing modules the Power Management group at National Semiconductor set up a study to investigate better methods of manufacturing modules.

Their aims were to produce a module which was in an i.c package. It would need to be possible to automate the manufacture of the package, and its cost would need to be comparable with that of an i.c.

The solution has been developed using a 24-pin dual in-line i.c. package, and it measures no more than 6mm above the board, making it ideal for a wide variety of applications. The inside consists of a "lead frame system" on which the components are mounted.

This does not have a substrate or insulating base material to act as a support for the lead frame. The plastic which is moulded around it gives the support. Areas where components are to be soldered are silver plated to give increased solderability.

the moulding process. The temperatures involved damaged many components and they could not be used.

To overcome this problem a number of special components were developed, and some existing ones were modified to cope with the very high temperatures. Coils particularly broke down under temperature with short circuit turns or the ferrites were damaged. A number of new techniques were used in the coil manufacture and this has cured the problem.

Capacitors now represent the major limitation to the technology. The physical size required for some capacitors means that they cannot be used. This limits the largest values which can be incorporated.

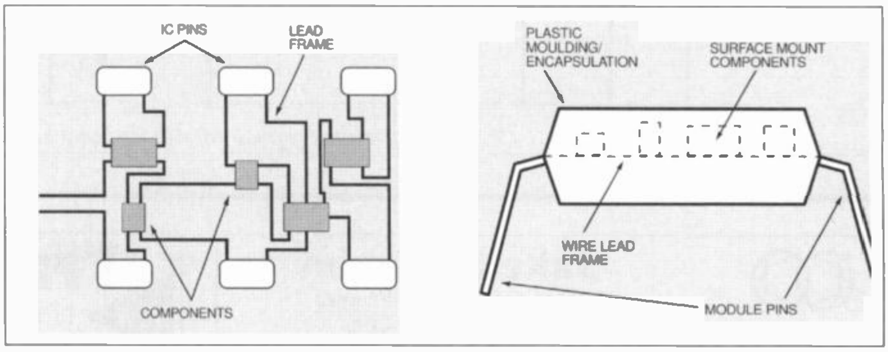

Fig. 1. Basic construction of a lead frame based module

One limitation of the system is that all the nodes must be brought out to the pins on the i.c. package because there are no mechanical supports for "internal islands". This limits the number of nodes in the circuit to only 24.

Nevertheless, this is quite sufficient for many small circuits and is unlikely to be a major limitation in the short term. At the moment even the full capacity of 24 nodes is not likely to be used. This is because the size of the internal components limits the complexity of the circuits which can be contained in the package.

Usually surface mount components are used. In the case of semiconductors the basic unpackaged die is used. The use of die instead of packaged semiconductors saves space in the module and also reduces costs if very large volumes are to be made.

Once the lead frame assembly has been assembled, it has plastic moulded around it. This gives the frame its strength and enables the required levels of reliability to be achieved.

Hurdles

One of the major problems encountered with the system was to find capacitors and inductors which could withstand

Current Usage

The new technique is being used for some d.c.-to-d.c. converters. In this manufacture yields of over 95 per cent have been achieved which is better than many i.c. processes.

Life testing has also been carried out and it has been calculated that the reliability of the modules will exceed expectations. Their reliability is now compared to that of an i.c. which is operating well within its limits.

Heat dissipation capacity is an important factor. Current experiments show that relatively high levels of power can be dissipated. There are two reasons for this. The first is that the components are distributed around the package and not in contact with one another. The second is that the lead frame provides a means by which the heat can be extracted from the package. As relatively wide tracks are used, heat conduction is good.

A further advantage is that the use of standard components has shown that many designs give improved performance with regard to electro-static discharge (e.s.d.). In view of the possibilities and the low costs involved, it is likely that many more of these products will be seen in the near future.

Is your PCB design package not quite as "professional" as you thought? Substantial trade-in discounts still available.

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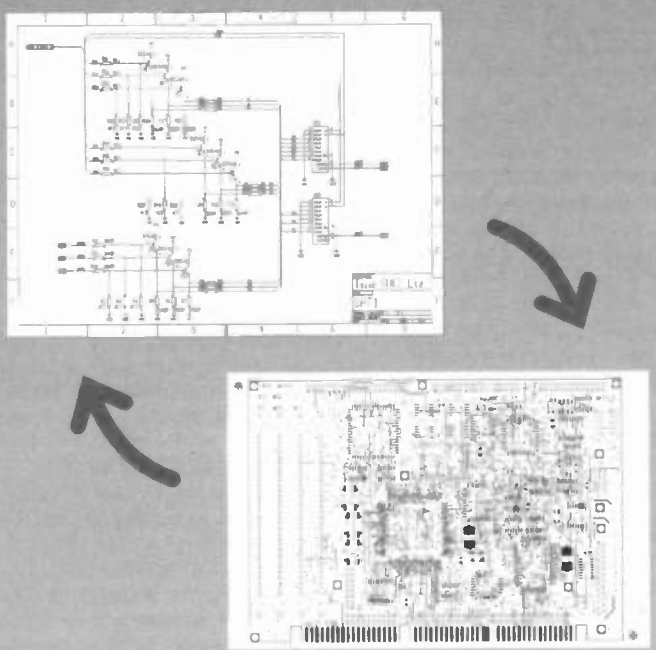

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- Full netlist support- BoardCapture, OrCad, Schema, Tango CadStar
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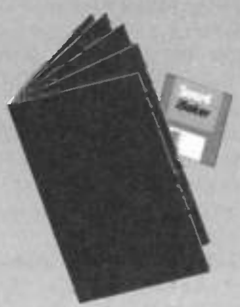

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Constructional Project

EPE ELYSIAN THEREMIN WITH MIDI BOX

JAKE ROTHMAN — PART 1

From being the sensation of the 20s the Theremin is about to be the hit of the 90s! Already in demand for "live performances" and for studio sound tracking.

FOLLOWING the soaring success of the simple, pocket sized, Theremin we are proud to present a "full-spec" design for the serious professional "musician" or studio user. As far as we can tell we believe the *EPE Elysian Theremin* is the first ever design with a MIDI Interface (details in January and February 1997 issues).

SIMPLE THEREMIN

In September last year *EPE* published a *Simple Theremin* design which became the world's first commercial pocket design *(the Sept '95 issue is completely "sold out" so we can only offer a photostat copy of the article – see "Back Issues" page – Ed)*. Its low-cost gave many people a taste of the instrument for the first time.

However, to achieve the low retail price the pocket Theremin did not have a volume aerial. This meant that the volume had to be controlled by other means, such as a foot pedal. The original RCA Theremins had a special loop which controlled the volume by hand capacitance, enabling the volume to be controlled by free-space hand movement as well as the pitch.

THEREMIN – THE LEGEND

Since the Theremin has received a lot of media attention recently, a whole mythology has been built up by non-technical people. Stories about Leon Theremin's abduction by the KGB and of inventing a colour television system in 1920s abound.

It is not *EPEs* job to elaborate on such conjecture, but to explain the technical details involved. Suffice it to say, it is the author's opinion that Theremin simply developed the well known radio phenomena of "hand capacitance" and the whistles that often accompanied it.

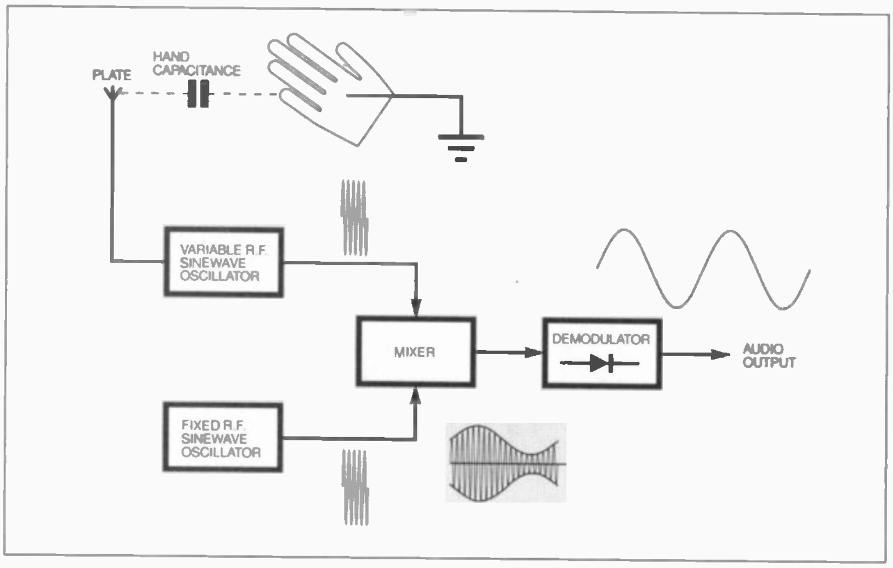

Fig. 1. Block diagram for a simple Theremin.

BASIC PRINCIPLES

The simplest Theremin consists of two radio frequency (r.f.) oscillators being mixed together, demodulated and then amplified as shown in Fig. 1.

Making the frequency of the oscillators higher increases the sensitivity although the tendency to instability increases. Aerial size also plays an important part since capacitance is proportional to area.

VOLUME CONTROL METHODS

The volume control has always been the most difficult aspect of Theremin design and virtually every commercial instrument has used a different approach. It is worth discussing briefly the circuits involved since they are all quite unique.

There have been basically five different methods used so far: damped oscillator; resonant plate; capacitive potential divider; dual-Theremin and finally phase control.

Damped Oscillator

This is the original method used in the RCA Theremin in the thirties. In this circuit the amplitude of a high frequency oscillator becomes damped or reduces as the hand approaches the aerial. This was then amplified to a few watts power to feed the heater of a directly heated triode valve. This enabled the brightness of the heater to vary with the oscillator output.

When the hand was near, the heater was almost cold, giving minimum volume. With the hand far away, full oscillator output was obtained giving full brightness, maximum electron emission and hence full volume. This valve circuit could be thought of as a crude form of voltage controlled amplifier or VCA for short.

One problem with this system was that there was a delay due to the thermal heating time of the filament and still today most Theremin parts are for slow sustained notes rather than percussive staccato

EVERYDAY PRACTICAL ELECTRONICS

READERSHIP SURVEY

We are determined that EPE will continue to be the leading UK publication in this market. To achieve this it is vital that we keep up-to-date with the interests and needs of our readership.

I would be grateful, therefore, if you would spare a few minutes to fill in and return (by FREEPOST) this questionnaire.

Every reply received before November 25th will be entered in a draw for one of two £75 prizes.

Many thanks for your help.

EDITOR

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If you wish to enter the draw for one of two £75 prizes please print your name and address below. This information will not be disclosed to any third party.

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Address...

....

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The names of the prize winners will be published in the February '97 issue of EPE

P.S. *The information you supply will be treated as strictly confidential and used only for the development of EPE.*

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Section 1 - THE MAGAZINE

1. How did you first hear about *Everyday Practical Electronics*?

Saw it in a newsagents ☐
Friend told me about it ☐
Saw it advertised ☐
Saw it at an exhibition / club ☐

Other *(please specify)*..

2. How did you get this copy of *Everyday Practical Electronics* ?

Went to the shop especially to buy it ☐
Saw it in a shop and decided to buy it ☐
I have it on subscription ☐ Please go to Question 4.

Newsagent saved it / delivered it for me ☐
A friend gave it to me ☐

Other *(please specify)*..

3. Where do you usually buy your copy of *Everyday Practical Electronics*?

W H Smith / John Menzies ☐
Other Large Newsagent Chains (Martins, Forbuoys) ☐
Local Shop ☐
Rail/Tube Station Kiosk ☐
Supermarket ☐

Other *(please specify)*..

4. How long have you been reading *Everyday Practical Electronics* ?

This is the first issue ☐
3 to 6 mnths ☐
6 mnths - 1 yr ☐
1 to 2 yrs ☐
2 to 3 yrs ☐
3 years + ☐

5. How many issues of *Everyday Practical Electronics* have you read in the last 12 months ?

1 - 3 ☐ 7 - 11 ☐
4 - 6 ☐ Every issue ☐ Please go to Question 7.

6. What made you buy this issue of *Everyday Practical Electronics* ?

I buy every issue ☐
The cover looked interesting ☐
Somebody else bought me the title ☐
A friend recommended it ☐
For a particular article/project ☐
To see the advertisements ☐

Other *(please specify)*..

7. How many other people read your copy of *Everyday Practical Electronics* ?

No one else reads it ☐
1 to 2 ☐
3 to 4 ☐

More than 4 *(please specify)*...

8. *Everyday Practical Electronics* is £2.45. How do you rate it in terms of value for money ?

Very good value for money ☐
Fairly good value for money ☐
Poor value for money ☐
Very poor value for money ☐

9. Have you ever had a problem finding *Everyday Practical Electronics* in a shop ?

Often ☐
Sometimes ☐
Never ☐

10. Please indicate which of the following regular items you find of interest ?

	Very interesting	Quite interesting	Not interesting
Teach-In/Theory Series and Features	☐	☐	☐
Ingenuity Unlimited	☐	☐	☐
Circuit Surgery	☐	☐	☐
Interface	☐	☐	☐
Techniques	☐	☐	☐
Net Work	☐	☐	☐
Innovations	☐	☐	☐
New Technology Update	☐	☐	☐
Fox Report	☐	☐	☐
Ohm Sweet Ohm	☐	☐	☐
Advertisements	☐	☐	☐

11. Please indicate which articles in this issue of *Everyday Practical Electronics* you found of interest ?

	Very interesting	Quite interesting	Not interesting
Theremin	☐	☐	☐
Central Heating Controller	☐	☐	☐
Scratch Filter	☐	☐	☐
DC to DC Converters	☐	☐	☐
Build Your Own Circuits	☐	☐	☐

12. Which of the following types of projects are you interested in ?

	Very interested	Quite interested	Not interested
Radio	☐	☐	☐
Computing	☐	☐	☐
Test Gear	☐	☐	☐
Alarms	☐	☐	☐
PIC based/Microcontrollers	☐	☐	☐
Audio/Hi-Fi	☐	☐	☐
Musical	☐	☐	☐
Car	☐	☐	☐
Household	☐	☐	☐
Games/Toys	☐	☐	☐
Robots	☐	☐	☐
Metal Detecting	☐	☐	☐
Boating	☐	☐	☐
RC Models	☐	☐	☐
Photographic	☐	☐	☐
TV/ Video	☐	☐	☐

Other *(please state)*..

13. Are there any particular projects which you would like to see featured ? *(Please specify)*

....

....

14. On the whole, how would you describe the complexity of the projects in *Everyday Practical Electronics*?

Too simple ☐
About right ☐
Too complex ☐

15. How do you rate the cost of building *Everyday Practical Electronics* projects?

Inexpensive ☐
Reasonably priced ☐
Slightly overpriced ☐
Far too expensive ☐

16. How many purchases have you made by mail order from advertisers in the magazine in the last year ?

1 -3 ☐
4 - 6 ☐
6 or more ☐
None ☐ Please go to Question 18

17. How much have you spent on these products in the last year ?

£1 - £15	☐	£51 - £75	☐
£16 - £30	☐	£76 - £100	☐
£31 - £50	☐	Over £100	☐

18. How often do you buy each of the following electronics magazines?

	Subscribe	Regularly	Occasionally	Never
Electronics and Wireless World	☐	☐	☐	☐
Electronics: The Maplin Magazine	☐	☐	☐	☐
Electronics Today International	☐	☐	☐	☐
Elektor Electronics	☐	☐	☐	☐
Practical Wireless	☐	☐	☐	☐

Other *(please state)*...

19. Do you read or look at any of the following daily newspapers regularly (at least 4 times per week), occasionally or never ?

	Regularly	Occasionally	Never
Daily Express	☐	☐	☐
Daily Mail	☐	☐	☐
Daily Mirror	☐	☐	☐
The Sun	☐	☐	☐
Daily Telegraph	☐	☐	☐
The Guardian	☐	☐	☐
The Independent	☐	☐	☐
The Times	☐	☐	☐
The Scotsman	☐	☐	☐
Local Newspaper	☐	☐	☐

Other *(please state)*...

Section 2 - YOUR HOBBY

20. How much have you spent on electronics over the last year ?

£0 - £20	☐	£81 - £100	☐
£21 - £40	☐	£101 - £150	☐
£41 - £60	☐	£151 - £200	☐
£61 - £80	☐	Over £200	☐

21. Do you belong to any of the following groups / associations ?

RSGB ☐
IEEE ☐
BAEC ☐

Any other electronics/computing club or association

(please specify)...

....

22. On average, how many hours a week do you spend on electronics, in your spare time ?

1 - 4 hours ☐
5 - 8 hours ☐
9 - 16 hours ☐
Over 17 hours ☐

23. How long have you been involved in electronics ?

0 - 12 months	☐	4 - 6 years	☐
13 - 24 months	☐	7 - 10 years	☐
2 - 3 years	☐	Over 10 years	☐

24. How would you describe your skill level?

Beginner ☐
Intermediate ☐
Advanced ☐
Expert ☐

25. Do you have access to a PC compatible computer?

I own a computer but it is not PC compatible ☐ Please go to Q27
Yes, I own a PC ☐
Yes, at work ☐
Yes, at school/college ☐
Yes, I use a friend's PC ☐
I do not have access to a computer ☐ Please go to Q27

26. Does the computer have a CD-ROM drive?

Yes ☐
No ☐

27. If you do not own a PC compatible computer do you intend to buy one?

Yes, in the next year ☐
Yes, at sometime ☐
No ☐

28. Do you have access to the Internet?

Yes, through my computer ☐
Yes, at work ☐
Yes, at school/college ☐
Yes, through my friend's computer ☐
No ☐

Section 3 - ABOUT YOU

This section allows us to look at who buys *Everyday Practical Electronics*. Please note that your answers are *strictly confidential* and will only be used for the purposes of developing *Everyday Practical Electronics*.

29. Are you:

Male ☐ Female ☐

30. How old are you ?

Under 16	☐	30 - 39	☐
16 - 18	☐	40 - 49	☐
19 - 21	☐	50 - 59	☐
22 - 29	☐	60 +	☐

31. What is your marital status

Single ☐
Married ☐
Living with partner ☐
Separated / divorced ☐
Widowed ☐

32. How many children do you have ?

none	☐	3	☐
1	☐	4 or more	☐
2	☐		

33. Do you work ?

Full time	☐	Self employed	☐
Part time	☐	Unemployed	☐
Housewife	☐	Retired	☐
Student	☐		

34. The following question on annual income helps us to complete the picture on the demographic composition of our readers. What is your total household income?

Under £2, 500 ☐
£2, 501 - £5, 000 ☐
£5, 001 - £7, 500 ☐
£7, 501 - £10, 000 ☐
£10, 001 - £15, 000 ☐
£15, 001 - £20, 000 ☐
£20, 001 - £30,000 ☐
Over £30, 000 ☐

35. Where do you live? (See map)

North ☐
Yorkshire / Humberside ☐
East Midlands ☐
East Anglia ☐
South East (excluding London) ☐
Greater London ☐
South West ☐
West Midlands ☐
North West ☐
Wales ☐
Scotland ☐
Ireland ☐

Overseas *(please specify)* ....

36. Do you have any electronics-related qualifications?

No qualifications ☐
GCSE ☐
A Level ☐
City & Guilds ☐
BTEC ☐
Degree ☐

Other *(please specify)*..

37. How would you describe your present involvement in electronics?

It's my hobby ☐
I am a student trainee ☐
I am a technician/service engineer ☐
I am a professional engineer/designer ☐

Other *(please specify)*..

38. In which of the following activities do you regularly participate?

Eating out	☐	Computing	☐
Walking	☐	Surfing the Internet	☐
Gardening	☐	Fishing	☐
Model making	☐	Home decoration/DIY	☐
Reading	☐	Radio Controlled Models	☐

Sport *(please specify)*..

The responses to all of these questions are strictly confidential and will not be disclosed to any third party, but will only be used to help us to design and produce a better magazine for you.

If you have any further comments or suggestions to make regarding *Everyday Practical Electronics*, please write them here:

effects (although the MIDI Box should change this). Another problem was that the volume control had a *negative* control characteristic, that is the volume reduced as the instrument was approached.

This was not considered a problem at the time, since the Theremin was used as an instrument for "classical" music in conjunction with an orchestra. In this situation, as anyone who has seen a conductor will know, a downward movement of the hand signifies a decrease in volume and an upward motion an increase.

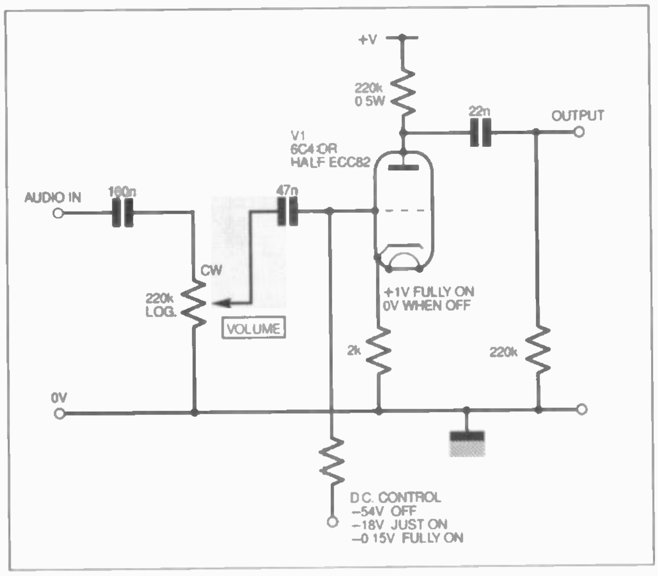

Fig. 2. Circuit for a valve voltage controlled amp. (VCA).

However, since Theremins have now taken off in pop and general electronic music, a positive characteristic is expected where the volume increases as the hand is brought closer. It is possible to obtain this characteristic by rectifying the output of the damped oscillator and inverting before feeding into the VCA. For those interested, a valve VCA is shown in Fig. 2.

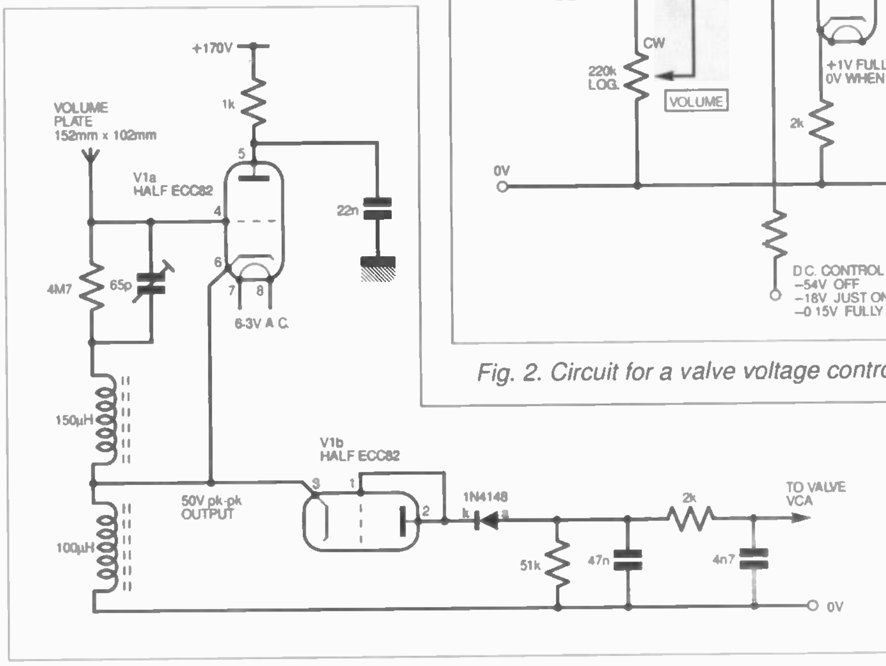

Fig. 3. Valve driven "damped oscillator" Theremin circuit.

The damped oscillator system works particularly well with valves because the high supply voltages used ensure that a large amount of "headroom" is available. A suitable circuit is shown in Fig. 3 for those wishing to build a valve Theremin.

With solid-state devices this system is not so effective since it is difficult to ensure a wide dynamic range, although this is not a problem if dual-rails of at least plus and minus 12V are used. This system is used in the Moog circuits.

