EVERYDAY WITH PRACTICAL ELECTRONICS

FEBRUARY 1995

INCORPORATING ELECTRONICS MONTHLY

FULLY S.O.R. £2.15

PROJECTS

12V 35W PA AMPLIFIER
Versatile, discrete, MOSFET design

THE ULTIMATE SCREEN SAVER
Save money and protect your computer monitor

FOOT-OPERATED DRILL CONTROLLER
Keep control of your p.c.b. drill

FEATURES

TRANSFORMERLESS POWER SUPPLIES
How capacitive supplies work

CIRCUIT SURGERY
Our surgeon dissects your problems

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THE No. 1 INDEPENDENT MAGAZINE for ELECTRONICS, TECHNOLOGY and COMPUTER PROJECTS

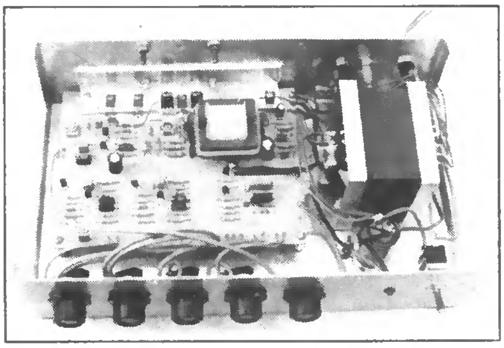
ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

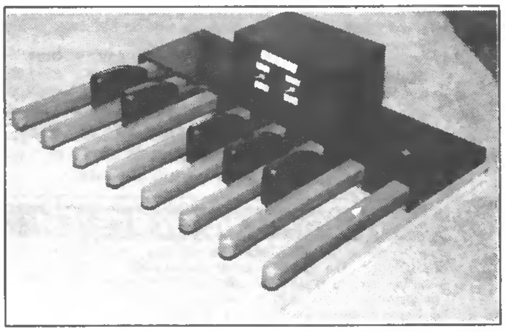
VOL. 24 No. 2 FEBRUARY 1995

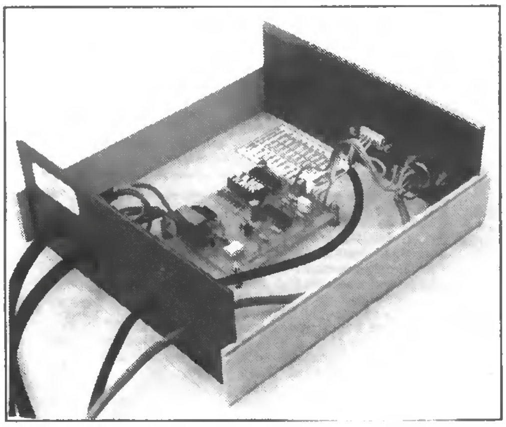
EVERYDAY WITH PRACTICAL ELECTRONICS

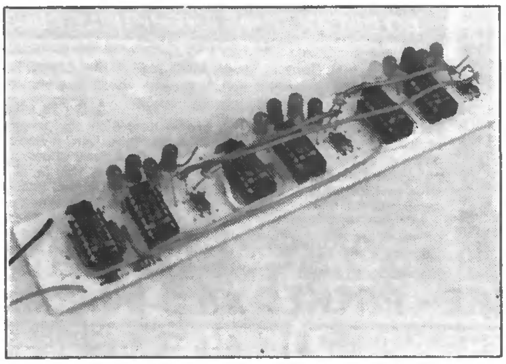
INCORPORATING ELECTRONICS MONTHLY

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









Projects

Series

Features

Our March '95 issue will be published on Friday, 3 February 1995. See page 87 for details.

Surplus always wanted for cash!

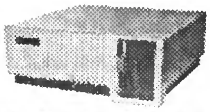
THE *ORIGINAL* SURPLUS WONDERLAND!

THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

Surplus always wanted for cash!

LOW COST PC's - ALL EXPANDABLE - ALL PC COMPATIBLE

SPECIAL BUY
AT 286
40Mb HD + 3Mb Ram

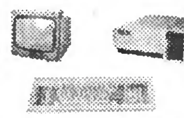


LIMITED QUANTITY only of these **12Mhz HI GRADE 286** systems Made in the USA to an industrial specification, the system was designed for *total reliability.* The compact case houses the motherboard, PSU and EGA video card with single **5¼" 1.2 Mb** floppy disk drive & **integral 40Mb hard disk drive**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

Order as HIGRADE 286 ***ONLY £149.00*** (E)
CALL FOR QTY DISCOUNTS

Optional Fitted extras: VGA graphics card	£29.00
1.4Mb 3½" floppy disk drive (instead of 1.2 Mb)	£32.95
NE2000 Ethernet (thick, thin or twisted) network card	£49.00

PC SCOOP
COMPLETE COLOUR SYSTEM
ONLY £99.00



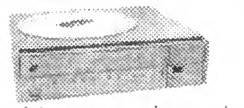
A massive bulk purchase enables us to bring you a **COMPLETE ready to run** colour PC system at an **unheard of price! The Display Electronics PC99 system** comprises of fully compatible and expandable XT PC with 256k of RAM, 5¼" 360k floppy disk drive, **12" CGA colour monitor**, standard 84 key keyboard, MS DOS and all connecting cables - **just plug in and go !!** Ideal students, schools or anybody wishing to learn the world of PC's on an ultra low budget. **Don't miss this opportunity.** Fully guaranteed for 90 Days.

Order as PC99COL **£99.00** (E)

Optional Fitted extras: 640k RAM	£29.00
2nd floppy drive, specify 5¼" 360k or 3½" 720k	£29.95
Above prices for PC99 offer ONLY.	

SPECIAL OFFER

Computer Controlled Laser Video Disk Player

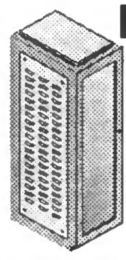


One of the most **amazing** surplus deals that we ever been able to offer you! The **Philips VP410** LaserVision player, in as new condition, unit features full computer control, Plays standard 12" LaserVision disks with **startling visual and audio quality** in two channel **stereo** or mono. When controlled by a computer, it may also be used as a versatile high quality storage / retrieval medium. It will play back either LaserVision CAV (active play) or CLV (Long Play) discs (which covers most types of commercially available video discs). Some of the many features of this incredible machine are:

RS-232 INTERFACE	**RGB / COMPOSITE VIDEO OUTPUT**
BNC+SCART INTERFACE	**PAL / RGB DECODER**
IR+WIRED REMOTE CONTROL	**FAST RANDOM ACCESS**

SPECIAL PURCHASE Only **£399.00** (F)

19" RACK CABINETS



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

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

Overall dimensions are: 77-1/2" H x 32-1/2" D x 22" W. **Order as:**

Rack 1 Complete with removable side panels.	**£335.00** (G)
Rack 2 Rack, Less side panels	**£225.00** (G)

Over 1000 racks in all sizes 19" 22" & 24"
3 to 44 U. Available from stock !!
Call with your requirements.

FLOPPY DISK DRIVES 3.5"- 8"

5.25" from £22.95 - 3.5" from £24.95

Massive purchases of standard 5.25" and 3.5" drives enables us to present prime product at industry beating low prices! All units (unless stated) are *BRAND NEW* or removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from standard voltages and are of standard size. **All are IBM-PC compatible** (if 3.5" supported on your PC).

3.5" **Panasonic** JU363/4 720K or equivalent	£24.95(B)
3.5" **Mitsubishi** MF355C-L. 1.4 Meg. Laptops only *	£36.95(B)
3.5" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop	£29.95(B)
5.25" **Teac** FD-55GFR 1.2 Meg	£29.95(B)
5.25" **BRAND NEW Mitsubishi** MF501B 360K	£22.95(B)
* Data cable included in price.	
Shugart 800/801 8" SS refurbished & tested	£195.00(E)
Shugart 851 8" double sided refurbished & tested	£250.00(E)
Mitsubishi M2894-63 8" double sided *NEW*	£275.00(E)
Mitsubishi M2896-63-02U 8" DS slimline *NEW*	£285.00(E)
Dual 8" drives with 2 mbyte capacity housed in a smart case with built in power supply. Ideal as exterior drives!	£499.00(F)

HARD DISK DRIVES

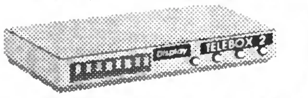
End of line purchase scoop! Brand new **NEC D2246** 8" 85 Mbyte of hard disk storage! Full **Industry standard SMD Interface**. Ultra hi speed data transfer and access time, replaces Fujitsu equivalent model. complete with manual. Only £299.00(E)

3.5" **FUJI** FK-309-26 20mb MFM I/F RFE	£59.95(C)
3.5" **CONNER** CP3024 20 mb IDE I/F (or equiv)RFE	£69.95(C)
3.5" **CONNER** CP3044 40mb IDE I/F (or equiv.)RFE	£89.00(C)
3.5" **RODIME** RO3057S 45mb SCSI I/F (Mac & Acorn)	£99.00(C)
5.25" **MINISCRIBE** 3425 20mb MFM I/F (or equiv.) RFE	£49.95(C)
5.25" **SEAGATE** ST-238R 30 mb RLL I/F Refurb	£69.95(C)
5.25" **CDC** 94205-51 40mb HH MFM I/F RFE tested	£69.95(C)
8" **FUJITSU** M2322K 160Mb SMD I/F RFE tested	£195.00(E)

Hard disc controllers for MFM , IDE, SCSI, RLL etc. **from £16.95**

THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER!

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

TELEBOX ST for composite video input type monitors	**£34.95**
TELEBOX STL as ST but with integral speaker	**£37.50**
TELEBOX MB Multiband VHF-UHF-Cable- Hyperband tuner	**£69.95**

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

FANS & BLOWERS

MITSUBISHI MMF-D6D12DL 60 x 25 mm 12v DC	£4.95	10 / £42
MITSUBISHI MMF-09B12DH 92 x 25 mm 12v DC	£5.95	10 / £53
PANCAKE 12-3.5 92 x 18 mm 12v DC	£7.95	10 / £69
EX-EQUIP 120 x 38mm AC fans - tested specify 110 or 240 v	£6.95	
EX-EQUIP 80 x 38mm AC fans - tested specify 110 or 240 v	£5.95	
VERO rack mount 1U x 19" fan tray specify 110 or 240v	£45.95 (B)	
IMHOF B26 1900 rack mnt 3U x 19" Blower 110/240v NEW	£79.95	

Shipping on all fans (A). Blowers (B). *50,000 Fans Ex Stock CALL*

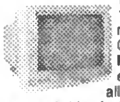
IC's -TRANSISTORS - DIODES

OBSOLETE - SHORT SUPPLY - BULK

5,000,000 items EX STOCK

For *MAJOR SAVINGS* - SAE or CALL FOR LATEST LIST

VIDEO MONITOR SPECIALS

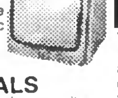


Superb quality 14" **FOREFRONT MTS-9600 SVGA** Multisync - Multimode monitor 0.28" dot pitch with resolution of **1024 x 768**. The multi mode input allows direct connection to a host of computers including **IBM PC's** in CGA, EGA, VGA & SVGA modes, **BBC, COMMODORE** (including Amiga 1200), **ARCHIMEDES** etc. The H version will also function with the **ATARI** in all modes inc **HI RES monochrome.** Complete with 'text' switching for WP use.(possible minor screen burns) Syncs down to 15 kHz. Supplied in EXCELLENT little used condition with full 90 day guarantee.

Order as MTS-9600 / H for ATARI	**£149.00** (E)
All modes as above Order as MTS-9600 / S	**£129.00** (E)

ELECTROHOME ECM-1211SBU 12" VGA multisync monitor with resolution 640 x 480. Multi input selection; 9pin CGA/ EGA ; 15 pin VGA or 5 BNC connectors. 0.31 pitch. Compatible with PCs, Amiga, Atari and others. In good used condition (possible minor screen burns)90 day guarantee. ..... **£99.00** (E)

KME 10" high definition colour monitors. Nice tight 0.28" dot pitch for superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13.5" x 12" x 11". **Only £125** (E) Good used condition. 90 day guarantee.
KME 10" as above for PC EGA standard £145.00 (E)



NEC CGA 12" colour IBM-PC compatible. High quality ex-equipment fully tested with a 90 day guarantee. In an attractive two tone ribbed grey plastic case measuring 15"L x 13"W x 12"H. The front cosmetic bezel has been removed for contractual reasons.

Only £49.00(E)

20" 22" and 26" AV SPECIALS

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

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

12" Mono. **Philips BM7542 /05G** for CCTV **NEW £69.95** (C)

DC POWER SUPPLIES

10,000 Power Supplies Ex Stock
Call for info / list

Power One SPL200-5200P 200 watt (250 w peak).Semi open frame giving +5v 35a, -5v 1.5a, +12v 4a (8a peak), -12v 1.5a, +24v 4a (6a peak). All outputs fully regulated with over voltage protection on the +5v output. AC input selectable for 110/240 vac. Dims13" x 5" x 2.5". Fully guaranteed RFE.	£85.00(B)
Power One SPL130. 130 watts. Selectable for 12v (4A) or 24 v (2A). 5v @ 20A. ± 12v @ 1.5A. Switch mode.New.	£59.95(B)
Astec AC-8151 40 watts. Switch mode. +5v @ 2.5a. +12v @ 2a. -12v @ 0.1a. 6-1/4" x 4" x 1-3/4" RFE tested	£22.95(B)
Lambada LYS-PV-12 200 watt switch mode.**+12V DC @ 29a** semi enclosed, 10" x 5" x 5". RFE and fully tested.	£59.95(C)
Conver AC130. 130 watt hi-grade VDE spec.Switch mode.+5v @ 15a,-5v @ 1a,+12v @ 6a.27 x 12.5 x 6.5cms.New.	£49.95(C)
Boshert 13090.Switch mode.Ideal for drives & system. +5v@ 6a, +12v @ 2.5a, -12v @ 0.5a, -5v @ 0.5a.	£29.95(B)
Farnell G6/40A. Switch mode. 5v @ 40a.Encased	£95.00(C)

SPECIAL INTEREST

INTEL SBC 486/133SE Multibus 486 system. 8Mb Ram	£1975
Zeta 3220-05 A0 4 pen **HPGL** RS232 fast drum plotter	£1950
3M VDA - Video Distribution Amps.1 in 32 out	£375
Trio 0-18 vdc bench PSU. 30 amps. New	£470
Fujitsu M3041 600 LPM band printer	£1950
VG Electronics 1035 **TELETEXT** Decoding Margin Meter	£3750
Andrews LARGE 3.1 m Satellite Dish + mount (For Voyager!)	£950
RED TOP IR Heat seeking missile (not armed !!)	POA
Tektronix 1L30 Spectrum analyser plug in	£330
Thurlby LA 160B logic analyser	£375
GEC 1.5kw 115v 60hz power source	£950
Brush 2Kw 400 Hz 3 phase frequency converter	£850
Anton Pillar 75 kW 400 Hz 3 phase frequency converter	POA
Newton Derby 70 KW 400 Hz 3 phase frequency converter	POA
Nikon PL-2 Projection lens meter/scope	£750
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
HP 7580A A1 8 pen **HPGL** high speed drum plotter	£1850
Kenwood DA-3501 CD tester, laser pickup simulator	£350
Computar MCA1613APC 16mm auto iris lenses 'C' mount	£125
Seaward PAT 2000 dual voltage computerised PAT tester	£585

TOUCH SCREEN SYSTEM

The ultimate in **'Touch Screen Technology'** made by the experts - ***MicroTouch*** - but sold at a **price below cost !!** System consists of a flat translucent glass laminated panel measuring 29.5 x 23.5 cm connected to a PCB with on board sophisticated electronics. From the board comes a **standard serial RS232** or TTL output. The output continuously gives simple serial data containing positional X & Y co-ordinates as to where a finger is touching the panel - as the finger moves, the data instantly changes. The X & Y information is given at an **incredible matrix resolution of 1024 x 1024** positions over the screen size !!! So, no position, however small fails detection. **A host of available translation software** enables direct connection to a PC for a myriad of applications including: control panels, pointing devices, POS systems, controllers for the disabled or computer un-trained etc etc Imagine using your finger in 'Windows' instead of a mouse !! (a driver is indeed available !) ***The applications for this amazing product are only limited by your imagination!!*** Supplied as a complete system including Controller, Power Supply and Data at an incredible price of only: ***RFE. Full Software Support Available - Fully Guaranteed*** **£145.00** (B)

LOW COST RAM UPGRADES

INTEL 'ABOVE' Memory Expansion Board. Full length PC-XT and PC-AT compatible card with **2 Mbytes** of memory on board. Card is fully selectable for Expanded or Extended (286 processor and above) memory. **Full data and driver disk supplied.** In good used condition fully tested and guaranteed.
Windows compatible. **Order as: ABOVE CARD** **£59.95**(A1)

Half length 8 bit memory upgrade cards for PC AT XT expands memory either 256k or 512k in 64k steps. May also be used to fill in RAM above 640k DOS limit. Complete with data.

Order as: XT RAM UG. 256k		**£32.95**(A1)
512k		**£38.95**(A1)
1 MB x 9 SIMM 9 chip 120ns	only	**£19.50**(A)
1 MB x 9 SIMM 3 chip 80 ns	only	**£23.50**(A)
1 MB x 9 SIMM 9 chip 80 ns	only	**£22.50**(A)

NO BREAK UNINTERRUPTIBLE PSU'S

Brand new and boxed 230 volts 1 KVa uninterruptible power supply from system from **Densel. Model MUD 1085-AHBH**. Complete with sealed lead acid batteries in matching case. Approx time from interrupt is 15 minutes. Complete with full manual. **£575.00**(G)

EMERSON ACCUCARD UPS, brand new 8 Bit half length PC compatible card for all **IBM XT/AT** compatibles. Card provides DC power to all internal system components in the event of power supply failure.The Accusaver software provided uses only 6k of base RAM and automatically copies **all** system, expanded and video memory to the hard disk in the event of loss of power. When power is returned the machine is returned to the **exact status when the power failed !!** The unit features full self diagnostics on boot and is supplied **brand new**, with full, easy fitting instructions and manual.
Normally £189.00 ***NOW!*** **£69.00** or **2 for £120** (B)

Issue 13 of *Display News* now available - send large SAE - PACKED with bargains!

DISPLAY -ELECTRONICS-

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Open Mon - Sat 9:00 - 5:30
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LONDON SE19 3XF

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FREE On line Database
Info on 1000's of items
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FAX 0181 679 1927

VISA

ESTABLISHED 25 YEARS

All prices for UK Mainland. UK customers add 17.5% VAT to TOTAL order amount. Minimum order £10. Bona Fide account orders accepted from Government, Schools, Universities and Local Authorities - minimum account order £50. Cheques over £100 are subject to 10 working days clearance. Carriage charges (A)=£3.00, (A1)=£4.00, (B)=£5.50, (C)=£8.50, (D)=£12.00, (E)=£15.00, (F)=£18.00, (G)=CALL. Allow approx 6 days for shipping - faster CALL. Scotland surcharge CALL. All goods supplied to our Standard Conditions of Sale and unless stated guaranteed for 90 days. All guarantees on a return to base basis. All rights reserved to change prices / specifications without prior notice. Orders subject to stock. Discounts for volume. Top CASH prices paid for surplus goods. All trademarks etc acknowledged. © Display Electronics 1995. E & O E. 1/11

FREE

PROBABLY THE MOST USEFUL P.C.B. EVER PRODUCED!

WORTH £3

YOU CAN BUILD ANY ONE OF SIX DIFFERENT PROJECTS ON OUR FREE P.C.B. THEY ARE:

Timer

Provides an automatic switch-off between about one and six minutes after switch-on. Other times possible by altering the CR timing network. Uses a very low current op.amp to provide micro-power operation once the relay has been switched off.

Continuity Tester

Uses an op.amp as a comparator so that it will only respond to resistances of a few ohms or less. The audible indication of continuity is provided by a ready-made buzzer. Maximum voltage across probes is a safe 6V, and the current is limited to less than 500 microamps.

Modulated Light Telephone

This is a modern version of the old torch bulb telephone idea. Uses an ultra-bright l.e.d. at the transmitter to give good range despite the relatively low current consumption. The audio quality is a lot better than the treble-free output from a torch bulb design. Can achieve a range of up to about 100 metres using a couple of cheap lenses. (This project requires two of the FREE P.C.B.s).

Sound Activated Switch

A simple and straightforward design using an op.amp as a high gain audio amplifier driving a rectifier/smoothing circuit and a common emitter relay driver. Reasonably sensitive using most low impedance dynamic microphones.

Audio Amplifier

A class-B audio amplifier which is capable of providing a few hundred milliwatts r.m.s. into an 8 ohm loudspeaker. Uses negative feedback and the high slew rate of an op.amp to combat cross-over distortion (there is no bias current through the output stage).

Automatic Light Switch

Basic design using a relay to switch something on or off when the light intensity falls below a preset threshold level.

Three of these projects will be published next month, when our issue will have the FREE P.C.B. attached to the front cover. The other three designs will be presented in the following issue.

DON'T MISS THIS VALUABLE ISSUE – PLACE AN ORDER WITH YOUR NEWSAGENT NOW!

EVERYDAY WITH PRACTICAL ELECTRONICS

MARCH '95 ISSUE ON SALE FRIDAY, 3rd FEBRUARY

NEXT MONTH

SURVEILLANCE

PROFESSIONAL QUALITY KITS

No. 1 for Kits

Whether your requirement for surveillance equipment is amateur, professional or you are just fascinated by this unique area of electronics SUMA DESIGNS has a kit to fit the bill. We have been designing electronic surveillance equipment for over 12 years and you can be sure that all our kits are very well tried, tested and proven and come complete with full instructions, circuit diagrams, assembly details and all high quality components including fibreglass PCB. Unless otherwise stated all transmitters are tuneable and can be received on an ordinary VHF FM radio.

Genuine SUMA kits available only direct from Suma Designs. Beware inferior imitations!

UTX Ultra-miniature Room Transmitter
Smallest room transmitter kit in the world! Incredible 10mm x 20mm including mic. 3-12V operation. 500m range....................£16.45

MTX Micro-miniature Room Transmitter
Best-selling micro-miniature Room Transmitter
Just 17mm x 17mm including mic. 3-12V operation. 1000m range....................£13.45

STX High-performance Room Transmitter
Hi performance transmitter with a buffered output stage for greater stability and range. Measures 22mm x 22mm including mic. 6-12V operation, 1500m range....................£15.45

VT500 High-power Room Transmitter
Powerful 250mW output providing excellent range and performance. Size 20mm x 40mm. 9-12V operation. 3000m range....................£16.45

VXT Voice Activated Transmitter
Triggers only when sounds are detected. Very low standby current. Variable sensitivity and delay with LED indicator. Size 20mm x 67mm. 9V operation. 1000m range...£19.45

HVX400 Mains Powered Room Transmitter
Connects directly to 240V AC supply for long-term monitoring. Size 30mm x 35mm. 500m range....................£19.45

SCRX Subcarrier Scrambled Room Transmitter
Scrambled output from this transmitter cannot be monitored without the SCDM decoder connected to the receiver. Size 20mm x 67mm. 9V operation. 1000m range....................£22.95

SCLX Subcarrier Telephone Transmitter
Connects to telephone line anywhere, requires no batteries. Output scrambled so requires SCDM connected to receiver. Size 32mm x 37mm. 1000m range....................£23.95

SCDM Subcarrier Decoder Unit for SCRX
Connects to receiver earphone socket and provides decoded audio output to headphones. Size 32mm x 70mm. 9-12V operation....................£22.95

ATR2 Micro Size Telephone Recording Interface
Connects between telephone line (anywhere) and cassette recorder. Switches tape automatically as phone is used. All conversations recorded. Size 16mm x 32mm. Powered from line....................£13.45

★★★ Specials ★★★

DLTX/DLRX Radio Control Switch
Remote control anything around your home or garden, outside lights, alarms, paging system etc. System consists of a small VHF transmitter with digital encoder and receiver unit with decoder and relay output, momentary or alternate, 8-way dil switches on both boards set your own unique security code. TX size 45mm x 45mm. RX size 35mm x 90mm. Both 9V operation. Range up to 200m.
Complete System (2 kits)....................£50.95
Individual Transmitter DLTX....................£19.95
Individual Receiver DLRX....................£37.95

MBX-1 Hi-Fi Micro Broadcaster
Not technically a surveillance device but a great idea! Connects to the headphone output of your Hi-Fi, tape or CD and transmits Hi-Fi quality to a nearby radio. Listen to your favourite music anywhere around the house, garden, in the bath or in the garage and you don't have to put up with the DJ's choice and boring waffle. Size 27mm x 60mm. 9V operation. 250m range....................£20.95

UTLX Ultra-miniature Telephone Transmitter
Smallest telephone transmitter kit available. Incredible size of 10mm x 20mm! Connects to line (anywhere) and switches on and off with phone use.
All conversation transmitted. Powered from line. 500m range....................£15.95

TLX700 Micro-miniature Telephone Transmitter
Best-selling telephone transmitter. Being 20mm x 20mm it is easier to assemble than UTLX. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1000m range....................£13.45

STLX High-performance Telephone Transmitter
High performance transmitter with buffered output stage providing excellent stability and performance. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. Size 22mm x 22mm.
1500m range....................£16.45

TKX900 Signalling/Tracking Transmitter
Transmits a continous stream of audio pulses with variable tone and rate. Ideal for signalling or tracking purposes. High power output giving range up to 3000m. Size 25mm x 63mm. 9V operation....................£22.95

CD400 Pocket Bug Detector/Locator
LED and piezo bleeper pulse slowly, rate of pulse and pitch of tome increase as you approach signal. Gain control allows pinpointing of source. Size 45mm x 54mm. 9V operation....................£30.95

CD600 Professional Bug Detector/Locator
Multicolour readout of signal strength with variable rate bleeper and variable sensitivity used to detect and locate hidden transmitters. Switch to AUDIO CONFORM mode to distinguish between localised bug transmission and normal legitimate signals such as pagers, cellular, taxis etc. Size 70mm x 100mm. 9V operation....................£50.95

QTX180 Crystal Controlled Room Transmitter
Narrow band FM transmitter for the ultimate in privacy. Operates on 180 MHz and requires the use of a scanner receiver or our QRX180 kit (see catalogue). Size 20mm x 67mm. 9V operation. 1000m range....................£40.95

QLX180 Crystal Controlled Telephone Transmitter
As per QTX180 but connects to telephone line to monitor both sides of conversations. 20mm x 67mm. 9V operation. 1000m range....................£40.95

QSX180 Line Powered Crystal Controlled Phone Transmitter
As per QLX180 but draws power requirements from line. No batteries required. Size 32mm x 37mm. Range 500m....................£35.95

QRX180 Crystal Controlled FM Receiver
For monitoring any of the 'Q' range transmitters. High sensitivity unit. All RF section supplied as a pre-built and aligned module ready to connect on board so no difficulty setting up. Outpt to headphones. 60mm x 75mm. 9V operation....................£60.95

A build-up service is available on all our kits if required.

UK customers please send cheques, POs or registered cash. Please add £1.50 per order for P&P. Goods despatched ASAP allowing for cheque clearance. Overseas customers send sterling bank draft and add £5.00 per order for shipment. Credit card orders welcomed on 0827 714476.

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£1 BARGAIN PACKS – List 1

1,000 items appear in our Bargain Packs List – request one of these when you next order.

1 x 12V Stepper Motor. 7·5 degree. Order Ref: 910.
1 x 10 pack Screwdrivers. Order Ref: 909.
2 x 5 amp Pull Cord Ceiling Switches. Brown. Order Ref: 921.
5 x reels Insulation Tape. Order Ref: 911.
4 x 14mm Ball-races. Order Ref: 912.
2 x Cord Grip Switch Lamp Holders. Order Ref: 913.
1 x DC Voltage Reducer. 12V-6V. Order Ref: 916.
1 x 10 amp 40V Bridge Rectifier. Order Ref: 889.
Lightweight Stereo Headphones. Moving coil so superior sound. Order Ref: 896.
2 x 25W Crossovers. For 4ohm loudspeakers. Order Ref: 22.
2 x NiCad Constant Current Chargers. Easily adaptable to charge almost any NiCad battery. Order Ref: 30.
18V-0-18V 10VA mains transformer. Order Ref: 813.
2 x White Plastic Boxes. With lids, approx. 3" cube. Lid has square hole through the centre so these are ideal for light operated switch. Order Ref: 132.
2 x Reed Relay Kits. You get 8 reed switches and 2 coil sets. Order Ref: 148.
12V-0-12V 6VA mains transformer, p.c.b. mounting. Order Ref: 938.
1 x Big Pull Solenoid. Mains operated. Has ½" pull. Order Ref: 871.
1 x Big Push Solenoid. Mains operated. Has ½" push. Order Ref: 872.
1 x Mini Mono Amp. 3W into 4 ohm speaker or 1W into 8 ohm. Order Ref: 495.
1 x Mini Stereo 1W Amp. Order Ref:870.
15V DC 150mA p.s.u., nicely cased. Order Ref: 942.
1 x In-Flight Stereo Unit is a stereo amp. Has two most useful mini moving coil speakers. Made for BOAC passengers. Order Ref: 29.
1 x 0-1mA Panel Meter. Full vision fact 70mm square. Scaled 0-100. Order Ref: 756.
2 x Lithium Batteries. 2·5V penlight size. Order Ref: 874.
2 x 3m Telephone Leads. With BT flat plug. Ideal for 'phone extensions, fax, etc. Order Ref: 552.
1 x 12V Solenoid. Has good ½" pull or could push if modified. Order Ref: 232.
4 x In-Flex Switches. With neon on/off lights, saves leaving things switched on. Order Ref: 7.
2 x 6V 1A Mains Transformers. Upright mounting with fixing clamps. Order Ref: 9.
5 x 13A Rocker Switch. Three tags so on/off, or changeover with centre off. Order Ref: 42.
Mini Cassette Motor, 9V. Order Ref: 944.
1 x Suck or Blow-Operated Pressure Switch. Or it can be operated by any low pressure variation such as water level in tanks. Order Ref: 67.
1 x 6V 750mA Power Supply. Nicely cased with mains input and 6V output lead. Order Ref: 103A.
2 x Stripper Boards. Each contains a 400V 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers, etc. Order Ref: 120.
12 Very Fine Drills. For PCB boards etc. Normal cost about 80p each. Order Ref: 128.
5 x Motors for Model Aeroplanes. Spin to start so needs no switch. Order Ref: 134.
6 x Microphone Inserts. Magnetic 400 ohm, also act as speakers. Order Ref: 139.
6 x Neon Indicators. In panel mounting holders with lens. Order Ref: 180.
1 x In-Flex Simmerstat. Keeps your soldering iron etc always at the ready. Order Ref:196.
1 x Mains Solenoid. Very Powerful as ½" pull, or could push if modified. Order Ref: 199.
1 x Electric Clock. Mains operated. Put this in a box and you need never be late. Order Ref: 211.
4 x 12V Alarms. Makes a noise about as loud as a car horn. All brand new. Order Ref: 221.
2 x (6" x 4") Speakers. 16 ohm 5 watts, so can be joined in parallel to make a high wattage column. Order Ref: 243.
1 x Panostat. Controls output of boiling ring from simmer up to boil. Order Ref: 252.
2 x Oblong Push Switches. For bell or chimes, these can switch mains up to 5A so could be foot switch if fitted in pattress. Order Ref: 263.
50 x Mixed Silicon Diodes. Order Ref: 293.
1 x 6 Digit Mains Operated Counter. Standard size but counts in even numbers. Order Ref: 28.
2 x 6V Operated Reed Relays. One normally on, other normally closed. Order Ref: 48.
1 x Cabinet Lock. With two keys. Order Ref: 55.
6½ 8Ω 5 Watt Speaker. Order Ref: 824.
1 x Shaded Pole Mains Motor. ¾" stack, so quite powerful. Order Ref: 85.
2 x 5 Aluminium Fan Blades. Could be fitted to the above motor. Order Ref: 86.
1 x Case, 3½ x 2¼ x 1¾ with 13A socket pins. Order Ref: 845.
2 x Cases. 2½ x 2¼ x 1¾ with 13A pins. Order Ref: 565.
4 x Luminous Rocker Switches. 10A mains. Order Ref: 793.
4 x Different Standard V3 Micro Switches. Order Ref: 340.
4 x Different Sub Min Micro Switches. Order Ref: 313.

MISCELLANEOUS BARGAINS

Almost all of the bargains offered last month are still available. If in doubt, give us a ring (see below).

0V-20V DC PANEL METER. This is a nice size 65mm sq. It is ideal if you are making a voltage variable instrument or battery charger. Price **£3,** Order Ref: 3P188.
FLASHING BEACON. Ideal for putting on a van, a tractor or any vehicle that should always be seen. Uses a XENON tube and has an amber coloured dome. Separate fixing base is included so unit can be put away if desirable. Price **£7.50**, Order Ref: 7.5P13.
12V 2A TRANSFORMER. £2, Order Ref: 2P337.
ANOTHER 12V-0V-12V TRANSFORMER is a 50VA and is suitable for dropping through the chassis or as it is fitted with 4 pillars it can be mounted above the chassis. Also should you want a 12V 4A transformer, then this one should be quite suitable, you use just one half of the secondary. Price **£3.50,** Order Ref: 3.5P7.
HIGH RESOLUTION MONITOR. 9" by Philips, in metal frame for easy mounting. Brand new, offered at less than price of tube alone, only **£15,** Order Ref: 15P1.
15W 8" 8 OHM SPEAKER & 3" TWEETER. Amstrad, made for their high quality music centre, **£4** per pair, Order Ref: 4P57.
INSULATION TESTER WITH MULTIMETER. Internally generates voltages which enables you to read insulation directly in megohms. The multimeter has four ranges, AC/DC volts, 3 ranges milliamps, 3 ranges resistance and 5 amp range. These instruments are ex-British Telecom but in very good condition, tested and guaranteed OK, probably cost at least £50, yours for only **£7.50** with leads, carrying case **£2** extra, Order Ref: 7.5P4.
WE HAVE SOME of the above testers but slightly faulty, not working on all ranges, should be repairable, we supply diagram, **£3,** Order Ref: 3P176.
250W LIGHT DIMMER. Will fit in place of normal wall switch, only **£2.50** each, Order Ref: 2.5P9. Note these are red, blue, green or yellow but will take emulsion to suit the colour of your room. Please state colour required.
TOUCH DIMMERS. 40W-250W, no knob to turn, just finger on front plate will give more or less light, or off. Silver plated on white background, right size to replace normal switch, **£5,** Order Ref: 5P230.
LCD 3½ DIGIT PANEL METER. This is a multirange voltmeter/ammeter using the A-D converter chip 7106 to provide five ranges each of volts and amps. Supplied with full data sheet. Special snip price of **£12,** Order Ref: 12P19.
MULTI TESTER. 19 range, ex-British Telecom, reconditioned. These measure AC and DC volts, DC milliamps and have three resistance ranges made to BT specification and 20,000 opv movement. Complete with test prods, **£8.50**, Order Ref: 8.5P3. Carrying case with handle **£2** extra.
⅓rd HORSE POWER 12V MOTOR (Sinclair C5) **£29.50,** Order Ref: 29.5P1.
SPEED CONTROLLER Suitable for the C5 or other DC 12V motor. Complete kit **£18,** Order Ref: 18P8, already made **£29.50**, Order Ref: 29.5P2.
CLOCK MODULE. 2" LCD display, requires 1·5V battery, goes back to zero when switched off so ideal for timing operations, **£2,** Order Ref: 2P307.
MINI BLOW HEATER, 1kW, ideal under desk, etc. Needs only a simple mounting frame, **£5,** Order Ref: 5P23.
MEDICINE CUPBOARD ALARM. Or it could be used to warn when any cupboard door is opened. The light shining on the unit makes the bell ring. Complete built and neatly cased, requires only a battery, **£3,** Order Ref: 3P155.
DON'T LET IT OVERFLOW! Be it bath, sink, cellar, sump or any other thing that could flood. This device will tell you when the water has risen to the preset level. Adjustable over quite a useful range. Neatly cased for wall mounting, ready to work when battery fitted, **£3,** Order Ref: 3P156.

POWER SUPPLIES – SWITCH MODE

(All 230V a.c. mains operated)

Astec Ref. B51052 with outputs +12V 0·5A, −12V 0·1A; +5V 3A; +10V 0·05A; +5V 0·02A, unboxed on p.c.b., size 180 x 130mm, **£5**, Order Ref: 5P188.
Astec Ref. BM41004 with outputs +5V 3½A; +12V 1·3A; −12V 0·2A. **£5**, Order Ref: 5P199.
Astec No. 12530, +12V 1A; −12V 0·1A; +5V 3A; uncased on p.c.b., size 160 x 100mm. **£3**, Order Ref: 3P141.
Astec No. BM41001 110W 38V 2·5A 25·1V 3A part metal cased with instrument type main input socket and on/off d.p. rocker switch, size 354 x 118 x 84mm. **£8.50**, Order Ref: 8.5P2.
Astec Model No. BM135-3302 +12V 4A; +5V 16A; −12V 0·5A totally encased in plated steel with mains input plug, mains output socket and double-pole on/off switch size 400 x 130 x 65mm. **£9.50** Order Ref: 9.5P4.

POWER SUPPLIES – LINEAR

(All cased unless stated)

4·5V d.c. 150mA. £1, Order Ref: 104.
5V d.c. 2½A PSU with filtering and volt regulation, uncased. **£4**, Order Ref: 4P63.
6V d.c. 700mA OUTPUT, £1, Order Ref: 103.
6V d.c. 200mA output in 13A case, **£2**, Order Ref: 2P112.
6-12V d.c. for models with switch to vary voltage and reverse polarity, **£2**, Order Ref: 2P3.
9V d.c. 150mA, £1, Order Ref: 762.
9V 2·1A by Sinclair, **£3**, Order Ref: 3P151.
9V d.c. 100mA, £1, Order Ref: 733.
12V d.c. 200mA output in 13A case, **£2**, Order Ref: 2P114.
12V 500mA on 13A base, **£2.50**, Order Ref: 2.5P4.
12V d.c. 1A filtered and regulated on p.c.b. with relays and piezo sounder, uncased, **£3**, Order Ref: 3P80.
Amstrad 13·5V d.c. at 1·8A or 12V d.c. at 2A, **£6**, Order Ref: 6P23.
24V d.c. with 200mA twice for stereo amplifiers, **£2**, Order Ref: 2P4.
9·5V 60mA a.c. made for BT, **£1.50**, Order Ref: 1.5P7.
15V 320mA a.c. on 13A base, **£2**, Order Ref: 2P281.
A.C. out 9·8V @ **60mA** and 15.3V @ 150mA, **£1**, Order Ref: 751.
BT power supply unit 206AS, charges 12V battery and cuts out should voltage fall below pre-set. **£16**, Order Ref: 16P6.
Sinclair Microvision PSU, £5, Order Ref: 5P148.

LASERS AND LASER BITS

2mW Laser, Helium Neon by Philips, full spec. **£30**, Order Ref: 30P1.
Power supply for this in kit form with case is **£15,** Order Ref: 15P16, or in larger case to house tube as well, **£18**, Order Ref: 18P2.
The larger unit, made up, tested and ready to use, complete with laser tube, **£69,** Order Ref: 69P1.

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100mA solar cell, **£1,** Order Ref: 631.
400mA solar cell, **£2,** Order Ref: 2P119.
700mA solar cell, **£3,** Order Ref: 3P42.
1A solar cell, **£3.50,** Order Ref: 3.5P2.
3V 200mA solar cell, **£2,** Order Ref: 2P324.
15V 200mA solar cell, **£15,** Order Ref: 15P47.
Solar Education Kit with parts to make solar fan, **£8,** Order Ref: 8P42.
Solar kits – make vintage gramophone, **£7.50,** Order Ref: 7.5P3.
Make Helicopter, £7.50. Order Ref: 7.5P17.
Make Monoplane, £7.50, Order Ref: 7.5P18.

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EPE MICROCONTROLLER P.I. TREASURE HUNTER

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

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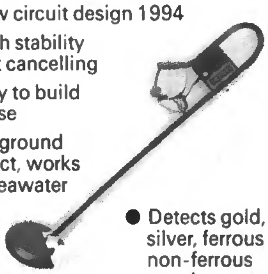
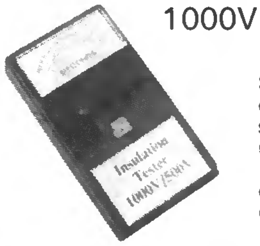
- Easy to build & use
- No ground effect, works in seawater
- Detects gold, silver, ferrous & non-ferrous metals
- Efficient quartz controlled microcontroller pulse generation.
- Full kit with headphones & all hardware



KIT 847......................£63.95

1000V & 500V INSULATION TESTER



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

KIT 848..................£32.95

SPACEWRITER

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

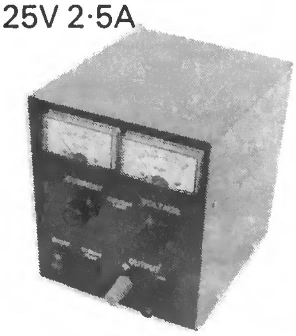
KIT 849......................£16.99

12V EPROM ERASER

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

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

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



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

KIT 845...........£64.95

MOSFET 25V 2.5A POWER SUPPLY

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

KIT 769.........................£56.82

INSULATION TESTER

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

KIT 444..........................£22.37

DIGITAL LCD THERMOSTAT

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

KIT 841..........................£29.95

ULTRASONIC PEsT SCARER

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

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

KIT Ref. 812...£14.81

DIGITAL COMBINATION LOCK

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

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

PORTABLE ULTRASONIC PEsT SCARER

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

KIT 842.........................£22.56

'COMSTEP' P.C. COMPUTER STEPPING MOTOR INTERFACE

An exciting project supplied with two 200 step motors, interface board, and easy to use P.C. software.
Allows independent control of both motors – speed, direction, number of steps, and half/full step mode. Connects to computer parallel port. Requires 12V 1A D.C. supply and printer lead.

