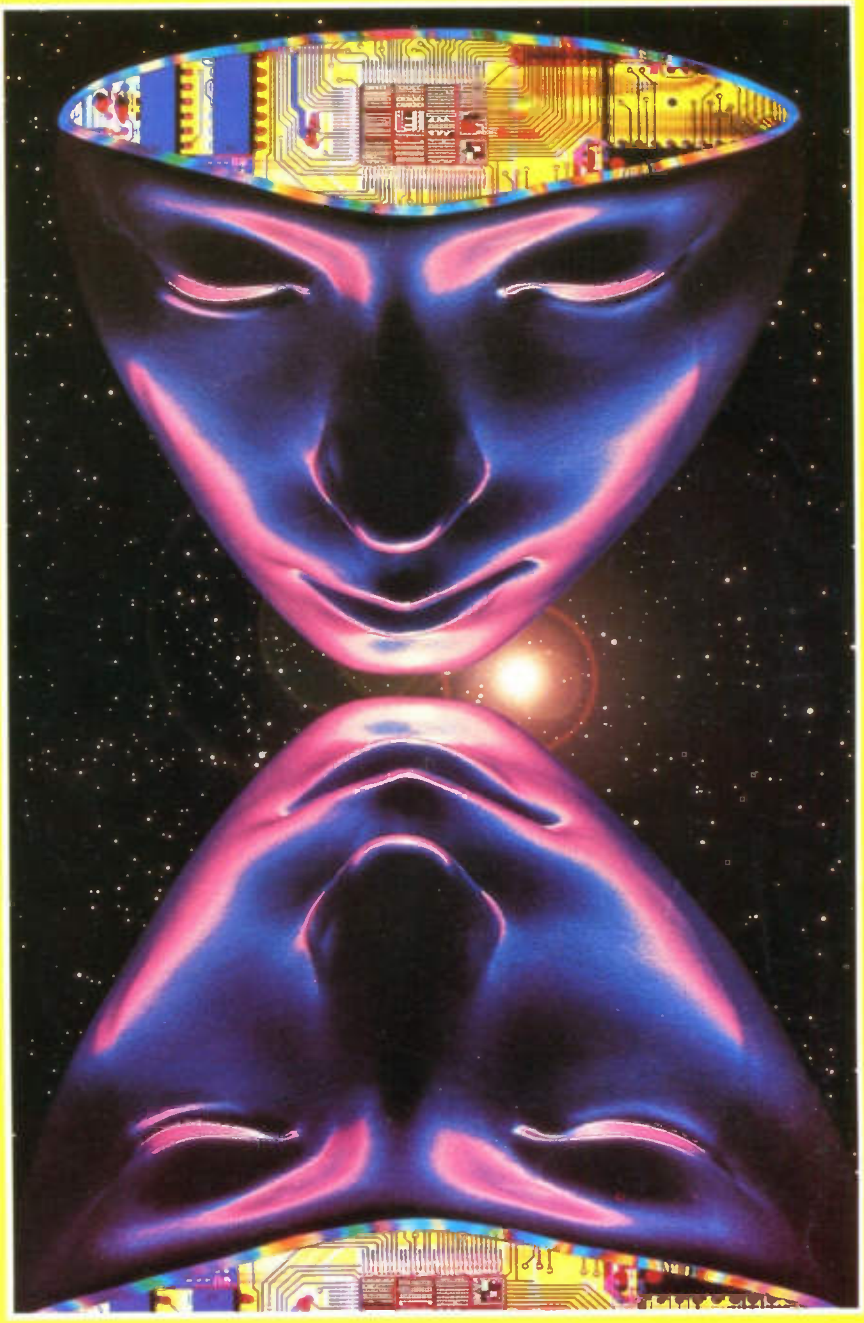
EVERYDAY

MARCH 1996

PRACTICAL ELECTRONICS

£2.45

FREE! INSIDE GREENWELD WINTER CATALOGUE SUPPLEMENT



MIND MACHINE MK III

Mind Entrainment for relaxation

MULTI PURPOSE MINI AMP

Use your Headphones with this general purpose/test amp

INFRA-RED ZAPPER

Fun shooting game – a Teach-In '96 project

HIGH CURRENT P.S.U.

Supplies up to 7·5A stabilised

Run your 12V equipment off the mains

INGENUITY UNLIMITED

Readers Circuit Ideas

THE No. 1 INDEPENDENT MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

03
9 770262 361072

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

RADIATION DETECTOR SYSTEM Designed to be wall mounted and connected into a PC, ideal for remote monitoring, whole building coverage etc. Complete with detector, cable and software. £19.95 ref BAR75.

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.

TANDATA TD1400 VIEWDATA Complete system comprising modem, infra red remote keyboard, psu, UHF and RGB output, phone lead, RS232 output, composite output. £9.95 ref BAR33.

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

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.

LUBITEL 166U Twin lens Russian 2 1/4" sq reflex camera supplied with two free rolls of colour film, flip up magnifier, 3 element f 4.5 lens. £19.99 ref BAR36.

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. £210 ref BAR61. 1 years warranty

FILIN-1 150m range, 15 deg angle of view, focusing 10m-infinity, £179 ref BAR62. A separate infra red light is available at £30 ref BAR63.

WHITE NIGHT SIGHTS Excellent professional night sight, small, hand held with camoflaged carrying case £325. 1 years warranty.

MEGA AIR MOVERS 375 cubic feet per min!, 240v 200 watt, 2,800 rpm, reversable, 7"x7" UK made, new, Aluminium, current list price about £180 ours? £29.95 ref BAR35.

LIQUID CRYSTAL DISPLAYS Bargain prices,
16 character 2 line, 65x14mm £1.99 ref SM1612A
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 details £249 ref TAL-1

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.

COMMODORE GAMES CONSOLES Just a few of these left to clear at £5 ref SA31. Condition unknown.

COMPUTER DISC CLEAROUT We are left with a lot of software packs that need clearing so we are selling at disc value only! 50 discs for £4, thats just 8p each!!(our choice of discs) £4 ref EF66

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 £4.99 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, pack of two psus **SALE PRICE £5 FOR TWO!! ref EP61**

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**

BITS AND BOBS We have a quantity of cased modems, multiplexers etc different specs but ideal strippers. £4 each ref EP63

RED EYE SECURITY PROTECTOR 1,000 watt outdoor PIR switch **SALE PRICE £9.99 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 (0345-326009 try before you buy!) **Current retail price is £129, SALE PRICE** £9.95 ref SA12. SAVE £120!!!

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

MINI MICRO FANS 12V 1.5" sq **SALE PRICE £2.** Ref SA13.

REUSEABLE HEAT PACKS. Ideal for fishermen, outdoor enthusiasts elderly or infirm, warming food, drinks etc, defrosting pipes etc.reuseable up to 10 times, lasts for up to 8 hours per go, 2,000wh energy, gets up to 90 degC. **SALE PRICE £9.95 REF SA29**

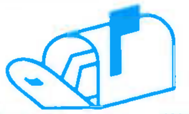
12V 2AMP LAPTOP psu's 110x55x40mm (includes standard IEC socket) and 2m lead with plug. 100-240v IP. **£6.99 REF SA15.**

PC CONTROLLED 4 CHANNEL TIMER Control (on/off times etc) up to 4 items (8A 240v each) with this kit. Complete with Software, relays, PCB etc. £25.99 Ref 95/26

COMPLETE PC 300 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. **SALE PRICE just £69.00.**

SOLAR PATH LIGHTS Low energy walklights powered by the sun! built in PIR so they work when you walk past. Includes solar panel & rechargeable bat. **SALE PRICE £19.95 REF EP62**

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

COMPUTER RS232 TERMINALS. (LIBERTY) Excellent quality modern units,(like wyse 50,s) 2xRS232, 20 function keys, 50 thro to 38,400 baud, menu driven port, screen, cursor, and keyboard setup menus (18 menu's). £29 REF NOV4.

RUSSIAN MONOCULARS Amazing 20 times magnification, coated lenses, carrying case and shoulder strap £29.95 REF BAR73

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.

SWINGFIRE GUIDED MISSILE WIRE. 4,200 metre reel of ultra thin 4 core insulated cable, 28lbs breaking strain, less than 1mm thick! Ideal alarms, intercoms, dolls house's etc. **£13.99 ref EP51**

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

ASTEC SWITCHED MODE PSU BM41012 Gives +5 @ 3.75A, +12@1.5A, -12@.4A. 230/110, cased, BM41012. £5.99 ref AUG6P3.

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt. **£8.99 REF SA25.**

TOP QUALITY CENTRIFUGAL MAINS MOTORS SALE PRICE2 FOR JUST £2.50 REF SA38

ECLATRON FLASH TUBE As used in police car flashing lights etc, full spec supplied, 60-100 flashes a min. **£6.99 REF SA15.**

24v AC 96WATT Cased power supply. New. £9.99 REF SA40

MILITARY SPEC GEIGER COUNTERS Unused anstraight from Her majesty's forces. **SALE PRICE £44 REF SA16**

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 SA16**

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

POWER SUPPLY fully cased with mains and o/p leads 17v DC 900mA output. Bargain price £5.99 ref MAG6P9

ACORN ARCHIMEDES PSU +5v @ 4.4A. on/off sw uncased, selectable mains input, 145x100x45mm **£3.99** REF MAG7P2

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

200 WATT INVERTER Converts 10-15v DC into either 110v or 240v AC. Fully cased 115x36x156mm, complete with heavy duty power lead, cigar plug, AC outlet socket. Auto overload shutdown, auto short circuit shut down, auto input over voltage shutdown, auto input under voltage shut down (with audible alarm), auto temp control, unit shuts down if overheated and sounds audible alarm. Fused reversed polarity protected. output frequency within 2%, voltage within 10%. A well built unit at an keen price. Just £64.99 ref AUG65.

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**

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. Complete kit £8.99.

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 £15 **REF: MAG15** 12v psu is £5 extra **REF: MAG5P2**

***FM CORDLESS MICROPHONE** Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 9v battery. Tuneable to any FM receiver. Price is £15 **REF: MAG15P1**

***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.

RATTLE BACKS Interesting things these, small piece of solid perspex like material that if you try to spin it on the desk it only spins one way! In fact If you spin it the 'wrong' way it stops of its own accord and go's back the other way! £1.99 ref GI/J01.

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.

SANYO NICAD PACKS 120mmx14mm 4.8v 270 maH suitable for cordless phones etc. Pack of 2 just £5 ref EP78.

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. Ref 95/300.

SOLAR POWERED CAR VENTILATOR Simply fits along the top of the glass in a side window and provides a constant supply of fresh air in hot sunny conditions! keeps your car cool in summer. £19.95 ref s/vent.

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

BULL ELECTRICAL

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

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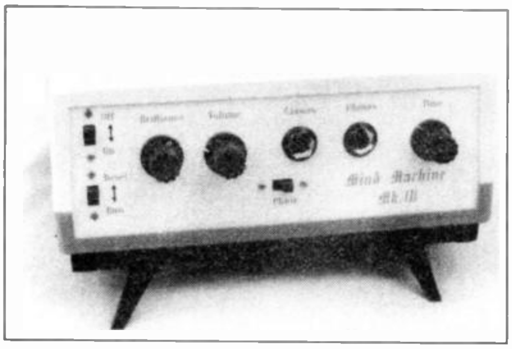
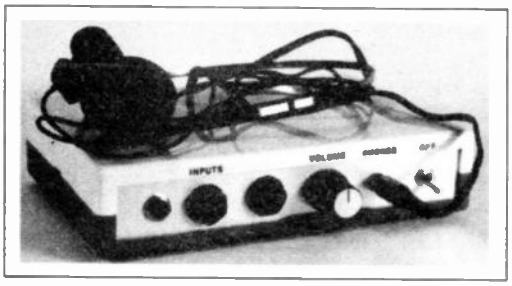
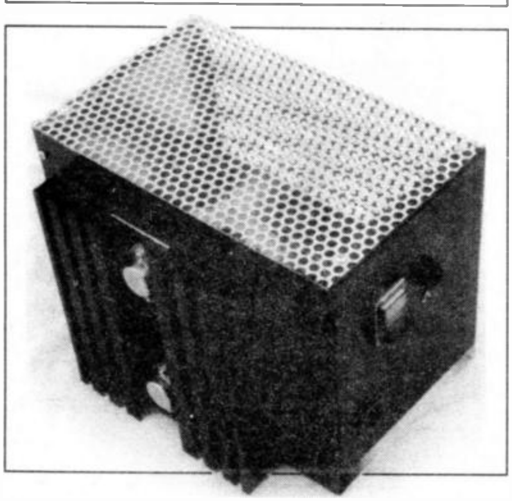
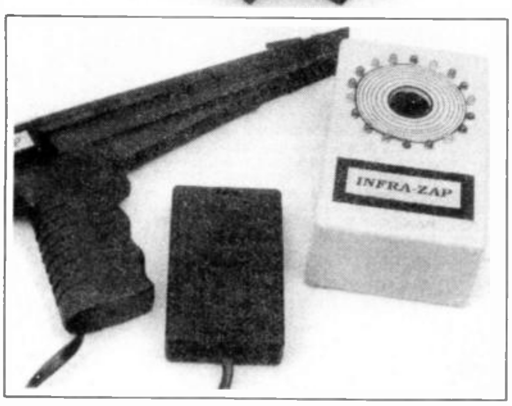








Projects

Series

Features

Our April '96 issue will be published on Friday, 1 March 1996. See page 171 for details.

NEXT MONTH

FREE! DOLBY PRO-LOGIC BOOKLET with all copies.

Ever wondered how the amazing "cinema sound" can be recreated in your home by the Dolby Pro-Logic system? This booklet explains exactly how the processor works and what is required to reproduce the "cinema sound" in your front room. Not only that, it gives full constructional details for the only d.i.y. kit available in the world for a:

DOLBY PRO-LOGIC DECODER...

which you can build for under £100 (plus case). This is the genuine article, approved and licensed by Dolby Laboratories in California.

Don't miss the project of the decade – order your copy now!

BAT BAND CONVERTER

Find out if you've got bats in your belfry! This clever device converts the bat's ultrasonic calls into a medium wave signal for reception on a small portable a.m. radio. Uses the latest technology – a Surface Mount Device.

HEARING TESTER

Arguably, next to sight, hearing is our second most valuable sense. Consequently, it can be reassuring to have its quality assessed in terms of frequency and amplitude threshold response.

The Hearing Tester offers a means of doing a non-medical check of how well your ears behave.

PLUS Special Feature

VALVES TODAY

The trusty thermionic valve still finds uses in a wide variety of applications. Whilst it may not seem like the latest in technology, valves still have their place in today's equipment. This feature looks at the history and present day use of valves in general.

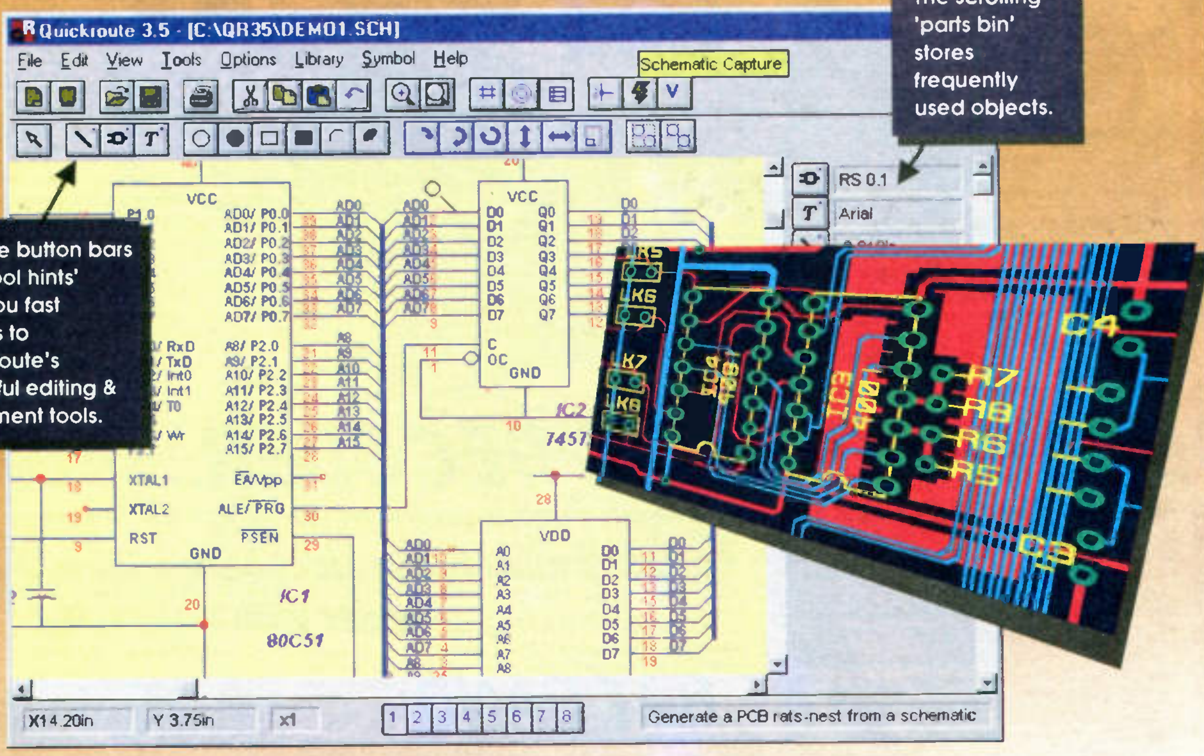
EVERYDAY PRACTICAL ELECTRONICS

APRIL ISSUE ON SALE FRIDAY, MARCH 1

QUICKROUTE™

New Version 3.5

Integrated PCB & Schematic Design System for Windows™



"..of all the products included here, this is my personal favourite... Really, thats all I have to say about Quickroute - it certainly gets my vote!"

Review of QR 3.0 & other products
Computer Shopper Nov 95

EASY TO USE
Quickroute 3.5 is a powerful, affordable and easy to use integrated schematic & PCB design system for Windows. With its multiple button bars, 'tool hints' and 'parts bin', Quickroute helps you to design quickly and efficiently

POWERFUL
There are four different versions of Quickroute giving you a choice of features & price. Quickroute is available with multi-sheet schematic capture, auto-routing, 'engineering change' (modification of a PCB from a schematic), copper fill, and a range of file import/export options. See the table for a selection of features.

AFFORDABLE
Prices are Designer (£149), PRO (£249) and PRO+ (£399). The Personal edition is available for just £68, but has the manual provided on disk as on-line help. Post & Packing is £5 (UK), £8 (EC), £12 (World). VAT must be added to the total price.

	Personal	Designer	PRO	PRO+
PCB & Schematic Design	✓	✓	✓	✓
Schematic Capture		✓	✓	✓
Auto router			✓	✓
Design Rule Checking			✓	✓
Export WMF & Tango			✓	✓
Export Gerber/NC-Drill			✓	✓
Extended Libraries			✓	✓
Tango + Gerber import				✓
Update PCB from schematic				✓
DXF & SPICE Export				✓
Copper Fill				✓

Tel/Fax 0161 449 7101

QUICKROUTE SYSTEMS

Quickroute Systems Ltd., 14 Ley Lane, Marple Bridge, Stockport, SK6 5DD, U.K.

email info@quicksys.demon.co.uk

Phone now for more information

HART AUDIO KITS – YOUR VALUE FOR MONEY ROUTE TO ULTIMATE HI-FI

HART KITS give you the opportunity to build the very best engineered hifi equipment there is, designed by the leaders in their field, using the best components that are available.
Every HART KIT is not just a new equipment acquisition but a valuable investment in knowledge, giving you guided hands-on experience of modern electronic techniques.
In short HART is your 'friend in the trade' giving you, as a knowledgeable constructor, access to better equipment at lower prices than the man in the street.
You can buy the reprints and construction manual for any kit to see how easy it is to build your own equipment the HART way. The FULL cost can be credited against your subsequent kit purchase.
Our list will give you full details of *all* our Audio Kits, components and special offers.

INTRODUCING
The Hart *"Chiara"*

Single-Ended Class "A" Headphone Amplifier.

Most modern high fidelity amplifiers either do not have a headphone output facility, or this may not be up to the highest standard.
The new Hart "Chiara" has been introduced as an add-on unit to remedy this situation, and will provide two ultra high quality headphone outlets. This is the first unit in our 2000 Range of modules to be introduced through the year. Housed in the neat, black finished, Hart Minibox it features the wide frequency response, low-distortion and "musicality" that one associates with designs from the renowned John Linsley Hood.
Both outputs will drive any standard high quality headphones with an impedance greater than 30 ohms and the unit is ideal for use with the Sennheiser range. A signal link-through makes it easy to incorporate into your system and two extra outputs, one at output level and one adjusted by the Volume control are available on the back panel. The high level output also makes a very useful long-line driver where remote mounted power amplifiers are used. Power requirements are very simple and can be provided by either of our new "Andante" power supplies. Use the K3565 to drive the "Chiara" on its own, K3550 if driving other modules as well.
Volume and Balance controls are provided and as befits any unit with serious aspirations to quality these are the ultra high quality Alps "Blue Velvet" components.
Very easily built, even by beginners, since all components fit directly on the single printed circuit board and there is no conventional wiring whatsoever. The kit has very detailed instructions, and even comes with a roll of Hart audiograde silver solder. It can also be supplied factory assembled and tested.
Selling for less than the total cost of all the components, if they were bought separately, this unit represents incredible value for money and makes an attractive and harmonious addition to any hifi system.
K2100 The total cost of a complete set of all components to build this unit is £126.37. Our **special discount price** for all parts bought together as a kit is **£109.50**
K2100SA Series Audiophile, with extra selected components **£112.46**

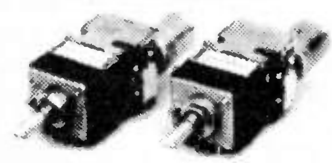
HART TC1D *Triple Purpose* TEST CASSETTE

Now available again and even better than before! Our famous triple purpose test cassette will help you set up your recorder for peak performance after fitting a new record/play head. This quality precision Test Cassette is digitally mastered in real time to give you an accurate standard to set the head azimuth, Dolby/VU level and tape speed, all easily done without test equipment.
TC1D Triple Purpose Test Cassette £9.99

NEW BOOK
"Audio Electronics"

And now, hot off the press, yet another classic from the pen of John Linsley Hood. Following the ongoing enormous success of his "Art of Linear Electronics" the latest offering is the all-new edition of "Audio Electronics", now entirely re-written by the master himself.
Underlying audio techniques and equipment is a world of electronics that determines the quality of sound. For anyone involved in designing, adapting or using digital or analogue audio equipment understanding electronics leads to far greater control over the reproduced sound.
The subjects covered include tape recording, tuners, power output stages, digital audio, test instruments and loudspeaker crossover systems. John's lifetime of experience and personal innovation in this field allow him to apply his gift of being so familiar with his subject that he can write clearly about it and make it both interesting and comprehensible to the reader.
Containing 240 pages and over 250 line illustrations this new book represents great value for money at only £18.99 plus £2.50 postage. Send or telephone for your personal copy now.

ALPS *"Blue Velvet"*
Precision Audio Controls



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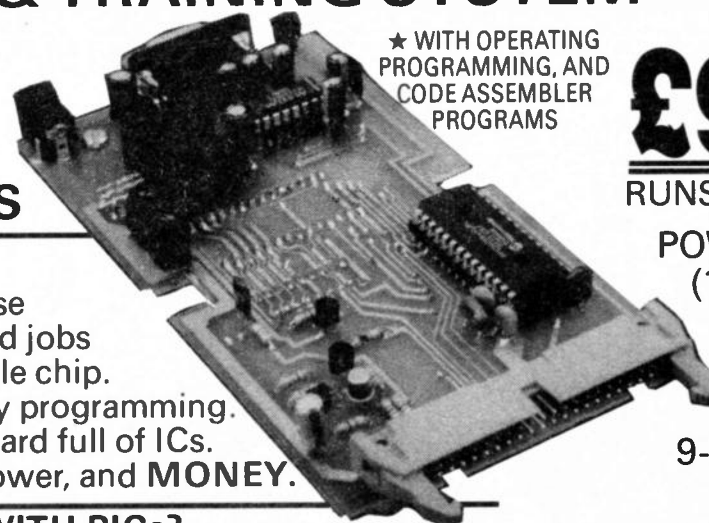

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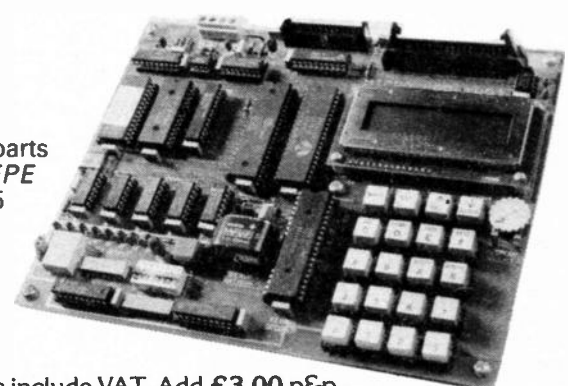

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2200	£0.37	£0.57	---	---	---
4700	---	£1.11	---	---	---

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1.0	---	---	£0.11	£0.10	£0.19
2.2	---	---	£0.10	£0.10	£0.22
4.7	---	---	£0.10	£0.10	---
10	---	---	£0.12	£0.12	£0.57
22	---	£0.12	£0.13	£0.17	£1.06
47	£0.10	£0.11	£0.16	£0.20	---
100	£0.10	£0.14	£0.21	---	---
220	£0.13	£0.18	£0.42	---	---
470	£0.21	£0.24	£0.69	---	---
1000	£0.33	£0.40	£1.05	---	---
2200	£0.52	£0.64	---	---	---
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FIRST

The publication of the *Dolby Pro-Logic Decoder* in the booklet to be given away *Free* with next month's issue represents a first in the UK. In fact we are not aware of any other kit available anywhere in the world for this item.

This project was jointly developed by Silicon Chip and Jaycar in Australia and has been approved by Dolby Laboratories. The project is only available in kit form as this is the only way to satisfy the Dolby licensing requirements.

The booklet will also give a full description of how the Pro-Logic system works. Back in the 60s and 70s there were a number of "surround sound" audio systems available from various companies but, due to the lack of any standard, these all fell by the wayside. Dolby Pro-Logic has become the standard for "cinema sound" on films and videos and is now used throughout the world. This has ensured its acceptance and the range of available equipment, both built into TV sets, as HiFi separates and in mini and midi hifi systems, has rapidly grown and no doubt will continue to do so.

PRICE BREAK

Our project enables a decoder to be built for under £100 (although that price does not include the case), thus making it a realistic add-on unit for the hobbyist with some constructional experience. It is not very often that items of this nature can be built for less than the cost of similar commercial products but in this case there is a good saving to be made. No doubt this situation will change over the next three to five years as Dolby Pro-Logic gradually becomes standard on most commercial TV and hifi systems but, thanks to this excellent project, you can enjoy the experience of "cinema sound" in your home now!

If you have any doubts about just what a difference this system makes to the enjoyment of watching a film then go and experience a demonstration at your local retailer – you will be impressed!

Mike Kenward

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Constructional Project

MIND MACHINE Mk III

ANDY FLIND

Part One

Why wait? Capture that "feel good factor" now with this latest relaxation machine. A "user friendly" Programmer will be added next month.

FOLLOWING on the popularity of the earlier *Mind Machine* designs of a couple of years ago, the time seems about right for an updated version. New technology and fresh circuit techniques have made it possible to produce a design that is simpler and cheaper to construct, and experience gained with the original units has led to a more "user friendly" control system.

Readers who saw the previous designs will probably be familiar with the principles of brainwave biofeedback and "entrainment", but for those new to the concept, here is a potted history and description of the use of these techniques.

BRAINWAVES

Ever since the development of electronic technology made it possible, researchers have been studying the electrical activity of the human brain. This is known to employ rhythmic signals, mostly in the range of 2Hz to 20Hz, and some of these have been found to correlate with certain mental states.

At some time during the 1960s, the age of "Woodstock" and "Flower Power" and all that – hands up those old enough to remember it! – someone decided to examine the signals occurring in the brain of a Zen adept during deep meditation. A high level of "Alpha", a frequency of around 8Hz to 14Hz, was discovered.

Subsequently it was found that a person using a monitor to indicate this activity in their own brain could quickly learn to produce it at will and in greater strength, and for a brief time in those far-off heady days some of us thought we'd found the secret of life! With a simple alpha monitor, we could all become Zen Masters overnight!

Sadly, of course, it wasn't that simple. Most people either couldn't produce the signals despite the monitor, or they experienced at best a pleasant "relaxed awareness", good for stress relief, but hardly the expected "Nirvana". In addition, the monitors were relatively difficult to design due to the tiny amplitudes of the signals they had to detect, and they were tedious to use with electrodes contacting the scalp through the hair with dollops of messy electrode "gel".

Time has moved on, and with it has come new knowledge and technology (though sadly, as yet, no instant Nirvana). Most enthusiasts of this field now know that there are at least *four* generally recognised brainwave frequency bands with corresponding mental states.

The highest is *Beta*, 15Hz and upwards, found during the normal alert state. Hopefully, *EPE* readers will be generating Beta whilst absorbing this article! The *Alpha* mentioned earlier, 8Hz to 14Hz, is generally believed to promote "relaxed awareness".

Below this comes *Theta*, 4Hz to 7Hz, associated with day-dreaming and of considerable interest to many users for promoting creativity. Below 4Hz is *Delta*, found normally in deep sleep and young babies.

OUTSIDE INFLUENCES

The passive monitors used by the early experimenters have mostly given way to "entrainment" devices using various external stimuli to encourage production of the desired brainwave frequencies, instead of just detecting and indicating what happens to be there. The two most popular stimuli are flashing l.e.d.s placed close to the eyes, and "hemisync" sound played through headphones.

Instruments of this type are now available commercially. Common in America, they are only just beginning to catch on in Britain, though readers may have spotted occasional newspaper advertisements for a machine operating on this principle. It's priced at around £250.00, and "programs" appear to be restricted to those available on tape from the suppliers, so it's still worth constructing your own.

MIND MACHINE

So what will it do for you? Most users say that they find the experience very relaxing, with effects persisting for some time after the session has ended. It is sometimes similar to meditation, though experienced meditators say it is "different". However, in this age of stress and stress-related sickness, anything that promotes such mental relaxation has to be worth trying. With this project, readers can have a first-class entrainment machine for a fraction of the normal cost.

WARNING NOTICE

Photic stimulation at Alpha frequencies can cause seizures in persons suffering from Epilepsy. For this reason such people MUST NOT try this project.

A user who is not a known epileptic, but when using the *Mind Machine* begins to experience an odd smell, sound or other unexplained effects, should TURN IF OFF IMMEDIATELY and seek professional medical advice.

Because of the above possibility, the *Mind Machine* should not be used while on your own.

YOU MUST TREAT THIS UNIT WITH DUE RESPECT

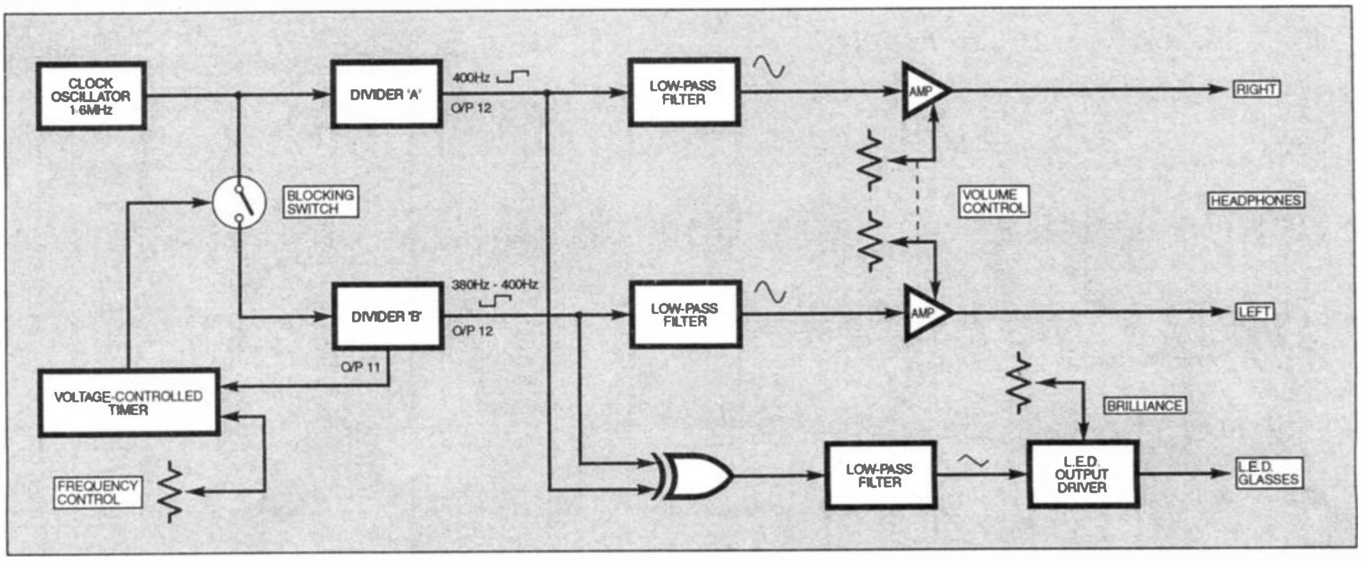


Fig. 1. Block schematic diagram of the Mind Machine Mk III Sound and Light circuit.

The use of flashing lights to induce specific brainwave frequencies is by far the most effective technique, but "hemisync" sound is also useful. A combination of the two stimuli is very potent, and has been used in most of the previous *Mind Machine* projects.

Some readers will be familiar with the "beat note" effect, where two tones with frequencies differing by a few Hertz combine to produce a "wah-wah" effect with their changing phase relationships. With "hemisync", the two tones are played separately, one into each ear, through headphones and the "beat" is synthesised within the brain itself.

The term "hemisync" was coined by the inventor of this technique and the sound, as perceived by the user, is a pleasantly soothing bell-like tone. Combined with lights flashing at the same frequency it is very effective indeed so the *Mind Machine Mk. III*, like its predecessors, uses both stimuli simultaneously.

"Programming" the circuit to follow a preset frequency pattern during use enhances effectiveness considerably, and projects for doing this will be presented in subsequent articles. Constructors who still have the author's original *Mind Machine* might like to know that the new programmers will be compatible with the original sound and lights board, and their use with this will be explained.

CLOCKING-OFF

In generating the sound and light effects, the greatest problem is to produce two audio frequencies just a few Hertz apart and control their difference reliably. At first sight the task seems easy, but in practice two oscillators of similar frequency will tend to lock-on or "pull" to each other, and most simple oscillator circuits are just not sufficiently stable anyway.

The method used for all the *Mind Machines* has been to start with a single, much higher "clock" frequency and reduce this through two dividers to obtain the two audio frequencies. One is used directly. The other has a circuit that, during each half-cycle of the output, blocks a few cycles of the input clock so that it runs at a slightly lower frequency than the first.

The "clock-blocking" period is easily adjustable so the output frequency difference is simply and accurately controlled, and since both outputs arise from a single clock oscillator the "pulling" problem doesn't exist. The snag is that adjustment is actually in discreet steps, and to keep these acceptably small the clock frequency must be relatively high.

In this and previous designs a clock frequency of 1·6MHz has been used with 12-stage dividers giving output signals of about 400Hz. A block diagram of this system is shown in Fig. 1.

Low-pass filtering converts the squarewave signals from the dividers into something close to sinewaves, and power amplifiers then drive the headphones. Note that the frequencies shown are approximate, and it doesn't actually matter which audio output is "left" and which "right"!

The control signal for the l.e.d.s is obtained by combining the audio signals through an Exclusive-OR gate, which produces their sum and difference frequencies. The sum is removed by a low-pass filter, leaving the difference frequency to operate the lights. Current control is used to adjust the brilliance.

CIRCUIT DESCRIPTION

The full circuit diagram for the Mind Machine Mk. III is shown in Fig. 2. The original Mind circuit used a crystal oscillator chip to generate the 1·6MHz clock, because CMOS *R-C* relaxation oscillators are unreliable at high frequencies. However, *L-C* oscillators are very stable and can

be built with a single CMOS inverter, such as one of the two to be found in IC4, a 4060B, which also contains the twelve stages of division needed to produce the first audio signal. Inductor L1 is a 100µH "choke", a wire-ended component just fractionally larger than a resistor, and together with capacitors C1 and C2 complete the resonant circuit.

The other internal inverter of IC4 conveniently supplies a buffered clock output from pin 9 for driving the second divider IC2, a 4040B. Control of the frequency difference is achieved by blocking this signal with IC1, an LM393 dual comparator. The outputs of this are, unlike ordinary op.amps, open transistor collectors so they can sink current to negative supply but cannot source it.

HOW IT WORKS

The circuit works as follows. Pin 15 of IC2 is the output preceding the one from which the audio signal is taken, so it has twice the frequency. Each time it goes positive the voltage applied through resistor R5 to IC1b pin 6 turns on the output which sinks the clock signal from R8 to ground.

At the same time, capacitor C2 starts charging through resistor R4. When the voltage across C2 exceeds the control voltage from R2, the output of IC1a turns on and sinks the current from R5 to ground, causing IC1b to release the clock signal again.

Since IC2 is a negative-edge triggered device and this action takes place on positive edges of the signal from pin 15, the clock-blocking takes place conveniently midway through each half-cycle of the final output. The higher the control voltage from R2, the longer the blocking period so the greater the difference in output frequencies. Although the action is related to the exponential charging of C1, if a maximum of half the supply voltage is used for control the frequency difference will appear to be linear with control voltage.

Passive filtering is applied to the squarewave divider outputs by resistors R9 and R10 with capacitors C5 and C6 on one side and R14 and R15 with C18 and C19 on the other. This converts them to approximately sinusoidal form, after which they pass through the "Volume" control VR1a and VR1b to IC3, a TDA2822 stereo amplifier.

This provides more than adequate drive from socket SK1 for a pair of "Walkman" type headphones, or the FREE cover-mounted headphones. Constructors of the original Mind Machine may remember that active filters were used to shape the signals, but this passive circuit works just as well. The previous design used two output chips in a quest for lower noise, but the single device used here is sufficient. More will be said about this later.

LIGHTING-UP TIME

The two divider outputs are also connected to IC5b, an Exclusive-OR gate. One of them, from IC4, first passes through IC5a. This inverts the signal polarity if the Phase switch S1 is closed, so the lights can be in either normal or opposite phase to the sound. Users can try both and make their own decisions as to which appears most effective.

The output of IC5b is a series of pulses with a duty cycle dependant upon the relative phase of the two inputs. The resulting average level is a triangular wave synchronised with the difference between the input frequencies.

Simple filtering by resistor R20 and capacitor C22 extracts this average, to which a d.c. voltage is added by R18 and R19 so that the output of IC5c is positive for about a quarter to a third of each cycle. IC5d reverses IC5c's output polarity.

Once again, in the original design active filtering was used with a comparator for determining the switching points. This circuit manages the whole operation with a single CMOS chip. Viewed on an oscilloscope, there is a bit of "splatter" around the switching points, but since the eye cannot see an 800Hz flicker this is not a problem.

Unlike its predecessor, this circuit uses only one l.e.d. driver. Improvements in l.e.d. performance provides sufficient stimulation with just one l.e.d. for each eye, and the two in series can be driven by the single output stage. The driver, IC6 with transistors TR1 and TR2, is actually a voltage-controlled current sink.

The control voltage from VR2 determines the current that will be drawn through the l.e.d.s connected to socket SK2. Note that VR2 is a "log" type since the eye, like the ear, has a logarithmic amplitude response!

The action of the signal from pin 11 of IC5d is to turn off the l.e.d.s by injecting positive current into the feedback loop of the driver circuit through resistor R22 and diode D1. This ensures that the lamps turn fully off by forcing the output of IC6 all the way to negative supply. The "end

COMPONENTS

Resistors — See SHOP TALK Page

R1	5k6
R2	470k
R3	560Ω
R4, R10, R15, R17, R19	100k (5 off)
R5, R6, R7	22k (3 off)
R8, R22, R23, R24, R25	10k (5 off)
R9, R14	15k (2 off)
R11, R16	150k (2 off)
R12, R13	4Ω7 (2 off)
R18	220k
R20	1M
R21	68k
R26	15Ω

Plus 4k7 for testing
All 0·6W 1% metal film

Potentiometers

VR1	10k dual rotary carbon, log
VR2	10k rotary carbon, log
VR3	10k rotary carbon for testing, lin

Capacitors

C1, C8, C9, C21	10µ radial elect. 50V (4 off)
C2	1n polystyrene
C3, C4, C17, C23, C26, C27, C28	100n resin-dipped ceramic (7 off)
C5, C7, C13, C14, C18, C20	100n polyester layer (6 off)
C6, C19	10n polyester layer (2 off)
C10, C11, C12	100µ radial elect. 25V (3 off)
C15	220p polystyrene
C16	150p polystyrene
C22	1n polyester layer
C24	1n resin-dipped ceramic
C25	4700µ radial elect. 16V

Semiconductors

D1, D2	1N4148 diode (2 off)
TR1	BC184L *npn* transistor
TR2	BC214L *pnp* transistor
IC1	LM393 Dual comparator
IC2	4040B CMOS 12-stage binary counter
IC3	TDA2822 Stereo power amplifier
IC4	4060B CMOS 14-stage binary counter with oscillator
IC5	4070B CMOS Quad Exclusive-OR gate
IC6	CA3130 CMOS op.amp

Miscellaneous

SK1	Stereo jack socket
SK2	Mono jack socket
L1	100µH wire-ended r.f. choke
S1, S2	Sub-min. slide switch (2 off)
B1	6 or 8 AA cells in holder, see text

Printed circuit board available from the *EPE PCB Service*, code 980; plastic case, size to choice; 8-pin d.i.l. socket (3 off); 14-pin d.i.l. socket; 16-pin d.i.l. socket (2 off); control knobs (2 off); 5mm 3·5cd Hyperbright l.e.d., 2 or 4 off (see text); multistrand connecting wire; screened lead; solder pins; solder etc.