Resonant Plate

Another volume control method is to use an oscillator feeding a tuned circuit comprising an inductor and the hand/plate capacitance (see Fig. 4). This system was used in the Theremin designed by the author for the *Modern Electronics Manual*.

This was the simplest circuit possible for a Theremin with a volume plate. However, as with all cheap and cheerful systems, the performance was compromised and the circuit only gave a range of a few inches and was quite abrupt and difficult to tune. This system was also used in the Babani circuit of the 1970s.

It is interesting to look at the developments of the next few circuits since these chart the commercial development of the original *MEM* circuit into the UK's first commercial Theremin called the Mk1 which was marketed and produced by Longwave Instruments.

Capacitive Potential Divider

The next stage in the development was to dispense with the tuned circuit and just rely on the capacitive potential divider effect, the principle of which

Features . . .

- World First Midi compatible Theremin! Interfaces with Adam Fullerton's MIDI Box *(Jan '97 issue – Order Your Copy – Now!)*
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- For the advanced constructor (oscilloscope required)

is shown in Fig. 5. This made the circuit simpler and less critical.

Later on, a pot. (potentiometer) was added to the volume plate oscillator to vary its output level to trim the volume plate so that it was just off when the hand was away from the plate. This maximised the sensitivity. Later a coil of much larger value (10mH) was put back, to ground the plate at low frequencies to reduce hum pickup.

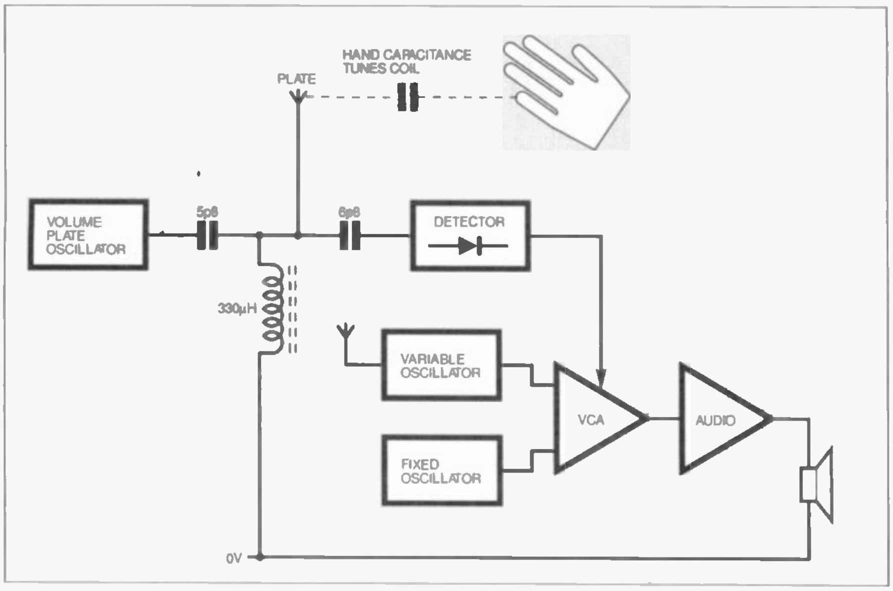


Fig. 4. Block diagram of resonant volume control used in MEM Theremin.

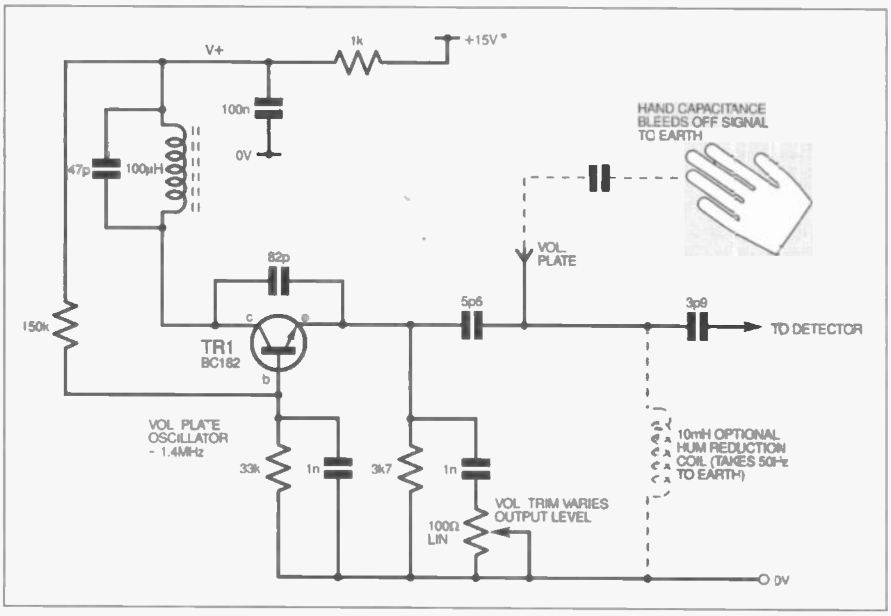


Fig. 5. Capacitive potential divider with volume trim on fixed oscillator.

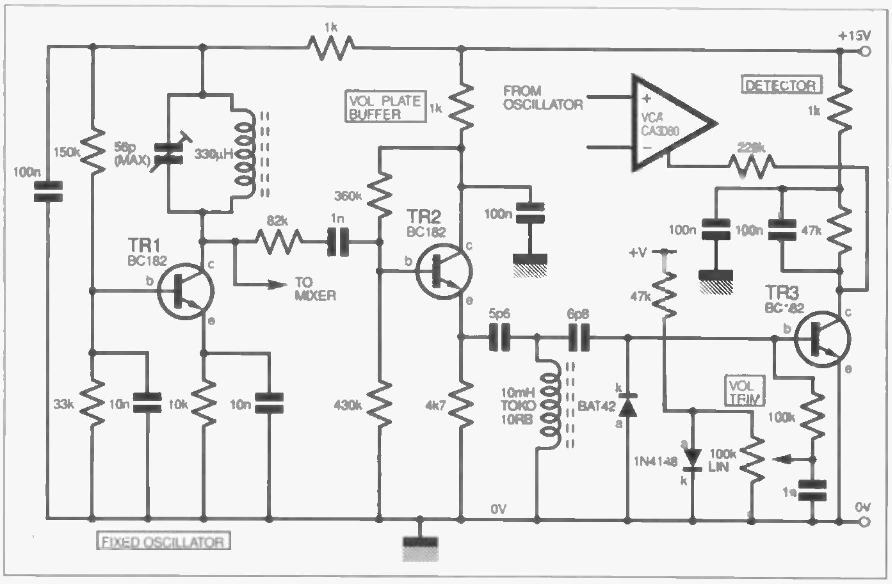


Fig. 6. Volume circuit, with bias control, for Mk1 model.

In the next design iteration, the volume trim control was replaced by a d.c. control varying the bias on the VCA control transistor as shown in Fig. 6. The final evolution in the Mk1 was to replace the volume oscillator with a buffer amplifier fed from the fixed oscillator. This resulted in the lowest coil-count and simplest circuit for any Theremin with a volume plate.

An unforseen side effect did occur however, and that was a slight pitch shift when the volume plate was used. This was traced to a bootstrapping effect due to the fixed oscillator signal coupling from one hand to the other, reducing the apparent capacitance seen by the pitch aerial. One advantage with this system was that with the absolute minimum of oscillators, the r.f. problems of electro magnetic compatibility (EMC) were minimised.

Eventually, the Mk1 was superseded by the Mk2 which was a Mk1 board with a special "turbo" board plugged into the VCA CA3080 socket. This was necessary to reduce the distortion caused by the simple combined mixer/VCA circuit of the Mk1. People in studios had requested the low distortion sinewave sound of the original and were fed up with having to filter the ramp waveform the Mk1 provided.

The Mk II turbo sounded good and was originally used for the development of the MIDI box. However, when transmitted into the unforgiving world of digital, certain limitations were revealed. In particular the volume plate had insufficient control distance (76mm/3in.) and the pitch shift became more noticeable.

Also, competition had finally arrived, a new foreign Theremin had come onto the market with a 203mm (8in.) volume range, although it used 15 coils! The end result was to design a new volume control circuit and combine it all on a new single p.c.b. with no wiring; so here it is.

Dual-Theremin

A commission to make a Theremin controlled radio circuit for an esoteric sculpture showed it was possible to make a Theremin-to-voltage converter circuit. Basically the new volume circuit entailed using a Theremin to control the volume of another Theremin producing the pitch, as shown in Fig. 7.

Although when the two Theremins were combined, difficult problems were encountered removing interactions and heterodyne whistles between the four oscillators. Eventually after several nights of analogue anarchy the whistles were laid to rest, culminating in the design given here. A Theremin popular with home constructors in the USA is the Theramax (TM) which also uses the dual Theremin system in conjunction with a discrete VCA.

Phase Control

The final volume control system is to use a phase detector with feed taken from the fixed oscillator as shown in Fig. 8. This gives the highest range (the one used by Lydia Kavina at the Science Museum lecture gave a range of three feet).

However, the system is very complex with numerous adjustments. This system is

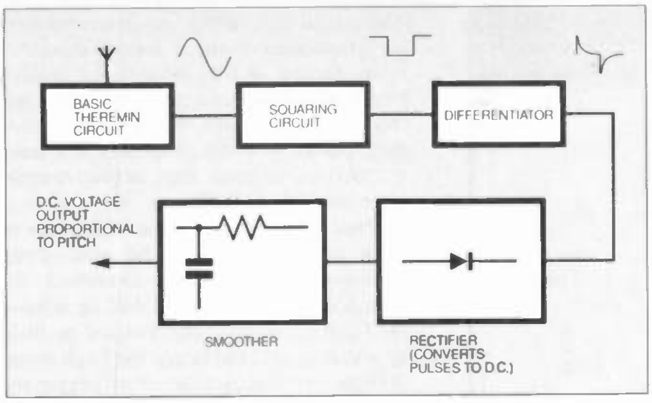


Fig. 7. Block schematic for a Theremin-to-voltage converter.

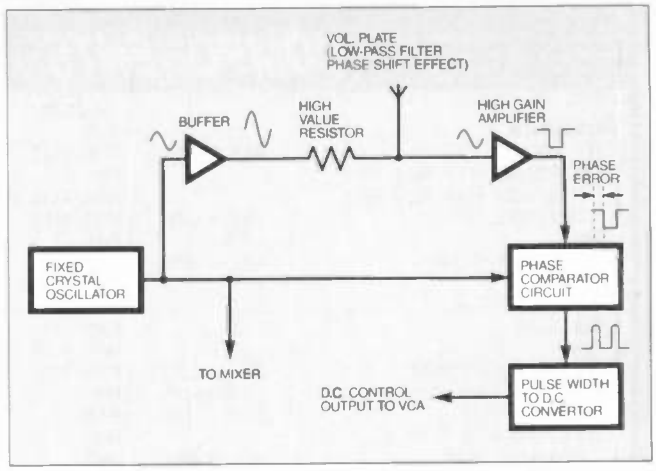


Fig. 8. Phase detector volume control system.

used on the highly regarded Tony Henk Theremins although these are still in the prototype stage and have not been "productionised" as yet.

FAKE SYSTEMS

All the preceding systems are true Theremin systems in that they respond to hand capacitance. A number of "fake" systems have appeared using infra-red, ultra-sound and microwaves which have the advantage of no interaction.

However, their wildly differing control laws make the instrument "feel" very different to a real Theremin.

OUTPUT WAVEFORM

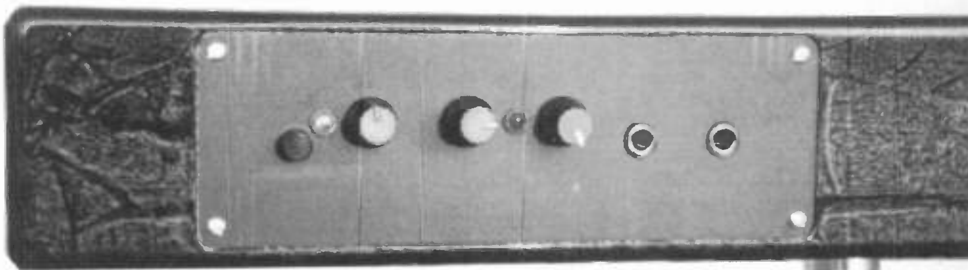
The original Theremins generated a slightly asymmetric sinewave with a few per cent total harmonic distortion. Later models included special distortion circuits to increase the harmonics to emulate a Violin tone.

The use of a transconductance amplifier in single-rail mode generates the required harmonics since it clips softly because it has no overall negative feedback. The asymmetries inherent in single-rail mode cause a slight bending of the waveform generating a few per cent of second harmonic distortion.

Below around 100Hz the waveform becomes more distorted due to the oscillators approaching lock and pulling on each other. Also, the filtering is less effective at low frequencies, this means that the Theremin sounds more "buzzy" at the low end as the waveform becomes more of a ramp. However, at higher audio frequencies the Theremin generates that characteristic smooth ethereal tone.

CIRCUIT DESCRIPTION

The final block diagram of the whole EPE Elysian Theremin is shown in Fig. 9.



Front panel control layout.

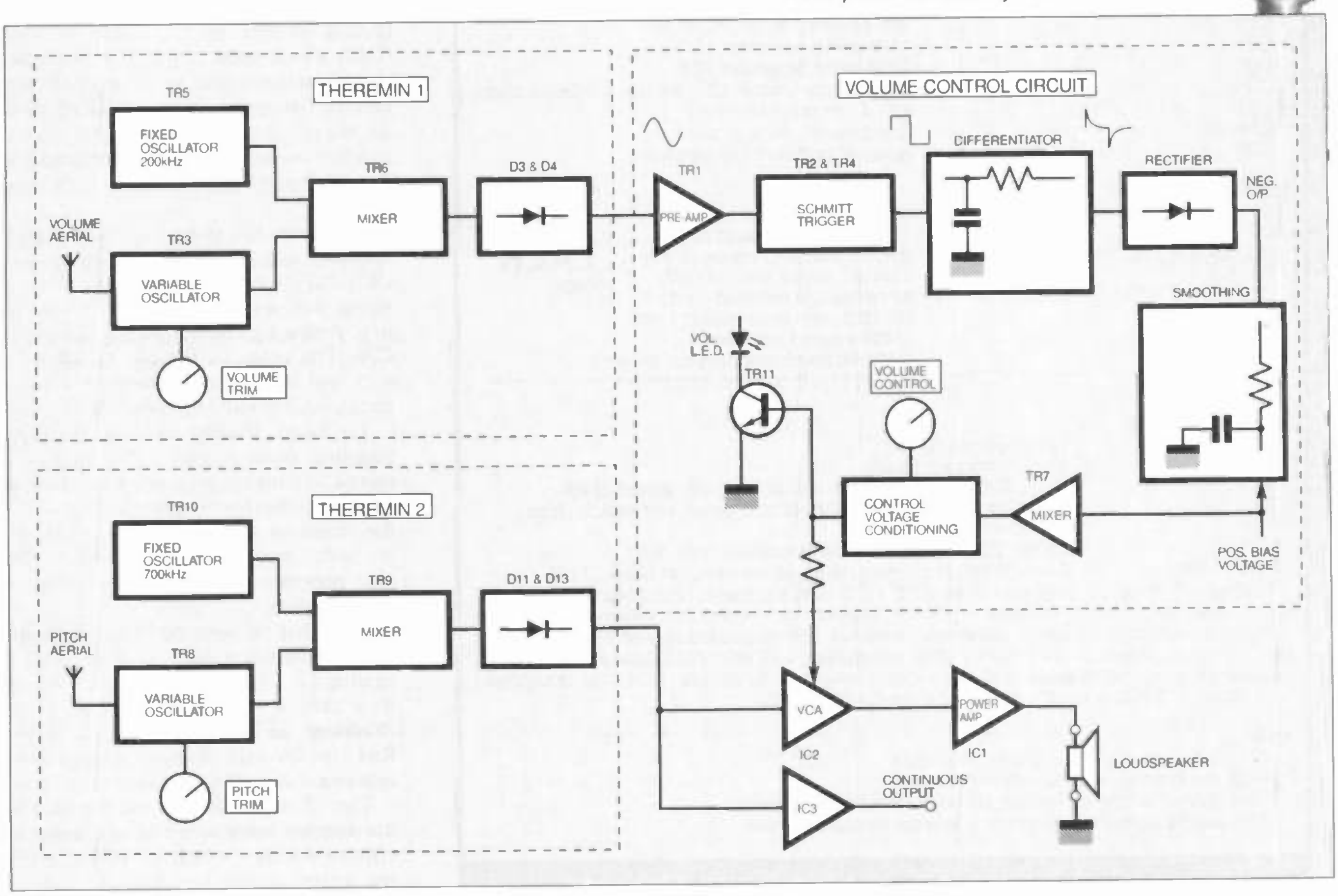


Fig. 9. Block diagram for the dual, Pitch and Volume, EPE Elysian Theremin.

COMPONENTS

Resistors

R1, R72	4k7 (2 off)	R23	2Ω2
R2, R3, R9, R17, R24, R31, R38, R39, R49, R52, R56, R61, R64, R76	1k (14 off)	R25, R47	1M (2 off)
R4	680k	R26	330Ω
R5, R32, R70, R77	47k (4 off)	R34, R36, R60	470Ω
R6	18k	R35, R43	68k (2 off)
R7	2k7	R40	200k
R8	1k8	R41	22k (or 39k if network fitted)
R10	130Ω	R42, R71, R81	22k (3 off)
R11, R29, R69, R74	33k (4 off)	R45	100k
R12, R30, R68, R75	150k (4 off)	R46, R78	100Ω (2 off)
R13, R18, R37	1M5 (3 off)	R53, R67	470k (2 off)
R14, R16, R28, R33, R50, R51 R54, R63, R80	10k (9 off)	R57	51k
R15, R19, R44, R55, R66, R79	2k2 (6 off)	R58	680Ω 1W 5%
R20	560Ω	R59	3k
R21	15k	R62	3M3 5%
R22, R27	1M (2 off)	R65	8M2 5% (or 13k if network fitted)
		R73	220k
		R82	10Ω 1W

All 0·6W 1% metal film, exept where stated

Potentiometers

VR1, VR2, VR3	47k min. p.c.b. mounting rotary carbon, linear
VR4	5k min. cermet preset, horizontal

Capacitors

C1, C46	100p ceramic NPO (black band) 2% (2 off)
C2	100μ radial elect. 25V
C3	optional padder (see text)
C4, C16, (5mm only), C20, C22, C28, C33, C38, C39, C42, C44, C49, C50, C52, C58, C65, C69	100n ceramic −20%+80% (16 off)
C5, C10, C13, C26, C27, C43, C53, C55, C61, C62	10n ceramic 20% (10 off)
C6	22μ tantalum bead, 16V
C7	47μ radial elect. 25V
C8, C14, C18, C23, C29, C30, C35, C45, C66, C70, C71	1n ceramic, 5mm 10% (11 off)
C9, C15, C36, C37, C41, C47, C48, C60, C64	10μ radial elect. 35V (9 off)
C11, C24, C54, C59	330p 5mm ceramic N150 (orange) or polystyrene 2% (4 off)
C12, C67	27p ceramic NPO (black band) 2% (2 off)
C17	10n polyester
C19, C21, C40	470μ radial elect. 35V (3 off)
C25, C63	68p ceramic N330 2% (2 off)
C31	150n 5mm polyester 10%
C32	220n 5mm polyester 10%
C34	68n 5mm polyester 10% (or 15n if network fitted)
C51	4n7 5mm polyester 10%
C56, C57	82p ceramic 10% (2 off)
C68	optional padder (27p ceramic)

Semiconductors

See SHOP TALK Page

D1	5mm blue diffused l.e.d.
D2, D6, D12	1N4001 rec. diode (3 off)
D3, D4, D5, D9, D11, D13	BAT25 Schottky diode (6 off)
D7, D8	1N4148 signal diode (2 off)
D10	5mm orange diffused l.e.d.
TR1 to TR11	BC182L *npn* transistor (11 off)
IC1	LM380 audio amplifier
IC2	CA3080 transconductance op.amp
IC3	TL081 j.f.e.t. op.amp (or similar)

Miscellaneous

L1, L2	1mH inductor (2 off)
L3, L4	330μH inductor (2 off)
JK1, JK2	SCJ-0639 switched, p.c.b. mounting, jack socket (2 off)
S1	pushbutton, p.c.b. mounting, dual changeover switch (Alps), with 8mm dia. button
LS1	8 ohm 102mm dia. 1·5W loudspeaker (see text)
TB1 to TB4	2-way 5mm, p.c.b. mounting, screw terminal block (2 off)

Printed circuit board available from *EPE PCB Service*, code 121; 25mm (½in.) MDF case, size 560mmm x 126mm x 75mm; copper-clad board for volume plate, size 120mm x 42mm; pitch aerial assembly; external 15V regulated power supply; 2·1mm dia. (internal) power socket; front panel; plastic knob (3 off); microphone stand fixing; loudspeaker mounting plate and grille cloth; length of solid-core 1/0·6 red equipment wire, approx. 125mm length; connecting wire; solder etc.

Note

Circuit design copyright of J.M. Rothman.
PCB design copyright of Adam Fullerton.
This design is offered for one-off home construction only.
This article does not constitute a licence for manufacture.

Approx Cost Guidance Only **£150** **excluding case, aerials and hardware**

The circuit diagram is split into two parts for convenience, the Pitch/VCA section being shown in Fig. 10 and the Volume Plate section given in Fig. 11. Note that the component designations follow their position on the printed circuit board (p.c.b.) rather than the circuit diagram since this aids assembly.

Since there are two basic Theremins for Pitch and Volume with the same circuit topology, these will be discussed first (component numbers used will be those of the Pitch oscillator). The Volume oscillator runs at around 200kHz and the Pitch around 700kHz, so a small amount of interference to MW/LW radios is to be expected if within a few feet of the Theremin.

The oscillators are a particularly interesting version of the Colpitts type. They cannot simply be defined as common base, emitter or collector as far as a.c. analysis is concerned, since it depends on what transistor connection node is taken to be reference 0V. In this case, they are drawn as "common emitter" circuits for convenience. The Colpitts configuration is preferred to others, such as the Hartley, since simple coils with no tappings are used.

The outputs of the oscillators are at quite a high level, in fact, slightly above the supply rail due to Q multiplication in the coils. The aerials are connected to the collector ends of the tank circuits (TR8/TR3) to provide the small frequency shift required. Capacitors (C66) are used to avoid the risk of an aerial short to ground burning out a coil and to limit the "splat" that occurs if the aerial is touched.

VARICAP CONTROL

Both Theremin sections can be trimmed to compensate for normal variations by panel mounted pots. These pots. vary a reverse voltage across a rectifier diode (D12) which cause a variation in its junction capacitance and hence a small variation in frequency. Proper varicap diodes are *not* needed in this application since the required capacitance swing is so small and the standard 1N4001 rectifier diode is perfect.

The diode has to be a.c. coupled to the oscillator and this is achieved by capacitor C67. R.F. has to be prevented from entering the pot. wiring so r.f. decoupling is provided by resistor R77 and capacitor C70. The range of the pot. is limited by R25 and the range of adjustment can be increased if desired by reducing its value.

To avoid loading the oscillators and coupling them together, the outputs are mixed via high value resistors (R65 and R62) into the low impedance base (b) of the common emitter mixing stage. This is built around transistor TR9 which also provides a degree of buffering and amplification.

Note that the mix resistors (R65, R62) are of different values to ensure that the beating r.f. signal waveform does not drop to a zero level at any point to prevent distortion, as shown in Fig. 12. Resistor R64 sets the gain of this stage and can be reduced if desired to overdrive the VCA.

The r.f. signal is then a.c. coupled into the detector stage which is configured as a voltage doubler, which as well as providing extra output is also self clamping (since D13 provides a d.c. path to ground) allowing the input to be a.c. coupled.