KIT 846 (with 2 motors) ....£62.99 (Printer lead £5.00)

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

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

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

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

DIGITAL CAPACITANCE METER

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

KIT 493.........................£39.95

IONISER

A highly efficient mains powered Negative Ion Generator that clears the air by neutralising excess positive ions. Many claimed health benefits due to the ioniser removing dust and pollen from the air and clearing smoke particles. Costs virtually nothing to run and is completely safe in operation. Uses five point emitters.

KIT 707..£17.75

ACOUSTIC PROBE

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

KIT 740..........................£19.98

BAT DETECTOR

An excellent circuit which reduces ultrasound frequencies between 20 and 100 kHz to the normal (human) audible range. Operating rather like a radio receiver the circuit allows the listner to tune-in to the ultrasonic frequencies of interest. Listening to Bats is fascinating, and it is possible to identify various different types using this project. Other uses have been found in industry for vibration monitoring etc.

KIT 814..£21.44

HAMEG HM303 30 MHz DUAL TRACE OSCILLOSCOPE & COMPONENT CHECKER

Western Europe's best selling oscilloscope - now improved. It now features 30MHz bandwidth, triggering to 100MHz and 2mV/div sensitivity.
Sharp bright display on 8 x 10cm screen with internal graticule. Special component tester built in – allows capacitors, resistors, transistors, diode, and many other components to be checked at a glance.
As with its predecessor, the QUALITY OF THIS INSTRUMENT IS OUTSTANDING. It is supported with a two year warranty covering parts and labour. If you are buying an oscilloscope, this is the one. It costs a fraction more than some others, but it is far far superior. Supplied with test probes, mains lead, and manual.

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A more advanced book to follow the others. No soldering. Circuits cover a wide range of interests.
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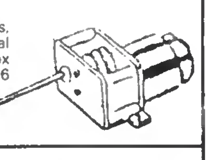
DC MOTOR/GEARBOXES



Ideal for robots, buggies, and many other mechanical projects. Min. plastic gearbox with 1.5-4.5V DC motor. 6 ratios can be set up.

Small type MGS....£4.77

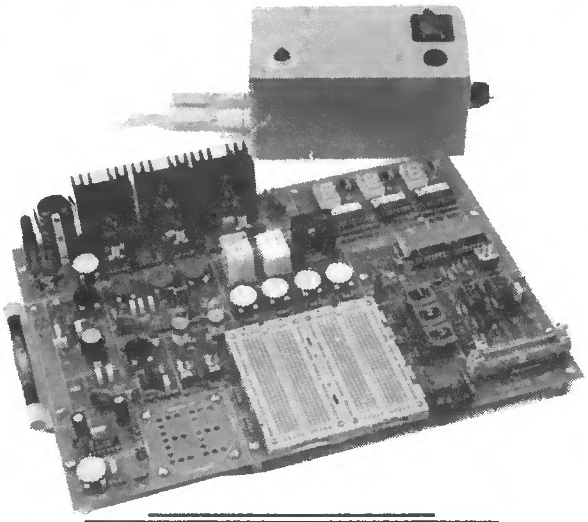
STEPPING MOTORS

For computer control via standard 4 pole unipolar drivers.

MD38 - miniature 48 steps per rev...............£9.15
MD35¼ - standard 48 steps per rev...........£12.99

MAGENTA

Teach-In '93



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ALL COMPONENTS TO ASSEMBLE THE EPE MINI LAB.

Follow this exciting educational series as featured in EPE through 1993.

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Components are supplied in packs to keep ordering simple.

A full MINI LAB consists of ML1, ML3, ML5, ML6. These are available at a special combined price of................................ **£119.95**
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ML2, ML3, ML5, ML6 at............... **£109.95**
The transformer unit ML4 is also needed.... **£22.55**

KIT ML1	MINI-LAB P.C.B. + all components inclusive of breadboard for Part 1 (Nov. '92)............................	**£52.45**
KIT ML2	All Components for Part 1 less p.c.b..	**£41.95**
KIT ML3	Power Supply components...........	**£20.95**
KIT ML4	Transformer unit...........................	**£22.55**
KIT ML5	L.E.D. Voltmeter, signal generator, audio amplifier and 555 timer..	**£35.65**
KIT ML6	Logic probe, display, radio tuner..	**£18.85**

(Note: batteries not included)

All prices include V.A.T. Add **£3.00** p&p.

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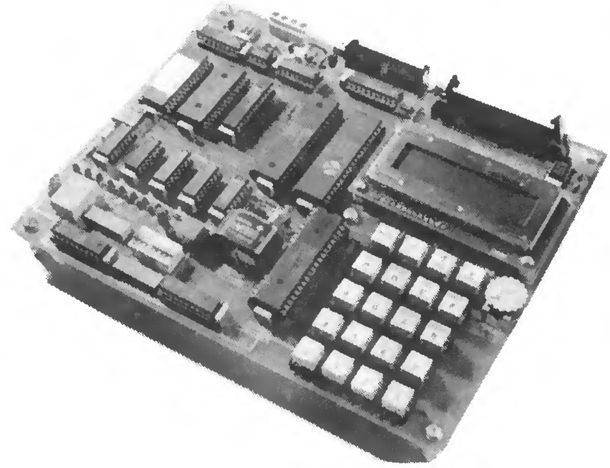
MAGENTA

Teach-In '93



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A 6502 Microprocessor trainer with many features. Accompanied by an excellent set of tutorial articles and a manual.

Repair/fault-finding help assured when you buy your kit from us.

Full MICRO LAB kit including PC Board, EPROM, PAL, & Manual.
MIC 1 .... **£155.95**
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SIXTEEN MILLION POUND MAPLIN

I wonder if the two men who started selling transistors by mail order in their spare time ever dreamed that the company they were launching would be worth around £16 million just 22 years later? They started with a two inch single column advertisement in *Practical Electronics* in 1972 – sold to them by our present advertisement manager Peter Mew.

The company is Maplin which last year had a turnover of around £30 million, has 33 shops and made £1.5 million profit. Maplin's shares have been transferred to Cannon Street Investments Plc, soon to be renamed Saltire. Maplin required extra funding to continue development of the company at a good pace and by linking with a Stock Market listed company this has become available. The main players in the C.S.I. Group are Altai – a company whose name many readers will know – they sell electronic equipment to wholesalers and retailers in Europe; Network – who manufacture TVs and other home appliances in Eastern Europe and Dunnet – who are a computer distributor in Holland.

We understand that it's no change at Maplin except that they can now go full steam ahead with new developments and expansions which include opening five or more new shops a year, expanding their present range of products and accelerating expansion of their professional distribution arm M.P.S. Roger Allen, MD, tells us that their present "pamphlet" (the 864-page Maplin catalogue) is just not big enough to cover the proposed product range and there are some areas that Maplin do not yet cover at all. Roger has been negotiating long and hard to achieve the link up with C.S.I. where Maplin will not be swamped as part of a massive conglomerate, but will have the resources required to accelerate their ongoing development.

Maplin's small management team will continue to run things and it looks like good news for everyone involved with the company, including the customer. I wonder how big next year's catalogue will be?

As an interesting aside Roger tells us he remembers offering 2N3055 transistors for 49p each in their early advertising. They believed by selling this popular power transistor at the lowest price everyone would buy from them – in fact it took them six months to sell the first one. They must, however, have done a few things right in the last 22 years. They still sell 2N3055s and probably more than two a year – but the price has gone up to £1.15; so that's how they made their profit!

Mike Kenward

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12V, 35W PUBLIC ADDRESS AMPLIFIER

JOHN ELLIS

A versatile discrete design using MOSFETs. Can provide 100V line and 8Ω outputs and may be used as a 12V to 240V inverter.

THIS audio power amplifier has been designed to operate from 12V and provide up to 35W power r.m.s.. It is a public address amplifier with 100V line output for loudspeaker distribution systems. An output transformer provides one low impedance winding for direct connection to a loudspeaker and two 100V secondaries for the line output. These are normally operated in parallel but if connected in series, the unit can provide 240V to double as a converter. Constructors can wind secondaries for different configurations if required. We suggest that you do not attempt to build this amplifier unless you are reasonably experienced in project construction.

INPUTS

Four inputs are provided with separate volume controls. Two inputs are amplified for signals from microphones or guitar pick-ups, while the other two are high level inputs suitable for radio or cassette signals. A mixer stage combines all four signals and provides a master volume control.

No input is provided for RIAA disc signals. This is because it is envisaged that the most likely use would be from cassettes or CD players and microphones. (Note that public playing of any recorded, published music will need licensing).

No tone controls are provided. Normally a P.A. amplifier is operated at or near full volume which leaves no headroom for boosting any particular frequency or band over another. If tone controls can't be used, there is no point having them.

The output stage uses power MOSFETs in a class-B configuration. The original design used bipolars but was re-designed – and modernised – when it was found that typical 8A rated types such as the 40251, or its standard equivalent, 2N6371, were uncommon, if not extinct, while MOSFETS with current ratings in the 15A to 30A range are now more common and possibly cheaper.

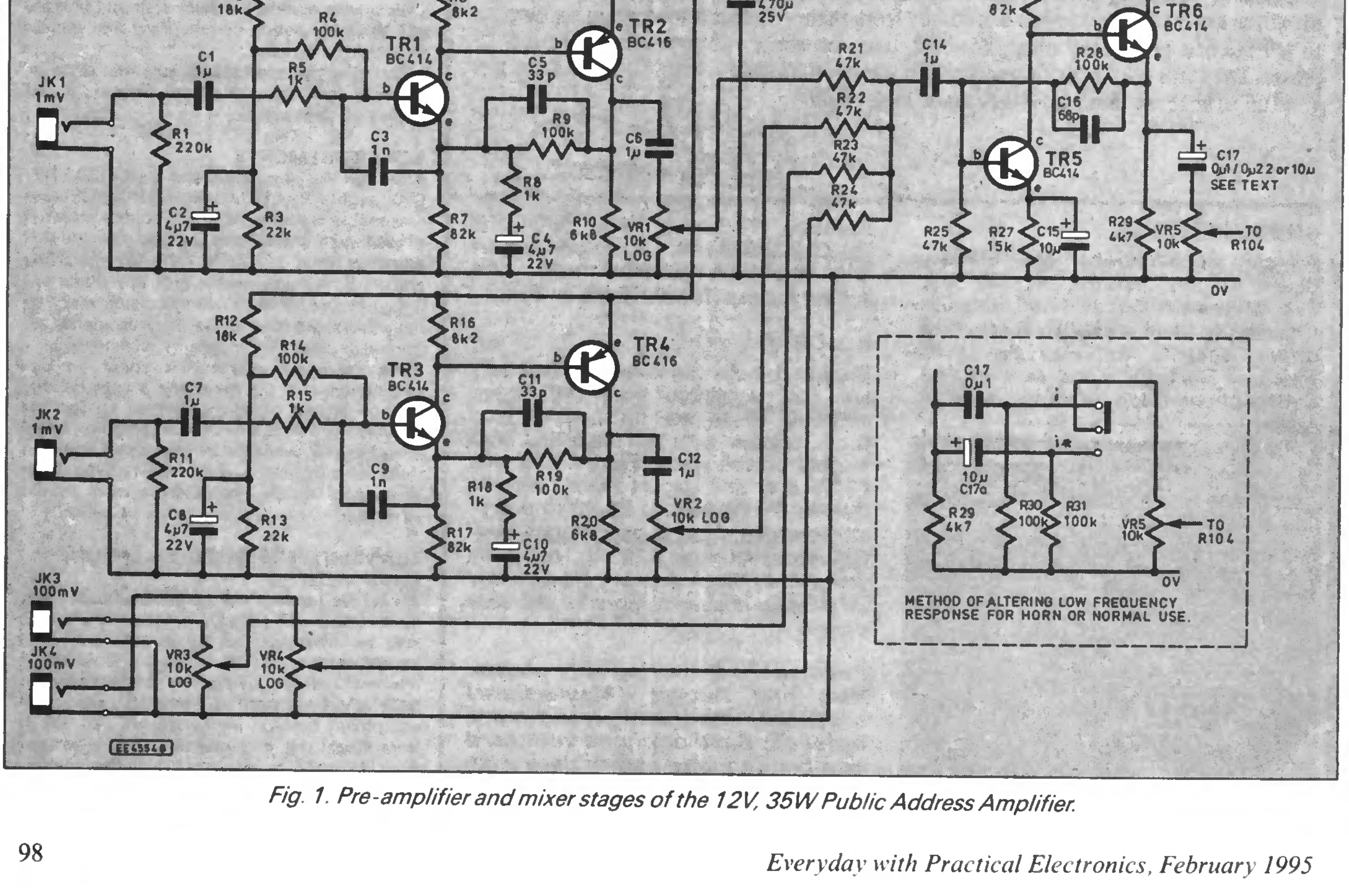
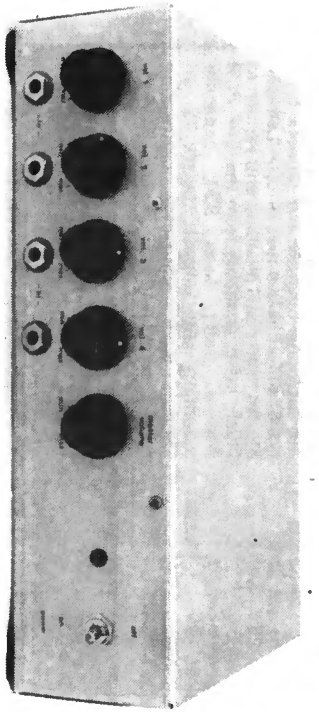
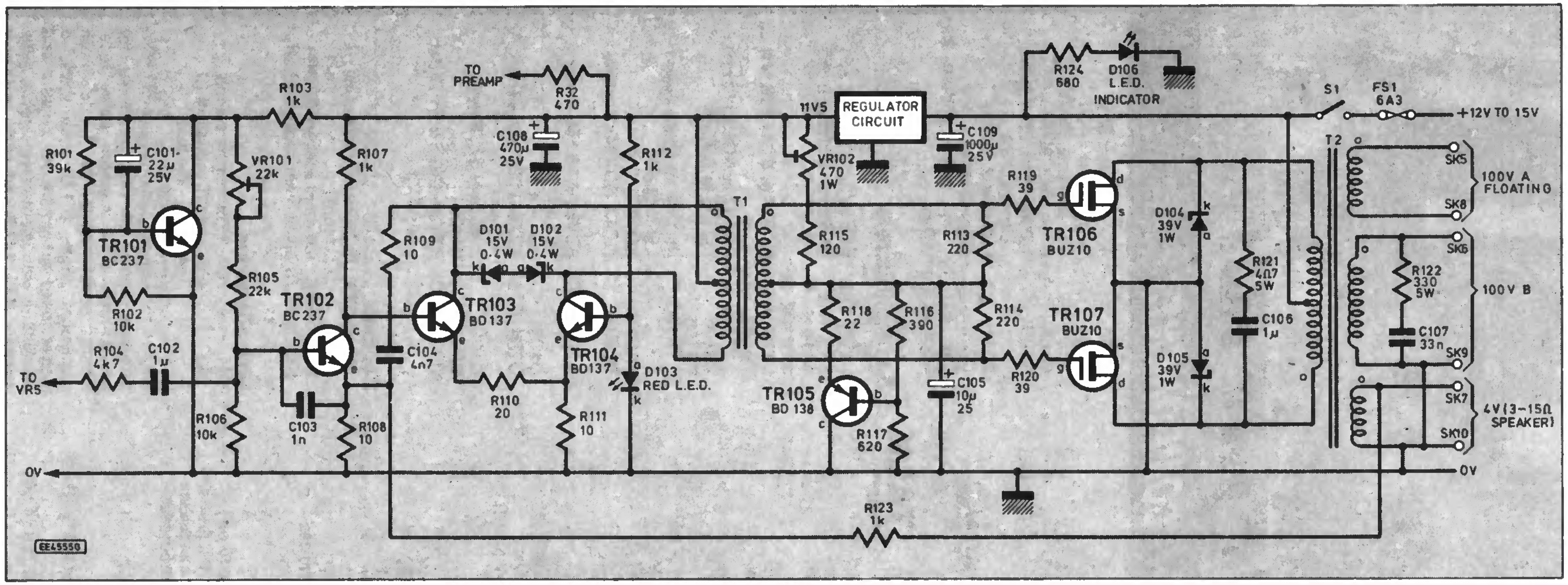


Fig. 1. Pre-amplifier and mixer stages of the 12V, 35W Public Address Amplifier.





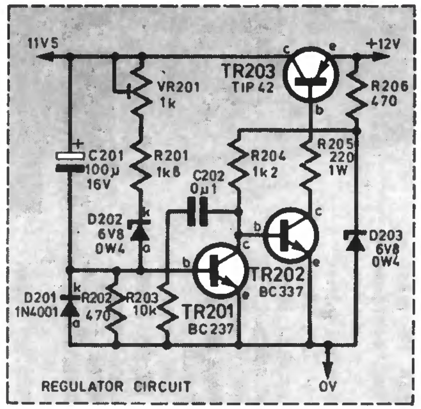


Fig. 2. Power amplifier circuit and regulator circuit (right).

PERFORMANCE

The amplifier signal-to-noise ratio and distortion figures are not the ultimate in hifi standards, but are respectable. Typically the distortion may be 0·5 per cent, but may worsen near clipping; the signal-to-noise figure is around 60 to 70dB and the frequency response 70Hz to 15kHz.

The low frequency limit can be modified as described later, but the 15kHz limit is unlikely to be improved without laminations thinner than the 0·35mm type used in the output transformer. Given that there is always a balance in transformers between low and high frequency response, this PA amplifier provides acceptable performance for PA work where horn speakers may well limit quality.

For a transformer output, public address, amplifier, discrete designs can perform adequately, are inexpensive and usually more serviceable than designs using i.c.'s.

INPUT STAGE

The pre-amp circuit is shown in Fig. 1. Transistor TR1 is biased at mid-rail by resistors R2, R3 and R4. An *npn-pnp* configuration offers simplicity with functionality. TR1 is operated at 60μA and TR2 at 600μA for low noise. BC414 and BC416 low noise types are used. Input filter R5 and C3 stop r.f. pickup, while the 33pF capacitor C5 stabilises the design at high frequencies and limits the bandwidth to 50kHz.

Volume control VR1 is used to set the level of the output signal. The gain of this stage, set by feedback resistor R9 and the ratio resistor R8, is 100. The input signal should be about 1mV. The second channel low level amplifier is identical.

The mixer stage uses a low current input transistor TR5 operated at 100μA with its output buffered by TR6 at 1mA. The bias is set by a classical potential divider with feedback through R28, and stabilised by R25 and R27. Capacitor C15 limits the frequency response to 25kHz for all inputs. This dual *npn* pair offer low noise and distortion with virtual earth input to enable the signals to be mixed without interference from each other. The output from this stage is taken via capacitor C17 and the Master Volume Control VR5 to the main amplifier. A similar circuit was first described by H. Walker in *Wireless World*, May 1971.

Capacitor C17 should be chosen for the application intended. It is smaller than normally used to limit the low frequency response in the output stage to prevent transformer saturation. For normal response to 70Hz C17 should be 220nF. If horn speakers are to be used, C17 should instead be 100nF. Note that this value allows for the power amplifier input impedance to load the volume control at full output.

If the amplifier is to be used as a 50Hz inverter, or if low frequency response is limited at the signal source, C17 should be 10μF. Two values of C17 can be selected with a slide switch, in this case 100nF and 10μF are recommended, or for critical applications a three-way selector switch could be used for 68nF (200Hz to 250Hz for horns), 220nF for 70Hz and 10μF for 50Hz inverter or wider bandwidth.

The preamplifiers are all operated from an 11·5V stabilised rail and a simple *RC* (R32, C13) filter to decouple ripple from the output stage.

OUTPUT STAGE

The output stage is shown in Fig. 2. The need for an output transformer is dictated by the 100V line requirement and operation from 12V d.c. Once this is established, it is fairly easy to decide on using a driver transformer too. Early transistor amplifiers used this approach but MOSFETs simplify the design.

The better driver configurations in "transformer" amplifiers minimised d.c. bias current in the driver transformer so that no air gap was necessary. This design uses a class-A push-pull driver stage, similar to one by R.C. Bowes first published in *Wireless World* in July 1961, which feeds a matched pair of MOSFETs to provide a relatively simple but powerful design. The BUZ10 MOSFETs are rated at 20A up to 50°C but must be derated to 15A above that temperature. The transconductance is 8A/V and threshold voltage 4V maximum. The maximum dissipation is 75W and operating voltage 50V.

Though it would seem that only 1V drive is needed to switch 8A, at low drain voltages the transistors enter their linear region when the gate drive needs to be increased to compensate. This is probably the biggest distortion mechanism near peak output and requires a larger gate drive to be available. Possibly, the low threshold voltage MOSFETS (e.g. BUK553-60B) could be driven with capacitor coupling, but transformer coupling allows a higher drive voltage swing for the standard types of MOSFET.

The input stage comprises an input transistor TR102 feeding a long-tail pair TR103 and TR104. The tail current is set by R111, and the base bias voltage of TR104, to 100mA. The bias voltage is obtained from the forward voltage of a red l.e.d. (D103) which is typically 1·6V and thermally compensates the base voltage drift in TR104. The current of 50mA in TR103 is set by the bias on TR102. This is adjusted from the bias regulator adjuster VR101, which is in turn stabilised by TR101.

The current in TR104 will automatically adjust to keep the tail current constant. The currents in TR103 and TR104 should be set equal, and around 50mA. TR103 and TR104 feed the driver transformer T1, which is a centre-tapped to centre-tapped 1:1 (or 1 + 1:1 + 1) ratio design.

The tap on the secondary is connected to a bias chain described below. Each output terminal is connected to a 220 ohm resistor (R113 and R114), to provide a low impedance load which improves the speed of the output stage, reduces the effect of winding capacitance on frequency response and, most importantly, defines the gain of the driver stage to improve stability. Small 39 ohm resistors are connected in series with the MOSFET gates to suppress high frequency oscillation.

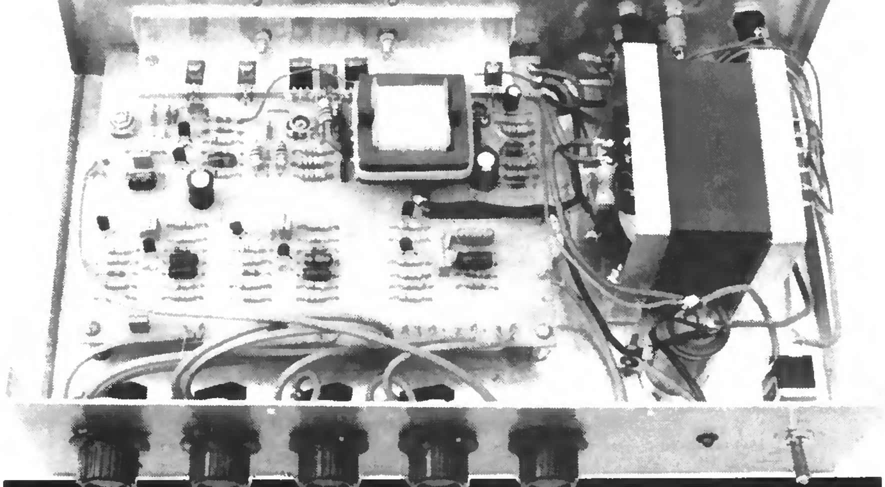
One bias chain is provided for both MOSFETs as, supposedly, they are able to be paralleled even without separate source resistors. But MOSFETs can show threshold voltage variations from 2V to 4V, so it is important therefore that matched MOSFETS are used to ensure that their quiescent currents are equal.

In practice, as was often the case for bipolars, two devices purchased at the same time will usually be from the same batch and be sufficiently close. In the author's design the quiescent currents, were 110mA and 140mA. This is about the limit of tolerable mis-match and lower distortion figures may be possible with a better match.

QUIESCENT CURRENT

The quiescent current is higher than would be used in a bipolar design because MOSFETs become quite non-linear near threshold (or cut-off). Even so, the overall quiescent current is a respectably low 0·4A.

The quiescent current must be stabilised against battery and temperature variation. MOSFETs exhibit two opposing thermal drifts. At gate voltages just above the threshold, giving low drain currents, the drift in threshold voltage downwards increases the drain current with increasing temperature. At high bias levels the mobility in the MOS channels dominates which reduces the drain current



COMPONENTS

Resistor

R1, R11	220k (2 off)
R2, R12	18k (2 off)
R3, R13	22k (2 off)
R4, R9, R14, R19, R28, R30, R31	100k (7 off)
R5, R8, R15, R18, R103, R107	1k (6 off)
R6, R16	8k2 (2 off)
R7, R17, R26	82k (3 off)
R10, R20	6k8 (2 off)
R21 to R25	47k (5 off)
R27	15k
R29, R104	4k7 (2 off)
R32	470 0·5W
R101	39k
R102, R106	10k (2 off)
R105	22k
R108, R109	10 (2 off)
R110	20 0·25W
R111	10 0·25W
R112	1k 0·5W
R113, R114	220 (2 off)
R115	120 0·5W
R116	390 0·25W
R117	620 0·25W
R118	22 0·25W
R119. R120	39 0·25W (2 off)
R121	4Ω7 5W
R122	330 5W
R123	1k 0·5W
R201	1k8 0·25W
R202	470 0·25W
R203	10k 0·25W
R204	1k2 0·5W
R205	220 1W
R206	470 0·5W

All 0·125W metal film unless otherwise stated.

See SHOP TALK Page

Potentiometers

VR1 to VR5	10k log. (5 off)
VR101	22k cermet preset
VR102	470 cermet preset
VR201	1k cermet preset

Capacitors

C1, C6, C7, C12, C14, C102	1µ polyester 63V (6 off)
C2, C4, C8, C10	4µ7 elect. 22V (4 off)
C3, C9, C103	1n ceramic 63V (3 off)
C5, C11	33p ceramic 63V (2 off)
C13	470µ radial elect. 25V
C15, C105	10µ elect. 25V (2 off)
C16	68p ceramic 63V
C17	100n polyester 63V (see text)
C17a	10µ elect. 25V (see text)
C17b	220n polyester 63V (see text)
C101	22µ elect. 25V
C104	4n7 polyester 63V
C106	1µ polyester 100V
C107	33n polyester 630V
C108	470µ elect. 25V
C109	1,000µ elect. 25V, ripple current > 3A
C201	100µ elect. 16V
C202	100n ceramic 63V

The 4µ7 to 22µ elects should be 12·5mm x 5mm types

Semiconductors

TR1, TR3, TR5, TR6	BC414 or BC549 (4 off)
TR2, TR4	BC416 or BC559 (2 off)
TR101, TR102, TR210	BC237 or BC547 (3 off)
TR103, TR104	BD137 or BD135 (2 off)
TR105	BD138 or BD136
TR106, TR107	BUZ10, matched – see text (2 off)
TR202	BC337
TR203	TIP42, BD224 or similar
D101, D102	BZY88-C15 15V Zener (2 off)
D103	red l.e.d.
D104, D105	BZX61-C39 39V Zener (2 off)
D106	indicator l.e.d. 5mm
D201	IN4001
D202, D203	BZY88-C6V8 6·8V Zener (2 off)

Sockets

JK1 to JK4	0·25 inch jack sockets (4 off)
SK5 to SK7	red 4mm sockets (3 off)
SK8 to SK10	black 4mm sockets (3 off)

Miscellaneous

S1	10A, 125V toggle switch
S2	slide switch, miniature (if required – see text)
T1	driver transformer (see text)
T2	output transformer (see text)

Control knobs (5 off); grommet for power lead; 6·3A medium delay fuse; 20mm panel fuseholder; one inch aluminium angle, 0·125 inch thick, 6 inches long; aluminium for chassis and heatsink or equivalent case; screws, nuts, washers (M3, M3.5 and M4); transistor insulating kits (TO220, 3 off); (TO126 2 off; additional bushes); self-tappers, 8 off no. 6; self-adhesive feet (4 off); Letraset, etc. for front panel labelling and varnish to finish; p.c.b. available from the *EPE PCB Service*, order code 930; capacitor mounting clip; support pillars (2 off 19mm); p.c.b. connector; connecting wire, screened lead etc.

Approx cost guidance only **£65** *excluding case*

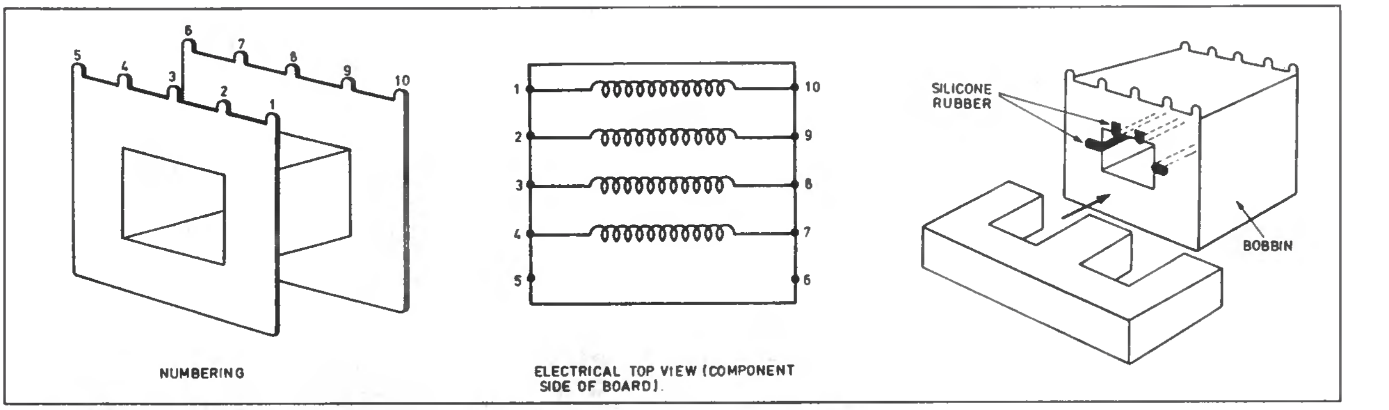


Fig. 3. Driver transformer winding and assembly.

with temperature. This prevents thermal runaway, but the zero-drift balance point corresponds to quite a high current (about 1A in the BUZ10).

The quiescent current is therefore stabilised against thermal drift by TR105. This is a conventional bias regulator which happens to match the thermal drift in a MOSFET at least approximately. The bias does depend a little on the setting of VR102. Fine tuning can be achieved by adjusting R116, R117 and R118, but is probably not necessary. TR105 is a *pnp* instead of the usual *npn* so that it does not require isolation from the heatsink, thus reducing thermal inertia.

The supply voltage to the bias network is also regulated because a car battery voltage can range from 12V to 12·5V when used alone (even when newly charged) to typically 14V when being charged (as "on the road"). To stabilise the bias (and pre-amp) voltage, a three transistor circuit (TR201 to TR203) is used with a *pnp* power transistor such as a TIP42 for TR203 in the so-called low dropout configuration. The stabiliser potentiometer VR201 is adjusted to give 11·5V output.

FREQUENCY RESPONSE

The frequency response of the amplifier is primarily limited by the output and driver transformers as mentioned. In the driver transformer, there is significant inter-winding capacitance while in the output transformer the metal laminations are not really up to providing more than the 15kHz achieved. To squeeze 20kHz through a transformer either use ferrite material or laminations of 0·05mm!

The overall gain is set by resistor R123 and input resistor R108 at 100, which is higher than would be used for a hifi amp. Consequently the distortion is not as low, but sensitivity is more important in PA equipment. The feedback is stabilised against oscillation by R109 and C104. The overall sensitivity is about 100mV for 6V r.m.s. into the primary windings rather than 60mV due to the input filter R106 and C103.

TRANSFORMERS

Both driver and output transformers made specially for this design are available – see *Shoptalk*. However it is possible for experienced constructors to make their own.

Starting with the transformer equation:

$N/E = 1/(4.44\,fAB)$

Where N/E is the turns per volt, f the (lowest) operating frequency, A the section of the core (in sq. m) and B the maximum flux density allowable (in Teslas), a couple of sample designs resulted in a choice of an E42/15 ferrite core or a metal core pattern 18 for the driver. These are 42 and 42·8mm wide. The ferrite core is 42mm high while the waste-free iron laminations give a shorter height of 35·7mm. Bobbins for these fit a 0·1 inch grid with pin spacings of 0·2 inches in rows of five at 1·4 inches and 0·9 inches apart respectively. The board is able to take either.

The ferrite core has a low saturation flux density of 0·35T and a low relative permeability (mu) of about 1200 to 1500. It therefore needs a high number of turns to achieve the inductance. This is 140 t.p.v. which gives an inductance of 1·1H, and frequency response of 35Hz. The iron core option was not used in the prototype despite having been used in a bipolar predecessor. The number of turns on each of the four coils is 600 for the ferrite core. The wire gauge, determined from the total number of turns and bobbin winding window, is 36s.w.g.

Since the turns ratio is 1:1 on four windings, the exact number of turns is not too critical if four insulated wires are wound together (quadrafilar) until the bobbin is almost full. Leave room for two layers of masking tape. The resistance of the windings should be 30 ohms per coil.

CONNECTIONS

When soldering the coils it is important to wire the starts and ends of the coils to the bobbin pins expected by the circuit board. Since the coils are all equal and wound side by side which coil is which is immaterial: but the end of one must be wired to the pin corresponding to its start. The circuit board layout assumes that the coil "starts" are taken to pins 1, 2, 3 and 4 and ends to 10, 9, 8 and 7 on the Siemens (ferrite) bobbin.

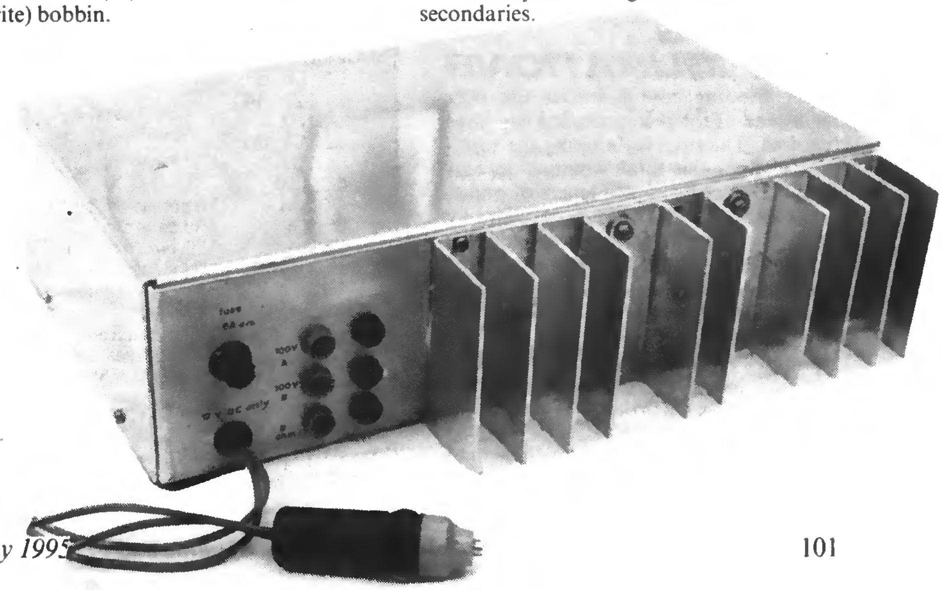
If you can get four different colours of insulation this helps. Solderable enamel is best, but appears to be supplied only in red or green, so you may have to use a meter to check!

The 36s.w.g. wire can conduct 50mA very comfortably at a current density of about 2A/sq.mm. Commercially, wire is used up to 4A/sq.mm in low power transformers. The ferrite core type E42/15 (Siemens part no. B66325-G0000-X127) and bobbin (B66242-J1000-D001) can be obtained from Electrovalue – see *Shoptalk*. Note that a single window bobbin is needed for audio transformers. Two E-core halves are needed for one transformer.

Before assembling the cores, short strips of silicone rubber should be inserted into the core to prevent slop after assembly due to the bobbin being marginally larger than the core as shown in Fig. 3. Use a tie-wrap (0·25 by 8-inch or larger) to keep the core halves together. Pull the tie-wrap tight and snip off the surplus.

OUTPUT TRANSFORMER

The starting point for the output transformer is again the transformer equation but with a core pattern 29 considered. This core is used commercially in a 1 inch stack for 50W mains transformers. It proved not to be possible to obtain 35W from it in class B with two primaries at 50Hz, in an amplifier if the magnetic flux density was kept well away from saturation. In a mains transformer the magnetic flux gets very near saturation to minimise the number of turns required. The solution is to increase the stack height from one inch to 1·5 inches. The turns ratio reduces to 4·6 (actually 5 turns per volt was used) needing 30 turns. Now the two primary coils fit in three layers leaving room for the three secondaries.



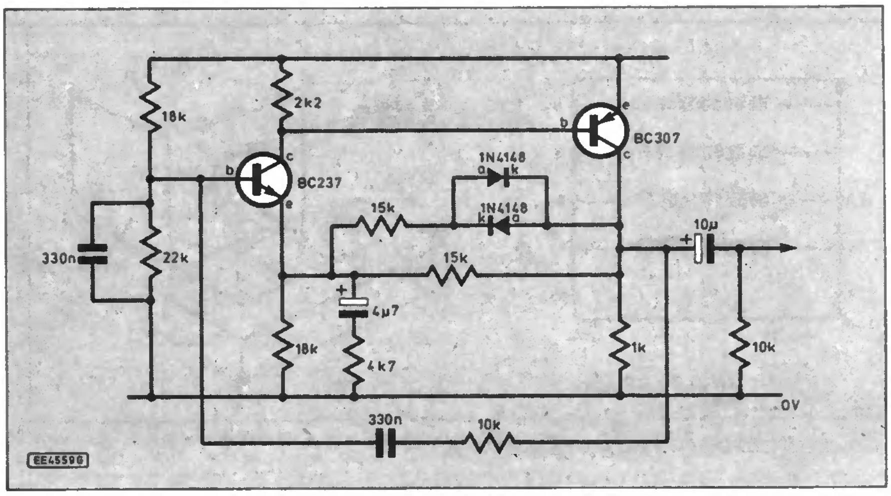


Fig. 4. A 50Hz near-sine wave generator.

The transformer is designed to operate with 6V r.m.s. into the primary. A peak voltage of 9V allows 3V for resistance losses in the primary and MOSFETs. The amplifier is thus able to deliver full power from a 12V battery off charge, unlike many transistor amplifiers which are designed for 14V – which is only obtained when the battery is being charged.

The two 100V secondary windings then need 16·7 times 30 plus 5 per cent or 525 turns, and the low voltage speaker winding 23 turns for 4V r.m.s. output. This will drive 4W into a 4 ohm load or 2W into an 8 ohm load. It is really for local monitoring purposes.

For home winding enthusiasts, the details are:

100V secondary 1: 525 turns of 34s.w.g.
Primary: Bifilar 30 turns of 18s.w.g.
Low voltage secondary: 23 turns of three 28s.w.g. wires in one layer.
100V secondary 2: 525 turns of 34s.w.g.

It is essential to use the same number of turns *exactly* as on the first high voltage secondary if the secondaries are to be wired in parallel. All wires should be enamelled copper or "solderable enamel" (polyurethane). Use a layer of paper between each complete winding to provide protection and to prevent coil slip to lower layers. Finish the bobbin by covering the windings in insulating tape, using several layers.

Assemble the E and I core plates alternately in a clean area to keep a good mating surface between the plates. Simple clamps can be fashioned from half-inch, 16s.w.g. aluminium angle (see Fig. 7). After testing, spray the finished core with a waterproof, electrical insulating varnish to prevent the core from rusting.

WINDING CONFIGURATIONS

Other winding configurations are possible instead of the recommended windings if required. The rules for altering the windings are, first, the total winding, including insulation and support layers of paper, must fit into a bobbin window of 33mm by 10mm. The primaries should remain the same. Secondaries should be wound at 5 turns per volt plus 1 per cent per 6W loading. Use only enamelled (or "solderable enamel") copper wire.