Approx cost guidance only **£25** *excluding case & batts.*

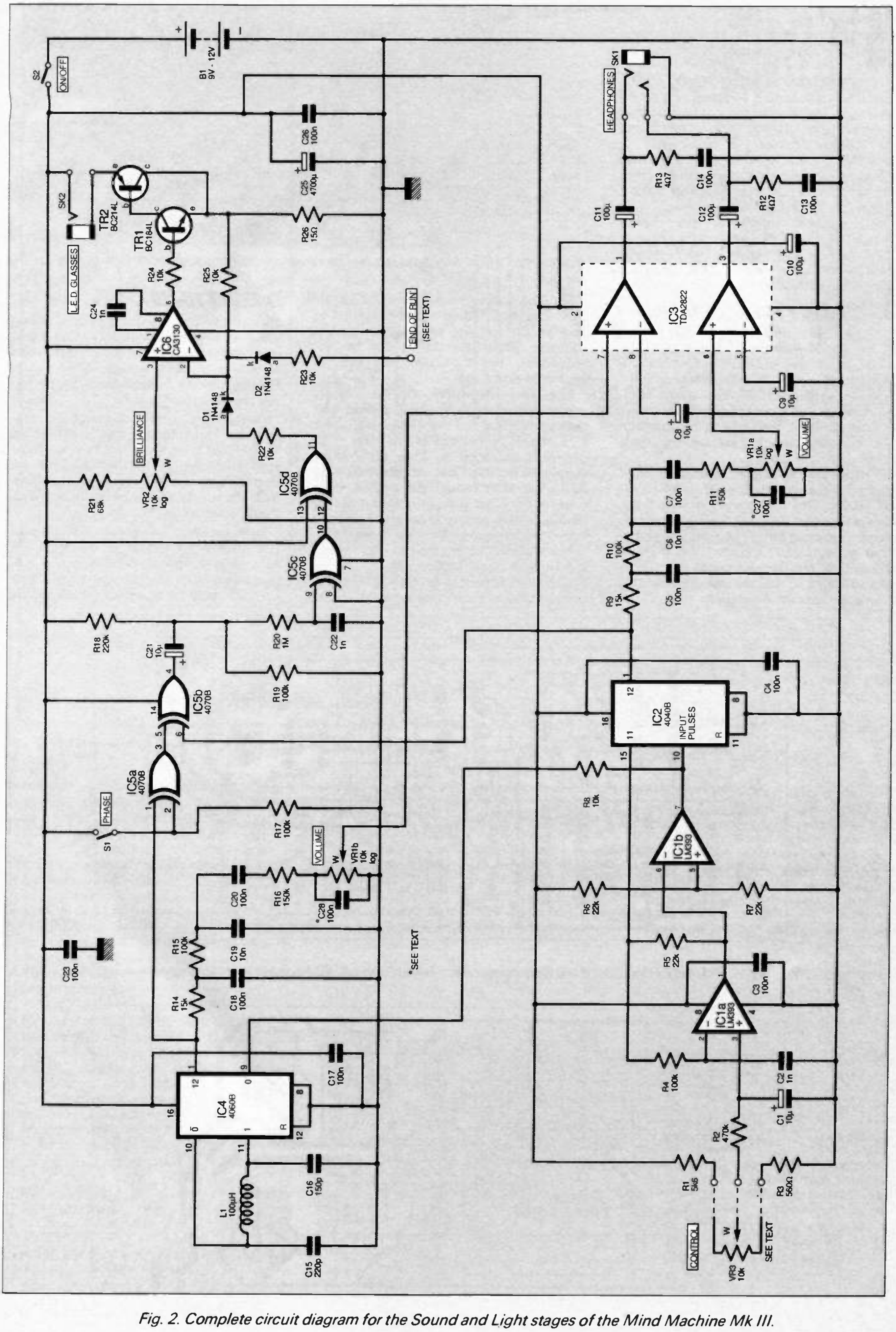
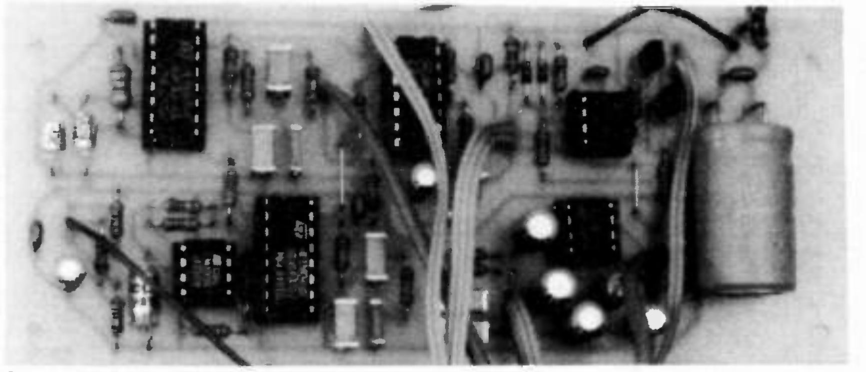


Fig. 2. Complete circuit diagram for the Sound and Light stages of the Mind Machine Mk III.

of run" input is provided for use with program generating circuits which can use a positive output signal to turn off the l.e.d.s.

This circuit has no supply voltage regulation. All the control voltages, including that from the programmers to be described in future issues, are relative to the supply so voltage regulation is unnecessary. It operates happily with supplies anywhere between 7V and 15V, the lower limit being set by the l.e.d. driver requirements and the upper one by the CMOS devices used.

The normal supply is 9V, though masochists might like to try four l.e.d.s in series with a 12V supply. The prototype uses a pack of eight "AA" NiCads supplying just under 10V.



Completed Mind Machine p.c.b. The radial smoothing capacitor C25 is laid flat on the board.

CONSTRUCTION

Construction and testing of this project is quite straightforward. The Sound and Light printed circuit board (p.c.b.) is available from the *EPE PCB Service*, code 980.

The positions for all the board components and full size copper foil master are shown in Fig. 3. For ease of construction the following assembly and testing procedure is recommended.

Firstly, all the passive components and diodes should be fitted, in order of physical height. This covers the two wire links, diodes D1 and D2, all the resistors, the tiny ceramic capacitors and the choke L1. Almost any 100μH inductor will work in this circuit, but the wire-ended type specified is simple to use and has a reasonable tolerance value of 10 per cent.

Six d.i.l. sockets should be fitted for the i.c.s. The use of these is recommended as they greatly simplify testing and troubleshooting. Should the project ever become redundant, the expensive i.c.s can be recovered easily, too.

The two transistors and the larger capacitors can now be fitted, ending with the electrolytics, but the 4700μF capacitor C25, should be omitted at this stage. This capacitor, intended to help the battery supply the bursts of current required by the l.e.d.s, can store enough energy to damage some of the other components so it should be fitted when testing is complete and the circuit is known to be working correctly.

Leads should be attached for the various control and signal connections, see Fig. 4. Screened leads should be used for connections to VR1, as these carry low level signals.

TESTING

Testing of the board can be commenced using a 9V supply, preferably from a current-limited bench PSU, though a 9V pack of AA cells could be used if necessary. During tests the current drawn by the circuit should be monitored.

Following a careful check of the construction and soldering, the board should be powered without any of the i.c.s fitted and, following an initial "kick" as the electrolytics charge, the current drawn from the supply should be negligible. With the prototype it was less than 20μA.

If this is satisfactory the oscillator and first divider IC4 should be inserted in its holder and power re-applied. Note that IC4, like some other i.c.s in this circuit, is a CMOS type so the usual anti-static handling

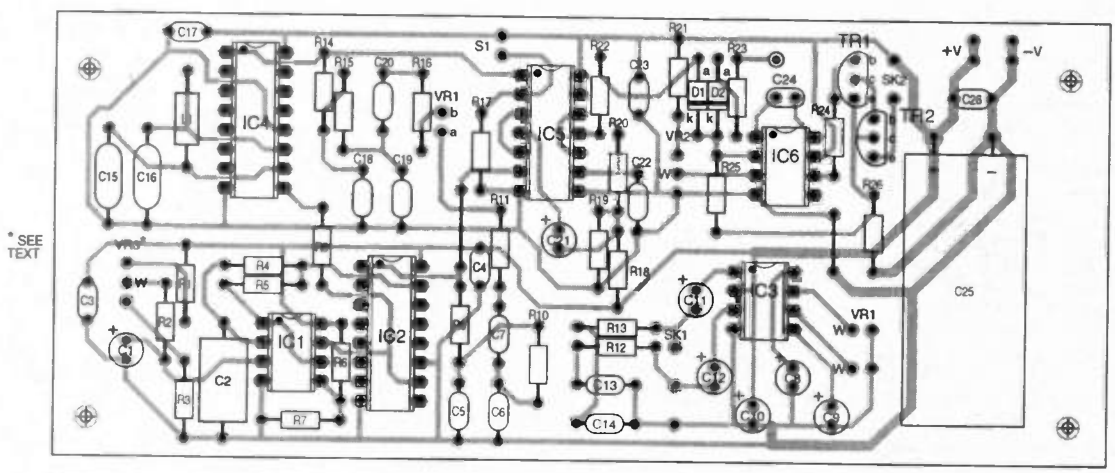
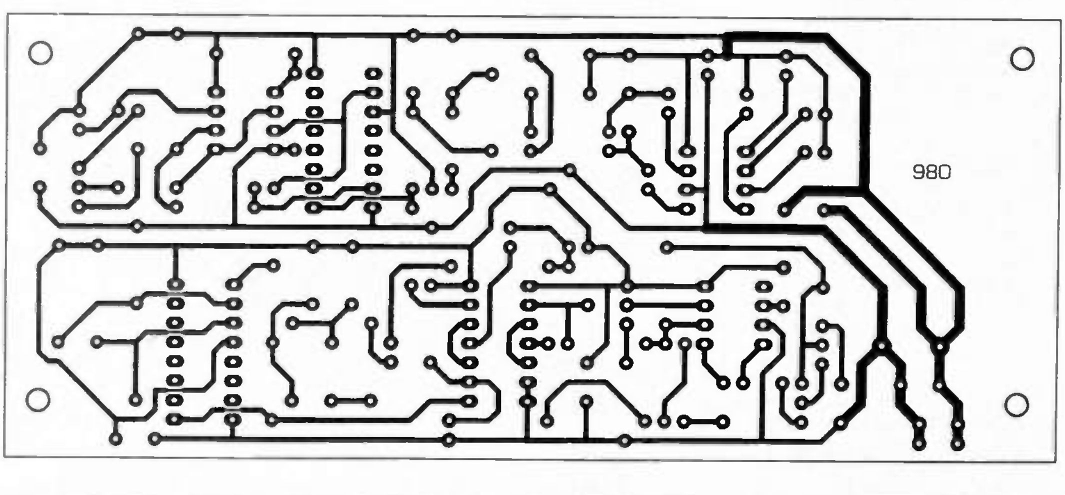


Fig. 3. Printed circuit board top side component layout and full size copper foil master pattern.



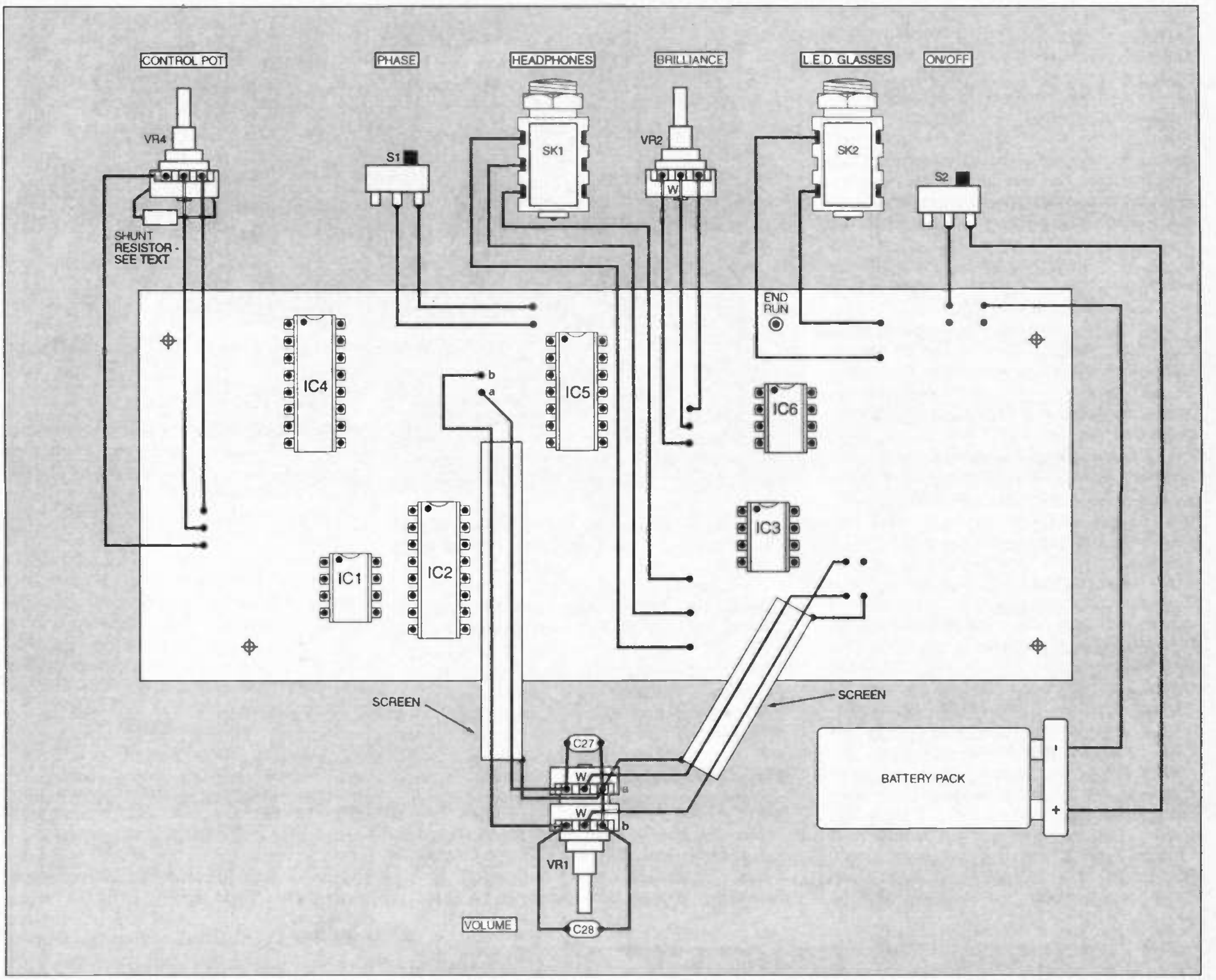


Fig. 4. Interwiring from the p.c.b. to off-board components. The phones and glasses sockets should be the plastic insulated types.

measures should be taken. If the oscillator is running correctly the supply current should be around 2mA and pin 1 of the i.c., the 400Hz output, should show an average d.c. level of half the supply on a voltmeter.

This can be followed by insertion of IC2, the second divider, which raises the current to about 3·5mA and should also have an average level of half the supply at pin 1. Next, control potentiometer VR3 should be connected to the p.c.b. input pins as shown in the interwiring diagram Fig. 4. The connection need only be temporary, and the control should be a linear type.

To allow for the large tolerance variation found in "pots", and the various types that may be used with the input, the circuit has been designed with values of resistors R1 and R3 for use with an overall control resistance of five kilohms. This can be obtained by shunting a standard 10k pot with resistor(s) selected to give this value. For testing, it is sufficient to just solder a 4k7 resistor across it as shown in Fig. 4.

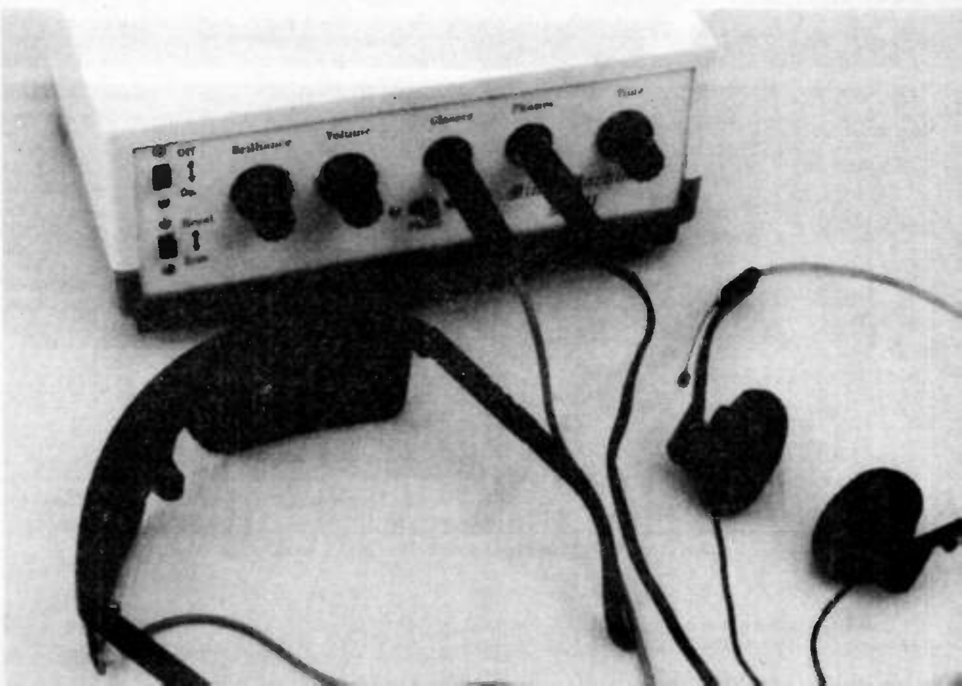
The comparator IC1 and the 4070B Exclusive-OR device IC5 should now be inserted, taking the overall supply current to about 5mA to 6mA. If the circuit is working correctly pin 11 of IC5 should show a d.c. value of about 6V and at low settings of the "test" control it may be seen pulsing at about 2Hz. Allowance should be made when altering the control setting for the slow response to changes due to the time constant of R2 and C1.

VISUAL TEST

An l.e.d. can be connected to the output (only one is needed for testing) and the Brilliance control VR2 should also be connected to the board. With IC6 in place, the l.e.d. should now flicker or flash, with brilliance controlled by VR2 and frequency set with the control pot VR3 on the input.

Following this it remains only to connect the Volume control VR1 to the screened leads, insert IC3 and try out the sound with a pair of headphones. Each phone on its own should produce a steady tone, whilst the two together should generate the "beat note" difference between them. The overall current drawn by the circuit will depend on the Brilliance and Volume settings, but with both turned right down it should be about 15mA.

Once everything is working satisfactorily, the large electrolytic capacitor C25



can be fitted. A bit of double-sided sticky tape or a dollop of adhesive should be used to secure this to the p.c.b.

FINAL ASSEMBLY

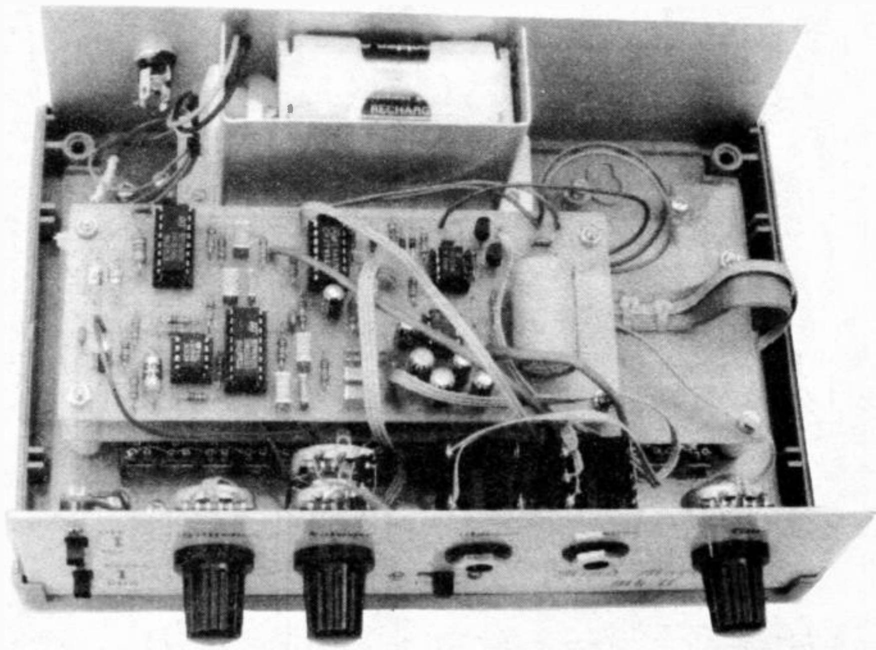
All the external interconnections are shown in Fig. 4. More will be said about layout in the next article, describing the programmer, but the prototype was assembled in a standard plastic case with all the controls and sockets for this board on the front panel. Where a metal panel is used, the headphone and glasses sockets should be *insulated* from it, otherwise they may short-circuit the supply.

Two points should be noted regarding sound quality. Because the two tones from this circuit are very pure, any noise or distortion can be unusually obvious and annoying, and two sources may be encountered.

The first is breakthrough of higher frequencies from other parts of the circuit, perceived as a slight "whine" on the output. This is easily cured by placing two 100nF ceramic capacitors, C27 and C28, across the two sections of the volume control VR1 as shown in Fig. 4.

A second is amplifier "hiss". In the original design this was eliminated by careful selection of device (hence the two separate i.c.s), and capacitance across the output, but this was a compromise as the amount required increased the supply current. A simpler solution is used with this version – cheap headphones!

Hiss will be very noticeable with expensive hifi phones, but a pair of really cheap ones just won't have the high frequency response and so will sound fine. "In-ear" types, with foam covering, are recommended. The absence of a headband prevents them from tangling with the glasses and the foam increases comfort whilst further reducing the hiss. Well, who wants to put high-level pure tones through their best hifi headphones anyway?



Layout of components inside the Mind Machine Mk III case. The lower board carries the programmer section to be described next month.

MAKING A SPECTACLE

The "glasses" should be constructed using plastic-lensed glasses of some kind as a base. Cheap ski goggles look good, but swimming goggles were preferred as these place the l.e.d.s very close to the eyes and their positions are to some extent individually adjustable.

The l.e.d.s are the highest output 5mm "Hyperbright" types obtainable, with output quoted as 3·5mcd, though 1mcd types should prove very nearly as effective. They are connected in series, and pressed into holes drilled in the lenses and connected as shown in Fig. 5.

Care is needed to find the optimum positions for them, remembering that when the user's eyes are *closed* and relaxed the eyeball position may alter slightly. A good way of locating the best position is to attach the l.e.d.s temporarily to some thin flexible wire, connect them to the circuit, put on the glasses, sit with *eyes closed* and experiment with position, using "Blu-Tak" to hold them in the best positions whilst marking out for drilling the holes.

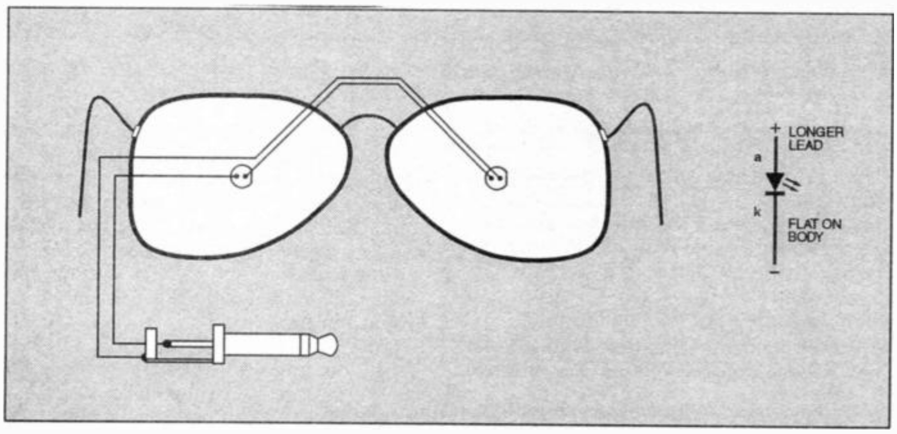
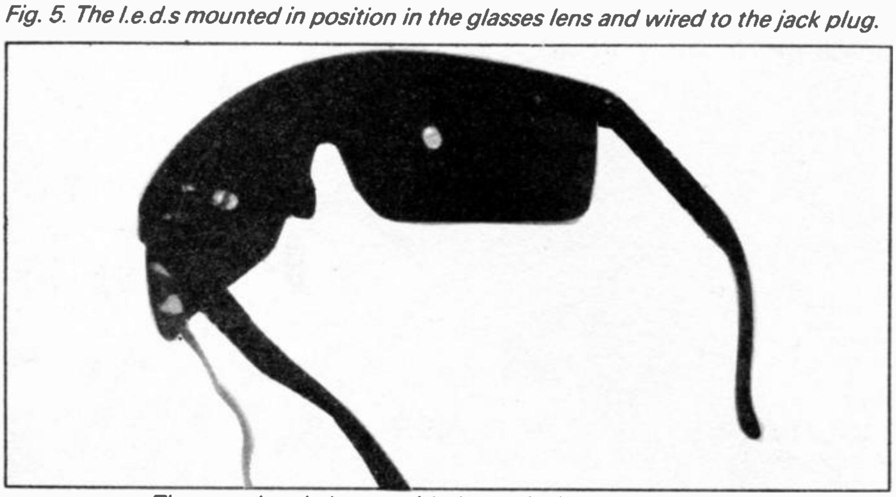


Fig. 5. The l.e.d.s mounted in position in the glasses lens and wired to the jack plug.



The completed glasses with the l.e.d.s fixed in position.

IN USE

The circuit may be used with the manual control VR3. Users will probably find the main effect is one of beautiful relaxation. Swirling patterns and colours are sometimes experienced in the lights, especially during initial sessions.

For best results a programmed "session" of twenty to thirty minutes is recommended so next month will see the first of two program controller circuits, the first being far more user-friendly and simple to operate than any of those previously published.

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- A 360kb system diskette containing the board driver files.
- An external power line for use with the experiment section.
- Various connection lines and block jumpers.
- The comprehensive PAL TRAINER User's Manual. This has been written in precise, easy-to-understand English, and takes the student right from unpacking and setting up the system, through a short demonstration program which runs without the need to go into PALASM and then, in a gentle step-by-step sequence, through 23 separate experiments.
- The complete PALASM software package, whose separate manual also contains a number of example programs.

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- include a top programming language - in this case AMD's PALASM Version 4, widely regarded as the PLD standard. Version 4, incidentally, can be linked to other schematic packages such as OrCad.

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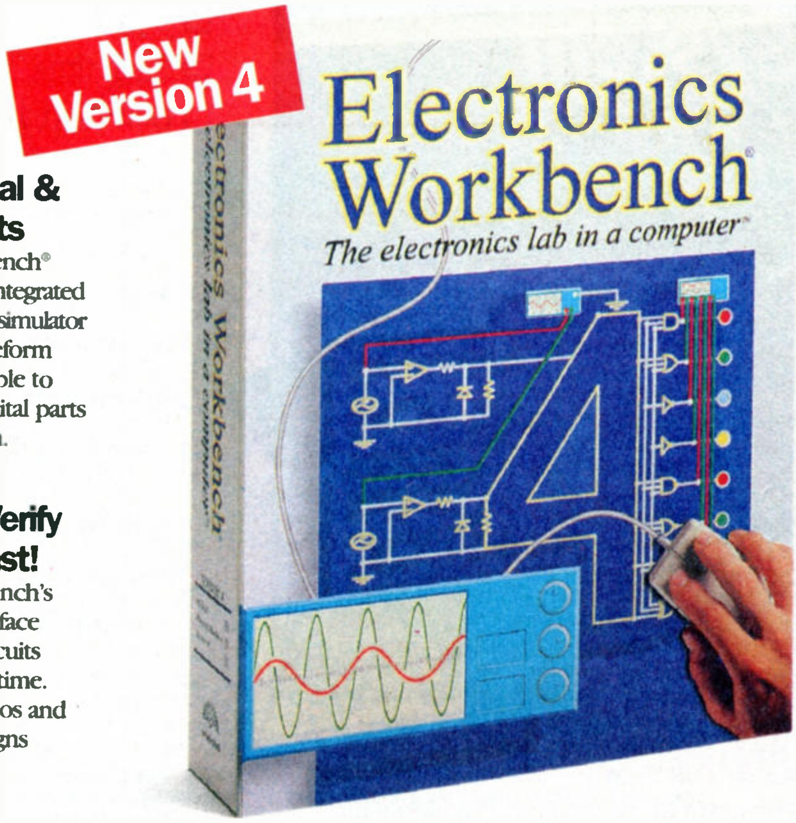

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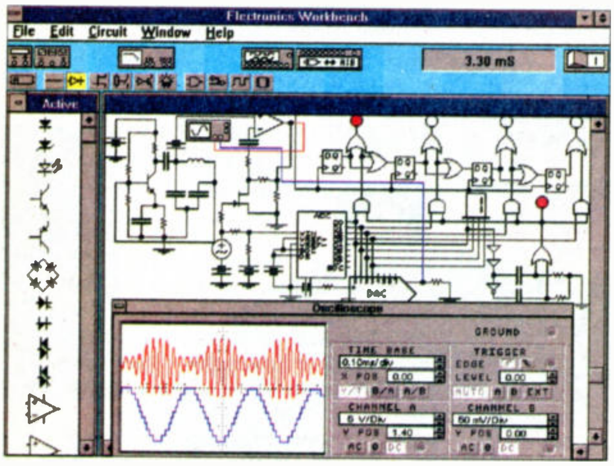

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INTERACTIVE

FOX REPORT

by Barry Fox

Encyclopaedic CDs

The new high density CDs and CD-ROMs, which are due on the market at the end of 1996, will store the equivalent of at least half a dozen conventional CDs. This means that one disc can store a shelf full of multimedia encyclopaedias, all the maps for Europe or the USA, and all the telephone numbers for a whole Continent.

The practical value of this will be immediatley obvious to anyone who juggles ROMs, just as we had to swap floppy discs to change PC programs in the days before a cheap hard disc stored everything for rapid access.

But think of the flip side.

When the first ROM encyclopaedias went on sale five years ago, they cost around £200 each. No-one bought them. There are now around 10,000 ROM titles available and the price has fallen to under £50. Encyclopaedic information has never been so cheap.

A high density CD will cost little more to press than an ordinary CD, which means they can be churned out for less than a dollar a time. But if one high density ROM holds the copyright material from six or seven ordinary ROMs, royalties will push the cost of a single disc up to several hundred pounds again.

So once again no-one will buy. Consumers will perceive the single disc as grossly over-priced. They will worry about their ROMs being stolen, or damaged. The price will once again shake down to whatever the consumer sees as the acceptable maximum, probably around £50.

The coming of high density ROM may thus have the happy side effect of driving down the cost of information to the lowest levels ever.

Data Retrieval

The idea of low cost, bulk information dates back to 1945. Vannevar Bush was Director of the Office of Scientific Research and Developement in the USA. He co-ordinated scientific and military research. As the war ended he wrote an essay in the magazine *Atlantic Monthly*, which warned that so much information was even then being published, that the availability of information extended far beyond the world's ability to make real use of it. Someone can live in a library, surrounded by books, but still be completely ignorant.

Bush saw photographic microfilm as the likely solution. "The *Encyclopaedia Britannica* could be reduced to the volume of a matchbox", he predicted. "The library of a million volumes could be compressed into one end of a desk".

Fifty years on microfilm remains a cheap method of archiving. Libraries routinely use it to store large volumes of old paper, such as patent specifications. But you have to know the date or number of the document you are looking for, and then read through it. There is no way of automatically searching the analogue text for keywords or phrases, as is now routinely done with text stored as digital code on magnetic or optical disc.

Banks and insurance companies make microfilm copies of all old cheques and transaction documents before they destroy the paperwork. They use a highly automated system of running all the paper at very high speed through a scanner and capturing the image on silver halide film emulsion.

To cut costs the companies do not even bother to process the microfilm rolls unless or until a query comes up and which no one can answer from the existing paperwork. They then cross fingers and develop the roll that is logged as containing a latent image of the document in question. No-one has ever been able to tell me what happens if the film is fogged or faulty, or the image blurred through malfunction of the scanner.

Internet Ferreting

I wonder what Vannevar Bush would have made of the Internet, and World Wide Web. They certainly bear out his warning of a world with too much information available. The Web straggles over so many Internet sites, with such hit and miss indexing, that searching for anything can become a full time job.

Californian software company Quarterdeck was founded in 1982, and became very successful with its Desqview multitasking and QEMM memory management systems for DOS, long before Microsoft released a stable version of Windows and the very poor Memmaker memory manager. Quarterdeck went public in 1991, ran into trouble the next year, and restructured in 1994. Staff had dropped to 200, but now it is up to 600. The company is flourishing again.

Quarterdeck still sells QEMM and it is still streets ahead of Microsoft's pale imitiations. But Quarterdeck has now started selling Internet software. One program, called Web Compass, would have suited Vannevar Bush. It is a search engine that uses keywords to ferret out information from the Internet.

It does this by first checking through a dozen or more of the existing index sites, like Yahoo, Lycos and CNN Online. The Compass search engine then uses artificial intelligence to analyse the results that come back from the index sites, and presents the searcher with a list of documents that are most likely to contain genuinely useful information.

Semantic Search

The intelligence comes from a "semantic database" which Compass uses as a personal reference book. If, for instance, the original search instruction was to find information on "trees", the first step is send the key word "tree" to the various index sites. These will then throw up large numbers of documents which refer to shoe trees, genealogy trees, logic trees, pine trees, tree houses and whatever goes on at any place with "tree" in the address.

Compass now gets clever. It scans the text, analyses the content, creates a summary, makes a judgement on the context of the keyword and sorts the documents into groups. The system is similar to that used by some busy company executives who only ever read a computer-condensed version of their incoming Email messages!.

The grouped summaries produced by Compass are stored on the PC's hard disc for off-line reading. The heart of the software is the semantic database, which contains around 40,000 known word linkages, such as shoe and tree, genealogy and tree, pine and tree and so on.

When the database is stumped, for example if it comes up against a document on "tree surgeons" and puts them under a medical heading, the searcher can correct the classification. The search engine learns from this for next time. So the more the search engine is used the more effective it becomes as a discovery tool.

Index-linked

Because the index sites are financed by advertising, Compass dutifully downloads some advertisements as well as searched text. Apart from this, the inevitable weak link is that the index sites only cover around half the material which is available in the Web. Everything on the Internet is changing so fast, with sites appearing and dissappearing daily, that probably no index will ever be able to catalogue everything that is available.

Intelligent search engines can only search through material that the indexes throw up. It is the price the world must pay for an Internet which is free from the kind of official control which would organise an efficient index but censor and ban some of the information, perhaps by the simple expedient of omitting it from the index.

ARMED WITH AN EXTRA DEGREE OF SAFETY

Advanced robotics development in the UK provides new degrees of freedom and safety for remote operators – *by Hazel Cavendish*

IN SOME respects, the world has become a more dangerous place as the frontiers of science are pushed forward. Human beings must always be protected from hazardous environments in which they are called upon to work – in space, in nuclear laboratories and deep underwater, and so on. To meet the challenge of such environments, teleoperated robotic systems are being developed.

It has long been recognised that if an operator is an essential – indeed vital – part of a teleoperated robotic system, that system must be viewed from his perspective, and designed so that he can perform his task easily and efficiently.

"There are still too many command, control and safety issues to be resolved in these hazardous unstructured environments before we leave them in the 'hands' of autonomous robots," wrote David Hooper and Cliff Boddy in an interesting recent paper. They were describing a task-centred robotic manipulator system originally developed for remote handling in nuclear environments, and now being used by the North Sea oil industry.

ADVANCED ROBOTICS

Some most exciting work has been taking place in Manchester where a 21-strong research team has been working at the National Centre of Advanced Robotics, where they achieved three "firsts" in the field of advanced robotics. These included the "Seven Degrees of Freedom" (7DOF) teleoperation controller – which embodies collision avoidance, the automatic tip stabilisation manipulator, and a high accuracy navigation vehicle for the construction industry.

This team formed its own company called UK Robotics Ltd. at the end of 1995, substantially backed by British Nuclear Fuels and InSys. BNFL intend that their investment will help the company to employ the latest robotic technology in new business.

Their business manager, Dr Martin Bucknell, said "Working closely with UK Robotics should provide us with another string to our technology bow, as we expect their know-how will give us the edge in maintenance, safety and the decommissioning of facilities."

TELEOPERATION TESTBED

A collaborative group of British companies, interested in solving a variety of remote handling problems in the nuclear industry, came together in 1993 to define the Advanced Teleoperation Testbed (ATT), founded upon the successful work undertaken at the National Advanced Robotics Centre. InSys, as the prime contractor, undertook all the R&D work.

The ATT system is the result of the integration of two robotic systems, and a wide variety of other input and output hardware and software spread across four computer programs. A simplified schematic of the physical system is shown in Fig. 1, which is re-interpreted from a task-centred point of view in Fig. 2.

With the Task at the centre and the Operator at the periphery, the ATT system is everything in between which enables the Operator to perform the Task remotely.

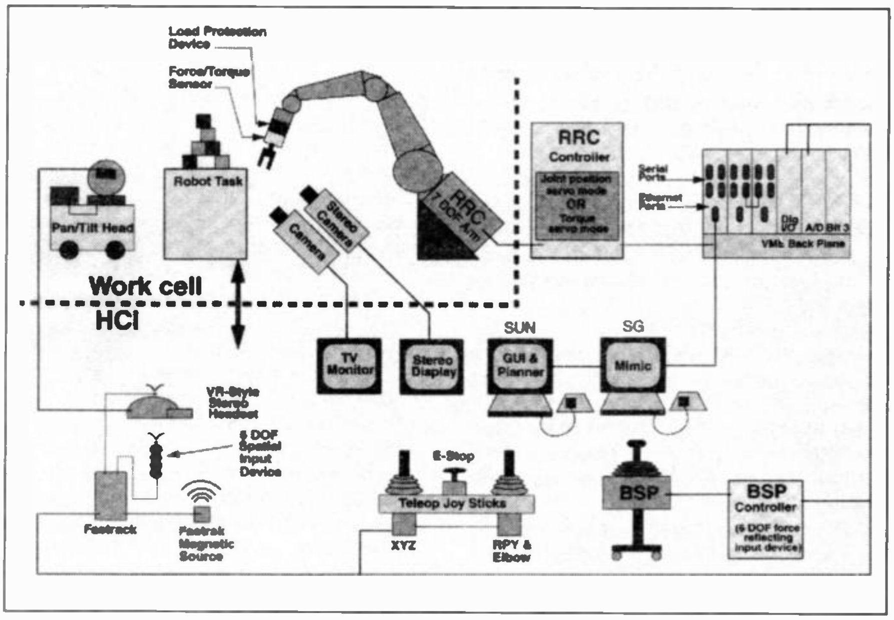


Fig. 1. Overview schematic of the ATT system.

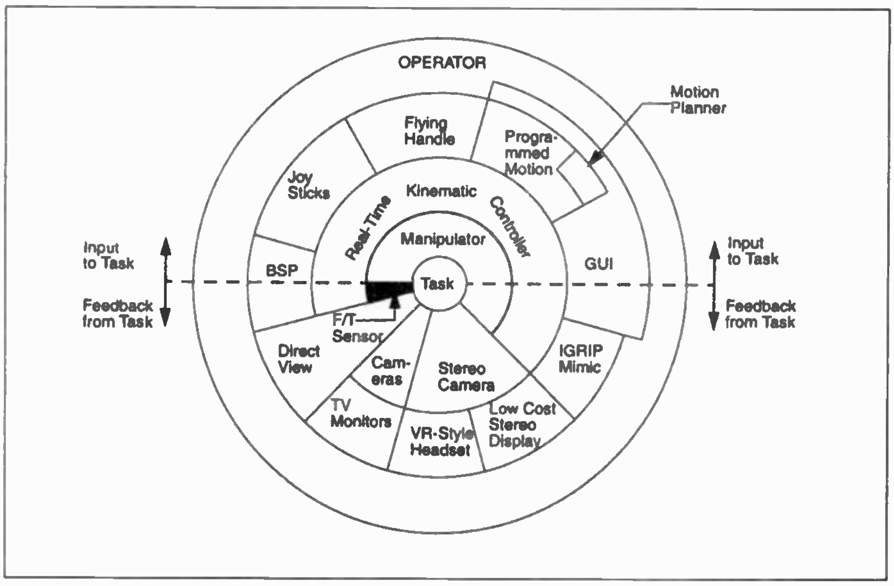


Fig. 2. A task-centred view of the ATT system.

The system consists of three layers which are effectively "transparent" to the operator, as is needed for a good task-centred system. A vertical line from the Task downwards to the Operator passes through an inner sector labelled Stereo Camera and an outer sector labelled VR-Style Headset. This is in the Feedback from Task hemisphere and indicates that the user can get a stereo visual image of the task he is performing, slaved to his head movements.

A line drawn from the Operator shows that inputs to the Task can be made using conventional joysticks, via the Real-time Kinematic Controller to the Manipulator that actually performs the Task.

The tasks to be achieved were defined in two representative mock-ups of nuclear plant: The first was electromechanical and had features that could be removed, avoided or swabbed. The second was an enclosed vessel that the manipulator could penetrate and was used for a variety of assembly and inspection tasks. Two vertical pipes were also used to restrict the workspace further so that the full effectiveness of the manipulator's dexterity could be tested.

MANIPULATOR AND CONTROLLER

At the heart of the ATT system is the Manipulator, which is the primary means of remotely performing the task. The manipulator is a "Seven Degrees of Freedom" device. Normally, six parameters define the pose of the end-effector, or arm. The seventh DOF relates to the elbow roll angle, so increasing the arm's dexterity. The operator can adjust the manipulator's configuration by moving the elbow in an "orbit" around the wrist/shoulder line.

The Operator does not have direct access to the Manipulator but is passed through the Controller. This sends commands at the servo level via a shared memory interface that allows alteration of servo code parameters as well as passing joint commands.