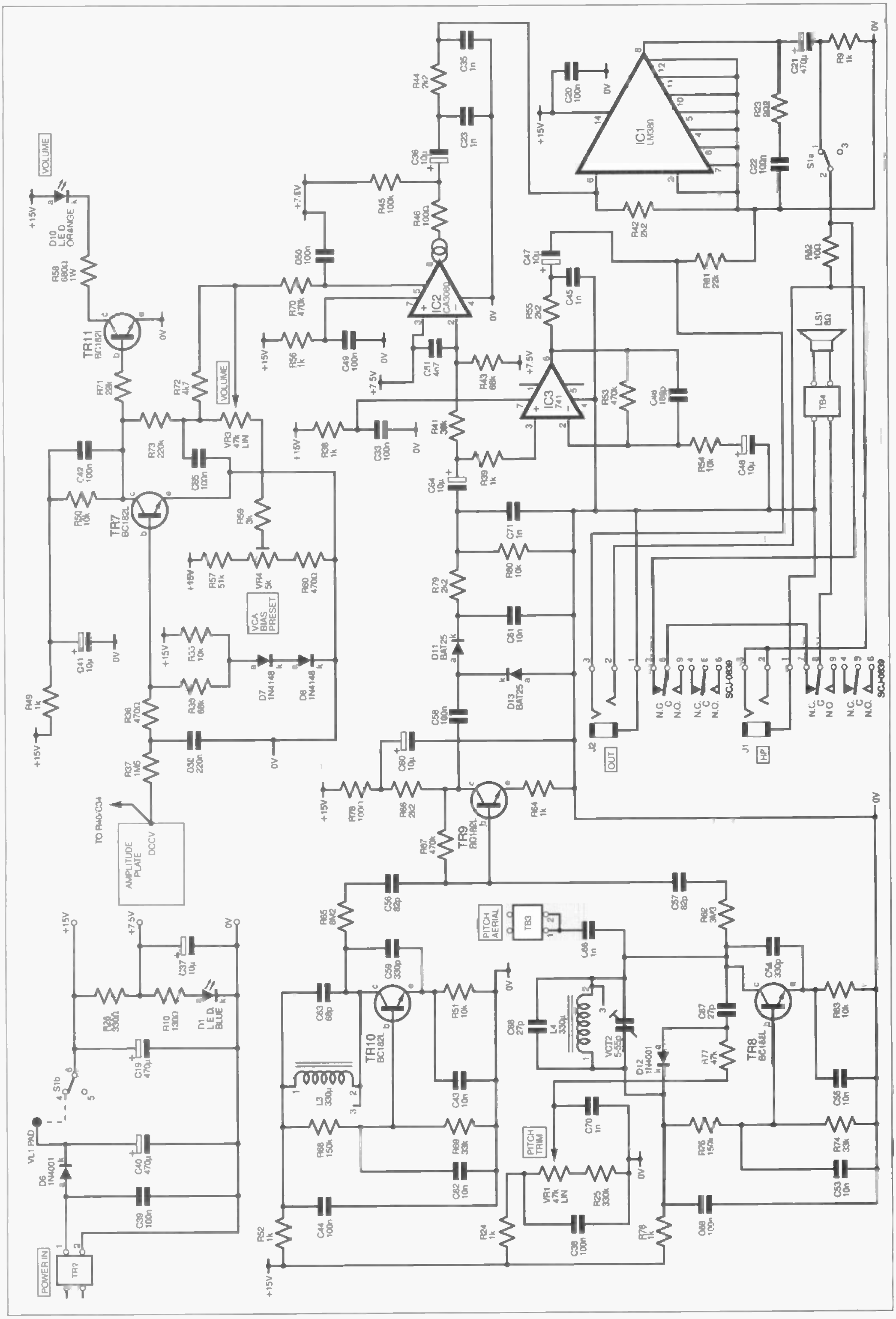


Fig. 10. Pitch section circuit diagram for the EPE Elysian Theremin. Note resistor R48 has been deleted (not used).

Capacitor C61 in conjunction with R79 and C71 constitute a *pi* network to provide r.f. filtering and recover the a.f.

Resistor R80 provides a d.c. load for the rectifier output which is in turn a.c. coupled through capacitor C64 into an attenuator consisting of resistors R41 and R43. This then feeds the inverting input pin (2) of the 3080 type transcoductance op.amp IC2 configured as a VCA.

Since IC2 is operated on a single 15V rail, its inputs have to be biased at half rail or 7·5V for a symmetrical swing. The half rail bias is provided by a potential divider (in the supply input circuit, top left Fig. 10) consisting of resistors R26 and R10 run at a high current of 20mA to give a low output impedance, obviating the need for a buffer. This current level is also sufficient to run a l.e.d. at full brightness so power indicator l.e.d. D1, is wired in series with R10, thus accomplishing two jobs at once.

The bias supply is decoupled by capacitor C37. Additional r.f. decoupling, plus a bit of breakthrough attenuation, is provided by C51 wired across both inputs of IC2. The VCA control current is provided via resistor R70. The variable output current from IC2 is developed into a voltage across resistor R45. Note that this resistor is connected to the half rail line rather than ground to reduce d.c. control thumps when the Volume Plate is played rapidly.

VOLUME CONTROL

The output volume is controlled by the current feeding the control pin (pin 5) of IC2. Any r.f. or audio riding on this signal is removed by capacitor C50 in conjunction with resistor R70 which also provides current limiting. Again, to reduce control thumps, C50 is taken to half-rail voltage.

The control panel Volume control (VR3) is inserted in the control line. The control current has to be above a certain

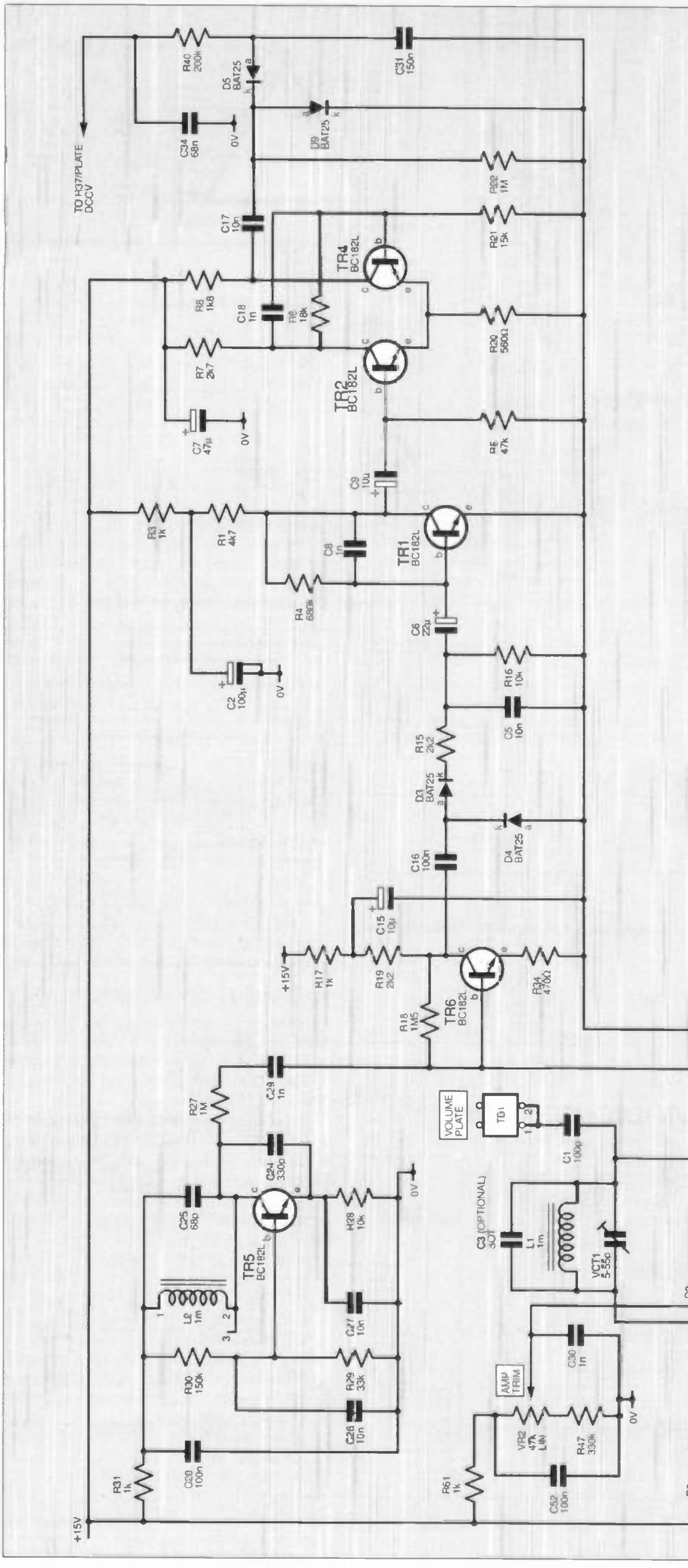
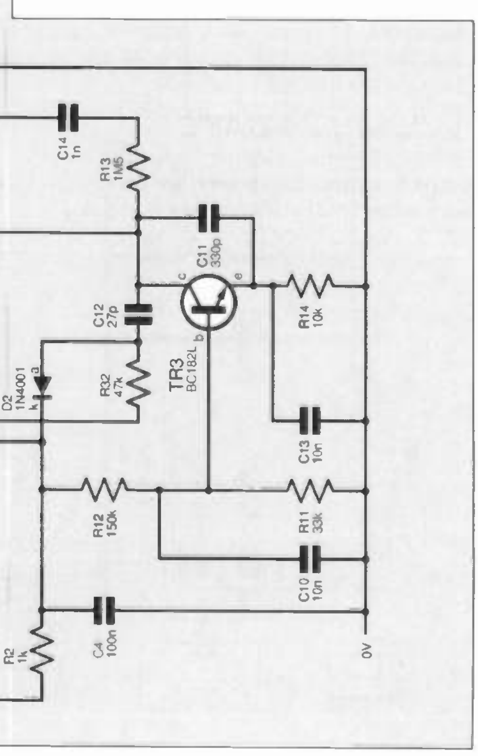



Fig. 11. Volume Plate circuit diagram for the EPE Elysian Theremin.

point before any audio output occurs and this is accounted for by a bias fed into the "earthy end" of the pot. The bias voltage required varies between different 3080 chips and preset VR4 is provided to accommodate this variation.

To obtain a good control law (or feel!) on the Volume pot. a law-faking bypass resistor (R27) is used. A visual indication of the control voltage is provided by l.e.d. D10, driven by transistor TR11. Note that the l.e.d. current limiting resistor R58 is rated at 1W so it runs cool.

Transistor TR7 provides the basis for conditioning the control voltage from the Volume control section. TR7s base-emitter junction is biased just into conduction by the 1·2V generated by diodes D7 and D8. This is fed into the base (b) of TR7 by R35 (whose value may have to be adjusted on some examples).

The control voltage generated by the Volume control circuitry is *negative* and this subtracts from the bias voltage. Thus, TR7 is off when the volume is high. Capacitor C42 is used to filter out any undesirable undulations in the control voltage along with C32 and R37 which provide further smoothing.

In practice there is a trade off in the speed of response and level of smoothing. Although, the smoothing is only a problem when the volume oscillators are just coming out of lock, beating at a very low frequency which may cause volume pulsing.

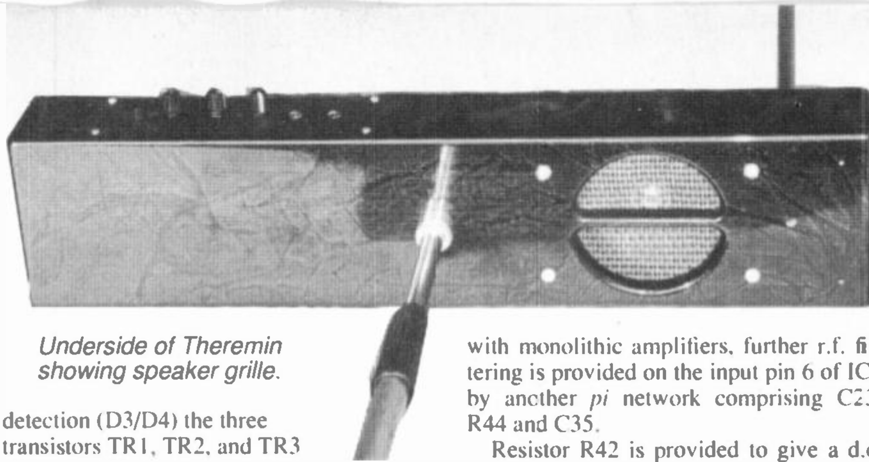
CONTINUOUS OUTPUT

A continuous output is obtained by feeding the detector output, from C64, directly into a non-inverting amplifier with a gain of 48 times, configured around IC3. Bias for this amplifier is provided from the same source as that for IC2.

Resistor R55 provides short circuit protection for the continuous output if a mono jack plug is inserted into socket JK2. Capacitor C45 provides yet more r.f. decoupling and many such capacitors are scattered around the circuit with every stage having its own *RC* network.

VOLUME PLATE

The Theremin Volume Plate signal is derived in the same way as the Pitch section except that the mixing stage (Fig. 11) is set at a higher gain with lower value mix resistors (R13/R27) and emitter resistor (R34). Distortion is worse, but a sinewave is not required; indeed after



Underside of Theremin showing speaker grille.

detection (D3/D4) the three transistors TR1, TR2, and TR3 convert it into a square wave. Transistor TR1 is simply a common emitter amplifier giving enough output to drive the Schmitt trigger circuit designed around TR2 and TR4.

The square wave is then fed into a differentiator consisting of C17 and R22. The short duration pulses are then converted to d.c. by a voltage doubler circuit consisting of diodes D9 and D5. Smoothing of the resultant control voltage is provided by capacitors C31 and C34. The output voltage increases as the frequency of the Volume Theremin increases, and this provides the smooth incremental increase in volume.

This method alone would not provide the dynamic range required, so the null/lock point of the Theremin is used to provide the "fully off" part of the volume control characteristic. Note that if the varicap trim control VR2 is adjusted to the other side of the null point the volume direction is reversed. It is this mode that is used for "Classical" playing.

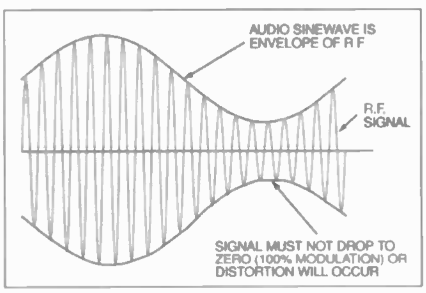


Fig. 12. Beat frequency waveform.

AUDIO SECTION

Power amplification is provided by the ubiquitous LM380 (IC1) providing about 2W into 8 ohms. It is also happy driving cables and headphones – see Fig. 10. Since instability is always a potential problem with monolithic amplifiers, further r.f. filtering is provided on the input pin 6 of IC1 by another *pi* network comprising C23, R44 and C35.

Resistor R42 is provided to give a d.c. path to "ground", necessary with only the odd example of LM380 to help maintain the d.c. potential of the output (pin 8) at half rail. Capacitor C22 and resistor R23 constitute a Zobel network and provide a h.f. load for the amplifier where the inductance of the speaker voice coil comes into play.

OUTPUT SWITCHING

When either Headphones or an external lead is plugged into the Theremin, the internal speaker LS1 is muted by the switch contacts on the jack sockets JK1, JK2.

The output amplifier IC1 is protected against cable shorts by resistor R82, a 10 ohm 1W type, in series when feeding headphones or an external load. This resistor also ensures stability when driving long screened cables with high capacitance.

DE-THUMPING

An important aspect of audio/music electronic design is that of de-thumping. The Theremin circuit can emit an excruciating "death rattle" when turned off, this is simply avoided by using the extra switch section on the power switch to break the output when turned off.

This primative de-thump protection does not work if the P.S.U. is yanked from its wall socket however! Switching clicks and jack connection thumps are reduced by pull-down resistors R9 and R81.

POWER SUPPLY

The power supply requirements for the EPE Elysian Theremin are modest, being a regulated 15V rail at a maximum of 300mA. This can be supplied via a simple 7815 +15V regulator.

It is essential that the Theremin is "earthed" to avoid modulation hum. However, if the 0V rail is connected *directly* to mains Earth there is the possibility of "earth loops" occurring when it is connected to external equipment such as mixers.

Both these requirements can be satisfied if the 0V rail is connected to mains Earth via a capacitor and resistor in parallel. The capacitor provides a low impedance at r.f., while maintaining a high impedance at audio frequencies. The resistor provides the standard ground lift function to prevent earth loops. A suitable power supply circuit is shown in Fig. 13.

Although a diode (D6) is used on the input of the Theremin for reverse polarity protection and capacitors C40 and C39 provide plenty of smoothing, a.c. *must* not be fed into the unit since awful modulation hum will result.

Next Month: Construction and setting up the EPE Elysian Theremin.

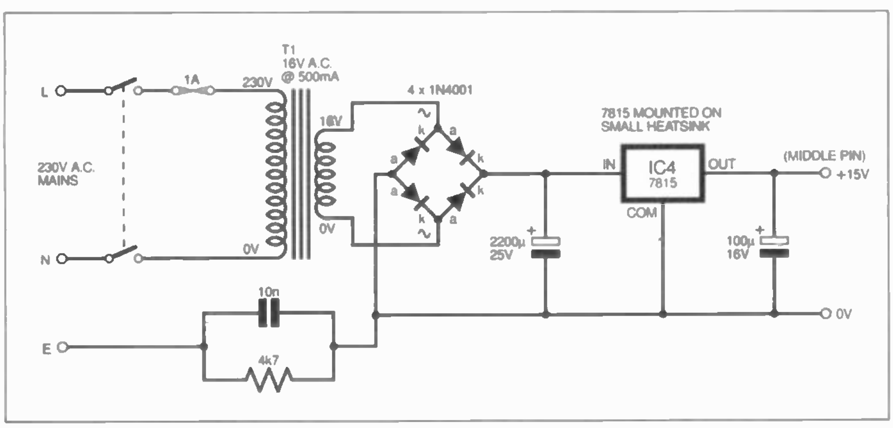


Fig. 13. Regulated power supply for the EPE Elysian Theremin.

BUILD YOUR OWN PROJECTS

Alan Winstanley

Part 1

IN THIS new series of articles which will be presented over the next few months, we shall be describing modern methods for constructing your electronic projects. This first part offers some initial tips for beginners and discusses essential tools and equipment needed to make a start.

Future parts will look at circuit board assembly, case and enclosure preparation, workshop tips and tricks – in fact, everything you need to know to get satisfying results when building your latest *EPE* project!

Alan is, of course, Surgeon-in-Chief at *Circuit Surgery*, and enjoys all aspects of electronics.

AS WITH any hobby or pastime, electronics offers many rewards, not least of which is the satisfaction derived from working with modern technology and applying it to fulfil a particular purpose.

There are several aspects to being an electronics enthusiast, and you can pick and choose whichever particular ones appeal to you most, depending on your needs: possibly you may wish to become proficient in circuit design, or perhaps concentrate on the constructional angle, or a bit of both.

You might simply have a passing interest in building pre-designed projects, keeping a keen eye on cost, and possibly *tweaking* them to meet your individual needs; after all, many readers seldom build projects exactly as described, but prefer to adapt them somewhere along the line!

RESOURCEFUL

Constructors sometimes need to be a bit resourceful, using parts from the *spares box* to keep the project rolling along. If you're fortunate enough to have a more generous budget, you might be able to afford more advanced test equipment, tools and other resources. Whatever your interest, though, electronics construction will involve you with modern electronic components, a field which is perhaps the most fast-moving of any technological field.

Many smaller parts cost literally "pennies" each and there has never been the requirement to keep up with the latest *cutting edge* electronic components to enjoy the hobby to the full, although we do indeed use some state-of-the-art devices, including the Arizona Microchip PIC microcontrollers.

Such products do not appeal to each and every reader, however, and happily many of our projects still use an assortment of highly effective *bread and butter* devices, some of which date back a couple of decades or so but are still as important today. At a time when components are smaller, cheaper and more powerful than they have ever been, electronics still has something to offer everybody, no matter what their skills or budget may be.

You do not need *many tools to successfully undertake electronics, but the primary one you* do *need is a multimeter, of which a wide variety are available.*

GO FOR IT!

There is nothing quite like the thrill of completing a project which you've built from raw materials with your own bare hands, and showing it off to your friends for the first time. Developing personal skills in technology, saving money by building it yourself, and customising something to meet your own precise requirements, are just some of the other benefits of being an electronics enthusiast.

This series of articles, *Build Your Own Projects*, will take you step-by-step through the methods of building electronic projects and prototypes from scratch, using modern electronic components, tools and equipment to prepare projects safely and efficiently.

Hopefully, by avoiding spoilt or wasted work which results in disappointment, there will be something in this series to appeal to everyone, whether a complete novice looking for guidance and encouragement, or a more seasoned constructor who may be interested in a few hints or tips relating to modern-day assembly techniques.

Just like those coffee-table home decor books which inspire but don't dictate, *Build Your Own Projects* is not all *gospel* but may offer inspiration and pointers. Some things, though, will never change, so we'll start with some fundamental aspects behind electronics construction before moving onto real workshop techniques over the next few months.

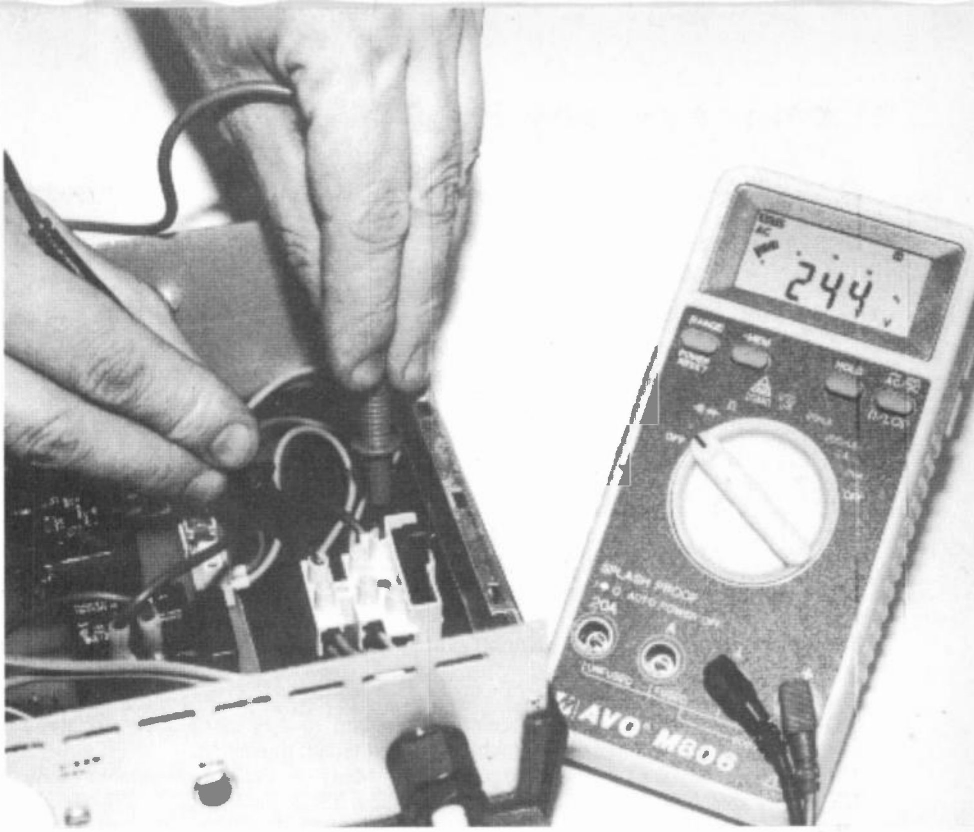
LET'S GET WIRED

Firstly, if you're becoming involved in electronics for the first time, you'll soon become aware that some designs, although quite straightforward in nature, require the mains electrical supply to operate properly. Many other circuits use batteries as their power source and it is these more modest types of project with which beginners ought really to consider starting.

Utilising the mains supply requires that your workmanship is of a satisfactory level and that certain precautions are followed, so that you endanger neither yourself nor the well-being of others who may handle the project routinely.

Hence, it's best to practise on the simpler constructional designs to begin with, and gradually acquire the skills needed to tackle more advanced work. *Everyday Practical Electronics* always screens projects carefully and publishes all the essential information you need to complete your prototype properly, and you should make a point of reading the author's notes thoroughly and following diagrams closely, cross-referring to the photographs as necessary.