Examples of other secondaries might be:

For 35W at 100V only, wind two 50V, 263 turn coils using 29s.w.g. These windings are connected in series for 100V.

For 35W into 8 ohms (and no 100V line) wind 27 turns in one layer using 19s.w.g., then the primaries, then two layers of 19s.w.g. (27 turns each).

It is important that transformers are not operated "open loop" due to the large possible voltage spikes which may arise as a result. Resistor-capacitor networks R121-C106 and R122-C107 help load the amplifier in the event of it being disconnected from loudspeakers. Zener diodes D104 and D105 are intended to protect the MOSFETs in the event of a large overdrive, and D101 and D102 prevent excessive current drive. A fuse protects the amplifier from sustained current overload. This is a 20mm fuse rated at 6·3A.

INVERTER

The amplifier can make a good inverter for 240V. The turns per volt of 5 will enable the flux to be increased to between 1.3 and 1.4T which corresponds to a square wave. This will push the output voltage up from 100V to 120V (the amplifier will operate near clipping) to get 240V from both secondaries in series. A 50Hz clipped sine wave or square wave at 200mV to 1V should be applied to a high level input and the volume controls adjusted for 240V output. The coupling capacitor C17 will need to be increased to 10μF for a good 50Hz wave shape as mentioned. Fig. 4 shows a suitable 50Hz generator circuit.

CONSTRUCTION

The "chassis" designed for this project is actually a simple aluminium box 12 inches wide by three inches high and seven inches deep. It is folded from 16s.w.g. aluminium in two sections as shown in Fig. 7, but a commercial box could also be used. It needs an aluminium back panel to allow a good heat transfer from the power transistor mounting bracket to the finned heatsink. Heatsink fins can be made from strips of aluminium three inches by various lengths and folded to provide a 1·5 inch fin, 8 inch wide heatsink at the back left, as shown in Fig. 8. This is probably overkill for a 35W amplifier and could probably dissipate 50 or 70W. Again a commercial alternative would be acceptable.

The power transistors are mounted on a one-eighth inch thick, one inch aluminium angle which is bolted to the rear aluminium case and heatsink. Two support pillars at the front complete the p.c.b. mounting so that in total four bolts hold the p.c.b. Construction of the p.c.b. is shown in Fig. 5.

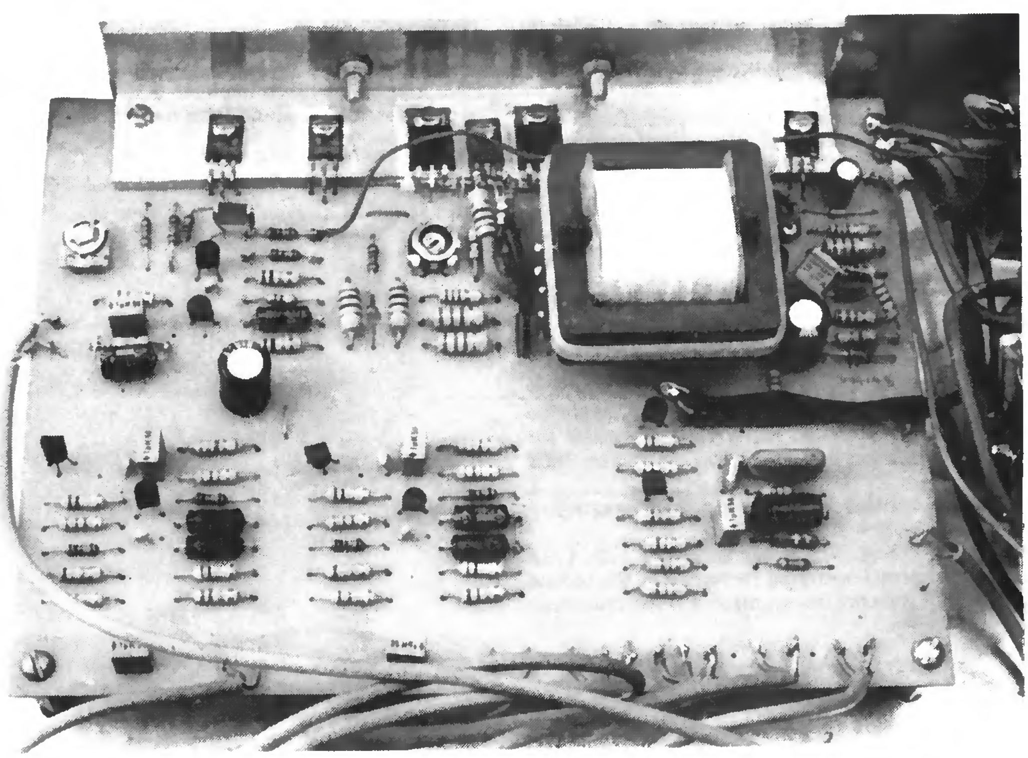
The five potentiometers (VR1 to VR5) are mounted on the front panel, with four 0·25 inch jack sockets (JK1 to JK4) and on the right, a power switch (S1) and indicator l.e.d. (D106). On the rear are three pairs of output sockets for the low voltage and two 100V outputs, a 20mm fuseholder (the maximum fuse rating is used of 6·3A) and an input lead grommet hole.

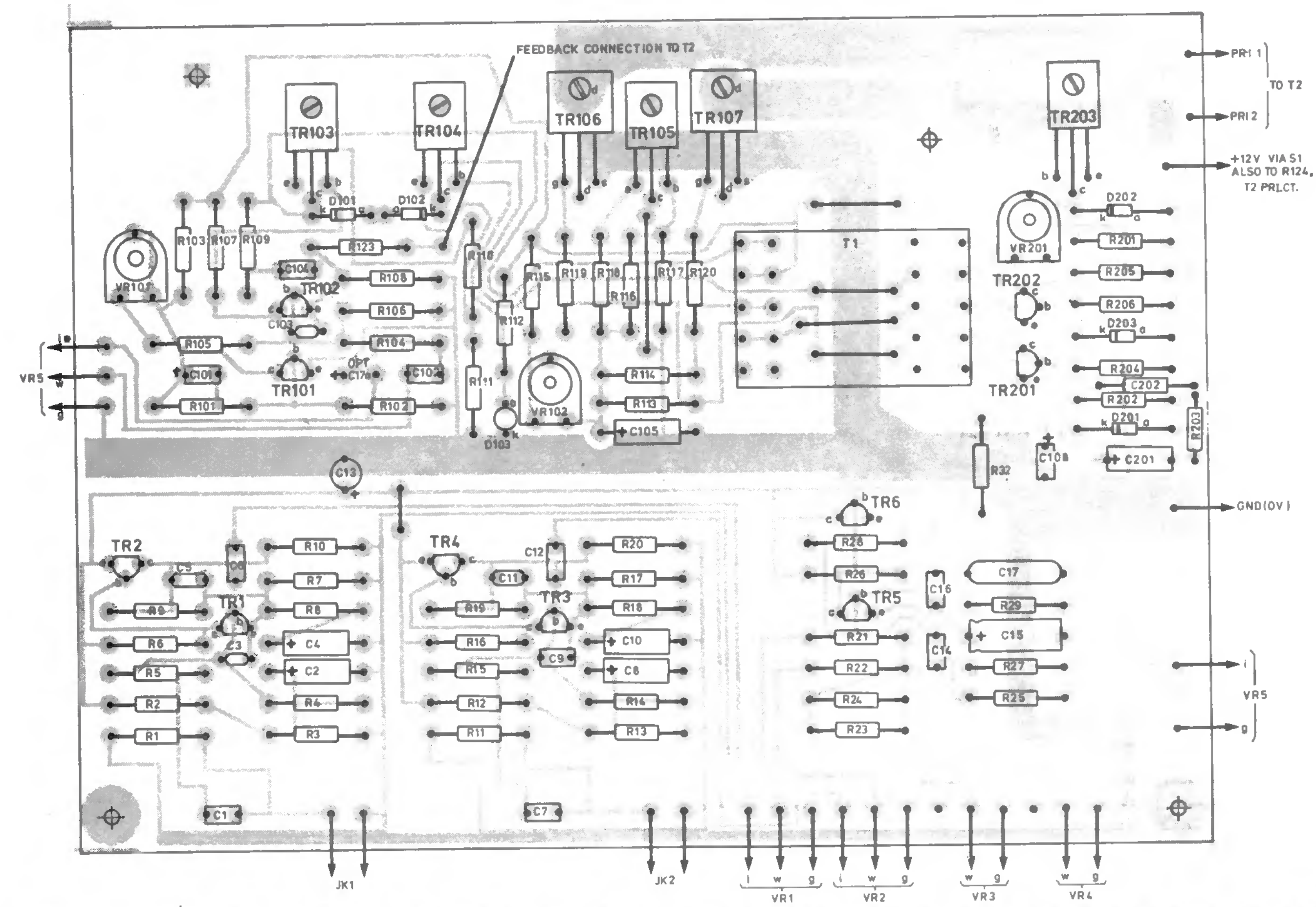
The output transformer (T2) is mounted on the base while the driver transformer (T1) is mounted on the p.c.b. A high current smoothing capacitor (C109) of at least 1,000μF is clamped to the base as well.

HEATSINK BRACKET

Drilling the heatsink angle bracket requires some explanation. Two M3 bolts are used to hold this in place but as they may overlap a copper track, drill the holes larger than the M3 bolt to take a nylon M3/6BA insulator which should be positioned on the copper side before assembly. The two TO126 transistors are mounted also with the insulating bushes, so drill holes large enough for clearance (4·5mm). The same also applies to the series regulator transistor.

The MOSFETs (TR106 and TR107), however, make contact to the wide tracks through the mounting bolts rather than the drain wires. Holes need to be drilled for M3 clearance in the p.c.b. To align the holes, drill the M3 clearance (3·2mm) through the aluminium angle and p.c.b., clamped by





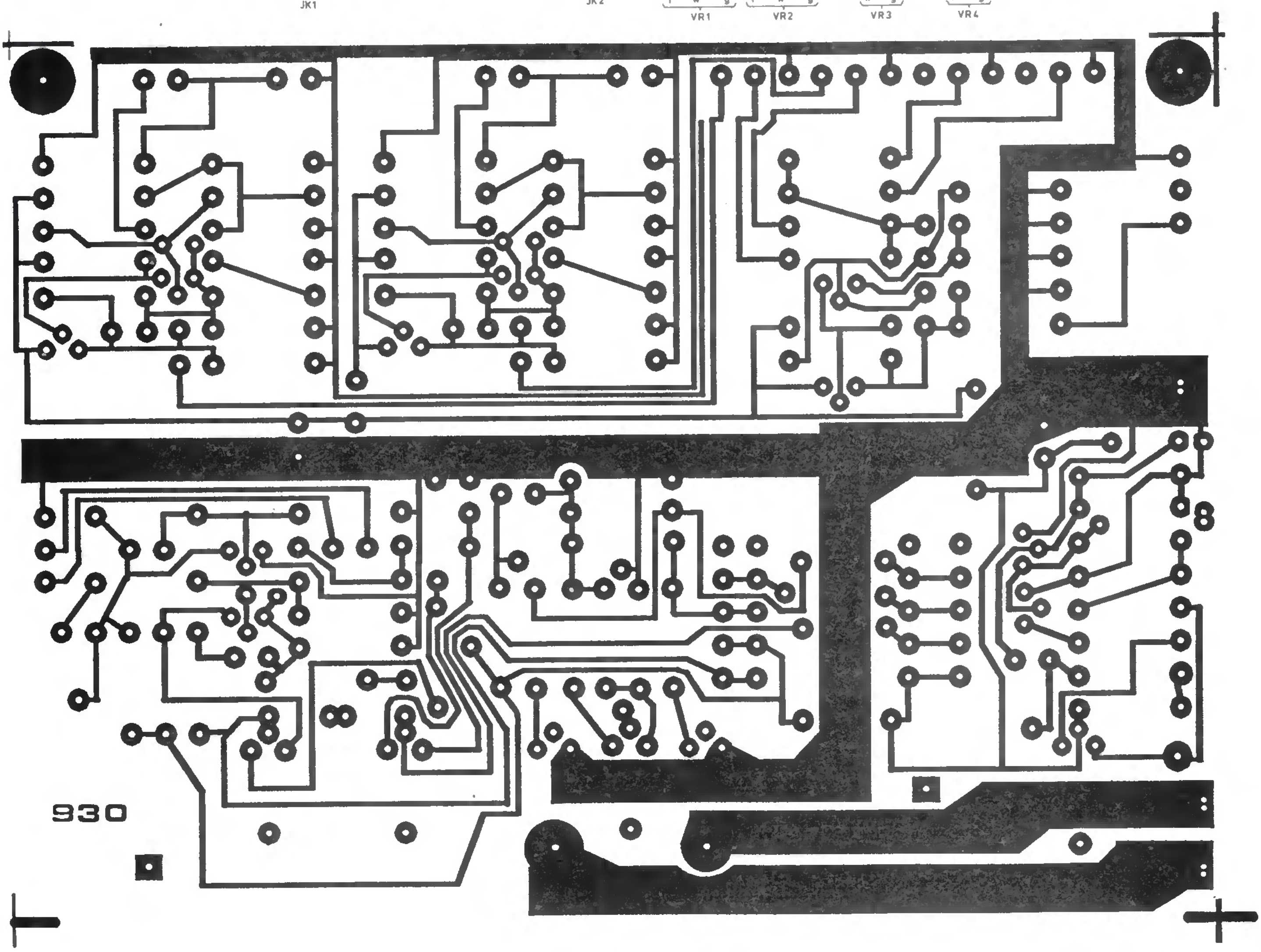


Fig. 5. P.C.B. layout and construction for the P.A. Amplifier. The copper foil master is shown full size.

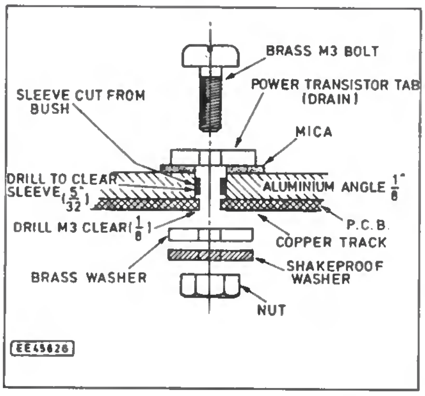


Fig. 6. Power transistor mounting for the "hot bolt" connection.

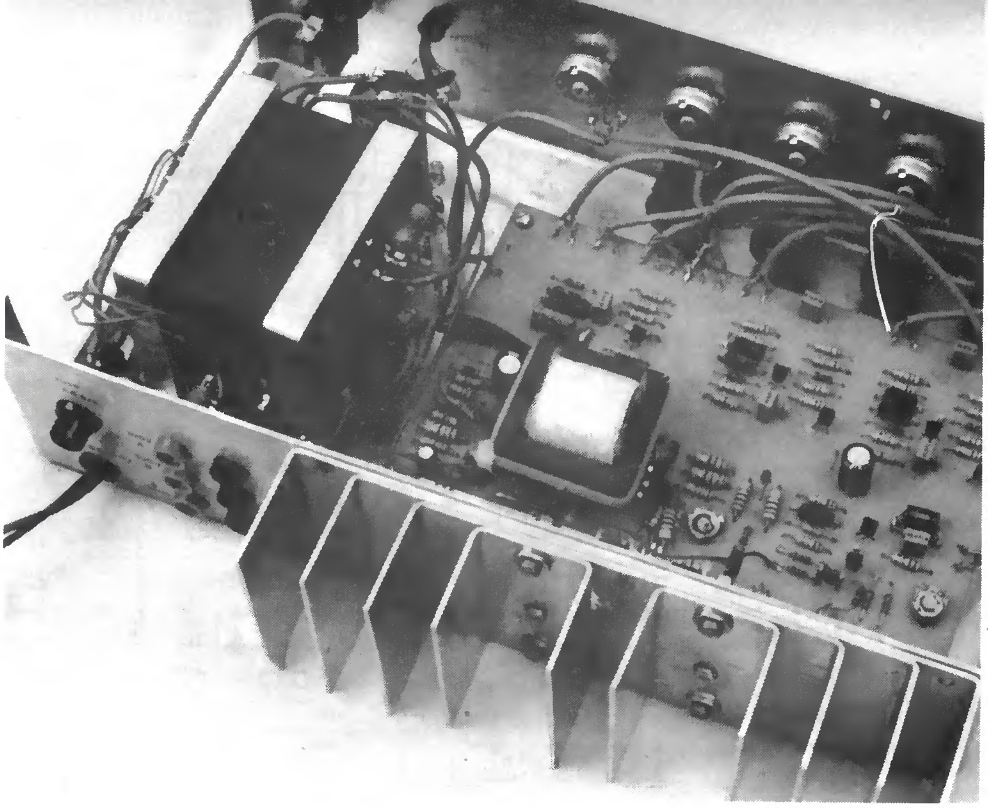
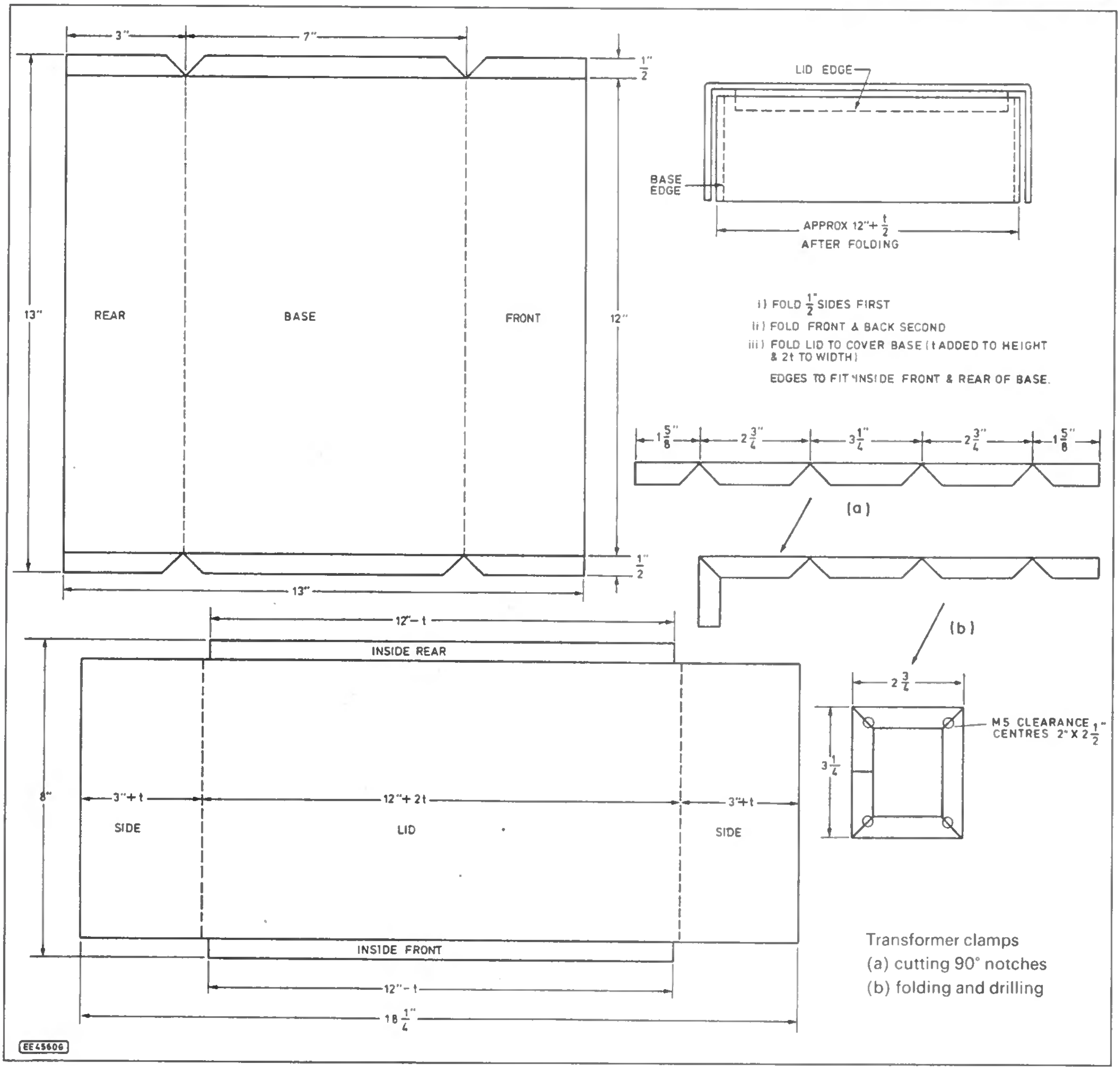


Fig. 7. (below) Construction of the aluminium case and the output transformer mounting clamps (two per output transformer).



Transformer clamps
(a) cutting 90° notches
(b) folding and drilling

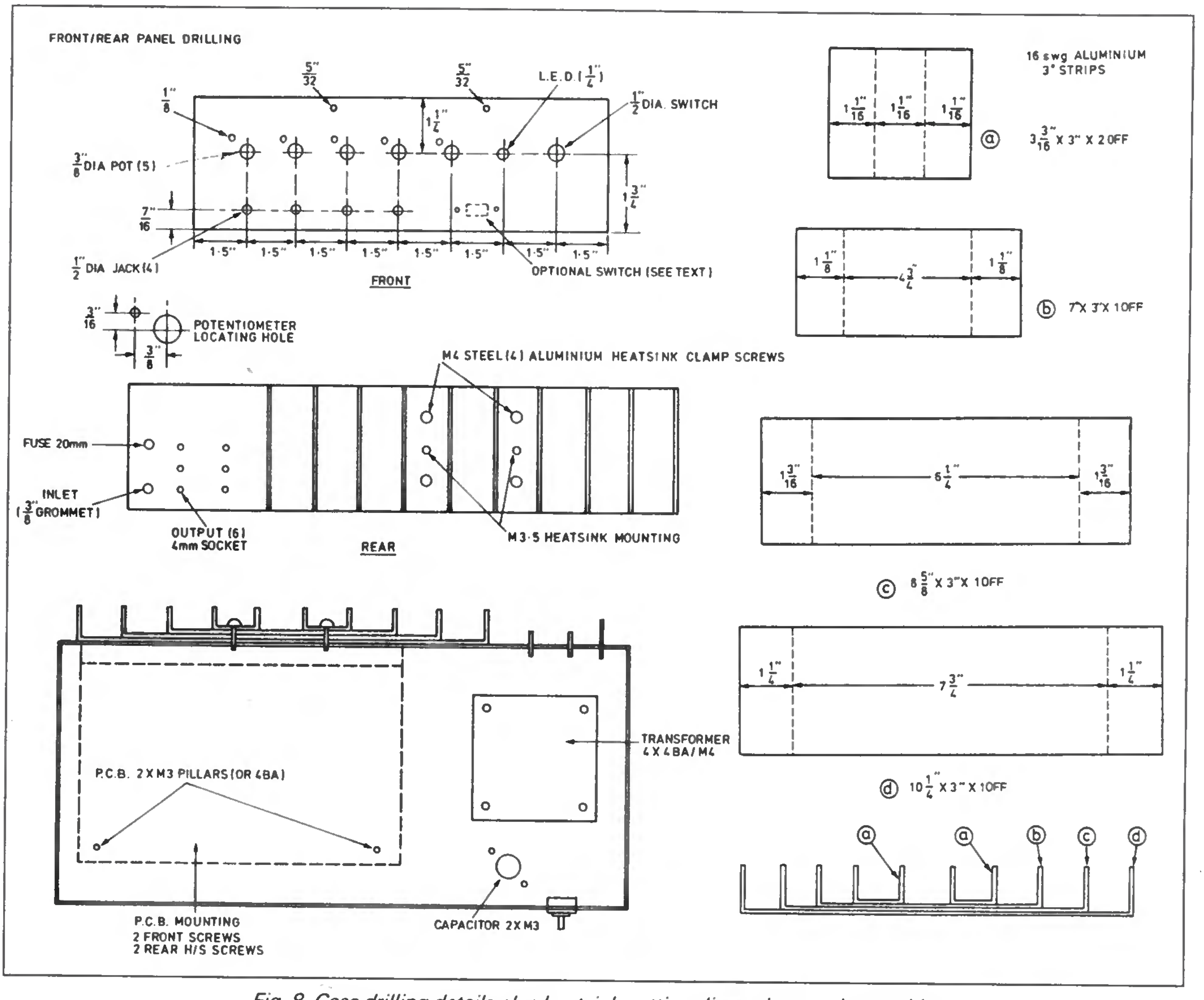


Fig. 8. Case drilling details plus heatsink cutting dimensions and assembly.

the two locating bolts. Then, remove the heatsink and open the holes in it to take an insulating bush using a larger drill. However, a sleeve is required rather than a bush as the transistor must be mounted flush on the heatsink to ensure good thermal contact.

Short lengths of the sleeve can be cut from a couple of bushes and inserted into each hole in the aluminium after remounting the angle bracket on the p.c.b. This will keep the M3 bolt insulated from the bracket while feeding the drain contact to the p.c.b. track underneath. Fig. 6 shows this.

All transistors fixed to the angle bracket should be mounted using heatsink compound and mica insulators except for the bias regulator (TR105). Bend the leads correctly and tighten all bolts using washers and shakeproof washers before soldering the other leads on the copper tracks. Check with a meter that no shorts have occurred after assembly. Zener diodes D104 and D105 are soldered to the copper side of the p.c.b. close to the output transistors with the anodes to ground. Components R121, R122, C106 and C107 are mounted on T1.

INTERWIRING

The interwiring is straightforward. All preamp controls and inputs are wired using screened leads. Input jacks are connected with the rear lead to the centre wire and the front lead to screen. The connections to the pins are in sequence of each control and in order: potentiometer live, potentiometer wiper and earth.

Power leads should be wired with a thick cable (peak currents of 9A are possible). 32/0·2 wire or two 16/0·2s should be used.

Feedback from the output to resistor R123 needs to be phased properly. If you have tracked the starts and ends of the transformer windings properly the "dot" lead or start of the low voltage secondary should be grounded and the other end connected to the "+" output terminal. If you get a horrible noise on switching on, swap the primary leads to the output-transformer at the p.c.b. or transformer connections.

Ground the "−" side of one of the 100V secondaries but leave the other floating so that the two outputs can be wired in series or parallel. Normally, the two negatives must be connected together and the two positives to operate in parallel. For series operation, 100V "A" negative must be connected to 100V "B" positive: **no other series connection will work** as coil "B" negative is grounded.

The feedback resistor may need to be changed if you have provided any output winding other than 4V. If you take it to a 100V output, use a 24k resistor and for any other voltage use V/4 kilohms. Connect the feedback resistor to a secondary whose other end is grounded!.

SETTING UP

After construction and careful checking, connect a meter and low resistance power resistor in series with the leads (10 ohms 25W or so would be ideal) since a short circuit from a car battery could wreck most of the p.c.b. and components. Set the MOSFET bias potentiometer VR102 fully anticlockwise for maximum resistance. Switch on and measure the current. If the current is over 200mA something is wrong. If the amplifier makes a noise in a speaker the feedback could be wrongly phased. If less than 200mA, switch off, take out the resistor and try again.

The pre-amp voltage should be set first to 11·5V using the regulator preset control (VR201). Then set the quiescent current to 320mA to 350mA by carefully rotating the MOSFET bias control (VR102) clockwise until this current is reached. Individual MOSFET currents can be checked by connecting the meter in place of the corresponding drain to primary coil wire.

The pre-amp current balance is then set by first measuring the voltage across R111 and setting the voltage at the junction of R110 and TR103 to twice this value using VR101. Then all should be ready to go!.

Test the unit with either a 3 ohm to 8 ohm speaker on the low voltage secondary or connect a speaker and a 100V line matching transformer at the appropriate power taps to the 100V line. Adequate sound levels should be reached using the microphone inputs and tape or radio inputs on the high level inputs. □

QUANTUM EFFECT ELECTRONICS

Keeping electrons tightly confined could achieve faster and more compact chips – *by Hazel Cavendish*

RESEARCHERS at the Toshiba Research Centre, working in collaboration with the Cavendish Laboratory at Cambridge University, have developed the world's first process for fabricating practical quantum effect integrated circuits.

This development could open the door to room temperature quantum effect circuits which, in turn, could result in logic circuits many hundreds of times faster, more compact memories, and new opto-electronic devices.

Molecular Beam Epitaxy

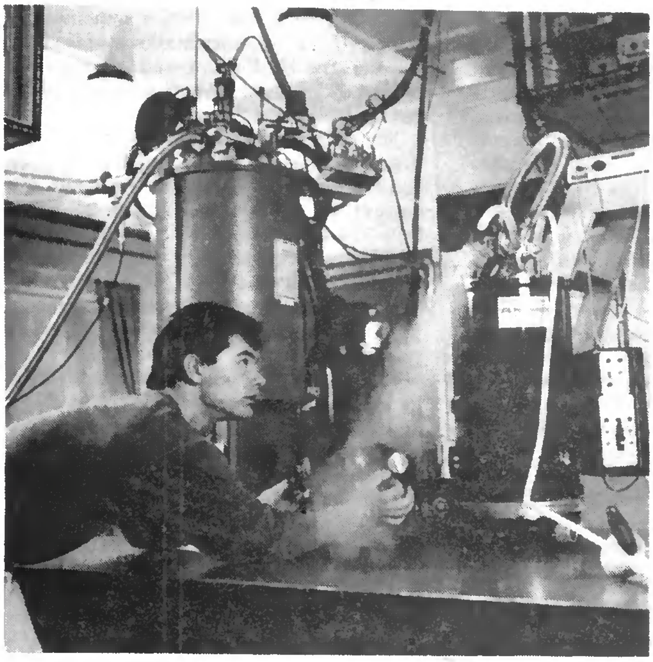
Although enormous advances have been made in the last 50 years, the optical systems used to define i.c. structures are reaching the limits of resolution, as set by the wavelength of light.

However, two new technologies have emerged from the Cavendish Laboratory which hold the promise of improving the integration process to near the atomic level. The use of Molecular Beam and Vapour Phase Epitaxy allows the building of i.c. structures in an entirely different way. Instead of modifying a layer of silicon or gallium arsenide by implanting or diffusing impurities, it is now possible to grow semiconductor materials by single atomic layers. Simultaneously, impurities can be introduced to modify material characteristics in the process and to form sandwich structures.

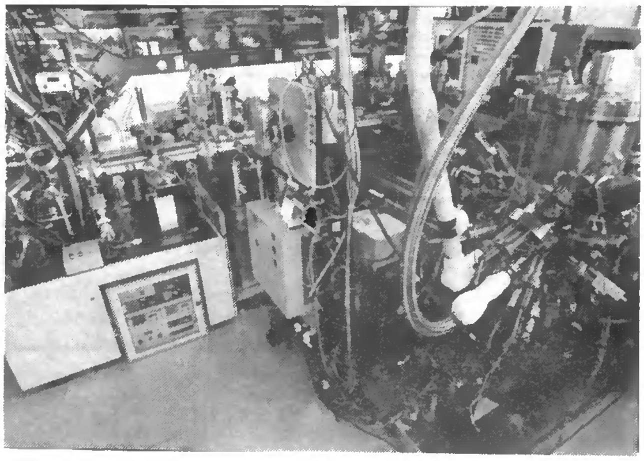
Apart from permitting manufacturers to make devices which are smaller, the process can be used to examine new concepts of operation that come into effect at near-atomic dimensions.

Many of the new concepts involve quantum phenomena and are based around exploitation of the wave-like properties of the electron. Remarkably, the new fabrication technology allows the composition of the semiconductor to be manipulated over lengths comparable with, or less than, the electron wavelength. Quantum interaction is achieved by trapping electrons in a "potential well" within the semiconductor lattice, comparable to that found in MOS devices.

As the strength of the quantum phenomena increases with greater confinement, one of the team's research aims has been to confine trapped electrons within regions only a few atoms across. The Toshiba-Cavendish achievement has been to develop a process for the fabrication of the various structures that is both easier and more precise.



Toshiba-Cavendish optical laboratory.



MBE (Molecular Beam Epitaxy) equipment in laboratory.

The most exciting prospect is that of i.c.s. many thousands of times more densely packed than currently possible. Typically, a one square centimetre chip might contain 10^{12} gates or memory cells – at least three orders of magnitude more than current memory chips.

Super-fast logic circuits will be able to operate on quantum switching principles, promising speeds up to 1000 gigahertz, 500 times faster than today's i.c.s. Super-capacity logic and memory circuits will work by switching only a few electrons between high and low energy states.

The new technology allows a sandwich of semiconductor materials to be built up on a suitable substrate. The thickness of each layer can be controlled to within one atom, while its electrical properties can be customised by varying the mix of impurities incorporated during growth. A succession of layers can be laid down in one continuous process.

Electron beam lithography is currently used to define the highest resolution in i.c. manufacture, but the process is slow and has practical resolution limits. The research team has overcome this problem by developing a process using optical lithography to define non-critical dimensions, while the critical ones are defined by using the new epitaxial process.

BT'S INTERACTIVE TV TRIALS

British Telecom has announced that it is to start consumer trials of BT Interactive TV, which includes video on demand, in the middle of 1995 with 2500 households in Colchester and Ipswich. This follows the success of its technical trials, held in Kesgrave, near Ipswich.

The world-leading new service promises to create a revolution in the home. It brings together the telephone and the television to enable customers to choose a range of services from a menu on an ordinary TV set. The material is then transmitted from a central database over the telephone network to the TV, while not affecting the normal telephone line.

During the trial period, BT aims to offer shopping on demand, a range of educational programming for homes and schools, movies and TV programming (video on demand), a home banking service, a magazine service and a community link providing local information. Additional services will be introduced during the course of the trials.

GIANT SRAM

What is claimed to be the world's largest dual-port SRAM (static random access memory) has been introduced by Integrated Device Technology. IDT's new IDT7007 has access times as fast as 25ns and is a 256K device which provides the highest possible density of true dual-port SRAM in the smallest possible area of board space. Configured as 32K x 8 bits, the SRAM provides four times the memory of IDT's closest competitor at a fraction of the cost.

Because of its extremely small size, the IDT7007 significantly simplifies system design, it also increases bandwidth and is ideal for use in high density situations. It is available in a 14mm square, 80-pin TQFP package as well as PLCC and PGA.

Giant SRAMs IDT7007.

For further information contact Integrated Device Technology, Prime House, Barnett Wood Lane, Leatherhead, Surrey, KT22 7DG. Tel: 0372 363734.

B.A.E.C. CHANGEOVER

We are always pleased to support the work of the British Amateur Electronics Club and to read its quarterly Newsletter. The latest issue, number 114 for December 1994, has just been received. We extend our welcome to its new editor Alf Denison, and send our best wishes to Herbert Howard who has retired from the post after several stalwart years.

In the latest 24-page Newsletter are more circuit ideas which will appeal to electronics hobbyists. Among them are circuits for current to voltage converters, relay control, more on computer interfacing, and "More Ways of Skinning a Cat". Moggies need not fear though: the article is about zero crossing detectors, not electronic taxidermy!

The regular Magart section of the Newsletter comments favourably on several projects recently published in *EPE*, notably the *Universal Digital Code Lock*, the *Experimental Electronic Pipe Descaler*, and the *Advanced Tens Unit*. We are pleased to learn that the latter has provided pain relief for still more people; it is probably one of our most popular projects ever.

We were, though, surprised to read that the *"Electronics from the Ground Up* ... series has come into some criticism because of its use of Computer Aided Design in teaching electronics." We are totally unaware of any such criticism and believe that, judging by the very large sales of the full software package, we are publishing a series of articles which had long been hoped for. Perhaps, Alf, you could kindly tell us what criticism you are aware of?

Readers who would like more information about the B.A.E.C. should write to J.F. Davies, Secretary, B.A.E.C. 70 Ash Road, Cuddington, Northwich, Cheshire, CW8 2PB, mentioning EPE.

ABOUT TIME TOO!

On February 1 1995, the long-awaited mains-plug legislation comes into effect. This will bring the UK into line with the rest of Europe by making manufacturers and importers fit approved standard plugs to all "white" and "brown" electrical goods. It is a direct result of a successful consumer and media (including *EPE*) safety campaign to reduce the number of accidents caused through badly wired plugs.

Many readers, of course, will now have found that items of electrical equipment are already usually being supplied with moulded-on mains plugs. (A sales manager from a large electrical retailer commented to us that his staff were never allowed to fit plugs on behalf of customers, even if they were obviously incapable of doing it for themselves; a most undesirable situation.)

During the period of 1st Feb. '95 to 1st Feb. '96, retailers have to clear their stocks of appliances without fitted plugs. After that time, with certain exceptions, there should not be a single domestic appliance with bare mains wires in any UK store.

One company which has recognised that complying with the new law also implies a responsibility to making sure that its customers are equally well informed is Remploy Manufacturing Services. Remploy provides contract manufacturing and assembly skills for companies in the electronic, electrical, automotive and mechanical sectors. In their autumn issue of *Contract Manufacturing*, their customer Newsletter, Remploy looks at the implications of the long-awaited plug fitting legislation deadline.

For further information contact Remploy Ltd., Remploy Manufacturing Services, 33 Wales Farm Road, Acton, London W3 6XX. Tel: 0181 992 3007.

PAT VIDEO

The introduction of the Electricity at Work Regulations has highlighted the potential dangers of electricity in the workplace, and the duty of the employer to minimise the risks to all employees.

Clear and simple guidance on how to establish such a maintenance program has become available as a new video from AVO International. The video is called *"PAT Video II – Fundamentals of Risk Assessment, Visual Inspection and Test"* and lasts for about 30 minutes.

For more information contact Avo International, Archcliffe Road, Dover, Kent, CT17 9EN. Tel: 0304 202620.

ESSEX MEETING

The 10th South Essex Amateur Radio Society will be holding its Radio Rally on 5 February 1995, at The Paddocks, Long Road, Canvey Island, Essex. (The Paddocks is situated at the end of the A130.) Doors open 10.30 a.m.

Features include amateur radio, computer and electronic component exhibitors (bring and buy!), R.S.G.B Morse testing on demand (two passport photos required), and home-made refreshments. There is free parking with space outside the main door for disabled visitors. Admission £1,00.

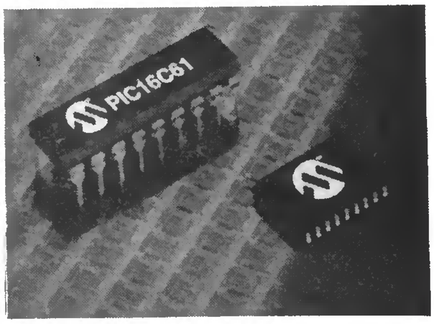
For further details ring Roger on 01268 693786 or Ken on 01268 755350.

ANOTHER NEW PIC

Regular readers will be aware that we have recently been featuring microcontrollers in some of our projects, including *Timeout*, *Universal Digital Code Lock*, *Spacewriter* and the *EPE Fruit Machine*. Many readers will thus be interested to know about the introduction by Arizona Microchip Technology of their new one-time programmable 8-bit microcontroller, the PIC16C61.

This chip has a 200ns instruction cycle, 1024 x 14-bit program memory and 36 bytes of data RAM, making it ideal for use in a wide range of applications. A low power "sleep" mode for battery operation reduces standby current to less than 1μA. In addition, a wide operating voltage range of 2·5V to 6·0V and a very small "footprint" (18-pin SOIC package) make it suitable for use in many portable applications.

The PIC16C61 is supported by the PICMASTER-16G Universal Development System, a fully integrated programming development and emulation environment, and is available in 4MHz plastic DIP and SOIC versions.



Two versions of the PIC16C61.

For more information contact Arizona Microchip Technology Ltd., Unit 6, The Courtyard, Meadowbank, Furlong Road, Bourne End, Bucks, SL8 5AJ. Tel: 01628 851077.

AUDIOPHILES TAKE NOTE!

Graham Nalty, whom many readers will associate with the company Audiokits, has introduced a quarterly newsletter aimed specially at electronics constructors and hifi enthusiasts.

The newsletter, entitled *"AP Performance Audio – The Journal of High Performance Audio Construction"*, will contain the latest news about high performance audio components, new products, cable features, price updates and "bargain bin", latest upgrading techniques for improving your own equipment, new amplifiers, pre-amps and other hifi projects to build, and readers' own feedback.

Copies of the newsletter will be supplied FREE to customers who purchase components from Audiokits valued at over £100 during the previous year. Other readers can subscribe to five issues up to the end of 1995 for only £5.

For further information, contact AP Electronics, Derwent Business Centre, Clarke Street, Derby, DE1 2BU. Tel: 01332-674929.

New Technology Update

Ian Poole takes a look at a new research development project, using existing CD technology, that is expected to give a ten-fold increase in data storage.

THE ADVENT of new and exciting developments associated with the computer industry has increased the demand for convenient forms of storing vast amounts of data. The new idea for the information super-highway along with the increasing size of software applications indicates that within a few years conventional forms of storage will be unable to cope with the demands placed upon them.

At the moment CDs are providing a way of storing large amounts of data in a compact and convenient way. They are finding many uses, particularly in the computer games market.