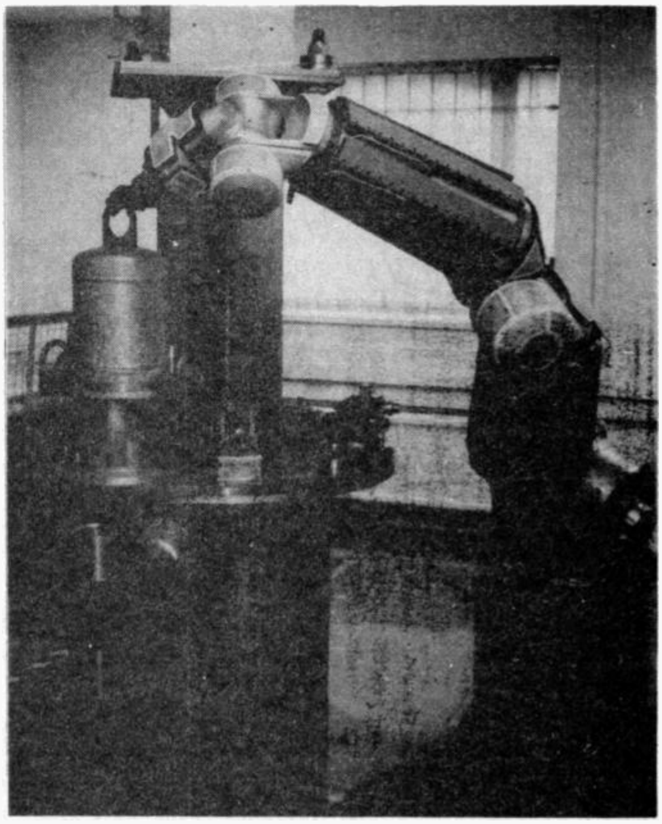
Working at a higher level, the controller "cocoons" the manipulator, providing the Operator with enhanced functionality and an additional level of safety and robustness.

MOTION PLANNER

The Motion Planner can be used to find a collision-free path, in joint space, that will move the manipulator between two specified points in a cluttered environment.

The remainder of the ATT system forms the Man/Machine Interface (MMI) which is split across three computer platforms. An accurate model of the manipulator and its workcell has been created in the IGRIP section – an exact kinematic representation of the real manipulator, including joint offsets and joint limits, which can be set to detect collisions or near misses between any objects in its workcell.

Teleoperation allows the user to remotely operate the manipulator with any one of three different input devices: joysticks, the "Flying Handle" or BSP.



UK Robotics' 7DOF remotely controlled arm is being evaluated by BNFL.

The "Flying Handle" is a 6DOF spatial input device that uses Polhemus Fastrak magnetic field technology. The Fastrak sensor has been placed inside an InSys grip. With this device the operator commands linear and angular position using natural hand movements and the end-effector is slaved to the operator's hand motion.

BSP is a force-reflecting input device based upon a Bilateral Stewart Platform, and comprises a joystick mounted on a platform and attached to six actuated legs in a parallel configuration, plus a PC based controller.

Other teleoperation functions are provided, such as motion scaling, trajectory record and replay, and position recording. Moves may be made joint-by-joint or in a variety of resolved motion frames.

EXPANSION ANTICIPATED

After eight years of developing advanced robotics, the team is confident that it has arrived at a good telerobotic system that is both transparent and semi-autonomous, easy to learn and logically consistent. Geoff Pegman, UK Robotics' new MD, who was previously Engineering Manager of InSys, says he anticipates expansion of his company will be "fairly rapid".

"UK Robotics is largely product-based, yet is very different from any other robotics company in this country. Our core marketplaces are Europe and the US.

"Becoming a separate company emphatically does not mean we will be turning our back on research. It is vital we stay several steps ahead, so we have a continuing partnership with Edinburgh and Salford Universities, and with Professor Mike Brady at Oxford University Robotics Laboratory."

LIBRIS BRITTANIA

Last month, the Public Domain Software Library (PDSL) were mentioned in connection with the software for the Simple PIC16C84 Programmer.

Over the past few years, PDSL has issued CD ROMs containing almost all the programs in its library called *"Libris Brittania"*, several thousands of them. Now the fifth edition of the work has been released in the form of a two-part set of CD ROMs, each of which comes in its own book with descriptive detail of each library program contained on the CD.

The first part CD is called *"The Scientific and Technical Library CD ROM"*. Subjects include Artificial Intelligence, Communications, Maths, Technical Drawing, Security Programming, Ham Radio and so on, and there are lots of utilities.

The second part CD is called *"The Business Software Library"* and contains 25 categories covering Business and Leisure programs.

Both parts sell individually at £29 each, or both CDs can be bought together at a discounted price of £49. VAT and postage are inclusive.

For further information, contact Susanne Lawrence, Public Domain and Software Library, Dept. *EPE*, Winscombe House, Beacon Road, Crowborough, Sussex TN6 1UL. Tel: 01892 663298.

COMING-UP

Sunday 4th Feb. The Lancastrian Rally, the north-west premier event for radio amateurs, computer and electronic specialists. At the University of Lancaster, doors open 10.30am. Tel: Sue Griffin, 01524 64239.

Sunday 5th May. National Vintage Communications Fair, NEC, Birmingham. Open10.30am to 5pm. Tel: Jonathan Hill, 01398 331532.

GONE-BY

Did you know that 100 years ago, Marconi arrived in Britain and took out the world's first patent for a workable system of wireless communication? Or that it's 60 years since the BBC introduced the world's first high-definition TV service from Alexandra Palace, London?

Constructional Project

MULTI-PURPOSE MINI AMPLIFIER

ROBERT PENFOLD

Low-budget, three input general purpose headphones amplifier.

★ Radio Tuners ★ Cassette Decks
★ Guitar Pick-Ups ★ Microphones
★ General Testing and Fault Finding

THIS simple amplifier is primarily intended for use with the headphones supplied FREE with this issue of *Everyday Practical Electronics* (UK copies only), but it should work with any similar headphones. In other words, any medium impedance headphones of the type generally sold as replacements for personal stereo units.

This amplifier is intended to be a general purpose type which will operate properly with most signal sources. It has three inputs which provide widely differing levels of sensitivity. The High Level input is for use with signal sources such as Tuners, Cassette Decks, etc., which provide signal levels of at least 100mV r.m.s.

The Medium level input is primarily for use with Guitar pick-ups, but it might be usable with other signal sources. It requires an input level of only around 10mV r.m.s. The Low level input is extremely sensitive, and it will provide good volume from signal sources such as high or low impedance Dynamic Microphones, Electret Microphones, and very low output Guitar pick-ups.

Obviously this amplifier can be used for a specific task, such as a Guitar Practice Amplifier, but it is primarily intended for use as a general purpose test amplifier. As such, it only drives the headphones monophonically, but there should be no difficulty in building a *stereo* version of the amplifier. This just entails building *two* amplifier boards, one to drive each earphone.

CIRCUIT DESCRIPTION

The full circuit diagram for the Multi-Purpose Mini Amplifier is shown in Fig. 1. This breaks down into two main sections, which are a preamplifier stage based on IC1 and a small power amplifier built around IC2. Potentiometer VR1 is the Volume control, and it is used in the coupling between the two stages.

An operational amplifier, IC1, is utilized here in the inverting mode. Resistors R4 and R5 provide a bias voltage of about half the supply potential to the non-inverting input, pin 3, of IC1. C5 is a decoupling capacitor, and its purpose is to avoid feedback through the power supply lines.

This feedback can occur due to variations in the supply current loading the battery, and causing variations in the supply voltage. Supply decoupling capacitor C1 also helps to minimise any stray feedback via this route.

INPUTS

The gain and input impedance of the preamplifier is determined by two resistors which form a negative feedback network. Resistor R6 always provides one section of the negative feedback network, but the other section is formed by resistor R1, R2, or R3, depending on which input is in use.

With Input One in use, the two negative feedback resistors are R1 and R6. The input impedance of the circuit is equal to the value of the input resistor, which is R1 in this case. The circuit therefore has an input impedance of 10k (kilohms) at Input One.

Calculating the voltage gain of an inverting mode circuit is very straightforward, and in this case the gain is equal to the value of R6 divided by the value of the input resistor. This works out at 1000k (1M) divided by 10k, which is obviously 100 times.

This relatively high gain gives the circuit high sensitivity when Input One is used, but with an input impedance that is not particularly high. This gives input characteristics that are well suited to many types of microphone, and to very low output guitar pick-ups.

Resistor R2 becomes the input section of the negative feedback network with Input Two in use. This has a value that is ten times higher than that of R1, which gives a higher input impedance of 100k, but provides a lower voltage gain from IC1.

In fact, the voltage gain is reduced to just 10 times. This still gives quite good sensitivity, and this input is well suited to use

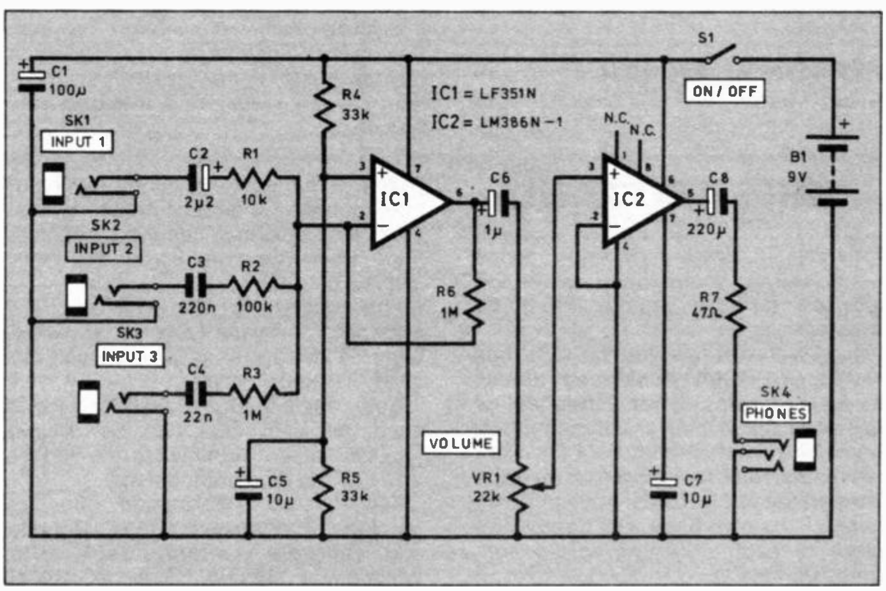


Fig. 1. Full circuit diagram for the Multi-Purpose Mini Amplifier.

with most guitar pick-ups, older hi-fi equipment which has a relatively low output level, etc.

With Input Three in use, R3 acts as the input resistor. Its value is 10 times higher than that of R2, giving another tenfold increase in the input impedance, but also a tenfold reduction in the voltage gain provided by IC1.

In other words, the input impedance is one megohm and the voltage gain is unity. IC1 really just acts as a buffer amplifier when Input Three is in use.

This input gives low sensitivity, but it is well suited to use with most tuners, cassette decks, compact disc players, etc. It is also suitable for use with very high output guitar pick-ups, which might produce overloading and an unwanted "fuzz" effect if used with Input Two! Due to its high input impedance, this input is also suitable for use with crystal and ceramic pick-ups.

POWER AMPLIFIER

Electrolytic capacitor C6 couples the output signal from the preamplifier stage IC1 to the Volume control, which has its wiper (moving contact) directly coupled to the non-inverting input, pin 3, of IC2. This is an LM386-1, which is a small audio power amplifier i.c. having a class B output stage. No coupling capacitor is needed at the input of IC2 as this chip is designed for direct connection to a Volume control.

The inverting input at pin 2 of IC2 is not required in this circuit, and this pin is connected to the 0V supply rail to avoid stray pick-up. Capacitor C7 provides supply decoupling to the input stage of IC2.

The voltage gain of IC2 can be boosted somewhat by connecting a capacitor between pins one and eight, but for the present application the basic voltage amplification of IC2 is perfectly adequate. Consequently, pins one and eight are left unconnected.

OUTPUT

Capacitor C8 provides d.c. blocking at the output, and resistor R7 provides a certain amount of attenuation in conjunction with the impedance of the headphones. The sensitivity of medium impedance headphones varies considerably, but in general the "inner-ear" variety have higher sensitivity than the conventional type.

The direct output of IC2 is slightly excessive for conventional medium impedance headphones, and is much too strong for most inner ear types. R7 provides sufficient attenuation to prevent grossly excessive volume levels with the FREE *EPE* headphones, but it is still possible to obtain high volume levels if desired.

If the amplifier is used with sensitive inner-ear headphones it would be preferable to use a higher value for R7. A value of about 220 ohms should give safe results but still permit good volume levels to be obtained.

The quiescent supply current of the circuit is approximately 5mA, but the current drain rises significantly when the amplifier is used at high volume levels. A PP3 size battery is adequate to power the unit, but six HP7 size cells in a holder are a better choice if the unit is likely to be used for long periods.

CONSTRUCTION

The Multi-Purpose Mini Amplifier is built on a small printed circuit board

(p.c.b.) and housed in a two-tone, medium size case, with aluminium front and rear panels. The printed circuit board is available from the *EPE PCB Service*, code 976.

Details of the topside p.c.b. component layout and interwiring to off-board components are provided in Fig. 2. The actual size copper foil master pattern for the printed circuit board is also included separately.

Neither of the integrated circuits are static sensitive, but it is advisable to fit them in holders anyway. Be careful to fit both i.c.s and the six electrolytic capacitors the right way round.

The electrolytics must be miniature radial types if they are to fit neatly onto the board. C3 and C4 should be printed circuit mounting types having a lead spacing of 7·5mm (0·3 inches).

Fit single-sided solderpins to the board at the points where connections to the controls and sockets will be made. One millimetre diameter pins are required. The tops of the pins should be "tinned" with a generous amount of solder, which will make it easy to make reliable connections to them.

The unit should fit into practically any medium size metal or plastic case. With any piece of sensitive audio equipment there is an advantage in using a metal case, as it screens the circuit board and wiring from sources of mains "hum" and other sources of electrical noise. However, it is not essential, and with this project there is a slight complication if a metal case is used.

INSULATED SOCKETS

Because the stereo headphones are driven monophonically, no connection is made to the "earth" tag of the output

COMPONENTS

Resistors See SHOP TALK Page

R1	10k
R2	100k
R3,R6	1M (2 off)
R4,R5	33k (2 off)
R7	47Ω (see text)

All 0·25W 5% carbon film

Capacitors

C1	100µ radial elect. 10V
C2	2µ2 radial elect. 50V
C3	220n polyester, p.c.b. mounting with 7·5mm lead spacing
C4	22n polyester, p.c.b. mounting with 7·5mm lead spacing
C5,C7	10µ radial elect. 25V (2 off)
C6	1µ radial elect. 50V
C8	220µ radial elect. 10V

Semiconductors

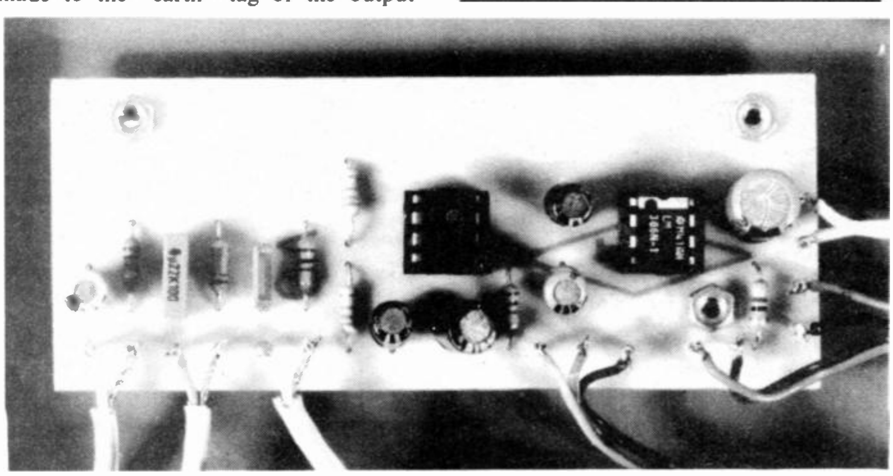
IC1	LF351N Bifet op.amp
IC2	LM386N-1 325mW audio power amp

Miscellaneous

SK1	3·5mm jack socket
SK2, SK3	Standard 6·35mm jack socket (2 off)
SK4	3·5mm stereo jack socket
S1	s.p.s.t. min toggle switch
B1	9V battery (PP3 size or 6 x HP7 pack)

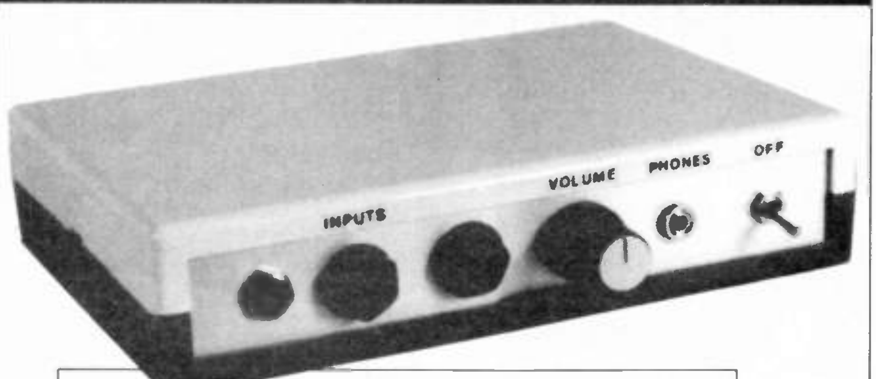
Printed circuit board available from *EPE PCB Service*, code 976; plastic or metal case about 180mm x 120mm x 41mm; battery connector; 8-pin d.i.l. holder (2 off), control knob, solder pins, multistrand connecting wire, solder, etc.

Approx cost guidance only **£12** *excluding case*



Layout of components on the p.c.b. Note the use of i.c. sockets.

MINI AMPLIFIER CONSTRUCTION



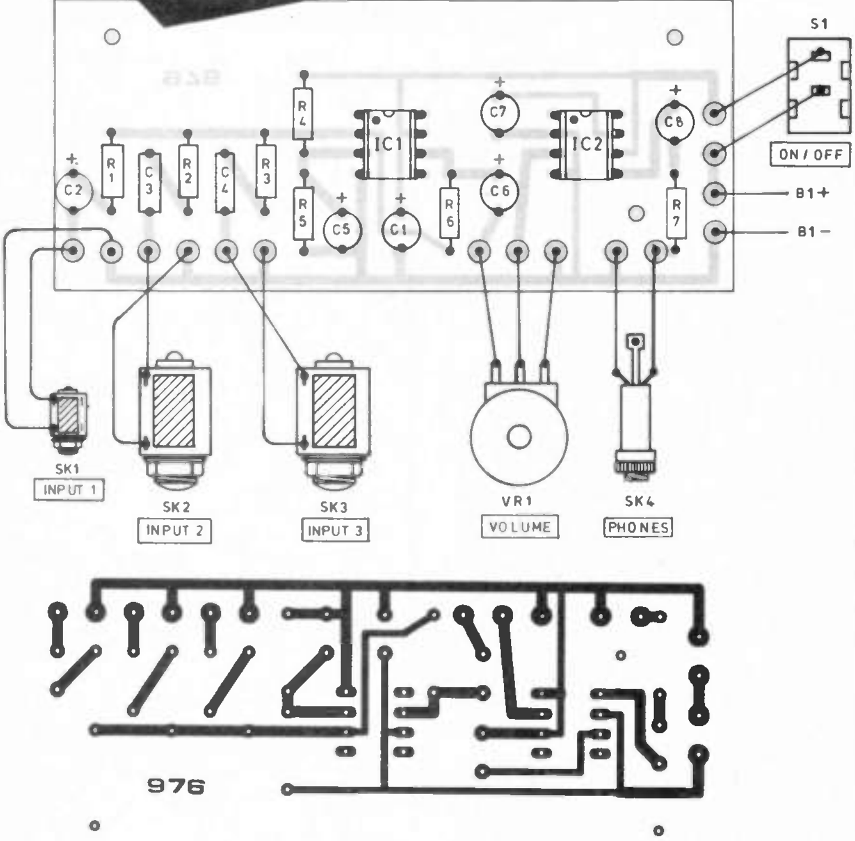
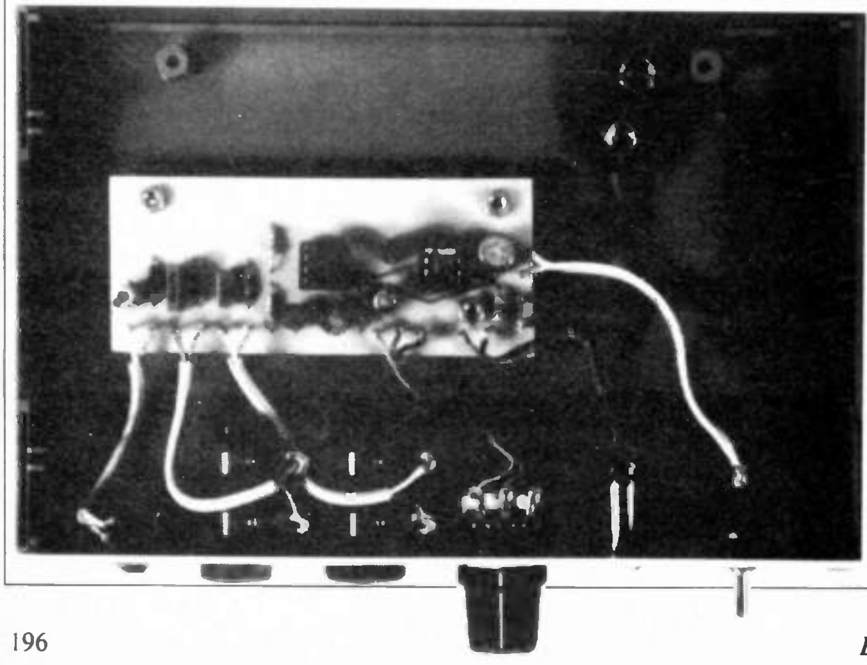


Fig. 2. Mini Amplifier printed circuit board component layout, off-board component interwiring and full size foil master. The completed amplifier showing wiring can be seen below.



socket SK4. The two output terminals of the amplifier connect to the two *non-earth* tags of SK4, and the headphones are then driven in series. Driving the phones in parallel would in some ways be more satisfactory, but would also be very inefficient, and would give poor battery life.

The problem with using a metal case is that many sockets have their earth tags connected *internally* directly to their mounting bushes. This provides connections between the earth tags via the case.

In this instance these connections can provide an unwanted connection to the earth tag of the output socket. This places a short circuit across one of the earphones, effectively rendering it inoperative.

The easy way around the problem is to use an insulated jack for output socket SK4, or to use insulated input sockets (SK1 to SK3). The prototype amplifier is housed in a plastic case having metal front and rear panels. Socket SK1 is an insulated 3.5mm jack socket, and SK2 plus SK3 are insulated standard (6·35mm) jacks.

Insulated jack sockets often have extra tags which connect to built-in switch contacts. These switches serve no useful purpose in this application, and any extra tags are simply ignored.

If you wish to use open (non-insulated) sockets the unit should be housed in a *plastic* case, so that the unwanted earth connection is avoided. The amplifier should then be operated where it is well clear of any strong sources of electrical noise, such as television sets and computer systems.

INTERWIRING AND LAYOUT

The general layout of the unit is not critical, but try to keep the input sockets reasonably well separated from the output socket. Also, keep the input wiring well separated from the output lead to SK4. This helps to avoid problems with instability due to stray feedback.

The printed circuit board is mounted in the case using 6BA or metric M3 fixings, including spacers about 6mm long. Fig. 2 shows the hard wiring, which is mainly straightforward.

It is not essential to use screened cable for the connections from the input sockets to the circuit board, but doing so helps to minimise any stray pick-up of electrical noise, particularly if a plastic case is used. It also reduces the risk of stray feedback and instability.

IN USE

If the unit is functioning correctly, with the Volume control well advanced there should be plenty of "hum" and other noise from the headphones if the non-earth tags of any of the input sockets are touched. If there is a lack of response from the unit, switch off immediately and recheck all the wiring.

The best input for a given signal source can be determined by trial and error. A more sensitive input must be used if it is not possible to obtain a high enough volume level. Clipping and severe distortion on the output signal will be evident if the input signal overloads the preamplifier stage. A less sensitive input should then be used. Remember that Input 1 is the most sensitive, and Input 3 has the lowest sensitivity. □

New Technology Update

Ian Poole casts his eyes over the problems of producing 3D images and discovers that the age of the 3D Surgeon is not too far off.

ENTERTAINMENT plays a large part in our society today, and ever since the first radio broadcasts, people have been seeking to make entertainment in the home more realistic. High quality audio transmissions were introduced using v.h.f. f.m. in the 1950s and this was followed by stereo.

Television arrived and then it was improved in the UK by increasing the definition from 405 lines to 625 lines. Colour was also introduced shortly afterwards. All of these are now standard items in most homes, but with technology pressing forwards wide screens and a host of other developments are on the horizon.

3D Images

One idea which has always been of interest is the display of three dimensional (3D) images. This is the ultimate in reality where the image could be suspended in mid-air and it would even be possible to see behind the displayed object.

True 3D images can be displayed using holograms, but the technology has not been developed to a stage where it is viable for the home, and certainly not for broadcast transmission.

Despite this, many companies are developing various forms of flat 3D displays, bringing three dimensional television a step closer. Most of the early attempts at creating a 3D image revolved around the use of spectacles with two lenses having different colours or polarisations. The two images can then be displayed together on the screen, leaving the spectacles to filter out the right and left images.

These systems have been used on a number of occasions. Recently the BBC transmitted a few programmes using this method. The spectacles were sold in the shops with the proceeds going to charity.

Obviously, systems like these lack the full reality of a true 3D system, and this is why they are not widely used. However, many developments are taking place with the ultimate aim of being able to display proper images.

Head Start

The main idea behind systems for creating a stereo image is to be able to send two slightly different images to each eye. There are naturally a number of different ways of achieving this. One method which is starting to appear in a number of forms is to generate two images and ensure that one reaches the left eye and the other reaches the right one.

To ensure this happens, a knowledge of the position of the viewer is needed. In one system developed by the University of Dresden, this is aptly called a "head finder".

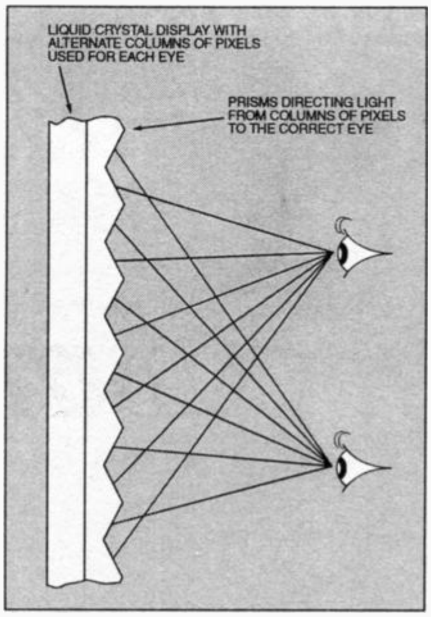


Fig. 1. Prisms used to direct the correct image to each eye.

The equipment consists of a camera from which the information is image processed to give a knowledge of the angle and hence the position of the head. The two viewing fields are then adjusted to give the correct images for the viewer to see the "stereoscopic" image. A very similar positioning system is also used in the second system developed by Sharp's Oxford research laboratories.

Two Views

The major areas of development are in generating the two images together. The two images required for the Dresden system are created on one liquid crystal display (l.c.d.). Odd columns of pixels display the image for the left eye and the even columns give the right eye picture.

The crucial part of the system lies in the collimator. This consists of a series of prisms, each one allocated to a specific pixel column. These direct the light in the direction of the respective eye as shown in Fig. 1.

Production of the prism is the key to the success of the project. It is manufactured by coating a sheet of glass with an ultraviolet sensitive varnish. A master prism is used to imprint the correct shape into the varnish which is then hardened and the master prism removed.

The Sharp system uses two l.c.d. panels placed at right angles to one another as shown in Fig. 2. A half silvered mirror placed at an angle of 45 degrees between acts as a combiner.

Positioning of the image so that it is seen by the correct eye is undertaken by placing a specialised light source behind the liquid crystal display. By controlling the effective position of this the light is directed towards the correct eye and away from the other

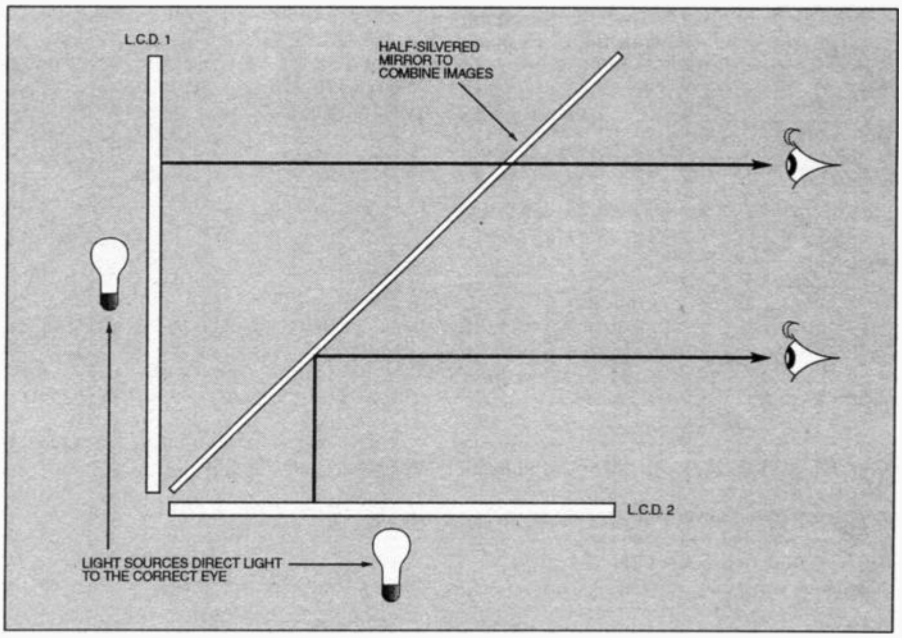


Fig. 2. Two images combined to give a 3D display.

one. In this way only one image is seen by each eye.

One of the advantages of the Dresden system is that the whole display is anticipated to be only about 60 per cent more expensive than an existing one. The l.c.d. uses existing technology, and the prism can be manufactured relatively cheaply.

The display itself is still not finalised, requiring additional work on the head positioning and movement. However, it is sufficiently advanced for initial production.

In Reality

There are many uses for 3D display systems. Many CAD systems now cater for 3D images, being able to rotate them and give views of how different parts fit together.

The main problem is that these images are usually displayed on a standard two dimensional cathode ray display. If these images could be displayed three dimensionally it would enable the designer to use the system more effectively.

Apart from CAD applications there are many other areas where a 3D display would be an advantage. Video games is one of the first areas which springs to mind. Here there is a vast market which would be very keen to employ a new technique to bring more reality to the games.

3D Surgeons

Another area where three dimensional displays may be very important is within remote control applications. In the press, the idea of surgeons performing operations over a remote link with very specialised robot arms has been developed. Currently the arms have been built and in themselves they are a revolutionary development being capable of very fine movements and giving a sense of feel at the controlling end.

To be able to perform operations of this nature satisfactorily surgeons must have the most realistic feedback possible, making them feel that they are actually at the remote site performing the operation. Another way of improving this is to give a three dimensional display. This would give a more realistic impression of depth, enabling the operation to be carried out more successfully.

Whilst this may seem a far fetched idea today, it may be a life saving technique, enabling the top surgeons to perform operations all over the world without having to spend valuable time in travelling.

It has also been suggested that it would be very valuable in war scenarios. The remote operating theatre could be set up in the war zone so that the wounded could be brought in quickly and easily. The surgeon with the relevant experience and located in a safe area could then be used for the operation.

With the computer and electronics world progressing towards making more life-like representations of visual images it is certain that at least some of the ideas for three dimensional displays will be taken up. Those which have little cost increase over the two dimensional ones are likely to have an excellent chance of being widely used, even if there are a number of limitations.

Ohm Sweet Ohm

Max Fidling

Mog-nificent

I just knew it was going to be one of those days! I could tell when I accidentally kicked the bowl of cat food all over the kitchen floor, thereby incurring a filthy look from the Boss, not to mention the usual quizzical look from my beloved moggie, Piddles.

From experience, I knew when it was time to beat a hasty retreat to the workshop, so I ambled into my shack in the back garden, to leave the Boss clearing up a tin-full of Whiskas, ably assisted by the cat who tackled the Max-induced spillage with gusto!

On the bench was a copy of a recent electronics magazine and I'd decided to whittle away my time by having a bash at building one of the featured projects. My latest brainchild was gradually emerging on the bench – a small battery-operated thermostatic alarm which I was in the process of adapting to warn of low temperatures in the attic.

Frigid Fidlings

You see, in the recent wintry weather, the Fidling household had had more than its fair share of domestic disasters as we bravely huddled together inside, trying not to succumb to the icy fingers of the Arctic weather which had reached across from Siberia and were gradually getting a stranglehold grip on the British Isles (as it said on the telly). The frozen weather had resulted in a burst pipe in the attic, and water had started to trickle through, of all places, an upstairs light switch!

Now, to have the Niagara Falls dribbling through a 230V wall switch is not the happiest way to enjoy life intact, and yours truly, intrepid as ever and fearing nothing, had received his orders to investigate the cause of this unexpected deluge. I switched off all the electrical supplies at the fusebox, thereby blanking out the lights not to mention the telly, which the Boss had been watching avidly at the time.

Chill Out

Fumbling around in the garage, I eventually stumbled across my Woolworth's plastic torch which I always kept for such emergencies. The lantern flickered into life. Back inside, I gingerly clambered up a teetering step-ladder and into the attic, rather in the manner that a certain moggie stalked meeces in the garden.

The plumbing in the attic still bore the signs of my earlier attempts to repair it. The overflow had previously leaked and this had done interesting things to the ceiling, such as creating rusty brown stains in the white emulsion. Furthermore, on at least one occasion I'd managed to stick my foot right through the plasterboard and hence I'd had to re-decorate the whole lot!

So this time, I trod very cautiously, like a sapper in a minefield. I soon spotted the cause of the burst pipe: amongst all the fleecy if rather horrid loft insulation, I could see a thin trickle of water stemming from a small split in a copper pipe. The pipe had obviously frozen solid during the recent icy snap and this had split the pipe. Only when the weather had perked up a little had the ice thawed and now water was winging its way ceiling-wards, much to our horror!

In fact, the water had been running along the ceiling until it found a piece of electrical conduit standing proudly upwards. Down into the conduit ran an electric light cable, and the conduit terminated in . . . a light switch! So the escaping water had managed to navigate around the attic and was trickling down the conduit and downstairs through a switch below!

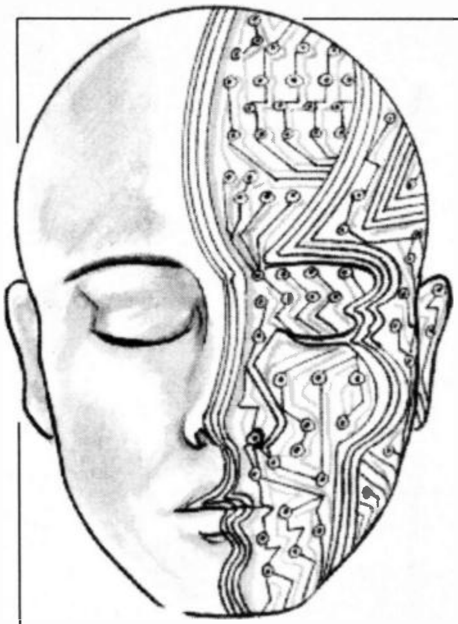
Bog-standard Bodging

Not being one to spend money unnecessarily, I was determined to impress the Boss with my D.I.Y. skills once more! Who needs plumbers anyway?

There was only one thing for it – I scampered back downstairs and out into the workshop. I stumbled upstairs again with my trusty toolbox plus a large bag of cat litter. I reckoned the cat litter would be useful for soaking up, erm, excess liquid spillage other than its intended application, so in the murky gloom I sprinkled handfuls of the stuff onto the pools of water on the attic floor, with a view to hoovering it up later. What a neat idea!

I had a large reel of gaffer tape which I started to wrap around the burst pipe, which by now had slowed to a drip. So a goodly-bodged repair should be OK until warmer weather allowed a more expert approach. It seemed to work a treat!

Then I suddenly realised: there was a good chance that the cat litter I'd been showering around the attic may actually be *used* litter, since the Boss had a habit of putting the old stuff into a big bag, and keeping it near the bin ready for disposal . . . Nobody knows to this day! (About the gaffer tape, I mean, what else?)



INGENUITY UNLIMITED

Our regular round-up of readers' own circuits. We pay between £10-£50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit tips, not simply mechanical or electrical ideas. Ideas *must be the reader's own work* and **not have been submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should preferably be typed or word-processed, with a brief circuit description showing all relevant component values. Please draw all circuit schematics as clearly as possible.

Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. They could earn you some real cash!

Rain sensor – banish washday blues!

ORIGINALLY designed to generate a warning sound when it started raining, Fig. 1 shows a simple Rain Sensor design which incorporates pitch and volume controls in the alarm signal. Whenever the sensor is bridged by droplets of water, the Darlington transistor TR1/TR2 will conduct.

This enables IC1, a 555 astable tone generator, to function, powering a small loudspeaker through a driver transistor TR3. VR2 determines the pitch of the audio tone which can be anything from about 25Hz to 18kHz, whilst VR3 adjusts the volume.

The sensitivity of the circuit is set by VR1. The Darlington pair could be constructed with two separate ZTX300s or a single TIP122. For the sensor itself, I used a small piece of stripboard, linking alternate strips into an interlocking design. The circuit will operate from a standard 9V PP3-type battery.

M.R.L. Chapman,
Rogate, Hampshire.

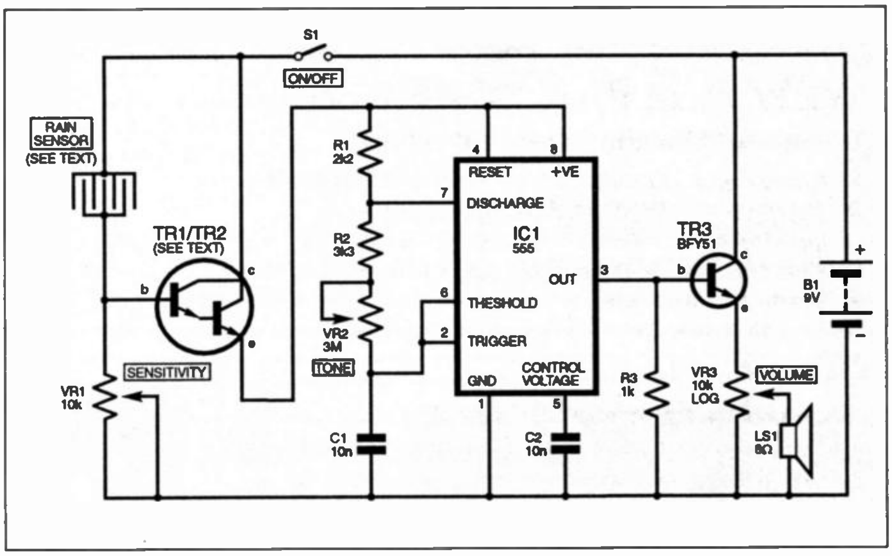


Fig. 1. Circuit diagram for a simple Rain Sensor.

High Gain Transistor Amplifier – turn it up

THE high gain inverting amplifier stage illustrated in Fig. 2 was developed for use as part of a tone control circuit. The stage was designed to operate with a rail of between 3V to 30V. It includes a bootstrap network (R1, C2) which serves to increase the gain of the stage to approximately 3,000 as well as offering a low distortion output waveform at maximum amplitudes.

The input impedance is approximately 80 kilohms at 200Hz., the output level is 80% at 20kHz and noise at the output is 14mV peak-to-peak. R5 and D1 were included to proportionately lower the bias to TR1 to compensate for any increases in the rail voltage; R5 may be omitted and D1 shorted out if the rail is constant.

With a supply rail of 30V the author found that the best quality of output was obtained with the d.c. output level set to 16·5V, which gave a maximum output swing of 24V peak-to-peak. VR1 is adjusted to give symmetrical clipping of the maximum output signal.

M. Richardson,
New Malden, Surrey.

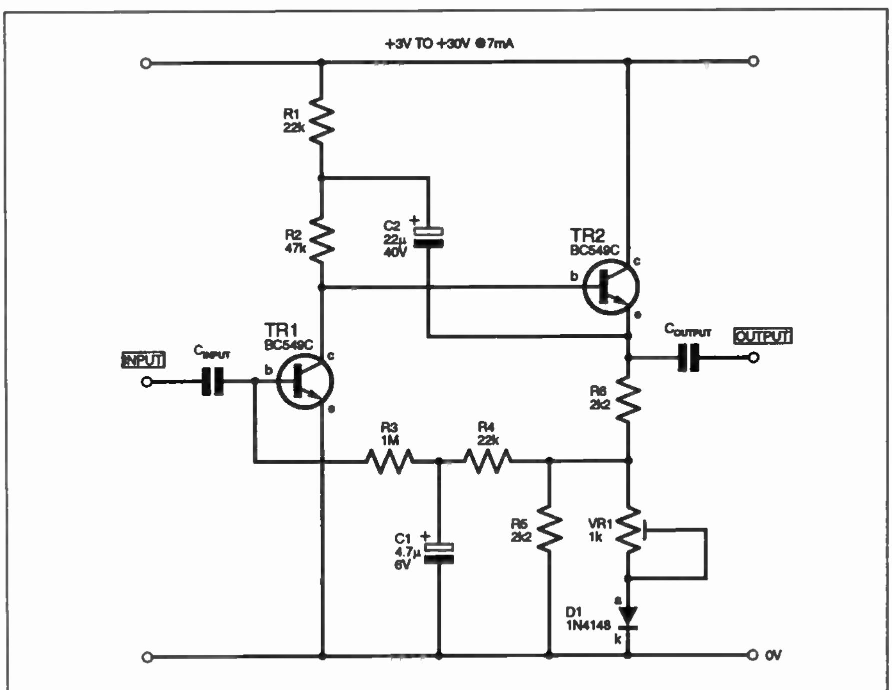


Fig. 2. Circuit diagram for a high gain transistor amplifier stage.