Some constructional projects may involve more advanced skills, particularly soldering small components on densely-populated boards, and these techniques are only ever acquired with practice. Rather like an author feeling comfy with a favourite pen (or keyboard, in my case!), you'll get the *feel* of a soldering iron and with practice you'll learn how to master the various tools and associated gear in order to produce results you can be really pleased with.



Ensure that you have high quality meter probes so that high voltage readings can be safely made.

BUT DON'T OVERREACH

It would be regrettable if an enthusiast embarked upon a particularly ambitious project whilst lacking relevant experience or resources: this will invariably end in disappointment and may deter him or her from tackling other circuits. So, choose your projects with a little forethought, so that you can tackle the challenge of a new prototype without facing potential disappointment by being over-enthusiastic.

Incidentally, there will almost certainly come a time when you *have* built a project, yet you cannot quite manage to make it function fully, if at all. This can be a major source of disappointment amongst beginners and often damages their confidence. Fault-finding and troubleshooting are black arts which come with experience, and my own advice (easily said but harder to follow at the time) is to persevere and not be deterred, because there is often a very simple explanation for the fault.

Without question, fault-finding goes hand in hand with electronics, and it is all part of the electronics *experience* to resolve such problems: eventually, you will look back and laugh!

In any case, if you are struggling for whatever reason with an *EPE* project, you will find that most contributors are very willing to give you advice if you drop them a line via the Editorial address, explaining the symptoms fully, so help is never very far away.

WHERE TO BUY

Having considered the scope and nature of the project carefully, you will probably have priced it up and pencilled in an estimate of the likely constructional costs. With luck you may have at least some of the parts already to hand, but there will often be the need to buy in particular components.

Every *EPE* project has a full Components List and we also make a deliberate point (often overlooked by readers, to our dismay) of publishing all component buying matters in our *Shoptalk* column. This should always be your first port of call before you pick up the phone or write out that order!

Because of the immense range of components now available, you shouldn't be surprised if often some unusual parts are called for, which may or may not be available from a local electronics retailer (possibly see *Yellow Pages* for names and addresses). A mail order source is usually suggested in *Shoptalk* for those out-of-the-ordinary parts, which means that they are only a phone call or letterbox away and are accessible by everybody!

Of course, we carry advertisements for many mail order specialists in our pages and you should make a point of acquiring at least *some* price lists and catalogues from advertisers. Indeed, mail-order components are a critical part of the electronics *scene* and it would be completely impossible for many readers to enjoy the hobby if it wasn't for mail-order suppliers making parts available conveniently by post.

MINIMISING COSTS

Bear in mind that there is little money made (except by the Post Office) in mailing out small, cheap components and therefore suppliers – even the largest ones – will commonly levy a handling charge for small orders. Mail order sources work hard for their money! You can cut your costs by planning ahead and grouping orders together to help reduce handling and postage charges.

If you can afford it, also think about *doubling-up* your order for some parts so that you can build up a modest stock of parts to keep on the shelf. Typically, I carry most small parts *in stock* but will send out by mail order for unusual or expensive components, or instrument cases in particular. Other sources of parts include surplus boards, savaging them with a soldering iron and stripping them down, something I enjoyed tremendously when I picked up an iron for the first time!

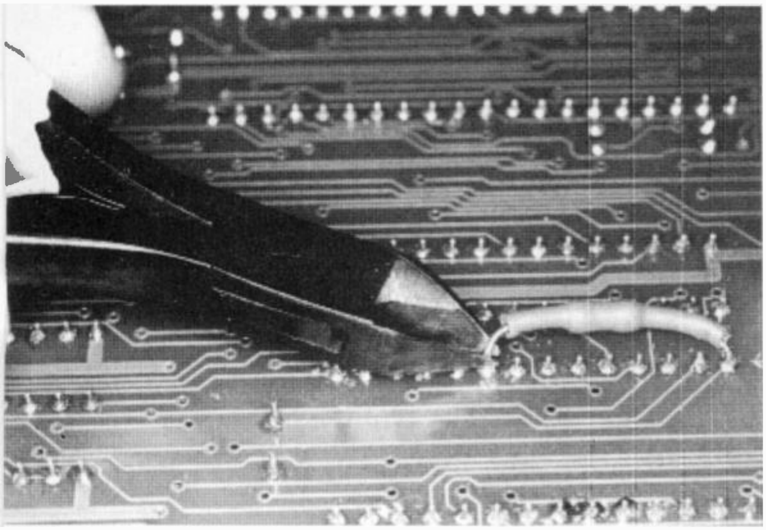
However, it is sometimes more trouble than it's worth trying to re-cycle certain parts from surplus boards, since they may be damaged by excessive heat, they do not always come away cleanly and many chips are cheap when new, anyway. It's fun though, and surplus equipment often yields valuable or unusual parts. You might consider re-cycling parts from discarded projects, too.

TEST EQUIPMENT AND TOOLS

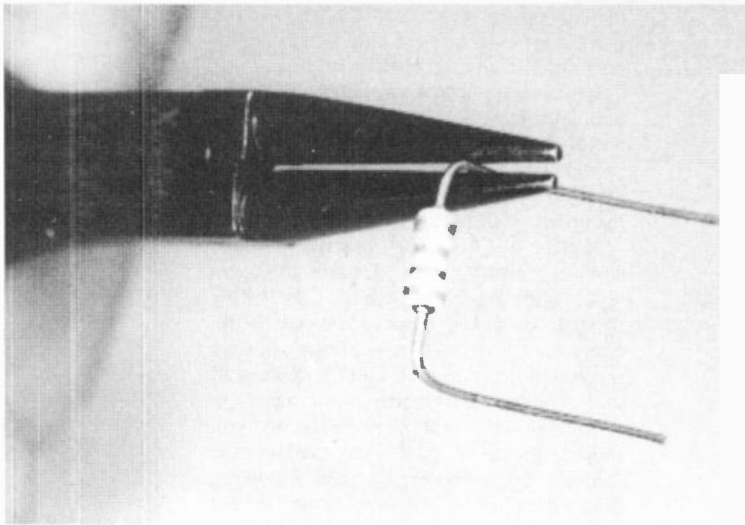
It is possible to spend from a few tens, to many thousands of pounds on test equipment, but the first thing you are likely to require is a Multimeter to take test readings and measurements (voltage, current and resistance). You might follow on with more esoteric items of gear including mains power supplies (consider building your own), signal and function generators, oscilloscopes and so on, as your experience and confidence grows.

A multimeter is an essential item of measuring equipment and, briefly, they fall into two categories: analogue (moving coil) and digital. Analogue meters use a traditional-style moving coil meter movement but are falling out of favour in preference of their digital counterparts which are far more convenient to use.

A multimeter is not quite the *perfect* instrument you might think it is, because the meter itself possesses a certain resistance which can affect the circuit being tested. In the case of analogue meters in particular, this can easily result in false readings, because the meter's own movement will behave like a resistor, loading the circuit under test.



There are many wires to be snipped during construction, so get a good pair of wire cutters.



Similarly, there are many things to be picked up, and neatly shaped, so decent pliers are a MUST as well.

Quite how much it loads the circuit is specified by a meter's sensitivity, which will be quoted in *ohms per volt* (o.p.v.). The higher this figure, the better its sensitivity (and accuracy) will be.

A typical modest moving-coil meter may have a sensitivity of, say, 2,000 ohms per volt, so if you set it to a 10V range, the meter behaves like a 20kΩ resistor. Put simply, if you were using it to measure the voltage across a 1MΩ resistor, for example, then you would be *shunting* that resistor to form a 19·6kΩ resistor, no less! (1M and 20k in parallel.)

Thus the meter has introduced an error into the circuit which may give you a false reading, but this also depends on other factors in the circuit under test. 20,000 o.p.v. is a good, general-purpose value to aim for with this type of instrument. The trick is to read voltages using the highest possible meter range, so as to avoid loading the circuit too much. Ideally, the resistance of your meter should be at least ten times that of the effective resistance under test.

Also check the other ranges offered on the meter, especially direct current (d.c.), which should ideally cope with, say, 2A or more. (I guarantee you will use it.) Resistance ranges will probably extend to 10MΩ or so, and the meter may or may not cater for alternating current (a.c.). Any extra features (e.g. transistor checking or continuity buzzers) are bonuses which may prove handy from time to time.

DIGITAL PRECISION

A digital multimeter (DMM) is the best way of obtaining accurate results; numerical displays are very convenient to read and many meters are *auto-ranging*, where they select the best range themselves – so there is no danger of trying to read 50V on a 5V range, or 2A on a 200mA range (though you'll find that not every meter auto-ranges on current).

Also, they should often be auto-polarising, so that they read a voltage regardless of which way round you have connected the positive and negative meter leads, which can be extremely useful at times. Some have a *hold* feature that acts like a memory and displays the latest value until you reset it.

Most importantly, they have a very high input impedance, typically 10MΩ or higher, so they won't adversely affect the test circuit much.

Many models are available, some of them for a modest cost, and advertisers' catalogues should be consulted. You could buy a *starter* digital meter for as little as £20 and they may include other convenience functions such as a transistor or diode checker.

Small *pocket* moving coil meters costing under £10 should be treated virtually as a consumable item, or something you can have *kicking about* in the tool box which you're not afraid of damaging.

The photos show several types of meter, including a handy pen-type digital multimeter which I like to keep to hand for quick tests. Also, have a look at test leads and connectors, as you may be able to make your own additional leads using extra-flexible test lead wire with (usually) 4mm plugs and test clips.

You will find a variety of ready-made test gear available by mail order or from local electronics stores. However, you may prefer to build at least some of the gear yourself, based on a constructional project.

A mains-operated bench power supply, capable of providing, say, 0 to 25V at 0 to 1A or more, is a good next move, and will enable you to start prototyping circuits and powering them economically, obviating the need for batteries.

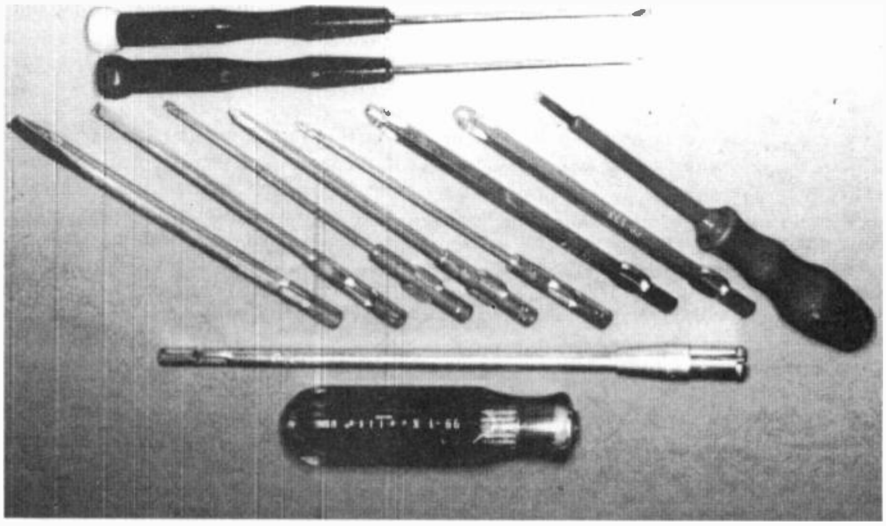
More serious constructors will also think about purchasing an oscilloscope. We published a two-part series on the use of oscilloscopes in the June/July 1996 issues (see *Back Issues* page).

TOOLING UP

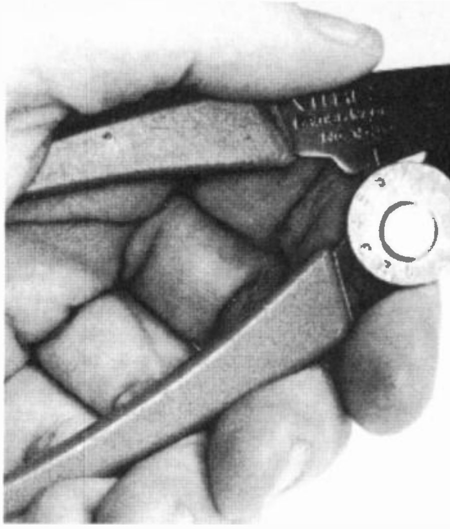
Unlike our contributor Max Fidling of *Ohm Sweet Ohm* infamy, whom it seems likes to collect colourful tools mainly to impress his chums (!), you can spend as much or as little as you like on hand tools and equipment. *(Max, are you going to stand for such abuse? Ed.)*

One rule passed down to me was that you should always buy the best tools you can possibly afford, consider them as investments and they will reward you with a lifetime of faithful service. There are enormous differences in the qualities of hand tools available, which are always reflected in their price.

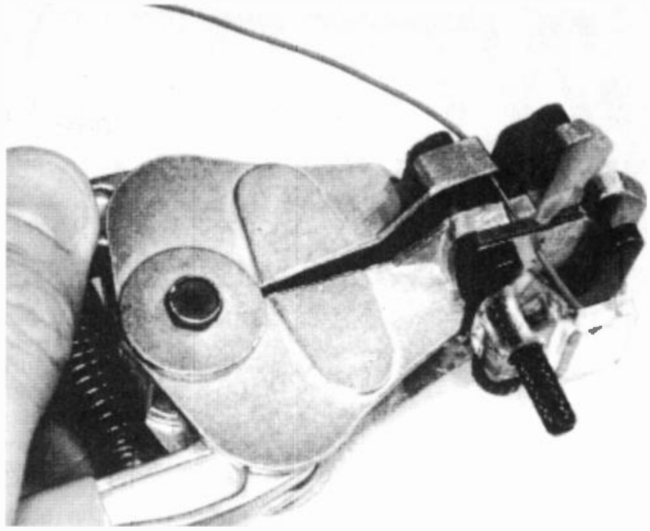
I've snapped the jaws of some Taiwanese wire cutters, and broken the handle or blunted many a cheap screwdriver; I would not reasonably expect a 49p screwdriver to be as strong or last as well as my favourite Xcelite 99 series driver set (the American firm



When it comes to screwdrivers, the more the merrier, but you can economise by using the interchangeable blade type for some applications.



Simple wire strippers are good for most simple tasks, like these dial-type ones from Vitrex.



But there are even more sophisticated wire strippers for the connosieur, such as the Ideal Stripmaster.

Xcelite having invented the plastic-handled screwdriver, by the way). I would expect that some £30 Lindstrom wire cutters will almost last forever, unlike a cheap version at one-tenth the price, which you may have to throw away within a year or two. With hand tools more than anything else, you get what you pay for.

Ideally, cheap tools should serve as nothing more than to register your interest in electronics: upgrade when you can afford it, and you'll not regret it because quality tools make assembly a pleasure.

However, everybody obviously has to start somewhere and you may well choose to start with a modest set of tools, and build from there in the years ahead, depending on your budget and level of interest.

Personally, I used to buy the occasional tool on a *need to buy* basis along with mail-order components, and have built up a dazzling array over the years.

HAND TOOLS NEEDED

For hand tools, you should consider buying the following, at a minimum:

● *Long-nose, fine point pliers*, preferably with serrated jaws – useful for gripping wires securely to form them or solder them, and for holding small components.

You may see them listed as *radio pliers*. Look for PVC insulated handles (more for the comfort aspect). Spring-loaded jaws are available in some types, which are more convenient to use. *Box jointed* pliers have a precision-made joint for more accurate operation and alignment of the jaws.

● *Wire cutters* – ordinary *side cutters* are used for snipping wires to length. Again, PVC handles, and box jointed for more discerning users. They're normally designed for cutting copper wire with a high degree of precision, and are not suitable for cutting steel wire, for example – they'll be ruined.

● *Electrician's wire cutters* are heavy-duty snips having larger blades and a wider jaw, useful for cutting electrical cables and mains flex, etc. to length. Usually they are more crudely finished, giving a less precise cut than smaller versions for electronics/radio use.

Personal favourites in this area include Xcelite *Superior* and Lindstrom *Supreme* hand tools, but it's recognised that these are priced with the serious constructor and professional user in mind. Much more modest tools – but ideal for beginners or light use – are available which are made from pressed steel. Check your local DIY stores for some ideas, or refer to a mail-order catalogue.

More luxurious electronics hand tools (i.e., not necessarily essential, but very nice to have), include:

● *Round-nosed pliers* having circular jaws, for shaping wire ends into perfect loops or for bending wire leads accurately.
● *Flat-nose pliers* have smooth jaws for gripping wires, handling delicate components. Especially useful for straightening bent i.c. pins, etc.
● *Diagonal side cutters*, for snipping soldered joints on printed circuit boards, or for cutting small wires where access is restricted.

There are some weird and wonderful-looking hand tools available which make light work of stripping insulation from wire. I recommend the *Toggle* wire stripper as an indispensable aid when dealing with multi-core mains cable (or co-axial); this will guillotine 13A 3-core wire with surgical precision and then, with the twirl of a finger, slit the insulation using a rotating blade effect to produce perfect results. They are cheap to buy from most DIY shops.

For dealing with thin-gauge wires, you might opt for a simple wire-stripper with a dial-type setting (e.g. as manufactured by the British tool manufacturer Vitrex, see photo), which ensures that you cut the insulation without damaging the copper core.

A fearsome-looking but extremely impressive gadget for the more adventurous constructor is the famous *Ideal Stripmaster*, made in the USA, but with some imitators at one third the price which you might find quite acceptable. These grip the wire, cut the insulation at the desired point and then pull it off, all in one easy action (see photo). They are rather a luxury but speed up the sometimes tiresome chore of interwiring immensely. Again, such tools are readily available from various mail order houses, costing from £8 to £20 or so.

DRIVING HARD BARGAINS

Screwdrivers are another area where it's worth spending a few pounds building up a reasonable array of the most useful types. Again, price is everything and there are several options available. I favour owning a number of smaller-handled screwdrivers for precision work in fiddly places, and insulated shaft screwdrivers enable work to be carried out with no risk of accidentally touching *live parts*.

I am also a believer in using screwdriver sets which have only one handle and many interchangeable bits. This saves you having to store a range of bulky-handled screwdrivers, which is important if you want to save space in a toolbox. The larger handle also allows more leverage to be applied to larger screw fittings.

Some more expensive screwdriver ranges (Xcelite 99, for instance) have a complete range of extensions, ratchet handles, nutdrivers, Torx keys, hexagonal keys etc., available too, so one of these can become an indispensable item to which you may add various blades in the future.

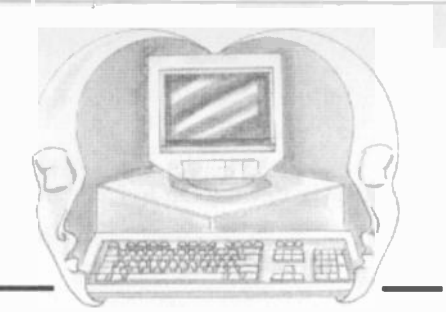
Alternatively, C.K. produce an excellent magnetic ratchet screwdriver set which *freewheels* in one direction but drives in the other. It has no less than 32 bits plus 12 sockets. The magnet is built into the shaft, to hold the bits in place (also good for wiping floppy disks!) and it's retained in a handy storage box.

Many such tools are available from the larger electronics suppliers, but you'll see large ranges of hand tools at all the larger DIY superstores, too. Prices vary, so shop around, and don't forget to check out motorist's discount stores, as well.

You will find that rechargeable battery-powered screwdrivers have a place in electronics construction, but may need to be used with care at times, especially on plastic boxes or similar where it's possible to smash some fittings. We'll be describing these and other tools in forthcoming parts of *Build Your Own Projects*.

NEXT MONTH

In Part Two, next month, we'll be taking a look at soldering techniques, service aids, and circuit board assembly.



INTERFACE

Robert Penfold

AUTO-RANGING RESISTANCE METER INTERFACE

LAST MONTH'S *Interface* article covered a simple PC-based Capacitance Meter. This month we continue in a similar vein, with a PC-based Auto-Ranging Resistance Meter.

The system has eight-bit resolution and full scale values of 2540 ohms, 25·4k, 254k, 2·45M, and 25·4M. The fact that the system has five ranges is not readily apparent to the user due to the auto-ranging. You simply connect up any resistor from a few tens of ohms to many megohms in value, and the value of the resistor is displayed on the screen of the monitor.

Constant Current

The block diagram of Fig. 1 helps to explain the basic principle used in the Resistance Meter Interface. The resistor under test is fed from a constant current generator, and the voltage developed across the resistor is then proportional to its value.

For example, suppose that a current of one milliamp (0·001 amps) is used. With a one kilohm test resistor the voltage developed across the resistor would be one volt (1000 ohms × 0.001 amps = one volt). A resistance of two kilohms would give an output voltage of two volts (2000 ohms × 0·001 amps = two volts), a resistance of three kilohms would give an output voltage of three volts, and so on.

In other words, the circuit operates as a simple resistance-to-voltage converter. The computer measures the output voltage via an analogue-to-digital converter and uses some basic mathematics to give an answer in ohms, kilohms, or megohms.

A very high input impedance buffer amplifier ensures that the converter draws no significant current from the constant current generator. This enables very low test currents to be used. In the actual interface the buffer amplifier is an integral part of the converter chip.

The interface actually has five switched currents, which provide it with the five measuring ranges. The constant current generator is under computer control via five outputs of the printer port, and the software selects the best range to use for a given resistance (i.e. the range that gives the highest in-range reading).

Meter Circuit

The full circuit diagram for the Auto-Ranging Resistance Meter Interface is shown in Fig. 2. The analogue-to-digital converter IC1 is a TLC548IP serial type.

This part of the circuit is essentially the same as the converter that was described in the November 1995 issue, and it utilizes the same method of connection to the host PC's printer port. Refer to the November 1995 issue of EPE if you require more information on the converter.

The converter differs from the original design only in that resistors R1 and R3 are used to set the full scale value of the converter at a little under 4V, whereas the original circuit had a full scale sensitivity of 5V. This is done to ensure that the resistance meter circuit can drive the converter to its full scale value.

The constant current generator actually consists of five generator circuits, with a different one being used for each range. If we consider the current source based on transistor TR2, this is basically just a conventional constant current generator having temperature stabilisation provided by diode D1.

Preset potentiometer VR1 enables the output current to be set at the correct level of one milliamp. The emitter resistances in the other current sources are progressively higher, giving output currents of 100µA, 10µA, 1µA, 100nA, and 10nA.

Transistor TR1 operates as a common emitter switch, and it is controlled by one of the data outputs of the printer port. If the line controlling TR1 is set high, TR1 conducts and brings transistor TR2 into operation. With the line controlling TR1 set low, TR1 does not conduct, and TR2 is switched off. In use only one of the five lines controlling the current sources is set high at any one time, so that four of the sources are switched off, and one is brought into action.

The outputs of the constant current generators are connected in parallel. The output current from transistor TR10 is extremely low, which could give problems with minute leakage through TR2, TR4, TR6, and TR8 adding significantly to TR10's output current. No significant problems of this type were experienced with the prototype system, but accuracy on the 25·4M range might not be as good as on the other ranges.

Because very low test currents are used on the higher ranges, the circuit is vulnerable to stray pickup of electrical noise. This could result in unstable readings.

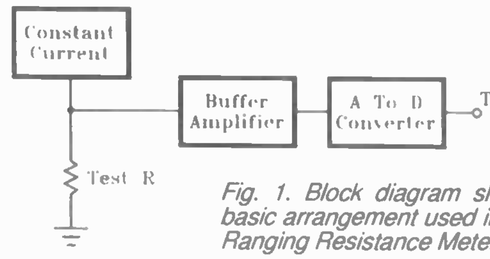


Fig. 1. Block diagram showing the basic arrangement used in the Auto-Ranging Resistance Meter Interface.