However, in a few years time it is expected that even these will not be able to provide sufficient storage. With software packages giving more facilities, and containing far more visual and audio effects, the amounts of storage which are needed are poised to increase by orders of magnitude. Another important factor is that any improvements to storage systems must be cost effective and reliable.

Multilayer CD

Now a new development has built on the current CD technology to give a ten-fold increase in data storage for very little increase in cost. This has been achieved by researchers at IBM's Almaden Research Centre at San Jose in California by using a multi-layered CD.

Today's CDs used for audio and data storage consist of a single surface. This has a reflective coating onto which the data is stored as small non-reflective areas. A laser is focused onto the track as the disc rotates and the reflected light is detected to give the data which is encoded onto the disc surface.

Many methods of increasing the data density of CDs have been investigated. To achieve this it is either necessary to increase the density of the data, or the area available for storage.

Most solutions have focused on ways of increasing the actual data density on the surface of the disc. This is not particularly easy because it requires much greater levels of accuracy, both in the recording stages and in the system for reading the data. This results in a significant increase in cost of the CD itself and in the drive for reading the data.

It is also estimated that improvements along these lines will only double the storage capacity of these systems. This is not expected to be sufficient to cater for the needs into the foreseeable future and make the system viable for development and marketing.

Many of the other solutions which sought to increase the storage area were not convenient because they had to use a totally new standard for the discs. This was not favoured because the CD format is already well established.

New Approach

Researchers at IBM have adopted a new approach. They have developed a unique design for CDs using several layers of data within the disc. By using this method, the data density on *each* surface is not increased over the current CDs. This means that standards of quality and reliability are not sacrificed in any way, whilst still maintaining a low cost solution. It also has the advantage of retaining many of the specifications of the existing CD format.

The new disc is largely based on existing technology, but updated to give the additional layers. It consists of individual layers or discs made of plastic which are then bonded together with spacers. In this way a very compact CD stack is formed – See Fig. 1.

Light from the laser in the disc drive is able to penetrate all of the layers. To achieve this all the discs are made of transparent material, and lack the reflective aluminium coating used for standard CDs.

In view of the absence of this coating, modifications have been made to the optical system to compensate for the different levels of reflected light. However, the performance of the new system with these changes is equally as good as the original, and very high signal-to-noise ratios have been achieved.

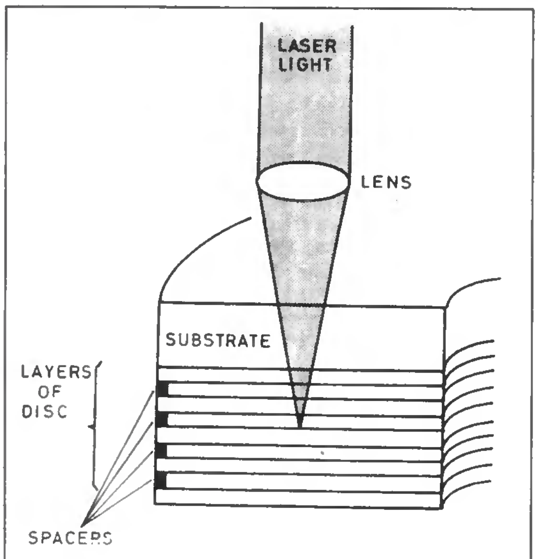


Fig. 1. Structure of the multilayer CD.

To read or write to a particular layer, the laser beam is accurately focused to the correct distance. This is achieved relatively easily, and it has been found that spurious reflections from the other layers can be reduced to levels where no significant crosstalk is achieved.

Whilst it is possible to produce systems which can read and write, read only systems require only relatively small changes to those designs which already exist. This should make them cheap and easy to manufacture.

Drives with write capabilities are more difficult as they require much greater levels of complexity. Despite the problems which exist it has been possible to demonstrate a four layer write-once, multiple-read disc system.

Read only discs up to six layers have been successfully tested, and it is expected that ultimately the number of layers may rise to ten or more. The number is ultimately limited by the power of the laser and the transparency of the material.

Freedom of Choice

The design of the new systems is being undertaken so that the new drives will be able to accept both new and conventional discs. Although it has not reached the stage of manufacture yet, there is widespread interest from industry.

This is hardly surprising because it offers major improvements by employing relatively minor changes to an existing technology. This means that any companies manufacturing current disc systems will be able to start making the new ones with quite small amounts of investment.

It is expected that there will be a large number of uses for the new discs. Obviously computer software publishers will have fewer restrictions on memory. This will give much more freedom when writing new programmes. Games writers will be able to add far more visual and audio effects.

Other uses for the new discs include video recordings because the new discs could conceivably hold a complete film. Alternatively they could be used for storing optical libraries or vast amounts of music.

IBM are looking into more improvements to the system. Further into the future ideas of having a single disc capable of storing 25 Gbytes or more may soon be a reality. As these discs are small and easy to change in the drive, vast amounts of data can be stored and accessed exceedingly easily.

Constructional Project

FOOT-OPERATED DRILL CONTROLLER

EDWARD BARROW

Don't foot the bill – foot the drill!

THIS PROJECT was designed as an aid to precision drilling work by hand. For example, when drilling p.c.b.s using a 12V hand-held drill, the author has often experienced problems with the drill bit skating across the surface of the board. This causes off-centre holes, damages the surface of the board and its tracks, and can cause drill bits to break.

The effect is partly due to the high speeds at which such p.c.b. drills operate, typically 15,000 r.p.m. The jerks caused by the large acceleration when the drill starts are not easily tamed when hand-holding the drill. This project offers some relief from the problem.

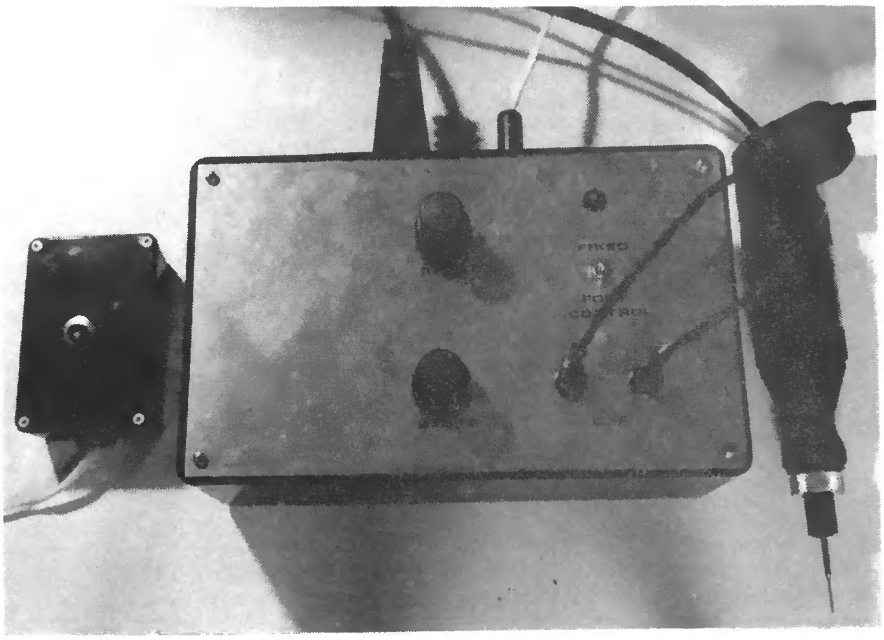
Firstly, it uses a footswitch to start and stop the drill, thus freeing one hand to help stabilise the drill, or to hold the item being drilled. Secondly, when the footswitch is pressed, the drill speed is gradually allowed to build up to a presettable maximum speed.

Naturally, since there is a direct relationship between drill speed and the voltage applied, in order to provide a smooth start-up, the applied voltage should follow an envelope similar to the one shown in Fig.1.

Thus, when the footswitch is pressed, the output voltage should rise slowly from zero, past the "Z" point at which the drill just starts to turn, and upwards to the preset maximum speed. When the footswitch is released, the control voltages should rapidly fall to zero.

HOW IT WORKS

Functionally, the circuit of the drill speed controller can be split into two main blocks, the envelope generator and the power output regulator.



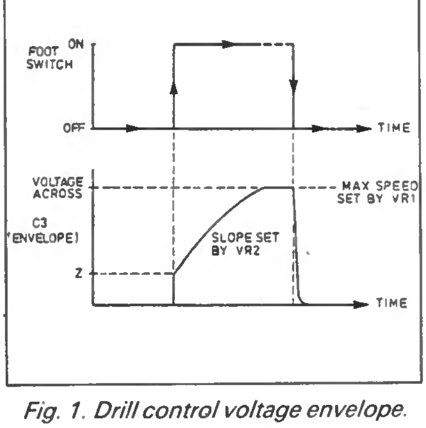


Fig. 1. Drill control voltage envelope.

The circuit diagram for the envelope shaper is shown in Fig. 2. This circuit has three variable control points, two of which are fed from the voltage reference circuit around Zener diode D1, resistor R1 and capacitor C2. Although the reference voltage is regulated, its actual value is somewhat arbitrary as it only needs to be somewhat less than the supply voltage which feeds the op.amps and bilateral switch i.c.s.

The purpose of the reference voltage is to preset the range of control voltage output to the drill motor. Potentiometer VR1 and preset VR3 form a voltage divider chain across the Zener-controlled reference point. Since VR1 and VR3 have nominally the same values, the control voltage range adjustable by VR1 is between the maximum as set by Zener diode D1, and half that level. Preset VR3 is used to set the "Z" point threshold voltage at which the drill will just start to rotate.

The controlling voltage envelope shape is created by the rate at which capacitor C3 is charged and discharged. Normally, when the footswitch is unpressed, the base of transistor TR1 is unbiased and consequently its collector at the junction with resistor R4 is at +12V. This voltage causes the analogue switch IC2c to be turned on via its control pin 6, internally connecting its pins 8 and 9. As a result, capacitor C3 is held discharged at 0V.

FOOT DOWN

When footswitch S1 is pressed, transistor TR1 is turned on by the current applied to its base via resistor R3, and its collector voltage falls to 0V, so turning off analogue switch IC2c. Simultaneously, +12V is applied to IC2a pin 13 and IC2b pin 12, so turning on both of these analogue switches. With both switches on, capacitor C3 is allowed to charge via both switched routes.

Of immediate interest is the charging route via IC2b. The voltage present at the wiper of preset VR3 is routed to pin 3 of the buffer op.amp IC1a. Via diode D2, the output voltage from IC1a pin 1 charges capacitor C3 to the same level. Referring back to Fig. 1, this level is the required "Z" point voltage at which the drill will just start to rotate. Diode D2 prevents IC2a from sinking the charging current supplied via potentiometer VR2.

There now follows a slow increase in the rate at which capacitor C3 is charged via the IC2a route. This rate is determined by the resistance value to which potentiometer VR2 has been set. The maximum voltage level to which C3 will charge is that set by the wiper of potentiometer VR1. Once having been reached, the level will remain steady for as long as the footswitch remains pressed.

When the footswitch is released, analogue switches IC2a and IC2b open, and IC2c closes. Via IC2c, capacitor C3 immediately discharges back to 0V, and the drill stops turning. Thus the fast envelope release shown in Fig. 1 has been achieved.

Under normal envelope control conditions, with switch S2 in position 1 as shown in Fig. 2, the envelope voltage is routed to the power amplifier stage. In position 2 of switch S2 the amplifier stage is connected to the wiper of potentiometer VR1. This allows the unit to be used as a manually operated drill speed controller.

DRILL POWERING

Insufficient power is present at the pole of switch S2 to directly supply the drill. It is necessary to increase the current available while still retaining the envelope voltage level. The circuit diagram for the power amplification stage is shown in Fig. 3.

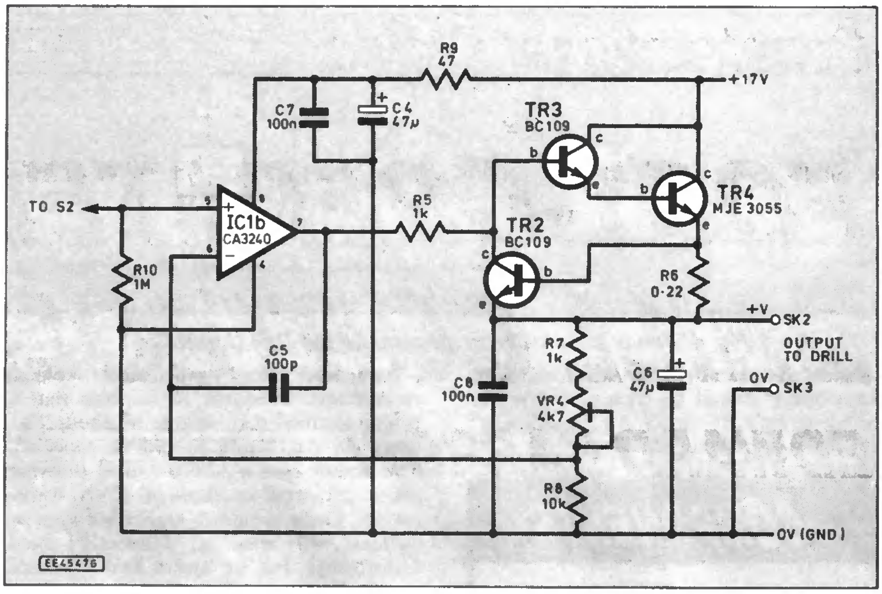


Fig. 3. Power output stage circuit diagram.

The first stage of the amplifier consists of the op.amp buffer IC1b. A MOSFET device was chosen for this purpose as its inputs have a high impedance and so will not adversely load capacitor C3. Additionally, the CA3240 device chosen has an output which operates at near 0V levels without the need for a negative supply line. Resistor R10 is included to prevent input pin 5 of the op.amp from becoming open circuit when S2 is switched between voltage sources.

The gain of the amplifier stage is limited by the amount of feedback set by preset VR4. Nominally, VR4 should be adjusted to set a gain of about 1.33, allowing the maximum 9V1 Zener voltage to be raised at the drill output to about 12V.

From the output of IC1b (pin 7), the amplified voltage is fed to the base of the Darlington pair configured around transistors TR3 and TR4. The latter is a high power device capable of providing a continuous current of about 4A.

To provide a degree of protection, a current limiter has been included by inserting resistor R6 into the output path between transistor TR4 and the drill. Across R6 are connected the base and emitter of transistor TR2. In effect, this sub-circuit senses the voltage drop across R6 which is dependent upon the current drawn by the drill. If the voltage drop exceeds the turn-on threshold voltage of TR2, nominally about 0·7V, the transistor will turn on and divert some of the current supplying the base of transistor TR3. As a result, the output voltage from TR4 will fall, and so too will its output current.

Resistor R5 limits the amount of current which can be drawn from op.amp IC1b. The inclusion of capacitors C5, C6 and C8 helps to provide stability to the amplifier stage.

POWER SUPPLY

The power supply circuit diagram is shown in Fig. 4. Mains 240V a.c. is reduced to 12V a.c. by transformer T1. The secondary voltage is rectified by REC1, and smoothed by capacitor C1 to an unregulated level of about +17V d.c. This voltage provides power to the drill via the amplifier stage in Fig. 3.

Power for the op.amp is taken from the raw +17V supply via resistor R9. In conjunction with capacitors C4 and C7, the inclusion of R9 helps to smooth the power supplied to IC1, whilst still allowing it to be powered at nearly the same voltage as is supplied to the drill via transistor TR4.

This has been done so that the output of op.amp IC1b can rise as close to the unregulated supply as possible. With the op.amp type chosen, its outputs can only rise to within about 1·5V of its supply rail. The output voltage is then reduced by about 1·4V across the base-emitter path of the Darlington transistor configuration of TR3 and TR4.

Consequently, a nominal +17V supply line can only deliver about +14V at the emitter of transistor TR4. In reality, the actual voltage delivered is likely to be less than this since the load imposed by the drill is likely to reduce the supply voltage to less than 17V.

The +17V supply is also regulated down to +12V by IC3, and provides power to the envelope shaper in Fig. 2. Note, though, that IC1a in Fig. 2 is physically housed in the same i.c. package as IC1b in Fig. 3 and is thus powered at +17V.

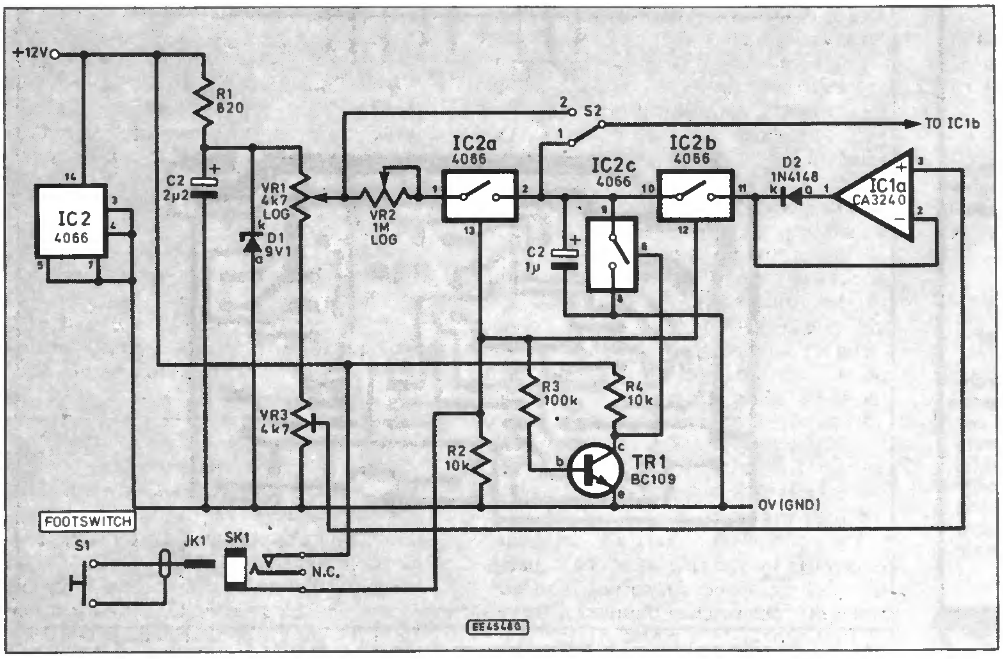


Fig. 2. Envelope shaping circuit diagram for the Drill Controller.

HEATSINK

Transistor TR4 is likely to get quite hot since it has to supply fairly large currents to the drill. If, for example, TR4 is delivering 12V at 2A from a 16V supply line, about 8W of power will flow: 2A x (16V-12V). To dissipate the resultant heat generated, transistor TR4 needs to be fitted with a heatsink. With the prototype, a heatsink having a rating of 6°C/W was found to be quite satisfactory.

If the heatsink or transistor TR4 are bolted to a metal case, an insulating washer must be used to prevent short-circuits to the case. To ensure good thermal contact with the heatsink, heatsink compound should be used.

TRANSFORMER

Although the transformer used by the author has a 12V a.c. output, other transformers having a different output may be

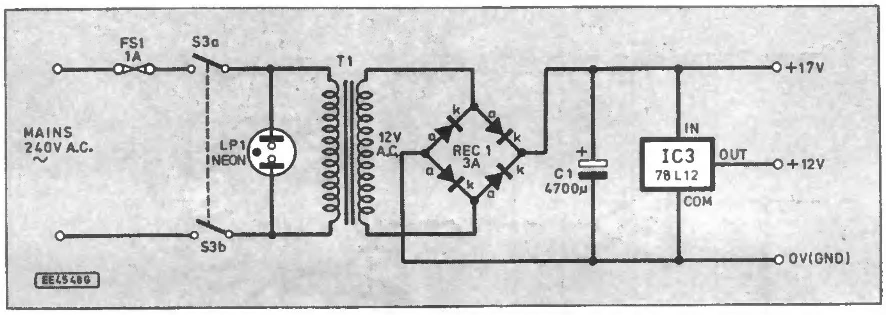


Fig. 4. Power supply circuit diagram for the Drill Controller.

substituted to suit the drill used. Ideally, the transformer should be chosen to give the circuit at least 4V to 5V d.c. "headroom" above the desired output voltage.

COMPONENTS

Resistors

R1	820
R2, R4, R8	10k (3 off)
R3	100k
R5, R7	1k (2 off)
R6	0Ω22 1W
R9	47
R10	1M

All 0·25W 5% carbon film except where stated

See SHOP TALK Page

Potentiometers

VR1	4k7 rotary carbon, log.
VR2	1M rotary carbon, log.
VR3, VR4	4k7 min. horiz. preset (2 off)

Capacitors

C1	4700μ axial elect. 25V
C2	2μ2 tantalum bead 25V
C3	1μ tantalum bead 25V
C4, C6	47μ axial elect. 25V (2 off)
C5	100p polystyrene
C7, C8	100n polyester (2 off)

Semiconductors

D1	9V1 Zener diode
D2	1N4148 signal diode
TR1 to TR3	BC109 (or similar) *npn* transistor (3 off)
TR4	MJE3055 (or similar) *npn* power transistor
IC1	CA3240 dual MOSFET op.amp
IC2	4066 quad bilateral switch
IC3	78L12 12V 100mA regulator
REC1	50V 3A bridge rectifier

Miscellaneous

S1	s.p. push to make footswitch
S2	s.p.d.t. min. toggle switch
S3	d.p.d.t. mains toggle switch
SK1	3·5mm mono jack socket (and plug)
SK2, SK3	4mm socket (and plug) (2 off);
T1	12V a.c. mains transformer 25VA (see text)

Printed circuit board available from the *EPE PCB Service*, code 928; plastic box with aluminium top panel, approimately 161mm x 96mm x 59mm; heatsink for TR4 (see text); 14-pin d.i.l. socket; 8-pin d.i.l. socket; knob (2 off); mains neon; 20mm panel mounting fuseholder; 20mm 1A fuse; mounting clip for capacitor C1; connecting wire; solder, etc.

Approx cost guidance only **£34**

Remember that transformer voltage ratings are, of course, in a.c. and that a bridge-rectified d.c. voltage of about 1·41 times the a.c. rating should be expected. The author uses a 12V d.c. drill drawing about 2A, and so chose a 12VA transformer. Drills requiring higher voltages or current will need a differently rated transformer, but be aware that op.amps usually have a supply voltage limit of less than 30V. If a current of more than 2A is required, it may be necessary to use a more powerful transistor for TR4, plus a larger heatsink. It may also be necessary to increase the value of smoothing capacitor C1 beyond the 4700μ value quoted here.

CONSTRUCTION

The printed circuit board layout and full size copper foil master track pattern are shown in Fig. 5. The p.c.b. is available from the *EPE PCB Service*, code 928.

Assembly of the components onto the p.c.b. is very straightforward and can be carried out in any order as convenient. Ensure that all semiconductors and electrolytic capacitors are correctly orientated. It is preferable to use i.c. sockets for IC1 and IC2. Both i.c.s are CMOS devices and the usual anti-static handling precautions should be observed.

For convenience, on the prototype, the large electrolytic capacitor C1 is mounted off-board. Connection to the footswitch is via a 3·5mm mono jack socket and plug. For the drill coupling, 4mm connectors are used. Other types of connector may be used to suit personal needs.

TESTING

Warning: when working on the unit, beware that mains voltages are present and that they can be lethal. Always taken extreme care! If in any doubt about any aspect of the mains connections, consult a qualified electrician.

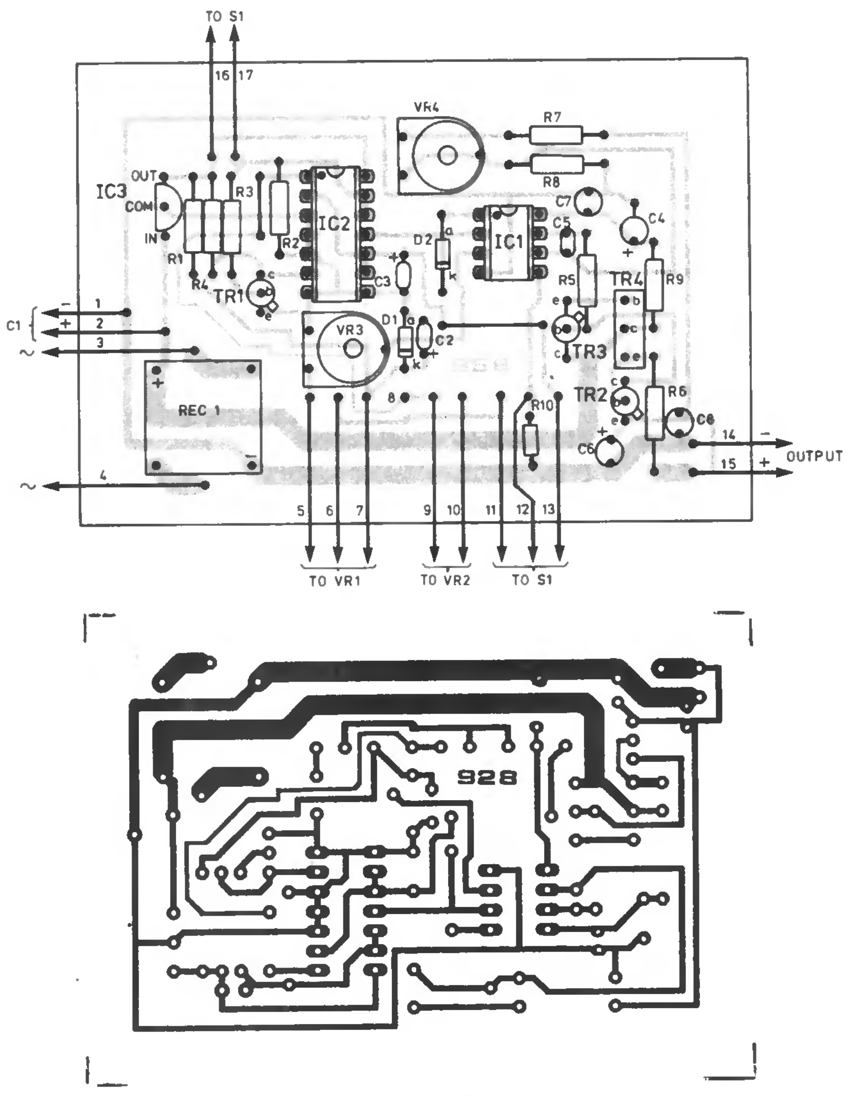


Fig. 5. Printed circuit board component layout and full size copper foil master track pattern for the Foot-Operated Drill Controller.

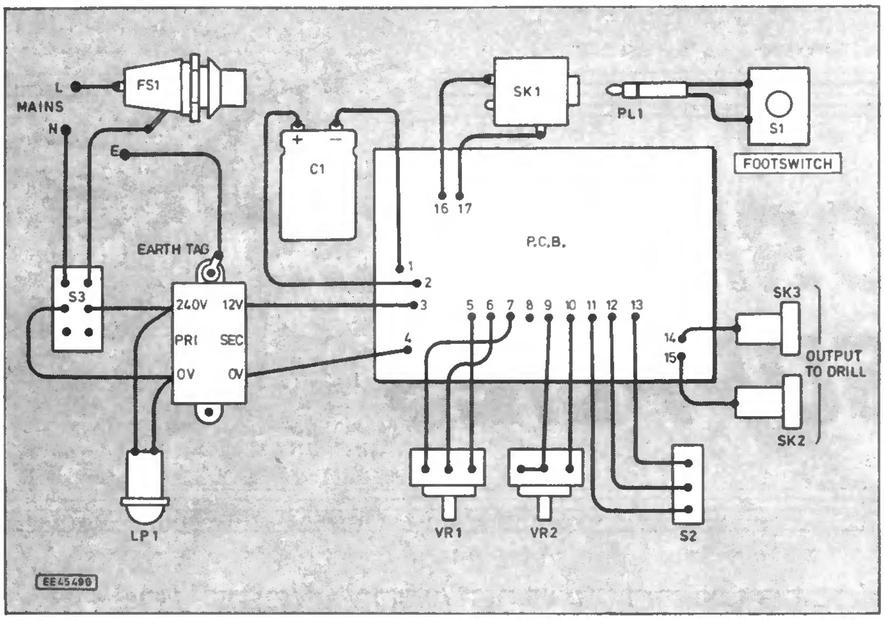
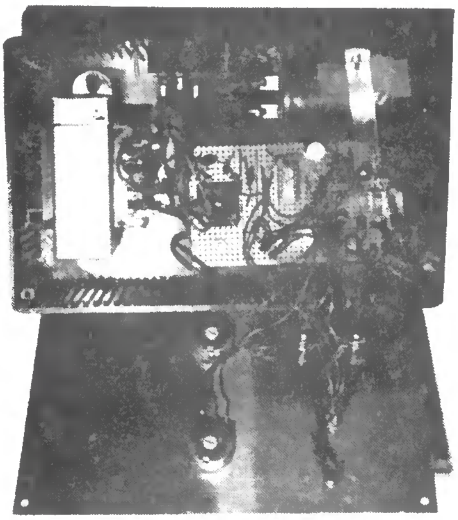


Fig. 6. Interwiring of the off-board components.

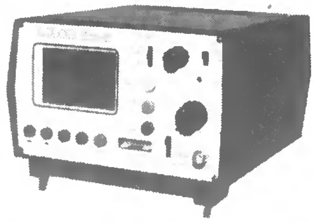


Prototype Foot Operated Drill Controller showing relative postitions of components built on strip-board within the case.

Before connecting the unit to the drill, press the footswitch and check with a meter that the bilateral switches within IC2 are all performing as they should. If your test meter has a high input impedance, check that capacitor C3 is charging correctly. Also check that when varying both potentiometers VR1 and VR2 the desired results are obtained. Finally check that the output voltage also corresponds accordingly.

To correctly adjust preset VR4, first turn VR1 to its maximum setting, and set switch S2 to "constant". Next, while monitoring the output voltage, adjust VR4 so that the desired voltage is present at the output to the drill. It may be preferable to put a load resistor of about 100 ohms across the output when doing this.

To correctly set preset VR3, connect the drill and set switch S2 to "envelope". Adjust VR3 so that the drill starts as soon as the footswitch is pressed (or to whatever setting you feel comfortable with). Assuming all is well, the drill controller is now ready for use. □



Special Feature

TRANSFORMERLESS POWER SUPPLIES

ANDY FLIND

Following recent projects using "transformerless" mains power supplies, several queries have been received asking for further explanation of the operation of this type of supply – here it is.

MOST projects operating from the household mains electricity supply require a means of reducing the 240 volt a.c. to a small d.c. voltage to power the electronics. The usual method employed is a transformer with a rectifier or diode arrangement but in some cases it can be advantageous to use a *capacitor* instead.

Many small transformers generate heat, and often they also emit noise in the form of "hum", which even at very low levels can be irritating. Capacitors suffer neither of these problems, and in addition are usually smaller, lighter and cheaper.

The use of capacitors as mains voltage droppers is not as inherently safe as that of transformers however, so experimenters wishing to use this method MUST be well acquainted with the potential hazards.

This article aims to provide comprehensive information about the operation of this type of circuit, so that constructors will fully understand it's operation and those experienced enough to avoid the dangers may use it in their own circuits.

BACK TO BASICS

A wide variety of capacitor power supply arrangements is possible, but for a thorough understanding of the principles it is best to begin with the basics and proceed in easy stages. If a capacitor of suitable voltage rating is placed across the mains as shown in Fig. 1a, an a.c. current will flow through it. Because the opposition to the current flow is capacitive, this current leads the voltage by ninety degrees. For part of each half cycle, energy flows into the capacitor, then for the next part it returns to the supply.

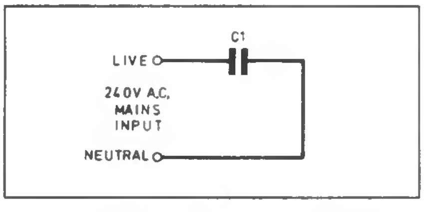


Fig. 1a. If a capacitor, correctly rated for continuous mains operation, is placed across the mains supply an a.c. current will flow.

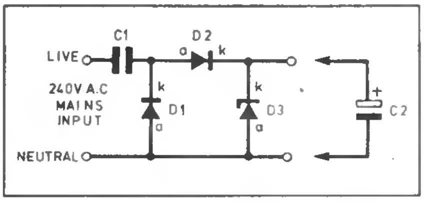


Fig. 1b. Adding diodes to produce a d.c. output voltage.

This is sometimes called "wattless" current because although energy flows back and forth, none is actually used. Because of this, no heat is generated. Due to it's design, your electricity meter should not register it's flow either.

As a matter of interest, a transformer should perform in a similar way when not connected to a load, save that in this case the opposition is inductive so the current should lag the voltage by ninety degrees. The snag is that the resistance of the primary winding also opposes current flow, especially with small, cheap transformers, resulting in the generation of heat.

In Fig. 1b, three diodes have been added to the circuit. If we take "Neutral" as the reference, during each *positive* half-cycle the capacitor current flows through diode D2 and the Zener diode D3, resulting in the appearance of the "Zener voltage" across this diode.

During *negative* half-cycles current returns to the capacitor through diode D1. If a large enough electrolytic capacitor C2 is connected across Zener diode D3, it will maintain the Zener voltage during the negative half-cycle, thus creating a basic power supply.

HAZARDOUS

By now the inherent hazards of this type of supply should be apparent. To begin with, the circuit is *directly* connected to mains Neutral, and to "Live" via a capacitor. It must always, therefore, be treated as "***Live***" and suitable safety precautions ***MUST*** be observed whilst working on it. The use of test equipment, particularly Earthed items such as oscilloscopes, can be difficult because of this.

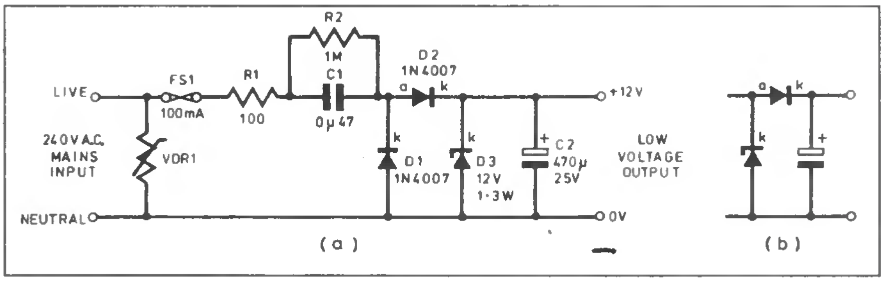


Fig. 2a. Complete circuit diagram for a basic positive low voltage power supply. An alternative output arrangement, saving one diode, is shown in (b).

Also, the possible consequences of component failure must be considered. A *short-circuit* capacitor C1 would allow uninterrupted flow of full mains power, with predictable results. An *open-circuit* Zener diode D3 would allow C1, D1 and D2 to act as a "voltage doubler" circuit, attempting to produce twice the mains peak voltage (about 700V) across capacitor C2.

The current from C1 must be regarded as "constant", as any interruption in it's path will result in the immediate appearance of a high voltage. Bearing these hazards in mind, the design and use of a practical circuit can now be considered.

POWER SUPPLY CIRCUIT

A complete power supply circuit diagram is shown in Fig. 2a. Capacitors C1 and C2, with diodes D1, D2 and Zener diode D3 operate as before to provide a positive output of about 12V with respect to the neutral.

Capacitor C1 ***MUST*** be rated for ***continuous*** operation when placed across the 240V mains. There are two basic types of capacitor with this rating, known as "class X" and "class Y". The "Y" type is specified for use where failure might lead to danger of shock, so is obviously preferable for this application.

In view of the problems that might follow diode failure, D1 and D2 should be from the robust 1N4000 series. Prices for these are so similar that the author generally uses the 1N4007 which has a 1000 volt reverse voltage rating. Zeners, fortunately, generally seem to fail "short-circuit", but again the use of 1·3W types in preference to the smaller 500mW variety is to be preferred. Capacitor C2 is non-critical, as any electrolytic of adequate voltage rating will suffice.

EXTRAS

Some extra components are included to improve safety. The first is the 250V a.c. transient suppressor VDR1. This clips the brief high-voltage spikes which often occur on the mains supply, providing protection for the capacitor. It is also useful if the circuit being supplied includes a triac, as these also dislike sudden high-voltage pulses.

A fuse is advisable. A small plug-top fuse would do, but a 100mA fuse in a p.c.b. or panel-mounted holder is better.

Resistor R1 is always included in circuits of this type, the value varying between 47 and 120 ohms. The 100-ohm shown is a good compromise.

The purpose of this resistor is to limit the instantaneous current if the circuit is connected to the mains at an instant where the cycle happens to be at a high voltage point. However, it sometimes serves as an unofficial fuse too, burning out quickly enough to prevent damage to the rest of the circuit if C1 fails!

Resistor R2 provides a discharge path across C1 when the circuit is disconnected. If it were omitted, and the circuit disconnected at a high-voltage instant of the mains cycle, a high-voltage charge might remain stored in C1 for some time. This could lead to unexpected shocks, possibly from the mains plug if one is used. R2 eliminates this.

Again, values used vary, but for a 0·47µF capacitor one megohm (1M) is adequate. Two factors must be taken into account when choosing this resistor. The first is that it represents a resistive path and so dissipates heat. For 1M this is only about a twentieth of a watt however, so is not a problem.

Secondly, it will have the full mains voltage across it, so it ***MUST*** be suitably rated for this. It can either be of a type with adequate voltage rating, or two lower-rated types of, say 470k, can be used in series.

The circuit diagram Fig. 2b shows a method sometimes used to eliminate one of the diodes, using the Zener to perform the function of diode D1 as well as regulation. If this is used, the "forward" drop of the diode feeding capacitor C2 should be taken into account.

OUTPUT CURRENT

The available output current can be calculated by taking the mains voltage, dividing it by the capacitor's reactance, then dividing the result by two as only positive half-cycles end up as usable output, and then derating by about 20 per cent to compensate for miscellaneous other losses.

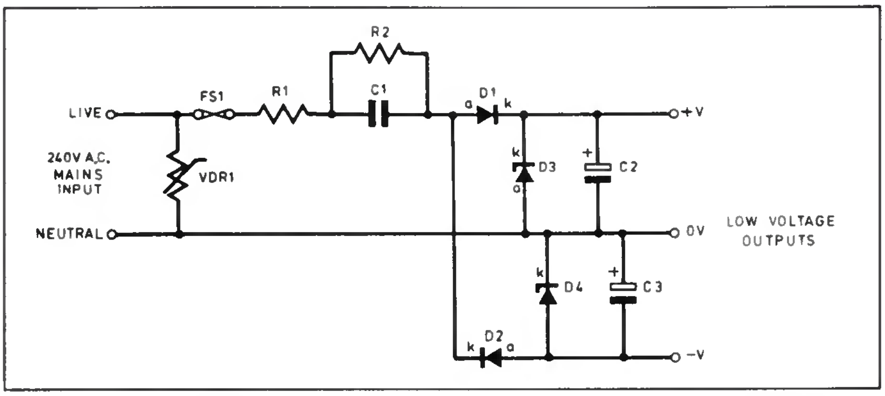


Fig. 4. Circuit diagram for a Dual-Output Transformerless Power Supply.

Most of the figures involved are constants, so an easier method is to multiply the capacitor value in µF by 30 for a result in mA. Thus a 0·47µF capacitor circuit as shown can supply about 14mA, enough perhaps for some CMOS, a low-power op.amp, and for triggering a triac.

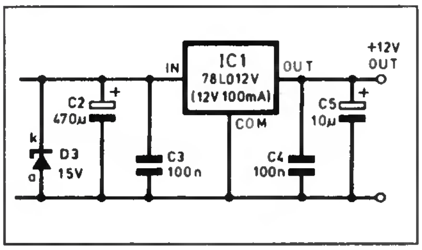


Fig. 3a. Using a 15V Zener and adding a 12V voltage regulator to provide a stable 12V output.

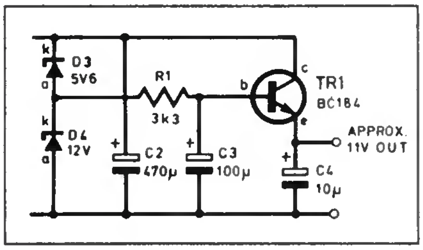


Fig. 3b. Ripple suppression circuit using a transistor. Zener diodes D3 and D4 replace D3.

Because the circuit is essentially a half-wave arrangement, the output contains ripple. Where this is a problem various ways exist to reduce it, the most obvious being an increase in the value of capacitor C2. With 470µF the circuit of Fig. 2a exhibits about 300mV peak-to-peak ripple at maximum output.

Another way to remove ripple is to start with a higher voltage and regulate down with one of the popular "78LO" series three-terminal voltage regulator i.c.s. For instance, with Zener diode D3 as 15V, a 78LO12 would provide a stable 12V output, as shown in Fig. 3a.

A minor snag is that these regulators use power themselves, and with so little available to start with this might be a problem. A micro-power regulator could be used. Alternatively, if the output voltage is not too critical, the circuit shown in Fig. 3b was tried and proved very effective at ripple suppression.

DUAL SUPPLIES

The circuit of Fig. 2a provides a *positive* d.c. output. If the three diodes and C2 are reversed, it will supply a *negative* output instead. This has sometimes been used in designs because experience has shown that the type of triac, the C206M, often employed with this circuit turns on more reliably when operated with negative gate current. The polarity reversal does make the circuit action harder to follow though.