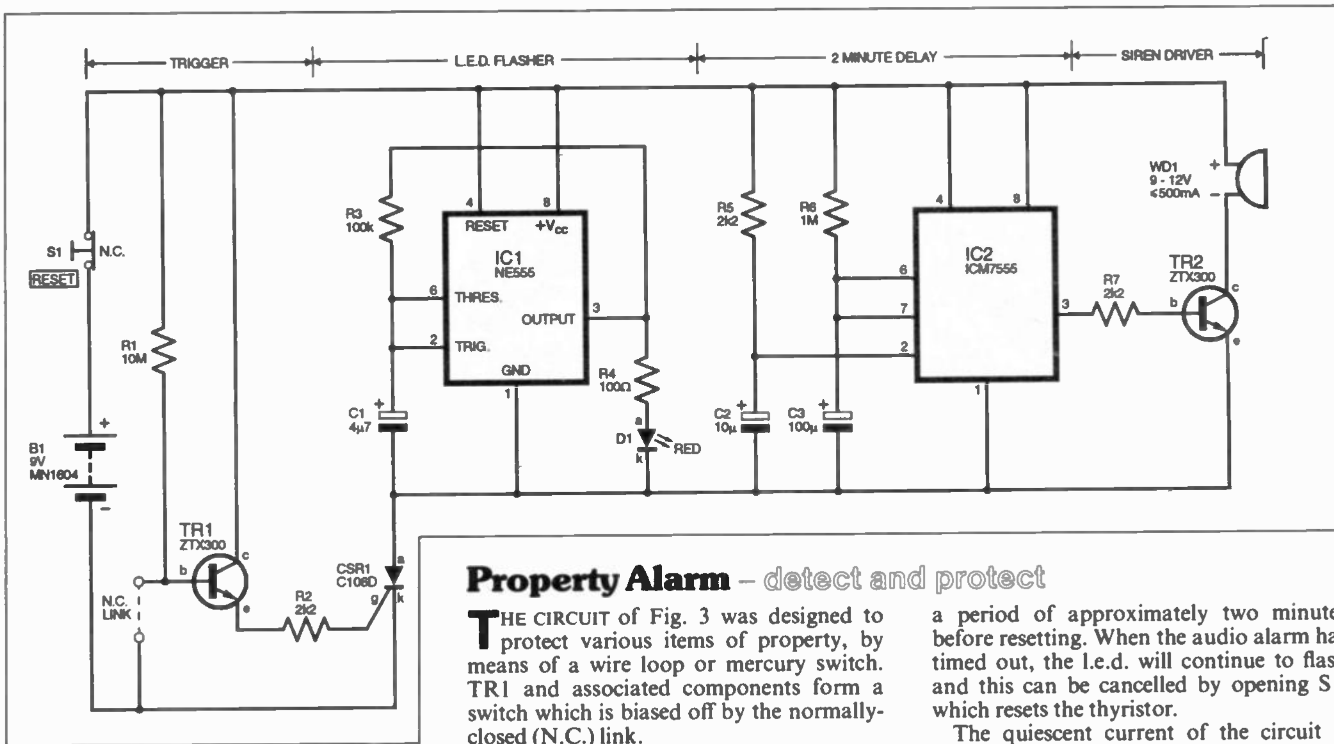


Fig. 3. Circuit diagram for a Property Alarm.

Property Alarm – detect and protect

THE CIRCUIT of Fig. 3 was designed to protect various items of property, by means of a wire loop or mercury switch. TR1 and associated components form a switch which is biased off by the normally-closed (N.C.) link.

When the link is broken, TR1 conducts and triggers the thyristor CSR1 into conduction. Consequently, the l.e.d. flasher centred around the 555 astable of IC1, causes D1 to blink.

Additionally, IC2 is a monostable timer which triggers through R5/C2 and drives an audible warning device via TR2 for a period of approximately two minutes before resetting. When the audio alarm has timed out, the l.e.d. will continue to flash and this can be cancelled by opening S1, which resets the thyristor.

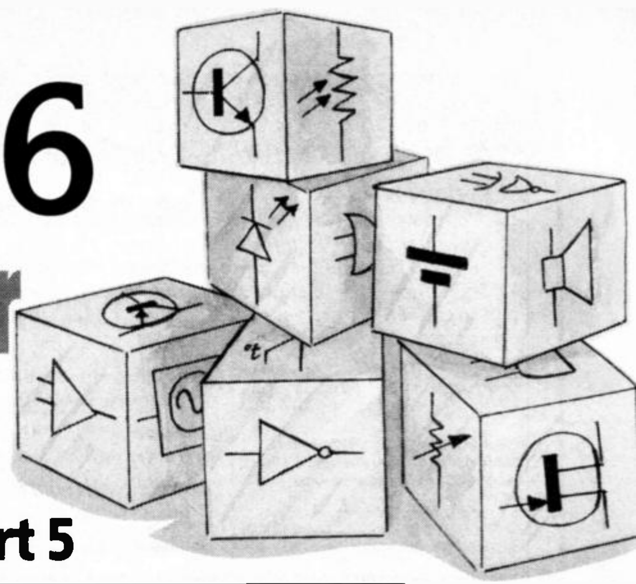
The quiescent current of the circuit is very low due to the high value of resistor R1. A mercury switch can be used in place of the wire link to act as an anti-tamper alarm, in which case care must be taken to avoid accidental contact with the mercury bead itself since it is highly toxic.

S.M. Spencer, Sleaford, Lincs.

NEXT MONTH CIRCUIT SURGERY

TEACH-IN '96

A Guide to Modular Circuit Design



Max Horsey **Part 5**

DURING this series of articles, a range of circuit modules is examined, divided into Input, Processor and Output sections. Where possible a choice of module is offered within each section.

Each of the ten Parts of the Series is accompanied by a constructional article explaining how a complete project may be devised by employing the modules described, together with a p.c.b. design. Each project will be one of many possible ideas that could be implemented and it is hoped that readers will design for themselves a variety of circuits by combining modules provided in the whole series.

The proposed range of modules covered by the Series is detailed in Part 1, Table 1.1. Each module is chosen to link easily with adjacent modules in the same Part, but modules may also be linked with modules in other Parts of the Series.

Max Horsey is Head of Electronics at Radley College.

THIS fifth Part of the *Teach-In* series continues with a look at more Input, Processor and Output modules, with a particular view towards an infra-red (IR) control system suitable for driving any output circuit in the series.

The following modules are discussed:

INPUT MODULE: IR receiver and preamplifier

PROCESSOR MODULES: Encoder/decoder, D-type bistable, T-type bistable, J-K bistable

OUTPUT MODULE: IR transmitter with high power pulsed Darlington output

One way in which the modules can be connected together to form an on/off remote control system is described in the accompanying project elsewhere in these pages, the *Infra-Zapper* – a device to test your "targeting" skill!

(Another use of similar modules is illustrated in the author's *Infra-Red Remote Control Unit* which controls his *Automatic Curtain Winder* project. These were published in *EPE* August and July '95 issues, respectively. The August '95 IR unit uses the same remote control encoder/decoder described here, together with T-type bistables.)

POWER SUPPLY

Some of the integrated circuits (i.c.s) in this part have rather awkward power supply requirements! The encoder/decoder i.c. (UM3750) can operate on 3V up to a maximum of 11V. The CMOS i.c.s used as bistables will work on 3V to 15V. However, the IR preamplifier i.c. (TBA2800) has a maximum working voltage of 5·5V. Consequently, to suit this i.c., *a 5V (or 4·5V) supply must be used with all the modules in this Part.*

IR RECEIVER AND AMPLIFIER

Several devices capable of responding to an infra-red signal are available, although discussing alternatives is beyond the scope of this article. Many electronic components catalogues, though, contain a range of substitutes and should be consulted if alternatives to the suggested combination of the IR photodiode sensor TIL100 and preamplifier TBA2800 are required.

Output signals available from IR photodiodes are very small, and may contain unwanted interference from other sources, such as lamps and daylight etc. The preamplifier must be carefully designed to reject this interference, yet still provide a large amount of signal gain.

The TBA2800 is specifically designed for infra-red work and achieves these requirements by means of three stages of amplification and includes automatic gain control. It is a complex device in a small, low-cost package.

The full circuit diagram of the IR Input Module is shown in Fig. 5.1. At first glance, the circuit appears complicated, but in fact

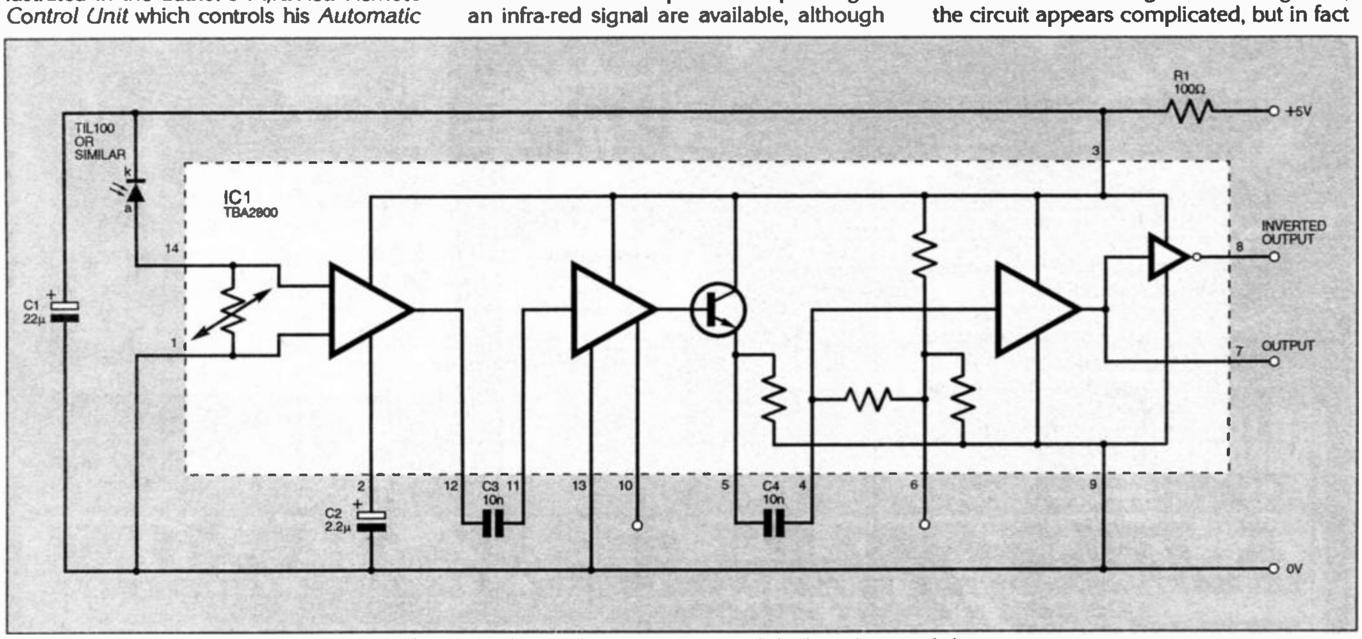


Fig. 5.1. Circuit diagram of the Infra-Red Input Module, based around the TBA 2800 i.c.

there are only six components needed in addition to the i.c., whose manufacturer has done the rest! The dotted box indicates the internal circuitry of the TBA2800 in block diagram form. The pin numbers of the i.c. are shown around the dotted box.

Two outputs are provided, a "normal" output from pin 7 and an inverted output from pin 8. The values of the capacitors have been chosen in relation to the signal being processed, as discussed later. Some experimentation may be necessary if other signals are required.

Resistor R1 provides a degree of isolation for the i.c. The effect of R1 together with capacitor C1 is to provide a very smooth electrical supply for the circuit, even if the voltage fluctuates elsewhere. All the spare connections should be left unconnected. Note that when connecting this module to the decoder described later, the inverting output (pin 8) should be used.

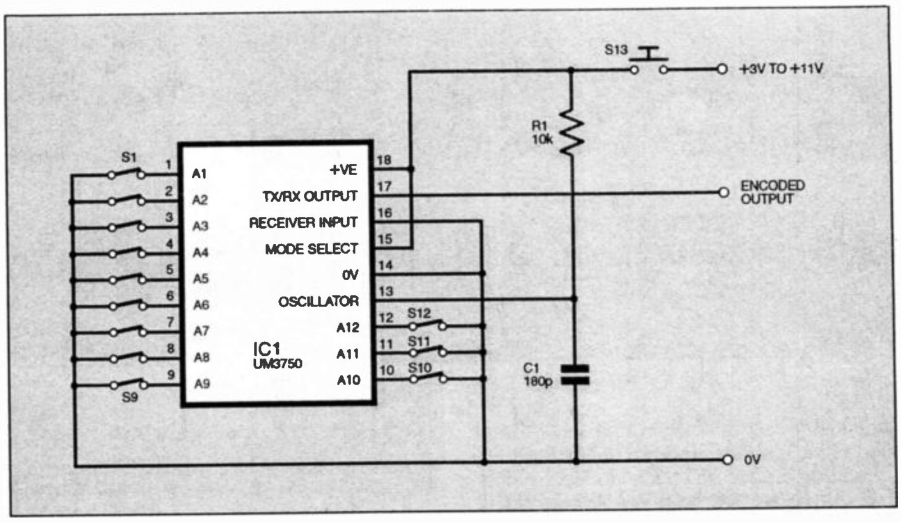


Fig. 5.2. Circuit diagram for the encoder module.

TESTING THE CIRCUIT

In the author's experience, testing infra-red control circuits is one of the more frustrating areas of electronics, but the following may be helpful, providing an oscilloscope is available. (In the absence of an oscilloscope, testing is best left until the IR Transmitter has been constructed.)

1. Borrow an infra-red remote control unit from a TV or video recorder
2. Connect the oscilloscope ground to 0V in the circuit
3. Connect the oscilloscope probe to the leg of the IR photodiode which is connected to pin 14 of the i.c.
4. Aim the remote control unit at the flat side of the photodiode and press any key – a signal should appear on the oscilloscope screen
5. If not, check that the IR photodiode is connected the correct way round (see Fig. 1.14 in Part 1)
6. An amplified signal should be present on pins 12 and 5 of the i.c.
7. Finally, a much amplified signal should be present at the output pin 7, and an inverted version at output pin 8.

ENCODING AND DECODING

The TBA2800 IR receiver/amplifier provides an output signal when any IR transmission is detected. However, most people have at least one, and in many cases several, remote control units. Encoding/decoding is necessary in order to differentiate between them. This has the additional advantage that a circuit can be programmed to "look" for a particular signal even though it may be much weaker than other IR sources, such as daylight.

Several dedicated encoders and decoders are available for IR control systems. Here an i.c. has been chosen which does both jobs, the UM3750.

The UM3750 encoding/decoding i.c. can be used with many types of control system, including infra-red, visible light, radio or ultrasonic. It is designed to send a particular code depending upon which of 12 input pins are connected to 0V or left open circuit. This provides a total of 4096 possible combinations.

A second UM3750 i.c. can be set to the same combination and will only provide an output when it receives precisely the same code.

Note that the system is designed for a single transmitted signal. For example, to open a garage door or close a pair of curtains. It could be adapted for a multi-channel system, such as the type used to control a video recorder, but other specialised i.c.s are available for this purpose.

Whatever type of transmission control system the pair of circuits might be used with, it is important to ensure that the exact shape of the coded signal remains intact.

ENCODING CIRCUIT

One method by which encoding can be accomplished is shown in Fig. 5.2

Switches S1 to S12 can be toggle switches, p.c.b. mounting d.i.l. (dual-in-line) switches, or simply wire links, inserted or not inserted to make up a particular code. Switch S13 must be pressed to transmit the encoded signal.

When experimenting, all i.c. pins 1 to 12 can be left open circuit (i.e. not connected). The only reason for connecting some to 0V is to ensure that another remote control unit (with the same circuit) will not operate your device accidentally..

The combination of resistor R1 and capacitor C1 sets the frequency of the coded signal. Depending upon the control and transmission system used, R1 and/or C1 may need to be changed in value. It is essential to make identical changes in the decoder circuit.

DECODER

The decoder circuit is very similar to the encoder, and is shown in Fig. 5.3.

For testing purposes, the encoded output (Fig. 5.2) can be connected to the encoded input (Fig. 5.3). The output from Fig. 5.3 is normally high (positive). When the correct code is received, it goes low for a short time (about 0·1s). In fact, the i.c. waits until it has received four valid codes in quick succession to ensure against false triggering.

The output is capable of sinking 2mA when low (active). Although this *could* be used via a transistor circuit to operate an l.e.d., the short time for which the output is pulsed low suggests the need for a monostable to extend the pulse length (described in Part 2, Fig. 2.8 and Fig. 2.9), or a simple latching circuit (Part 3, Fig. 3.8, Fig. 3.10 and Fig. 3.11).

A monostable allows a short input pulse to trigger an output pulse of any preset duration required. A latching circuit enables a short input pulse to be used to indefinitely switch on an output device.

Obviously, in a practical situation, the latch must have a means of being unlatched (reset) when required and some more complex latches or bistables are described shortly. These latch when the first pulse is received, then unlatch at the second pulse, etc.

BISTABLES (FLIP-FLOPS)

In Part 3, a bistable made from a pair of NOR gates was examined (Fig. 3.11) and its use as a latch discussed. A bistable (which is also commonly known as a *flip-flop*) is a circuit configuration which has

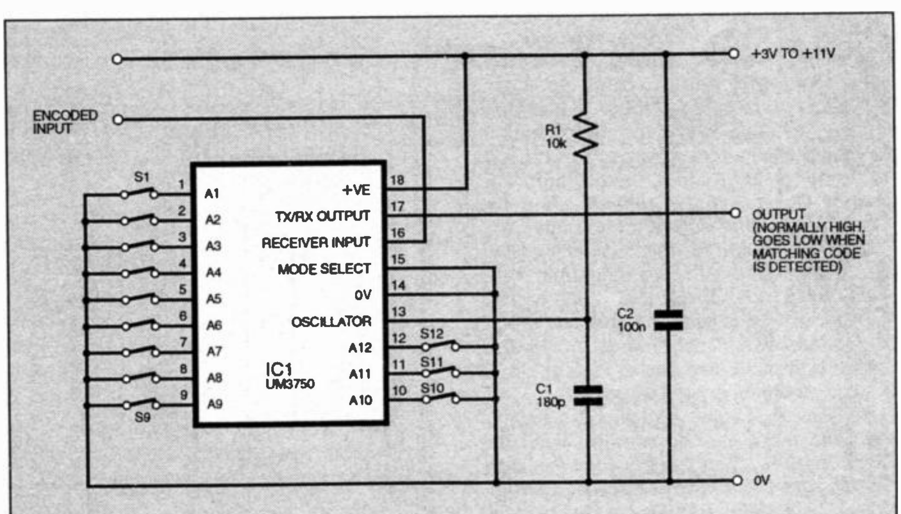


Fig. 5.3. Circuit diagram for the decoder module.

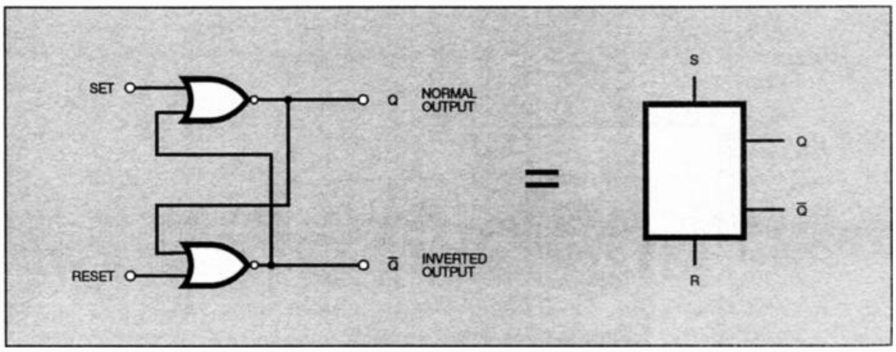


Fig. 5.4. Simple representation of a bistable (flip-flop).

two stable states. One circuit representation of the concept is shown in Fig. 5.4

Assume that in an initial situation, inputs Set and Reset are held low. When Set is made high (positive) for a moment, output Q latches high, and $\overline{Q}$ (pronounced *NOT* Q) latches low. When Reset is made high for a moment, output Q latches low, and $\overline{Q}$ high.

The D-type bistable (D for Data) uses two extra connections, the Clock and Data inputs, as shown in Fig. 5.5.

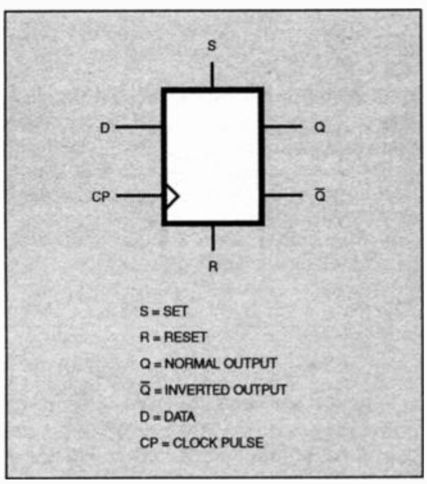


Fig. 5.5. D-type bistable symbol.

The pin labelled *D* is the Data input. The pin labelled *CP* (or *CK*) is the Clock input. The state of the Data input is ignored by the bistable unless the Clock input is switched from low to high.

To help understand this, only output Q will be considered, since $\overline{Q}$ will always be the opposite.

First, assume that output Q is low (0V) and that the Clock input CP is also low.

If the Data input is switched up or down between 0V and positive, the outputs will not change their logic state. If the Data input is held high, and at the same time the Clock input is switched from low to high, Q will copy the Data input, i.e. go high. The change occurs *at the instant* when the Clock input switches from low to high.

If the Data input is switched back to low, the outputs will not change their logic state, even though the Clock input is still high. If the Clock input is now switched low again, the outputs will still not change. However, if the Clock input is switched to high again, Q will copy the data input and go low.

To sum up, Q always copies the state of the Data input at the moment when the Clock input is changed from low to high. This operation is known as *edge-triggering*.

The Set and Reset inputs can still be used as before and control the bistable independently of the Data and Clock inputs.

PRACTICAL NOTE

When using a D-type bistable, such as the CMOS 4013B, note that the positive supply is connected to pin 14, and the 0V supply to pin 7. All inputs must be connected in some way, i.e. not left open circuit. Spare unused inputs can be connected directly to either power line, 0V or +VE, as most convenient.

For example, the CMOS i.c. type 4013B contains a pair of D-type bistables. If only one of them is needed, then all the inputs of the other bistable can be connected to 0V. *Spare outputs should be left unconnected.*

ADDING SWITCHES

The circuit shown in Fig. 5.6 indicates how the D-type bistable may be tested using push-to-make switches. Note the use of tie-down resistors which hold the inputs at 0V unless a switch is pressed, at which time they are forced positive. This type of switching and biasing arrangement has been shown in earlier parts of the Series.

In practice, designers would rarely wish to connect the Clock and Data input in this way, but it is a useful technique for controlling the Set and Reset inputs, and an ideal way of experimenting.

A voltmeter may be used to monitor the state of, say, output Q. Alternatively, an l.e.d. with a series resistor of about 330Ω may be connected between the output and 0V. The l.e.d. will tend to pull down the logic level at the output. This will not cause damage, but do not expect the output to also drive another input at the same time. (The series resistance required with l.e.d.s is discussed at the end of Part 4.)

The applications of the D-type bistable

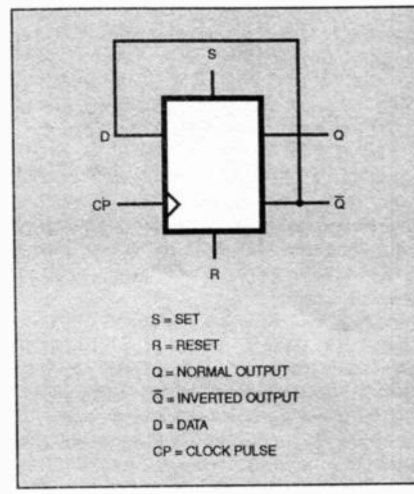


Fig. 5.7. Using a D-type bistable as a T-type.

may not be obvious, but it forms the heart of virtually all counting and computing circuits and, above all, is easily made into a T-type bistable – a very useful device!

T-TYPE BISTABLE

The T-type (T for Toggle) bistable produces the same action as a push on/push off switch, the type fitted to many TVs, etc. The first push latches the switch, the second push unlatches it. The T-type bistable does this electronically and can easily be made from a D-type bistable, as shown in Fig. 5.7.

Notice that the inverted output $\overline{Q}$ is connected to the Data input. This simple connection makes output Q change state every time the Clock input is switched from 0V to positive. This is how it works:

Begin by assuming that output Q is low, and therefore output $\overline{Q}$ is high.

Imagine that the Clock input is switched from low to high. Since the Data input is high (remember $\overline{Q}$ is high), this will be copied to Q, making Q high and $\overline{Q}$ low. Even though the Clock input may remain high, the outputs will be stable in this new state since data is only copied to Q at the moment when the Clock input changes from low to high.

Output $\overline{Q}$ will now be low, making the Data input low. If the Clock input is made low, nothing happens. However, when the Clock input becomes high again, the Data input is copied to Q making Q low, and therefore $\overline{Q}$ high.

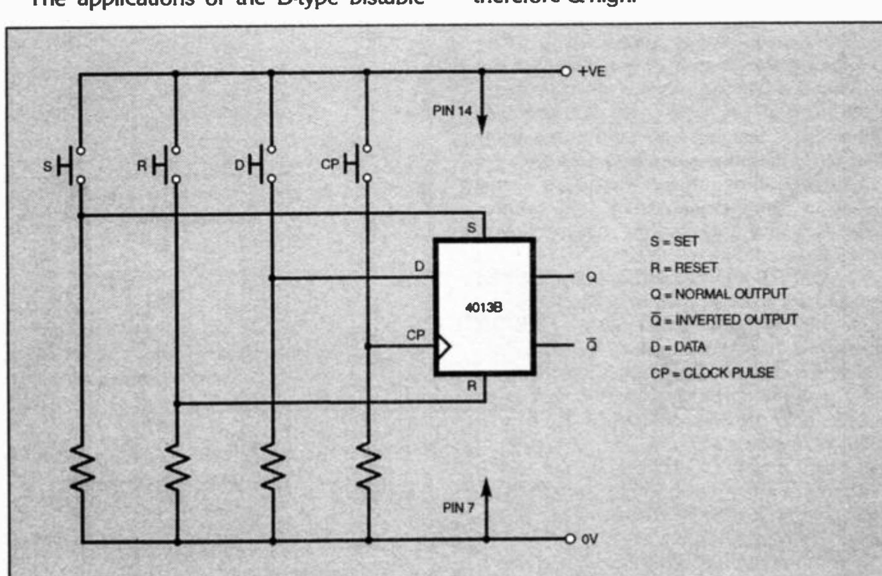


Fig. 5.6. Circuit diagram showing how a D-type bistable can be tested.

To sum up the operation of the T-type bistable:

First clock pulse causes Q to switch to high
Second clock pulse causes Q to switch to low
Third clock pulse causes Q to switch to high . . . etc.

Notice that Q switches between low and high at half the rate of the clock pulse. For this reason the circuit is sometimes called a frequency divider.

The two waveforms shown in Fig. 5.8 illustrate the relationship between the Clock input and the Q output. The clock pulse may or may not have an equal mark/space ratio, but the output from Q will *always* have an equal mark/space ratio when the clock pulse has a stable frequency.

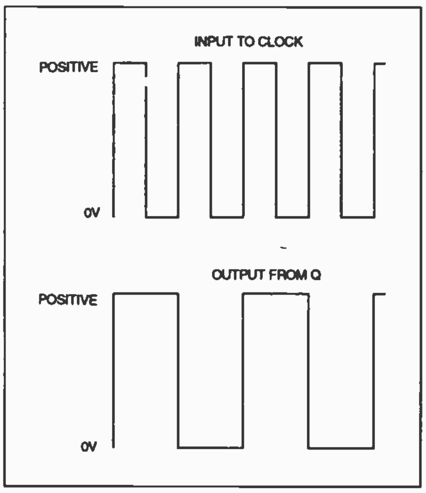


Fig. 5.8. Waveforms illustrating relationship between T-type input and output.

This toggle action is very useful. It could, for example, be used in conjunction with a simple remote control system, where the first press of the transmitter turns on a light, and the second press turns it off.

The modules can be cascaded (several modules connected one after the other) and used as a frequency divider, since each stage divides by two. The counting/timing projects in Parts 6 and 7 of this series use this principle. The way that T-type bistables can be cascaded is shown in Fig. 5.9. Used like this, they can form the heart of a binary counter.

Three T-type bistables are shown, although any number can be connected in the same way. Notice that the $\overline{Q}$ output from each module is connected both to the Data input of the same module and the Clock input of the next. If an l.e.d. is connected between each Q output and 0V (via a suitable resistor), the behaviour of the system can be observed. The Set and Reset functions can still be used as before.

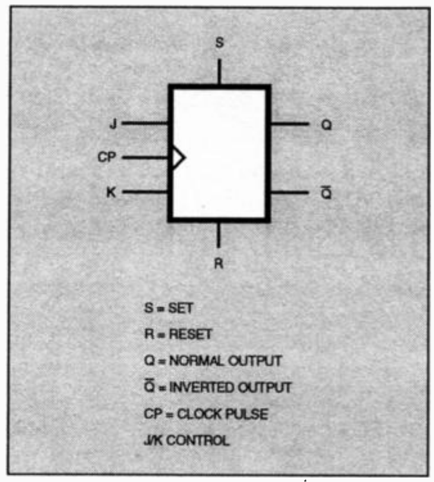


Fig. 5.10. J-K bistable symbol.

As discussed above, note that the inputs *must not* be left floating. Either connect them to 0V directly, or via resistors as shown in Fig. 5.6 if switches are required for setting or resetting.

J-K BISTABLE

A J-K bistable is an even more flexible bistable, and is arranged as shown in Fig. 5.10.

The Set and Reset inputs work in the same way as with the D-type bistable, in other words they are independent and override the J, K and Clock inputs.

The J and K inputs also control the state of the outputs, but only at the moment when the Clock input changes from low to high (0V to positive):

INPUT	INPUT	OUTPUT
J	K	Q
Low	Low	no change
High	Low	switches to high
Low	High	switches to low
High	High	changes state at each clock pulse

In other words the bistable behaves as a T-type if both J and K are held at logic 1 (i.e. positive).

The J-K bistable provides greater flexibility than the standard D-type, but it may be a few pence more expensive, and has more pins.

A typical i.c. example of a dual J-K bistable is the CMOS 4027B, which is housed in a 16-pin d.i.l. package.

LOGIC CONTROL

It is sometimes necessary to perform a sequence of events which move step by step with a clock pulse. Take, for example, the circuit in Fig. 5.11. This uses two D-type bistables and two NOR gates to control a sequence of three events, Open, Close and Stop.

The sequence can be controlled by a signal connected to the Clock input. The signal could be derived from another circuit, or a pushbutton switch could be used to create a single clock pulse whenever it is pressed.

At the start of the cycle, Stop is high, and Open and Close are low. When the switch is pressed, Stop goes low and Open goes high. At the next switch press, Open goes low and Stop goes high. At the next press, Stop goes low and Close goes high. The next press of the switch returns the module to its starting point.

To sum up, the sequence controlled by the circuit in Fig. 5.11 is:

Stop – Open – Stop – Close – Stop

This repeatable sequence is very useful for remote controlling mechanisms such as garage doors or curtains, etc.

To understand the working of the circuit, first recall the logic of a NOR gate truth table, in which High = 1 and Low = 0, as follows:

INPUT A	INPUT B	OUTPUT
0	0	1
0	1	0
1	0	0
1	1	0

Relating this table to IC2a, pin 8 is Input A, pin 9 is Input B and pin 10 is the output. With IC2b, the equivalent pins are 12, 13 and 11, respectively.

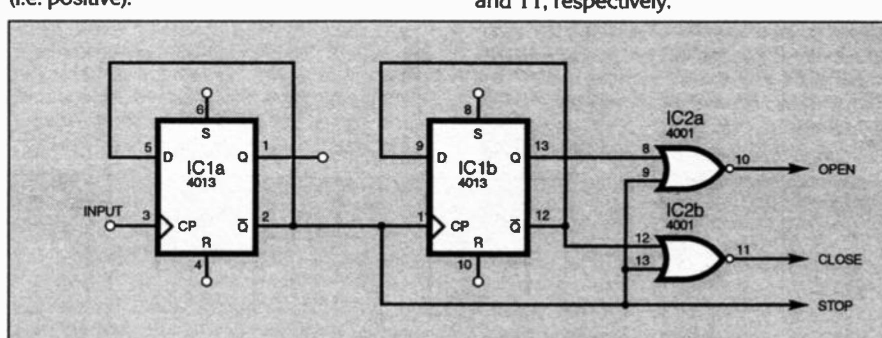


Fig. 5.11. Circuit for controlling a 3-event sequence.

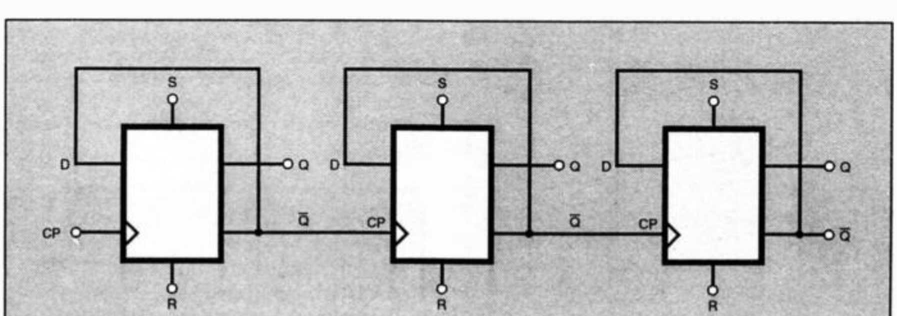


Fig. 5.9. Cascading T-type bistables.

In Fig. 5.11, clock pulses are fed to IC1a pin 3. Output pin 1 (Q) is not connected but is shown for reference. Output pin 2 ($\overline{Q}$) is used as the clock source for the next bistable and provides the input logic level to Inputs B of both NOR gates IC2a and IC2b. Thus:

Output at IC2a pin 10 =
IC1a pin 2 NORed with IC1b pin 13

Output at IC2b pin 11 =
IC1a pin 2 NORed with IC1b pin 12

The logical sequence is shown in Table 5.1.

Table 5.1. Logic table for Fig. 5.11.

CONDITION	IC1	IC1	IC1	IC1	IC2	IC2	STATUS
	Pin 1	Pin 2	Pin 13	Pin 12	Pin 10	Pin 11	
Fully reset	0	1	0	1	0	0	Stop
1st pulse	1	0	0	1	1	0	Open
2nd pulse	0	1	1	0	0	0	Stop
3rd pulse	1	0	1	0	0	1	Close
4th pulse	0	1	0	1	0	0	Stop

OUTPUT MODULE

The output module about to be described shows how an encoder may be linked to a Darlington transistor pair to make a remote control transmitter.

The method by which a signal can be encoded was shown in Fig. 5.2. What is now required is a way of boosting the output to a current capable of driving three infra-red l.e.d.s to full capacity.

In Part 1, a Darlington pair configuration which is capable of considerably boosting a small current was described (Fig. 1.13b). The Darlington principle is used at the heart of the output transmitter circuit shown in Fig. 5.12.

Within the dotted box, designated TR1, two transistors are shown representing the Darlington pair. In practice, this configuration may be either a single *npn* Darlington transistor, such as a TIP121 or TIP122, or may be comprised of two separate *npn* transistors, such as a BC184L (or similar) followed by a power transistor, such as a TIP41A.

The parallel value of resistors R2 to R4 (3·3 ohms) appears to allow a total of over 2A to flow. Clearly, neither the l.e.d.s nor a conveniently-sized battery would be able to tolerate this current, so the circuit contains an additional 100 ohm resistor, R5, which limits the total current to less than 100mA.

This extra resistance would reduce the possible transmission range and so the current is used to charge electrolytic capacitor C1. When switch S1 is pressed, a large current flows from the capacitor through the l.e.d.s for a short time. The pulse is too short to cause any damage, but provides the punch necessary to increase the range of the remote control system to several metres.

Of course, as discussed in Part 1, the transistors will not turn on without at least 1·4V applied to the Darlington base (b) via resistor R1. This voltage would normally be supplied in the form of a pulsed signal and in this case the module can be driven from the output of the encoder module described earlier.

Diode D4 prevents disaster to the circuit if the supply is accidentally reversed. Such action will cause the battery to short circuit through the diode and resistor. This is preferable to destroying the IR l.e.d.s and capacitor etc. A series diode could be used instead of the parallel diode shown, but its forward voltage drop may be unacceptable when every ounce of power is needed.

When setting up the infra-red l.e.d.s, try to point them in slightly different directions, so that the remote control unit is not too directional. If you are happy to point the unit *carefully* at the receiver, one or two infra-red l.e.d.(s) might be sufficient. It is also worth experimenting with high power IR l.e.d.s if available.

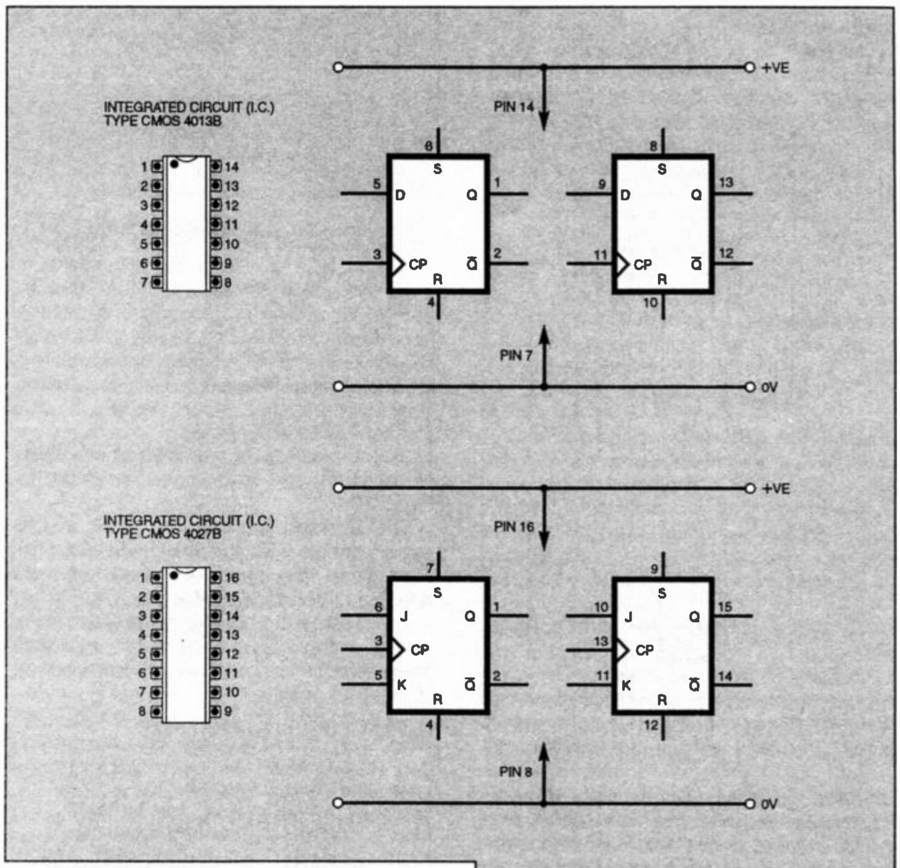
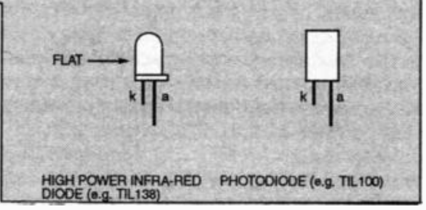


Fig. 5.13. Additional pin-out data.



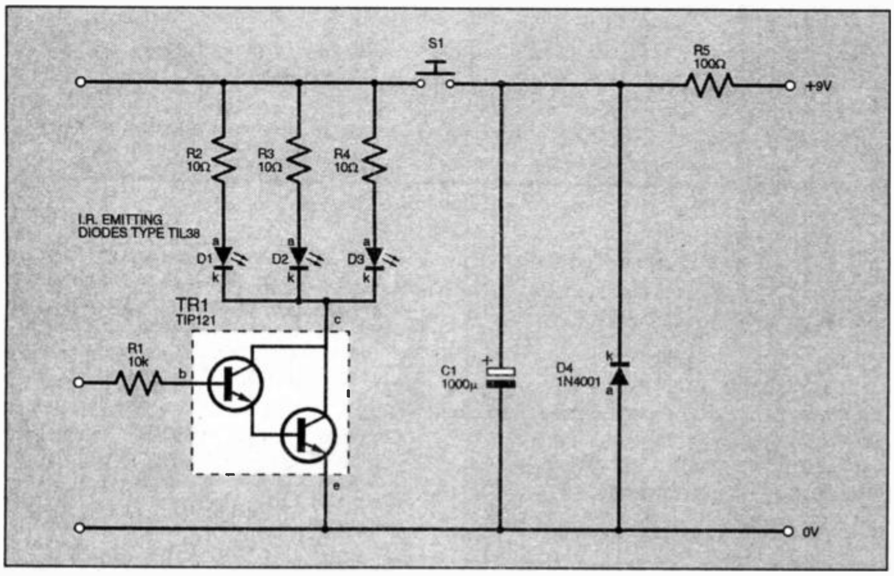


Fig. 5.12. Output transmitter circuit diagram.

PINOUT DATA

Pinout data for the semiconductors used in the *Teach-In* series so far is given in Part 1, Fig. 1.14, except for the CMOS 4013 and 4027 bistables, and the TIL138 and TIL100 diodes, whose pinouts are shown in Fig. 5.13.

PART SIX

The modules to be examined in *Teach-In* Part 6 are: switch debouncer, R/C monostable, more counters and a liquid crystal decoder/driver. The example project is an Event Counter.

EXAMPLE PROJECT

The Infra-Zapper unit is the example project (elsewhere in these pages) which shows how the modules in *Teach-In* Part 5 can be combined in a practical application.

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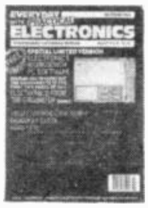

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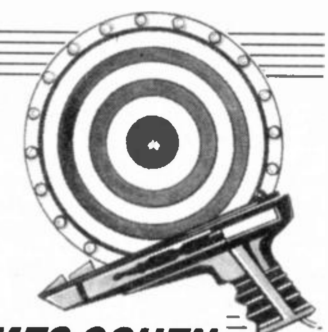


INFRA-ZAPPER

MAX HORSEY

PCB DESIGN BY JAMES COHEN

Improve your targeting aim and make light work of that flashy ring leader. Illustrates how Teach-In Part Five might be applied.