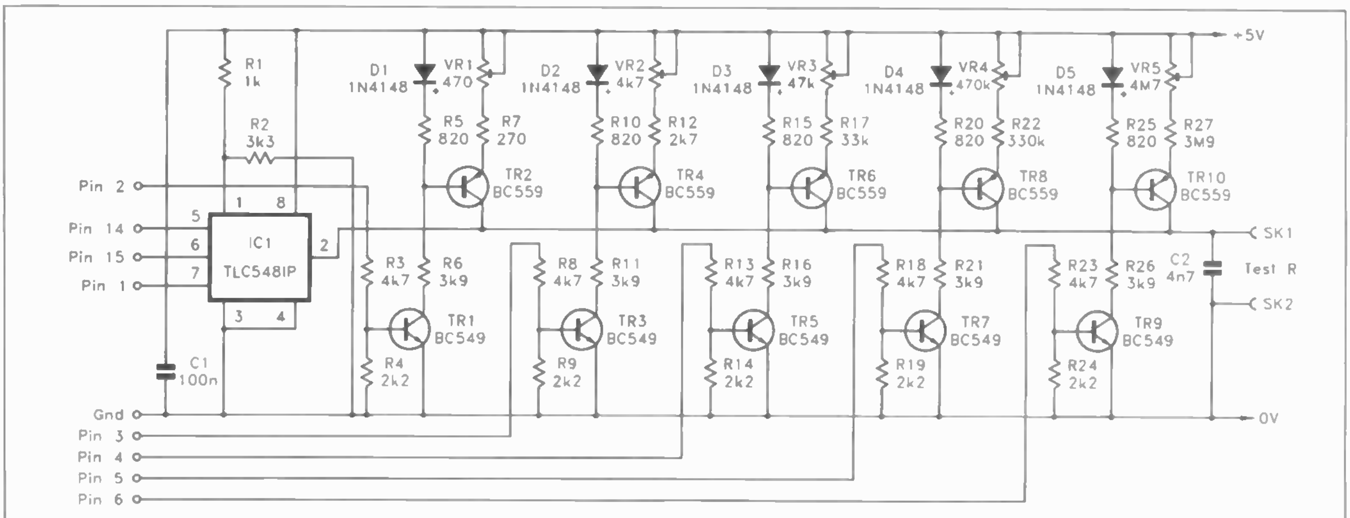


Fig. 2. Full circuit diagram for the Auto-Ranging Resistance Meter Interface, which connects to one of the PC's printer ports.

To minimise this problem the wiring to the "Test" sockets SK1 and SK2 *must* be kept as short as possible. Filter capacitor C2 should then be sufficient to keep the noise down to an insignificant level.

Software

The software for the Auto-Ranging Resistance Meter Interface is provided in Listing 1. The subroutine at line 310 is essentially the same as the routine provided in the November 1995 issue, and it simply reads the converter. The returned value is placed in variable "X." Double reads of the converter are used to ensure that the program always operates on fresh data.

The main program tries the unit on the lowest range, and if necessary works through to the highest range in an attempt to obtain an in-range reading. If an in-range reading is obtained, the program branches to the appropriate sub-program where the value in "X" is manipulated into the correct units and printed on screen.

For example, a value of 121 on the second range will be printed on screen as "12·1 kilohms", and not simply as "121." The program blanks the screen if no in-range reading is obtained, and then loops until an in-range reading is detected.

A delay is used each time the system is switched to a new range, to give the constant current generator circuit a chance to adjust to the change-over before a new reading is taken. The value of 10000 used at lines 40, 90, 140, 190, and 240 gives good results with a 75MHz Pentium PC, but a higher value might be needed for faster PCs. With very slow PCs each loop of the program might take an inordinately long time, and a lower value would then be appropriate.

Initially the five preset resistors should be set for about half maximum resistance. Close tolerance resistors having values of 2k2, 22k, 220k, 2M2, and 10M are used to calibrate the interface. Connect the 2k2 resistor to SK1 and SK2 and adjust VR1 for a reading of 2k2, connect the 22k resistor instead and adjust VR2 for a reading of 22k, and so on, working through to the 10M resistor and a reading of 10M set via preset VR5.

Listing 1: Auto-Ranging Resistance Meter Interface.

```
10 REM Resistance meter program
20 CLS
30 OUT &H378,1
40 FOR D = 1 TO 10000:NEXT
50 GOSUB 310
60 GOSUB 310
70 IF X < 255 THEN GOTO 730
80 OUT &H378,2
90 FOR D = 1 TO 10000:NEXT
100 GOSUB 310
110 GOSUB 310
120 IF X < 255 THEN GOTO 760
130 OUT &H378,4
140 FOR D = 1 TO 10000:NEXT
150 GOSUB 310
160 GOSUB 310
170 IF X < 255 THEN GOTO 790
180 OUT &H378,8
190 FOR D = 1 TO 10000:NEXT
200 GOSUB 310
210 GOSUB 310
220 IF X < 255 THEN GOTO 820
230 OUT &H378,16
240 FOR D = 1 TO 10000:NEXT
250 GOSUB 310
260 GOSUB 310
270 IF X < 255 THEN GOTO 850
280 LOCATE 10,30
290 PRINT "                "
300 GOTO 30
310 OUT &H37A,1
320 OUT &H37A,3
330 OUT &H37A,2
340 X = INP(&H379) AND 8
350 X = X*16
360 OUT &H37A,3
370 OUT &H37A,2
380 Y = INP(&H379) AND 8
390 Y = Y*8
400 X = X + Y
410 OUT &H37A,3
420 OUT &H37A,2
430 Y = INP(&H379) AND 8
440 Y = Y * 4
450 X = X + Y
460 OUT &H37A,3
470 OUT &H37A,2
480 Y = INP(&H379) AND 8
490 Y = Y * 2
500 X = X + Y
510 OUT &H37A,3
520 OUT &H37A,2
530 Y = INP(&H379) AND 8
540 X = X + Y
550 OUT &H37A,3
560 OUT &H37A,2
570 Y = INP(&H379) AND 8
580 Y = Y/2
590 X = X + Y
600 OUT &H37A,3
610 OUT &H37A,2
620 Y = INP(&H379) AND 8
630 Y = Y/4
640 X = X + Y
650 OUT &H37A,3
660 OUT &H37A,2
670 Y = INP(&H379) AND 8
680 Y = Y/8
690 X = X + Y
700 OUT &H37A,3
710 OUT &H37A,1
720 RETURN
730 LOCATE 10,30
740 PRINT X * 10;"ohms    "
750 GOTO 30
760 LOCATE 10,30
770 PRINT X / 10;"kilohms  "
780 GOTO 30
790 LOCATE 10,30
800 PRINT X;"kilohms  "
810 GOTO 30
820 LOCATE 10,30
830 PRINT X / 100;"megohms  "
840 GOTO 30
850 LOCATE 10,30
860 PRINT X / 10;"megohms  "
870 GOTO 30
```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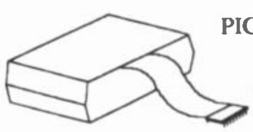

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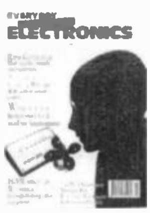

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FEATURES ● Static ● Circuit Surgery.

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PROJECTS ● Simple Theremin ● Low Range Ohmmeter Adaptor ● Comprehensive Security System ● Vandata ● Hum-Free Battery Eliminator.
FEATURES ● Cave Radio ● Ingenuity Unlimited.

OCT '95

PROJECTS ● Ginormous VU Meter ● Sound Switch ● Audio Sinewave Generator ● Treble Booster ● Infra-Red Controller/Alarm ● Capacitor Check ● Experimenter's Bargraph Test Board.
FEATURES ● Circuit Surgery ● Security Tagging ● Using Bargraph Displays.
FREE ● Multi-Project PCB with this issue.

NOV '95 Photostats Only (see below)

PROJECTS ● Digital Delay Line ● Video Enhancer ● 50Hz Field Meter ● Temperature Warning Alarm ● Current Tracer ● Distortion Effects Unit.
FEATURES ● Teach-In '96 Part 1 ● Developments in Radio Broadcasting Technology ● Turnpike for Windows Review ● Ingenuity Unlimited.

DEC '95 Photostats Only (see below)

PROJECTS ● Light Operated Switch ● Stereo "Cordless" Headphones ● EPE Met Office – 1 ● Modular Alarm System ● Audio Meter and Amplifier.
FEATURES ● Teach-In '96 Part 2 ● Circuit Surgery ● Index for Volume 24.

JAN '96

PROJECTS ● Printer Sharer ● Mains Signalling Unit ● Automatic Camera Panning System ● Audio Signal Generator ● EPE Met Office – 2.
FEATURES ● Teach-In '96 Part 3 ● Ingenuity Unlimited ● European Consumer Electronics Show ● Techniques – Actually Doing It ● Maths Plus Review ● Decibels and dBm Scale.

FEB '96 Photostats Only (see below)

PROJECTS ● Simple PIC16C84 Programmer ● Mains Signalling Unit – 2 ● PIC Electric Meter – 1 ● Vari-Speed Dice ● Analogue Frequency Meter.
FEATURES ● Teach-In '96 Part 4 ● Circuit Surgery ● Making Your Own P.C.B.s ● Techniques – Actually Doing It.

MARCH '96

PROJECTS ● Mind Machine Mk III Part 1 ● High Current Stabilized Power Supply ● Multi-Purpose Mini Amplifier ● Infra-Zapper ● PIC-Electric Meter – 2.
FEATURES ● Teach-In '96 Part 5 ● Ingenuity Unlimited ● Flight PAL Trainer Review.
FREE ● Headphones (UK copies only).

APRIL '96

PROJECTS ● Dolby Pro-Logic Decoder (*Free* Booklet) ● Bat-Band Converter ● Event Counter ● Mind Machine Mk III Part 2 – Programmer ● Hearing Tester.
FEATURES ● Teach-In '96 Part 6 ● Circuit Surgery ● Thermionic Valves Part 1.

MAY '96

PROJECTS ● Midi Analyser ● Mind Machine Mk III Part 3 – Tape Controller ● Versatile PIR Detector Alarm ● Countdown Timer ● Bat Band Converter B.F.O.
FEATURES ● Teach-In '96 Part 7 ● Ingenuity Unlimited ● Thermionic Valves Part 2 – The C.R.T.

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JUNE '96

PROJECTS ● Sarah's Light ● Ultra-Fast Frequency Generator and Counter Part 1 ● VU Display and Alarm ● Pulstar ● Home Telephone Link.
FEATURES ● Teach-In '96 Part 8 ● More Scope for Good Measurements Part 1 ● Circuit Surgery ● Miniscope Review.

JULY '96

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

AUG '96

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

SEPT '96

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

OCT '96

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

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NEXT MONTH

STEREO CASSETTE RECORDER
A complete, easy to build, design that can be used with most "surplus" cassette decks. An absorbing project produced by Robert Penfold as a result of many requests from readers.

VARI-COLOUR CHRISTMAS TREE LIGHTS

The electronically controlled Christmas tree lights featured in this article consist of a string of ten or twelve tri-colour light emitting diodes (l.e.d.s). A range of colourful effects can be produced, and standard flashing Christmas tree lights simply do not bear comparison to this system. The basic effect is for the lights to be cycled through red, green, yellow and off in a pseudo random fashion.

PIC D/A TACHOMETER
Most tachometers are either digital or analogue each with its advantages and disadvantages. The digital ones clearly indicate steady r.p.m. but are not good for indicating trends or where the rotation rate is not steady. On the other hand analogue types are excellent for displaying trends but the meter movements used in automobiles and motorcyles are heavily damped to give a slow response time, because there is a lot of vibration in these environments.

This design combines both digital and analogue displays in a compact, simple design based around a single chip microcontroller. The digital display is a two-digit seven segment type which will display the r.p.m. as multiples of 100 up to 9900 r.p.m. The analogue display consists of a baragraph with 17 elements. The length of the bar indicates the r.p.m. The resolution of the baragraph corresponds to 500 r.p.m. per l.e.d.

EVERYDAY PRACTICAL ELECTRONICS

DECEMBER ISSUE ON SALE FRIDAY, NOVEMBER 1

SHOP TALK
with David Barrington

D.C.-To-D.C. Converters

The main concern for those undertaking any of the *D.C.-To-D.C. Converter* modules is likely to be the sourcing of the "switch-mode" i.c.s. It is quite possible that they will not be available from local or usual mail order outlets.

The TL497CN chip called for in the *Negative Supply Generator* is not exactly the latest chip in switch-mode i.c.s, so it should be carried by quite a few of our component advertisers. However, if you do hit problems, it is currently listed by **Farnell Components** (***Tel:0113 263 6311***), code TL497ACN. It is also listed by RS (code 126-6885) but not in Electromail, their mail order outlet.

The 330μH inductor coil must be a type that is intended for switch-mode power supplies. An ordinary r.f. choke will not work in this design. If it is to fit on the p.c.b. it should have 5mm lead spacing. The one in the model is a RS type and came from **Electromail** (***Tel:01536 204555***), code 228-523.

Turning to the *Step-Down Regulator*, the circuit is based on the LM2575T-ADJ which is claimed to make switch-mode regulators as easy to use as ordinary series voltage regulators.

There are several versions of the LM2575T available and the device used here has an *ADJ* suffix added to its type number. This indicates that it has an adjustable output voltage and must be this type for this circuit. The one used in the module came from **Maplin** (***Tel:01702 554 161***), code AD86T.

The inductor L1 must be a switch-mode type and be capable of handling currents up to 1A. It was found that the 330μH "Bobin Type", code AH23A, from the above company and the almost identical RS "High Current" type-A version, **Electromail** code 228-438, both performed satisfactorily.

The LM2577T-ADJ needed for the *Step-Up Regulator* can provide output currents up to 3A, with built-in over-current and thermal protection, and was purchased from **Maplin**, code AD90X. It must be the "ADJ" device.

Once again, the 100μH inductor must be a high current type and can be either the RS High Current type-A (Code 228-416) or the Bobin Type, code AH21X, from **Maplin**. On the subject of inductors, its worth checking out the extensive range in the new **Cirkit** catalogue (see advertisement).

The Schottky diodes used in all three modules also came from Maplin, code GX30H.

Central Heating Controller

With the choice of a pre-programmed microcontroller or source code disk for the *Central Heating Controller*, only a couple of problems could be encountered when searching for components.

If you wish to undertake your own programming, the AT89C2051 microcontroller is listed by RS and should be available through **Electromail** (***Tel:01536 204555***), code 157-7567. The 16x2-line liquid crystal display module (code DK63T) and the 5A 240V a.c. single-pole changeover (s.p.c.o.) relays (code YX97F) came from Maplin (Tel. 01702 554 161).

We can only find the 8-bit A/D Converter type ADC0831 listed by **Farnell Components** (***Tel:0113 263 6311***), code ADC0831CCN. They also supplied the mains transformer (code 432-696), the pushbutton switches (code 150-247) and the clear display bezel (code 175-708).

A ready-programmed microcontroller is available directly from the designer, Richard Stone for the sum of £20 all inclusive. (Overseas readers should add £2 to their order). All orders should be sent to: **Richard Stone, 2 Carmargue Fold, Bradford, BD2 1HB.** *Make cheques payable to Richard Stone.*

The software source code (8051 machine code) is obtainable on a 3·5in. disk from the Editorial Offices for the sum of £2.50 (Overseas: £3.10 surface; £4.10 airmail), see page 875. Alternatively, Internet users can download it *free* from our ftp site:

ftp://ftp.epemag.wimborne.co.uk

EPE Elysian Theremin

Some of the components needed to put together the *EPE Elysian Theremin* could be described as being marginally special items. Most of these are the "hardware" requirements.

As far as the "active" components go, items such as the diodes and i.c.s. should be stocked by most of our component advertisers. The switched jack sockets, SCJ-0639, are special commercial types used in sound studios and can be purchased from the author, **Jake Rothman**, who specialises in audio work. The nearest we have come to these are the **Maplin** "PCB sockets", with switch contacts.

The designer, Jake Rothman, has put together a range of kit options, including hardware, so that readers can select their own requirements. For further details write to him at: **93 St, Johns Road, Frome, Somerset, BA11 2BE.** *Also see his advertisement on page 841.*

Tuneable Scratch Filter

Only the 8-pin switched capacitor filter i.c. type LTC1063CN8 is likely to cause problems when hunting down parts for the *Tuneable Scratch Filter* project. This appears to be only available from **Electromail** (***Tel:01536 204 555***), code 311-956.

Details for all this month's printed circuit boards can be found on page 875.

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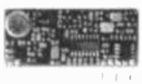

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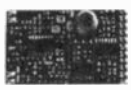

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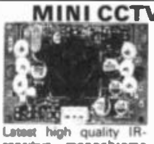

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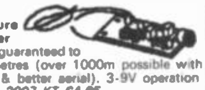

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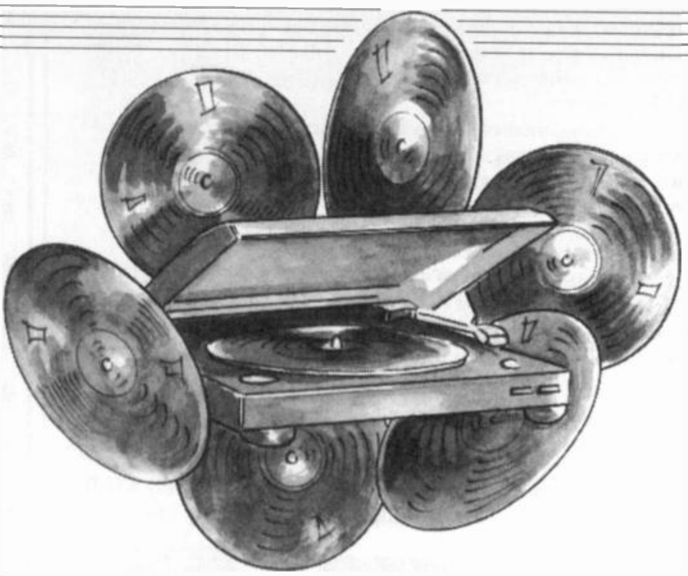
TUNEABLE SCRATCH FILTER



ROBERT PENFOLD

Bring your treasured "golden oldies" up to scratch and give your ageing "vinyls" a new spin!

VINYL records are no longer in large scale commercial production, having been supplanted by compact discs (CDs), but many people still have large collections of ageing LPs.

Much of the programme matter on these LPs has been made available on compact discs, but there is still a fair percentage of material which has yet to be released on CD. Even where your favourite "golden oldies" are available in digital form, buying everything in your collection again could prove to be prohibitively expensive!

UP TO SCRATCH

Although LPs are obsolete, it seems likely that they will still be in widespread use for many years to come. Record players and record decks are certainly still available and selling in large numbers.

This leaves the problem of extracting reasonably high fidelity from increasingly worn records. Using high quality playing equipment and record cleaning devices will minimise wear, but there seems to be an inevitable increase in "surface" noise over the years.

The standard way of dealing with this background "crackling" sound is to use a scratch filter to process the signal from the record deck. A filter of this type is just a simple lowpass type which has a cut-off frequency that is usually at about 5kHz to 7kHz.

Surface noise is produced by tiny imperfections in the groove walls, or by minute particles of dust in the grooves. The small size of the imperfections and dust particles results in them producing very brief "click" sounds. The frequency content in these sounds is predominantly at high audio frequencies at around 5kHz to 20kHz.

Because surface noise is largely at high frequencies, attenuating these frequencies produces a large amount of noise reduction. It also produces some loss of fidelity, because some of the main signal is also attenuated. This gives a less "bright" sound, but where the surface noise has become quite severe, the reduction in noise easily outweighs the general loss of treble.

ROLL-OFF RATE

There seems to be no generally accepted optimum attenuation rate for a scratch filter. Backing off an ordinary treble tone control will give a reduction in surface noise, but the attenuation rate of 6dB per octave means that the improvement is limited, and there is some attenuation of signals at lower frequencies.

A roll-off rate of 12dB or 18dB per octave is generally considered to give better results, and true "brickwall" filtering having an attenuation rate of about 100dB per octave is sometimes used. However, for most tastes such sharp filtering sounds rather too obvious, and unmusical.

The cut-off frequency of most scratch filters is fixed, and has to be a compromise figure. If a record is suffering from a moderate amount of surface noise a relatively high cut-off frequency of about 8kHz or 9kHz will probably provide the best results.

For a record that is in rather poor condition a much lower cut-off frequency is usually needed in order to effectively reduce the surface noise. A cut-off frequency as low as 3kHz to 4kHz might be needed.

The Tuneable Scratch Filter described here provides an attenuation rate of 30dB per octave, which is high enough to ensure a high degree of noise reduction while leaving the music as little affected as possible. The roll-off rate is not so high as to make the filtering over-obvious and intrusive.

Using switched capacitor filters makes it possible to vary the filter's cut-off frequency over a useful frequency range. The −6dB point can be varied from under 3kHz to around 9kHz to 10kHz. The cut-off frequency can therefore be varied to suit the surface noise present on each record. This factor, together with the relatively high attenuation rate of the filtering, enables excellent results to be obtained with practically any record.

SWITCHED CAPACITORS

Conventional active filter configurations can easily provide attenuation rates of around 30dB per octave, but it is impractical to have a high attenuation rate and a variable cut-off frequency. An attenuation rate of 30dB per octave would require a five-gang potentiometer, or a 10-gang type for a stereo filter.

Switched capacitor filters are a more practical proposition, as they permit high attenuation rates to be obtained, and the

cut-off frequency is controlled via a clock signal. In order to vary the cut-off frequency, it is merely necessary to vary the clock frequency.

A basic switched capacitor filter is quite similar to a conventional *CR* filter. Fig. 1a shows the circuit for a single stage *CR* lowpass filter.

With a low frequency input signal the charge on capacitor C1 can accurately track the input voltage, giving no significant losses through the circuit. At higher frequencies the current flow in and out of C1 must be higher in order to maintain an output signal at virtually the same level as the input signal.

Resistor R1 limits the amount of current that can flow, and above a certain frequency it begins to keep the current flow below the level at which the output level can be sustained. Taking the input frequency above this frequency produces increasing losses through the circuit, with an ultimate attenuation rate of 6dB per octave. In other words, each doubling of the input frequency causes the losses through the circuit to double.

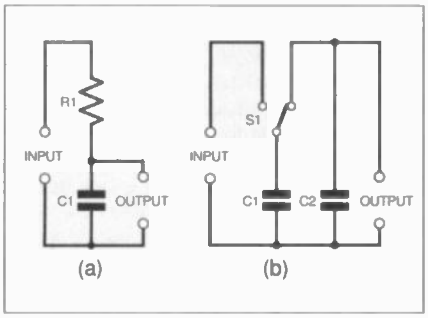


Fig. 1(a). A normal CR filter and (b) the switched capacitor equivalent.

ALL PUMPED-UP

The switched capacitor equivalent to a *CR* lowpass filter is shown in Fig. 1b. The resistor is replaced by a switch and a capacitor (C1 and S1). In a practical circuit the switch is an electronic type controlled by a clock oscillator. Capacitor C2 is the equivalent of C1 in the *CR* filter.

The basic action of the circuit (Fig. 1b) is for C1 to be connected to the input where it charges to the input potential, and then to C2 where it modifies the charge on C2. In practice, switch S1 is operated continuously, and at a frequency that is typically between about 20kHz and 1MHz.

With a static input voltage, capacitor C2 is soon charged to a potential that is virtually equal to the input voltage. Capacitor C1 repeatedly charges from the input signal, and discharges into C2, rapidly "pumping-up" the potential on C2 to a level that is virtually the same as that on C1.

If the input voltage increases, the same action will again boost the charge on C2 to a level that is practically the same as the input voltage. A reduction in the input voltage results in C1 being charged from C2, and discharged to some extent into the signal source. The charge on C2 therefore falls to a level that is virtually the same as the input voltage.

This circuit can couple the input signal through to the output with minimal losses, but only if the "electronic" switch S1 is operated at a frequency that is much higher

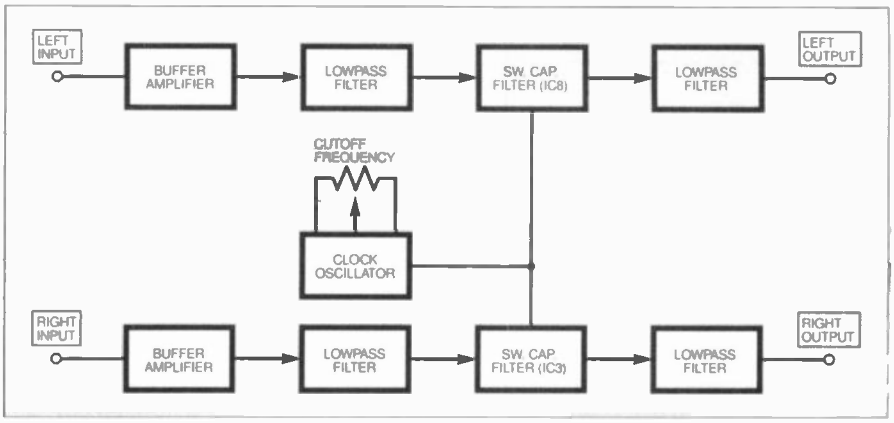


Fig. 2. Block diagram for the Tuneable Scratch Filter.

than the input frequency. This is due to the fact that C1 is made much lower in value than C2.