From reversed polarity, it is a short progression to a dual-rail circuit. Fig. 4 shows how this is done, with just one extra Zener and an electrolytic capacitor. The two output voltages don't even have to be the same, a +5V and −12V version, for example, could be built by simply using suitable Zeners.

FULL-WAVE

All the circuits so far have been half-wave examples. Although not recommended, it is possible to produce a full-wave single-output version, as shown in Fig. 5. The two Zeners are of equal value. Theoretically this should manage twice the output of the half-wave version, and a smaller capacitor could be used for C2.

To aid explanation of the circuit action, it has been redrawn in simplified form in Fig. 6a and Fig. 6b, showing the effective circuits during *positive* and *negative* half-

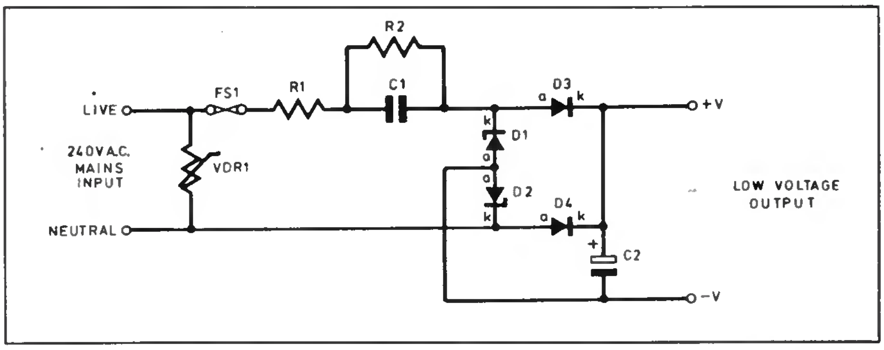


Fig. 5. Circuit diagram for a full-wave version of the "Capacitor" power supply.

cycles respectively. The current paths in each case are shown by the shaded arrows. It can be seen that D1 and D2 act as both Zeners *and* ordinary forward-biased diodes.

If the voltage of point "X" is taken during a positive half-cycle it can be seen that it is about 0·6V positive of neutral, due to forward biasing of D2. During the negative half-cycle, it is negative of neutral by about the supply voltage.

Likewise the point "Y" will also be jumping up and down, so there is no stable point which can be taken as a test reference for external equipment. For this reason, coupled with the difficulty of explaining the action, it has never been used by the author.

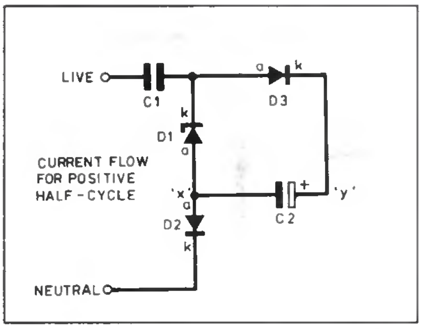


Fig. 6a. Current flow for the positive half-cycle in a "Full-wave" version.

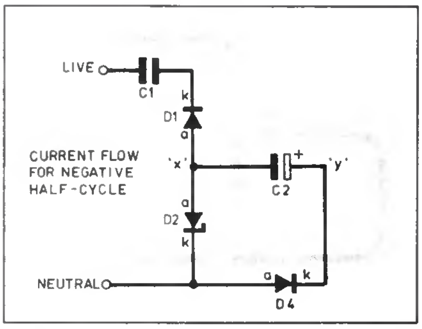


Fig. 6b. Full-wave version current flow during the negative half-cycle.

CONCLUSION

This type of supply is best suited to simple, low-current circuits which are already in contact with the mains at some point, such as those using triacs. The fact that they are unsafe to touch is not then an additional problem. Electronic precision thermostats and lighting effect controllers immediately spring to mind, although other applications will no doubt occur to many experimenters. Safe interfacing to the outside world can be achieved with opto-isolators, so is not a major problem.

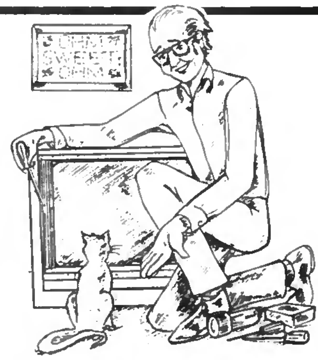
RELIABILITY

With regard to reliability, the author has two of these supplies in thermostats which have been running continuously for several years without trouble. A third, in a version of the *Visual Doorbell* project (March '94), has been operating almost as long.

On one occasion one used in a thermostat by a colleague kept blowing the resistor used for R1 (it wasn't fused!). The problem disappeared when capacitor C1 was replaced, so it was suspected that the original capacitor was shorting occasionally, blowing the resistor, then "self-healing" before the cause could be pinpointed. □

Ohm Sweet Ohm

Max Fidling



The Terminator

IT'S amazing how the word gets around that you're the "one who tinkers with electrical stuff". I've had a plethora of past-it bits of electrical equipment come my way, owners thinking "innocently" that I can make them as good as new with one wave of the soldering iron (the equipment I mean, not the owners).

The trouble is, one half of the time I don't have the time, if you see what I mean, and the other half I wish I hadn't bothered, because invariably they want it done for next to nothing – and they also want a lifetime guarantee thrown in! Back they come, weeks or even months later, holding the wretched toaster/electric fire/car radio or whatever, which I had magically transformed from a sorry state back into a fully fledged bit of kit, only this time it's got a different fault – and fingers are pointing in a roundabout sort of way at the workmanship of the earlier attempts of yours truly! What a life, I mutter to myself, as I spend more hours pinning down the latest fault on something which should have been recycled into a can-opener long ago.

Like grappling with plumbing or car maintenance, it's handy to have a certain bit of electronics know-how, though you need a good Degree in Micro-Surgery and Arc Welding (Hons.) to just remove the back panel from most of the modern gear you buy these days. However, repairing stuff is my attempt as a consumer to beat the system and score points over the High Street stores.

Take our old ITT-KB colour television for example. In a polished wooden cabinet with a sliding "tambour" door, as ITT called it, this gogglebox was a feat of woodworking which would have made old Thomas Chippendale's (wooden?) chest swell with, er, well, something or other. Apprehension, probably. This masterpiece of multimedia entertainment needed approximately a week's written notice of when its services would next be required, such was the time its throbbing valves took to warm up and gladden our hearts.

One great novelty of its era was the telly's touch-sensitive channel selector switches which were actually years ahead of their time. By poking the requisite little panel with a finger, two touch pads were bridged in resistance-pad fashion and if the trusty old ITT was feeling in the mood, a change of channel would result, accompanied by a red indicator lamp sputtering into life. (ITT spared every expense.)

Don't push me

As if not satisfied with the finest contributions which British broadcasting could muster, Piddles, the family cat, took great delight in nosing the channel selector when it took its fancy, or maybe it found the moving pattern of red lights more captivating than the offering of the tube. (Piddles always did have good taste.)

Things took a turn for the worse one particular day though, when the devil's lantern resolutely failed to respond to the satin silver "ON" button. The blank, murky green screen refused to burst into life. With "Coronation Street" due on the box any minute, the pressure was suddenly on to enable the Boss of the household to have her weekly dose of soap. Life would be unbearable otherwise! Worse – no grub for a week!

This wasn't the time to thumb through the Yellow Pages to book a repairman – desperate action was needed! This was a job for the multi-purpose screwdriver kit which I'd bought from a mail order catalogue some weeks earlier, and I had been itching for an excuse to use it ever since. This was my moment, an opportunity to demonstrate my electronics prowess and expertise, and I seized it with relish!

Having unplugged the set, quick as a flash, I unscrewed the rear cover of the TV, while Piddles and the Boss looked on anxiously. Poking around in the back of a colour television without some knowledge is definitely not recommended if you want to enjoy life, so I was wary of the extra high tension voltages lurking around unseen on those old capacitors. Nerves of steel, that's me, I thought, as I stroked my chin, pretending I knew exactly where the fault would lay.

I peered gingerly amongst the glistening silvery-topped valves into the works, assisted by my Ever Ready plastic torch which I had bought from Woolworth's specially for such catastrophes. Gritting my teeth, I fought my way through those dusty wiring looms and wonderful web-covered valves, in search of anything blindingly obvious which could have caused the downfall of the terminated television, whilst trying not to touch anything remotely HT at the same time. Ruined resistors? Damaged diodes? Nothing would escape my scrutiny, I decided, confident that I could beat the repairman on this one.

Aha! There it was... a small 20mm cartridge fuse, resplendent in its paxolin fuseholder, blackened and looking decidedly culprit-like, I reckoned. Wielding my multimeter impressively, a deft resistance check confirmed that the fiendish fuse had indeed caused the premature interruption of our evening's entertainment. Probably just old age, I thought, and rummaging through my biscuit tin of sundry bits, I happened to have one of the same rating (for once) so a quick replacement was made and the back cover was re-fitted with a twirl of my new screwdriver.

Piddles was looking up at the channel selectors, tail swishing expectantly, waiting for his incandescent cue to start switching over. A quick press on the "ON" switch, and the valves throbbed into life once more, and my life was saved. A hero in the making, that's me, I mused.

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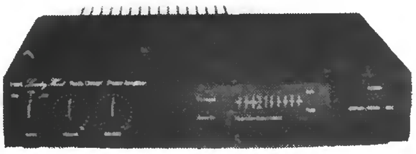

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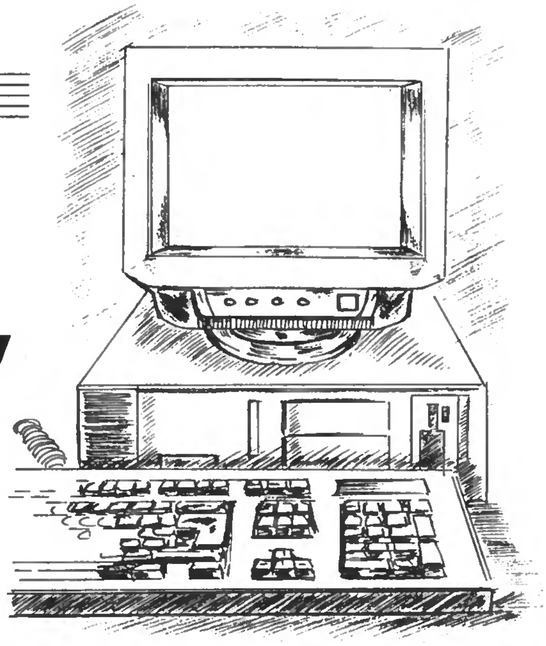
Constructional Project



THE ULTIMATE SCREEN SAVER!

PAUL STENNING

Give your PC screen a "tea break" and save yourself some money.

Most laptop computers have sophisticated power management facilities, which shut down the screen and hard disk after a period of inactivity to save battery life. Until recently these facilities have not been available on desktop computers.

Some "Green" PCs are now becoming available, with the aim of reducing power consumption when they are not actually being used. However, if your existing PC is OK, spending over a thousand pounds on a new one just to save a few pounds worth of electricity does not make economic sense!

Software screen savers are available, mostly running under Microsoft Windows, but all these do is prevent a static image burning into the phosphor of the c.r.t. (cathode ray tube). Indeed some of these are sold more on their amusement value than their original purpose!

SCREEN SAVER

The unit described here takes the screen saver idea to its logical conclusion. If the Keyboard and Mouse are not used for a preset period, the Monitor is switched off. As soon as you touch the keyboard or mouse, the monitor is switched back on again.

This not only prevents phosphor burn, but also saves electricity. In addition it will reduce the emission of electromagnetic radiation and positive ions, if these things concern you. Also, it costs no more than a screen saver software package.

If you leave your computer on all the time but only use it for a few hours each day, this unit could save you over £70 per year in electricity costs alone! (Calculation based on six hours use for five days each week, 125VA monitor and electricity costing 8p per unit = £71.76 saving over 52 weeks.)

The time period before switching off can be anything from 15 seconds to over one hour, selectable by internal d.i.p. switches. The unit is powered by the 5V supply to the keyboard, consuming just 20mA. Because of this, it will also power down the monitor when the PC is switched off – even if the two units have separate mains feeds.

The monitor is controlled by an opto-isolated triac, which being solid-state should have a longer working life than a relay. The maximum current is 3A continuous – if your monitor consumes this much there is something wrong with it!

The design as shown is intended for a *serial* mouse, connected to a COM port on the PC. It is probably possible to use it with a bus mouse, if a suitable signal can be found on the connection to the PC and the appropriate connectors can be obtained. Alternatively you can just use the keyboard.

TAKE CARE

SECTIONS OF THIS CIRCUIT OPERATE AT POTENTIALLY LETHAL MAINS VOLTAGES. *DO NOT BUILD IT IF YOU ARE IN ANY DOUBT ABOUT YOUR ABILITY TO DO SO SAFELY. You should seek the advice of a qualified person.*

Although this unit removes power from the monitor, it does not provide isolation from the mains. All mains connections must be regarded as live and dangerous, even if this Screen Saver has operated.

CIRCUIT DESCRIPTION

The complete circuit for the Ultimate Screen Saver is shown in Fig. 1. Capacitor C1, resistor R1 and the 2-input NAND Schmitt trigger IC1c form a simple oscillator, running at (ideally) 1·07Hz. The frequency is not precise, but it is more than adequate for our purposes.

This oscillator arrangement will only work with logic CMOS gates having Schmitt trigger inputs. The oscillator can be stopped by taking pin 9 of IC1c low.

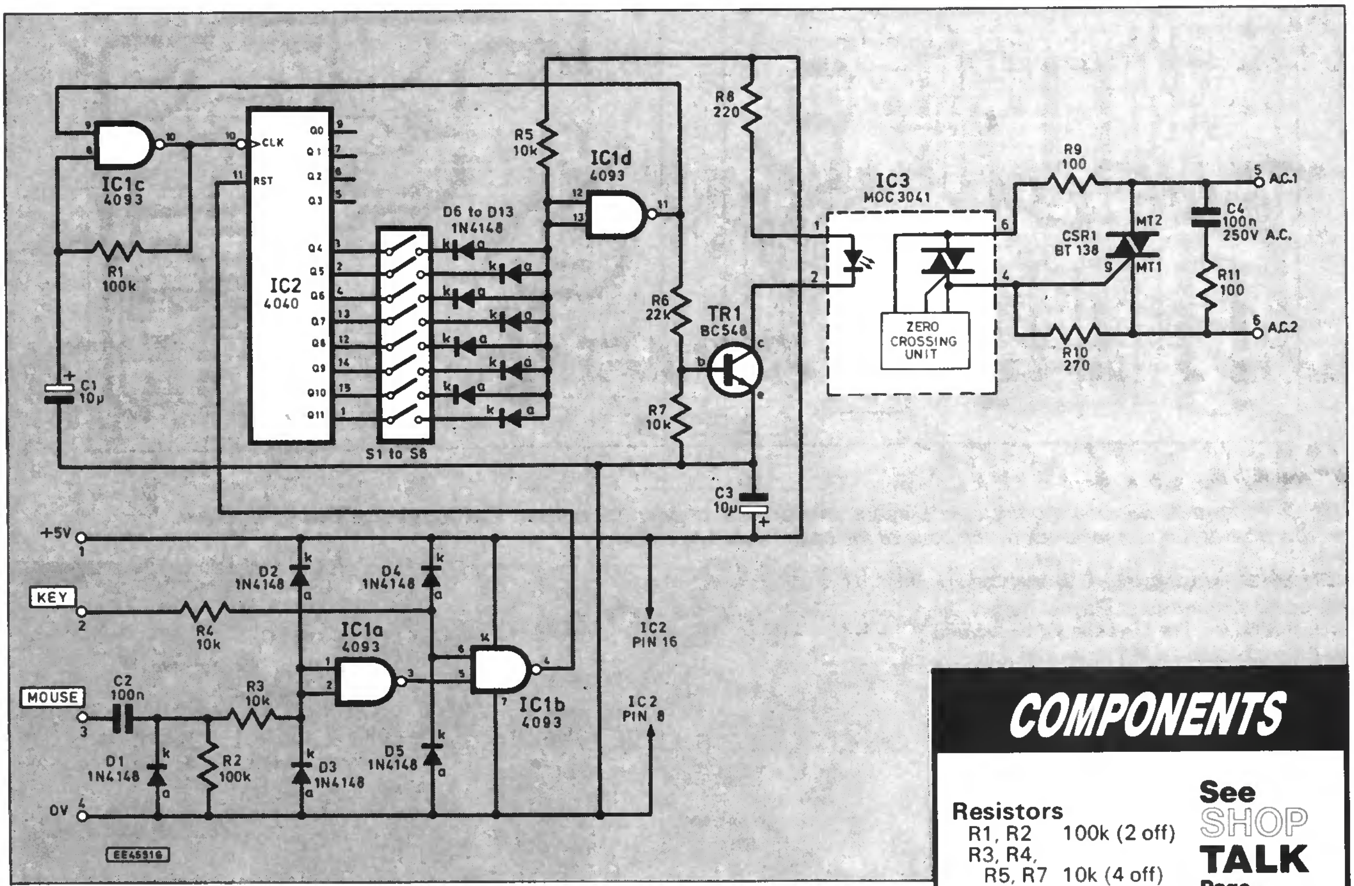


Fig. 1. Complete circuit diagram for The Ultimate Screen Saver. The numbers against the input and output points on the circuit refer to solder pins on the circuit board.

The clock signal is fed to the clock input of binary counter IC2. The outputs of this will count up in the usual binary pattern. Once 16 clock pulses (approx. 15 seconds) have been received, Q4 will go high.

If the top switch S1 of the d.i.l. switches (S1 to S8) is closed and the others are open, this high level would arrive at the inputs of IC1d, via the diode AND gate. The output of IC1d will therefore go low, disabling the oscillator, and switching off transistor TR1 and the l.e.d. in the opto-isolator IC3.

The MOC3041 opto-isolators contain full zero-crossing circuitry and a triac output stage. They are ideally suited to driving triacs in this manner, since they do all the hard work for you! The l.e.d. current for guaranteed operation is 7mA max.

Other devices in this useful family include the MOC3040 which needs a 15mA input (it is slightly cheaper), and the MOC3020 which does not have the zero crossing circuit.

The triac CSR1 used in the prototype is a BT138 type, however most 600V TO220 packaged triacs should be suitable, including C206M, C225M, C226M, BT137, BT139, BTA08-600B etc. Capacitor C4 and resistor R11 form a snubber network to ensure the triac switches off cleanly with an inductive load. C4 MUST be a Class X rated component, suitable for *direct connection* across the mains

TIMING

The d.i.l. switches in S1 to S8 are binary weighted and give the following times (from top): 15 seconds; 30 seconds; 1 minute; 2 minutes; 4 minutes; 8 minutes; 16 minutes and 32 minutes. The diode AND gate arrangement allows these times to be added if more than one switch is closed – thus to obtain a time of 40 minutes the 32 min. and 8 min. switches would be closed.

The precision of the timer is about +/−10 per cent, which is adequate for the intended purpose. Repeatability is better as would be expected, about +/−2 per cent.

Binary counter IC2 is reset every time the keyboard or mouse is used. The keyboard sends a burst of serial data on pin 6 whenever a key is pressed. This line is normally high, and pulses low. Since these are normal logic levels, the line is connected directly to IC1b, with a series resistor and clamping diodes D4 and D5 to protect against the unknown!

The mouse output is a low level RS232 signal, and requires a little more processing. The output from my cheap-and-nasty Tiwanese rodent is normally at −2·5V and pulses to +2·5V whenever it is operated. These levels are actually below the minimum RS232 specification of +/−3V, but it works OK. It is assumed that some other breeds will have a larger output, so we have tried to cater for all variants.

Capacitor C2, diode D1 and resistor R2 shift the signal so that the negative level is at about 0V, and the pulses are positive. This passes to IC1a via R3, and if the level is above 5V peak-to-peak it is clamped by diodes D2 and D3.

CONSTRUCTION

All the components are mounted on a single-sided printed circuit board (p.c.b.), which is available from the *EPE PCB Service*, code 927. The component topside layout and full size underside copper foil master pattern is shown in Fig. 2.

The i.c.s may be mounted in sockets if desired, but since they are all low cost devices this is not strictly necessary. IC1 and IC2 are static sensitive, so should be fitted last and handled with due care.

COMPONENTS

See SHOP TALK Page

Resistors

R1, R2	100k (2 off)
R3, R4, R5, R7	10k (4 off)
R6	22k
R8	220
R9, R11	100 (2 off)
R10	270

All 0·25W, 5% carbon film or better

Capacitors

C1, C3	10µ radial elect. 25V (2 off)
C2	100n ceramic (0·2 in. pitch)
C4	0·1µ metallised polypropylene, 250V a.c. continuous (Class X)

Semiconductors

D1 to D13	1N4148 or 1N914 signal diode (13 off)
CSR1	BT138 600V 12A triac or similar (see text)
TR1	BC548 *npn* silicon transistor or similar
IC1	4093 quad 2-input NAND Schmitt trigger
IC2	4040 12-stage binary counter
IC3	MOC3041 opto zero-crossing triac isolator

Miscellaneous

S1 to S8	8-pole s.p.s.t. d.i.p. switch
SK1/PL1	5-pin 180 degree panel DIN socket and cable DIN plug
SK2/PL2	9-pin D-connector socket, plug and cover.

Printed circuit board available from *EPE PCB Service*, code 927; metal case, size approx. 165mm x 70mm x 190mm; IEC (Euro) mains cable plug; IEC (Euro) mains cable socket; 6A 3-core mains cable; 6-core screened cable; single screw-terminal block; rubber grommets or cable glands (4 off); strain relief clips; coloured multistrand connecting wire; solder pins; p.c.b. stand-off pillars or nuts, bolts and spacers; solder tag (Earth); solder; red l.e.d. for testing.

Approx cost guidance only **£25**

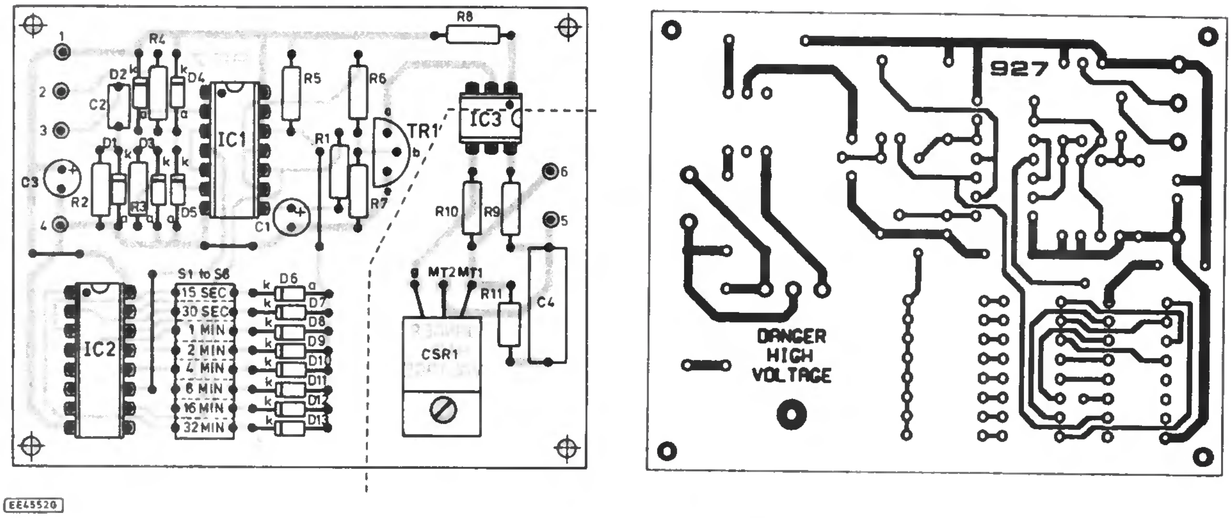
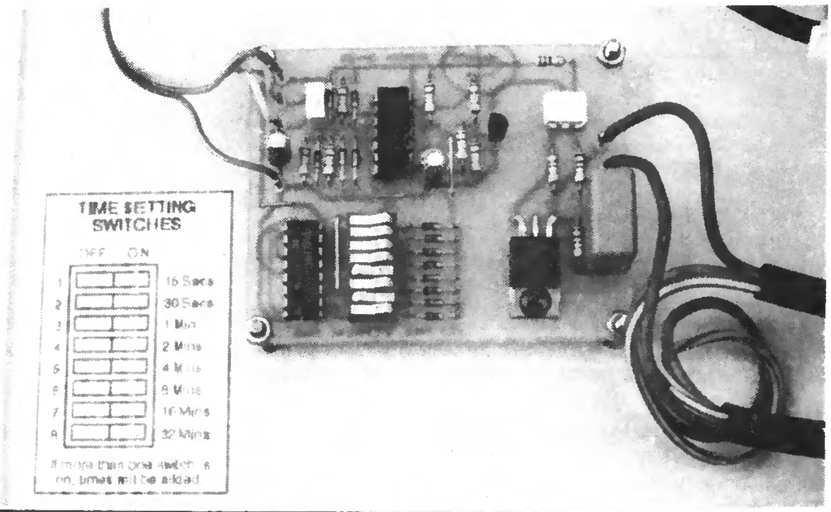


Fig. 2. Printed circuit board component layout and full size copper foil master. The completed board, together with a time setting panel stuck to the base of the case, is shown below.



Solder terminal pins may be used for the off-board connections. Do not forget the four link wires. The triac should be secured to the p.c.b. with an M3 screw and nut.

Take extra care when assembling the high voltage section – that to the right of the dotted line. This dotted line indicates the safety isolation barrier – a band or gap at least 5mm wide between the high voltage and low voltage sections.

Do not fit IC3 at this stage. Instead, fit a spare l.e.d. temporarily between pins one and two positions on the p.c.b., with the anode (a) to pin one. The l.e.d. will be removed and IC3 fitted once the low voltage sections have been tested.

CASE

The prototype was constructed in a plastic case, however this is not really suitable. A *metal* case should be used, which ***MUST*** **be properly Earthed for safety.**

The lid must be secured by screws, so that it cannot be removed without the use of a tool. A suitable label should be fixed to the lid, warning of the high voltages inside.

The p.c.b. should be held in place with M3 screws and spacers. Ensure that the triac mounting screw clears the case by at least 5mm. Suitable cutouts should be made in one end of the case for the Keyboard (normally 5-pin DIN) and Mouse (9-pin D) connectors.

Four holes are needed in the other end, to accommodate the cables. These should be fitted with grommets or cable clamps, and the cables adequately secured against being pulled out. An additional hole in the base is required for securing an Earth solder tag. The final interwiring between the p.c.b. and all off-board components is shown in Fig. 3.

TESTING

Before making any connections to your PC, switch it off at the mains. If this is not done there is a small possibility of causing damage – it's not worth the risk!

Set d.i.l. switch S1 (top) on, and the rest off. Leave the case cover off for now – since the unit will not be connected to the mains.

Unplug the keyboard and mouse from your PC, and connect them to the sockets on this unit. Connect the leads on this unit to the appropriate sockets on the back of the PC. Do *not* change the monitor connections at this stage.

Switch the PC back on, and watch the screen carefully as the PC goes through it's power-on self test, and boot up. If any error messages appear or the mouse driver

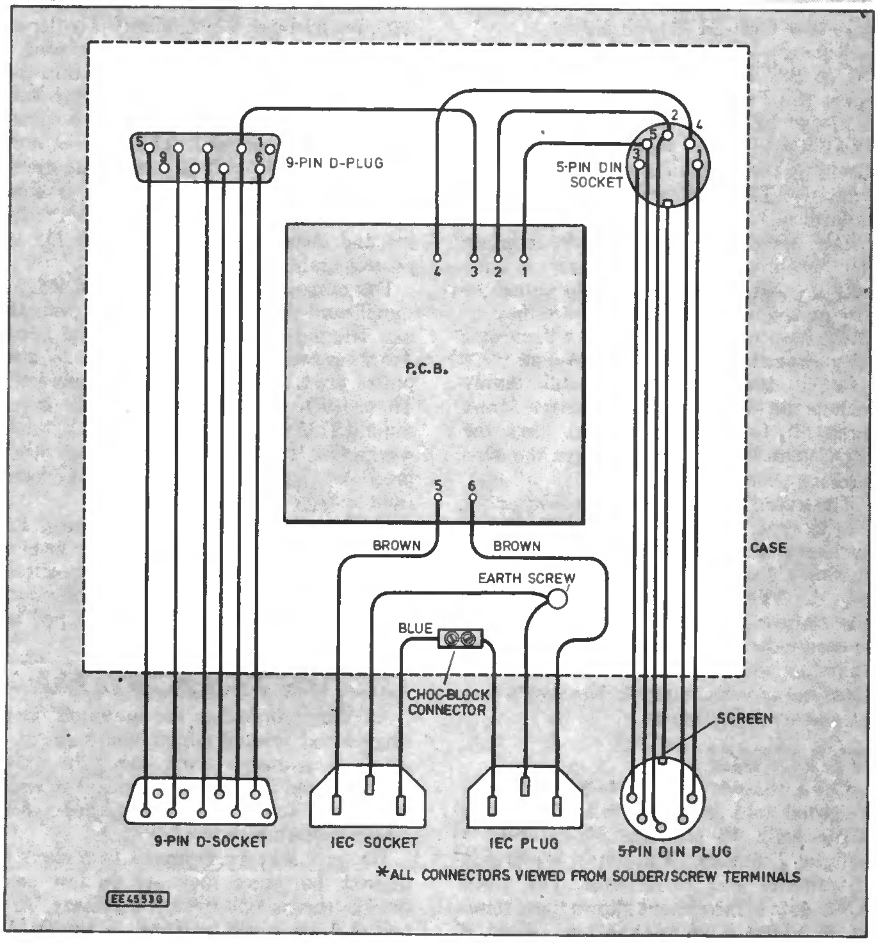
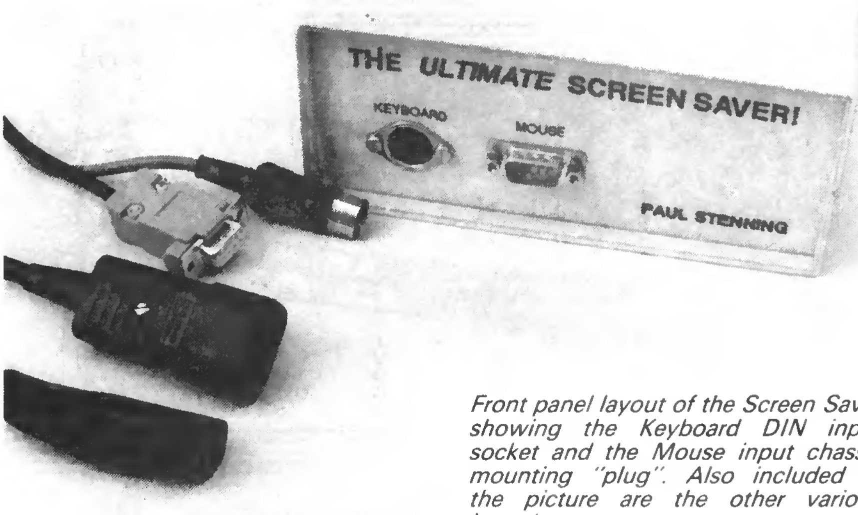


Fig. 3. Interwiring from and between all off-board components.



Front panel layout of the Screen Saver showing the Keyboard DIN input socket and the Mouse input chassis mounting "plug". Also included in the picture are the other various input/output connectors.

fails to load, switch off *immediately* and carefully recheck your wiring.

If the "temporary" l.e.d. in the Screen Saver unit did not light when the PC was switched on, it should have come on at some point during the booting up process. If you don't touch the keyboard or mouse for about 15 seconds the l.e.d. should go off.

Operate the keyboard and the l.e.d. should immediately come on again, and extinguish after you have stopped typing for 15 seconds. The same situation should occur with mouse movement. Again, in the event of any problems, check your wiring carefully.

Switch S1 off and S2 on. The delay should now be about 30 seconds. You may wish to check some of the longer delays, if you have the patience!

Now switch the PC off. Remove the temporary "test" l.e.d. from the Screen Saver board, and fit the opto-triac IC3. Set the d.i.l. switches to give a delay of one minute, and fit the cover securely.

Disconnect the power lead from the back of your monitor, and connect it via this unit. Switch the PC on, the monitor should also be on by the end of the boot-up. As previously, if you don't operate the keyboard or mouse for about one minute, the monitor should turn off.

SWITCH-OFF DELAY

Once you are happy that the unit works satisfactorily, set the d.i.p. switches S1 to S8 to a suitable delay and tuck the unit tidily behind the PC (do not obstruct any ventilation holes or the fan). Always switch off at the mains before removing the cover to operate the d.i.p. switches.

It is suggested that a delay of about 20 or 30 minutes would be reasonable in most cases. Times of less than about five minutes are probably not practical, and indeed this sort of repeated switching may cause undue stress to the monitor.

If you have a software screen saver you could set this to come in two or three minutes before the Ultimate Screen Saver to act as an early warning.

MODIFICATIONS

The following suggestions are offered for experimentation by *experienced constructors only*, and have NOT been tested.

As it stands, the Screen Saver may be of limited use to PC game players, since it does not detect joystick activity. However, it should be a relatively simple matter to replace the mouse 9-pin D-connectors with 15-pin types to suit the joystick.

Solder pin 3 on the p.c.b. would need to be connected to the main "Fire" button connection (probably pin 2 or pin 4). This should work regardless of the fire signal polarity, because of the capacitor coupling (C2) and pull down resistor (R2).

There is no easy method of monitoring the Keyboard, Mouse and Joystick together with the design as it stands. It may be possible to devise an arrangement using diode logic on one of the existing inputs, depending on the polarity of the fire signal from the joystick.

If you have a *bus* mouse, you will need to replace the 9-pin D-connectors with types to suit your mouse. You will then need to pick off the connection for the left button or one of the direction signals to connect to solder terminal pin 2 on the p.c.b.

If your keyboard or mouse uses 6-pin miniature DIN (PS2 type) connectors, you will need to obtain these and fit them in place of the types suggested. For the keyboard you will need to connect through all lines except pin 2. Pin 4 is +5V, pin 3 is 0V and pin 1 is Data – these need to connect to the p.c.b.

It has not been possible to establish the PS2 mouse connections, although it is quite possible they are similar to the keyboard since the same type of plug is used. You will need some very thin 6-core cable for these!

ACCESS TIME

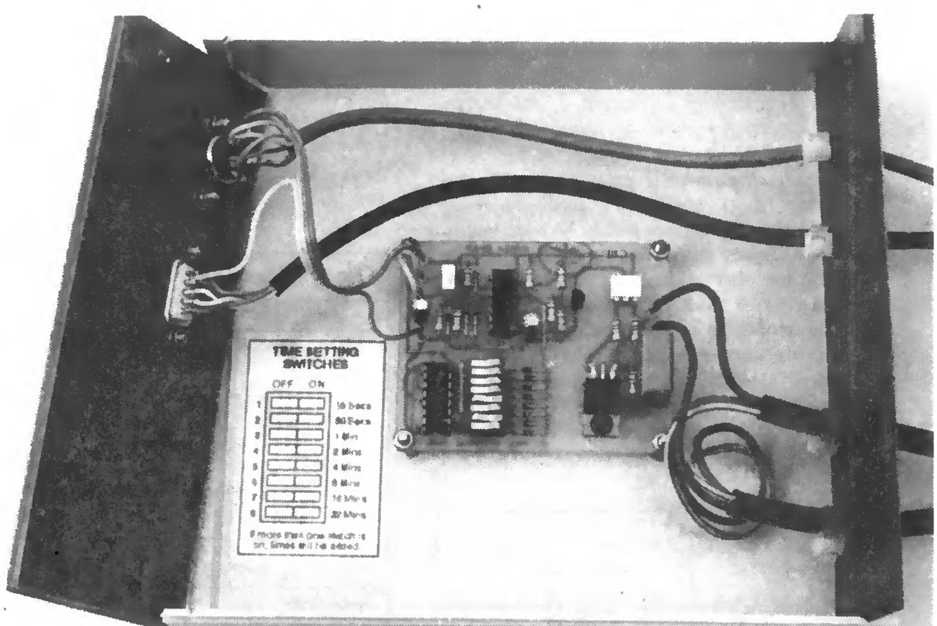
If you wish to access the d.i.p. switches S1 to S8, without dismantling the unit, the connections can be extended so that the switch protudes through a cutout in the case. The easiest arrangement would be to mount the switch on the underside of the p.c.b., so that it is accessible through a hole in the base of the case.

The switch body must fit through the hole so that there is no possibility of anything entering the case through the cutout. You may need to use one or two i.c. sockets, possibly wirewrap types, to extend the switch to fit your cutout.

An l.e.d. can be connected in series with resistor R8 if required, to show the state of the unit. R8 should be reduced to about 150 ohms in this case. This l.e.d. will light when the monitor is on.

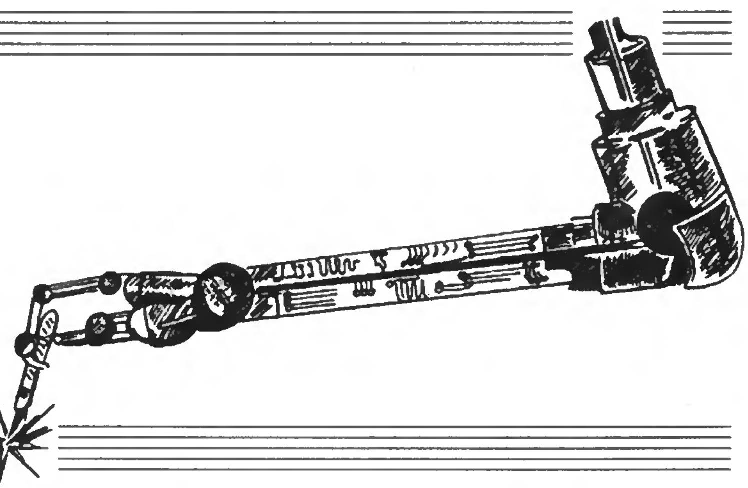
You may want a light to indicate that the monitor is off. The easiest way to achieve this is to connect a neon indicator across the triac output pins (5 and 6 on p.c.b.). Sufficient current will be able to pass through the monitor to illuminate this neon, providing the switch on the monitor itself is on.

The timing period is set by resistor R1 and capacitor C1. Increasing either of these will increase the delay. If R1 is increased to 220 kilohms the delays achieved will be about twice those stated previously – giving a range of 30 seconds to over two hours. A value of 390 kilohms should give about one minute to four hours – although leakage currents may affect this. □



Layout of components inside the completed prototype model. For added safety, the plastic case should be replaced by a METAL case which should be Earthed by a bolt and solder tag – see Fig. 3.

CIRCUIT SURGERY



ALAN WINSTANLEY

Our monthly column which answers readers' queries and offers useful hints and tips this month investigates regulated power supply design in depth, including a look at heatsinks. Also, a suggestion for a simple camcorder battery discharger, with other possible uses.

Power Supplies

REGULATED power supplies are quite simple and satisfying to construct. Using just one three terminal regulator device, it's possible to assemble a bench power supply which offers a neat and tidy solution to all those power problems – and you can benefit from full overload protection to help nurture your newly-crafted circuits! But they have limitations, especially if you want high current and flexibility across a range of output values.

Mr David Jones of Llanelli starts this month's round-up with the following query:

I'm interested in building a 0V to 30V 5A Variable Power Supply. I know that I can use additional transistors to boost the current requirements of ordinary three-terminal fixed voltage regulators. Can I use this type of circuit for variable regulators? Or could I use several regulators in parallel to reduce the power dissipation at low output voltage/high current situations? I have plenty of high current pnp *transistors and plenty of LM338s. Any advice would be welcomed.*

Mr. Jones drew the suggested circuit diagram shown in Fig. 1. to illustrate the general idea. It uses a fixed 5V 1A regulator type 7805 or similar. The external bipolar transistor TR1 is called a "pass" transistor and in this example is a power *pnp* type capable of high dissipation (150W) and high collector currents (15A), though it has low gain (say 10 to 50). It behaves as a current amplifier allowing the power supply to provide higher output currents.

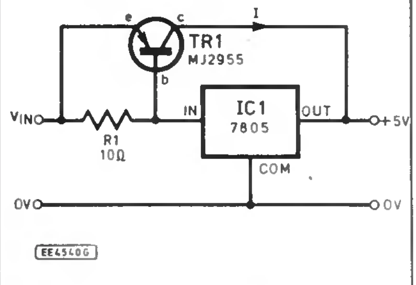


Fig. 1. Fixed +5 V regulator with external pass transistor.

The voltage drop across the resistor R1 forward biases the base whilst the transistor's collector is clamped at 5V, and its emitter is at the supply input voltage. The transistor itself is not protected against shorts or temperature overloads, but generally it's hoped that its high power ratings can cope with any abuse.