BASED on the information provided in *Teach-In* Part 5, this article shows how modules may be selected and combined to produce a working project.

The Infra-Zapper is designed for target practice! An infra-red "gun" is aimed at a target consisting of a circular set of lights which appear to rotate. There is hole in the centre of the circle behind which is a target detector activate by an infra-red (IR) light beam. When the target is hit, a buzzer sounds for a short time, and the rotating lights pause.

The system uses the infra-red modules from *Teach-In* Part 5, plus a transistor driver from Part 1, a monostable from Part 2, and an Astable and Decade Counter from Part 4.

An output is also provided which will link with the *Event Counter* module to be described in *Teach-In* Part 6. Apart from being a fun project in its own right, the Infra-Zapper also proves that a variety of modules from different areas of the Series really will work together!

TRANSMITTER BLOCK DIAGRAM

To begin with, take a look at the block diagram of the Transmitter, as shown in Fig. 1.

The Transmitter, which is constructed in the shape of a gun, has a pushswitch (the gun's trigger). When triggered, it switches on an encoder module, based on Part 5 Fig. 5.2.

The output from the encoder is amplified by means of a Darlington driver (as shown in Part 5 Fig. 5.12) before being delivered to a single infra-red transmitting l.e.d. Although the use of *several* l.e.d.s was described in Part 5, a single l.e.d. is suggested here in order to make the transmitter more directional; after all, the purpose is to test your ability to hit a target!

TRANSMITTER CIRCUIT

The full circuit diagram of the Transmitter is shown in Fig. 2. The encoding circuit is based on IC1, the UM3750. Switches S1 to S12 set the code required. In practice, one or two wire links can be used instead of switches since the code is unlikely to have to be changed. If wire links are omitted, it is the equivalent of switching off a particular switch (unused inputs to IC1 do not need to be connected to the positive power rail).

Resistor R1 and capacitor C1 set the frequency of the encoded signal, and C2 removes any spikes on the supply rails. The output from the encoder i.c. is via IC1 pin 17 and is fed through limiting resistor R2 into the base (b) of Darlington driver transistor TR1. The amplified signal controls the high power infra-red l.e.d. D2. Resistor R3 limits the current through the l.e.d. in conjunction with R4.

When switch S13 is pressed, the charge on capacitor C4 is delivered to the circuit to provide a surge of energy for a short time. This makes it more difficult to cheat by holding the trigger and sweeping the gun across the target. Some experimentation with the values of R4 and C4 may be necessary for the best effect in a particular situation.

Diode D1, with help from capacitor C3, ensures that a reasonable supply voltage exists across IC1 even though the voltage across C4 collapses immediately S13 is pressed.

A monostable (from Part 2) could have been used to provide a carefully measured pulse from the gun. However, the design in Fig. 2 was chosen for its simplicity and hence compactness.

RECEIVER BLOCK DIAGRAM

Referring to the Receiver block diagram in Fig. 3, the signal from the infra-red sensor is amplified in a circuit based on Part 5 Fig. 5.1. The signal is then decoded, before being used to trigger a monostable.

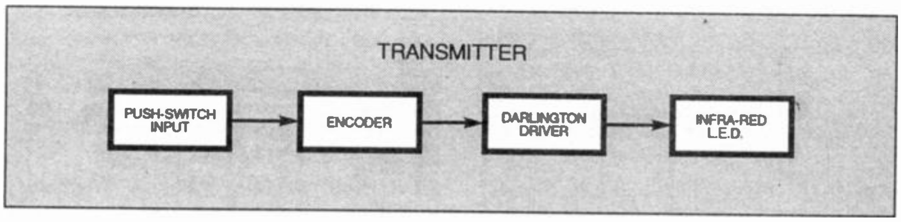
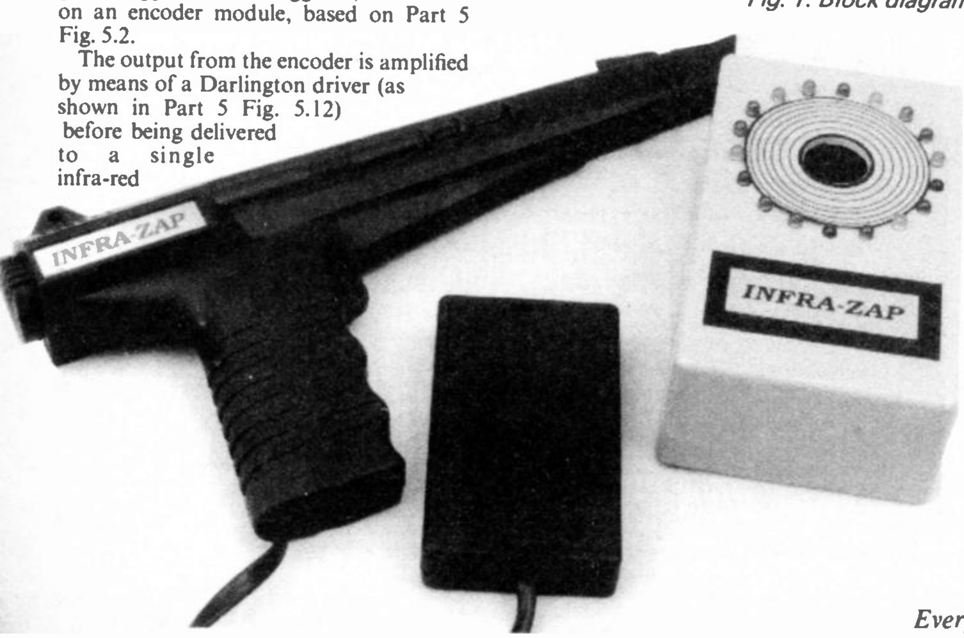


Fig. 1. Block diagram for the Transmitter.



The monostable in turn is used to trigger a buzzer to signal a successful "hit", and "jam" the astable which "freezes" the rotating l.e.d. display by inhibiting the astable. The astable normally oscillates when the monostable is untriggered and drives the chaser set of l.e.d.s.

RECEIVER CIRCUIT

The full circuit diagram of the receiver is shown in Fig. 4. The infra-red receiver and amplifier is a direct copy of Part 5 Fig. 5.1. The inverted output from IC1 pin 8 is fed to IC2 pin 16. This i.c. decodes the signal according to the settings of switches S1 to S12. Again, in practice, wire links may be used instead of the switches. If a wire link is inserted, it represents a closed switch. A wire link not inserted represents an open switch, as described for the Transmitter.

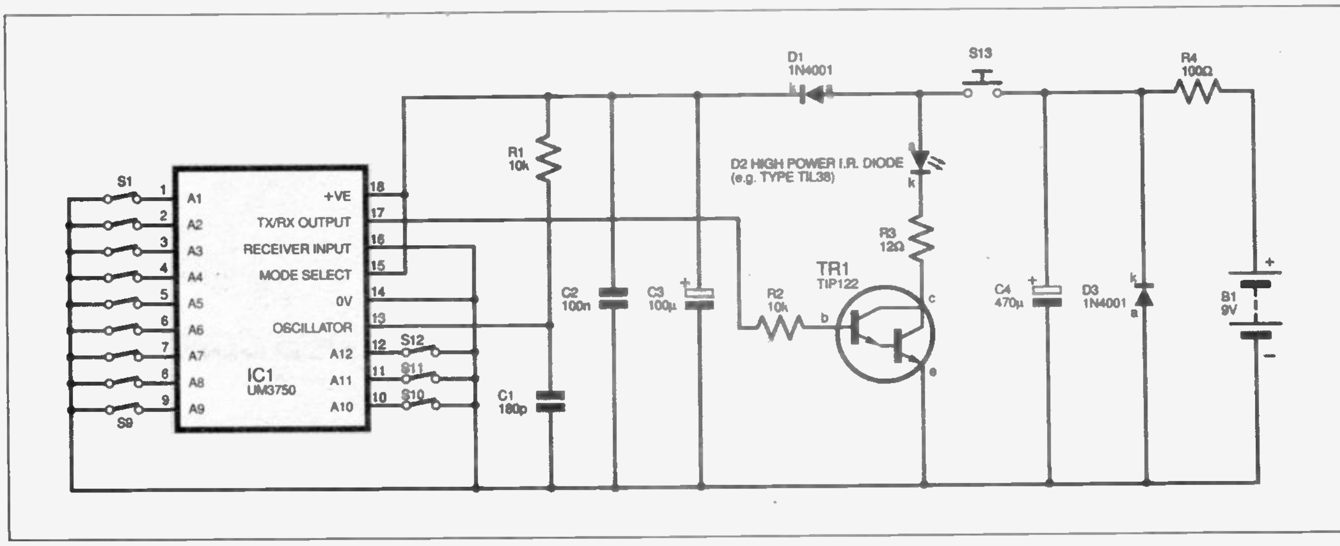


Fig. 2. Circuit diagram for the Transmitter module.

COMPONENTS

TRANSMITTER

Resistors

R1, R2	10k (2 off)
R3	12Ω
R4	100Ω

All 0·25W 5% carbon film or better

See SHOP TALK Page

Capacitors

C1	180p polystyrene
C2	100n ceramic disc
C3	100µ elect. axial, 16V
C4	470µ elec. axial, 16V

Semiconductors

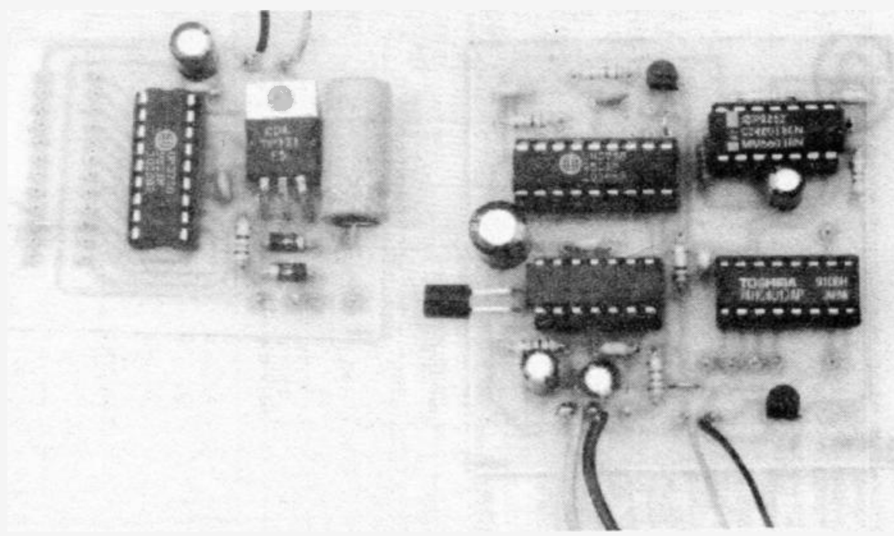
D1, D3	1N4001 rectifier diode (2 off)
D2	Infra-red l.e.d., high power (e.g. TIL38)
TR1	TIP121 or TIP122 *npn* Darlington transistor
IC1	UM3750 encoder/decoder

Miscellaneous

S1 to S12	see text
S13	push-to-make switch

Transmitter printed circuit board, available from *EPE PCB Service*, code 981 (see *Shop Talk*); plastic case 100mm x 60mm x 23mm, with belt clip (see text); gun-shaped case to suit taste (see text and *Shop Talk*); PP3 9V battery and clip; red plastic lens (see text); 18-pin d.i.l. socket; connecting wire; solder, etc.

Approx cost guidance only **£8** *excl. case and battery*



Assembled p.c.b.s for (left) Transmitter and (right) Receiver.

It is important to ensure that exactly the same pattern of wire links is used for the Transmitter and the Receiver, i.e. the Transmitted code must be identical to the code being sought by the Receiver. The printed circuit board (p.c.b.) design does not allow easy access to switch positions S1 to S9 since this number of combinations is not required, and so the actual code is set up on positions S10 to S12.

When the code is not being received, IC2 pin 17 is high (positive). The output from pin 17 is fed via limiting resistor R3 to the base (b) of transistor TR1 (a processor module technique discussed in Part 1 – Fig. 1.5). The effect of TR1 is to invert the output from pin 17. So, when pin 17 is high, the output from the collector (c) of TR1 is low (about 0V) and, therefore, IC3 pin 1 is low.

When the correct code is received by the circuit, IC2 pin 17 switches from high to low. As a result, TR1 is switched off and its collector voltage changes from 0V to positive, which in turn triggers the monostable comprised of NOR gates IC3a and IC3b. This monostable module was described in Part 2 (Fig. 2.8 and Fig. 2.9).

The values of resistor R5 and capacitor C6 set the time for which the monostable output (IC3b pin 4) stays high. The output from the monostable is delivered via resistor R6 to the base of TR2 (another output module discussed in Part 1 – Fig. 1.13a) to drive the buzzer WD1.

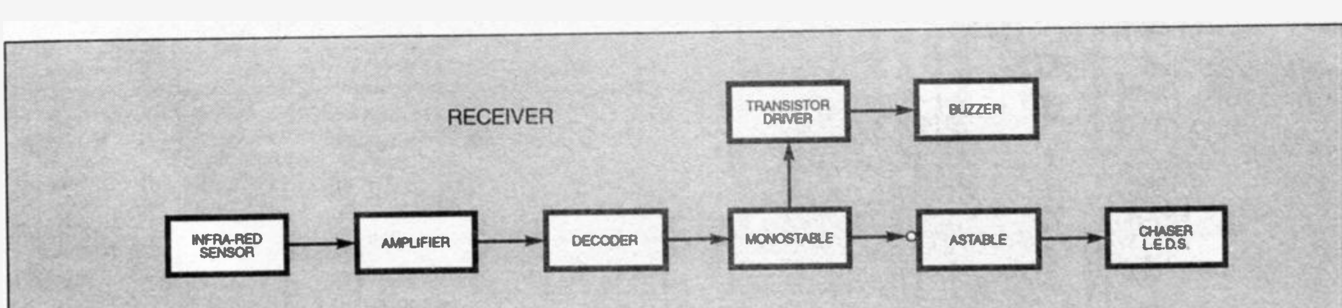


Fig. 3. Block diagram for the Receiver.

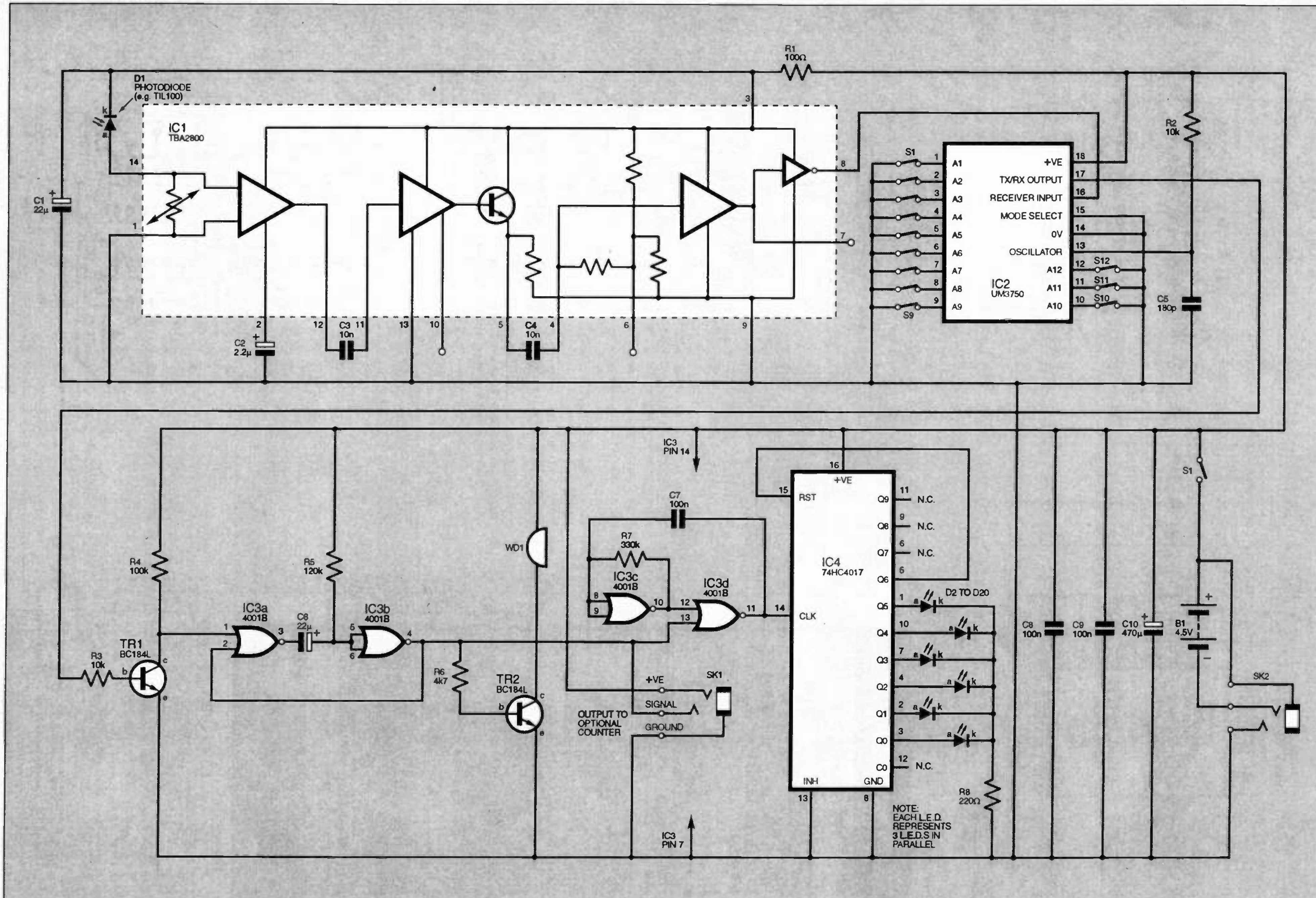


Fig. 4. Circuit diagram for the complete Receiver module.

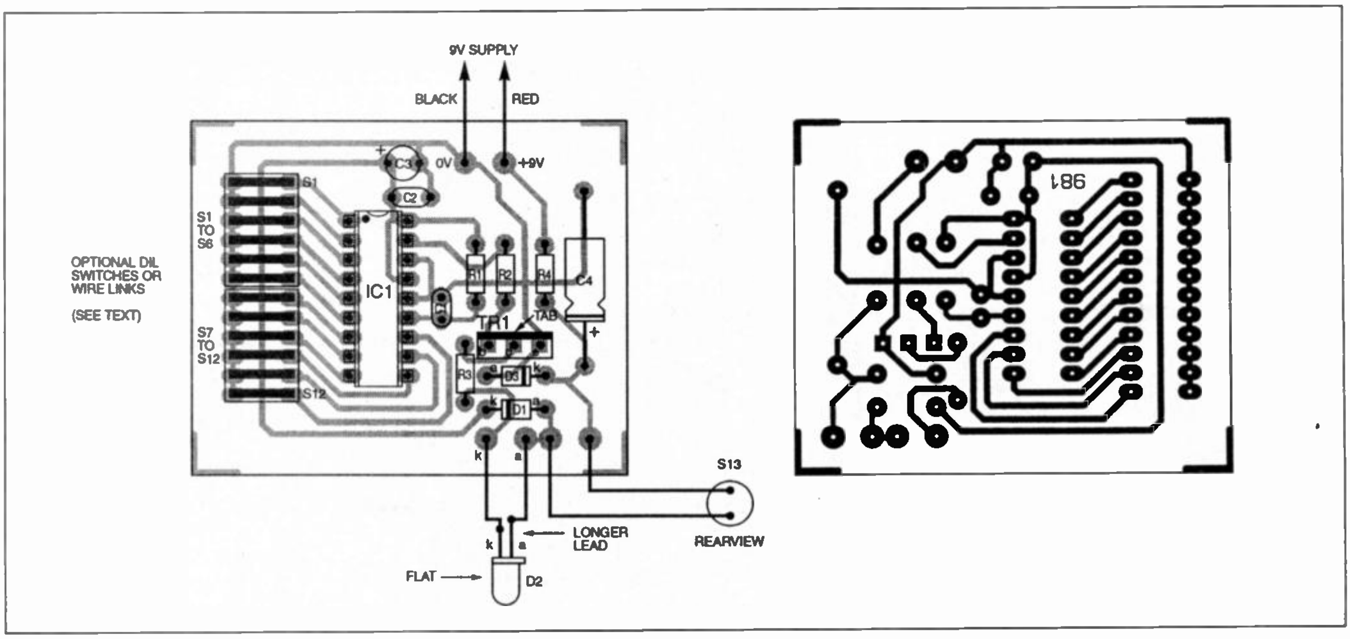


Fig. 5. Transmitter p.c.b. component layout and full-size underside copper foil track master pattern.

COMPONENTS

RECEIVER

Resistors

R1	100Ω
R2, R3	10k (2 off)
R4	100k
R5	120k
R6	4k7
R7	330k
R8	220Ω

All 0·25W 5% carbon film or better

See SHOP TALK Page

Capacitors

C1, C6	22µ elect. radial, 16V (2 off)
C2	2µ2 elect. radial, 63V
C3, C4	10n ceramic disc (2 off)
C7 to C9	100n ceramic disc (3 off)
C5	180p polystyrene
C10	470µ radial elect., 16V

Semiconductors

D1	TIL100 infra-red receiver
D2 to D20	round l.e.d.s, (6 off each of 3 colours)
TR1, TR2	BC184L transistor (2 off)
IC1	TBA2800 infra-red receiver/amplifier
IC2	UM3750 encoder/decoder
IC3	4001B quad 2-input NOR gate
IC4	74HC4017 decade counter

Miscellaneous

WD1	solid state buzzer or piezo sounder
S1	s.p.s.t. on/off switch

Receiver printed circuit board, available from the *EPE PCB Service*, code 982 (see *Shop Talk*); 14-pin d.i.l. socket (2 off); 16-pin d.i.l. socket; 18-pin d.i.l. socket; AA size battery (3 off); 3 x AA size battery holder; plastic case 150mm x 90mm x 54mm; power supply socket (SK2) (see text); stereo 3·5mm jack socket (SK1) (see text); red plastic lens (see text); connecting wire; solder, etc.

Approx cost guidance only **£15**
excl. case and batteries

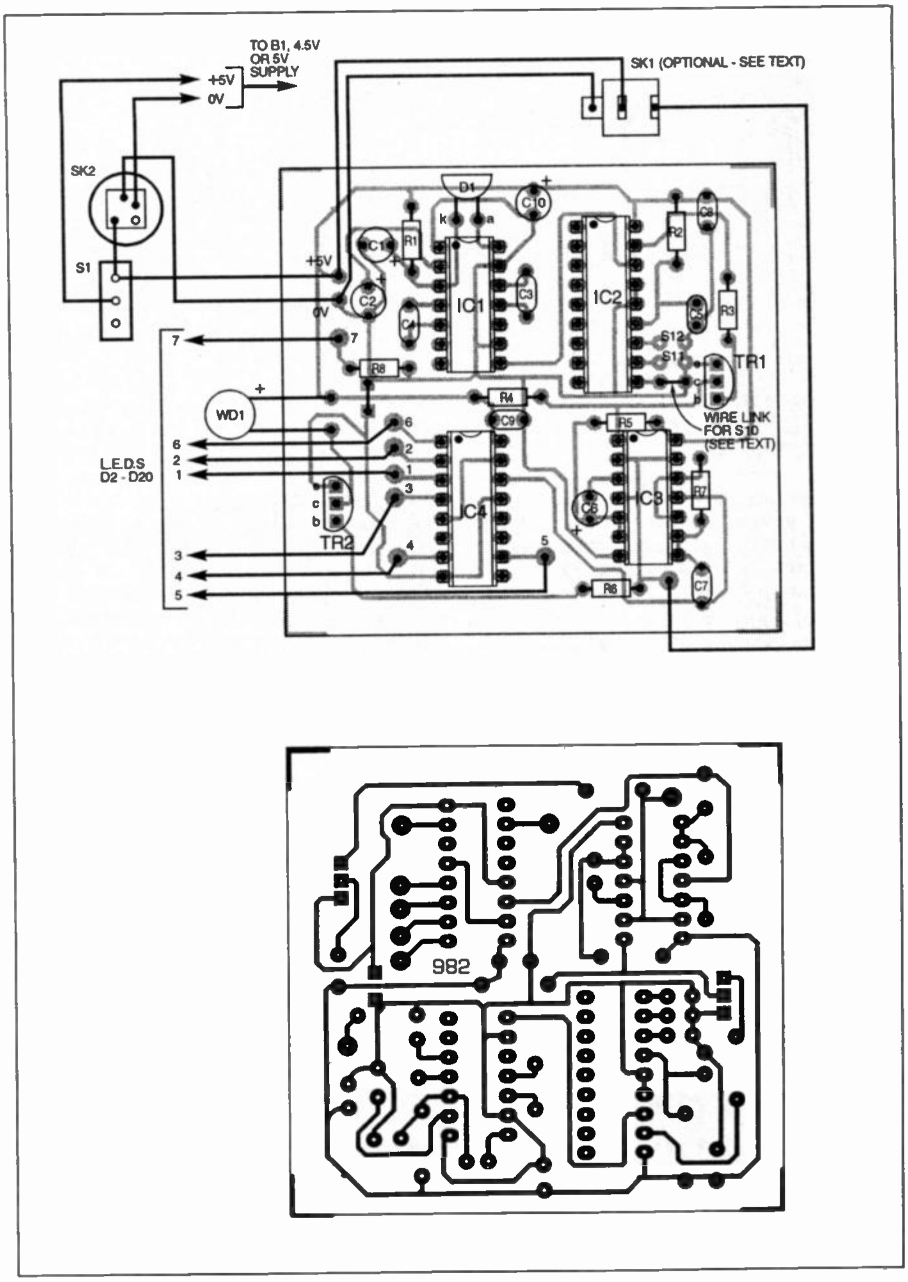


Fig. 6. Receiver p.c.b. component layout and full-size underside copper foil track master pattern.

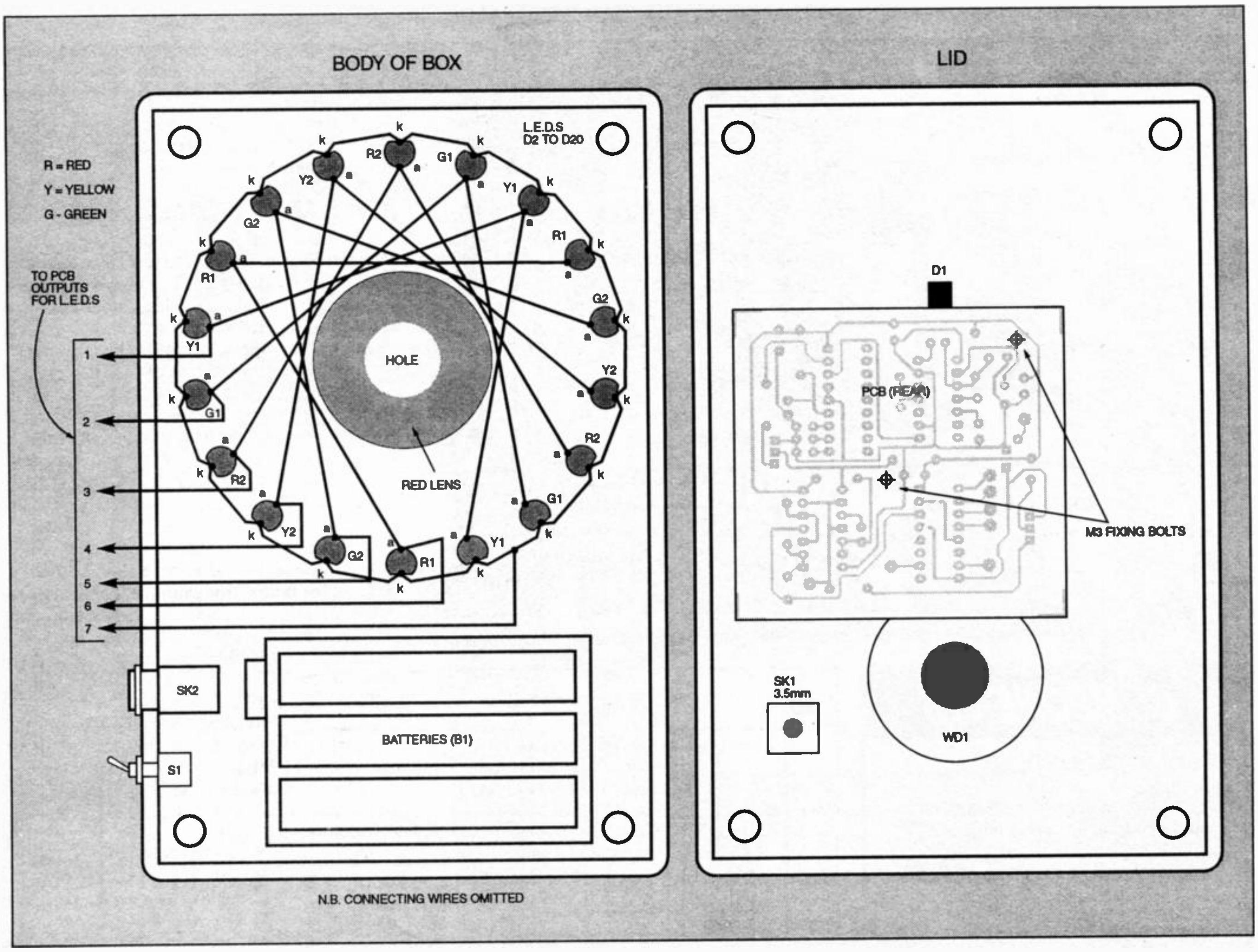


Fig. 7. Interior layout of Receiver case, showing interwiring of l.e.d.s.

The monostable output is also fed to IC3d pin 13. Both NOR gates IC3c and IC3d form the astable (see Part 4, Fig. 4.2) which is normally allowed to oscillate. The frequency of oscillation is determined by R7 and C7. When the output from the monostable goes high, the astable is "jammed".

In Part 4, the problem of this type of astable "jamming" when power is first applied was discussed (Fig. 4.5). However, in this circuit the problem is unlikely to occur since the monostable is likely to apply a pulse when first switched on, and in any case the "jam" would clear at the first "hit". Consequently, additional "kick-start" components are not needed here.

The output from the astable, IC3d pin 11, is delivered to the clock input, pin 14, of IC4. The circuit around IC4 is the decade counter described in Part 4, Fig. 4.12.

Only six counter outputs are used to drive l.e.d.s, the seventh (pin 5) being used to reset the i.c. so that the l.e.d.s light in a repeated sequence with no gaps. Six l.e.d.s are shown in the diagram, but in practice a larger number may be used if they are a multiple of six. In the prototype, 18 l.e.d.s were used (notated as D2 to D20 in Fig. 4), an additional two l.e.d.s being wired in parallel with each of the l.e.d.s shown.

Decoupling is provided by capacitors C8, C9 and C10, the first two of them (C8 and C9) are placed in different positions on the p.c.b. to decouple their nearby circuits.

Note the use of a 4·5V battery rather than a 9V or 12V. IC1 *must not* be used on a supply of more than 5·5V, due to the limitations of IC1. It would have been possible to drive the circuit from a 12V supply, with a 5V regulator supplying power to IC1 and IC2. However, there was no need in this application.

EXTERNAL INTERFACING

The inclusion of socket SK1 in Fig. 4 allows other modules to be connected and triggered by each "hit". A particularly useful module to connect is the *Event Counter* to be described in Part 6.

Two versions of an Event Counter will be discussed in Part 6: one is a full circuit with a liquid crystal display, the other is based on a ready-made module which only requires a simple interface circuit.

It is advisable to operate the counters from the same supply as the receiver, which is also available from SK1.

CONSTRUCTION

Complete details of the printed circuit boards for the Transmitter and Receiver are shown in Fig. 5 and Fig. 6. These boards are available from the *EPE PCB Service* as a pair, codes 981/982.

Begin construction of the p.c.b.s by inserting the i.c. sockets, checking that their notches agree with the diagrams. Although the i.c. sockets do not *have* to be fitted the correct way round, the notch serves as an indicator to help insert each i.c. correctly. Do not fit the i.c.s yet!

A careful look at the Receiver p.c.b. near the region of IC2 shows that only the last three "switch" links (S10 to S12) are available for coding use. The others were omitted to save space on the p.c.b. and, since this project is not intended to be part of a security system, the limited number of codes so provided is acceptable.

However, the Transmitter p.c.b. contains pads to allow connections to be made to all twelve coding positions, spaced to accept wire links or d.i.l. (dual-in-line) p.c.b. mounting switches. This provides greater flexibility and allows the Transmitter to be used as a remote control unit and/or zapper.

Continue building the p.c.b.s, inserting, say, just one link on the Transmitter, in position S10, S11 or S12, and matching this with a wire link in the equivalent position on the Receiver. In the prototype, position S10 was selected for the wire link on both boards.

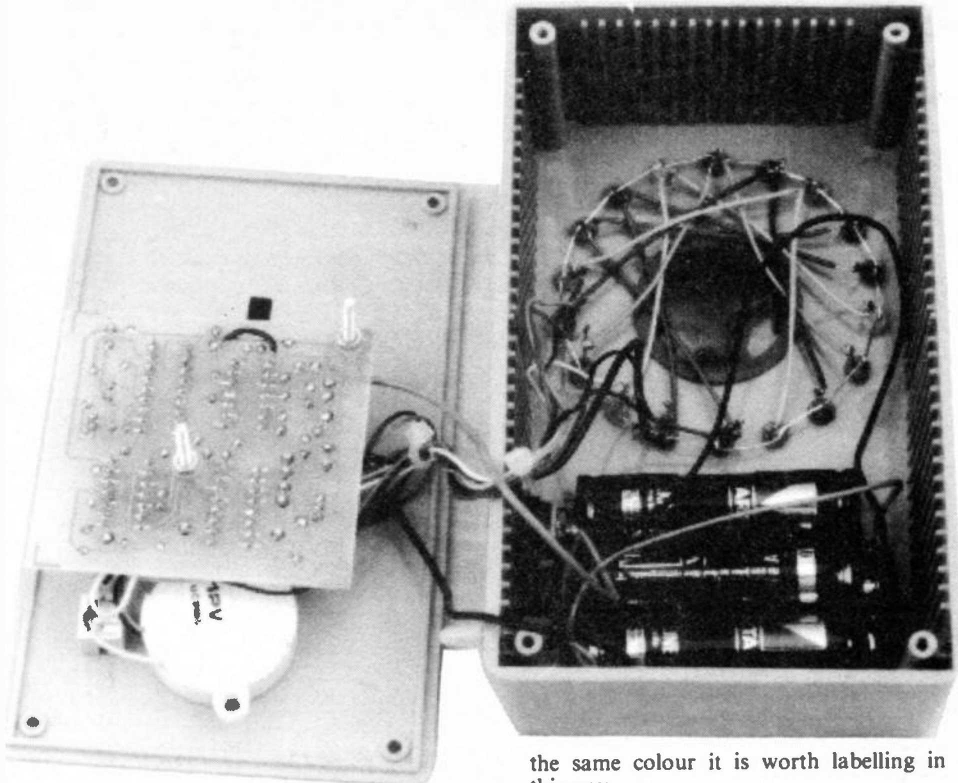
Check that diodes, transistors and electrolytic capacitors are fitted the correct way round, and insert terminal pins for all the external connections.

Pay great attention to fitting the IR sensor D1 the correct way round on the Receiver p.c.b. It can be mounted directly to the p.c.b., soldering it to leave its leads as long as possible between the sensor body and p.c.b. It should then be bent over the edge as shown in Fig. 7, facing upwards towards the target hole in the case.

The infra-red l.e.d. on the Transmitter can be soldered temporarily to its terminal pins for testing. Later, a longer pair of wires will connect the l.e.d. output to the "gun".

RECEIVER CASE

It is much easier to mount the l.e.d.s in the Receiver case before attempting to connect them to the p.c.b. Since this involves drilling the case, it is wise to drill all the



other holes required at the same time. It is worth taking care with the drilling, to obtain a good circle.

Have an enlargement photocopy made of Fig. 7 and use it as a lifesize template. The enlargement required is about 123 per cent. Using a small drill first, carefully drill a hole at each l.e.d. position. Then use the correct size drill to suit the l.e.d.s themselves.

Drill a hole in the case body for the IR beam to pass through to the sensor, and possibly a hole in the lid for the sound of the buzzer to escape.

Drill other holes in the body for the on/off toggle switch S1, an audio power socket (SK2) if an external power supply is required, and add a hole in the lid or body for a 3·5mm stereo jack socket (SK1) if connection to the *Event Counter* in Part 6 will be required.

The p.c.b. may be mounted on the lid by means of two M3 bolts and spacers with the copper side towards the l.e.d. display. This allows the sensitive surface of the IR sensor to face the red lens.

L.E.D. MOUNTING

When drilling is complete, mount the l.e.d.s in the case as shown in Fig. 7. While inserting them into their holes, try to keep all the longer leads on the inside of the circle. This will help the wiring operation.

Bend each of the shorter cathode (k) leads towards the outside of the circle and towards the next l.e.d. in the circle. It should be possible to connect all the shorter leads together by careful bending and soldering to form a complete ring of wire.

The longer anode (a) l.e.d. leads are more complicated. Each l.e.d. must be connected to the seventh l.e.d. from it around the circle. If three l.e.d. colours have been used, as recommended, such as yellow, green and red, then the operation is more obvious, especially if they are carefully placed in sequence and labelled G1, Y1, R1, G2, Y2, R2, and then back to G1, Y1, R1, etc., as shown in Fig. 7.

Connect together the three anodes of the l.e.d.s labelled Y1, the three anodes labelled G1, etc. Even if all the l.e.d.s are the same colour it is worth labelling in this way.

Six leads (colour coded if possible) are then used to connect these commoned anode groups to the p.c.b. Don't forget to add one extra lead from the cathode side of the l.e.d.s back to the p.c.b.

Complete the other external connections. If in doubt when the optional power supply socket (SK2) is fitted, use a meter to confirm the connections so that the battery automatically disconnects when external power is applied.

If the optional 3·5mm stereo jack socket (SK1) is fitted for an external counter, note that in the prototype, and as shown in Fig. 6, the screen pin of the socket was connected to 0V, the right hand stereo channel to positive, and its tip (left hand stereo channel) to the output pad next to R6 on the p.c.b. This allows the counter to be powered from the Infra-Zapper's power supply.

Do not use a mono jack plug with the stereo socket, or a short circuit may occur.

Connect the 9V PP3 battery clip to the Transmitter p.c.b. Finally, insert all the i.c.s into their sockets, taking care to install them the correct way round, and taking the usual precautions regarding static charge.

In other words, briefly earth yourself by touching an earthed metal object (e.g. the metal case of an appliance plugged into the mains supply), and do not walk over a nylon carpet before handling the i.c.s.

Once installed into their sockets, under normal circumstances the components in the rest of the circuit will provide all the necessary protection.

TESTING

When power is applied to the Receiver, the l.e.d. sequence display should appear to rotate. Failure of some of the l.e.d.s to light indicates faulty wiring somewhere around the circle. Failure of all the l.e.d.s to light indicates a serious problem!

Assuming all is well, try aiming the Transmitter at the Receiver. Hold the Transmitter a metre or more from the Receiver and press the trigger button. The l.e.d.s should stop rotating and the buzzer should sound. Note that stray IR reflections can upset reception of the code.

The Receiver may work more reliably if some black paper is placed on the test bench. Alternatively, place the Receiver near the edge of a table. When the system is installed in the case, reflections should not be a problem.

FAULT FINDING

A general guide to fault finding was provided at the end of Part 1. As stated in Part 5, infra-red systems can be frustrating, particularly if it is not clear whether the Transmitter or Receiver is at fault.

An oscilloscope will detect the presence of a signal at the anode (a) of the IR sensor, i.e. the side connected to IC1 pin 14. If no signal is detected, try any remote control transmitter; a signal should be detectable by an oscilloscope even though it cannot be decoded. It is possible to trace the signal through the i.c. by touching the 'scope probe on IC1 pins 12, 11, 5, and 4 in turn.

Once the signal is decoded in the Receiver by IC2, simple voltmeter tests may be used to check for faults. For example, connect the voltmeter to the collector of the transistor TR1, and/or IC3 pin 1. Force the base of TR1 low by shorting it to the 0V line. The collector should switch to positive each time the base is made 0V.

Repeat the shorting action, but now check the voltage at the output of the monostable, IC3b pin 4. This should switch to positive for a fixed time after the base of TR1 is connected to 0V. Check that this is copied at IC3d pin 13.

Check the voltage at IC4 pin 14. An oscilloscope should display a square wave unless the monostable is triggered. A voltmeter will give a rather flickery voltage around half the supply. If the voltage at pin 14 is either fully positive or 0V, try forcing it high or low (briefly connect a wire between it and one of the power rails) and see if the display moves on by one step.

This "forcing" may sound dangerous to IC3d, but in practice the outputs of CMOS gates will tolerate a short circuit for a short time! If courage is lacked about treating IC3 in this way, remove it first.

Fault finding the Transmitter is difficult without an oscilloscope and is largely confined to visual checking. An oscilloscope will indicate the production of a signal at

IC1 pin 17 when the trigger switch S13 is pressed. This signal should also be present at the collector of transistor TR1 in that circuit (Fig. 2).

RECEIVER HOUSING

Once the Receiver has been tested, it remains to fix in place the battery box, optional power socket and toggle switch in the body of the case, plus the p.c.b., buzzer and optional 3·5mm stereo jack in the lid.

The p.c.b. should be mounted so that the IR sensor is directly in line with the centre of the l.e.d. circle. A red lens may be glued behind the hole in the centre to create a neater effect. However, it makes only a marginal difference to the working of the project.

TRANSMITTER HOUSING

A gun-like case is ideal for this project. The prototype used a gun which was originally part of a TV game. If one is not already owned, a trip to the local toy shop should produce a low cost gun-like item.

The gun case was opened and the infra-red l.e.d. inserted, together with a small lens to focus the beam. Some experimentation is required since the lens makes only a marginal difference to the operation of the system.

The Transmitter p.c.b. itself may or may not fit inside the gun. The prototype p.c.b. is housed in a small case intended for use as a remote control unit. The case has a compartment for a PP3 battery and a belt clip. A 4-core wire connects the circuit with the gun: two wires for the infra-red l.e.d. and two for switch S13, which should be linked to the trigger of the gun.

Note that a 3-core wire will suffice since the anode of the l.e.d. is the same electrical connection as the lower side (as on Fig. 5) of S13.