It therefore takes several charge transfers for the output voltage to respond to a sudden voltage change at the input. Like the resistor in the *CR* filter, the switch and capacitor can only provided a limited current flow into and out of the filter capacitor, and a 6dB per octave lowpass filter action is obtained above a certain frequency.

The cut-off frequency of a switched capacitor filter is controlled by the clock frequency, and by the relative values of C1 and R1. Practical switched capacitor filters are mostly designed to have a cut-off frequency that is a fiftieth or a hundredth of the clock frequency.

SYSTEM OPERATION

The block diagram of Fig. 2 shows the general arrangement used in this Tuneable Scratch Filter. The two stereo channels are identical.

A buffer amplifier at the input provides a suitably low drive impedance for the next stage, which is an ordinary *CR* active lowpass filter. This has a cut-off frequency that is well towards the upper limit of the audio range, and it does not significantly aid the scratch filtering. Its purpose is to ensure that no high frequency signals enter the switched capacitor filter, where they could react with the clock signal to produce heterodyne tones.

Practical switched capacitor filters invariably seem to have more than one stage, and the device used in this circuit is a five stage type. It has a frequency response which closely approximates that of a "Butterworth" lowpass filter. The clock oscillator is common to both channels, and the filter's cut-off frequency is one hundredth of the clock frequency (±0·5%).

Another lowpass filter is used at the output of the unit. The degree of clock breakthrough at the output of the switched capacitor filter is very low at only about 50μV r.m.s., which, on its own, is insufficient to merit any output filtering.

However, the output waveform is a stepped type, rather like the digitised audio output from a digital-to-analogue converter. The high frequency content on the output from the switched capacitor filter will not necessarily cause any problems, but it is as well to severely attenuate it in order to ensure that it cannot cause any difficulties.

COMPONENTS

Resistors

R1, R2, R13, R14	100k (4 off)
R3, R4, R5, R8, R9, R10, R15, R16, R17, R20, R21, R22	5k6 (12 off)
R6, R7, R18, R19	3k9 (4 off)
R11	4k7
R12	1k5

All 0·25W 5% carbon film

Potentiometer

VR1	4k7 rotary carbon, lin

See **TALK** Page

Capacitors

C1, C12, C23, C24	100n ceramic (4 off)
C2, C13	470n polyester (2 off)
C3, C7, C14, C18	3n3 polyester (4 off)
C4, C8, C15, C19	4n7 polyester (4 off)
C5, C9, C16, C20	330p polystyrene (4 off)
C6, C17	4μ7 radial elec. 50V (2 off)
C10, C21	10μ radial elec. 25V (2 off)
C11	180p polystyrene
C22	1000μ radial elec. 25V
C25	100μ radial elec. 25V

Semiconductors

D1, D2	1N4002 100V 1A rectifier diode (2 off)
IC1, IC2, IC4, IC6, IC7, IC9	LF351N bifet op.amp (6 off)
IC3, IC8	LTC1063CN8 switched cap. filter (2 off)
IC5	4046BE CMOS phase-locked loop
IC10	μA78L12 12V 100mA regulator

Miscellaneous

SK1 to SK4	phono socket, chassis mounting (4 off)
T1	230V mains transformer, with twin 12V 250mA secondaries (or 12V-0V-12V 250mA secondary)
FS1	250mA 20mm quickblow fuse
S1	rotary mains switch, d.p.s.t.

Metal instrument case, size about 203mm x 127mm x 51mm; printed circuit board, available from the *EPE PCB Service*, code 115; 8-pin d.i.l. holder (8 off); 16-pin d.i.l. holder; control knob (2 off); pair of 20mm fuse-clips; M3 or 6BA fixings; mains lead and plug; multistrand connecting wire; solder pins, solder, etc.

Approx Cost Guidance Only £45 excluding case

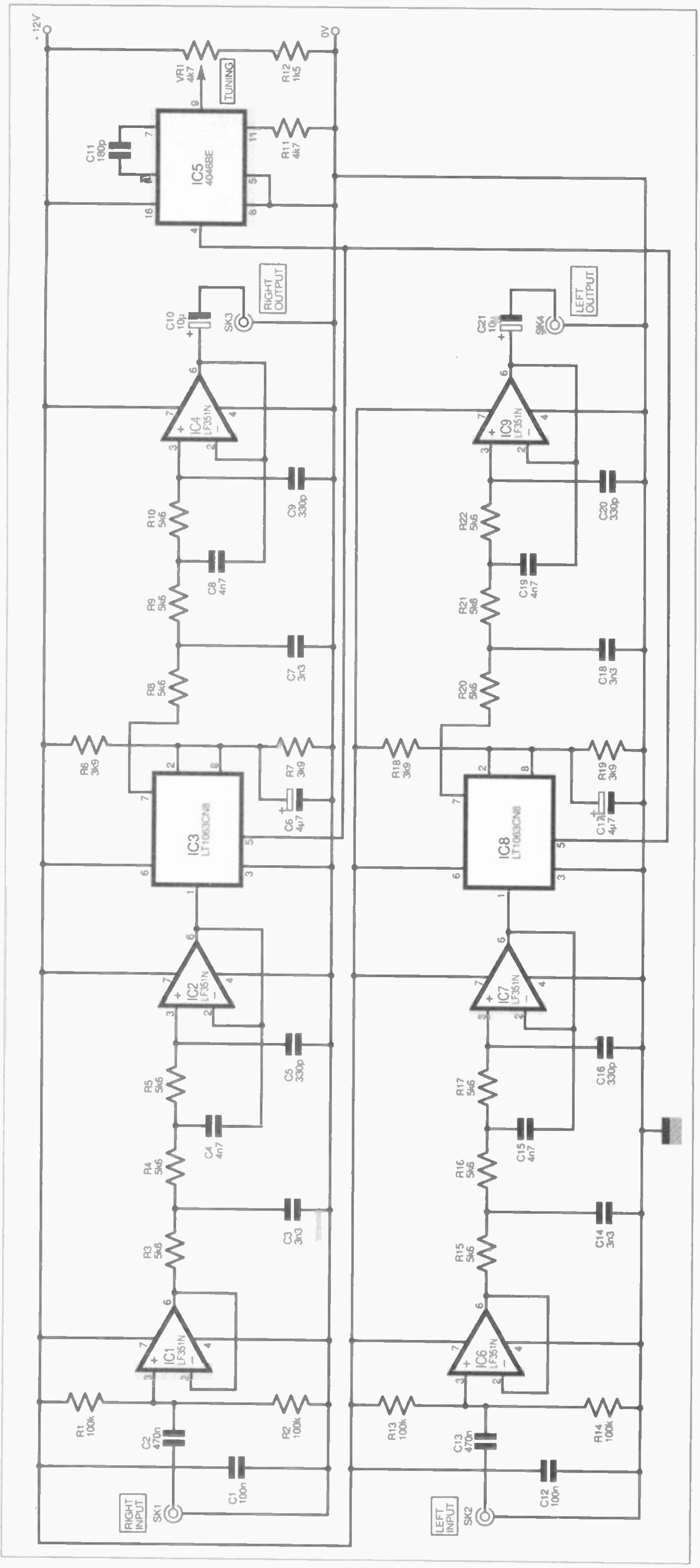


Fig. 3. Main circuit diagram for the Tuneable Scratch Filter.

CIRCUIT DESCRIPTION

The main "active" circuit diagram for the Tuneable Scratch Filter is given in Fig. 3. As the two stereo channels are identical we will only consider operation of the right hand channel. IC1 is used as the input buffer amplifier, and its input impedance is set at 50 kilohms (50k) by bias resistors R1 and R2. It drives a conventional third order (18dB per octave) lowpass filter, formed around IC2, which has a cut-off frequency of about 16kHz.

An LTC1063CN8 switched capacitor filter is used for IC3. Some switched capacitor integrated circuits are state variable filters which can be used in a variety of modes. The LTC1063CN8, without the use of some additional active circuitry, can only operate as a lowpass filter. This limitation is clearly of no importance in this context, where it is a lowpass filter that is needed.

A minimal number of discrete components are required. Apart from the input and output filters and the clock generator, only resistors R6, R7, and electrolytic capacitor C6 are required. These provide a half supply voltage bias to ground (0V) and output voltage adjustment terminals (pins 2 and 8 respectively).

The LTC1063CN8 is primarily designed for use with dual balanced supplies, but it works well when used with a single supply and a bias circuit to effectively provide the central 0V "ground supply." The output voltage adjustment terminal is only needed in d.c. circuits where it enables an output offset voltage to be introduced, or an unwanted offset to be trimmed out. It serves no useful purpose here, and is simply biased to the mid-supply voltage.

Direct coupling is used at the input and output of IC3. In fact the circuit is direct coupled throughout, apart from the input and output coupling capacitors. IC4 is used as the buffer amplifier in the output filter, which is identical to the input filter.

CLOCKING-OUT

The LTC1063CN8 has a built-in clock oscillator that only requires a discrete timing resistor and capacitor. However, the integral clock oscillator is only designed for operation up to about 500kHz. With a maximum cut-off frequency at about 9kHz to 10kHz, and the clock frequency 100 times higher than the cut-off frequency, this application requires a maximum clock frequency of almost 1MHz.

An external clock circuit is therefore used, and it is based on IC5. The latter is a CMOS "micropower" phase-locked loop, but in this circuit only its voltage controlled oscillator (v.c.o.) is used, and no connections are made to the other stages of the device. Capacitor C11 and resistor R11 are the timing components.

Control potentiometer VR1 and resistor R12 provide a variable voltage to the control input of IC5, and VR1 enables the output frequency to be varied from under 300kHz to around 950kHz. The output signal of IC5 is a squarewave signal at normal CMOS levels, which gives good results with the LTC1063CN8.

The approximate frequency response of the Tuneable Scratch Filter, with VR1 set for a −6dB point at 5kHz, is shown in Fig. 4. The Butterworth type response gives minimal losses immediately below

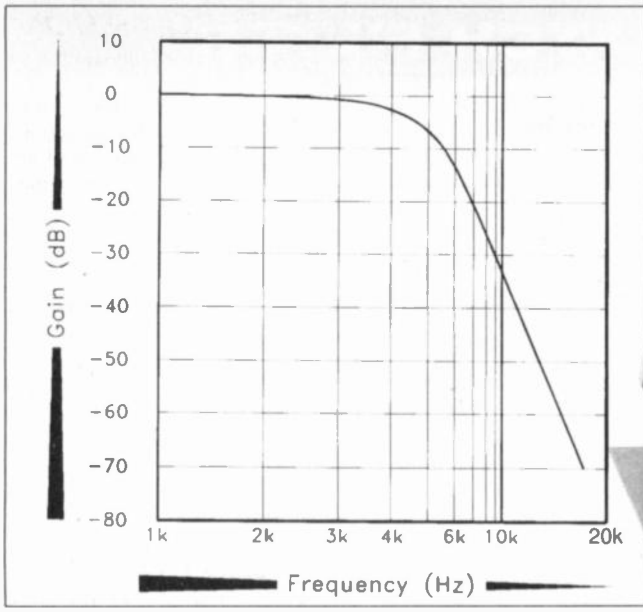
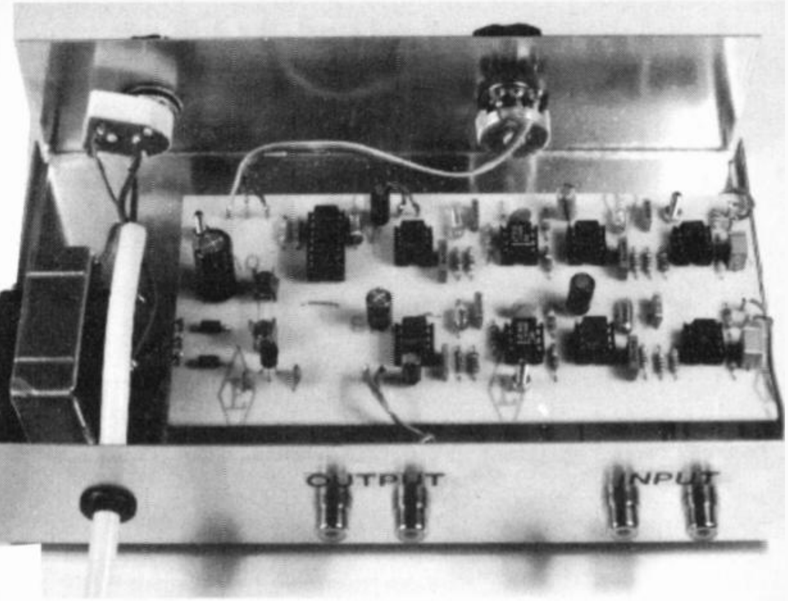


Fig. 4. Approximate frequency response of the Scratch Filter, with VR1 set for a –6dB point at 5kHz.



Completed unit showing wiring to the Mains on/off switch and tuning control VR1.

the cut-off frequency, and a rapid introduction of the full roll-off rate. Together with the fairly high attenuation rate of 30dB per octave, this gives excellent results.

POWER SUPPLY

A well smoothed and reasonably stable 12V supply is required. The current consumption of the circuit should be no more than about 60mA, and is typically only about 40mA or so. It is possible to use a fairly high capacity battery as the power source, such as eight HP7 size cells in a holder, but a mains power supply circuit is the more practical choice.

A recommended circuit diagram for the mains power supply appears in Fig. 5. This is a conventional design using full-wave push-pull rectification (T1 and D1/D2) and a small 12V voltage regulator IC10 to stabilise the output voltage and provide electronic smoothing.

On the face of it, a transformer having a current rating of 100mA is adequate for this circuit, but in practice the loaded input voltage to IC10 might be inadequate. A 12V transformer having a 200mA or 250mA current rating provides a more than adequate input voltage to IC10, and a 15V type having a current rating of about 100mA to 166mA is also suitable.

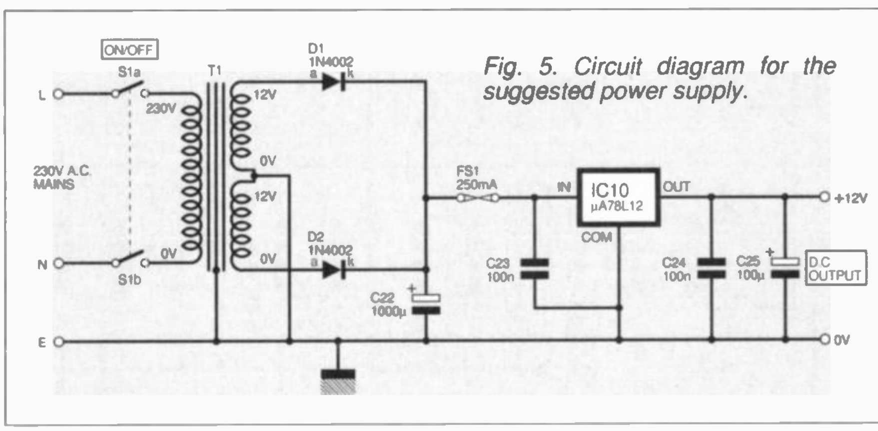


Fig. 5. Circuit diagram for the suggested power supply.

BYPASS SWITCHING

The Tuneable Scratch Filter is designed to handle a high level signal of up to about 2V r.m.s., and it will provide insignificant noise and distortion levels when used with a reasonably high signal level. The signal-to-noise ratio will be very poor indeed if it is used between a magnetic cartridge and the preamplifier.

Ideally, the unit should be fitted between the RIAA preamplifier and power amplifier. If you are using a separate preamplifier and power amplifier there should obviously be no difficulty in doing this, and many combined pre/power amplifiers have provision for using external signal processors. Even if there is no facility for external signal processing, in most cases there is a tape monitoring facility that can be pressed into service for this purpose.

In either case, the amplifier's built-in switching should provide a means of bypassing the filter when it is not needed. If the filter is connected between separate pre- and power amplifiers it might be necessary to provide it with built-in bypass switching. This requires a four-pole changeover switch connected in the manner shown in Fig. 6.

Another way of using the unit is to provide it with an integral RIAA preamplifier (see Oct. and Nov. 93 issues for a suitable design), and connect its output to the "Aux" input of the amplifier, or any other spare high level input. The built-in bypass switching will also be needed if this method is utilized.

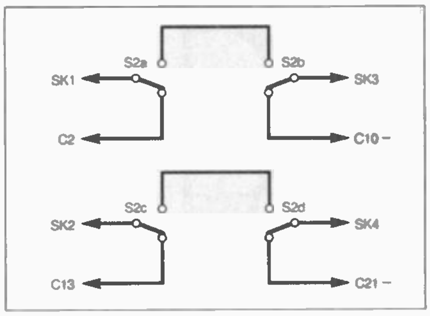
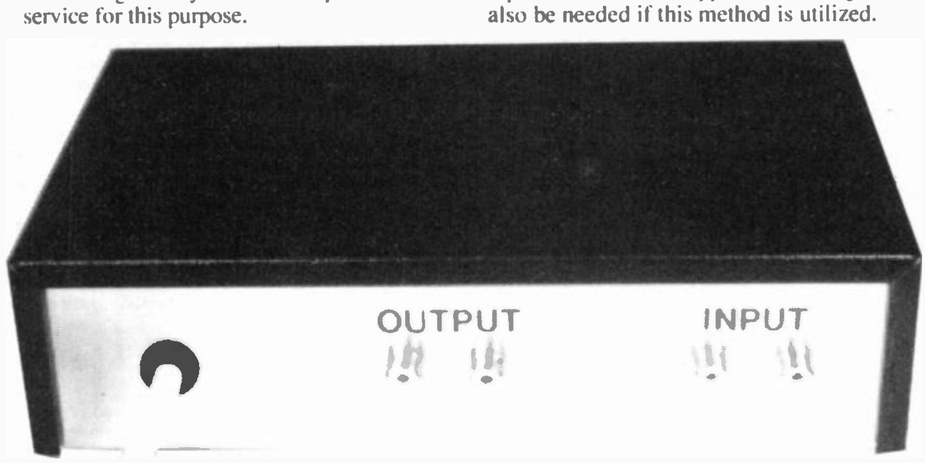


Fig. 6. Built-in bypass switching can be provided by a four-pole changeover switch.



The input and output phono sockets on the rear panel.

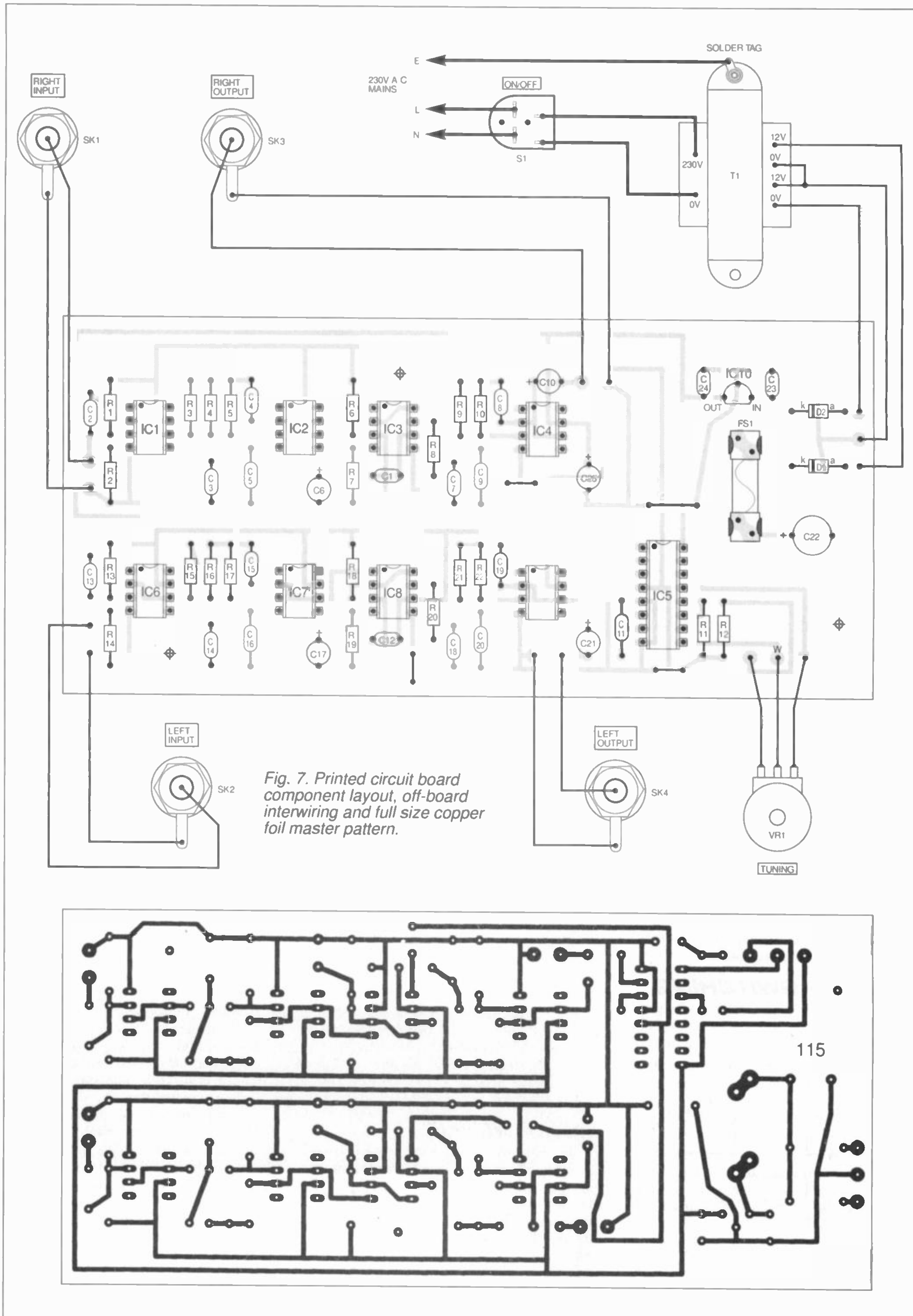


Fig. 7. Printed circuit board component layout, off-board interwiring and full size copper foil master pattern.

CONSTRUCTION

The topside component layout and actual size copper foil pattern for the Tuneable Scratch Filter printed circuit board (p.c.b.) are shown in Fig. 7. This board is available from the *EPE PCB Service*, code 115.

The 4046BE and LTC1063CN8 are CMOS devices that are static-sensitive. The LTC1063CN8 is also a relatively expensive component. Therefore, the normal anti-static handling precautions must be scrupulously adhered to when dealing with IC3 and IC8. It is advisable to use holders for all the d.i.l. integrated circuits, but they should *definitely* be used for IC3, IC5 and IC8.

Do not fit the i.c.s into their holders until the board and hard wiring have been completed. Until then they should be left in their anti-static packaging, which in the case of IC3 and IC8 will probably be a conductive plastic holder.

When "plugging" the i.c.s into their holders try to handle them no more than is absolutely necessary and, as far as possible, avoid touching the pins. It is obviously important to keep well away from sources of static electricity (televisions, computer monitors, carpets that are prone to generating static discharges, etc.) when fitting the three MOS integrated circuits.