The transistor dissipates ($V_{in}-5V$) × *I* watts. By paralleling several pass transistors, the power dissipation can be spread across several devices, see Fig. 2. Note that low value series resistors are inserted as shown, since each bipolar transistor is likely to have a different gain resulting in uneven distribution of the total current – some transistors work harder than others.

The resistors *R* each produce a small error voltage when the transistors conduct, which means that the transistors share the total power dissipation more evenly and one doesn't try to shunt the others. By the same token, it is possible to use regulators in parallel (again with

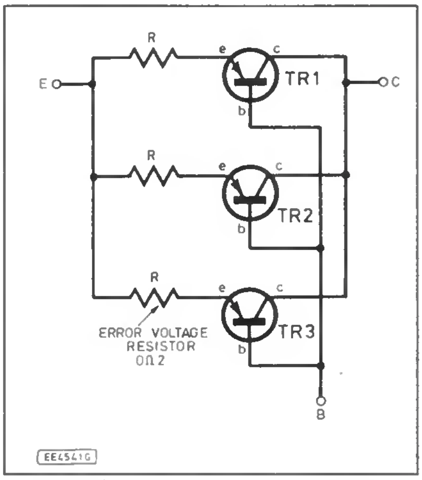


Fig. 2. Two parallel pass transistors with series error voltage resistors.

Table 1: Adjustable Voltage Regulators

Device Name	Output Current	Output Voltage	Package Type
LM317LZ	100mA	+1·2 – 37V	TO-92
µA723	150mA	+2 – 37V	14 pin d.i.l.
LM317MP	500mA	+1·2 – 37V	TO-202
LM78G	1A	+5 – 30V	TO-202/4 pin
LM317T	1·5A	+1·2 – 37V	TO-3
L200CV	2mA	+2·8 – 36V	TO-202/5 pin
LM350T	3A	+1·2 – 33V	TO-202
LM350K	3A	+1·2 – 33V	TO-3
LM338T	5A	+1·2 – 32V	TO-202
LM338K	5A	+1·2 – 32V	TO-3
LM396K	10A	+1·2 – 15V	TO-3

series resistors) to increase the available current and spread the load.

A simple but neat way of constructing a higher current power supply might be to use a variable three terminal regulator such as the LM338 Mr. Jones mentioned. This dispenses with the need to configure separate discrete transistors and greatly simplifies design and construction, although there are still some pitfalls to be avoided. Table 1 ists a variety of popular regulators: the LM338 seems to fit the bill for a 5A supply, and its Data Sheet claims a guaranteed 5A output current, with 7A peak output (surge) possible.

Indestructible?

The LM338 seems to have the sort of built-in protection which we now take for granted, including short circuit protection and thermal overload limiting. However, this does not render it indestructible, and there are still a few ways to damage a three terminal regulator in use, especially in the context of a bench power supply. Here's my short list.

1. *Exceed the input/output voltage differential* – the maximum voltage permitted *across* the device. A figure of 40V to 50V is fairly typical. Surpass this value of input voltage and then short the output to 0V at your peril. Watch the regulator's input voltage carefully.
2. *Reverse the polarity of the regulator.* Several subtle ways of doing this include assorted output capacitors (possibly in the load itself) retaining their charges and causing the regulator's output pin to exceed the voltage at its input, should the input voltage dip for any reason. Inductive loads are also troublesome – back e.m.f. is not appreciated and it's sometimes worth adding a protective diode.
3. *Punish the regulator by forever cycling its temperature between extremes* (thermal stress). Decent heatsinking is the best way for reliability, otherwise it may not survive for ever under such stressful conditions. I know the feeling!

Regulators are very simple to use "on paper", they only require a fixed resistor and a potentiometer to provide a complete variable power supply. The formula for the output voltage is derived from that of a potential divider, since

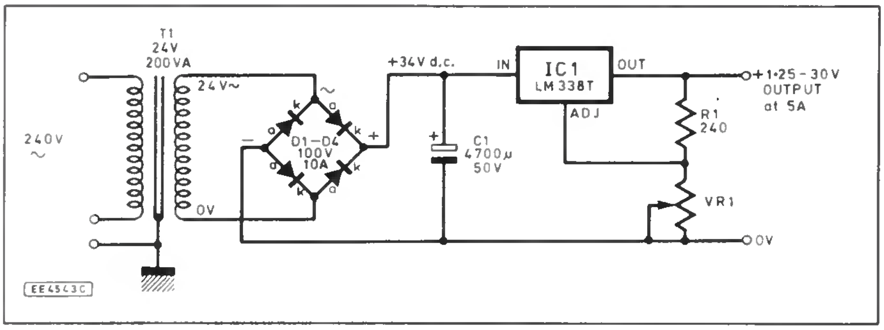


Fig. 4. 30V 5A power supply which will thermally shut down due to excess power dissipation in IC1.

these chips use a 1·25V reference voltage between the adjustment and output pins.

In Fig. 3, a basic configuration is shown which is good for both the LM317 and LM338, and the output voltage Vo is:

$$Vo = 1{\cdot}25 \times \left(1 + \frac{R2}{R1}\right)$$

It's worth including those protection diodes D1 and D2 to shunt out capacitors C2 and C1 respectively when either the input or output is shorted to ground. Diode D3 is included to protect against back e.m.f. in the load, when applicable. However, referring back to Mr. Jones' request, developing this circuit into a 30V 5A Variable P.S.U. presents several problems which renders this approach impractical, see Fig. 4.

To be realistic, we are restricted by the availability and cost of components so performance may need to be traded off against price and practicalities. The design looks straightforward on paper but in fact proves to be less feasible after taking extreme operating conditions into account. Here's why.

Starting with the transformer, catalogues quote transformer secondary a.c. current values as r.m.s. figures *assuming a simple resistive load.* The average currents are higher in this application because we are placing a large smoothing capacitor after the rectifiers.

In the case of a full-wave bridge rectifier arrangement, it is necessary to derate the transformer by "grossing up" its VA rating by a factor of roughly 0·6, if you want the transformer to handle peak demands safely. A full 5A output implies a transformer secondary current of 8A (5 ÷ 0·6). Hence if you want to design conservatively for the worst case, the transformer specification is a mighty 200VA (24V a.c. × 8A).

A 24V a.c. secondary winding would be sufficient to develop a 34V d.c. rail (24V × $\sqrt{2}$) across the smoothing capacitor, ignoring the transformer's regulation and any voltage drop amongst the rectifiers. It may be several volts higher at lower currents. One may well decide to compromise the finished design by reducing the transformer's VA rating on grounds of cost and size, but this reduces the maximum output current which can safely be drawn from the design. Myself, I would like to live a few more years yet!

The bridge rectifier is a conservative 100V 10A device or higher. The switch-on surge current through the bridge is determined by the size of the smoothing capacitor plus its effective series resistance (ESR), together with the resistance of the transformer windings. The 4,700μF (or more) electrolytic smoothing capacitor should be rated at 50V minimum.

Too Hot to Handle

The main problem surrounds the regulator itself (literally). It's necessary to ensure that it is adequately heatsinked to cope with worst case conditions or the device will simply shut down.

In practice it's more difficult to ensure that the regulator performs reasonably right across the range, because of thermal problems at maximum power dissipation. Since the heatsink arrangement has a direct impact on the performance of the power supply, let's examine the implications of the heatsinking more closely.

The LM338T device arrives in the plastic TO220 package (that's the "T" in LM338T). The first step is to calculate the maximum power in watts which the i.c. is likely to be asked to dissipate. This equates to *maximum* input voltage, *minimum* output voltage (assume a short circuit to 0V for our bench power supply) with *maximum* current throughput. It equals $(V_{in} - V_o) \times I_{out}$ or (34V – 0V) × 5A – an unhealthy 170 watts peak! This really confirms that this initial simple solution is pretty impractical, for general bench use at least, if you examine the following heatsink calculations.

Determine the ambient temperature around the i.c.; this could be say 40°C or more though it depends on construction. The Data Sheet for the LM338T specifies a maximum "junction" temperature of 125°C, so the maximum temperature rise

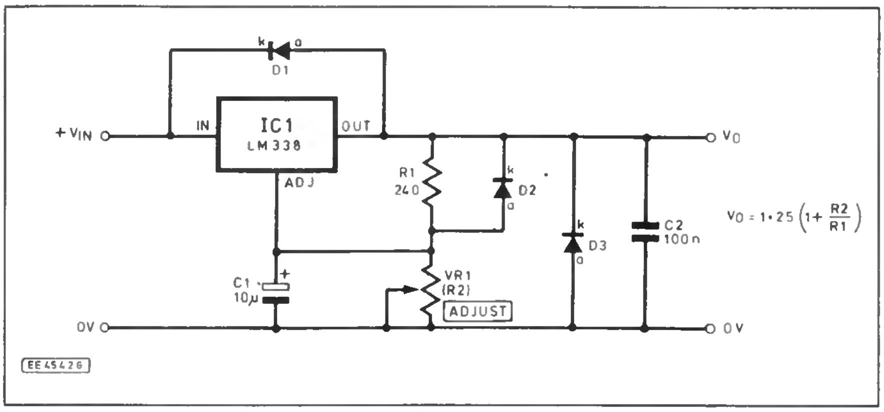


Fig. 3. Variable voltage 5A three terminal regulator with protection diode.

allowed in the total heatsink system (from chip to ambient) is therefore 85°C over and above ambient.

The ***thermal resistance*** of a heatsink is measured in units of Degrees Celsius/Watt, and is a measure of the heat rise generated per watt of power. A better heatsink has a lower thermal resistance so it doesn't rise in temperature as much, per watt dissipated.

The maximum permissible thermal resistance we may allow to get in the way between the regulator's junction and ambient surroundings, is 85 degrees/170 watts = **0·5°C/W**. The problem is, the Data Sheet tells us that the thermal resistance from the junction to the package (θ_{jc}) is **4°C/Watt** alone! The LM338K (TO3 can) version is an improvement – its thermal resistance is 1°C/W, but it isn't possible to sink away the temperature sufficiently to prevent the junction from reaching its maximum temperature, and the regulator will thermally shut down at maximum output.

Not so Good

In fact, even using the largest and most expensive heatsinks available (say 0·4°C/W or better), this design cannot pass a full 5A output at anything other than 30V output, when the voltage across the i.c. is at lowest value. The lower the output voltage, the more the regulator dissipates and very quickly it will thermally limit and cripple the performance.

It was calculated that for a 5V load (e.g. a logic circuit), it will only pass about 650mA before the maximum junction temperature is reached (= 19 watts over 4·4°C/W total thermal resistance at 40°C ambient). So it's really back to the drawing board!

We could possibly use several regulators in parallel to distribute the power dissipation and improve the efficiency of the heatsinking. Using several LM338s means that you can forget about 5A total current limiting, so the rest of the circuit isn't protected against current excesses.

It may be better to utilise LM317T regulators in parallel (say four off) but heatsinking becomes awkward and they will still dissipate some 40 watts each, worst case. The final alternatives are to use a pass transistor as explained earlier, or discard the three-terminal design and use discrete circuitry for voltage regulation and selectable current limiting.

If readers are looking for a power supply to construct for general use, you could check out our own *MOSFET Variable Bench Power Supply* project designed by Mark Stuart which is ideal for the more serious hobbyist. It offers 0V to 25V at up to 2·5A variable, which in my view will meet the needs perfectly of most constructors. See the April 1994 issue or contact regular advertiser Magenta Electronics on **01283 565435** – they offer a complete kit for this excellent design.

Protected MOSFETS

Mr. P. J. Newton of Liverpool has also been experimenting with power supplies, this time trying to develop a 0V to 24V 0A to 10A monster! Having experienced various setbacks he kindly sent me data and drew my attention to the availability of MOSFET transistors which are *temperature and overload protected*. These "TOPFETs" are manufactured by Philips mainly for the automotive markets but could have other applications – use in linear mode as a fully protected external pass transistor perhaps.

For example, the Philips BUK100-50GS TOPFET is a 15A 40W device, whilst the BUK106-50S is good for no less than 50 amps at 125 Watts! I have only seen these devices listed by Farnell (***Sales ☎ 0113 263 6311***) and RS Electromail (***☎01536 204555***), who show a selection of these BUK protected f.e.t.s in their catalogues.

A worthwhile Data Book is Philips' Power MOS Transistors (Farnell 171-454). Another alternative to investigate would be the "PROFET" range of protected MOSFETs such as the BTS410E or BTS412B, manufactured by Siemens and listed by Farnell. I have a feeling that these devices will catch on.

Mr E.J. Bibby of Warrington is a regular correspondent to *Circuit Surgery* – he suggested placing three rectifiers in series with a voltage regulator input in order to "lose" up to 2V voltage drop. Each rectifier has a 0·7V forward voltage drop, which could help to avoid exceeding the regulators input-output differential voltage; it also marginally reduces the power dissipation of the regulator, possibly reducing heatsink requirements in lower power applications. Use 1N5401s for a rating up to 3A.

Ni-Cad Discharger

The charging of nickel-cadmium (NiCad) cells involves the use of a constant current and is a popular subject for our project pages, but how about a NiCad *Discharger*? Why would you want to deliberately flatten a rechargeable battery? In the past, emphasis seems to have been placed just on the convenience of being able to re-cycle NiCads say 500 to 1,000 times. One problem is that they suffer from a "memory effect" which means that they gradually lose their capacity (literally) to hold their charge if they are not used regularly.

It's said that giving them a heavy *discharge* once in a while improves their effectiveness and lessens the memory effect. For example, a certain rechargeable electric razor includes advice from the manufacturer which recommends completely discharging the NiCad batteries every six months, but not leaving them in the discharged state for long periods or they might under-perform thereafter.

NiCad Dischargers are now being included with some battery chargers to help maintain their condition. If you own a camcorder, then you will want to preserve those expensive battery packs ready for your next blockbuster home movie. ***Mr. R. Crawford*** of Ashford, Kent asks if it's possible to help with a simple discharger.

I'm studying for a Degree in Electrical and Electronic Engineering. I wondered if you could help me with a simple way to discharge camcorder batteries. I know there are dischargers available on the market but I would like to have a go at one myself.

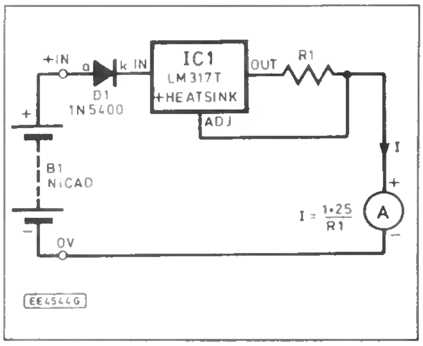


Fig. 5. Suggested Ni-Cad Discharger.

One idea for a NiCad Discharger circuit is shown in Fig. 5, it uses an LM317T regulator i.c. set as a constant current load. In effect, it has no load and its output is shorted to 0V. The i.c. limits the current at a level determined by resistor R1; the current is (1·25V/R1) amps.

By selecting different values for R1, the discharge rate could be adjusted. Possibly select values for 250mA, 500mA or 1A. The resistor dissipates 1·56/R1 watts.

The current rating for an LM317T is 1·5A peak and it will need approximately 10°C/W heatsinking or better. Built into the LM317T is thermal overload and current limit protection which should ensure that your battery pack is never short circuited.

The input to the regulator IC1 is actually the NiCad battery pack itself. These could be 6V or 9·6V types. Diode D1 prevents reverse connection. The regulator requires a minimum input of roughly +2·5V (the "dropout voltage") to conduct, so the device will automatically stop discharging the NiCad when it has fallen below 3V or so, including the diode drop.

The optional ammeter could be your multimeter, set to a suitable current range. The biggest problem is probably mechanical, in that you have to make a reliable connection to the battery pack contacts. You may have to improvise with brass strip or tinplate. The same circuit could also be used to test d.c. power supplies, acting as a dummy load.

How's Your Ingenuity

Finally this month, don't forget we're still sifting through your circuit ideas for the next *Ingenuity Unlimited* feature. If you have any circuit suggestions for possible inclusion in this feature, drop us a line at the editorial address. Show all circuit values and diagrams clearly and include a brief circuit description.

We will pay between £10 to £50 for items, depending on their merit. So if you have an idea, why not try sending it in? It could earn you some real cash!

Write to me care of editorial address: Alan Winstanley, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF.

Next time: I'll be checking out heatsinks in general, plus an adaptable design for an Automatic Porchlight Controller to shed some light on your night-time callers.

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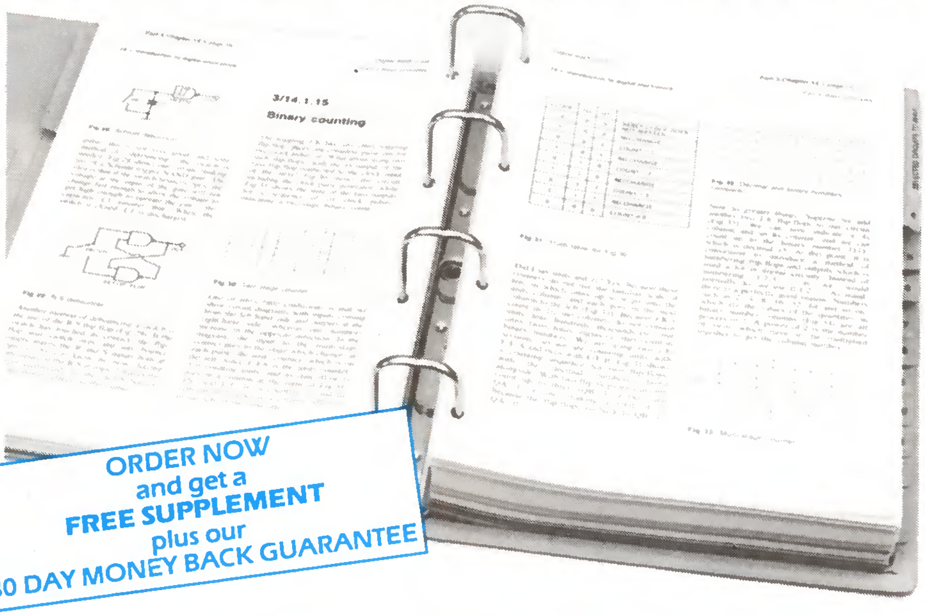

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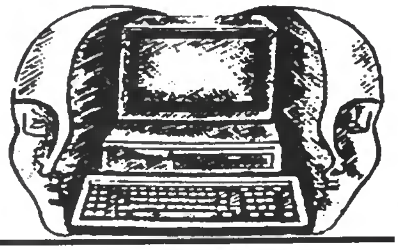


Robert Penfold

JUDGING from the readers' letters I have received, there is currently a lot of interest in using the Parallel Ports of PCs as a cheap and easy means of interfacing to user add-ons. This is understandable, since many PCs are supplied with two printer ports as standard, but in most cases only one of these is required for use with a printer.

Even if only one printer port is fitted, an expansion card costing a few pounds is all that is needed in order to add a second parallel port. Interfacing via a printer port is much easier than making up your own expansion cards, and is much cheaper than using ready-made parallel interface adaptor cards.

Using a printer port as a general purpose input/output port is a subject that has been covered in a previous article, although not in any great depth. In this article we will recapitulate to some extent before delving into the ins and outs of PC printer ports in more detail.

Out and Out

It is clear from some of the letters I have received that many PC users are under the impression that the printer port can be used as an eight-bit input or output port, in rather the same way as the user port of a BBC computer. In other words, each data line can be set to operate as an input or an output.

Unfortunately, this is definitely not the case. Inspecting the circuit diagrams of some PC printer cards reveals that the data outputs are provided by devices that can only provide outputs. Using the data outputs to directly act as inputs is simply not possible.

Probably this misconception has arisen because some commercial add-on units that connect to a printer port claim to use high speed bidirectional parallel data transfer. However, the normal way of achieving this seems to be by using the eight data outputs as an eight-bit output port, with some of the handshake lines being used to provide a form of eight-bit input port.

However, there are insufficient input lines to provide a straightforward eight-bit input port. Some simple circuitry and one of the handshake outputs are needed in order to give a form of eight-bit input.

A PC printer port occupies three consecutive addresses in the input/output map. The base addresses are normally &H378 for LPT1, and &H278 for LPT2. We will only consider LPT1 here, but LPT2 is used in exactly the same way. When using LPT2 it is just a matter of using addresses &H278 to &H27A instead of &H378 to &H37A.

Writing data to the eight data outputs is perfectly straightforward, and it is just a matter of writing the values to the base address (&H378). The usefulness of a printer port for general interfacing is greatly enhanced by the unusually large number of handshake lines. These comprise four outputs and five inputs. Strictly speaking these are not all true handshake lines, and some have functions such as indicating error conditions and whether or not an auto linefeed is required.

As some of these input/output lines have minor functions it is not possible to guarantee that they will all be present on every PC printer port, but they seem to be present and correct on all modern PC parallel ports. With older printer port cards it might be as well to check the instruction booklet to determine whether or not a full set of handshake lines are included.

At address &H379 there are five input lines, and these are at bits 3 to 7. Bits 0 to 2 are unused. Fig. 1 shows the ins and outs of the PC printer port. A look at Table 1 will show the normal function of each input, and its pin number on the printer port's 25-way D-connector.

Table 1: Pin function for the Printer Port's D-connector

Bit	*Function*	*Pin No.*
3	Error	15
4	Select in	13
5	Paper empty	12
6	Acknowledge	10
7	Busy	11

Taking a Nibble

Although there are only five inputs available, it is still possible to input eight-bit bytes of data. Obviously all eight-bits cannot be input simultaneously. Instead, the data must be read as two four-bit nibbles, with an output of the port being used to select the desired nibble.

The obvious way of handling things is to use bits 4 to 7 of the input port, and to read the least significant nibble first. The value returned is then divided by 16 to compensate for the fact that bits 0 to 3 are being read on input lines 4 to 7.

Next the output line is toggled so that bits 4 to 7 can be read. The value returned from these is then added to the value read from the least significant nibble, and this gives the full value from the eight input lines.

In practice there is a minor problem with this method in that there is an inverter added ahead of the Busy input at pin 11 (bit 7 of the port). This problem could be overcome by adding another inverter ahead of this input, or by using some additional software routines to effectively re-invert this line. It is probably easier to use the error line (bit 3 of the port) instead.

The same basic method of reading the port as two four-bit nibbles is used, but the mathematics is slightly different. The value returned from the least significant nibble is divided by eight instead of 16 in order to produce the correct value. The figure returned from the most significant nibble is multiplied by two before being added to the corrected value from the least significant nibble.

Whichever method is used, it is clearly somewhat slower than simply reading an eight-bit input port. Two read operations are required, plus write operations to the output line, followed by some simple mathematics.

Even using an up-market PC, reading megabytes per second is probably out of the question. On the other hand, using machine code routines it would presumably be possible to read many thousands of bytes per

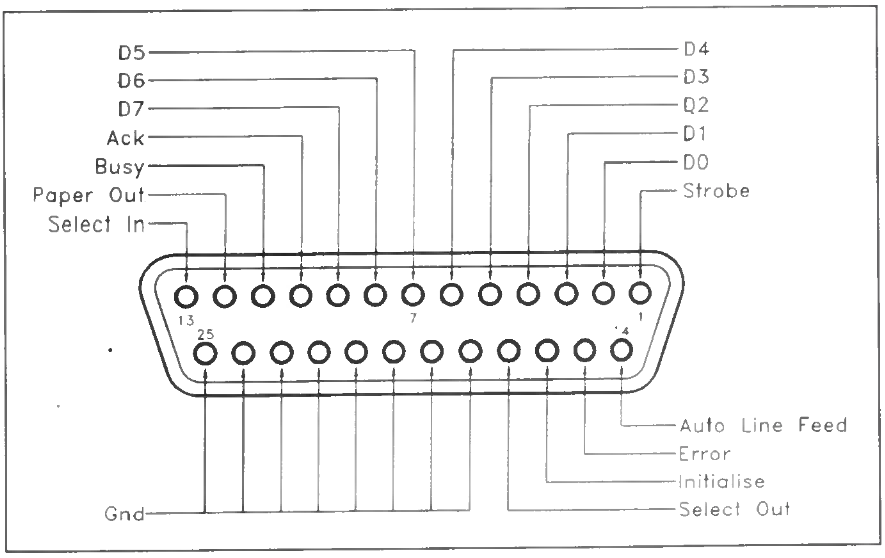


Fig. 1. Connection details for the PC printer ports. There are 12 outputs and five inputs.

second. Even using an interpreted BASIC on an average PC it should be possible to read a few hundred bytes per second, which is more than adequate for many applications.

The four handshake outputs are at bits 0 to 3 of address &H37A, and are detailed as follows:

Bit	Function	Pin No.
0	Strobe	1
1	Auto linefeed	14
2	Initialise	16
3	Select out	17

Apart from the initialise output at pin 16 of the port, these outputs are inverted. This is not of great importance, since these lines would normally be used individually, and not collectively as a nibble output.

Unfortunately, these lines cannot be used in a similar manner to the handshake inputs, with bytes being output in two halves. This is not possible because there is no fifth output to control a four-to-eight line converter.

The printer port is still quite versatile though, and with only a small amount of additional circuitry it can provide an eight-bit output port, and an eight-bit input port. This still leaves three outputs and one input for handshake purposes, or for use as general purpose input/output lines.

Two-Into-One Will Go

The circuit diagram for an eight-bit input port, which uses a PC printer port and the techniques outlined previously, is shown in Fig. 2. This is based on a 74LS244 which is generally described as being an eight-bit tristate buffer.

However, it is in fact two independent four-bit tristate buffers. The most significant nibble is fed to one set of buffers, and the least significant nibble is fed to the other. Pairs of outputs are used to drive the inputs at bits 3 to 6 of the printer port.

The two sets of buffers are controlled using the initialise output, but the control input of one set is driven via an inverter (IC2). This gives the required anti-phase operation with the least significant nibble being fed through to the printer port when the initialise input is low, and the most significant nibble being fed through to the port when the initialise output is high.

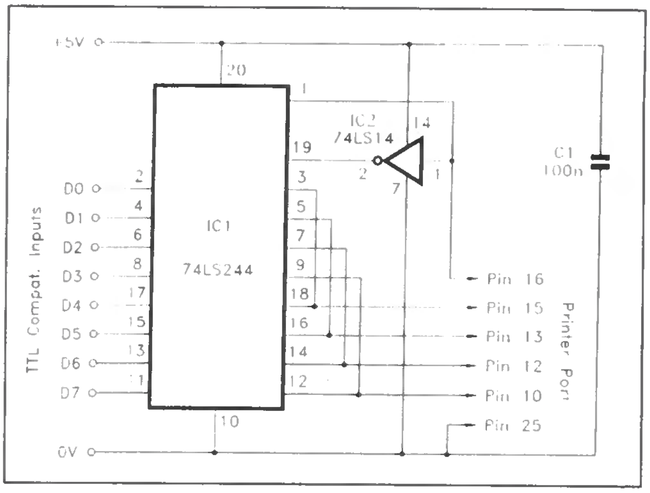


Fig. 2. An 8-bit output port using a PC printer port.

It is possible to dispense with the inverter if two of the printer port's output lines are used to control the tristate buffers. If you are not using one of the other handshake outputs for other purposes, I suppose that this would be the most sensible way of handling things.

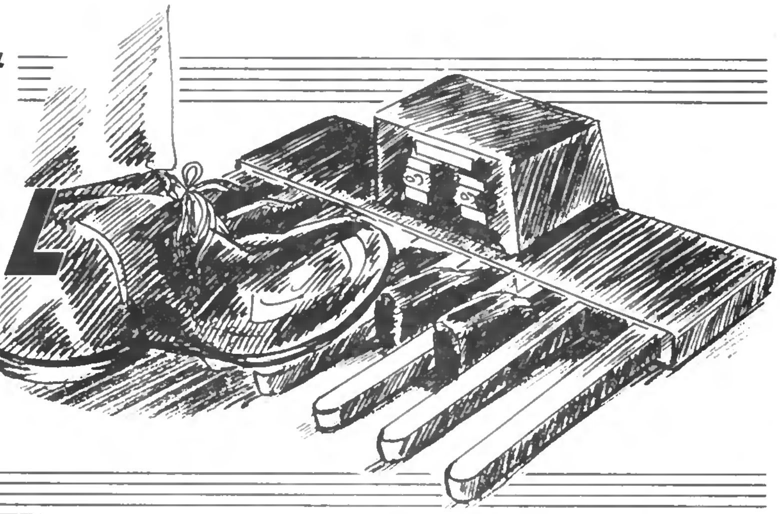
This simple GW BASIC routine can be used to read the input port and print the returned value on the screen:

```
10 OUT &H37A,0
20 X = INP(&H379) AND 120
30 X = X/8
40 OUT &H37A,4
50 Y = INP(&H379) AND 120
60 Y = Y * 2
70 Z = X + Y
80 PRINT Z
```

First the initialise output is set low so that the least significant nibble can be read. The returned value is ANDed with a masking number of 120 to mask bits 1, 2, 3, and 7 of the printer port. The value returned from bits 3 to 6 is placed in variable "X", which is then divided by eight to give the correct value.

Next the initialise output is set high, and the same basic procedure is used to read the most significant nibble and place it into variable "Y". In this case the returned value is multiplied by two in order to obtain the correct value. Variables "X" and "Y" are then simply added together to give the final answer which is printed on the screen by the final line of the program.

If you have a spare printer port on your PC, this method must represent the simplest and least expensive method of obtaining eight-bit input and output ports, complete with some handshake lines. It should be possible to interface a wide range of user add-ons to this port, which is a topic we shall pursue in future articles.



MIDI PEDAL BOARD

TONY GEERING

Take centre stage and make great sounds with this MIDI output pedal – Let your feet do the "talking".

★ Fully Polyphonic ★ Touch Sensitive ★ One Octave Range ★
★ Standard MIDI Interface Output ★ Switchable MIDI Channel ★

AFTER many fruitless hours searching for an inexpensive add-on pedal board for use with the popular keyboards and synthesisers it was decided a "build-your-own" approach was the only answer. The result is a project that will, it is hoped, appeal to two groups of electronics constructors: those who play the organ and wish to convert a synthesiser into one; and keyboard players who wish to experiment with foot control

This article describes the construction of a one octave pedal board for use with any musical device having a standard MIDI input. For example it can turn a keyboard or synthesiser into a home organ. Also, the pedal unit has been used successfully with a Clavinola, which has some organ sounds.

MIDI PEDAL

The MIDI Pedal Board comprises two sections. One is the mechanical pedal sub-assembly which is available complete. It has 13 individual pedals, one per semitone.

The other section is the electronic circuit with MIDI output. The circuit is built around the keyboard scanner i.c. type E510. This i.c. is fully Polyphonic, Touch Sensitive and has a selectable MIDI output channel – Channel 1 or Channel 2.

The E510 will scan up to 128 notes by use of a fan-out arrangement of scanning i.c.s 74HC138, but has been reduced to 13 notes here. (See Fig. 2)

The circuit operates at five volts, so a stabilised power supply is included. (See Fig. 3). This allows a general purpose 9V to 12V unregulated power supply to be used.

The unit draws only a small current when in use (20mA), so one of the popular battery-eliminator type power supplies giving +9V to +12V output is adequate. Alternatively, the unit could be powered from a small +9V battery inside the box.

CIRCUIT DESCRIPTION

The full circuit diagram for the MIDI Pedal Board is shown in Fig. 2. The E510 keyboard scanner IC1 can scan up to 128 keys by means of the 7-bit address bus A0 to A6 (pins 7 to 1), with a resolution of 256µS. Details of the pinout information for the E510 are given in Fig. 1.

A large address decoder would be required to decode all 128 addresses. The arrangement of IC2, IC3 and IC4 decodes 13 adjacent addresses for scanning the 13 pedal contacts of the one octave pedal sub-assembly. A two stage decoder i.c. type 74HC138, using 3-bit binary to 1-out-of-8 decoder function, is used for IC2, IC3 and IC4.

ADDRESS DECODER

The four most significant bits (MSBs) of the address from IC1 (A3-A6) are fed to the data inputs of IC2, pins 1 to 4. See Fig. 1. There are three data leads, plus Enable ($\overline{E1}$) lead which acts as a fourth data lead.

The output of IC2 is an active-Low signal on one of the eight output leads, pins 7, 9 to 15. These signals are used to select each of the secondary decoder i.c.s in turn (IC3 and IC4). The three least significant bits (LSBs) of the address from IC1 (A0 to A2) are fed directly to the secondary decoders IC3 and IC4.

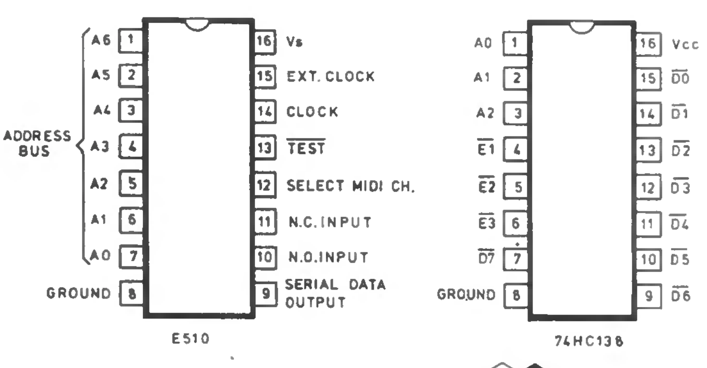
Links L1 and L2 transfer the Enable signal to IC3 and IC4, see Note Range Table 1. This allows selection of the musical range of the single octave.

IC3 and IC4 decode the three LSBs of the address to allow scanning of eight pedal contacts per i.c. IC3 can therefore scan the first eight contacts of the pedal unit, corresponding to the first eight semi-tones C to G. IC4 scans the next eight semi-tones, but only five are required to complete the octave, namely G# to C.

KEYBOARD OUTPUT

Every time a key is pressed or released, the velocity is calculated by the E510 keyboard scanner (IC1) using a 7-bit reverse counting timer. At the same time every press and release is tested for validity. The key is only recognised if it goes from pin 10 to pin 11 or vice-versa, and thus key bounce is eliminated.

An internal FIFO register (First-In-First Out type of storage device) allows fully polyphonic playing and thus several keys can be pressed simultaneously. The MIDI data output on pin 9 transmits data according to the MIDI specification; key number, key velocity, key ON or OFF, channel number.



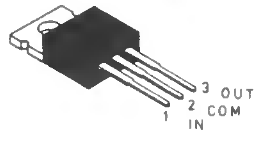


Fig. 1. Pinout details for the E510 keyboard scanner, 74HC138 decoder and the 7805 voltage regulator.

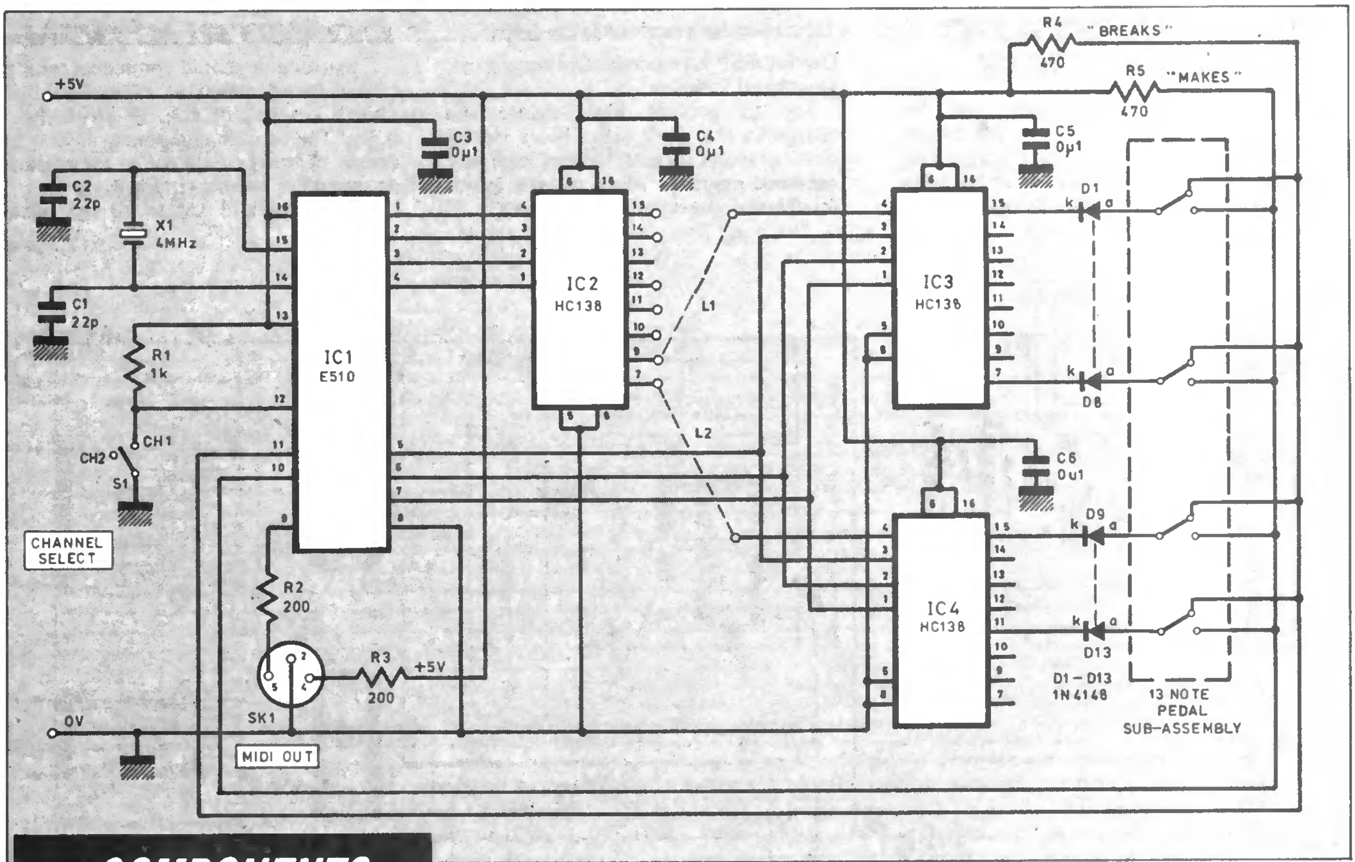


Fig. 2. Full circuit diagram, except voltage stabliser, for the MIDI Pedal Board. MIDI: Musical Instrument Digital Interface.

COMPONENTS

Resistors

R1	1k
R2, R3	200 (2 off)
R4, R5, R6	470 (3 off)
R7	22

All 0·6W 1% metal film

See SHOP TALK Page

Capacitors

C1, C2	22p ceramic (2 off)
C3 to C6, C9	0µ1 min. disc ceramic (5 off)
C7	220µ radial elect. 16V
C8	16µ bead tantalum, 16V

Semiconductors

D1 to D13	1N4148 signal diode (13 off)
D14	3mm or 5mm red l.e.d.
D15	1N4001 rec. diode
IC1	E510 MIDI keyboard scanner
IC2 to IC4	74HC138 3-bit binary to 1-in-8 decoder (3 off)
IC5	7805 +5V 1A voltage regulator

Miscellaneous

X1	4MHz crystal
S1, S2	s.p.s.t. min. toggle switch (2 off)
SK1	5-pin 180 degree DIN socket
SK2	d.c. power socket, 2·1mm

Plastic case, size 176mm x 120mm x 84mm approx; 0·1in. stripboard, 39 strips x 62 holes; pedal sub-assembly, with changeover contacts – see text; 16-pin d.i.l. socket (4 off); coloured multistrand connecting wire; aluminium or wood for legs and pedal cover, cut to fit.

Approx cost guidance only **£50**

excluding pedal board

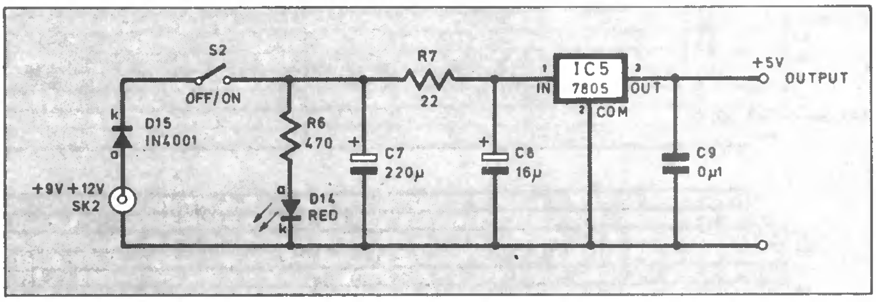
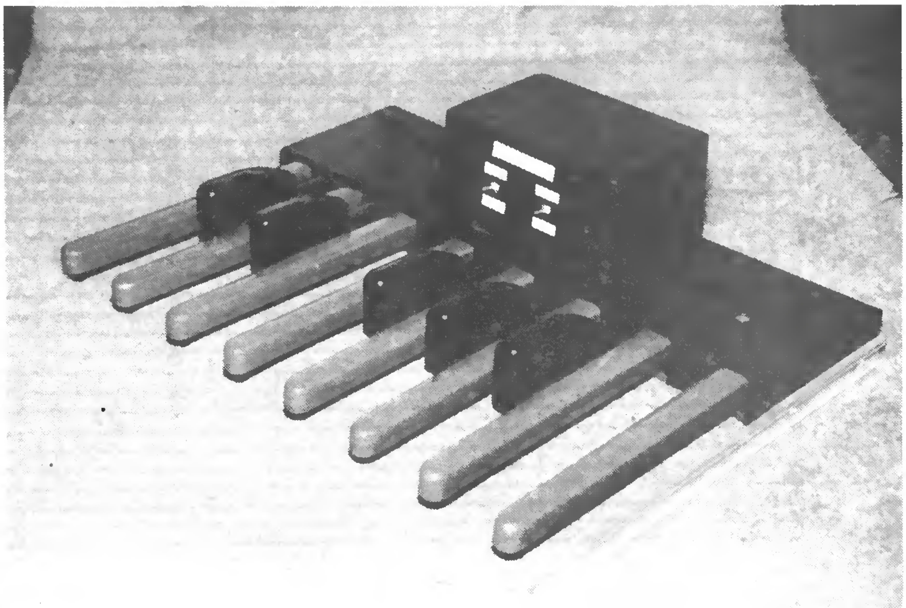


Fig. 3. Circuit diagram for the power supply voltage stabiliser. The unit drains only a small current, about 20mA, so a 9V to 12V battery eliminator or a 9V battery can be used as the power source.