PART SIX

Accompanying *Teach-In* Part 6 as the illustrative projects are two Event Counter modules which, among other functions, can be linked with the Infra-Zapper to indicate your score. Happy zapping!

SHOP TALK
with David Barrington

High Current Stabilized Power Supply

Although there is not an abundance of components in the *High Current Stabilized Power Supply*, one or two of them will need selecting with care if the cost is to be kept to a minimum. The main smoothing capacitor C1 should have a minimum capacity of 22,000µF and be rated with at least a figure of 10A "ripple current".

The capacitor appears to be the most expensive item in this project and shopping around has produced prices from around £16 to well over £30.

The next most expensive, and probably the most important, is the 120VA toroidal transformer. Once again prices do vary, the one in the model was purchased from **Electrovalue (☎ *01784 433603*)**, code T12015 for the sum of £12.23 plus VAT. A post and packing charge will also be made. Note that the leads from the two 15V secondaries must be parallelled together in this design.

The 10-pin metal can voltage regulator type L123, which may be hard to find locally, in currently listed by **Electromail (☎ *01536 204555*)**, code 305-440. You can if you wish, use the more readily available *14-pin d.i.l.* version type LM723. You will, of course, have to adapt the p.c.b. to take this i.c. if you opt for the 14-pin version.

If any readers have difficulty in finding a suitably rated bridge rectifier, **Maplin** stock one, code BH47B. They also stock a suitable small TO220 heatsink for TR3, code JW28F, if you do not want to make your own.

The large power heatsink should be readily available from most of our component advertisers. The price may vary from shop to shop and it is claimed that a plain aluminium, unanodised and undrilled one will cost about half as much (we have not been able to find one).

Mind Machine Mk III

We do not expect any buying problems to be encountered by readers tackling the *Mind Machine Mk III* project. Most components should be "off-the-shelf" devices.

Almost any 100µH inductor will do the job of L1 in this circuit, but wire-ended types are easier to accommodate on the p.c.b. and have a reasonable operating tolerance of about 10 per cent. The one used in the prototype is an r.f. type and was ordered from **Maplin**, code WH41U.

The "Hyperbright" l.e.d.s gave the best performance and should be used if possible. These also came from the above source, code UK20W.

Finally, all readers must heed the "warning panel" in the article about possible side effects when using the unit.

Multi-Purpose Mini Amplifier

No problems should arise when ordering parts for the *Multi-Purpose Mini Amplifier*. This project was specially designed for headphone operation (including the Free ones banded to UK copies) and will accept inputs from most sound equipment.

The output jack socket in the model is a miniature, metal bodied, stereo type and the output leads are soldered to the channel tags only, the common (body) connection being left free.

Infra-Zapper (Teach-In '96)

Most components advertisers will either stock the specified infra-red l.e.d. and detector diode or be able to offer suitable equivalents for the *Infra-Zapper*, this month's *Teach-In* project. If maximum range is important it is worth experimenting with alternative IR transmitting l.e.d.s.

The UM3750 encoder/decoder used in the Transmitter and Receiver came from Maplin, code UK77J. The "hip" mounting case (KL95D) and the "target" case (YU54J) were purchased from the same source. The prototype plastic "gun" originally came from **Bull Electrical (☎ *01273 203500*)**. No doubt, most local toy shops will stock a suitable plastic gun.

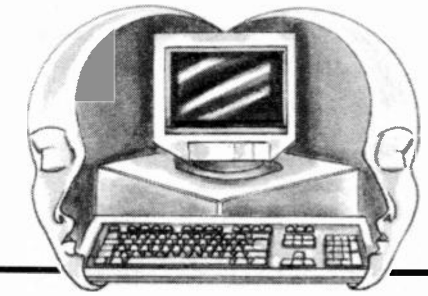
PIC-Electric Meter

All the "hard to find" components for the PIC-Electric Meter were covered in last month's article. As a point of interest, readers who buy the ready-programmed PIC from **Magenta Electronics** do not need to possess a computer to build this project.

The source-code listing is obtainable on a 3·5in Disk (together with the Simple PIC Programmer (last month) software) from the Editorial Offices (see page 181 for address) for £2.50 (overseas – surface £3.10; airmail £4.10). Please note that there is a minium order charge of £5 levied for Credit Card transactions.

All the printed circuit boards for this month's project are available from the *EPE PCB Service* – see page 243.

INTERFACE



Robert Penfold

A SIMPLE television style quiz monitor based on a PC was described in a previous *Interface* article. The system described in that article had provision for four pushbutton switches, with each switch monitored via a separate input line of the printer port.

It would not be difficult to extent the original system to accommodate more switches, but more input lines would be required. In fact a lot more input lines could be required. As an example, on the basis of one input line per pushbutton switch, four teams of four players would require some 16 input lines.

It would be possible to use standard multiplexing techniques to provide 16 inputs via the printer port, but a proper PIO card would probably be a better way of providing the input lines. Fortunately, there are simpler and less expensive means of monitoring numerous switches.

Probably the most simple method is to use a scanning technique. This is basically the same method that is used in many computer keyboard circuits.

The scanning system described here can monitor up to 16 switches, and it is presented as a 16-Station Quiz Monitor. However, the hardware should be usable in practically any situation where up to 16 pushbutton switches, microswitches, etc. must be monitored.

Ins and Outs

This system is based on a CMOS 4514BE four-to-16 line decoder. Pinout details for the 4514BE are given in Fig. 1.

There are 16 output pins ("Out 0" to "Out 15"), and only one of these is high at any one time. The required output is set high by feeding the appropriate four-bit binary value to the data inputs ("D0" to "D3"). For example, a binary value of 0110 (equivalent to 6 in decimal) would set Out 6 (pin 5) high.

The 4514BE has two control inputs, one of which is an Inhibit input (pin 23). This is taken low for normal operation, or high to switch off all the outputs.

The Strobe input at pin 1 can be used to latch data into the transparent latch at the four data inputs. Data is latched by taking pin 1 through a high to low transition. If the latching facility is not required, the latch can be made "transparent" by holding pin 1 high.

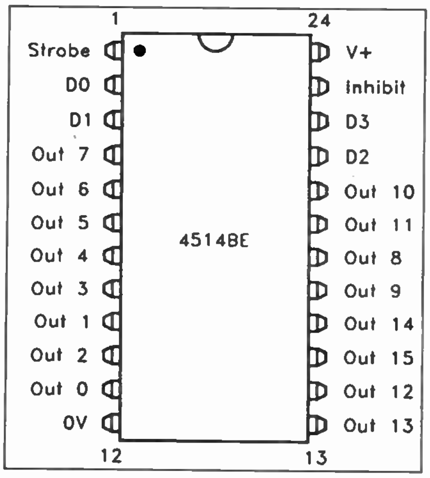


Fig. 1. Pinout details for the 4514BE four-to-16 line decoder.

One-by-One

On the face of it the 4514BE is of little use in the current context, as it gives 16 outputs from four inputs. We require something that provides the opposite action, with 16 inputs being multiplexed down to four outputs. The 4514BE can in fact provide the required action, but only in conjunction with a digital input line and some simple gating.

Four outputs and one input line are well within the limits of the PC printer ports. The circuit diagram for the 16-Station Quiz Monitor appears in Fig. 2.

The inhibit and latching facilities are not required in this case. Consequently, pin 1 is taken high and pin 23 is tied to the 0V supply rail.

The four data inputs of IC1 are fed from the four least significant data outputs of the printer port. These are at address &H378 for printer port 1, and &H278 for printer port 2. S1 to S16 are the pushbutton switches, and diodes D1 to D16 provide the gating.

An output that is high can take the input line high if the corresponding pushbutton switch is closed, but an output that is low cannot hold the input line low. The input line is provided by one of the printer port's handshake inputs. This line is bit 4 at address &H379 for port 1, or &H279 for port 2. Under standby conditions this line is taken low by resistor R1.

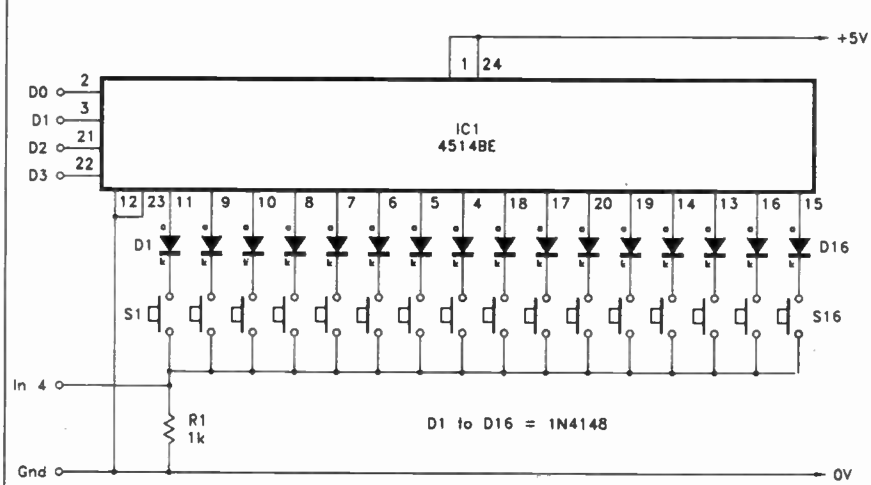


Fig. 2. Circuit diagram for the 16-station Quiz Monitor.

Action Stations

The basic action of the software is to first write a value of zero to IC1, and then check to see if the input line has been taken high. This can only occur if push switch S1 is closed. It then connects output 0 of IC1 to the input line via diode D1.

Next a value of one is written to IC1, which sets output 1 high. The input line is then checked again, and it will only be high if switch S2 is closed.

This process is continued, with the value written to IC1 being raised by one, and the input line checked, until a value of 15 has been used. At this point switches S1 to S16 have all been checked, one-by-one.

This process is repeated until one of the switches is closed. The software detects that the switch has been closed the next time that particular switch is scanned. In a quiz monitor application the software must then indicate which switch has been activated, and then wait for the quiz master to reset the system.

Details of the connections to the printer port are provided in Fig. 3. The connections to the computer are made via a 25-way male D-type connector.

Software

The accompanying program listing is for a basic 16 station quiz monitor. Line 20 clears the screen, and the next two lines print a couple of on-screen instructions.

These are simply to press the "R" key to Reset the system after a key press has

Listing 1: 16-Station Quiz Monitor

```
10  REM 16 Station Quiz Monitor Program
20  CLS
30  PRINT "Press 'R' Key To Reset Monitor"
40  PRINT "Press 'S' Key To Stop Program"
50  PORT = &H378
60  SWITCH = &H379
70  OUT PORT,0
80  IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 1 Pressed"
90  IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
100 OUT PORT,1
110 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 2 Pressed"
120 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
130 OUT PORT,2
140 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 3 Pressed"
150 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
160 OUT PORT,3
170 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 4 Pressed"
180 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
190 OUT PORT,4
200 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 5 Pressed"
210 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
220 OUT PORT,5
230 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 6 Pressed"
240 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
250 OUT PORT,6
260 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 7 Pressed"
270 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
280 OUT PORT,7
290 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 8 Pressed"
300 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
310 OUT PORT,8
320 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 9 Pressed"
330 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
340 OUT PORT,9
350 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 10 Pressed"
360 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
370 OUT PORT,10
380 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 11 Pressed"
390 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
400 OUT PORT,11
410 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 12 Pressed"
420 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
430 OUT PORT,12
440 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 13 Pressed"
450 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
460 OUT PORT,13
470 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 14 Pressed"
480 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
490 OUT PORT,14
500 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 15 Pressed"
510 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
520 OUT PORT,15
530 IF (INP(SWITCH) AND 16) = 16 THEN PRINT "Player 16 Pressed"
540 IF (INP(SWITCH) AND 16) = 16 THEN GOSUB 560
550 GOTO 70
560 A$ = INKEY$
570 IF A$ = "r" THEN GOTO 600
580 IF A$ = "s" THEN END
590 GOTO 560
600 CLS
610 RETURN
```

been detected, and to press the "S" key to stop the program. Note that the program can only been halted after a pushbutton has been operated, and the program has branched out of the main loop.

Lines 50 and 60 set variables "PORT" and "SWITCH" at values of &H378 and &H379 respectively. These are the addresses of the output port and the input line, and are correct for printer port 1.

If you will be using port 2 these values should be changed to &H278 and &H279 respectively. No other changes should be required.

The main program is the loop from lines 70 to 550. This scans the switches, and prints an appropriate on-screen message when a switch is operated. Also, whichever switch is operated, the program branches to the subroutine at lines 560 to 610.

The program loops around lines 560 to 590 until either the "R" or "S" key is pressed. Line 580 brings the program to a halt if the "S" key is operated. If the "R" key is operated, the program branches from line 570 to line 600. Here the screen is cleared, and then the program returns to the main loop.

The program is written in such a way that there can never be a "dead heat" if two switches are pressed more or less simultaneously. Although it might appear as though the scanning process favours low switch numbers, bear in mind that the scanning count could be at any value when two or more switches are activated.

Which switch "wins" is therefore purely random, with the system having no built-in bias. Of course, the faster your PC, the better the system is able to pick the correct switch when two or more are pressed almost together.

With a reasonably fast PC each complete scan should take under a millisecond. This should give fine enough resolution to ensure fair results.

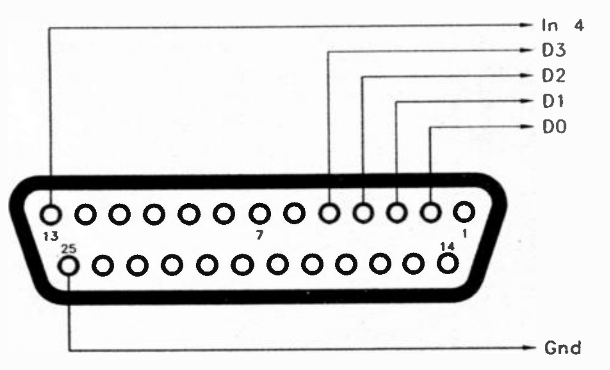
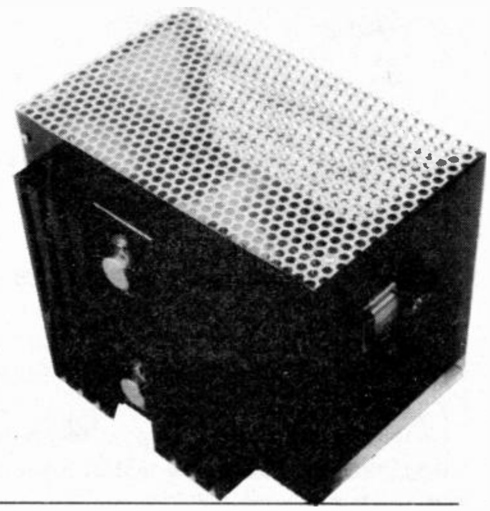


Fig. 3. Details of the connections to the PC printer port.

HIGH CURRENT STABILIZED POWER SUPPLY



STEVE KNIGHT

A robust stabilized "power broker" that will deliver up to 7·5A. Output voltage can be preset from 12·5V to 16V. Run your 12V equipment from the mains.

This Stablized Power Supply unit, besides being a general purpose high current supply, enables certain battery powered equipment to be operated off the mains rail. This is a useful feature particularly for the indoor operation of otherwise mobile equipment, such as solid state amateur transceivers which normally operate from car battery sources.

This relatively simple design will provide the nominal fully-charged voltage of a battery supply from mains input, and with a current rating sufficient for almost all commonly used equipment. The output is 13·8V up to a current limit of 7·5A, with safety limiting at about 8A, stabilized within 0·2V over the current range. An adjustment is available for setting the output to a voltage level from about 12·5V to 16V if this is required, the current limit and stabilization remaining as before.

The design is developed around the 10-pin L123 metal can voltage regulator i.c., although for those who can design their own board the 14-pin L723 d.i.l. version of this regulator may be used instead. The operating characteristics of both versions are identical except for the power dissipation rating of the metal can which is 800mW against 650mW for the d.i.l. version, but this is of no importance in the present usage.

The pin connections for the metal can version are shown in Fig. 1. It is important to notice that this view is made looking from the *top* of the can, *not* the pin view.

REGULATION CIRCUIT

The basic internal structure of the L123 voltage regulator i.c. is shown within the broken lines of Fig. 2. This is a quite conventional arrangement; the series emitter-follower transistor TRA is used as the control element between the input voltage point V+ and the output voltage point V_O.

The output voltage across the load is sampled at the connecting point of the voltage divider chain R1 and R2 and compared with that of a reference voltage V_{REF} derived from a constant current (Zener) source, this being available at pin 4. By connecting this pin to the non-inverting input of the error amplifier at pin 3, this point is held at the reference level so that a comparison can be made between it and the sampled voltage from the output which is applied to the inverting input via pin 2.

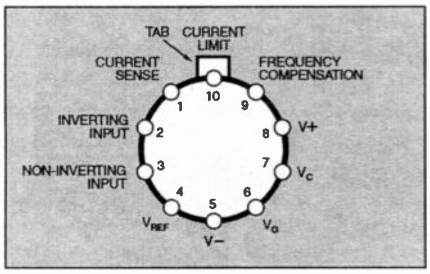


Fig. 1. Top view of the LM123 regulator showing the pin functions. Pin 10 is indicated by a protruding tab on its metal case.

Any difference between these voltages is detected by the comparator and after amplification is fed back to the base of the series regulator so as to maintain the output voltage V_O at pin 6 at a constant level.

The direct amplifier output is also available at pin 9; this enables a compensating capacitor C to be wired to the inverting input at pin 2 which reduces the amplifier gain at high frequencies and helps to maintain overall stability. Make a point of noticing that the feedback around the control loop is negative.

A protection circuit which operates against the effect of overloading at the output, such as an inadvertant short-circuit, is provided by the internal transistor TRB. The base and emitter connections of this transistor are available at pins 10 (Current Limit) and pin 1 (Current Sense) respectively.

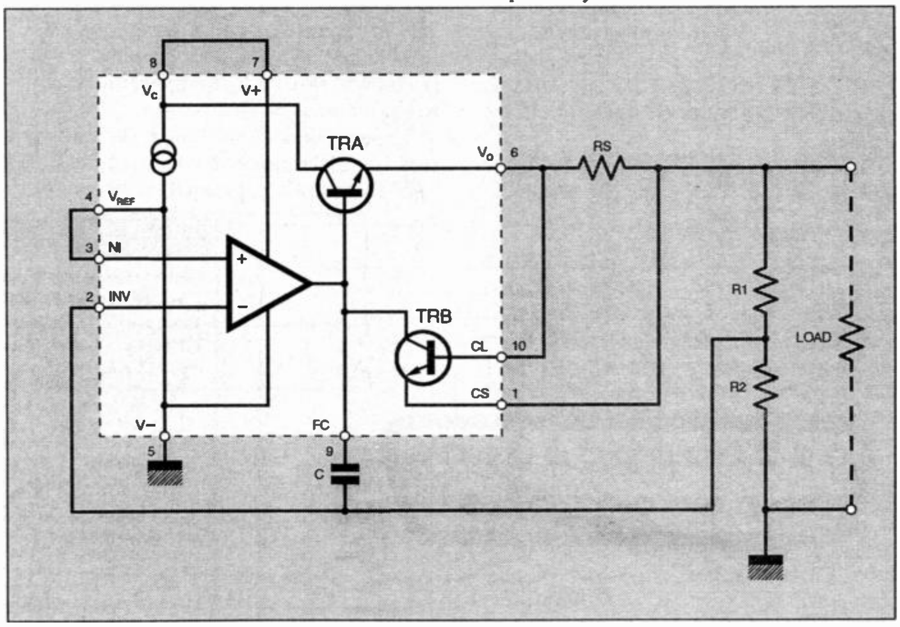


Fig. 2. The regulator internal structure and essential external connections. The external components are those outside the dashed area.

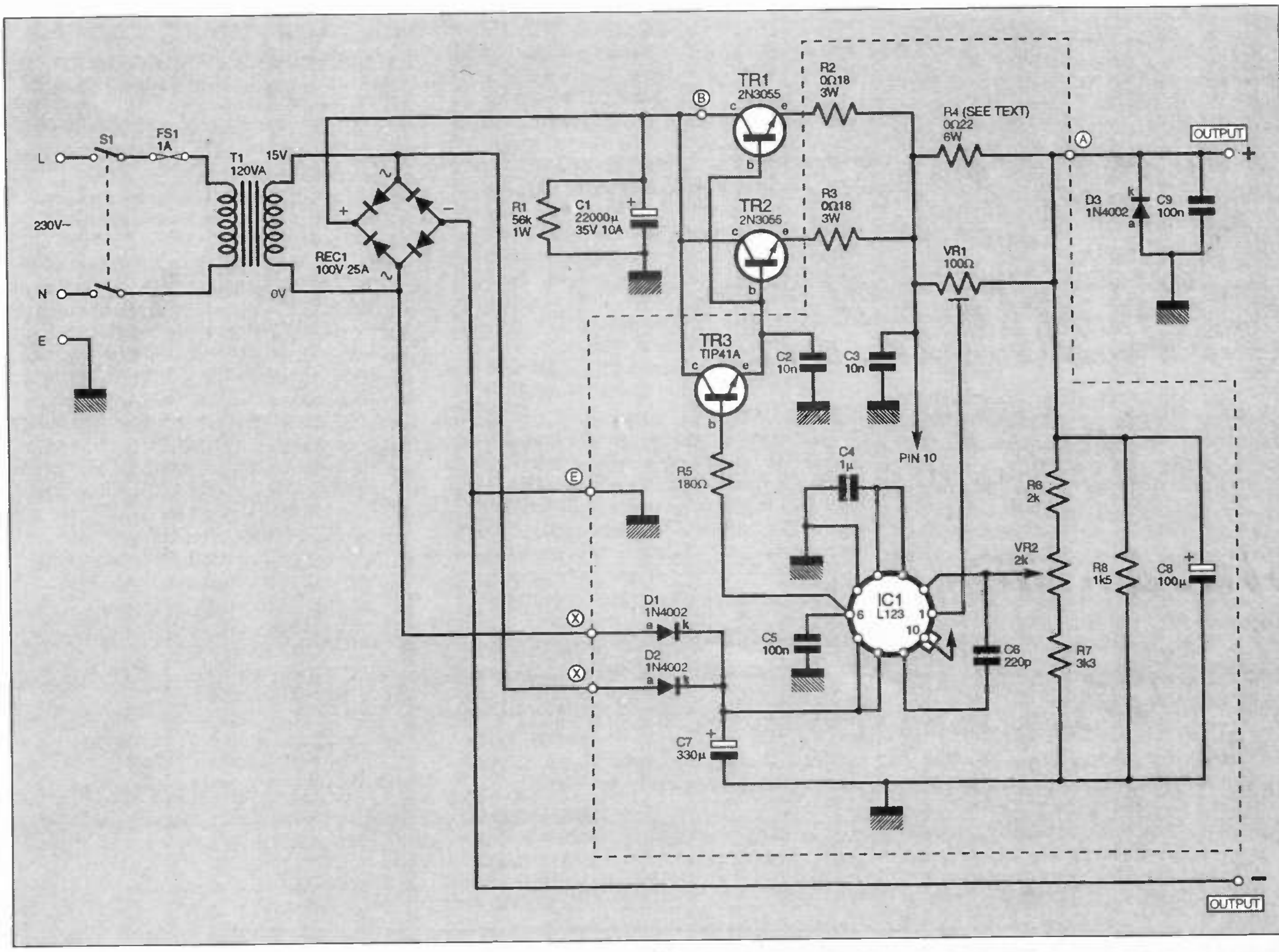


Fig. 3. Complete circuit diagram for the High Current Stabilized Power Supply. The components inside the dashed area are all mounted on the p.c.b.

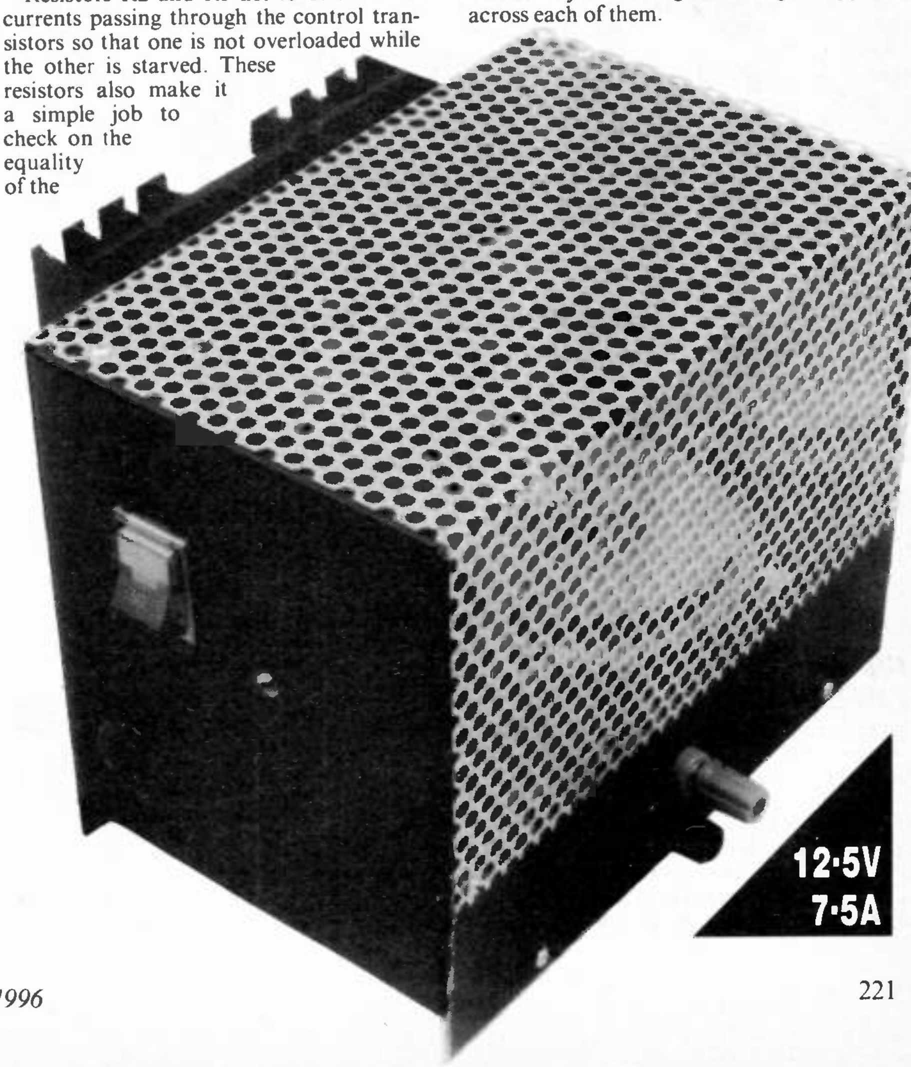
By connecting these pins across a sensing resistor *RS* in series with the positive output lead, transistor TRB is switched on when the voltage across *RS* exceeds about 0·65V, which is the nominal current sense operating voltage. By the right choice of resistance value, this voltage can be made to have its effect when the output current reaches a desired maximum level. Transistor TRB then conducts and a low resistance path is introduced across the base-emitter junction of TRA, so tending to cut its collector current off and reduce the output current to a safe maximum limit.

EXTERNAL CONTROL

Since the maximum power dissipation of the L123 is only 800mW and this derates by about 7mW per degree Centigrade rise in temperature, the regulator on its own cannot provide the 7·5A design level for this power supply unit. The answer to this is to use the voltage regulator merely as a *current* drive to an external series control system which is capable of handling the high current required; the regulator will, of course, still provide the necessary stabilization of the output voltage.

The external control system is made up from three transistors, TR1 to TR3, as can be seen from the full circuit diagram of the High Current Stabilized Power Supply shown in Fig. 3. Transistors TR1 and TR2 are a pair of our old and trusted 2N3055's, being readily available and very cheap, connected in parallel to share the load current with their "commoned" bases driven in turn by TR3, a TIP41A fed from the regulator output pin.

Resistors R2 and R3 act to balance the currents passing through the control transistors so that one is not overloaded while the other is starved. These resistors also make it a simple job to check on the equality of the currents by measuring the voltage dropped across each of them.



POWER SUPPLIES

The supply to the regulator board, within the dashed area, is taken separately from that feeding into the control transistors. The latter being derived from bridge rectifier REC1 and reservoir capacitor C1. These components along with the mains transformer T1 and the power transistors are, of course, separately mounted and hard wired away from the regulator board.

Capacitor C1 should have a minimum capacity of 22000μF and be of at least 10A ripple current rating. Resistor R1 is simply a "bleed" resistance which discharges C1 after switch off and is in no way critical in value.

The regulator section itself is effectively fed from a bi-phase arrangement of diodes D1 and D2, the transformer "centre tap" being created by the action of the bridge rectifier. Capacitor C7 smooths the regulator supply and need have no special qualities outside of an adequate voltage rating. Adjustment of preset VR2 varies the feedback voltage so that a precise level of output voltage can be set within the range already mentioned.

VOLTAGE LIMITING

To make it possible to obtain the correct limiting voltage across the sense resistor R4, this component needs to be adjustable; since it is carrying a current up to a possible 7·5A, however, it must of necessity be of high wattage rating and a variable resistance is out of the question. However, by shunting it with a preset control (VR1) high enough in value relative to that of R4 (so making the current through this preset very small), a voltage can be tapped off which will operate the low current requirement of the limiting transistor inside IC1.

Taking the upper acceptable limit to be 9A with a short-circuited output, the voltage developed across R4 must, at that current level, reach the nominal 0·65V in order to operate the internal transistor. The required resistance value of R4 must then be $0{\cdot}65/9 = 0{\cdot}07\Omega$ at a power rating of $9^2 \times 0{\cdot}07 = 5{\cdot}7$W.

Such a value is unlikely to be found in an advertiser's list, so the resistance has to be made up from obtainable values. By placing two 0·22Ω, 6W resistors in parallel, a value of 0·11Ω at 12W is obtained; this will be adequate to produce a sufficient voltage at a current of 9A or so, and the proper point of this can be selected by adjustment of preset VR1.

There is little more to say about the circuit design; capacitor C9 and diode D3 are wired directly across the output terminals and these help to prevent any instability from arising. D3 also protects against reverse voltage pulses fed back from external circuits that may be highly inductive.

CONSTRUCTION

The components to be mounted on the regulator printed circuit board (p.c.b.) are those shown within the dotted lines of Fig. 3. The full size copper foil master pattern and the topside component layout is given in Fig. 4, with an indication of the wiring to the external parts of the circuit. This board is available from the *EPE PCB Service*, code 979.

When assembling the board, the only awkward component is the 10-pin regulator IC1. If you undertake to make your own p.c.b., the holes for IC1 should be very carefully drilled through the appropriate pads with a 0·5mm drill, and when threading the ten wire connections through these, great care (and a bit of patience) has to be exercised.

It is essential to get the orientation of the regulator IC1 right *before* soldering it in place as it is practically impossible to remove the component afterwards without damaging it or the board. The small projection or tab on the base corresponds to pin 10; get this in the right hole and the rest will be automatically correct. Solder very carefully to avoid unwanted bridging, and space the metal can about 3mm to 5mm above the board surface.

The remainder of the components can now be fitted, noting the following particular points: Resistors R2, R3, and the two parallel resistors making up the

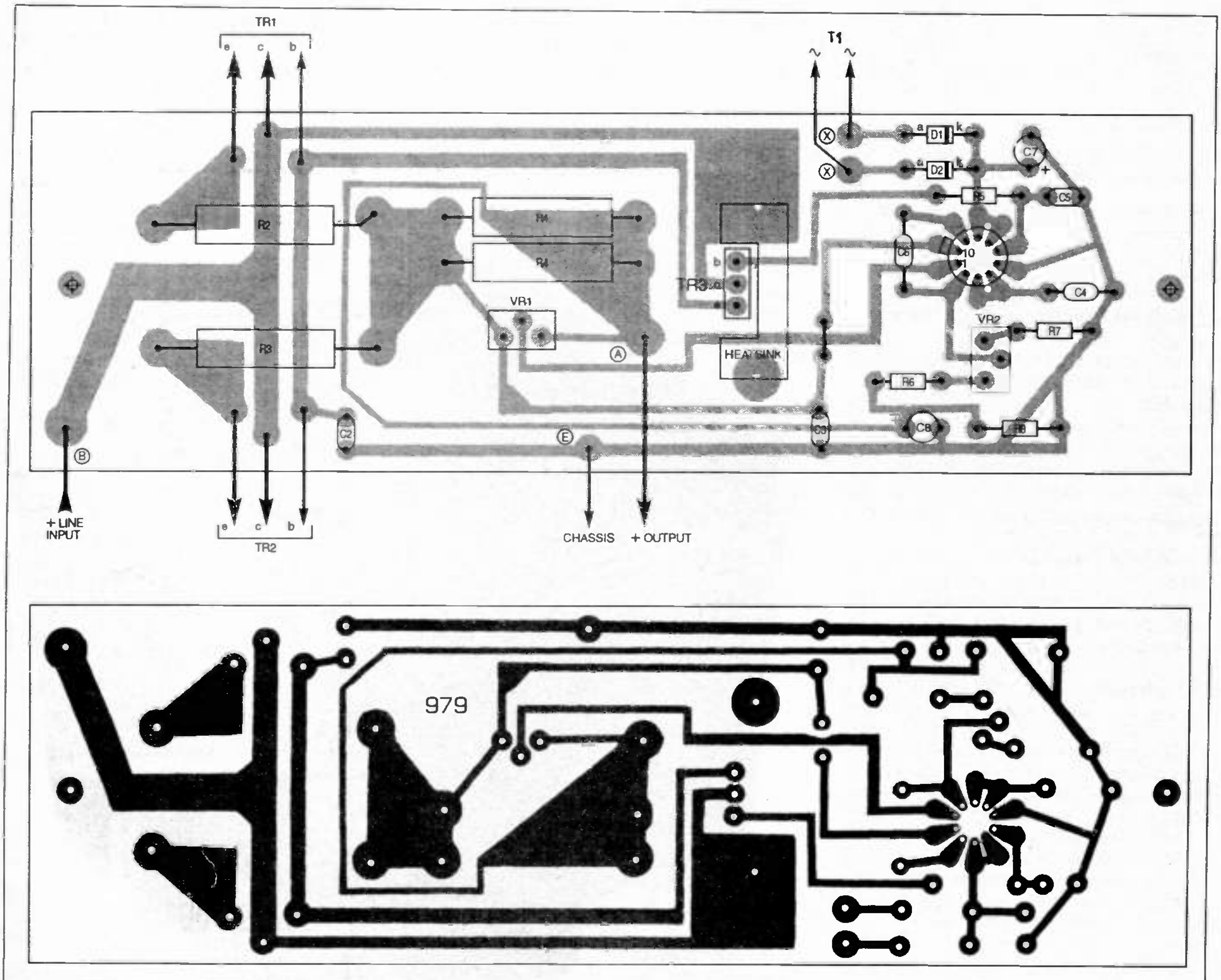


Fig. 4. Power supply printed circuit board component layout and full size copper foil master pattern. Note that the high wattage resistors must be mounted clear of the p.c.b.

"sense" resistor R4 should *NOT* be in contact with the board, space them at least 6mm above the board. Transistor TR3 is fitted to a small heatsink which is soldered to the board by two legs.

An alternative heatsink can be made from a piece of 18 s.w.g. aluminium bent to the dimensions shown in Fig. 5. Here actual fixing to the board can be ignored, the heatsink being supported directly by the transistor itself.

Make a note that trimmer potentiometer VR1 is of the horizontal mounting type; if a vertical type is used its adjustment will be fouled by the R4 resistors, unless you tilt it about 45 degrees so that screwdriver access to the adjusting screw is possible.

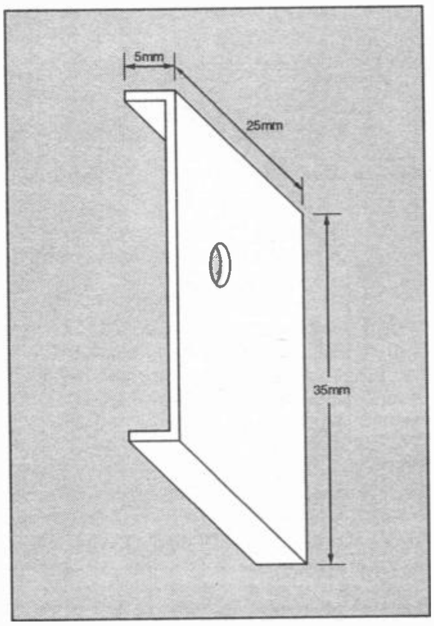


Fig. 5. Dimensions for the 18 s.w.g. aluminium "homemade" heatsink for transistor TR3. The mounting hole is central and 5mm from one end.

MAIN HEATSINK

The main heat sinking for the two pass transistors, TR1-TR2, has to be substantial as something of the order of 100W is delivered by the unit at its maximum output. The heatsink used here has a thermal rating of 1·25°C/W and any alternative used (or fabricated) should be *at least* of this rating. By buying an un-anodised version of this heatsink (that is, a plain aluminium finish), the cost is almost halved from that of a ready anodised type, and it is not a lot of trouble to spray this cheaper version either with matt or satin black car primer type paint.

Fixing of the heatsink is carried out using four captive nuts which can be slid into position on the rear of the 'sink, and these will be used later on in the construction. First of all, holes have to be drilled (if this is not already done) for the two 2N3055 pass transistors, see Fig. 6a; these are TO3 mountings and an insulating washer can be used here as a template.

Drill these holes accurately and (for the actual fixing holes) of the correct size to suit the insulating washers and bushes supplied for the 2N3055's. Ensure that the holes are thoroughly de-burred or you will have trouble with the insulation when you carry out the mounting procedure as illustrated in Fig. 6.

If mica washers are used, they should be given a smear of heat conductive compound on each side. The alternative silicone rubber washers do not need this and this sort give a better heat transfer than mica types.

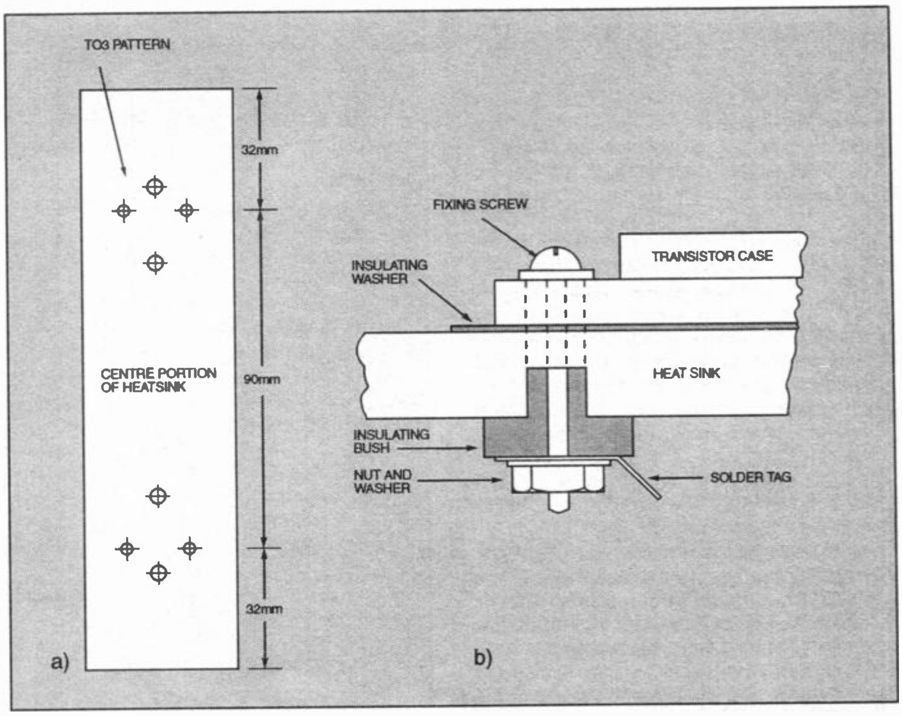


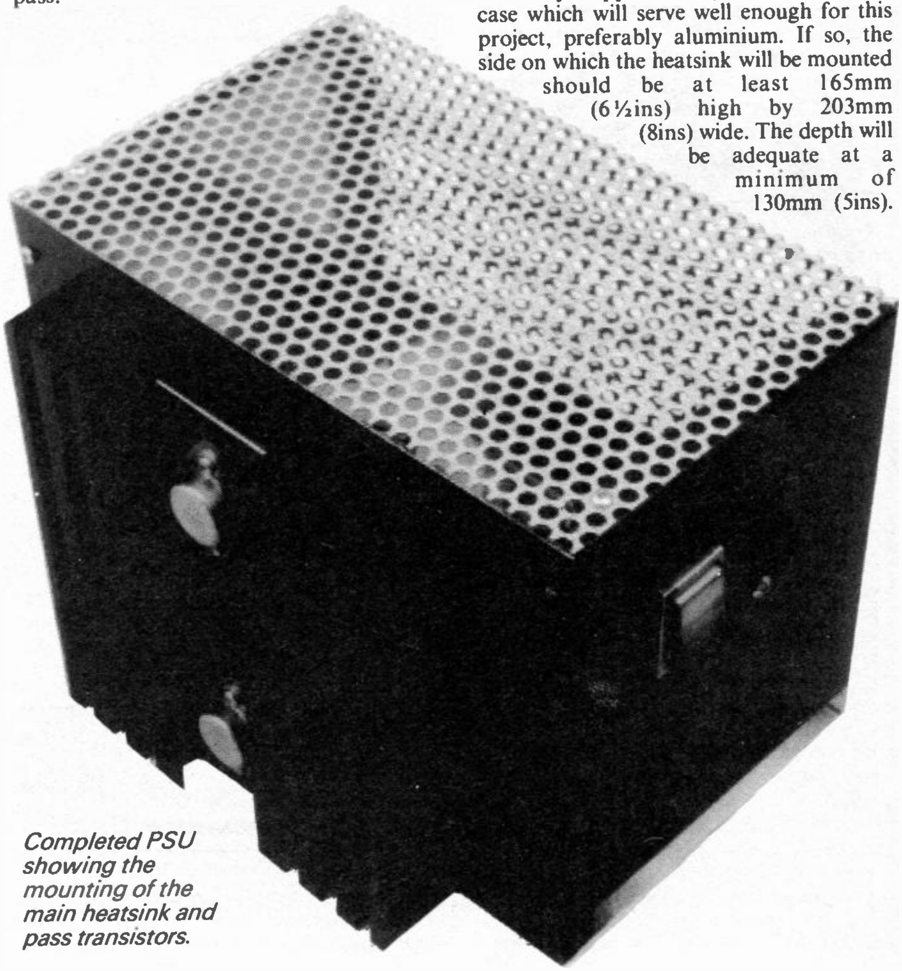
Fig. 6. The main heatsink drilling and mounting details for the power transistors TR1 and TR2. Note that the transistor body is also its collector contact.