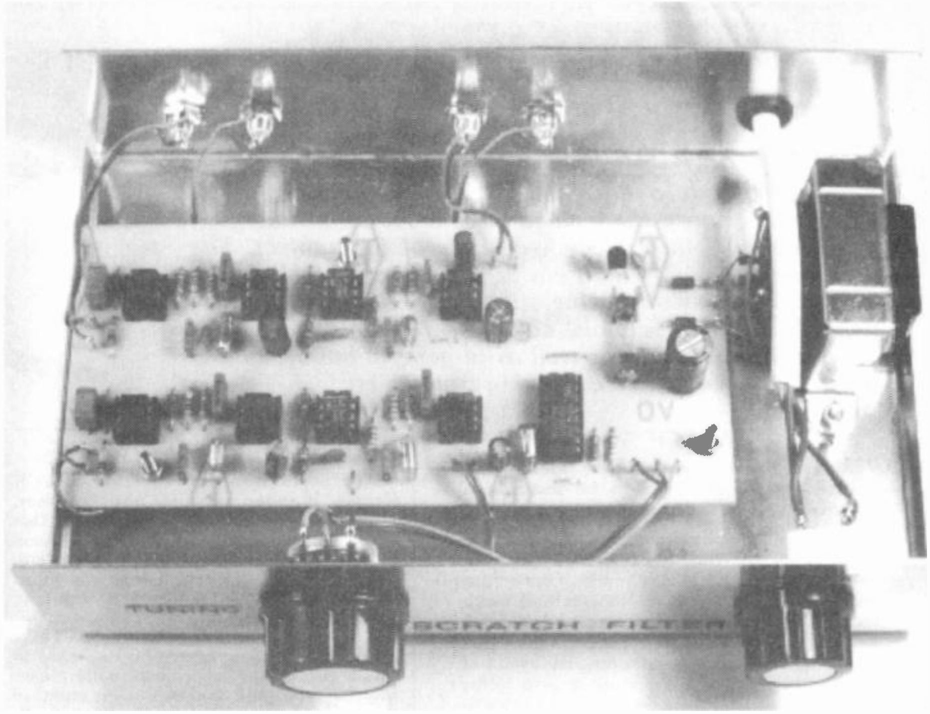
Start construction of the board by fitting single-sided solder pins at the positions where connections to the controls, sockets, etc. will eventually be made. Then fit the integrated circuit holders, the resistors, the capacitors, and the four link-wires. The latter are quite short and can be made from trimmings from the resistor leadouts.

The polyester capacitors should be p.c.b. mounting types having 7·5mm (0·3 in.) lead spacing. It could be difficult to fit other types onto the board properly.

For the same reason the electrolytic capacitors must be miniature p.c.b. mounting components. Be careful to fit them with the right polarity, ***especially C22.*** This component could literally explode if it is fitted the wrong way round.

Fuse FS1 is mounted on the circuit board via a pair of fuse-clips. To finish the board add voltage regulator IC10 and the two rectifier diodes D1 and D2, being careful to fit the rectifiers with the correct polarity.

The integrated circuits (apart from IC3, IC5 and IC8) can now be fitted into their holders. Once again, be careful to fit these components the right way round.



Completed Scratch Filter showing positioning of p.c.b. and the mains transformer. Use a "strain-relief" type grommet for the mains lead entry.

CASE

Ready-made hi-fi style cases do not seem to be available any more, so a *metal* instrument case is probably the best choice unless you are prepared to take the do-it-yourself approach. As this project is mains powered it is *important* that the case is largely of *metal construction*, and that it is reliably "earthed" to the mains Earth lead. The case must have a screw fitting lid, not a clip-on/clip-off type that would provide easy access to the dangerous mains wiring.

The input (SK1/SK2) and output (SK3/SK4) sockets are mounted on the rear panel of the case, with output sockets at roughly the middle of the panel, and the input sockets well towards the left end (as viewed from the front). Phono sockets are used on the prototype, and these are now by far the most common form of connector on hi-fi equipment. Obviously a different type of connector can be used if it will be a better match for the rest of your hi-fi system.

A hole for the mains lead is made at a position well towards the right end of the rear panel. This hole must be fitted with a grommet to protect the mains cable. Switch S1 is mounted on the front panel, roughly opposite the entrance hole for the mains lead.

Mains transformer T1 is mounted on the base panel of the case, as far to the right as possible. Using the specified case it must be mounted towards the rear of the case so that it does not obstruct one of the fixing screws for the outer casing.

A solder tag is fitted on one of T1's mounting bolts, and this provides a chassis connecting point for the mains Earth lead. Potentiometer VR1 can be mounted anywhere on the large expanse of otherwise unused front panel.

There is just about sufficient space for the component p.c.b. on the base panel of the case to the left of T1. It is mounted using 6BA or metric M3 screws, with spacers being used to hold the board about 12mm clear of the metal base panel. This relatively large stand-off is needed to ensure that the board is kept clear of the second fixing screw for the outer casing.

INTERWIRING

The hard wiring from the printed circuit board to the case-mounted components is also shown in Fig. 7. It is not essential to use screened lead to make the connections from the p.c.b. to VR1 and the sockets, but try to keep this wiring reasonably short. Make sure that the mains earth (E) lead is connected to the solder tag on T1 by way of a strong soldered joint. If the quality of this joint is in any doubt, clean away all the solder and try again.

In Fig. 7, T1 is shown as a type having twin secondary windings, which is the type that most retailers now offer. The two secondary windings are connected in *series* to give what is effectively a centre tapped secondary. If a genuine 12V-0V-12V type is used, the 0V terminal simply connects to the centre pad, and the 12 volt terminals connect to the outer copper pads alloted for the mains transformer.

Switch S1 is a rotary mains switch on the prototype, but it is in order to use any form of double-pole mains switch here. The tag arrangement for other types of switch is almost certain to be different to that shown. If in doubt, check the switch with a continuity tester to determine the correct method of connection.

As this is a mains powered project it is essential to thoroughly check all the wiring before switching on the unit and testing it. Pay particular attention to the wiring around T1 and S1.

IN USE

The Tuneable Scratch Filter is connected to the hi-fi system using ordinary twin-screened phono leads.

The effect of the unit will be very obvious if it is functioning correctly. With front panel control VR1 set for maximum cut-off frequency there is only a small amount of high frequency loss, but with it fully backed-off the loss of high frequency response is massive, and obvious on any programme material.

For most records, results are best with VR1 at a "middle" to "high" setting, but it is really a matter of experimenting a little to find the setting that gives what are judged to be the best results.

Note that a filter of this type is not effective against large scratches. These contain strong signals at relatively low frequencies, which makes it impossible to counteract them using simple filtering. A Scratch Blanker, which works on a totally different principle, is the only effective way of counteracting large scratches.

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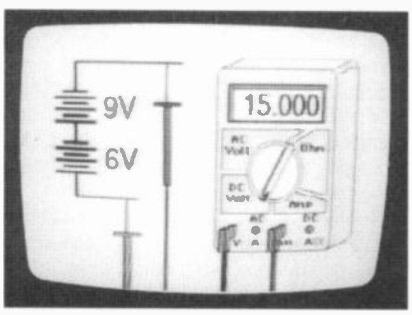

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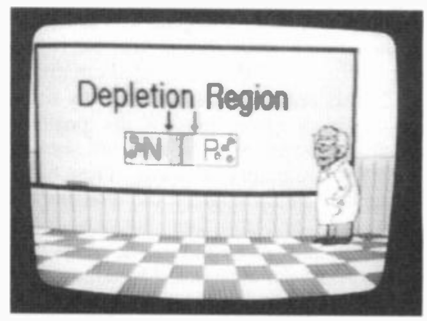

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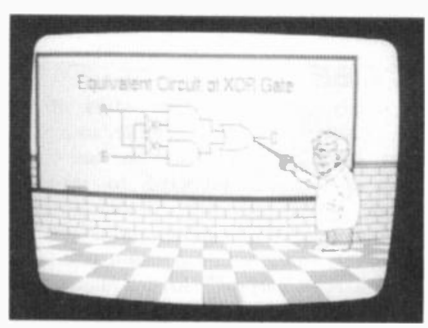

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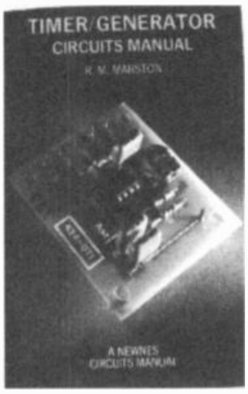

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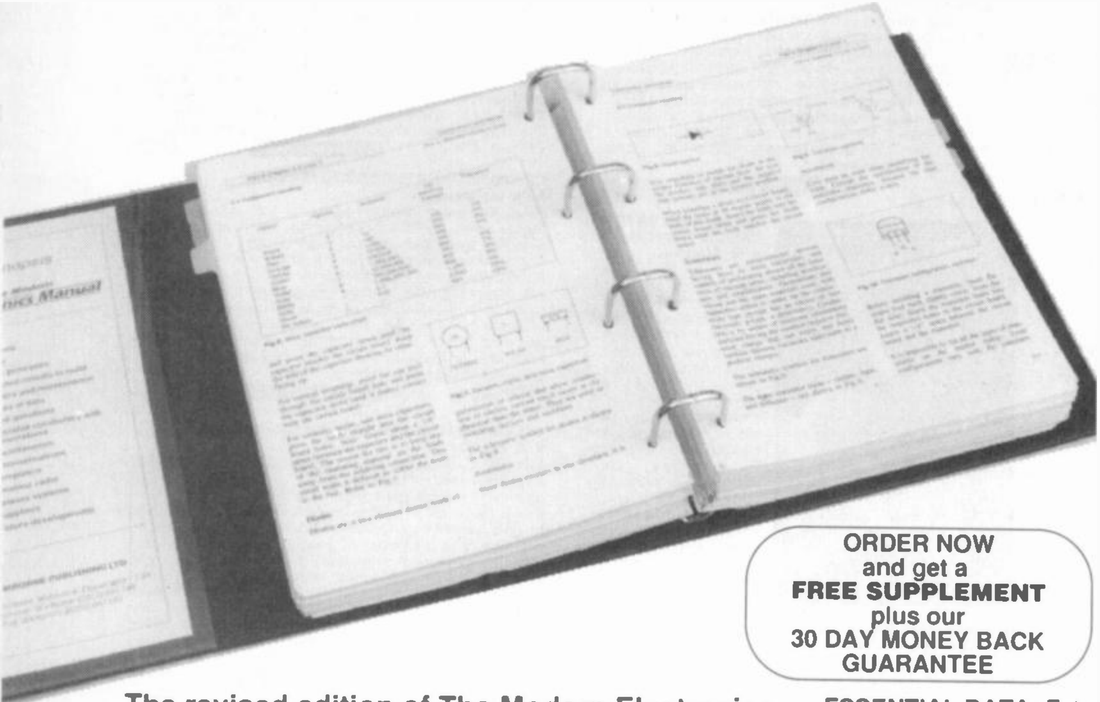

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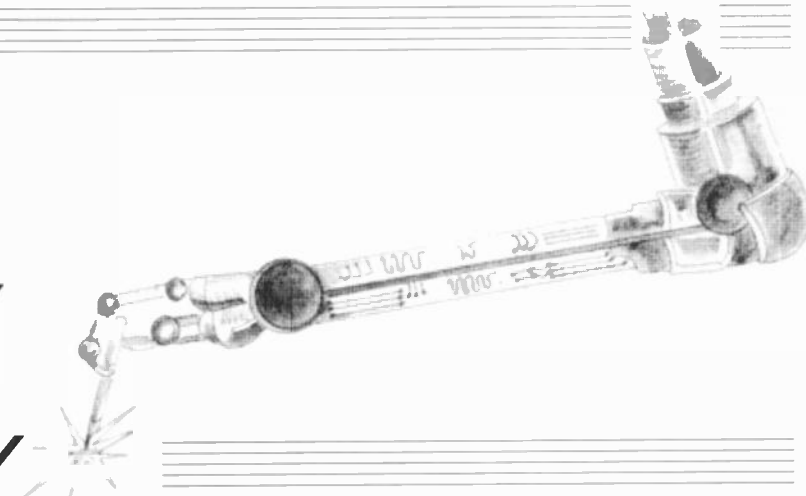

ALAN WINSTANLEY

This month our resident surgeon investigates a faulty project, flashing l.e.d.s, hole storeage noise and some useful battery tips.

Too Hot

We sometimes receive calls for help from constructors who might be experiencing problems with constructional projects. Extensive care is taken to ensure that all published information is accurate, and it is extremely rare for errors to creep into a project article. We try to help as much as possible though we don't guarantee that we can assist with projects over five years old: parts become obsolete, suppliers disappear, and technology moves on, making it occasionally not at all worthwhile trying to diagnose the ills of such a project.

Simpler projects using discrete components generally have a good lifespan, though. If things go wrong, and the project doesn't quite operate as expected, there is often a very simple reason for the failure and – most importantly – I'm keen to stress that things *do* go wrong from time to time, as part and parcel of electronic construction, but you shouldn't let this deter you.

Fault-finding and troubleshooting are all part of the deal when you become involved in electronics. For instance, ***M. Neill*** of Formby High School, Liverpool asks:

I would be grateful for your help in solving a problem with the Vehicle Voltage Monitor *project (February 1991 issue). When I use the circuit, both transistors and both resistors get extremely hot! I changed the resistors for higher power versions and I changed TR1 and TR2 for TIP31A and TIP32A power types, too. I made the circuit with a p.c.b. instead of the suggested stripboard – I hope you can help find a solution.*

The circuit in question is shown in Fig. 1. In my experience, transistors are easily the main source of problems in circuits such as this. It's easy to connect them incorrectly by identifying the leads wrongly, or even by accidentally inserting the wrong device altogether.

In the *Voltage Monitor* circuit, the two transistors are simply driving or shunting light-emitting diodes. If the l.e.d.s were shorted out, for example, the fact that each transistor has a 220 ohm resistor in its load says that the maximum current which

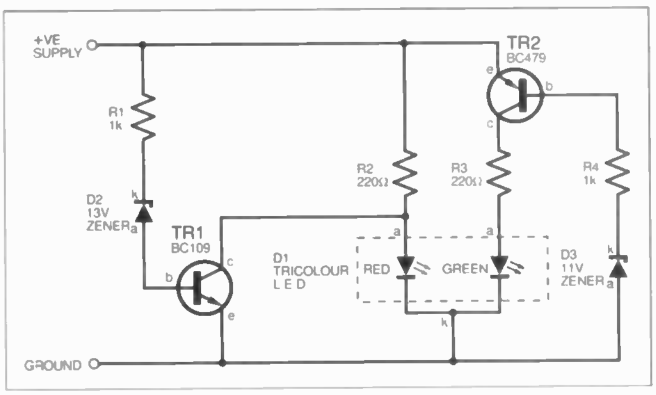

Fig. 1. Circuit of the Voltage Monitor project from Feb. '91.

could flow through each transistor as collector current would be (12/220) = 50mA. Note that it's not necessary to be accurate, we're only looking for clues as to what to expect in this circuit, so that we can check things further.

This means that the resistors would be dissipating, say, 0·6 watts (12 × 0·05) or so, and indeed the designer specified 0·6W resistors in the published parts list, so I would expect the resistors to become quite warm to the touch. It could be that you're using ordinary 0·25W resistors instead, which will become hot in use.

It's a bit odd, though, if the transistors become hot, and there should definitely be no need to change them for the power transistors mentioned. How do I know? By doing a few rule of thumb calculations, you can glean a few more clues as to what's going on: the transistors, in use, are acting as switches. This means that when they are switched hard on (saturated), there is only a small voltage drop between their emitter and collector terminals. Now, the power dissipated by a transistor is calculated by multiplying this voltage drop by the current flowing through it. The result is a power dissipation, in watts.

In this circuit, only a rough calculation is needed to tell you that there's something wrong somewhere. Take the case of the *pnp* transistor TR2. If TR2 is switched on, then the green l.e.d. will be glowing and TR2 will be saturated. I would expect (rule of thumb time) to see no more than perhaps 0·2V to 0·4V or so across the transistor's collector/emitter. With 50mA flowing through the l.e.d., this means that the transistor will dissipate no more than 0·4V × 50mA = 0·02W or 20mW.

A TIP31A power transistor is good for no less than 40 watts! So it would be reasonable, Mr. Neill, to expect that neither transistor became at all warm because they dissipate so little. Weighing it up, I would only guess that the transistors have been incorrectly connected, especially if you departed from the published design and built the project on a home-made p.c. board.

In general terms, if readers do have cause to contact us concerning a problem with a project, please write to us providing as much relevant information as you can, including test readings where possible. We will do our best to help you get up and running – and, best of all, the service is free!

Flashy!

A quick note from ***Mark McGuinness*** of Clondalkin, Ireland concerning the use of flashing l.e.d.s, Mark says:

I've found that a flashing l.e.d., of the type containing an internal flasher i.c., can be used to pulse other non-flashing, standard l.e.d.s. connected in series. Small relays can also be pulsed on and off when connected in series with the flashing l.e.d.

Just to illustrate the point, this month's *Ingenuity Unlimited* features a simple project which Mark designed to test light emitting diodes.

Hole Storage Noise

If you ever see capacitors surrounding a bridge rectifier, you might wonder what they're for. It's to combat hole storage noise which may be generated by the semi-conductor junctions. ***Mr. B.J. Taylor*** confirms the score:

In June 96 Circuit Surgery *(Page 477) you mentioned rectifier diode noise. You were correct that the effect is called hole storage noise but this doesn't get mentioned much these days. I have known the effect give problems on FM tuners where it appeared as modulation buzz. But it seems very rare to encounter it these days, probably because of the routine use of voltage regulators, and their ability to eliminate nearly all noise on the supply. I had a noise problem with a couple of 15W valve amplifiers which was only eventually eliminated by wiring 10nF 800V a.c. capacitors across the rectifiers.*

I'm seeing more of this form of filtering, typically 10 to 220nF capacitors placed in parallel with each rectifier diode. In some commercial equipment I've also seen a 220nF polyester capacitor placed across a transformer secondary, also to combat noise.

Challenge

Finally this month, from a regular reader – and we chat on the Internet from time to time – thanks to ***Mr. Walter Gray*** who presents us all with a challenge! Walter writes:-

Here's a simple 9V (PP3-style) Ni-Cad Discharger: three green l.e.d.s. in series with a 68 ohm resistor for current limiting. Safe if left overnight because the final discharge rate is only about 50 microamps or less!

And a simple PP3 battery tester – a 180 ohm and an 82 ohm resistor in series, with a red l.e.d. connected across the 82 ohms. Draws 40mA from a fresh battery – useful!

I have built both of these on the back of 9V battery snaps and encapsulated them with hot glue. Perhaps you should start a "How many parts can you get onto a battery snap competition!"

See you next month for a further round-up of readers' questions and comments.

At your service

Circuit Surgery is *your* page. If you have any questions to ask or comments to make, please write to Alan Winstanley, *Circuit Surgery*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF. E-mail **alan@epemag.demon.co.uk**

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Ohm Sweet Ohm

Max Fidling

Mystique

Each and every year the Boss decides our holiday destination and gives me my marching orders. It's a pretty simple arrangement, really – all I have to do is drive and pay for everything!

One slight handicap exists, though, in the form of our faithful old caravan. Since there's hardly any free-standing area left at *Fidling Acres*, the caravan is stored at a nearby farm, for a nominal yearly rent, and one of my chores involves checking out the old *Vin Blanc* every now and then, and doing the honours with repairs.

Not being one to spend money if I can at least avoid it, I'd worked the previous weekend rummaging through the shack looking for some heavy duty wire and crimp connectors, of the sort used on vehicle's electrical systems. Car electrics are something which have a mystique all of their own, and ever since I installed a pair of foglights which only came on with the indicators, the Boss looked upon my motoring maintenance with a wary eye. Most unfair, given my reputation as a member of the electronics elite!

Anyway, I cycled over to the farm and was greeted by the sight of my caravan, having survived another over-wintering in the company of an old combine harvester, and shored up on wooden blocks looking somewhat sorry for itself. A couple of hours work fitting the wheels back on (always useful things to have on caravans – they make the car go faster), sprucing up with a bucket of water from the farm tap, and *Vin Blanc* was soon feeling happier, I sensed, as I whistled a tune and scrubbed away at the polycarbonate windows with a sponge till they glistened.

Back to the crimp connectors and the wire. The previous camping holiday had had added excitement in that the indicators mounted on the rear of the caravan, didn't always work properly. Maybe it was a bad earth or something.

It was possible to give an *approximate* idea of one's intentions to following motorists, by carefully juggling a combination of the brakes, indicator and headlamp switch – though this did nothing to help any hapless motorists following me but it made life in the car more interesting, as the Boss tended to get nervous if ever the indicators flashed *left* but I turned *right* instead or vice versa.

Plundered

So for our next adventure holiday to a nearby caravan site (ten miles away, quicker by bike), I'd designed a way of monitoring the indicators of the caravan so that I would know when they were actually working (if at all). I'd plundered the idea from a magazine project, my usual source of inspiration for my madcap ideas, and had eventually arrived at a contraption which needed plumbing into the indicator wiring.

It would buzz in the car when the caravan's indicators sprang into life. Apparently similar things are needed by law anyway, a point lost on yours truly in these halcyon days of holiday making.

The scheme was to tap into the caravan's indicators somehow, and run the cable back to the new bleeper project which I'd fitted in the boot. After ferreting around in the caravan for some considerable time, removing furniture and fittings which never quite go back the same way, I'd fitted the wiring in the rather dingy-smelling caravan, and I left the windows open to let some fresh air in as I cycled back home to the shack, dinner and the cat.

The day quickly arrived when, fully loaded with suitcases, holiday gear and cat food, the Boss, myself and Piddles the cat boarded this spectacle and headed down the road at 40 miles an hour in search of the caravan site. The moggie hates travelling, but I'd long ago abandoned the idea of using a travel basket since he made the most insufferable noise whenever I put him in it! Hence he was on the back seat on the tartan rug, when we came upon the first roundabout (a fine feat of British road engineering if ever there was one). The indicators were duly switched on as I aimed for the third exit, and the buzzer bleeped in the boot like a good un. Even the Boss seemed happy so far!

Catcophony

The caravan lurched as we turned off en route for the holiday camp – the trouble was, although I cancelled the indicators, the buzzer kept buzzing! I twiddled the indicator stalk to and fro but it made no difference!

I could see a tailback of about a dozen cars behind me, and there was nowhere to pull in! *Trouble!* Piddles ears pricked up at the sound of this angry buzzing noise (either that or he was about to be car sick) and he started wailing too!

Desperately, I clicked all the lighting switches, fan, radio – you name it – but still the buzzer kept bleeping! What a commotion! Believe me, readers, you haven't lived till you've driven ten miles at forty m.p.h. towing a caravan, with a bleeping buzzer, a tailback of traffic, an irate Boss and a wailing cat being ill in the back. Thank heavens for tartan rugs!

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Automatic Camera Panning (Teach-In '96)		972	£6.63
Printer Sharer		973	£9.93
Analogue Frequency Meter	FEB'96	957	£6.70
Vari-Speed Dice (Teach-In '96)		974	£5.69
Mains Signalling Unit – 2			
12V Capacitive PSU		975	£6.07
PIC-Electric Meter – Sensor/PSU– Control/Display		977/978 (pr)	£9.90
Multi-Purpose Mini Amplifier	MAR'96	976	£6.12
PIC-Electric – Sensor/PSU – Control/Display		977/978 (pr)	£9.90
High Current Stabilised Power Supply		979	£6.62
Mind Machine Mk III – Sound and Lights		980	£7.39
Infra-Zapper Transmitter/Receiver (Teach-In '96)		981/982 (pr)	£8.01

PROJECT TITLE		Order Code	Cost
Mind Machine Mk III – Programmer	APRIL'96	983	£7.36
Bat Band Converter/B.F.O.		984a/b	£5.80
Hearing Tester		985	£6.87
Event Counter (Teach-In '96)		986	£8.39
B.F.O. and Bat Band Converter	MAY'96	984a/b	£5.80
Versatile PIR Detector Alarm		988	£6.76
Mind machine Mk III – Tape Controller		989	£6.70
Midi Analyser		992	£6.74
Countdown Timer (Teach-In '96)		993	£9.44
Sarah's Light	JUNE'96	996	£7.17
Home Telephone Link		997 (pr)	£10.72
PulStar		998	£6.60
VU Display and Alarm		999	£7.02
Ultra-Fast Frequency Generator and Counter – Oscillator/L.C.D. Driver	JULY'96	994/995 (pr)	£12.72
Timed NiCad Charger		100	£6.99
Single-Station Radio 4 Tuner		101	£7.02
Twin-Beam Infra-Red Alarm – Transmitter/Receiver		102/103 (pr)	£10.50
Games Compendium		104	£6.09
Mono "Cordless" Headphones – Transmitter/Receiver	AUG'96	990/991 (pr)	£10.16
Component Analyser (double sided p.t.h.)		105	£12.18
Garden Mole-Ester		106	£6.07
Mobile Miser		107	£6.36
Bike Speedo		108	£6.61
PIC-Tock Pendulum Clock	SEPT'96	109	£6.31
Power Check		110	£6.42
Analogue Delay/Flanger		111	£7.95
Draught Detector		112	£6.22
Simple Exposure Timer		113	£6.63
Video Fade-to-White	OCT'96	114	£6.98
Direct Conversion 80m Receiver		116	£7.52
Vehicle Alert		117	£6.55
10MHz Function Generator			
– Main Board		118	£7.33
– PSU		119	£5.39
Tuneable Scratch Filter	NOV'96	115	£7.83
Central Heating Controller		120	£7.85
EPE Elysian Theremin		121	£22.00
D.C. to D.C. Converters			
– Negative Supply Generator		122	£5.96
– Step-Down Regulator		123	£6.01
– Step-Up Regulator		124	£6.12

EPE SOFTWARE

Software programs for the following *EPE* projects (PIC-microcontrolled except for Met Office and Central Heating Controller) are available altogether on a *single* 3·5 inch PC-compatible disk, or as needed, via our Internet site: Met Office (Dec '95) – GWBasic; Simple PIC16C84 Programmer (Feb '96); PIC-Electric Meter (Feb '96); PulStar (June '96); Games Compendium (July '96); PIC-Tock Pendulum Clock (Sept '96); PIC Disassembler (unpublished); Central Heating Controller (Nov '96) – 8051 machine code.