The completed Pedal Board with the "Scanning" unit mounted on top of the made-up pedal housing.

ELECTROSTATIC PRECAUTIONS

All semiconductor devices can be degraded or even destroyed by the action of electrostatic discharge (ZAP!) from the human body. Much has already been written on this subject, so only brief details of recommended precautions are given:

Use full ESP kit – conductive bench mat, wrist band, cord. or

Try to prevent high electrostatic charge in the work area. Work on an Earthed metal surface. Do not wear any synthetic materials which cause a build-up of static like rayon and polyester.

CONSTRUCTION

Construction should commence with the circuit board which is a piece of 0·1in. matrix stripboard, size 39 strips by 62 holes. The topside component layout and details of breaks required in the trackside copper strips is shown in Fig 4.

First place and solder all the passive

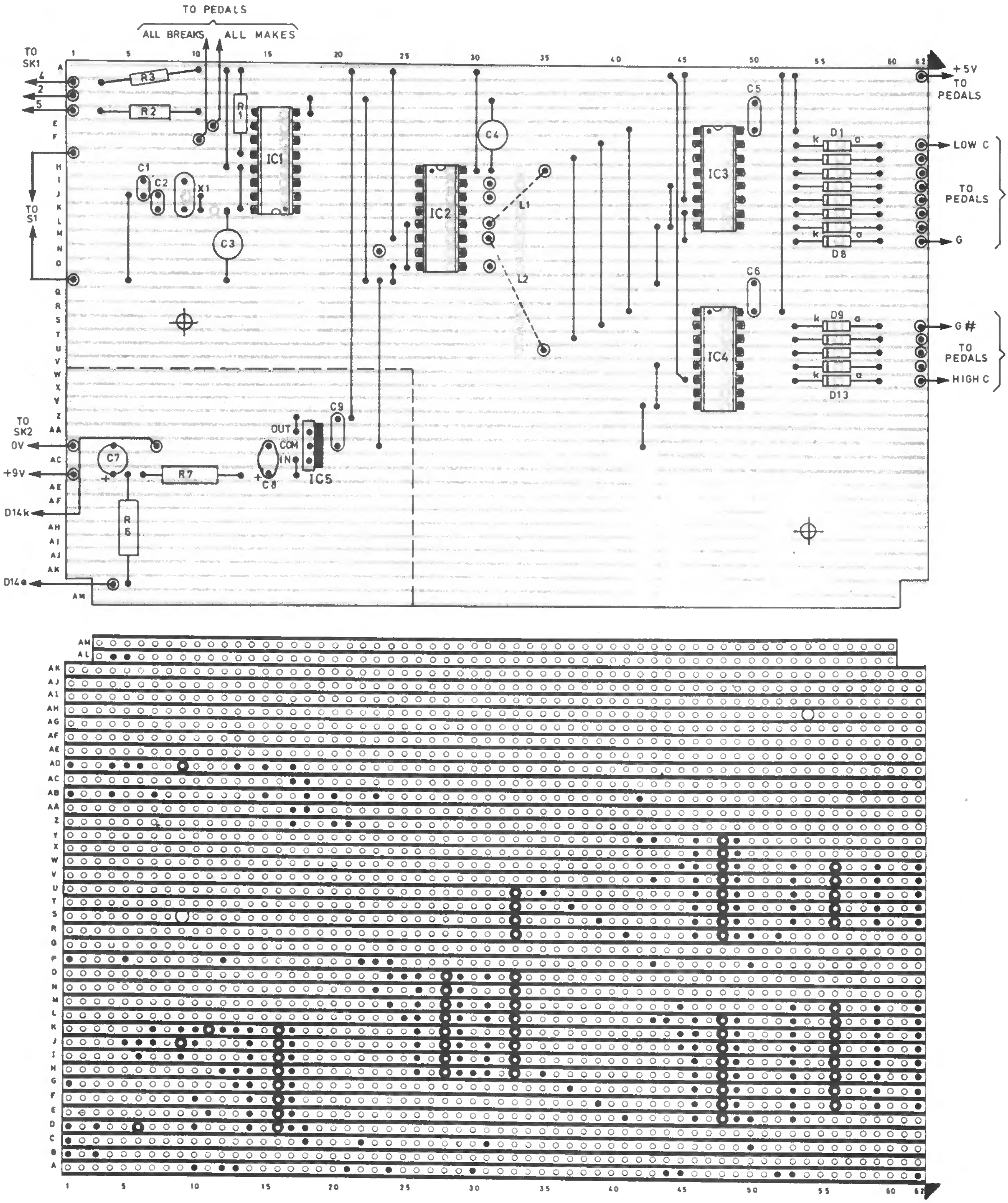
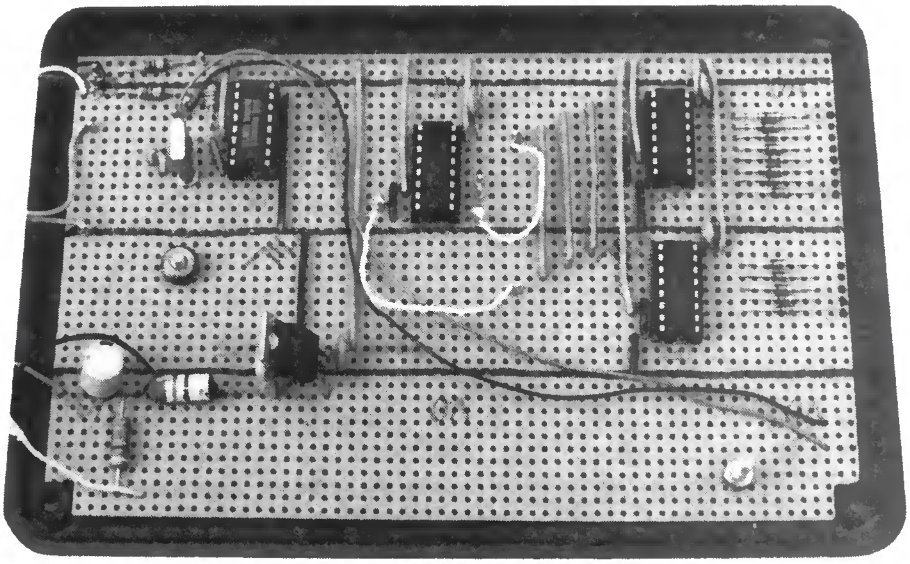


Fig. 4. Stripboard topside component layout and details of breaks required in the underside copper strips. The circled connections on the topside layout represent solder pins.



components – i.c. sockets, resistors, link wires etc. Also, set the two jumper "note" links L1 and L2 for the required note range using Table 1. Then cut the underside tracks as indicated.

Next, fit the trackside decoupling capacitors C3 and C4 to IC1 and IC2 pins is as shown. Fit diodes and crystal, then lastly insert the i.c.s into their holders.

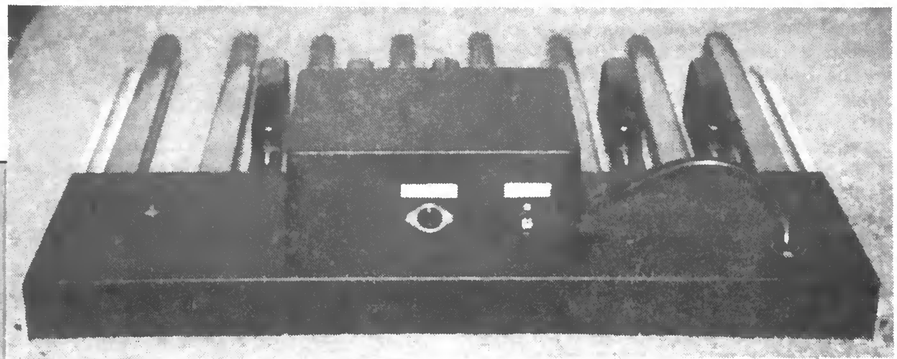
Before fitting i.c.s you could power-up and check with a meter that +V is only on the following pins:

IC1 pins 13 and 16; IC2, IC3 and IC4 pins 6 and 16.

Visually check the board for faults. The board should then be fitted onto the underside of the plastic box lid, the sockets and switches being fitted in the sides of the box. A 16-way cable was brought out of the box to wire to the pedal sub-assembly. See Fig. 5 and photograph.

On the front of the plastic box are the On/Off and CH1/CH2 switches, and the Power On l.e.d. The user may wish to consider placing the switches on one of the other faces of the box, to prevent accidentally catching them with the foot when in use. On the back of the box is the MIDI output DIN socket, and the +9V power input socket.

The complete prototype circuit board mounted on the underside of the case lid. The two leads that go from the top left to the right-hand edge are so that all connections to the keyboard come from the same side of the board.



Rear view of the Pedal Board showing the MIDI input and the Power-In sockets. Note also the 16-core cable sleeving, taking the note leads to the pedal sub-assembly.

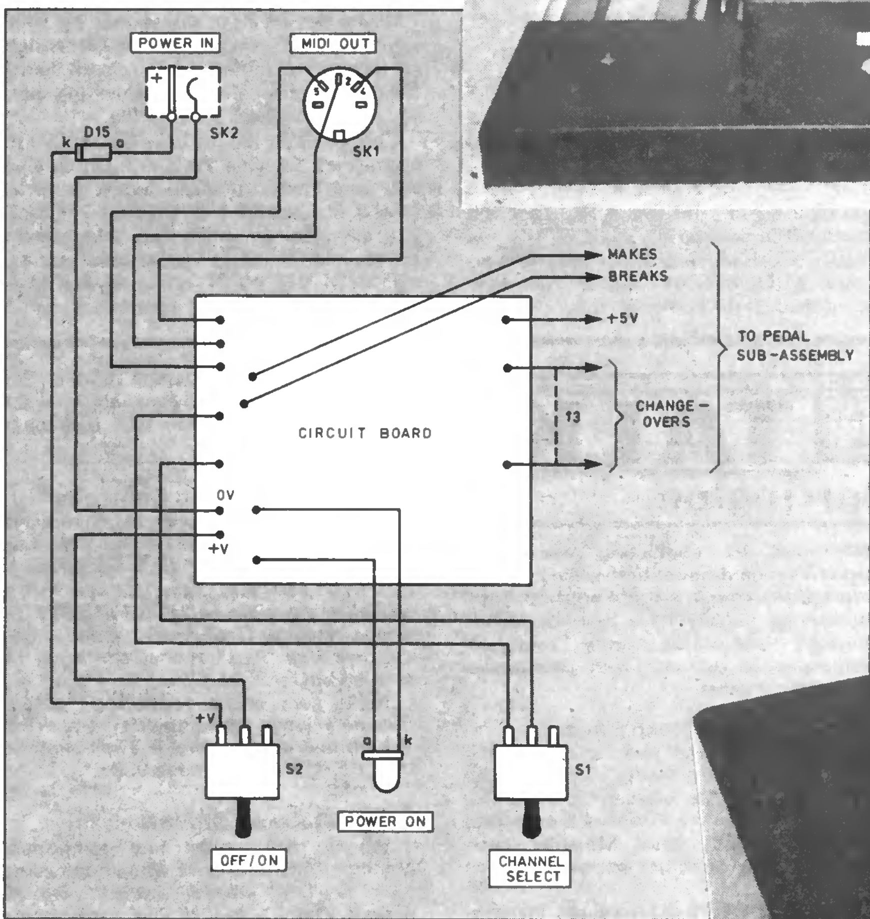


Fig. 5. Interwiring from off-board components to the circuit board

PEDAL ASSEMBLY

The pedal sub-assembly requires two stabilising legs, one on either side to enable the unit to be free-standing. These should

Table 1: Jumper connections for Note Ranges

Link L1	Link L2	Note Range
IC2/15 – IC3/4	IC2/14 – IC4/4	C-2 to C-1
IC2/12 – IC3/4	IC2/11 – IC4/4	C0 to C1
IC2/9 – IC3/4	IC2/7 – IC4/4	C2 to C3

Note: Some keyboards do not accept the lowest note range, but all should accept the highest range which is the octave just below middle C. (Middle C = C3).

The completed keyboard scanner unit showing the MIDI Channel select switch and On/Off switch. These switches could be mounted on one of the side panels, away from any "flying feet."

be fashioned from aluminium or wood approximately 356mm × 25mm × 12mm – see Fig. 6. Likewise a cover should be made from sheet aluminium or plywood to cover the contact body.

On the pedal sub-assembly, all the "make" contacts are strapped together, and all the "break" contacts are also strapped together as shown in the circuit diagram Fig. 2. The +5V supply is connected, via resistors R4 and R5, to the strapped-up contacts. The wire for each pedal from diodes D1 to D13, are connected to the "changeover" contacts. (D1 = Low C, D13 = High C). Once the wiring has been completed, the box containing the electronics should be securely fastened to the body of the sub-assembly.

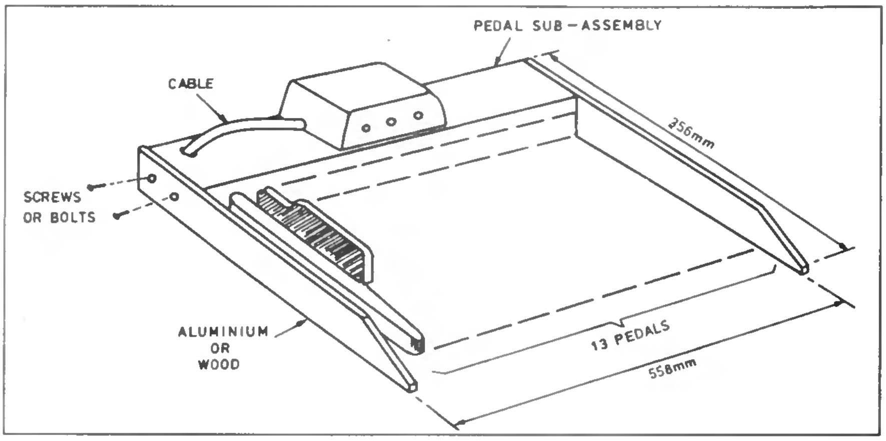


Fig. 6. Suggested method of housing the pedal sub-assembly.

SETTING UP

Connect the MIDI output to the MIDI input of your keyboard using a MIDI cord. Power-up the Pedal Unit and the Keyboard. Press each pedal and confirm that the correct note is heard. Pressing quickly should give a louder note due to the touch sensitive processing in the E510.

The E510 IC1 has an internal scanner which scans each pedal in turn, via IC2, IC3 and IC4, and diodes D1 to D13. The contact transit time, and hence the pedal speed, is measured by IC1 pins 10 and 11.

Thus the harder you press the pedal, the faster it moves and so the louder will be the note velocity signal generated by the E510. It is important that the contact gaps be all the same so that the volume of each pedal is the same, see Fig 7.

When a pedal is pressed, the E510 sends MIDI NOTE-ON and VELOCITY data for that note on the selected MIDI CHANNEL. The data is then converted into a musical note by the synthesiser in the remote keyboard.

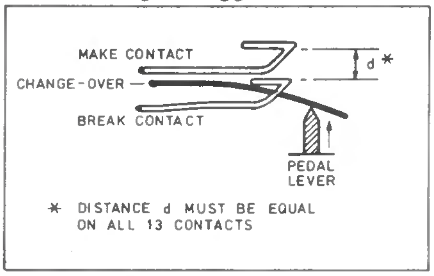


Fig. 7. Pedal switch contacts.

MIDI COMPATABILITY

The MIDI Pedal Unit sends data on MIDI Channel 1 or Channel 2, depending upon the setting of Channel Select S1. Many keyboards default to OMNI when first switched on, this means that they will accept MIDI data on any channel. You can usually select which channel you want to receive MIDI data on, consult your keyboard manual for how to do this.

Depending on the type of keyboard or synthesiser, you may be able to control two individual voices: for example the keyboard on Channel 1 playing a solo voice, and the pedal-board on Channel 2 playing a bass voice. Your keyboard manual should explain how to do this.

TROUBLE SHOOTING

If you do not hear any sounds on your keyboard when you press the pedals, switch off the power and re-check the circuit board for errors, touching tracks, solder splashes, dry-joints etc. Check pedal wiring.

Check that the jumper links L1 and L2 are appropriate for your keyboard. Check also that your keyboard MIDI receive is set to OMNI or Channel 1 or Channel 2. Check that any other parameters are set correctly on your keyboard to enable data receive, e.g. MIDI REC = ON – refer to your keyboard manual for further information. □

SHOP TALK

with David Barrington

12V 35W PA Amplifier

Both the driver and output transformers used in the *12V 35W Public Address Amplifier* were specially designed for this project. They are available from **Tavistock Electronics, Unit 8, Crelake Industrial Estate, Pixon Lane, Tavistock, Devon, PL19 9AZ.** (☎ *0822 617289*).

For those who wish to attempt winding their own ferrite driver transformer, the ferrite core type E42/15 (Siemens part B66325-GX127) and bobbin (B66242-J1000R1) can be purchased from **Electrovalue** (☎ *0784 442253*).

The printed circuit board is available from the *EPE PCB Service*, code 930 (see page 163).

MIDI Pedal Board

Only the special E510 MIDI keyboard scanning i.c. used in the *MIDI Pedal Board* project will not be obtainable from your local supplier. This is, of course, apart from the pedal assembly.

The E510 i.c. seems to be only available from Maplin, code KU41U. Currently, their stocks stand at about 50 items. This is an expensive chip at £33.50 so it makes it even more important to use an i.c. socket with this device.

It is suggested that an inexpensive source for the pedal assembly may be found by contacting your local organ/keyboard shop, and asking for the address of an organ repair workshop. Such workshops usually have new or reconditioned one-octave units available. Remember to get one with *changeover* electrical contacts.

The Ultimate Screen Saver

We can only find two listings for the MOC3041 "zero-crossing" opto-isolator triac i.c. used in the *Ultimate Screen Saver* project. These are from **Electromail** (code 301-628) and **Maplin**, code RA56L. There does not appear to be an equivalent.

Capacitor C4 MUST be rated for *continuous* operation when placed across the 240V a.c. mains. There are two basic types with this rating, known as class X and class Y. The one chosen here is class X. These should be generally available, but in case of difficulty Maplin list it as code JR34M.

The triac used in the model is a BT138 type, however most 600V TO220 package triacs, such as C206M, C226M and BTA08-600B, should work here. One of these should be stocked by most of our component advertisers.

The Euro connectors and 8-pole d.i.l. switch are items that should be available from your regular component supplier. The printed circuit board is available from the *EPE PCB Service*, code 927 (see page 163).

Foot-Operated Drill Controller

Some difficulties may be experienced in finding a 50V 3A bridge rectifier called up for the *Foot-Operated Drill Controller*. If this is the case you could use one with a higher rating, such as the BR32 200V 3A bridge listed by **Greenweld**. Choose one that has wire "legs" as they can easily be splayed out to fit the p.c.b.

Make sure you specify "log" potentiometers when ordering VR1 and VR2. The printed circuit board is available from the *EPE PCB Service*, code 928.

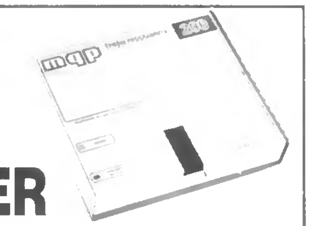
Model Railway Signals

We do not expect any component buying problems to arise when purchasing parts for the *Model Railway Signals* project. Quite a few of our components advertisers stock the small glass reed switches and most come with a small magnet.

The printed circuit board is available from the *EPE PCB Service*, code 929. Note that the p.c.b. is supplied as a three-module strip and can hold three Two-Aspect circuits plus additional parts for three Three-Aspect operation.

The a.c. supply from a model railway transformer **must not be used** to power this circuit. It may, however, be rectified and stabilised at +5V d.c. in the conventional fashion and then used as the power source.

SYSTEM 200 DEVICE PROGRAMMER



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FOX REPORT

by Barry Fox

Cloning Macs

Even before it went into print, my prediction that Apple would have to change its policy on clone Macs, had come true. The company will now start to licence third party manufacturers to use the Mac operating system.

Recently I got my first chance to try an Apple Mac "out of the box". The company has always had the policy of loaning equipment only to bona fide reviewers, with specific review projects in hand. Columnists are expected to make do with demonstrations given by Apple, which is no way to judge how easy it is to plug in a system and start using it.

On this occasion I was helping a glossy magazine write a review of portables and the first two Macs supplied by Apple had been faulty. Apple was very anxious not to be left out, so sent the third direct to me for a weekend.

The first surprise was how heavy and chunky the Apple portable felt, compared to modern DOS/Windows laptops. Apple has fallen literally years behind in the size and weight race. Although Apple subcontracts manufacture of its designs to firms (e.g. Sony and Sharp) in the Far East, licencing Far Eastern clone makers to do their own thing should create Mac laptops that look and feel as compact as DOS/Windows laptops.

Without doubt the Mac operating system is very to easy to use. I got the hang of it within minutes. Five years ago it would have blown the early versions of Windows and DOS out of the water. But after more than ten years of clumsy trial and error by Microsoft, DOS 6 and Windows 3.1 finally work together as something approaching a coherent team that mimics a Mac.

The two last big advantages left to the Mac are speed of operation and plug-and-play set up of software and peripherals. Windows is slow because its graphics capability sits on top of DOS. The Mac operating system grew out of Apple's Lisa project and was thus designed from the ground up to present the user with a graphics interface i.e. pictorial icons to click on instead of a DOS prompt into which the user must key cryptic text commands.

Dark Horse Games

Here, two dark horses enter the picture. One is Microsoft's new operating system, previously known as Chicago and now renamed Windows 95 because it will arrive sometime in the first half of 1995. Windows 95 will effectively get rid of DOS, so speeding everything up. Or at least, that's the theory.

The other dark horse is Intel's plan for hardware modifications to the IBM PC standard, which of course is really just a mess of almost-but-not-quite standards. It is this mess that makes running one piece of PC hardware with another piece of PC software such a hit and miss affair. Intel and Microsoft plan to create plug and play compatibility between new PCs and Windows 95, so that everything works with everything else. This is especially important for CD-ROM games.

At the Screen Entertainment 2000, New Technology Agenda, conference in London recently, Keith Benjamin, of US analysts Roberston Stephens and Co told delegates:

"The games business is not a fad. As video games players grow up they migrate to PCs, and play games.

"I see a yuppie mass market boom, with people boasting that my drive is bigger than yours.

"The gross margins for PC games are 65%, compared to 35% for video games.

"Top of the top ten games for Christmas will be Doom II. In fact I am flying back early to the States to try and reach the next level".

Trade insiders admit that there are now so many firms producing often inadequate PC ROM games that shops will only stock them on sale-or-return basis. It is often the packaging that sells the game. When customers cannot get a game to work they ask for their money back.

Plug and Play PC Standard

Although Mac ROM games can be relied on to plug in and play, Benjamin discounts the Mac as a games platform because well under 10% of the computer population are Macs. He pins his faith in the Intel/Microsoft plan for a plug-and-play PC standard. "They will be almost idiot-proof" he predicts. "Plug and play turns the PC into something like a stereo. Until now PCs have been for Nerds and Geeks. Some time next year a normal person will find them friendly. People will no longer have to know about autoexec.bat and config.sys files".

By coincidence, Paul Maritz of Microsoft was in London on the very same day. Maritz is one of founder Bill Gates' right hand men.

Ducking any firm launch date for Windows 95 Maritz says it "will not be done until it's done". This is certainly better than launching too early, and leaving users to trap the bugs, as has happened with virtually every version of DOS and Windows up until the current 6/3.1 pairing.

"It should have been done years ago" says Maritz of plug-and-play, perhaps overlooking the fact that it is a decade of selling PC operating systems that has made Microsoft the largest software company in the world.

One hard fact emerges, however. Users will not get the full benefits of plug-and-play simplicity until they have paired new hardware with new software. It remains to be seen whether PC users stick with what they have got, or are willing to junk it all to buy into the world of plug-and-play. It also remains to be seen whether they will buy into PC plug-and-play or switch to the Mac world. The promise of Mac clones may tip some balances. So may the compatibility bridges which Apple is now building with the DOS world.

Publicity Driving

Once the Windows and Mac operating systems are fully bridged, and the same clone makers are making PCs and Macs, purchase decisions shake down to price, performance and style. The way the companies sell themselves will carry a lot of weight, too. Intel and Microsoft are now gearing up to a publicity drive on the advantages of plug-and-play simplicity.

Perhaps we may now even see an end to Applespeak, the fogging technique by which statements with enough factual content to fill a page are stretched into a multi-page ramble of cotton wool confusion.

Apple's press release on the monumental decision to licence clone makers is typical.

"Licensing to phased approach focussing first on vendors with complementary strengths" reads the snappy headline of a press release which was sent to those who knew they could have it if they asked for it.

"Broader installed base of Macintosh platforms ... creates new opportunities for ISVs ... reach customers in geographies where Apple has limited presence ... includes initiatives regarding extending the Macintosh platform's price/performance leadership".

One thing could still change all the rules of the game. If Windows 95 is bug-ridden, and fails to deliver plug-and-play simplicity, Apple and its licensed clone-makers get a golden opportunity to pounce on a market which Intel and Microsoft will have primed with their promises and advertising.

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

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

(All videos are to the UK PAL standard on VHS tapes)

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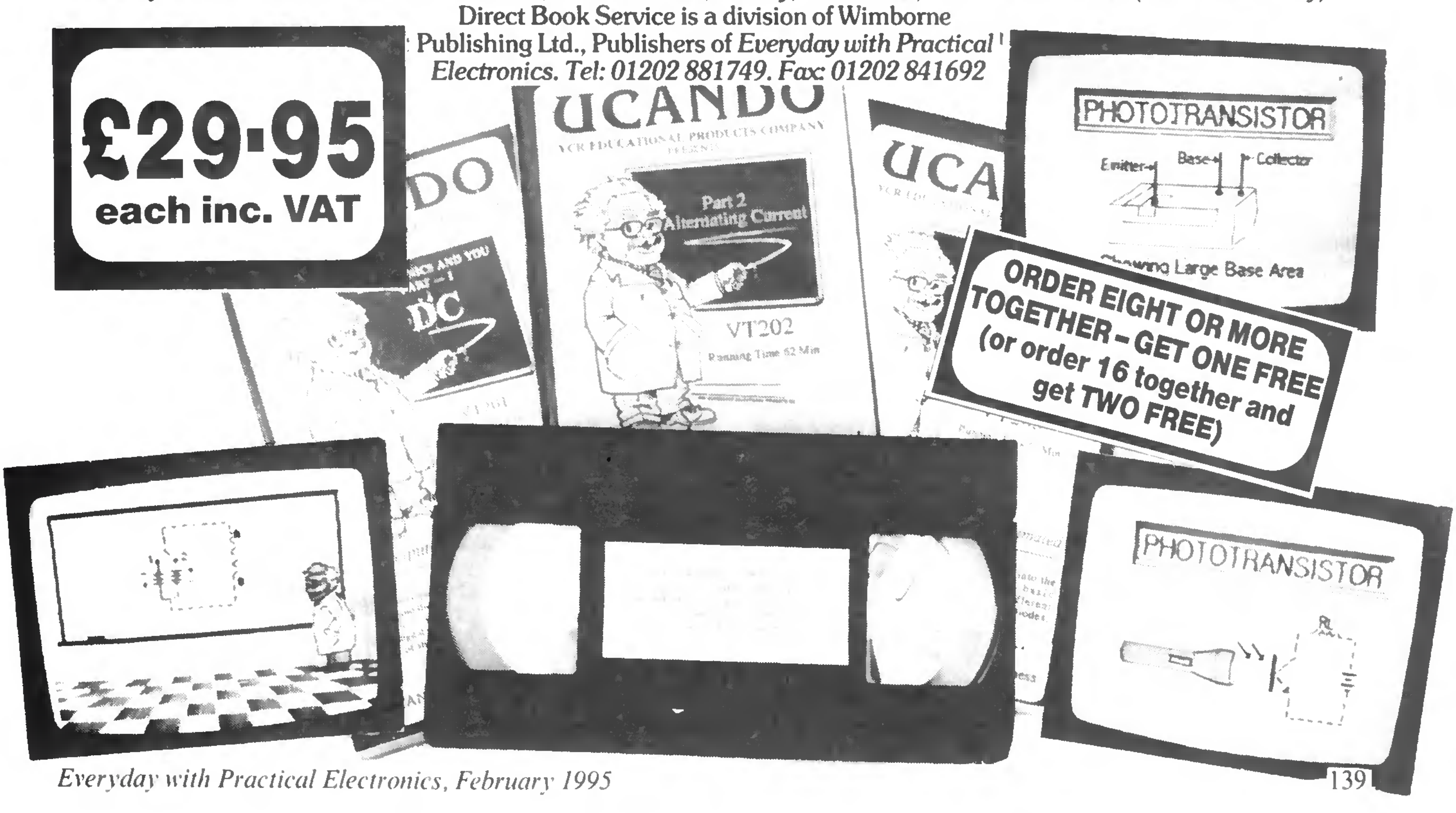


Electronics from the Ground Up

Mike Tooley, BA

Part 5

ELECTRONICS from the Ground Up is designed to provide you with a comprehensive and up-to-date introduction to the world of electronics. The series is based on *Electronics Workbench,* a remarkable new software package that lets you use your PC to build and test a wide range of circuits. Back issues of earlier parts of this series are available – see *Back Issues* page.

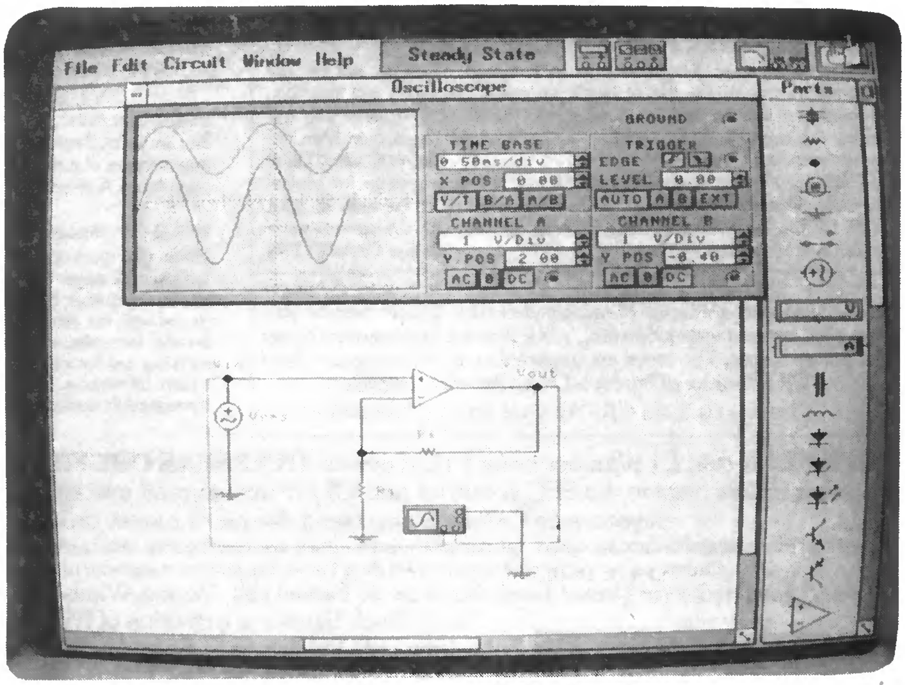
In this fifth part we introduce operational amplifiers. These handy devices were originally designed for use in analogue computers where they provided a means of performing mathematical operations such as addition, subtraction, integration and differentiation. Today, with the advent of integrated circuits, operational amplifiers have deservedly found their way into almost every field of electronics.

OPERATIONAL AMPLIFIERS

Operational amplifiers (op.amps) can be thought of as universal "gain blocks" to which external components are added in order to define their function within a circuit. By adding two resistors, we can produce an amplifier having a precisely defined gain. Alternatively, with three resistors and two capacitors we can realise a low-pass filter. From this you might begin to suspect that operational amplifiers are really easy to use. The good news is that they are!

The symbol for an op.amp is shown in Fig. 5.1. There are a few things to note about this. The device has two inputs and one output and no common connection. Furthermore, we often don't show the supply connections – it is often clearer to leave them out of the circuit altogether!

In Fig. 5.1, one of the inputs is marked "−" and the other is marked "+". These polarity markings have nothing to do with the supply connections – they indicate the overall phase shift between each input and the output. The "+" sign indicates zero



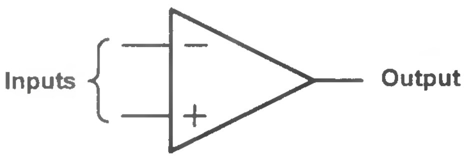


Fig. 5.1 Symbol for an op.amp.

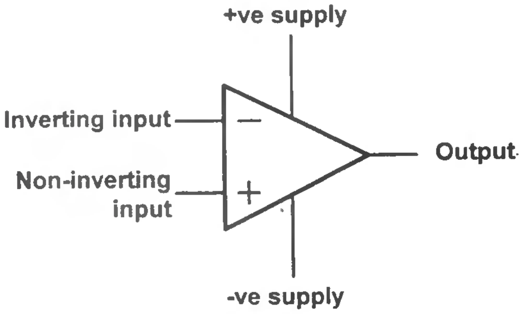


Fig. 5.2 Op.amp with supply connections.

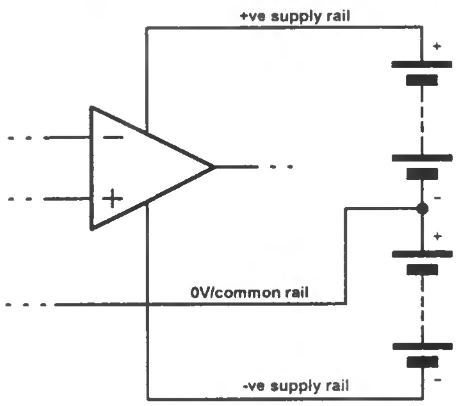


Fig. 5.3 A typical op.amp power supply arrangment.

phase shift whilst the "−" sign indicates 180° phase shift. Since 180° phase shift produces an inverted (i.e., turned upside down) waveform, the "−" input is often referred to as the "inverting input". Similarly, the "+" input is known as the "non-inverting" input.

Fig. 5.2 shows how the supply connections would appear if we decided to include them. Note that we usually have two separate supplies: a positive supply and an equal, but opposite, negative supply. The common connection to these two supplies (i.e., the 0V rail) acts as the common rail in our circuit. The input and output voltages are usually measured relative to this rail. Fig. 5.3 shows how the supplies are connected.

Terminology

Before we take a look at some of the characteristics of "ideal" and "real" op.amps it is worth introducing some of the terms that we apply to these devices:

(a) *Open-loop voltage gain.* This is the ratio of output voltage to input voltage measured with no feedback applied. Open-loop voltage gain may thus be thought of as the "internal" voltage gain of the device. In practice, this value is exceptionally high (typically greater than 100,000) but is liable to considerable variation from one device to another.

(b) *Closed-loop voltage gain.* This is the ratio of output voltage to input voltage measured with a small proportion of the output fed back to the input (i.e., with feedback applied). The effect of providing negative feedback is to reduce the loop voltage gain to a value which is both predictable and manageable. Practical closed-loop voltage gains range from one to several thousand but note that high values of voltage gain may put unacceptable restrictions on bandwidth, see later.

(c) *Input resistance.* This is the ratio of input voltage to input current expressed in ohms. It is often expedient to assume that the input of an op.amp is purely resistive though this is not the case at high frequencies where shunt capacitive reactance may become significant. The input resistance of op.amps is very much dependent on the semiconductor technology employed. In practice values range from about 2MΩ for common bipolar types to over $10^{12}\Omega$ for FET and CMOS devices.

(d) *Output resistance.* This is the ratio of open-circuit output voltage to short-circuit output current expressed in ohms. Typical values of output resistance range from less than 10Ω to around 100Ω depending upon the configuration and amount of feedback employed.

(e) *Input offset voltage.* An ideal op.amp would provide zero output voltage when 0V is applied to its input. In practice, due to imperfect internal balance, there may be some small voltage present at the output. The voltage that must be applied differentially to the op.amp input in order to make the output voltage exactly zero is known as the input offset voltage.

Offset voltage may be minimized by applying relatively large amounts of negative feedback or by using the

Table 5.1 Characteristics of ideal and real op.amps

	Ideal	Real
Voltage gain	Infinite	100,000
Input resistance	Infinite	100MΩ
Output resistance	Zero	20Ω
Bandwidth	Inifinite	2MHz

"offset null" facility provided by a number of op.amp devices. Typical values of input offset voltage range from 1mV to 15mV. Where a.c., rather than d.c., coupling is employed, offset voltage is not normally a problem and can be happily ignored.

(f) *Full-power bandwidth.* This is equivalent to the frequency at which the maximum undistorted peak output voltage swing falls to 0·707 of its low frequency (d.c.) value (the sinusoidal input voltage remaining constant). Typical full-power bandwidths range from 10kHz to over 1MHz for some high-speed devices.

(g) *Slew rate.* This is the rate of change of output voltage with time, when a rectangular step input voltage is applied. Slew rate is measured in V/s (or V/µs) and typical values range from 0.2V/µs to over 20V/µs. Slew rate imposes a limitation on circuits in which large amplitude pulses rather than small amplitude sinusoidal signals are likely to be encountered.

(h) *Common-mode rejection ratio.* This is the ratio of differential voltage gain to common-mode voltage gain. Common-mode rejection ratio is thus a measure of an op.amp's ability to ignore signals simultaneously present on both inputs (i.e., "common-mode" signals) in preference to signals applied differentially. Common-mode rejection ratio is usually specified in decibels and typical values range from 80dB to 110dB.

OP.AMP CHARACTERISTICS

The desirable characteristics for an op.amp are summarized as follows:

(a) The open-loop voltage gain should be very high (ideally infinite).
(b) The input resistance should be very high (ideally infinite).
(c) The output resistance should be very low (ideally zero).
(d) Full-power bandwidth should be as wide as possible.
(e) Slew-rate should be as large as possible.
(f) Input offset should be as small as possible.
(g) Common-mode rejection ratio should be as large as possible.

The characteristics of modern i.c. op.amps come very close to those of an "ideal" op.amp, as Table 5.1 will testify.

GAIN AND BANDWIDTH

It is important to note that, since the product of gain and bandwidth is a constant for any particular device, an increase in gain can only be achieved at the expense of bandwidth. Fig. 5.4 shows the relationship between voltage gain and bandwidth for a typical op.amp (note that axes use logarithmic, rather than linear scales). Typical voltage gains and corresponding bandwidths for an op.amp are shown in Table 5.2.

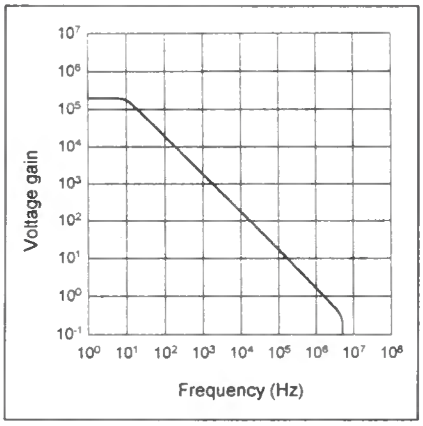


Fig. 5.4 Gain plotted against bandwidth for a typical op.amp.

Table 5.2 Table showing the relationship between voltage gain and bandwidth

Voltage gain	Bandwidth
1	d.c. to 2MHz
10	d.c. to 200kHz
100	d.c. to 20kHz
1000	d.c. to 2kHz

OP.AMP CIRCUIT CONFIGURATIONS

The three basic configurations for operational voltage amplifiers are shown in Figs. 5.5, 5.6 and 5.7. Supply rails have been omitted from these diagrams for clarity but are assumed to be symmetrical about 0V, as in Fig. 5.3. All three of these basic arrangements are d.c. coupled and their characteristics are summarised in Table 5.3.