Put a solder tag under one each of the transistor fixing nuts for making a later connection to the collectors (c) as Fig. 6 shows. When completed, check carefully that the collectors (the cases) are *insulated* from the heatsink and that the base (b) and emitter (e) pins are clear of any contact with the heatsink holes through which they pass.

You will need room to solder a fairly heavy-duty flexible lead to the emitter pins later on, so make sure you will have enough clearance for this stage. It is essential, however, that you do not make these pin holes excessively large or a large area of thermal contact with the heatsink will be lost; a 5mm hole should be considered a maximum size.

MAIN CHASSIS

It may happen that you have a metal case which will serve well enough for this project, preferably aluminium. If so, the side on which the heatsink will be mounted should be at least 165mm (6½ins) high by 203mm (8ins) wide. The depth will be adequate at a minimum of 130mm (5ins).



Completed PSU showing the mounting of the main heatsink and pass transistors.

For simplicity of assembling the project, however, it is as well to make up your own case, and this can be done by initially bending a piece of 18 s.w.g. aluminium measuring 347mm (13¾ins) by 205mm (8ins) approx. to the form shown in Fig. 7. The large vertical side of this then carries the heatsink and, on its inside face, the p.c.b.

The other large components then occupy the floor or base, with the output terminals on the smaller rear panel. Two sides are fitted later, one of which will carry the mains input socket and the mains switch.

The holes to be made in the base of this chassis are not shown in the diagram as their exact positions will depend upon the components used; the mountings and physical sizes can vary slightly between manufacturers. The fixing holes are therefore best left until the components are to hand. We will return to this later.

At this stage it is a good plan to get the heatsink mounted on the vertical side of the chassis. This means aligning it so that it is central on the aluminium face and that the two 12·5mm (½in.) holes coincide with the transistor positions already drilled on the heatsink. The collector, base and emitter wires can then in due course be brought through the holes for connection to the appropriate solder pins on the p.c.b.

The holes for securing the heatsink itself to the panel have to suit the positions set for the captive nuts and some care is required to ensure the coincidence of the holes and nuts. The best way here is to slide the nuts along their channels so that they are set in line with the mid-point of the transistor drilling groups at each end. The four fixing hole positions can then be fairly easily marked and drilled on the panel so that alignment is secured.

This arrangement of the holes is illustrated in Fig. 7, though you can, of course, do you own thing if you have other (and perhaps better) ideas of how to cope with the alignment. Using 4BA screws, now temporarily fit the heatsink to the panel as a general check on the positioning.

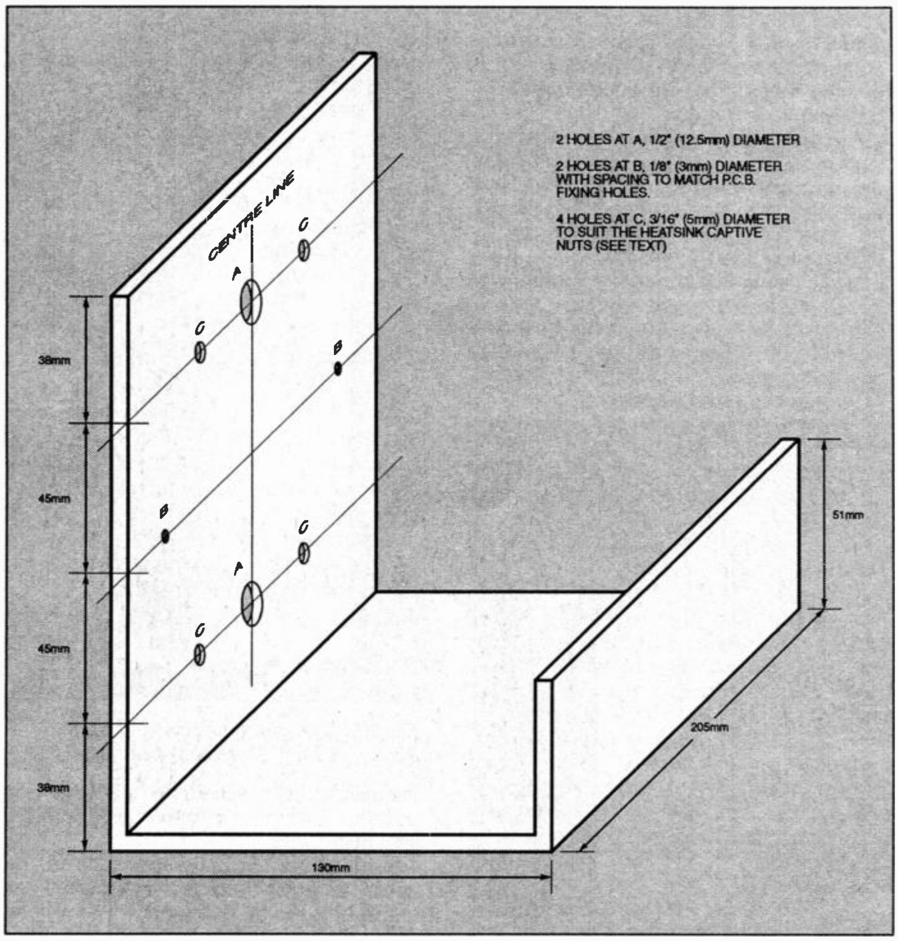


Fig. 7. General details of the main chassis. Side fixing holes and rear output terminal holes are not shown as this depends on components used.

TOROIDAL TRANSFORMER

There is nothing particular to say about the bridge rectifier REC1 or the reservoir capacitor C1, but a note is called for about the toroidal transformer. This component is easily fitted to the floor of the chassis by a single central bolt which is supplied with the transformer, along with a dished metal washer and two protecting pads. Make sure when mounting this component that these pads are fitted above and below the windings so that the dished washer is on top of the upper pad.

To make things neat and tidy and to avoid having to manipulate heavy gauge wiring around the assembly, the dished washer should have a strong 3-way tag strip (or a heavy-duty 2-way "chocolate block" may be used) bolted to it so that the secondary wires can be terminated close to the transformer itself; there are two secondary windings which are paralleled, and the connections to be made for this are supplied with the transformer. It is important when fitting the tag strip that the screw used is countersunk so that there is no projecting head pressing on to the upper pad when the washer is screwed down.

Under no circumstances must the dished washer be electrically connected to the chassis, or the central screw will act as a short-circuited turn and damage the transformer.

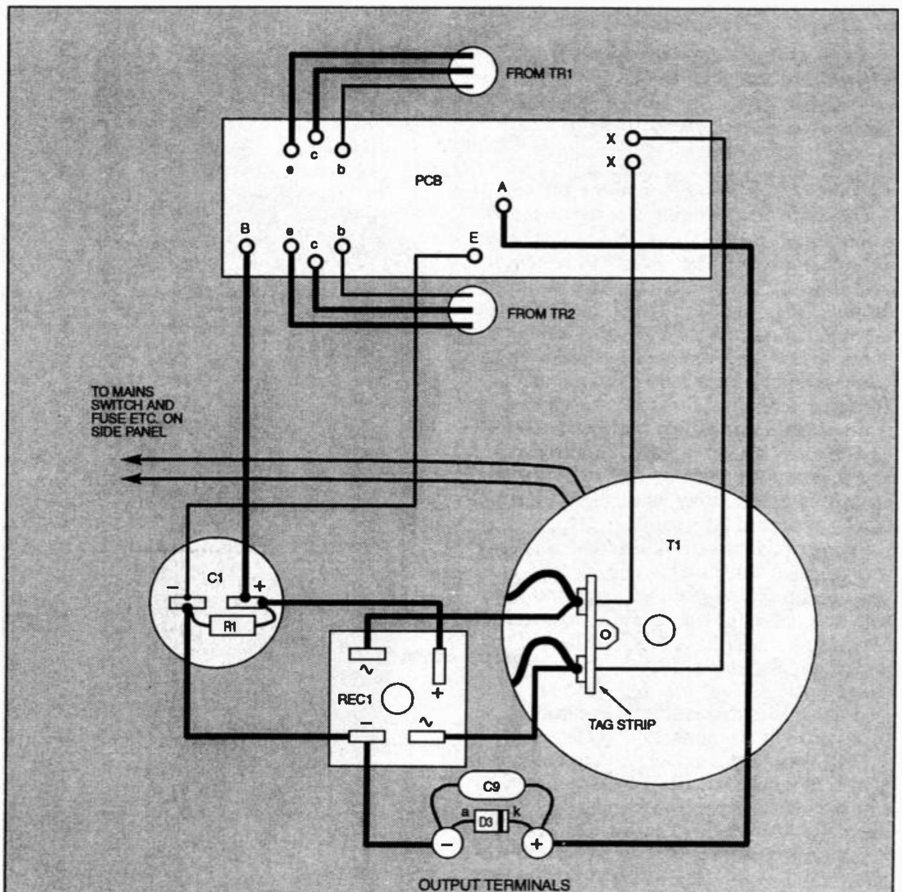


Fig. 8. Mounting positions of the "floor" components and interwiring. The heavy duty wires are shown as thicker leads. The two secondary windings of the transformer are paralleled together and their leads soldered to the tag strip.

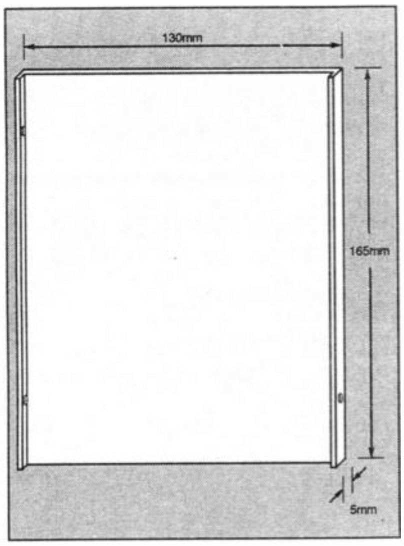


Fig. 9. Overall side panel details. Actual measurements depend on main chassis size..

COMPONENTS

Approx cost guidance only **£55**

Resistors

R1	56k 1W
R2, R3	0·18Ω 3W wirewound (2 off)
R4	0·22Ω 6W wirewound (2 off) – see text
R5	180Ω
R6	2k
R7	3k3
R8	1k5

All 0·25W carbon film, except where stated

See SHOP TALK Page

Potentiometers

VR1	100Ω enclosed, top adjust, carbon preset
VR2	2k enclosed, side adjust, carbon preset

Capacitors

C1	22,000µ radial elect. 35V, 10A ripple rating
C2, C3	10n min. polycarb. 63V (2 off)
C4	1µ polyester layer, 63V
C5, C9	100n poly. layer, 100V (2 off)
C6	220p ceramic
C7	330µ radial elect. 35V
C8	100µ radial elect. 35V

Working voltages are minimum values

Semiconductors

D1, D2, D3	1N4002 100V 1A rectifier diode (3 off)
TR1, TR2	2N3055 power transistors (2 off)
TR3	TIP41A power transistor
IC1	L123 voltage regulator, TO100 base
REC1	100V 25A bridge rectifier

Miscellaneous

T1	Toroidal transformer 120VA, 15V + 15V secondaries
S1	Double-pole on-off 250V toggle switch, or with indicator
FS1	Fuseholder, panel mounting, with 1A cartridge fuse
SK1	3-pin, chassis mounting, Bulgin plug with line socket
SK2, SK3	Red and black, chassis mounting, screw terminals

Printed circuit board available from *EPE PCB Service*, code 979; 18 s.w.g. aluminium sheet, for main chassis, size 347mm x 205mm approx.; aluminium side panels, size to choice – see text; ribbed 1·2W/°C (unanodised) heatsink, size 152mm x 130mm; small TO220 heatsink, 12·5mm p.c.b. spacers, 2 off; stick-on rubber feet, 4 off; fixing nuts and bolts; multistrand connecting wire, gauge to suit – see text; solder pins; solder etc.

OVERALL ASSEMBLY

Having completed the preliminary stages of construction detailed above, the overall assembly and wiring of this power supply is fairly straightforward. First of all, solder the collector, base and emitter leads to the pass transistors TR1 and TR2. These leads should at this stage be cut to about 100mm (4ins) in length, and for the collector and emitter, heavier gauge wires are needed.

Flexible 24/0·2 PTFE insulated wire should be considered as a minimum gauge; the base lead may, however, need be only 7/0·2 or similar. Use different colours so that there is no confusion when these wires are routed from the heatsink to the p.c.b. and check again *after* you have completed the soldering that there is no electrical contact between any of the leads and the heatsink.

Bolt the heatsink on to the chassis (which should have its main panel sprayed matt black on both sides), threading the connecting wires through their respective holes. Make sure that the leads come cleanly through the holes and do not get crumpled up between the heatsink and the chassis.

Now mount the printed circuit board to the rear of the panel, spacing it off by about 12·5mm (½in) with suitable spacers or nuts. Solder the leads from TR1 and TR2 transistors to the appropriate solder pins on the board, shortening them as necessary as you proceed but without pulling them tight in any way.

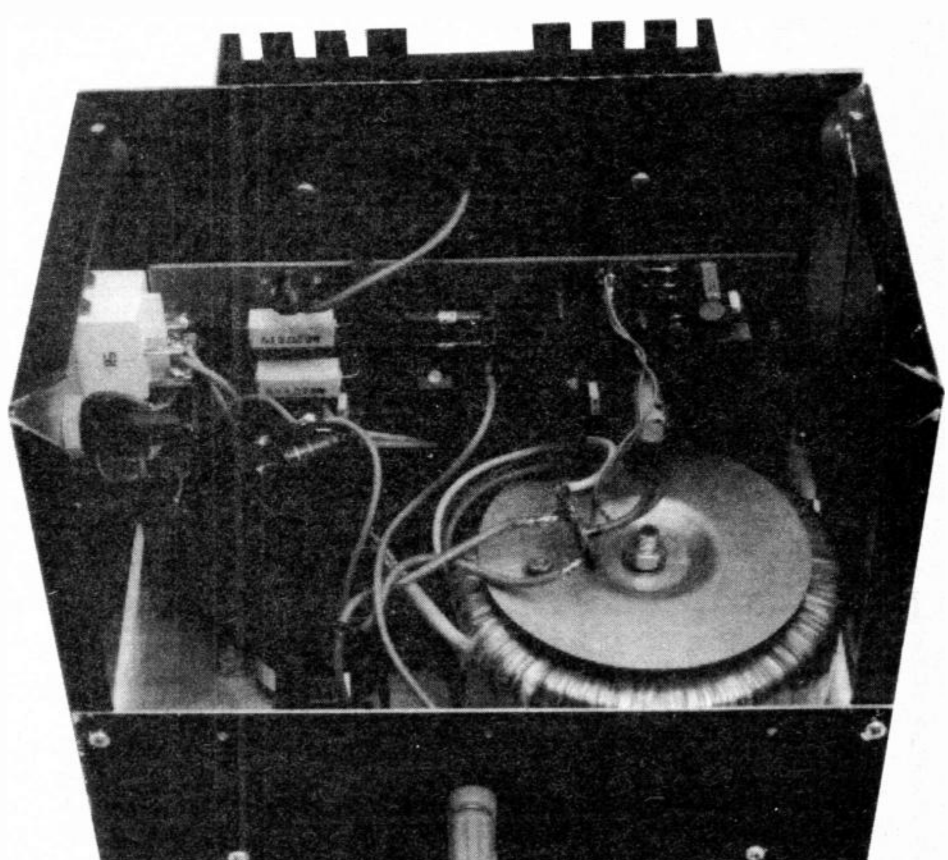
The remainder of the wiring can now follow the pattern shown in Fig. 8 which shows a flattened view of the assembly. Only those leads shown in the *heavy* lines need be of substantial gauge.

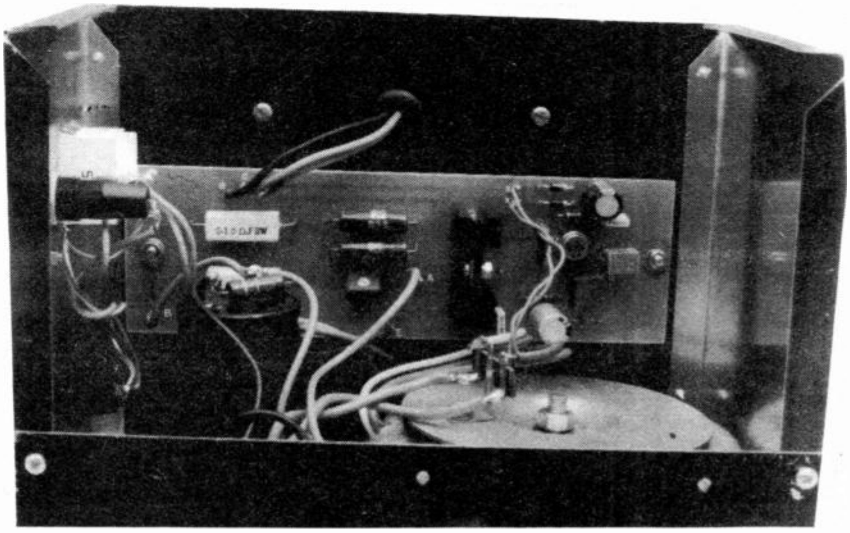
ON THE FLOOR

The floor mounted components (toroidal transformer, reservoir capacitor and bridge rectifier) are not particularly critical in their positions and for this reason no dimensions have been shown. Simply ensure that there is no fouling with other parts, then drill single fixing holes for the transformer and bridge, and two holes for capacitor C1 to suit the clip into which it will be mounted. The paralleled pairs of the secondary transformer windings are perhaps best shortened, thoroughly cleaned of enamel and soldered to the tag strip before mounting the component.

Connections to the bridge rectifier REC1 (and possibly to the large electrolytic capacitor) are best made using crimped push-on type connectors, though if your crimping may be suspect, these can be soldered to the leads. It is *not* good practice to solder directly to the bridge rectifier tabs.

The primary leads from the transformer are taken directly to the side panel (to be described) where the mains input socket, switch and fuseholder are fitted. Either side panel may be used for this purpose; just ensure that none of these side components will foul the internal parts when the side panel is fitted.





The completed p.c.b. bolted in position on the main chassis. Note the rubber grommet protecting the leads from the power transistors.

SIDE PANELS

Two side panels need to be fitted to the main chassis piece of Fig. 7 and these should be made to the pattern shown in Fig. 9. They should be bent to fit snugly into each side of the chassis and secured with self-tapping screws to suit holes in the front and rear panels. You will probably find that you have to adjust the given dimensions slightly, depending upon actual dimensions of the first chassis.

When these sides have been fitted, the unit will be secured in a box with a low back panel and an open top. The final boxing-in should not be done with solid aluminium sheet but to help with ventilation should be covered with some perforated material, steel or aluminium, bent to the shape as seen in the photograph(s) of the completed unit. This again is secured with a few self-tapping screws.

One of the side panels (you can make your own choice here) is drilled to accommodate the mains switch S1, fuseholder FS1 and (if required) a neon indicator. In the prototype an illuminated switch was used with a panel mounting fuseholder.

An ordinary double-pole toggle switch may be used instead, with a separate indicator, and the mains lead may be brought out through a suitably grommeted hole instead of using a 3-way mains input socket as in the prototype. This part of the construction is simply a matter of positioning whatever parts you have so that there is no fouling with other parts when the panel is fitted, and consequently the drilling pattern is a matter of your own choosing and convenience.

SETTING UP

There is little to do in the way of checking and setting up the project. Start with both preset potentiometers VR1 and VR2 set to their mid-positions and connect a voltmeter across the output terminals.

On switching on, the voltmeter should give an indication of the output voltage and be capable of adjustment through a limited range (about 11V to 16V) by preset VR2; set the output to 13·8V if this is the level you require, or whatever you might need within the available range.

Adjustment of preset VR1 must be made so that the output current for a short-circuit load condition does not exceed about 8A. The output characteristic is flat within about 0·2V over the range 0 to 7A, but *must* begin to *fall rapidly* after this level as the load increases, thus restricting the output current to about 8A under shorted conditions.

It is a bit difficult to check on the stability of the output over the current range without a fairly massive adjustable resistance to act as the load (a 15ohm slide type potentiometer capable of carrying 10A just happened to be to hand). But you can check the stabilization of the output voltage at a few current levels by using, say, 6W or 10W resistors of value 6·8Ω, 3·3Ω, and 2·2Ω, having them switched on *only* long enough for you to take the voltage reading. If the voltage remains within about 0·2V of your initial setting, there should be no problems with the stabilization.

It may happen that at a lower current, the voltage drops; this indicates that VR1 needs setting accurately, as the current limiting is coming on too soon. In this case, the setting of VR1 should be slightly increased with a clockwise rotation until the drop vanishes.

The easiest way of setting preset VR1 is to connect an ammeter capable of reading up to 10A (which most digital types will do) directly across the output terminals; this then acts as a virtual short-circuit. Switch on and adjust VR1 to give a reading of 8A on the meter. *Do not to take an excessive time over this check.* The unit should then be correctly set up.

CHECK POINTS

There are one or two measurements you can make around the circuit to provide a general purpose look at the unit's operation. The voltage across capacitor C1 should be about 23V to 24V when drawing a current of about 5A; this voltage will vary slightly with the actual load, but should not change by any significant amount.

The voltages across resistors R2 and R3 should be approximately equal; any serious difference will indicate that one of the pass transistors is not doing its stuff, and an investigation should be made.

Make sure, also, that the heatsink has clearance from any heated surfaces such as radiators and that the air flow around it is unrestricted.

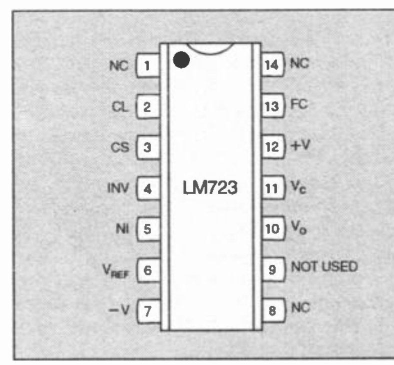


Fig. 10. Pinout details for the LM723 14-pin d.i.l. alternative regulator. If this device is used the p.c.b. will need altering.

ALTERNATIVE REGULATOR

For those who like to design and make their own boards, the TO100 based L123 can be replaced by the LM723 14-pin d.i.l. version.

There are three "no-connection" pins on this version, but the other pins are equivalents to the pins on the L123, though pin 9 is ignored. The pin connections for this regulator are given in Fig. 10. □

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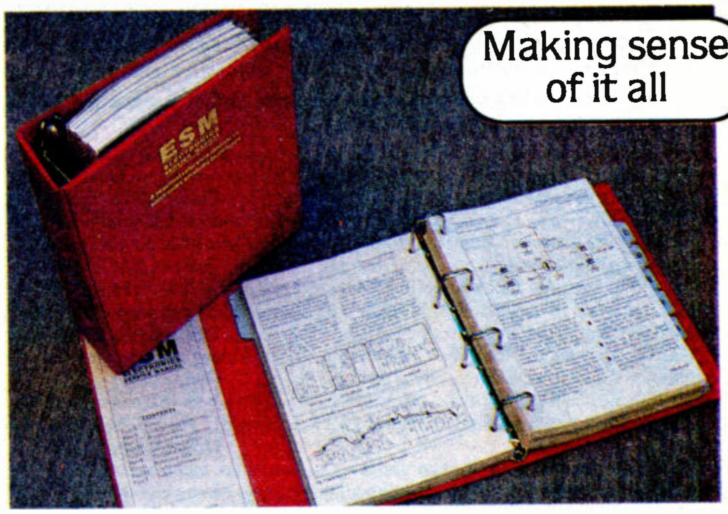

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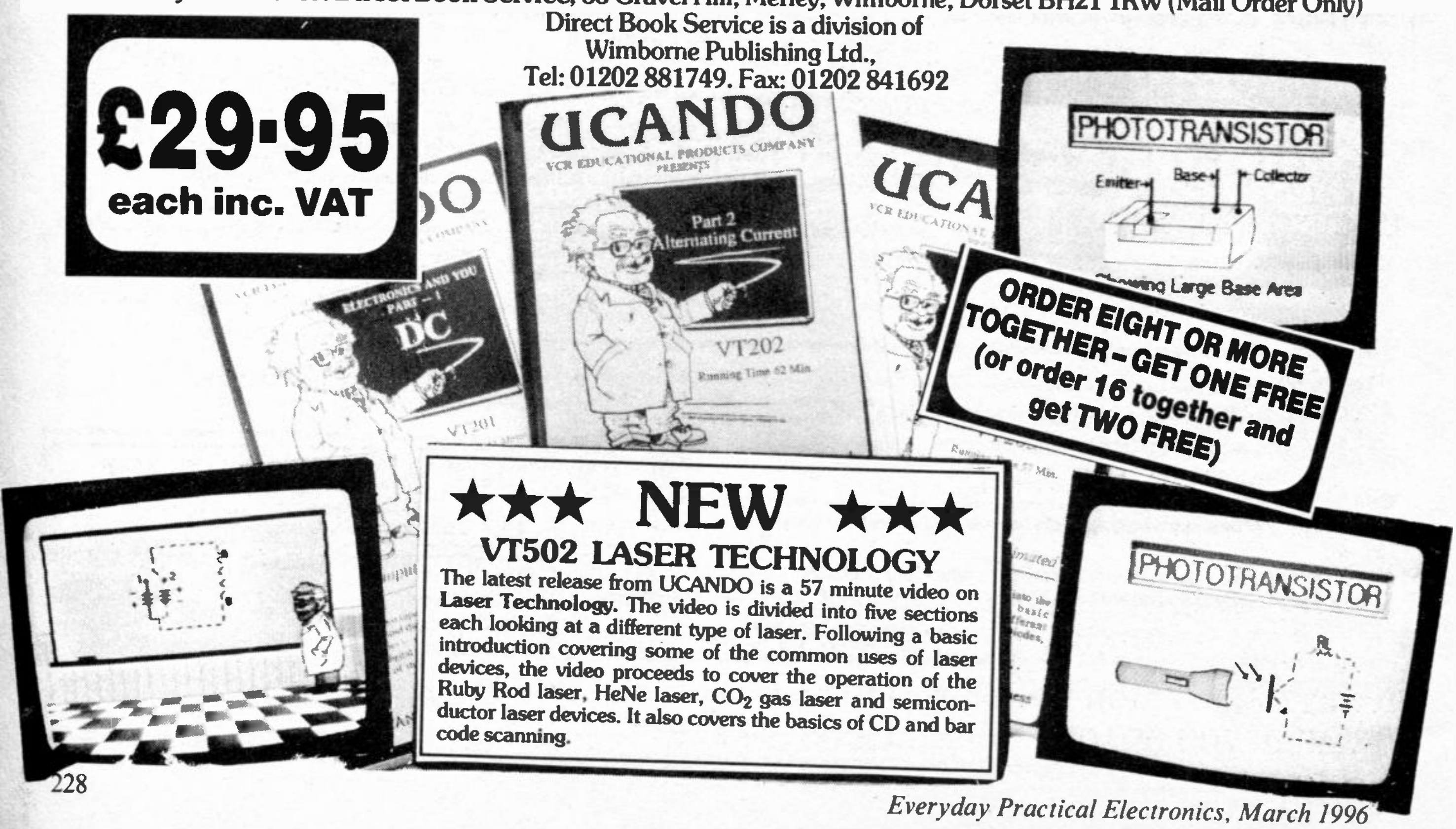

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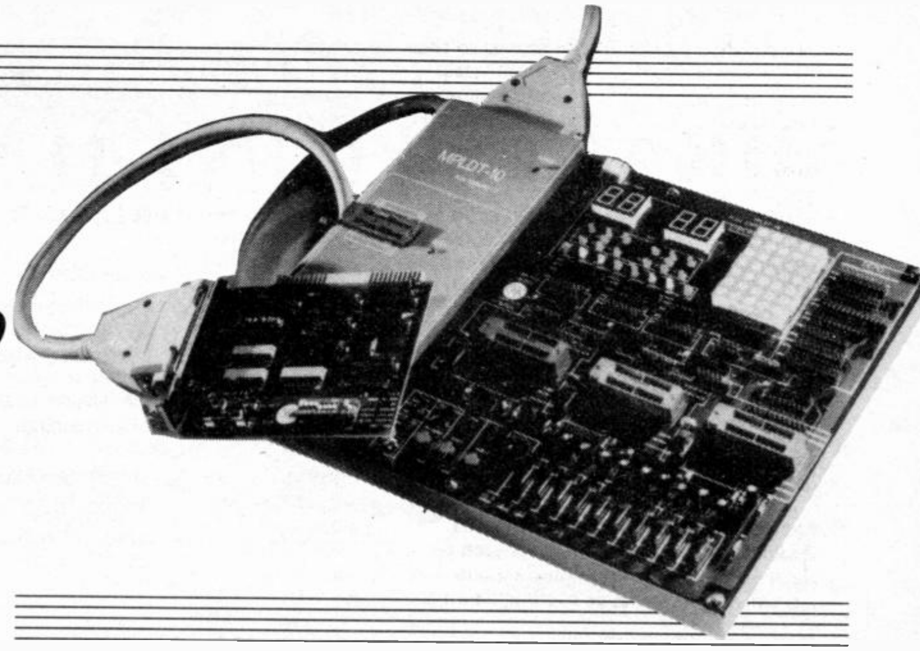
VT502 LASER TECHNOLOGY

The latest release from UCANDO is a 57 minute video on **Laser Technology**. The video is divided into five sections each looking at a different type of laser. Following a basic introduction covering some of the common uses of laser devices, the video proceeds to cover the operation of the Ruby Rod laser, HeNe laser, CO_2 gas laser and semiconductor laser devices. It also covers the basics of CD and bar code scanning.



PAL TRAINER REVIEW

CHRIS ROBERTS

Flight Electronics' PLD training system is an ideal tool for learning about and designing with programmable logic devices.

THERE has been a revolution in the field of digital electronics in the last few years since the advent of programmable logic devices (PLDs). These are essentially single chips containing large arrays of simple logic gates that can be interconnected in different ways to achieve complex circuit designs.

The interconnections are programmable. Hence the same type of inexpensive chip can be used to implement a large number of different designs. This revolution has led to a great reduction in the development and production costs of highly complex electronic systems.

One of the major advantages of PLDs is the effect of design changes. These would normally require changes to a printed circuit board layout when conventional logic is being used. When PLDs are used, though, it may only be necessary to modify the program.

PLD Training

It is very easy for both the hobbyist and the professional to be left behind when major revolutions occur. The main problem facing anybody trying to get to grips with such innovations has been that of choosing and obtaining the appropriate bits and pieces of hardware, the software needed to drive it, and sufficiently supportive documentation and information on how to make it all work!

The PC-based PLD training system reviewed here, the PAL Trainer supplied by Flight Electronics International Ltd., is a complete training system, comprising hardware, software and documentation, that has been designed specifically to fulfil this requirement. It is intended to be a complete self-teach package that would be beneficial in the workplace as a training system, but would have continued usefulness as a GAL (gate array logic) or PAL (programmable array logic) programming and testing system.

Its obvious application is as a training aid for use in colleges and training centres to promote understanding of PLDs at all levels.

System Requirements

An IBM-compatible PC is required to operate the system, but it does not have to be particularly exotic! The minimum requirements are an IBM PC XT, PC AT, PS/2 or 100% PC-compatible computer with a minimum of 512KB of free system RAM and 10MB of hard disk space for the software. The operating system should be MS-DOS 3.1 or later.

Hardware

The hardware includes a small interface card to be installed in the PC. This card only requires an 8-bit expansion slot. In the unlikely event of a conflict occurring, the I/O address can be changed to anything in the range 0 to 3FF hexadecimal by means of a 10-way dual-in-line switch on the card.

Connection of the interface card to the main unit is via a supplied cable having 37-way D-type connectors. The cable also provides the power for the main unit from the PC. The power supplies are protected by fuses on the interface card.

The main unit is constructed as a printed circuit board mounted on a sturdy metal case with external dimensions of approximately 30cm by 23cm. The left hand one-third of the unit is the GAL programmer. This section is totally enclosed by a metal cover that has a zero insertion force (ZIF) "Textool" socket mounted on it for programming and testing 20-pin or 24-pin GAL devices. One GAL 20V8 and three 16V8 devices are provided in the package.

GAL devices are electrically erasable programmable i.c.s that can be re-used to try out many different circuit designs. They can be used to emulate a large number of the one-time programmable PAL devices.

The remaining two-thirds of the main board is the experimental area. In the centre are three "Textool" sockets for receiving the GALs that the user has programmed in the programmer part of the unit. Their pin connections are brought out to rows of connectors on each side of the sockets. Patch leads are provided to enable connections to be made to the various input and output devices provided on the board:

There are 22 individual red, yellow and green l.e.d.s. They are arranged in patterns to facilitate the display of dice and traffic light patterns as well as for general use.

There are also four 7-segment l.e.d. displays which are ideal for building clock experiments. They are normally connected to 7447 decoder/driver chips and driven via these in 4-bit binary. However, the individual segments of one of the 7-segment displays can be driven directly by removing some jumpers provided on the board.

The third output system is a 5-by-7 dot matrix l.e.d. display. This can be driven to display a variety of symbols and patterns as well as alpha-numeric characters.

Input devices that can be connected to experimental GALs include ten individual slide switches that are all connected via debounce circuits to ensure clean high or low outputs. There are three debounced pushbutton switches, one of which has two complementary outputs.

Finally, three separate clock generators are included: one with a frequency of 1Hz; one at 10kHz; and one with a frequency that is variable from 1Hz to 1kHz.

This range of input and output facilities allows a wide range of practical experiments to be devised, as well as the testing of more complex designs by simulation.

Demonstration Experiments

One of the novel features of the trainer is the provision of some demonstration experiments that allow the first time user to obtain interesting results fairly rapidly. To implement this feature, the top right corner of the main board has an area of connecting pins arranged in sets, each associated with a particular experiment.

By fitting sets of jumper links, all of the interconnections needed for a particular experiment, between the GAL sockets and the input and output devices, can be set up very rapidly and accurately. This is so that students can avoid the laborious task of connecting up patch leads. The jumpers used to make these connections are similar to those used on PC motherboards and expansion cards to select options. Those provided are moulded into blocks capable of linking up to nine pairs of pins at a time.

However, the problem is that the friction of this number of connectors is enormous. They are small and fiddly and not provided with any sort of handle or gripping device. Consequently, they are very difficult to remove. I had to resort to a pair of pliers to remove one of them and ended up breaking the plastic body of the connector.

Another area of concern was triggered by this problem with the jumpers. Whilst attempting to prise them off with a screwdriver, I was conscious of the danger of an accidental short-circuit between pins. There is no power switch on the main unit and the connecting cable carries prominent red labels warning that the system's power should be switched off before connecting or disconnecting. Thus, to play safe, it appeared necessary to switch off the PC when removing the jumpers.

(Flight Electronics advise that the red labels refer to the programming section, not the experimental section, which has no power connections available to short-circuit as they are hidden. Ed.)

Software

Two software packages are provided with the training system. The first, called PGAL, is produced by Flight Electronics and is the program to operate the GAL programmer. It runs under MS-DOS and was very easy to install and use. It is menu driven and provides the following facilities:

EMULATION:
Modes can be selected whereby one of the two types of GAL provided can be used to emulate one of a large range of industry standard PAL types.

DOWNLOAD:
Loads a JEDEC standard programming file from disk into the PC memory ready for programming the GAL. This is the standard type of file generated by PLD design software such as PALASM 4. A number of demonstration files are provided with the software package, as described later.

PROGRAM:
Used to program the GAL in the programmer ZIF socket with the JEDEC file loaded into memory by the "download" facility.

VIEW:
Enables the contents of the PLD in the ZIF socket to be read.

This software was found to be very simple to use. I was able to work quite quickly through the examples provided, programming the GALs and trying out the designs on the experimental area of the trainer.

Professional PLD Software

The second software package provided with the training system is PALASM 4 produced by Advanced Micro Devices (AMD). This is a full blown professional PLD design system, widely regarded as the standard. It has to be installed from four diskettes and is supplied with two thick reference manuals. The software also runs under MS-DOS and is menu driven.

Because this is the full professional design system, it is very powerful and has many features. As a consequence it takes a little longer to find one's way around. There are worked examples provided both in the AMD reference books and in the Flight Electronics manual for the training system which ease the learning process considerably.

The software allows you to enter the details of your own logic design and convert it into the data required for programming the PLD. The first step is to designate the pin numbers that will correspond to the inputs and outputs of your circuit. The function of the circuit is then defined using Boolean algebra expressions relating to the designated pins. A simulation can then be performed to verify the function of the circuit design. The final stage is to compile the JEDEC file that will be used to program the PLD.

There is also a facility to link the program to the popular electronics CAD program OrCAD SDT/III. This facility allows the logic design to be entered as a schematic diagram instead of a text file containing Boolean expressions. Unfortunately, I did not have the facility to try this approach.

The software provided makes it possible to design complex logic circuits and implement them very rapidly in silicon. They can then be tested in the experiment area of the trainer.

Documentation

As already mentioned, PALASM 4 is supplied with its own manuals: a "getting started" workbook and a comprehensive reference manual. Together these cover the use of the PLD design software very thoroughly. In addition, and generally more useful initially, is the "user manual" for the training system provided by Flight Electronics.

This is very clearly presented in a user-friendly style. It covers the installation of the hardware and software very comprehensively. The philosophy of the manual is to lead the user quickly through the installation process and a brief tutorial on the software, into some practical experiments using example PLD programming files provided with the software. This captures the user's attention at an early stage by allowing him or her to produce some interesting results fairly rapidly.

It is a technique that works very well. There are four demonstration programs which range from producing dice patterns on a group of l.e.d.s to a four-digit 24-hour clock. The latter design, for demonstration purposes, uses three GALs to drive the hours, minutes and seconds displays.

After working through this tutorial the user should quickly become quite competent at using the programmer and experimental board. This naturally encourages users to progress to creating designs using PALASM. The system is then being used as a design tool rather than just a teaching aid.

The last chapter of the user manual is a tutorial on using PALASM 4. It contains 17 worked examples of producing combinational and sequential logic designs. These examples include those used for the four demonstrations in the introductory tutorial.

The user manual supplied is very impressive. Flight Electronics say that some minor omissions and errors in the one received have been corrected in the new version now released. They have gone to great lengths to make it easy to use, employing a step-by-step tutorial style.

For a total newcomer to PLDs, I felt that it would be useful to include a general introduction to these devices that explains the differences between the terms PLD, PAL, GAL etc. However, when this was discussed with Flight Electronics they advised that it has been done in the revised version of the manual.

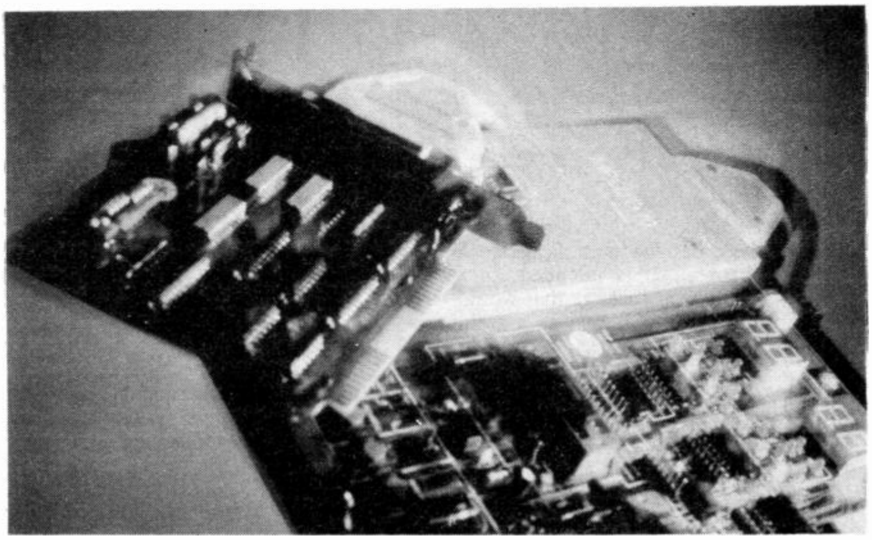
Overall Impression

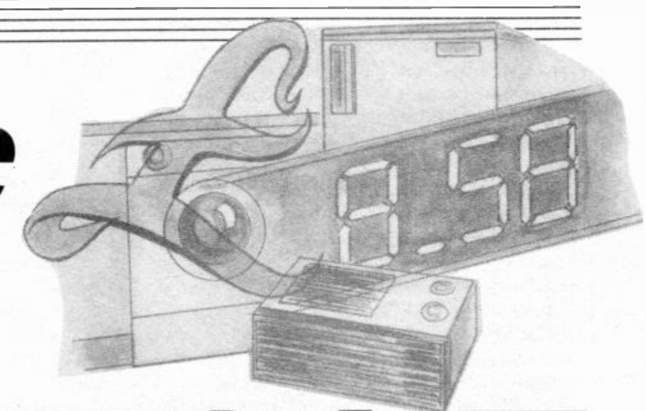
The system as reviewed provides an easy-to-use introduction into the world of PLDs. The excellent user manual means that the system could be used as a self-teach package. Provision of the professional PALASM 4 design software also means that the system is useful in a working environment as a design tool when not required for training purposes.

It would make a superb teaching aid for colleges of further and higher education, although I am not sure how student-proof it would be with the jumper removal problems.

Considering the whole package, which costs £695, the Flight Electronics PAL Trainer seems good value for money.

For further information about this trainer, contact Flight Electronics International Ltd., Dept. *EPE*, Ascupart Street, Southampton SO14 1WP. Tel: 01703 227721. My thanks are offered to Andrew Padley of that company for his assistance. □





PIC-ELECTRIC METER

JOHN BECKER

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- ★ Initial setting-up (very simple)

Last month the operating theory and circuit details, including the special current transducer, for the PIC-Electric Meter were introduced. This concluding article covers the practical construction, testing procedures and using the Meter.