The disk (order as "PIC-Disk") is available from the *EPE PCB Service* at £2.50 (UK) to cover our admin costs (the software itself is *free*). Overseas £3.10 surface mail, £4.10 airmail.

Alternatively, the software files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk**

EPE PRINTED CIRCUIT BOARD SERVICE

Order Code **Project** **Quantity** **Price**

....

Name...

Address...

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Minimum order for credit cards £5

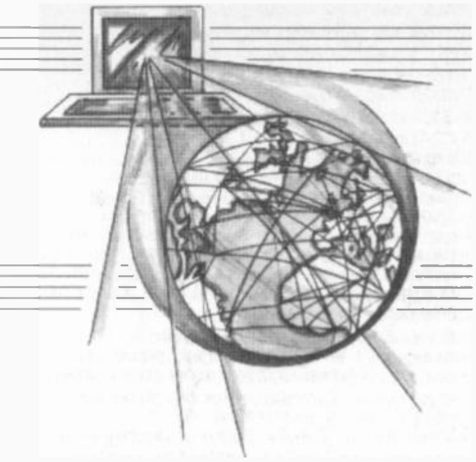
Signature..Card Exp. Date........................

Please supply name and address of cardholder if different from the address shown

SURFING THE INTERNET

NET WORK

ALAN WINSTANLEY



We hope you will take the time to visit the *EPE* World Wide Web site, the URL of which is **http://www.epemag.wimborne.co.uk** – the first electronics magazine in the UK to open a WWW page. Having been active on the Internet for two years, you can expect us to lead the way once again by adding new online services to our WWW pages in due course, telling you everything you need to know about us (we hope) and adding a further dimension to help you enjoy *Everyday Practical Electronics* even more! Also remember our FTP site which holds PIC files and more, at **ftp://ftp.epemag.wimborne.co.uk**

Secure Transactions

This month *Net Work* highlights a few projects which are destined for our WWW site. In particular, we're working on implementing Secure Electronic Transactions (SET) via the Web. Several readers have enquired about the facility of ordering on-line, though it's a complex matter which is causing a few global headaches at the moment.

We're not alone in this respect as security issues are involved, since the object is to offer a facility for web site readers to place an order safely on-line quoting credit card numbers, via security encryption systems which are being implemented on our server. A useful fill-in form will be available on screen, and readers will be able to select back issues, or take out a subscription, type in their details and the order will be processed swiftly and securely.

If you're interested in SET then look at **http://www.visa.com** – and **http://www.mastercard.com** – for the current specs. (Remember that all the URL's in this column are also made on the on-line version of *Net Work*, so all you need to do is browse, point and click – no need to type in those clumsy addresses! Furthermore, you can easily access the URL's from previous issues since these will be archived on the same *Net Work* page.)

You might often stumble across what are called – **mailto:** forms on the World Wide Web, where you fill in a selection of dialogue boxes, click radio buttons and generally make a selection from an on-screen page. The simplest implementation of this function simply sends the result of your input as a straight E-mail message to <whoever>@<wherever>. The problem is that this doesn't work with *Microsoft Internet Explorer* (MSIE) or, say, *AIR Mosaic* browsers, but it does work with *Netscape Navigator*.

Even though *Netscape* currently commands some 85 per cent of the global browser market, having some 38 million users, the safest and most reliable route from our point of view is to use a **cgi** (Common Gateway Interface) script which resides on our server and absorbs your input to the on-screen form. Regardless of what type of browser you use, this script or mini program will ensure that your instructions are received here safely and intact by the server, ready for processing by the *EPE* staff. Coupled with our ultimate aim of Secure Electronic Transactions, this will add a whole new dimension to the services we offer our readers.

On-site Feedback

Also on the web site, we're adding readers' feedback to the site by publishing an on-line version of Readout called *Dear EPE*, a selection of readers letters (both E-mail and snail mail). This fits in perfectly with our view that the WWW site should be an adjunct to the printed magazine, but will never replace it.

The *Printed Circuit Board Service*, suppliers' advertisements, the *Direct Book Service*, and – most importantly – our comprehensive *Back Issues Service* – will all eventually find their way onto the web site too. Such ambitious projects take time, though, but you can expect the site to develop nicely over the coming months. The HTML is written in-house and we hope you'll let us know the kind of things you'd like to see there. After all, it's your web site too!

Browser Battles

The web world is in for a stormy battle over the next twelve months. *Netscape Navigator*, being the most popular web browser on the planet, is set to meet an intense challenge from Microsoft who want the world to adopt their *Internet Explorer* (MSIE) browser instead. The latter is found in Windows 95 and is now being adopted by Demon Internet Services Ltd. as well as the likes of CompuServe, AOL and Netcom as their browser.

At the time of writing, events at Demon are quite interesting. Demon, the UK's largest ISP purchased the Internet access software company Turnpike (**http://www.turnpike.com**) some time ago, whose product has been reviewed in this magazine several times. Turnpike includes a licensed copy of *Netscape Navigator 1.22*, which is adequate for those who only access the web occasionally and don't mind missing out a few features (animated graphics, frames etc.) but most enthusiasts upgrade to *Netscape 2.0* or *3.0*.

Turnpike V3.0 (32-bit) in beta phase was promised to include *Netscape Navigator 3.0* as the new browser. In a sharp and embarrassing about-turn, Turnpike have suddenly shelved plans to ship *Navigator* and will instead be offering Microsoft *Internet Explorer 3.0* as their preferred browser, to the intense annoyance of an audience of expectant Turnpike users who fear they're being fobbed off with less than the real thing. Not surprisingly, Demon Internet have been chosen by Microsoft to serve out *Explorer* from their FTP site, in the UK. The impression is one of Turnpike having their own ideas, but Demon calling the shots.

At the end of the day, you pay your money (MSIE is free) and take your choice. In general, you can look forward to a chaotic scene of new releases, add-ons, and leap-frog moves as Microsoft attempts to gain the upper hand over *Netscape* to dominate the global browser market. One inside source guesses that *Explorer* will indeed displace *Navigator* within two years, leaving the latter confined to the fringes, e.g. Macintosh users. On future releases of the Windows GUI, there will also be a move towards browser-style screens away from the familiar *desktops* you see on PCs today. If you thought that the push for Windows 95 was tough enough, you've seen nothing yet!

New Links

Just time for some of the links I've spotted which may be of interest to electronics enthusiasts. Users of Hexfets (International Rectifier's name for their MOSFETs) will find a lot of information on them on the IR web pages at **http://www.irf.com** . Look for **tech info/design tips/application** notes. Probably the best and most comprehensive list of web sites for semiconductor manufacturers can always be found at **http://www.scruznet.com/~gcreager/hello5.htm.** This is generously maintained by Gray Creager, a Xicor applications engineer. CE Standards Engineers might check the Standards FAQ at **http://world.std.com/~techbook/standards_faq.html** . Tandy (known as Radio Shack in the USA) have a site that contains some useful data on their products, at **http://www.tandy.com** . A provider of electronics kits, DIY Electronics' can be found on **http://www.hk.super.net/~diykit** .

Join me for more *Net Work* next month. See you soon on our web pages!

DC TO DC CONVERTERS
DRM58 input 10-40vdc output 5v 8A £15
DRM128 input 17-40vdc output 12v 8A £50
DRM158 input 20-40vdc output 15v 8A £50
DRM248 input 29-40vdc output 24v 8A £40
DRS123 input 17-40vdc output 12v 3A £20
DRS153 input 20-40vdc output 15v 3A £20
DRS243 input 29-40vdc output 24v 3A £15

SOLID STATE RELAYS
CMP-DC-200P 3-32vdc operation, 0-200vdc 1A £2.50
SMT20000/3 3-24vdc operation, 28-280vac 3A £4.50
SMT20000/4 3-24vdc operation, 28-280vac 4A £5.00
ZRA6025F 28-280vd/ac operation, 28-280vac 25A £7.00

200 WATT INVERTERS Nicely cased units 12v input 240v output 150watt continuous, 200 max. £49 ref LOT62

6.8MW HELIUM NEON LASERS New units, £65 ref LOT33

COINSLOT TOKENS You may have a use for these? mixed bag of 100 tokens £10 ref LOT20

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

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

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

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

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

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

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

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

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

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

MYSTERY ANTI GRAVITY DEVICE PLANS Uses simple concept. Objects float in air and move to the touch. Defies gravity, amazing gift, conversation piece, magic trick or science project. £6/ set Ref F/ANT1K.

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

ULTRAHIGHGAIN AMP/STETHOSCOPIC MIKE/SOUND AND VIBRATION DETECTOR PLANS Ultrasensitive device enables one to hear a whole new world of sounds. Listen through walls, windows, floors etc. Many applications shown, from law enforcement, nature listening, medical heartbeat, to mechanical devices. £6/set Ref F/HGA7.

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

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

LASER LIGHT SHOW PLANS Do it yourself plans show three methods. £6 Ref F/LLS1

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

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

BUG DETECTOR PLANS Is that someone getting the goods on you? Easy to construct device locates any hidden source of radio energy! Sniffs out and finds bugs and other sources of bothersome

WOLVERHAMPTON BRANCH NOW OPEN AT WORCESTER ST W'HAMPTON TEL 01902 22039

interference. Detects low, high and UHF frequencies. £5/set Ref F/ BD1.

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

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

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

2 FOR 1 MULTIFUNCTIONAL HIGH FREQUENCY AND HIGH DC VOLTAGE, SOLID STATE TESLA COIL AND VARIABLE 100,000 VDC OUTPUT GENERATOR PLANS Operates on 9-12vdc, many possible experiments. £10 Ref F/HVM7/ TCL4.

INFINITY TRANSMITTERS The ultimate 'bug' fits to any phone or line, undetectable, listen to the conversations in the room from anywhere in the world! 24 hours a day 7 days a week! just call the number and press a button on the mini controller (supplied) and you can hear everything! Monitor conversations for as long as you choose £249 each, complete with leads and mini controller! Ref LOT9. Undetectable with normal RF detectors, fitted in seconds, no batteries required, lasts forever!

SWITCHED MODE PSU'S 244 watt, +5 32A, +12 6A, -5 0.2A, -12 0.2A. There is also an optional 3.3v 25A rail available. 120/240v I/P. Cased, 175x90x145mm. IEC inlet Suitable for PC use (6 d/drive connectors 1 m/board). £10 ref PSU1.

VIDEO PROCESSOR UNITS?/6v 10AH BATTS/12V 8A TX Not too sure what the function of these units is but they certainly make good strippers! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear. Inside 2 x 6v 10AH sealed lead acid batts, pcb's and a 8A? 12v torroidial transformer (mains in). Condition not known, may have one or two broken knobs due to poor storage. £17.50 ref VP2

RETRON NIGHT SIGHT Recognition of a standing man at 300m in 1/4 moonlight, hermatically sealed, runs on 2 AA batteries, 80mm F1.5 lens, 20mw infrared laser included. £325 ref RETRON.

MINI FM TRANSMITTER KIT Very high gain preamp, supplied complete with FET electret microphone. Designed to cover 88-108 Mhz but easily changed to cover 63-130 Mhz. Works with a common 9v (PP3) battery. 0.2W RF. £7 Ref 1001.

3-30V POWER SUPPLY KIT Variable, stabilized power supply for lab use. Short circuit protected, suitable for profesional or amateur use 24v 3A transformer is needed to complete the kit. £14 Ref 1007.

1 WATT FM TRANSMITTER KIT Supplied with piezo electric mic. 8-30vdc. At 25-30v you will get nearly 2 watts! £12 ref 1009.

FM/AM SCANNER KIT Well not quite, you have to turn the knob your self but you will hear things on this radio that you would not hear on an ordinary radio (even TV). Covers 50-160mhz on both AM and FM. Built in 5 watt amplifier, inc speaker. £15 ref 1013.

3 CHANNEL SOUND TO LIGHT KIT Wireless system, mains operated, separate sensitivity adjustment for each channel, 1,200 w power handling, microphone included. £14 Ref 1014.

4 WATT FM TRANSMITTER KIT Small but powerful FM transmitter, 3 RF stages, microphone and audio preamp included. £20 Ref 1028.

STROBE LIGHT KIT Adjustable from 1-60 hz (a lot faster than conventional strobes). Mains operated. £16 Ref 1037.

COMBINATION LOCK KIT 9 key, programmable, complete with keypad, will switch 2A mains. 9v dc operation. £10 ref 1114.

PHONE BUG DETECTOR KIT This device will warn you if somebody is eavesdropping on your line. £6 ref 1130.

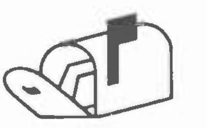
ROBOT VOICE KIT Interesting circuit that distorts your voice! adjustable, answer the phone with a different voice! 12vdc £9 ref 1131

TELEPHONE BUG KIT Small bug powered by the 'phone line, starts transmitting as soon as the phone is picked up! £8 Ref 1135.

3 CHANNEL LIGHT CHASER KIT 800 watts per channel, speed and direction controls supplied with 12 LEDS (you can fit triacs instead to make kit mains, not supplied) 9-12vdc £17 ref 1026.

12V FLOURESCENT LAMP DRIVER KIT Light up 4 foot tubes from your car battery! 9v 2a transformer also required. £8 ref 1069.

VOX SWITCH KIT Sound activated switch ideal for making bugging tape recorders etc, adjustable sensitivity. £8 ref 1073.



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PREAMP MIXER KIT 3 input mono mixer, sep bass and treble controls plus individual level controls, 18vdc, input sens 100mA. £15 ref 1052.

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SOUND EFFECTS GENERATOR KIT Produces sounds ranging from bird chips to sirens. Complete with speaker, add sound effects to your projects for just £9 ref 1045.

15 WATT FM TRANSMITTER (BUILT) 4 stage high power, preamp required 12-18vdc, can use ground plane, yagi or open dipole. £69 ref 1021.

HUMIDITY METER KIT Builds into a precision LCD humidity meter, 9 ic design, pcb, lcd display and all components included. £29

PC TIMER KIT Four channel output controlled by your PC, will switch high current mains with relays (supplied). Software supplied so you can program the channels to do what you want whenever you want. Minimum system configeration is 286, VGA, 4.1,640k, serial port, hard drive with min 100k free. £24.99

FM CORDLESS MICROPHONE This unit is an FM broadcasting station in minature, 3 transistor transmitter with electret condenser mic+fet amp design result in maximum sensitivity and broad frequency response. 90-105mhz, 50-1500hz, 500 foot range in open country! PP3 battery required. £15.00 ref 15P42A.

MAGNETIC MARBLES They have been around for a number of years but still give rise to curiosity and amazement. A pack of 12 is just £3.99 ref GI/R20

NICKEL PLATING KIT Proffesional electroplating kit that will transform rusting parts into showpieces in 3 hours! Will plate onto steel, iron, bronze, gunmetal, copper, welded, silver soldered or brazed joints. Kit includes enough to plate 1,000 sq inches. You will also need a 12v supply, a container and 2 12v light bulbs. £39.99 ref NIK39

Minature adjustable timers, 4 pole c/o output 3A 240v,
HY1230S, 12vDC adjustable from 0-30 secs £4.99
HY1260M, 12vDC adjustable from 0-60 mins £4.99
HY2405S, 240v adjustable from 0-5 secs £4.99
HY24060m, 240v adjustable from 0-60 mins £6.99

BUGGING TAPE RECORDER Small voice activated recorder, uses micro cassette complete with headphones. £28.99 ref MAR29P1.

POWER SUPPLY fully cased with mains and o/p leads 17v DC 900mA output. Bargain price £5.99 ref MAG6P9

9v DC POWER SUPPLY Standard plug in type 150ma 9v DC with lead and DC power plug. price for two is £2.99 ref AUG3P4.

COMPOSITE VIDEO KIT. Converts composite video into separate H sync, V sync, and video. 12v DC. £8.00 REF: MAG8P2.

FUTURE PC POWER SUPPLIES These are 295x135x60mm, 4 drive connectors 1 mother board connector. 150watt, 12v fan, iec inlet and on/off switch. £12 Ref EF6.

VENUS FLYTRAP KIT Grow your own carnivorous plant with this simple kit £3 ref EF34

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. Bargain price just £5.99 ea REF MAG6P12

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

ROCK LIGHTS Unusual things these, two pieces of rock that glow when rubbed together! beiived to cause rain! £3 a pair Ref EF29.

3' by 1' AMORPHOUS SOLAR PANELS 14.5v, 700mA 10 watts, aluminium frame, screw terminals, £44.95 ref MAG45.

ELECTRONIC ACCUPUNCTURE KIT Builds into an electronic version instead of needles! good to experiment with. £7 ref 7P30

SHOCKING COIL KIT Build this little battery operated device into all sorts of things, also gets worms out of the ground! £7 ref 7P36

FLYING PARROTS Easily assembled kit that builds a parrot that actually flaps its wings and flies! 50 m range £6 ref EF2.

HIGH POWER CATAPULTS Hinged arm brace for stability, tempered steel yoke, super strength latex power bands. Departure speed of ammunition is in excess of 200 miles per hour! Range of over 200 metres! £7.99 ref R/9.

BALLON MANUFACTURING KIT British made, small blob blows into a large, longlasting balloon, hours of fun! £3.99 ref GI/E99R

9-0-9V 4A TRANSFORMERS, chassis mount £7 ref LOT19A

2.5 KILOWATT INVERTERS, Packed with batteries etc but as they weigh about 100kg CALLERS ONLY! £120.

MEGA LED DISPLAYS Build your self a clock or something with these mega 7 seg displays 55mm high, 38mm wide. 5 on a pcb for just £4.99 ref LOT16 or a bumper pack of 50 displays for just £29 ref LOT17

CLEARANCE SECTION, MINIMUM ORDER £15, NO TECHNICAL DETAILS AVAILABLE, NO RETURNS, TRADE WELCOME.

2000 RESISTORS ON A REEL (SAME VALUE) 99P REF BAR340
AT LEAST 200 CAPACITORS (SAME VALUE 99P REF BAR342
INFRA RED REMOTE CONTROLS JUST 99P REF BAR333
CIRCUIT BREAKERS, OUR CHOICE TO CLEAR 99P REF BAR335
MICROWAVE CONTROL PANELS TO CLEAR £2 REF BAR 329
2 TUBES OF CHIPS(2 TYPES OUR CHOICE) 90P REF BAR305
LOTTERY PREDICTOR MACHINE!! JUST £1.50 REF BAR313
HELLA L/ROVER ELECTRIC H/LAMP LEVELLER £2 REF BAR311
SINCLAIR C5 16" TYRES TO CLEAR AT JUST 75P REF BAR318
LARGE MAINS MOTORS (NEW) TO CLEAR AT 75P REF BAR310
MODEMS ETC FOR STRIPPING £2.50 EACH REF BAR324
110V LARGE MOTORS (NEW) TO CLEAR AT 50P REF BAR332
MODULATOR UNITS UNKNOWN SPEC JUST 50P REF BAR323
GX4000 GAMES COSOLES JUST £4 REF BAR320
SMART CASED MEMORY STORAGE DEVICE, LOADS OF BITS INSIDE, PCB, MOTOR, CASE ETC. BUMPER PACK OF 5 COMPLETE UNITS TO CLEAR AT £2.50(FOR 5) REF BAR 330.
2 CORE MAINS CABLE 2M LENGTHS PACK OF 4 £1 REF BAR337
PC USER/BASIC MANUALS, LOADS OF INFO. £1 REF BAR304
PCB STRIPPERS TO CLEAR AT 2 FOR 99P REF BAR341
3 M 3CORE MAINS CABLE AND 13A PLUG. 80P REF BAR325

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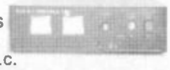

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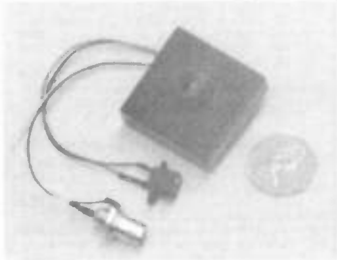

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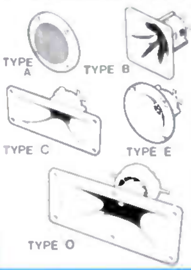

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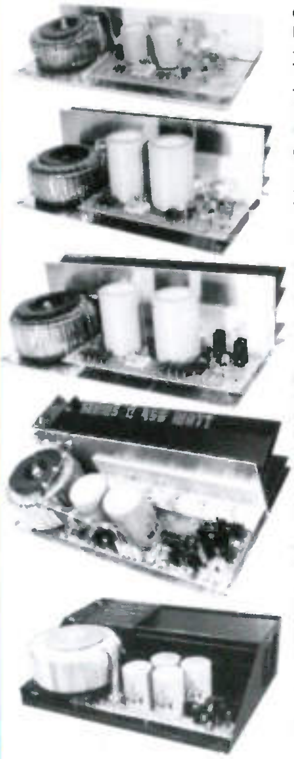

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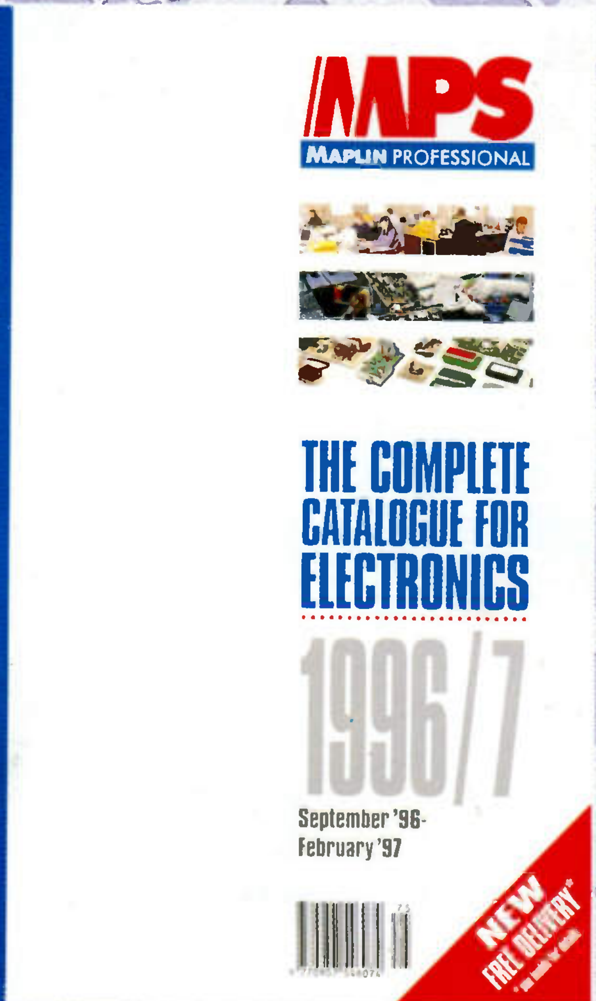

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