SOFTWARE

Software of the source-code listing for the PIC-Electric Meter (together with last month's Simple PIC16C84 Programmer software) can be supplied from the Editorial Office as a 3·5in. disk (UK £2.50, overseas surface £3.10, airmail £4.10). A pre-programmed PIC16C84 chip (together with p.c.b.s) for PIC-Electric, ready to plug straight in, is obtainable from Magenta Electronics. See *Shoptalk* for details.

Readers who buy the pre-programmed chip do not need to have a computer in order to build this project.

CONSTRUCTION

Two printed circuit boards (p.c.b.s) are used in the PIC-Electric Meter, the Sensor and PSU p.c.b. and the Control and Display p.c.b. They are available from the *EPE PCB Service*, codes 977 (Sen./PSU) and 978 (Cont./Dis), respectively. Their topside component positioning and full-size copper foil track master layouts are shown in Fig. 7, Fig. 8 and Fig. 9.

Start assembly of the boards by inserting the on-board wire links, two of which pass under i.c.s. Continue by inserting the resistors and diodes. Next, solder in the d.i.l. i.c. sockets. The remaining components can then be inserted in any order found to be most convenient.

Make sure that all polarity-conscious components are correctly orientated. Capacitors C7, C11 and C12 are mounted on the rear of the p.c.b. to keep a low profile on top of the board. Crystal X2 is mounted flat with the top of the board. A sub-miniature l.e.d. is suggested for D9 because of its low height.

If you do not intend programming your own PIC microcontroller, diode D7 may be replaced by a link wire and the following components may be omitted: S1, D8, D9, D10, R19, R22, R23.

The pushbutton switches, S2 to S4, used in the test model were short shafted types requiring the use a pencil or similar to access them through the case holes. Long shafted types, if available, may be substituted if preferred. Slide switch S1 is a plastic p.c.b. mounting type, with both sets of contacts connected in parallel on the board.

DISPLAY

Mounting the display module X3 first requires rigid wires to be soldered into its required connection holes (not all holes are used, as will be seen in Fig. 7). Some wires and holes may need to be soldered on both sides, as examination of the display module will show. Resistor off-cut wires can probably be used, though 25mm lengths of 24s.w.g. tinned annealed copper wire cut from a bobbin will prove more convenient.

Trim the loose wire ends to the same length, straighten and align them, then (patiently!) insert them into the p.c.b. holes.

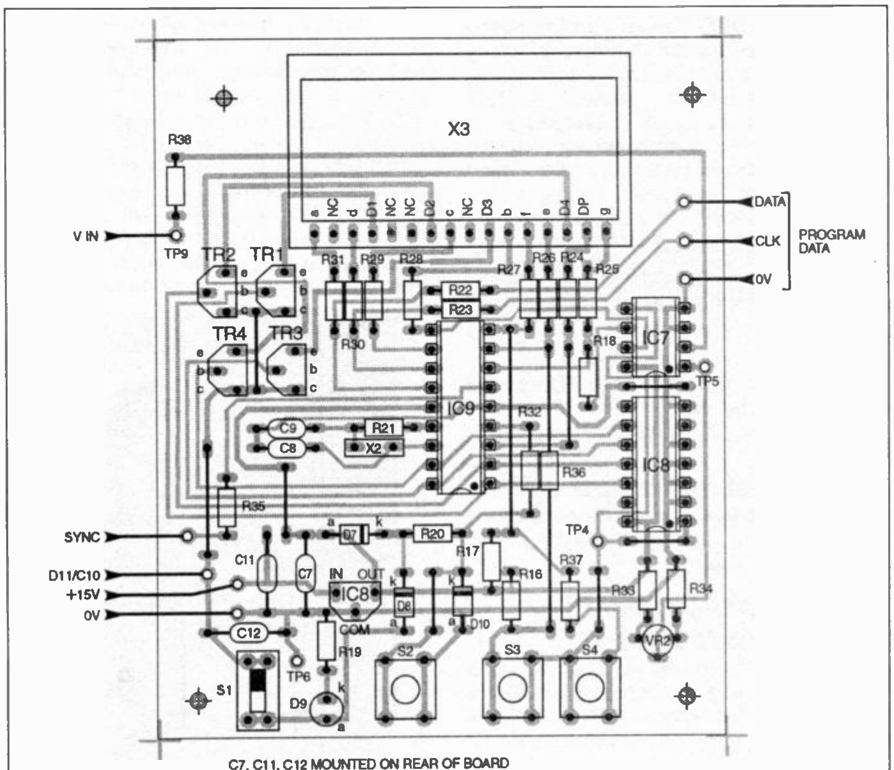


Fig. 7. Component layout for the Control and Display printed circuit board.

If a wire is reluctant to go into a hole, a thin bladed screwdriver can be used to assist. Make sure all wires are inserted, then press the display flat to the p.c.b. and solder the underside protruding wires to their pads.

Insert 1mm terminal pins into the boards for the test points (TP) and low voltage connecting wires.

CASE DETAILS

A plastic case measuring 188mm × 108mm × 160mm was used to house PIC-Electric. All holes should be carefully marked before drilling to ensure that they align with the p.c.b.s.

An oblong hole (see photographs) needs to be cut in the right-hand side of the lid for the display to be seen. This can be easily achieved by drilling a series of small holes around the inner perimeter of the area to be removed. Careful use of a chisel will make the final cuts between the holes, after which the edges can be filed to shape.

Three holes are needed to suit the push-button switches, and two holes in the side for the mains cable entry and exit glands. Four more holes are required for the bolts which secure the display board to the inside of the lid. It is best not to bolt this board in position until testing and PIC programming are complete.

The Sensor and PSU p.c.b. is bolted to the left-hand side of the base of the case via suitably positioned holes.

Mains carrying input and output cables MUST be capable of handing the maximum currents drawn by appliances which are to be monitored. Normal household 13A 3-core mains cable will normally be suitable. In the test model, the output cable was terminated by a 4-way 13A socket block enabling several appliances to be monitored simultaneously. Other sockets could be used instead.

A separate fuse was not used with the test model, though one may used if preferred, mounting its fuseholder in the side of the

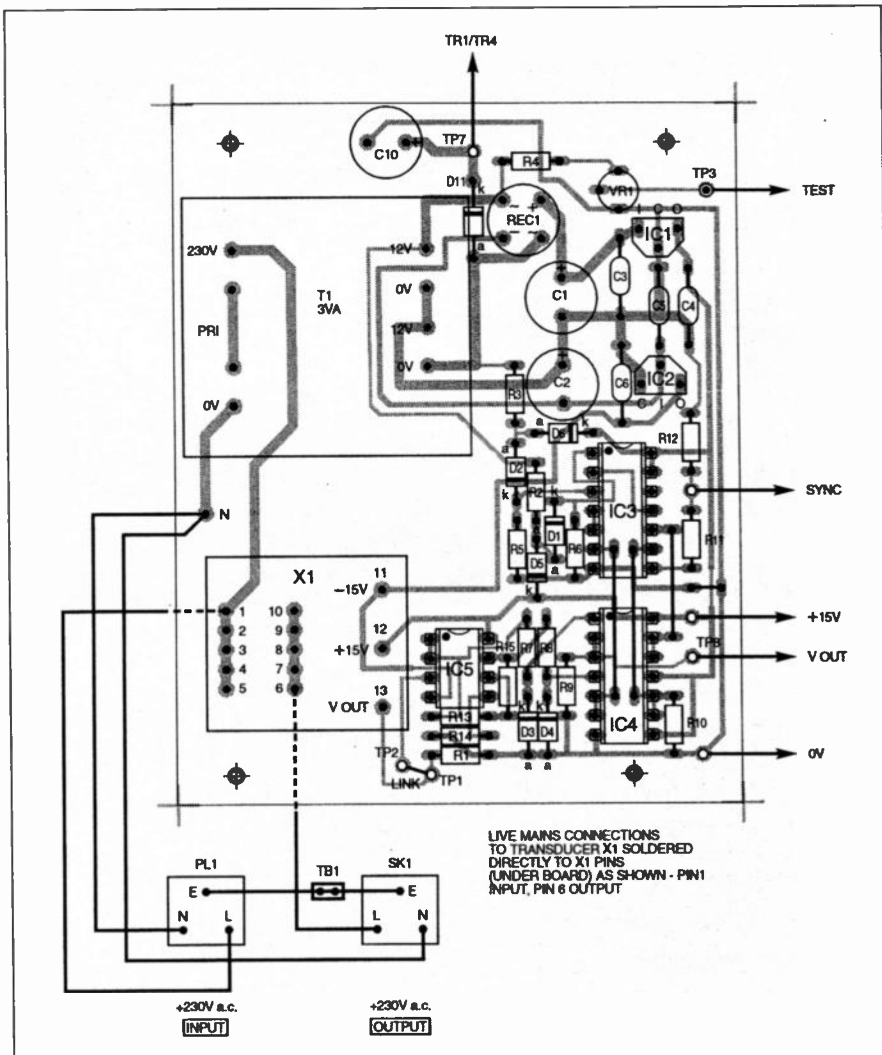


Fig. 8. Printed circuit board component layout and wiring for the Sensor/PSU board.

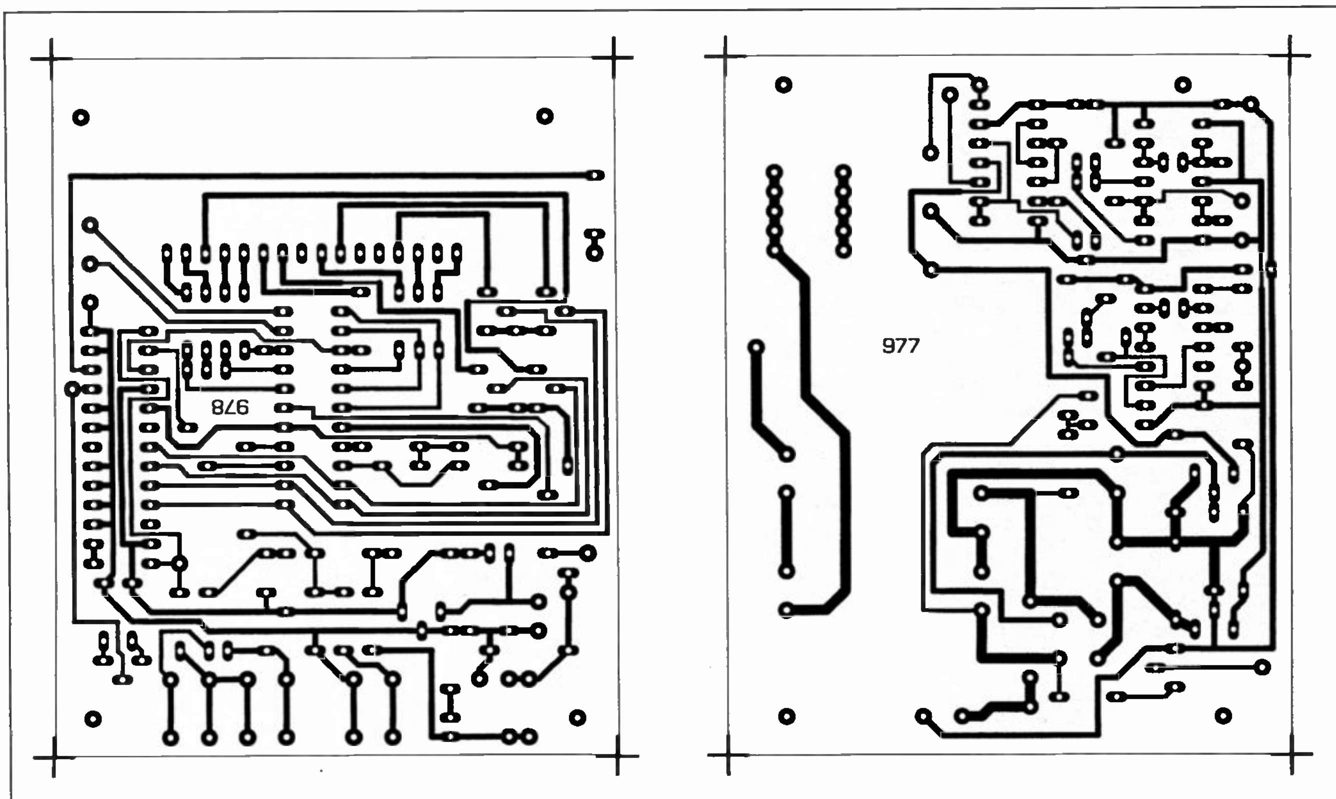
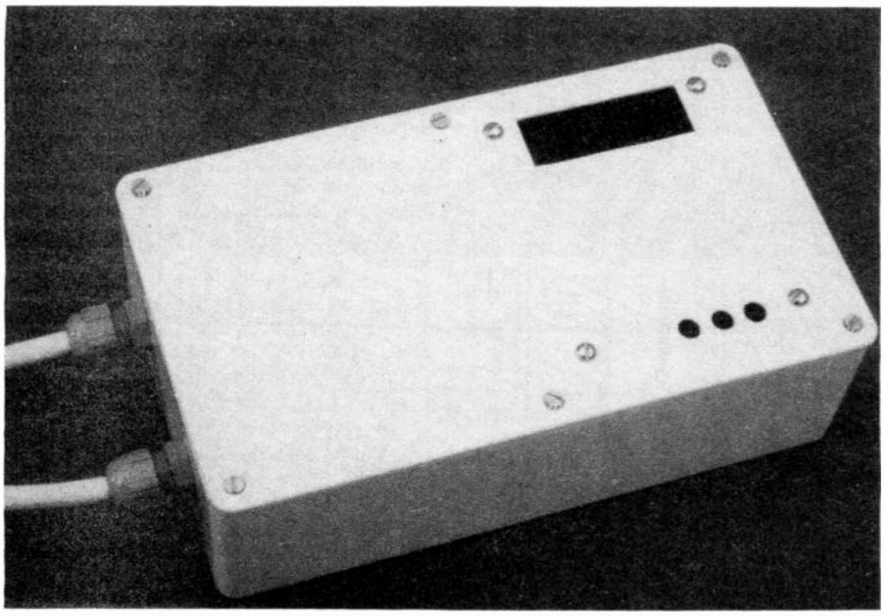


Fig. 9. Full size copper foil p.c.b. masters for the PIC Electric Meter.



Finished PIC-Electric Meter showing display cutout and three access holes for the function switches.

box. It must be rated to suit the appliances monitored.

Interwire the boards and make all external connections. The mains cables are soldered *directly* to the copper track side of the board, as indicated in Fig. 8.

Thoroughly check the complete assembly for component positioning accuracy and satisfactory soldering. Do not insert any of the d.i.l. i.c.s. yet. Set programming slide switch S1 off (towards rear of the p.c.b.).

FIRST TESTS

Beware that while PIC-Electric is plugged into the mains supply, potentially lethal voltages will be present within its case. If in any doubt about the assembly or testing, consult a competent electrician.

As warned earlier, this is not a project for the inexperienced. Always *unplug* the unit from the mains *before* making any assembly changes.

Do not plug any appliance into the output monitoring socket SK1 yet. Plug the unit into the mains and immediately check for the following voltages:

IC1 output pin: +15V
IC2 output pin: −15V
IC8 output pin: +5V
TP7: greater than +17V

If the three fixed voltages are not within about five per cent of nominal, recheck the assembly.

Unplug the "meter" from the mains supply and insert the remaining i.c.s, observing the usual anti-static handling precautions. Plug into the mains again and recheck the voltages.

The fixed voltages should be at the same values. If the microcontroller has already been programmed, though, the voltage from TP7 which powers the display, may now fluctuate from its previous maximum down to around +7V, or so, depending on which segments are active.

Monitor test point TP5, the reference voltage pin of the ADC (IC7), and adjust preset VR2 so that a reading of 1·530V is achieved, a value chosen to simplify the data processing routines.

SOFTWARE OPERATION

When the unit is first switched on, or is reset by pressing switch S2, the software first of all performs a few necessary setting-up procedures. One of these procedures being to read the EEPROM data memory for the stored value of the cost of each electricity unit, the Unit Cost.

An arbitrary value is assigned if the EEPROM memory has not yet been programmed by the user. A delay factor is also recalled from EEPROM memory.

Following the set-up routines, the status of Function switch S4 is read. If the switch is pressed, a Test and alignment routine flag is set, which is discussed later. Irrespective of S4's status, the program goes into a "holding loop" from which it waits for the occurrence of a sync pulse on the processor's RB0 data line.

INTERRUPTS

The holding loop is returned to at the end of each processing cycle of commands, which are initiated 100 times a second in response to the sync pulse received. The microcontroller has its initial parameters set by the program so that the sync pulses are treated as interrupts.

As soon as each interrupt is received, the program immediately jumps to a specifically allocated routine. At the end of the routine, it automatically returns to the point from which it jumped. Using this technique means that sync pulses do not need to be specifically looked for by the software.

However, use of an automatic interrupt procedure should be treated with caution if writing routines for other applications. Irrespective of where the software is in its processing cycle, received interrupts will automatically divert the microcontroller's attention to the predetermined routine in the program.

Unless suitable precautions are taken, this action could result in routines being disrupted and their intended functions corrupted. In PIC-Electric, the timing of other routines ensures that they are complete long before the next interrupt is due.

DISPLAY ROUTINE

On receipt of each sync pulse interrupt, the program jumps from the holding loop direct to the display routine and outputs data to the appropriate digit. Different digits of the multiplexed display are activated each time the display routine is called.

Software uses a look-up table to convert the decimal value for each digit (which can range from 0 to 15) to the correct binary code which activates the relevant l.e.d. segments. Code bits are set to zero to turn on the respective segment.

A timed delay loop is entered after the display routine has been run following the interrupt. At the end of this routine (assuming the Test flag has not been set) the main routine of ADC sampling and counter updating proceeds.

Following this sequence, the display routine is again called and data output to the next appropriate digit, after which the main holding loop is again entered. Doubly calling the display routine in this way increases its multiplexed rate to 200Hz, so eliminating a flicker effect which was apparent when multiplexed at 100Hz.

OPTIMISING SYNC

The next step in testing is to adjust the delay time setting and to optimise the point during the mains supply sinewave at which the ADC is sampled. The same action corrects for both factors and is carried out while the software is set to Test mode.

In order to simplify testing without having a mains appliance plugged in, the simple test circuit (R4 and VR1) in Fig. 5 is used at this stage. Remove the link wire between test points TP1 and TP2. Connect TP3 to TP1.

This links preset VR1 to the analogue processing circuit around IC5. Set VR1 to provide a sinewave of reasonable amplitude, about 0·7V a.c., for example. (If viewed on an oscilloscope, the waveform will appear a bit misshapen due to the total load on the transformer.)

Test mode is called up by having Function switch S4 already pressed when Reset switch S2 is pressed to reset the microcontroller. When S2 is released, followed by the release of S4, the Test flag is set and the program then automatically jumps to the test routine after completing the first display routine called at each 100Hz interrupt.

The waveforms which illustrate the timing required were shown in Fig. 4e to Fig. 4g last month. The latter waveform represents the analogue data presented to the ADC IC7. Fig. 4e shows the sync pulse.

Software jumps from its holding loop on the rising edge of each pulse, performs the display routine and enters the timed delay loop. At the end of this loop, ADC sampling occurs, as indicated by the negative-going pulse in Fig. 4f.

Ideally, the sampling pulse should occur midway between two rising edges of the sync pulse and at the peak of the analogue waveform. In reality, the precise timing of the sampling is not too critical since the plateau of the processed sensor waveform is fairly broad and flat, especially in comparison with the resolution of the ADC and the maximum voltage range with which it has to cope.

Of greater significance, perhaps, is the timing of the second display routine which follows the sampling. If this routine does not occur at roughly the midway point between sync pulses, an imbalance in alternate digit brilliance can occur.

For example, digits one and three can appear brighter than digits two and four, or vice versa. Correcting the length of the delay loop balances the respective brilliances and also, by programming design, optimises the sampling point of the analogue voltage.

DELAY TIME

Pushbutton switches S3 and S4 are used to correct the delay timing. Pressing S3 retards the sampling point, pressing S4 advances it.

Note, though, that if either point is taken too far, the sampling point reverts to a default value. The switches should be appropriately pressed until all four digits have similar brightness.

An oscilloscope will show the optimum point more precisely, but is not really necessary. If one is used, set sync to Channel 1, either positive or negative, and clip the probe for this channel to test point TP4. Clip the probe for Channel 2 to TP9, the analogue input to the ADC. Pressing either of switches S3 or S4 will be seen to shift the relationship between the two waveforms of Fig. 4f and Fig. 4g.

While the delay loop timing is being adjusted, the hexadecimal ADC value shown on the central two digits of the display will also be seen to change. The outer two digits are intentionally blank at this time. A maximum value will indicate the optimum sampling point of the analogue waveform.

Preset VR1 can be adjusted to change the analogue test voltage amplitude. The displayed value will change accordingly between hexadecimal extremes of 00 and FF (0 to 255 decimal).

If the ADC reference voltage preset VR2 is adjusted out of curiosity, the display value will also change, but make sure VR2 is eventually returned to its original voltage setting.

TESTING TIME-OUT

A time-out period of about 40 seconds has been written into the testing routine. At the end of this period, the delay value set by switches S3 and S4 is automatically stored in EEPROM memory, following which normal sampling and display commences.

This value will be recalled each time the PIC-Electric is switched on or reset using switch S2. No provision has been made to display the actual value of the delay timing.

If alignment has not been completed by the end of the time-out, re-initiate the test sequence as before, using switches S2 and S4. Once initiated, there is no way to override the time-out period, except by pressing reset switch S2, or switching off the power.

Once delay timing has been optimised, disconnect the wire between TP3 and TP1. Reconnect TP1 to TP2, so restoring X1 sensor signal to the circuit around IC5.

PRICE SETTING

The price per unit of electricity can be now changed.

Reset the unit by pressing switch S2 and watch the display. An arbitrary "Unit Cost" value will be seen with its left-hand digit flashing slowly on and off.

Pressing Function switch S3 causes the value of the flashing digit to be incremented at about 1Hz, passing back through zero after nine. Set the number to suit the tens of pence of the known price charged by the Electricity Board for each unit used (see your last electricity bill).

Press Function switch S4. The next digit will now flash, representing single pence of the cost. Press S3 to increment the price to the correct value. Repeat the process for the last two digits, representing the decimals of pence cost.

Now either press S4 or wait for the cost time-out period to end (see below). In either case, the new cost will be automatically stored in the EEPROM memory and normal monitoring commenced. The cost value will remain stored in memory until changed on some future occasion. It is not erased when the unit is switched off.

Correct storage of the new cost can be checked by pressing S2 to reset the unit, whereupon the display should show the new value. If S2 is pressed before the end of the cost changing procedure, the original value will be retained.

COST TIME-OUT

A time-out counter is incremented during Unit Cost display. The counter is reset to zero each time S3 or S4 is pressed. At the end of the time-out period, approximately ten seconds, one of two routines is called.

If either S3 or S4 has been pressed during this period, the prevailing Unit Cost value is stored in EEPROM as above. If neither switch has been pressed, the EEPROM store routine is bypassed.

There are two principles attached to this technique. Firstly, when first plugged in or reset, the meter will automatically start monitoring any connected mains appliances at the end of the time-out period without intervention of the user. Secondly, it avoids writing to the EEPROM memory except when necessary, even though its useful lifetime is in excess of one million write cycles.

Unnecessary writing to it is wasteful of its life! There is no practical limit to the number of times it can be read.

USER-READY

After the delay loop timing and unit price factors have been set, PIC-Electric Meter is ready for use. Unplug from the mains supply, plug the appliance to be monitored into the unit, a 100W lamp is suggested at this time.

Plug the unit back into the mains. As soon as power is applied, it will first pass through its normal initialisation routine, through the cost change time-out period, and into the main monitoring routine.

With a 100W lamp as the load, it will take about six minutes before a units-used reading of 00·01 will be seen. Depending on the price factor stored, a cost total of 00·01 pence should appear after only a few tens of seconds. (Note that 100W lamps will only nominally draw 100W – they have a wide tolerance factor!)

DATA GATHERING

Following the Unit Cost assessment routine, PIC-Electric goes into its main data gathering routine in which the ADC conversion value is read.

Ideally, each value read from the ADC should be added to a total which is then multiplied or divided to arrive at the actual electricity units used and their overall cost. The PIC16C84, though, does not have multiply or divide commands as part of its RISC (reduced instruction set commands) instruction armory. Although such instructions can be written as software routines, the number of commands involved is, in this application, too lengthy for a chip having only 1K bytes of program data memory available.

Consequently, an additive technique which does not require multiplication or division is used to cumulatively add fixed fractional values to running totals of units used and their cost. The addition is made each time the 100Hz interrupt occurs and according to the ADC value read. It is mostly carried out in decimal mode, as opposed to binary, making the most significant decimal places of the totals easy to access and display.

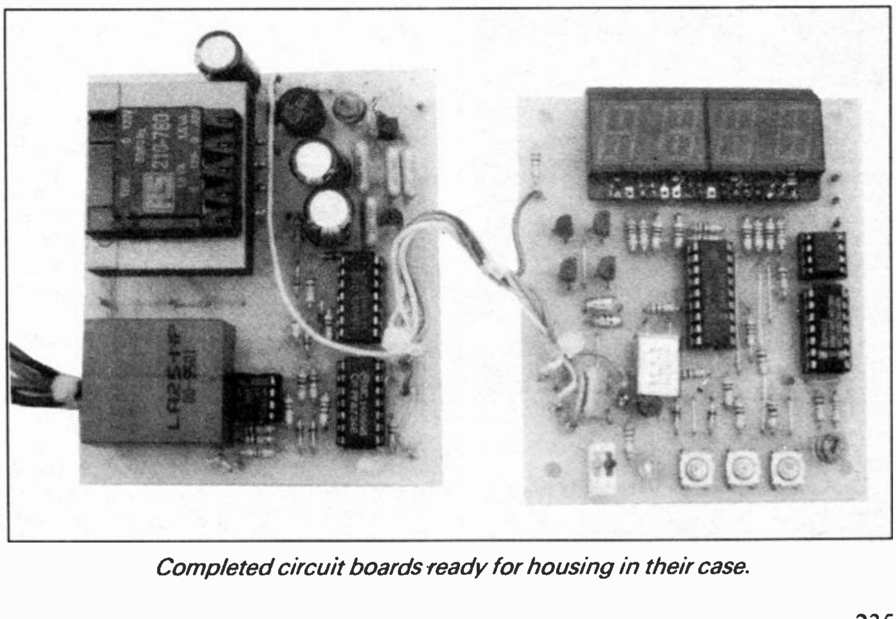
During the normal display mode, the source of the data displayed changes about every three or four seconds. The following is an example of a typical sequence:

1. Hundreds of units used: U- 01 (Units = 100)
2. Tens of units used : 51·74 (+ 51·74 units, total = 151·74)
3. Tens of pounds cost : C- 10 (Pounds = 10)
4. Tens of pence cost : 81·90 (+ 81·90 pence, total = 10·81·90p)

During stages 1 and 3, the letters U or C show whether Units or Cost is being displayed. Additionally in stages 1 and 3, the central segment of the second digit from the left is turned on if the ADC value is above zero, it is otherwise turned off.

This instantly shows whether an intermittent appliance, such as a fridge or washing machine, is actually drawing current at that moment. Thus the example display indicates that the appliance was consuming current when the reading was noted.

When the cost is below ten pounds, or the units used are below 100, the right-hand two digits of the display in stages 1 or 3 are turned off, as relevant.



Completed circuit boards ready for housing in their case.

ELAPSED TIME DISPLAY

An elapsed time counter is reset to zero at the end of the initial setting up sequence and subsequent unit cost assessment time-out period. The counter is incremented in one hundredths of a second at each interrupt. At the appropriate count, memory locations for seconds, minutes and hours are updated. The elapsed time can be displayed by pressing switches S3 and S4 at any time while PIC-Electric is monitoring current and without disrupting the accuracy of the units and cost counts.

Pressing S3 displays the Hours and Minutes count. Elapsed Minutes and Seconds are displayed when S4 is pressed. Beyond 99 hours, the left-hand digit shows the tens of hours in hexadecimal, as capital or lower case letters to suit a seven-segment display: A = 100 hours, b = 110, C = 120, d = 130, E = 140, F = 150. Beyond a count of F9 hours 59 minutes 59 seconds, the elapsed time restarts from zero.

ADC VALUE DISPLAY

The instantaneous value of the ADC count, in binary, can also be displayed at any time without disrupting the various counting routines. Pressing switches S3 and S4 together initiates this display routine.

It does not matter in which order they are pressed or released, as long as both are at some point simultaneously pressed the display will be triggered. The display will continue to show the ADC value for about 15 seconds after the switches are released.

Ideally, it would have been advantageous to show the ADC value as an amperage quantity in decimal. Regrettably, the necessary conversion routines which it is possible to write for a PIC16C84 are lengthy and comparatively slow to process, making their use in this unit untenable. The use of another look-up table would also take up too much chip program memory.

However, readers should have no significant difficulty in arriving at a rough approximation amperage value. If greater accuracy is required, use an ammeter!

PIC16C84 PROGRAMMING

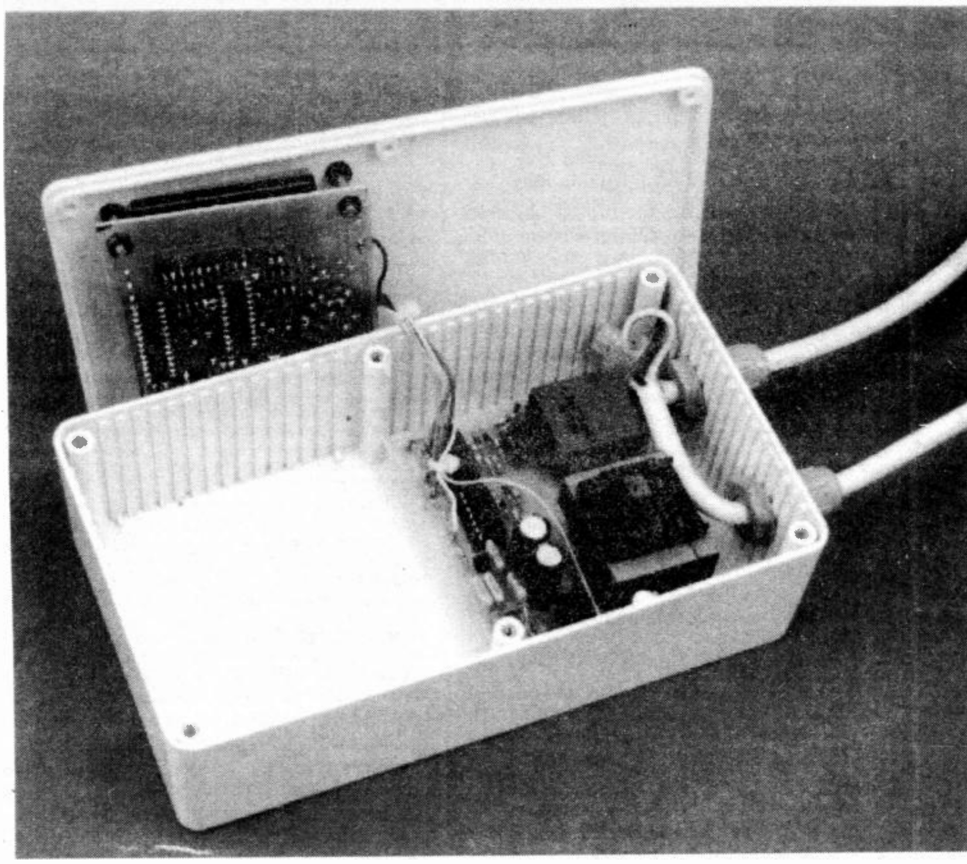
To program the PIC16C84 in situ, the following items are needed:

- PC-compatible computer
- PIC-Electric source code
- Suitable assembler and serial transfer software, such as that associated with the *Simple PIC16C84 Programmer* published last month
- PC parallel port connector with a 3-way cable of about one metre, unterminated at the far end

Solder the wires of the serial connecting cable to their designated points on the PIC-Electric board (see Fig. 7). Plug the connector into the computer's parallel port. Plug the PIC chip into the PIC-Electric board. Load the assembler software and compile the source code into a .OBJ (object file, commonly pronounced "dot O. B. J.") format.

Apply power to PIC-Electric, switch on S1 and check that l.e.d. D9 is on. If programming a PIC chip for the first time on the board, it is advisable to also check that +12V is present at IC9 pin 4 ($\overline{MCLR}$ pin). Run the serial transfer software.

The computer screen will ask if the PIC chip needs to be initialised. It will need to be on the first occasion that it is to be programmed.



The Sens/PSU board mounted in the base of the case and the Cont/Dis. p.c.b. secured to the inside of the lid.

A choice of oscillator type will be presented:

1. LP low power crystal oscillator (32kHz to 200kHz)
2. XT crystal oscillator (100kHz to 4MHz)
3. HS high speed crystal oscillator (4MHz to 10MHz)
4. RC resistor/capacitor oscillator

Select the XT crystal oscillator function.

The Watchdog Timer is not used by PIC-Electric, but when asked if it should be enabled, answer *yes*. The Power-up Timer is required, so respond that it should be enabled.

After the above questions have been answered, the chip will be initialised by the software. The PIC-Electric's .OBJ program codes can now be automatically downloaded to the chip in response to further simple screen prompts.

The screen will advise when down-loading is complete. Then switch off S1 to remove the +12V programming voltage from the chip and turn off the l.e.d. Press Reset switch S2. The PIC-Electric software will immediately start functioning.

Should it be necessary to again download a .OBJ file for any reason, if the program has been modified, for example, it will not normally be necessary to re-initialise a PIC chip. The author has had to do on one occasion, though. Inadvertently, programming switch S1 was opened during data transfer and the chip thereafter refused to be re-programmed until it had been re-initialised.

OTHER COUNTRIES

It seems probable that the PIC-Electric Meter could be modified to suit mains voltages lower than the 230V a.c. used in Britain, *providing the frequency is 50Hz.* (It is not suitable for 60Hz use). The transformer will need changing to one having the appropriate rating, but otherwise its seems that the only change needed is to alter the setting of the ADC's reference voltage.

The value required can be established by monitoring a fixed load for an exact period, comparing the displayed results with those calculated. The unit cost of electricity can be entered in any currency, although decimal places may be incorrect.

IN USE

Three questions in particular have been answered for the author using PIC-Electric Meter. The first concerns a 35-year old fridge which it was thought might be so expensive to keep on running that it would be more economical to replace it.

In a 24-hour sampling period, at the height of summer, PIC-Electric showed that it cost only 4·5p to run; obviously not worth replacing it. It compares favourably with a modern fridge/freezer of three times the capacity in the same kitchen, which cost 14p for a similar period, although the latter is more frequently opened. The very large 15-year old freezer in the garage cost 33p for the same period (a bit of an unwelcome surprise!)

The second question concerned how much a washing machine cost for similar loads on the same program cycle when having to heat its own water compared to being provided with hot water from the main domestic system. The answers were 50p and 10p, respectively, although the cost of heating the domestic tank could not be established since it is gas fired and was being used for general heating at the same time.

Thirdly, how much was the tumble dryer costing to dry an average Saturday's wash for two adults? Answer: 42·5p.

It is acknowledged, of course, that the cost of building the PIC-Electric Meter must be taken into account when considering the potential savings which could be achieved by using it. The proportional cost, though, can be improved if a group of neighbours combines to buy it. Or perhaps you could hire it out and make money! □

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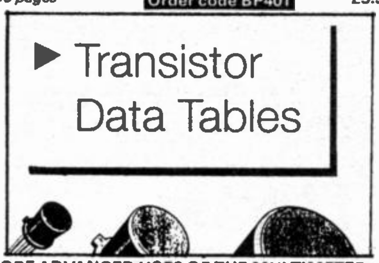

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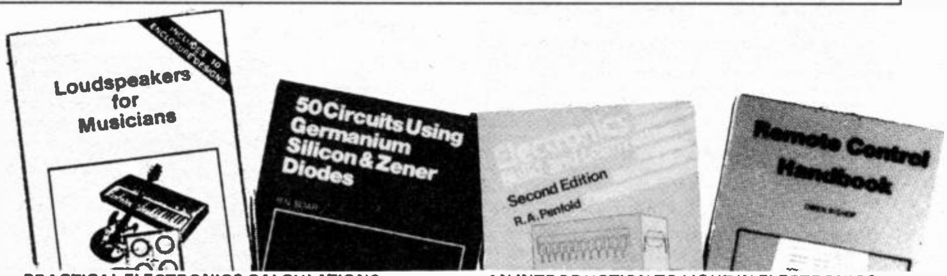

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REPORTING AMATEUR RADIO

Tony Smith G4FAI

IARP ADOPTED BY OAS

An International Amateur Radio Permit (IARP) has been adopted by the Organization of American States. The OAS is "convinced of the benefits of Amateur Radio" and has agreed "to facilitate and promote, by all means within its power, the continuing development of telecommunications in the countries of the Americas."

The IARP will be used by radio amateurs who are citizens of countries in North, Central and South America and the Caribbean, and who travel to other countries in that area.

The permit will operate rather like an international driver's licence. As conceived there will be two classes of permit: Class 1 will allow use of all amateur frequency bands to amateurs who have passed a Morse test in their own country, while Class 2 allows operation in the amateur bands above 30MHz.

Region 2 of the International Amateur Radio Union has been trying for more than 13 years to achieve an amateur radio licence recognized worldwide for travelling amateurs. Now it has been adopted by the Americas, the International Amateur Radio Permit has the potential to be eventually adopted everywhere.

The permit is currently in the process of being ratified by the various OAS member states. (Information from *The Canadian Amateur*).

NEWS FROM ISWL

The International Short Wave League has a new Honorary Secretary and a new headquarters. From January 1996, the Secretary is Mrs M.H. Carrington G0WDM, and all correspondence with the League should be addressed to *ISWL HQ, 3 Bromyard Drive, Chellaston, Derby DE73 1PF.*

The ISWL was founded in 1946 with the objectives of: a) bringing together Shortwave radio enthusiasts of the world regardless of Race, Creed or Politics; b) Fostering and promoting international goodwill through the medium of Shortwave radio; and c) Providing facilities to enable enthusiasts to carry out their hobby resulting in the greatest advantage to them and their fellow enthusiasts.

Such was the enthusiasm for the League's activities in the 1950s, that for a while several international broadcast stations, including HCJB Ecuador, Radio Turkey and Radio Spain, carried ISWL programmes.

In 1986, the ISWL ceased operation for a short period, but after reorganization, it recommenced activities in early 1987. Nowadays it is as enthusiastic as ever and membership remains open to anyone with an interest in amateur radio or shortwave listening.

50TH ANNIVERSARY

As 1996 sees the 50th anniversary of the formation of the League, members will be operating a special event callsign, GB50SWL, throughout the year.

Anyone hearing or working this callsign can receive the GB50SWL QSL card, by sending their own QSL or reception report via the bureau, or direct to the ISWL Club Callsign Manager, David Beale G0DBX, "Kenwood", London Road, Louth, Lincs LN11 8QH.

ISWL has several on-air nets each week, and there is an on-going programme of awards and contests, details of which are carried in the League's monthly journal *Monitor.* The ISWL encourages the exchange of QSL cards following amateur radio or shortwave listening activities, and has a QSL bureau for members for this purpose.

Additionally, it sells stationary and supplies for members, including QSL cards, ties, car stickers, reporting pads, etc. It also has a number of useful publications, including the twice-yearly *Guide to English Language Short Wave Broadcasts to Europe.*

The current subscription for ISWL membership is £18.00 per year, plus a further £6.00 for the services of the QSL bureau if required. Any quantity of cards can be sent through the bureau without restriction, and addressees do not have to be ISWL members – an important point for keen QSLers.

For more information about the League, write to the new address above, and be sure to mention that you read about the League and its activities in *EPE.*

REPEATER PROBLEMS

As reported in this column recently the Radiocommunications Agency, in its Annual Report for 1994/95, mentioned its concern at the continuing abuse of the amateur radio and CB services.

One of the main problems in amateur radio in the UK is abuse of repeaters. These are devices that receive radio signals on one frequency and simultaneously retransmit them on another. This way, they increase the range of low power mobile stations from a few miles to a much greater distance, depending on the terrain and the frequency used.

They are unmanned VHF or UHF stations sited on high ground, a tall building, or a tall mast to obtain a coverage area vastly greater than that of the stations working through them. The first amateur repeaters were brought into use in the early 1970s and were used for FM speech communication only. Nowadays there are repeaters for several other modes apart from FM.

From the time they began, a number of VHF/FM repeaters have suffered from the disruptive behaviour of a small number of operators. In the worst cases, they make new users unwelcome, interrupt on-going contacts with foul language, abuse, or illegal transmissions of music, and generally block access to a repeater for others who wish to use it.

MORE CONTROL REQUIRED

Various attempts have been made to deal with this problem over the years. A few identified offenders have been banned by the Radiocommunications Agency from using particular repeaters, and one or two repeaters have been closed down for a few months at a time in the hope that things would improve.

According to some users, however, the situation is no better and they feel that much stronger measures should be taken to deal with the problem. One correspondent to this column suggests that repeaters suffering serious abuse should only be allowed on the air when there is a "control operator" constantly monitoring transmissions, with the ability to switch the repeater off and back on again as required.

If the groups who put the repeaters on the air are not prepared to police them like this, he suggests that affected repeaters be closed down for a period of six months. If, on return to service they still suffer more abuse than proper use, they should be closed down permanently.

IS THERE ANOTHER WAY?

Many amateurs do not use repeaters because of their reputation, or because of their own experiences. Equally there are many who do use them and enjoy them despite the problems described.

The latter are unlikely to agree with the idea of permanent closedown of an unmanageable repeater, but if a problem remains unsolved for over twenty years, then surely previous measures must be judged as having failed?

Before I am inundated with protests, my correspondent does say that only a few well-known repeaters suffer this problem, and that most *ARE* used properly. He feels that the Radiocommunications Agency, although having limited resources, should take a more active interest in the matter in the interests of the amateur community.

It would be interesting to hear from regular repeater users what they think about all this. Why have previous measures failed? Can anything else can be done short of permanently closing down the most abused repeaters?

LF ALLOCATION SOON

As a result of ongoing negotiations between the RSGB and the Radiocommunications Agency, the RA has agreed an amateur frequency allocation around 73kHz. Discussions on the actual terms of licensing are continuing.

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