Practical assignment 5.1: Op.amp configurations

In this practical assignment you will investigate the three different circuit configurations used for op.amps (i.e., inverting amplifier, non-inverting amplifier, and differential amplifier).

Table 5.3 Characteristics of the op.amp circuits shown in Fig. 5.5, Fig. 5.6 and Fig. 5.7.

	Input resistance	Voltage gain	Phase shift
Inverting amplifier (Fig. 5.5)	R1	R2/R1	180°
Non-inverting amplifier (Fig. 5.6)	$R_{in} \times \dfrac{A_{OL}^*}{1+(R2/R1)}$	1 + (R2/R1)	0°
Differential amplifier (Fig. 5.7)	2R1	R2/R1	180°

*Where R_{in} is the input resistance of the op.amp, and A_{OL} is the open loop voltage gain.

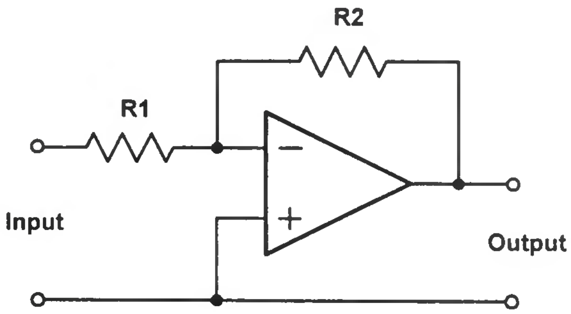


Fig. 5.5 Basic inverting amplifier circuit.

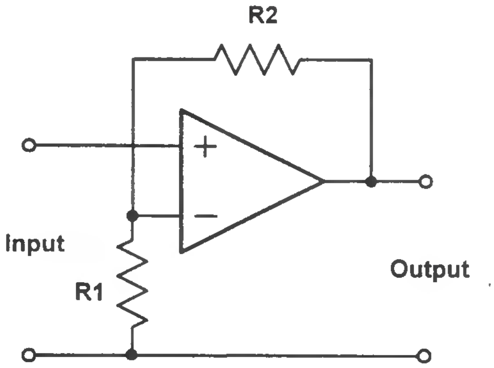


Fig. 5.6 Basic non-inverting amplifier circuit.

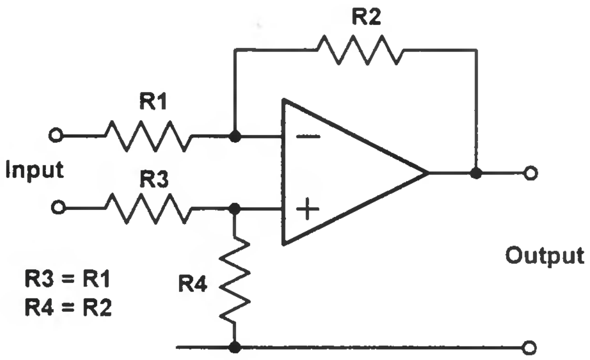


Fig. 5.7 Basic differential amplifier circuit.

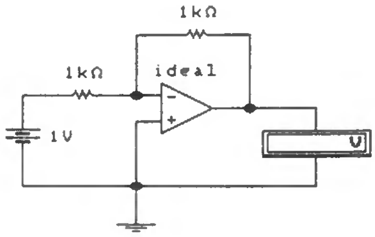


Fig. 5.8 Inverting amplifier circuit (Assignment 5.1).

Table 5.4 Measured values for the inverting amplifier with $R_F = 1k\Omega$.

V_{IN} (V)	1	−1	2	−2	3	−3	4	−4
V_{OUT} (V)								

Table 5.5 Measured values for the inverting amplifier with $R_F = 2k\Omega$.

V_{IN} (V)	1	−1	2	−2	3	−3	4	−4
V_{OUT} (V)								

Objectives:

5.1.1 To investigate the behaviour of inverting, non-inverting and differential amplifier stages.

5.1.2 To determine the voltage gain of an op.amp stage and to relate this to the component values used.

Instructions:

(a) Inverting amplifier

1. Connect the inverting amplifier circuit shown in Fig. 5.8. Check that the values of input and feedback resistor are both 1kΩ and that the input voltage (from the battery) is 1V.
2. Switch on the power to your circuit and measure the output voltage produced. Note this down in Table 5.4.
3. Reverse the battery connections and again measure the output voltage produced. Note this down in Table 5.4.
4. Repeat steps 1 to 3 using input voltages of 2V, 3V, and 4V. Once again, record the output voltages in Table 5.4.
5. Next, increase the value of feedback resistor to 2kΩ.
6. Repeat stages 1 to 4, recording values in Table 5.5.
7. Use the results from Tables 5.4 and 5.5 to plot two graphs showing V_{OUT} plotted against V_{IN} for input voltages over the range −4V to +4V. One graph will be for R_F = 1kΩ whilst the other will be for R_F = 2kΩ (see Figs. 5.9 and 5.10).
8. Finally, return to the circuit of Fig. 5.8 with V_{IN} = 1V. Choose a value for R_F that will produce an output voltage of 10V (i.e., a voltage gain of exactly 10). Check that the circuit works and note down the value of R_F used.

(b) Non-inverting amplifier

1. Connect the non-inverting amplifier circuit shown in Fig. 5.11. Check that the

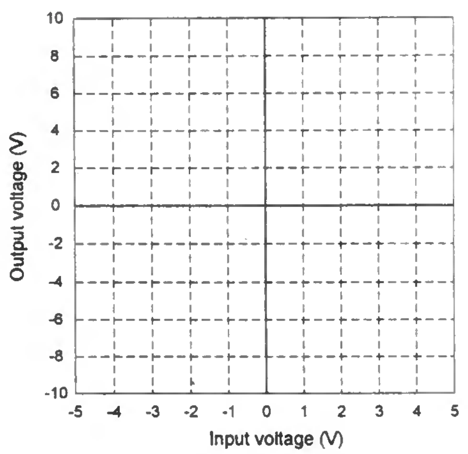


Fig. 5.9 Output voltage plotted against input voltage for the inverting amplifer $R_F = 1k\Omega$.

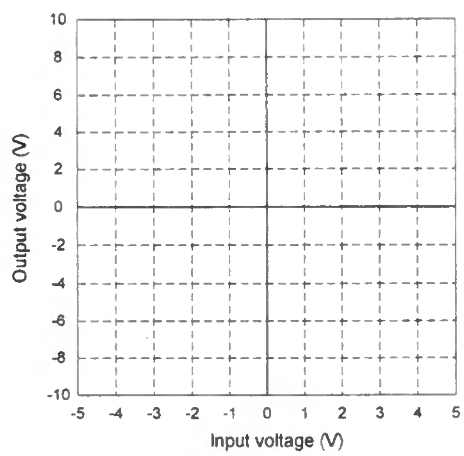


Fig. 5.10 Output voltage plotted against input voltage for the inverting amplifer $R_F = 2k\Omega$.

Table 5.6 Measured values for the non-inverting amplifier with $R_F = 1k\Omega$.

V_{IN} (V)	1	−1	2	−2	3	−3	4	−4
V_{OUT} (V)								

Table 5.7 Measured values for the non-inverting amplifier with $R_F = 2k\Omega$.

V_{IN} (V)	1	−1	2	−2	3	−3	4	−4
V_{OUT} (V)								

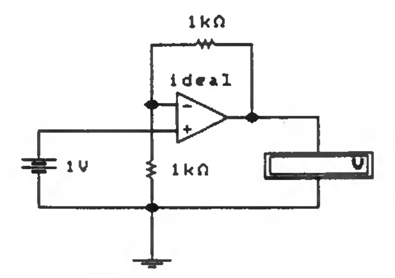


Fig. 5.11 Non-inverting amplifier circuit (Assignment 5.1).

values of input and feedback resistor are both 1k**Ω** and that the input voltage (from the battery) is 1V.

2. Switch on the power to your circuit and measure the output voltage produced. Note this down in Table 5.6.
3. Reverse the battery connections and again measure the output voltage produced. Note this down in Table 5.6.
4. Repeat steps 1 to 3 using input voltages of 2V, 3V, and 4V. Once again, record the output voltages in Table 5.6.
5. Next, increase the value of feedback resistor to 2k**Ω**.
6. Repeat stages 1 to 4, recording the values in Table 5.7.
7. Use the results from Tables 5.6 and 5.7 to plot two graphs showing V_{OUT} plotted against V_{IN} for input voltages over the range −4V to +4V. One graph will be for R_F = 1k**Ω** whilst the other will be for R_F = 2k**Ω** (see Figs. 5.12 and 5.13).
8. Finally, return to the circuit of Fig. 5.11 with V_{IN} = 1V. Choose a value for R_F that will produce an output voltage of 10V (i.e., a voltage gain of exactly 10). Check that the circuit works and note down the value of R_F used.

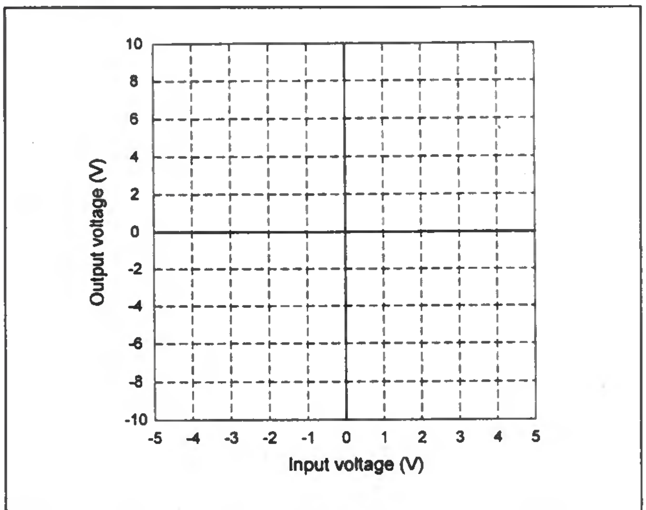


*Fig. 5.12 Output voltage plotted against input voltage for the non-inverting amplifier (R_F = 1k**Ω**).*

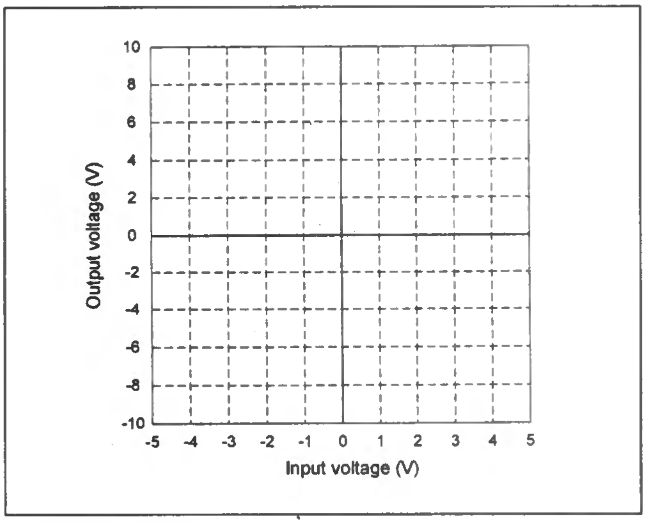


*Fig. 5.13 Output voltage poltted against input voltage for the non-inverting amplifier (R_F = 2k**Ω**).*

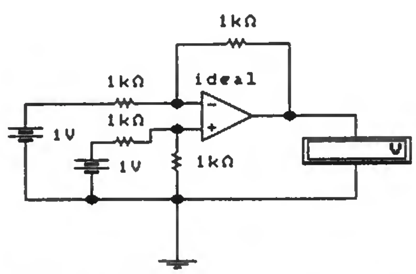


Fig. 5.14 Differential amplifier circuit (Assignment 5.1).

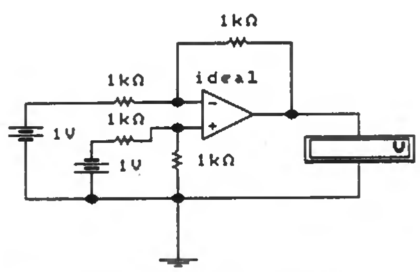


Fig. 5.15 Differential amplifier circuit (Assignment 5.1).

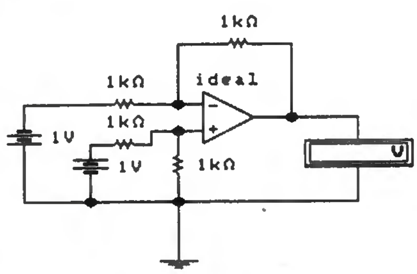


Fig. 5.16 Differential amplifier circuit (Assignment 5.1).

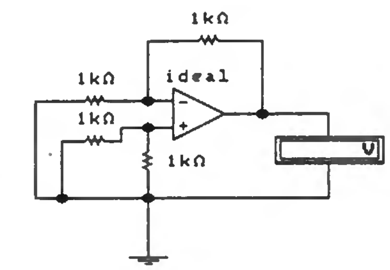


Fig. 5.17 Differential amplifier circuit (Assignment 5.1).

(c) Differential amplifier

1. Connect the differential amplifier circuit shown in Fig. 5.14. Check that all resistors are 1k**Ω** and that the batteries are connected in a sense that will produce an input of +1V at both the inverting and non-inverting inputs.
2. Switch on the power to your circuit and measure the output voltage produced. Note this down in Table 5.8.
3. Reverse *one* of the battery connections as shown in Fig. 5.15. This connection produces an inverting input of +1V and a non-inverting input of −1V. Once again, record the output voltage in Table 5.8.
4. Now reverse the battery connections as shown in Fig. 5.16. This connection produces an inverting input of −1V and a non-inverting input of +1V. Once again, record the output voltage in Table 5.8.
5. Finally, remove both batteries and connect both inputs to common (0V) as shown in Fig. 5.17. Record the output voltage in this condition.

Conclusions:

To what extent have the objectives for this assignment been met? Comment on the shape of the graphs showing output voltage plotted against input voltage for

Table 5.8 Measured values for the differential amplifier (all resistors = 1kΩ).

Fig. no.	5.14	5.15	5.17	5.17
Inverting input voltage (V)	+1	+1	−1	0
Non-inverting input voltage (V)	+1	−1	+1	0
V_{OUT} (V)				

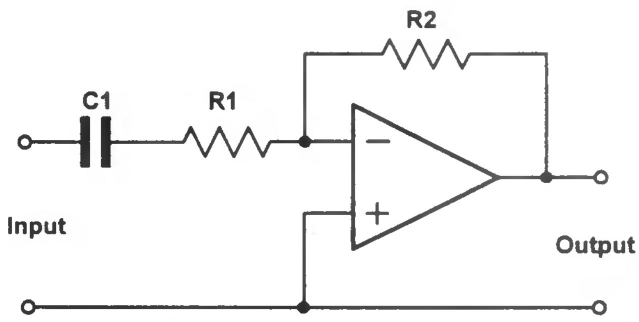


Fig. 5.20 Inverting amplifier with a.c. input coupling.

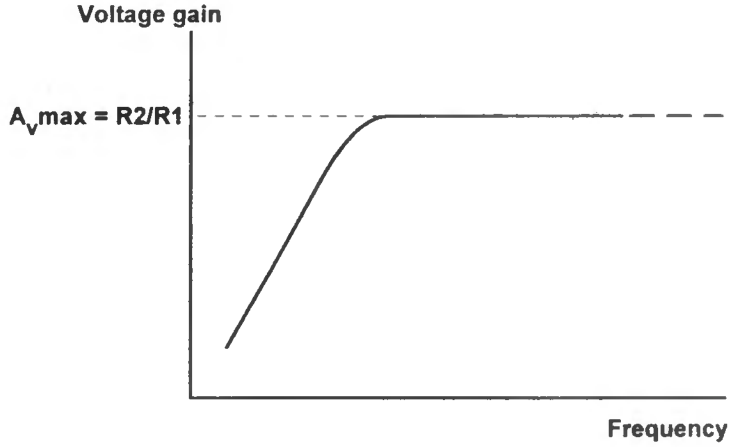


Fig. 5.21 Effect of C1 on the frequency response of the circuit shown in Fig. 5.20.

both the inverting and non-inverting circuits. What do you notice that is different about them? Does the measured voltage gain (i.e., the ratio of V_{OUT} to V_{IN}) agree with the calculated values (based on the formulae in Table 5.3). Can you suggest an application for the differential circuit?

IMPROVING SYMMETRY

To preserve symmetry and minimize offset voltage, a third resistor (R3) is often included in series with the non-inverting input (see Fig. 5.18). The value of this resistor should be equivalent to the parallel combination of R1 and R2. Hence:

$$R3 = \frac{R1 \times R2}{R1 + R2}$$

A number of op.amps provide a means of precisely balancing the differential input stage by means of an external potentiometer (see Fig. 5.19).

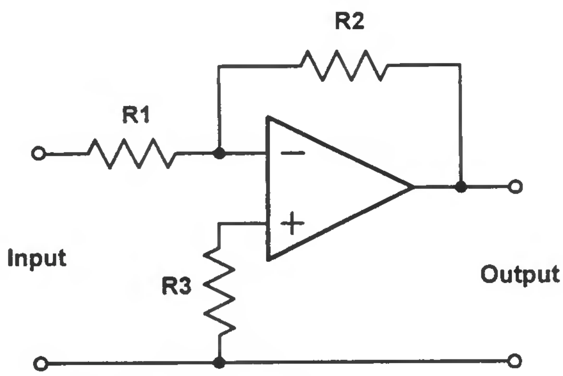


Fig. 5.18 Inverting amplifier with improved symmetry.

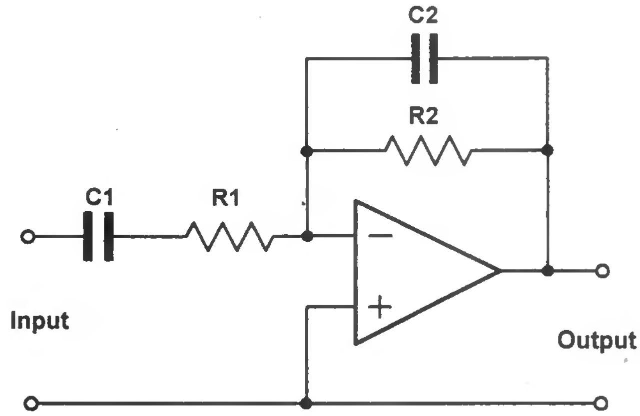


Fig. 5.22 Amplifier with tailored frequency response.

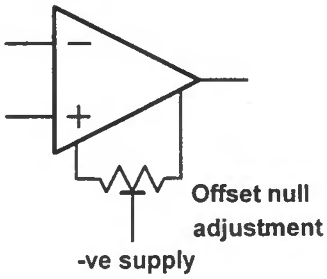


Fig. 5.19 Offset null adjustment.

FREQUENCY RESPONSE

All of the amplifier circuits described previously have used direct coupling and thus have frequency response characteristics which extend to d.c. This, of course, is undesirable for many applications, particularly where a wanted a.c. signal may be superimposed on an unwanted d.c. voltage level. In such cases a capacitor of appropriate value may be inserted in series with the input, as shown in Fig. 5.20. The value of this capacitor should be chosen so that its reactance is very much smaller than the input resistance at the lower applied input frequency. The effect of the capacitor on an amplifier's frequency response is shown in Fig. 5.21.

We can also use a capacitor to restrict the upper frequency response of an amplifier. This time, the capacitor is connected as part of the feedback path. Indeed, by selecting appropriate values of capacitor, the frequency response of an inverting operational voltage amplifier may be very easily tailored to suit individual requirements (see Figs. 5.22 and 5.23). The lower cut-off frequency is determined by the value of the input capacitance, C1, and input resistance, R1. The lower cut-off frequency is given by:

$$f_1 = \frac{1}{2\pi\, C1\, R1} = \frac{0.159}{C1\, R1}\text{Hz}$$

where C1 is in farads and R1 is in ohms.

Provided the upper frequency response it not limited by the gain × bandwidth product, the upper cut-off frequency will be determined by the feedback capacitance, C2, and feedback resistance, R2, such that:

$$f_2 = \frac{1}{2\pi\, C2\, R2} = \frac{0.159}{C2\, R2}\text{Hz}$$

where C2 is in farads and R2 is in ohms.

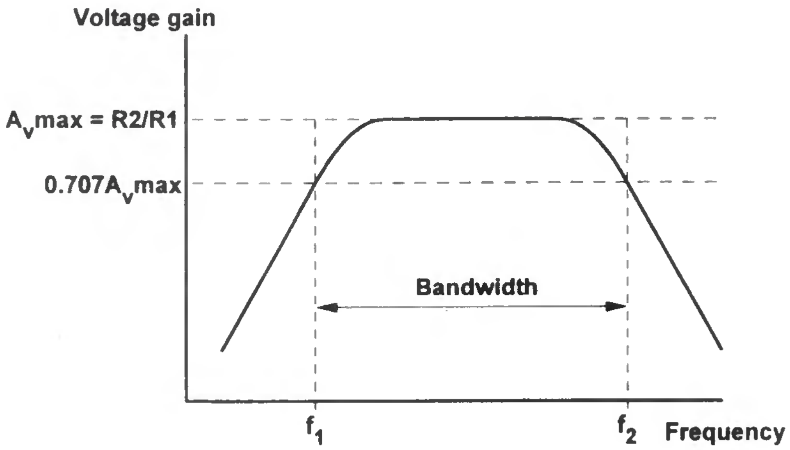


Fig. 5.23 Frequency resonse of the circuit shown in Fig. 5.22.

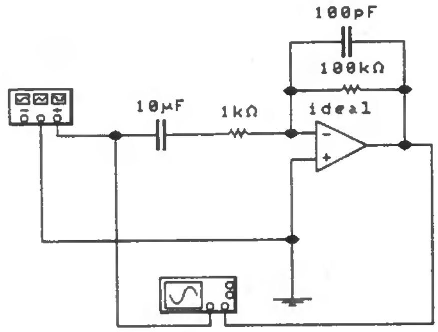


Fig. 5.24 Circuit for Assignment 5.2.

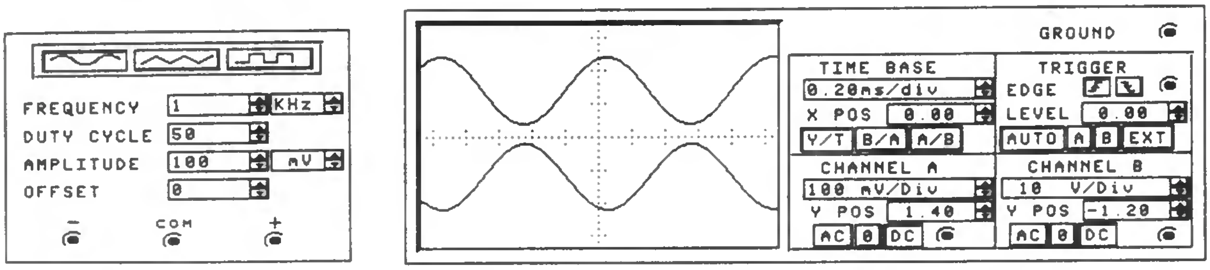


Fig. 5.25 Waveform generator and oscilloscope settings for Assignment 5.2.

Practical assignment 5.2:
Amplifier with tailored frequency response

In this practical assignment you will construct and test an amplifier in which the gain and frequency response can be accurately predicted by appropriate choice of component values.

Objectives:

5.2.1 To show how an op.amp can be used in a practical audio frequency amplifier.

5.2.2 To measure the voltage gain, phase change, and frequency response of an amplifier stage.

Table 5.9. Measured values for Assignment 5.2.

(a) *C1 = 10μF, R1 = 1kΩ, C2 = 100pF, R2 = 100kΩ*

Frequency (Hz)	2	4	10	20	40	100	200	400	1k	2k	4k	10k	20k	40k
Input voltage (V pk-pk)														
Output voltage (V pk-pk)														
Voltage gain														

(b) *C1 = 1μF, R1 = 1kΩ, C2 = 1nF, R2 = 100kΩ*

Frequency (Hz)	10	20	40	100	200	400	1k	2k	4k	10k	20k
Input voltage (V pk-pk)											
Output voltage (V pk-pk)											
Voltage gain											

Instructions:

1. Connect the circuit shown in Fig. 5.24 with C1 = 10μF, R1 = 1kΩ, C2 = 100pF, and R2 = 100kΩ.
2. Switch on the power to your circuit and adjust the function generator and oscilloscope controls as shown in Fig. 5.25.
3. Use the oscilloscope to measure and record the peak-peak input and output voltages and record the results in Table 5.9a.
4. Modify the circuit so that C1 = 1μF and C2 = 1nF and repeat steps 2 and 3. Once again, record your results in Table 5.9b.
5. Plot frequency response graphs (i.e., voltage gain plotted against frequency) for the two sets of values (you should use log-lin graph paper for this). Use the graphs to determine the mid-band voltage gain, upper and lower cut-off frequencies, and bandwidth.
6. Finally, observe the input and output waveforms at mid-band and hence determine the phase shift at mid-band.

Conclusions:

To what extent have the objectives for this assignment been met? Compare the measured values (voltage gain, upper and lower cut-off frequencies) with the calculated performance using each set of component values. Do the values agree? If not, why not? Comment on the shape of the frequency response graph. Is it what you would expect? Comment on the phase shift. Is it what you would expect?

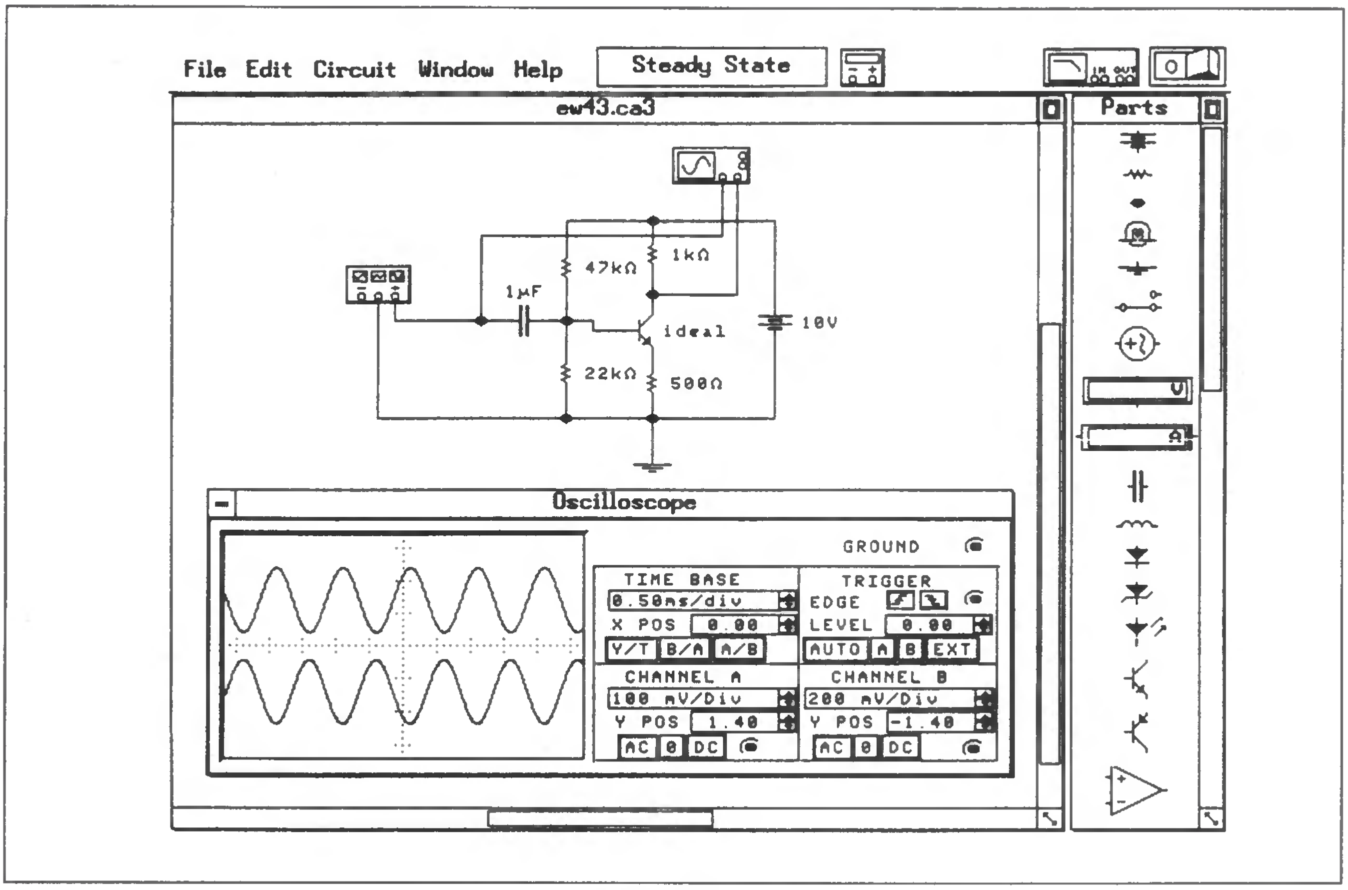


Fig. 5.26 Solution to last month's Brain Teaser.

BRAIN TEASER

This month's challenge for those of you who are using the full *Electronics Workbench* package is to design a circuit based on a single op.amp that will perform according to the following specification:

Voltage gain: 20
Frequency response: d.c. to 10kHz
Input resistance: 10kΩ
Phase-shift (mid-band): 180°

Test your solution using *Electronics Workbench.*

Answer to last month's Brain Teaser

Last month's Brain Teaser involved the design of an a.c. coupled class-A common emitter amplifier with the following specifications:

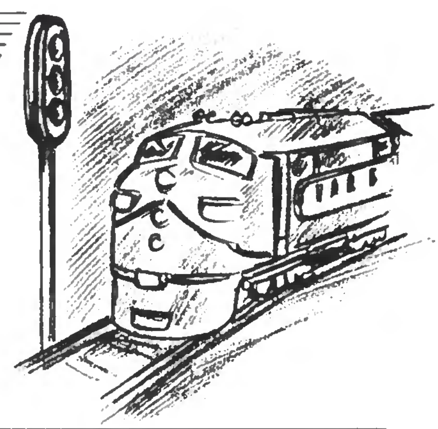
Voltage gain = 2
Overall phase shift = 180°
Supply voltage = 10V

Fig. 5.26 shows one solution arrived at using the full version of *Electronics Workbench.*

CORRECTION

In *Electronics from the Ground Up* Part 2, page 865, answer Q1(b) should read 3W, and answer Q5 should read (a) 16·62kΩ (b) 90kΩ.

Constructional Project



MODEL RAILWAY SIGNALS

GRAHAM LONG

Boolean logic and BR know-how combine to create enhanced model railway signalling reality.

As a technology teacher with a wood and metal-working background, the author had found that the National Curriculum demands for electronics and computer control had caused him some concern.

However, inspired by the 2-Aspect signals design published in *EPE* September 1992 (*Model Railway Automatic Signal* by Stuart Dando), he had the idea of using a model railway as an area on which to base projects for his classes. This seemed to provide many types of control problem suitable for both electronic and computer control, as well as being an area for links with the world of work.

When a group of pupils displayed at an open evening the *EPE* 2-Aspect signals they had built, the interest shown by parents and pupils encouraged him to think further.

HELPFUL BR

Letters from the author published in *EPE* and elsewhere requesting further information produced many useful replies. In particular, *EPE* reader Graham Knott, who is both a British Rail man and a railway modeller, was able to give advice through "having done it". Thanks to him, and through a secondment period with BR, the author gained an understanding of railway signalling procedures and some ideas about the type of circuit needed.

The circuit described here has been designed to be used as a single module board which can work either as an independent 2-Aspect (red and green) signal or, with three or more identically-assembled printed circuit boards (p.c.b.s), as an integrated 3-Aspect signalling system controlling red, yellow and green lights. The design allows flexibility for alternative connections.

Train detection is made via reed switches. By connecting capacitors across the switches and using screened cables for all the connections away from the circuit board, all false-signal problems were eliminated from the prototype circuit. The circuit can probably also be used with infra-red or other opto-sensors, or with manual switches.

If an older engine is being used and is causing problems with excessive stray radiated signals, a new suppressing capacitor of, say, 470 picofarads (470p) across the motor may help.

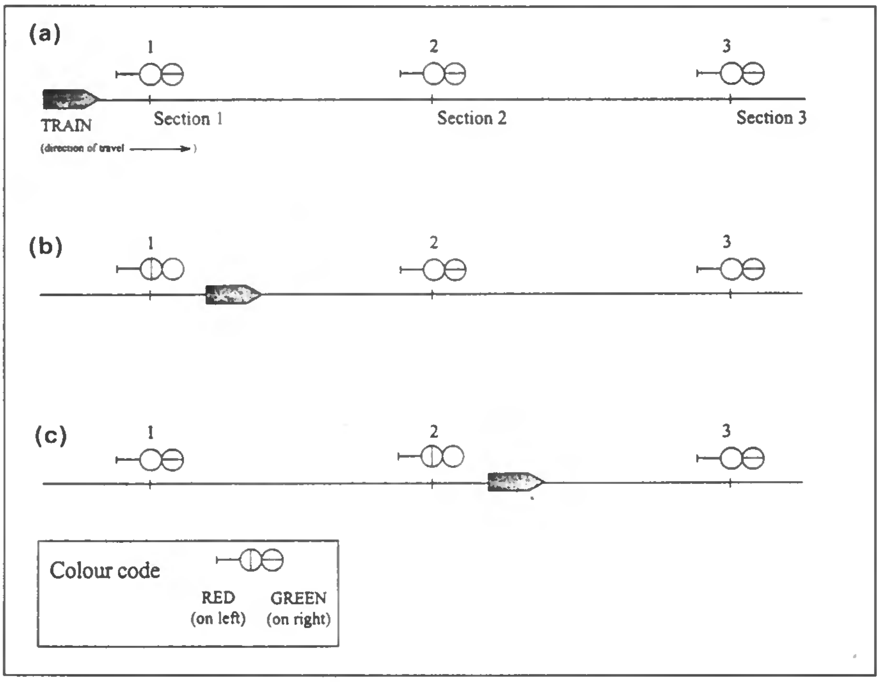


Fig. 1. 2-Aspect railway signal logic diagram.

SIGNALLING

Keen railway modellers will find this circuit useful for automating signalling on a large model electric railway system, but it is also ideal for use with a "dining room" table layout. An additional suggested circuit design is included to allow small filament bulbs to be powered, which should allow shop-bought model railway signals to be controlled by the circuit.

How the 2-Aspect signal works on an example model railway layout is shown in Fig. 1. This signal could be used on a quiet line, or perhaps on a siding. The control system illustrated in the schematic is: (a) the train has not entered Section 1 so the signals are all set at green; (b) the train moves into Section 1 and Signal 1 changes to red; (c) the train moves to Section 2, so Signal 2 changes to red and Signal 1 changes back to green as Section 1 is now clear.

The 3-Aspect signal, whose operational system diagram is shown in Fig. 2, could be used for a main line, most suitably with a circular layout. It could also be used on a straight backwards and forwards line with modification to the switching devices. The logic has four stages: (a) the train has not reached Section 1 so all signals show green; (b) the train enters Section 1 and Signal 1 changes to red; (c) the train enters Section 2, Signal 2 changes to red, Signal 1 changes to yellow, this warns that the next signal is red, so prepare to stop; (d) the train enters Section 3, Signal 3 changes to red, Signal 2 changes to yellow, signal 1 changes to green, therefore a train approaching Section 1 has two full sections of clear track in front of it.

2-ASPECT SIGNAL

The circuit diagram for the 2-Aspect signal controller is shown in Fig. 3. It uses two NAND gates, IC1a and IC1b, configured as a multivibrator, or flip-flop.

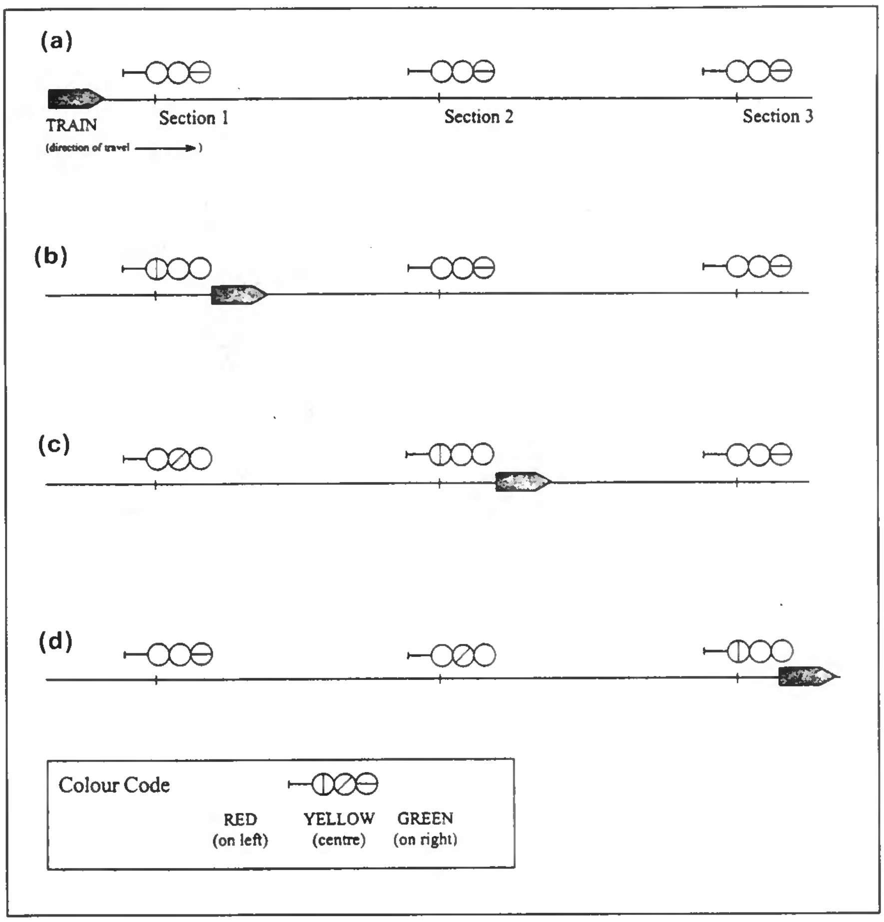


Fig. 2. 3-Aspect railway signal logic diagram.

If reed switch S1 is operated (i.e., closed), the input at NAND gate IC1b pin 4 will be taken to 0V. This will result in a logic 1 at the gate's output pin 6. This output is fed to the input at NAND gate IC1a pin 2.

When reed switch S2 is open, the input at IC1a pin is held high (logic 1) by resistor R2. Consequently, the output of this gate, pin 3, will be at 0V (logic 0).

The latter output is fed to input pin 5 of the first gate IC1b. Thus, even when switch S1 is released, there is still a logic 0 on this input, and so the gate maintains a logic 1 output level. Any further operation of switch S1 has no effect. When switch S2 is operated, a similar action takes place and both outputs, IC1a pin 3 and IC1b pin 6, change their logic states.

Resistors R1 and R2, respectively, are included to hold high the switched inputs of gates IC1a and IC1b and prevent them from "floating" (unconnected to either of the power supply lines) when switches S1 and S2 are open.

Each of the gate outputs, IC1a pin 3 and IC1b pin 6, controls its own light emitting diode (l.e.d.), D1 and D2. The respective l.e.d. will be turned on when the output of the controlling gate is at logic 1.

Resistor R3 is used as a common current limiter for both l.e.d.s.

3-ASPECT SIGNAL

The 3-Aspect signal controller is basically an extension to the circuit for the 2-Aspect unit, taking its control signal from the output of the flip-flop at IC1b pin 6. Thus each signal derived from one reed switch (S1 or S2) is held until the next switch is operated (S2 or S1 as appropriate) The practical circuit implemenation is shown in Fig. 4..

If there is a train in the corresponding track section controlled by the circuit, IC1a pin 3 (Fig. 3) will be at logic 1 and IC1b pin 6 will be at logic 0. The latter output level is inverted by IC1c in Fig. 4 and, from IC1c pin 11, controls D3, the red l.e.d. So in this instance the 2-Aspect signal shown in Fig. 3 will be set to red.

IC1b pin 6 is also taken to NAND gates IC2a (input pin 1) and IC2b (input pin 4). The output from IC2a pin 3 is inverted by IC2c and controls D4, the yellow l.e.d. Similarly, the output from IC2b is inverted by IC1d and controls D5, the green l.e.d.

The outputs from IC2a pin 3 and IC2b pin 6 are also fed to the NAND gate IC2d. This gate is actually used as though it were an OR gate and it detects if either yellow l.e.d. D4 or green l.e.d. D5 is turned on. The circuit is arranged so that if the red l.e.d., D3, is on, then D4 and D5, the yellow and green l.e.d.s, are turned off.

FORWARD LOGIC

However, the signals for this track section can only have a green light showing if the next track section's signals, controlled by an identical circuit, are not on red. Therefore a logic level is taken from the next track section's IC2d pin 8 and fed back to NAND gate IC2b pin 5 of this section which we are currently discussing.

Only if IC2d pin 8 of the next section and the output of flip-flop IC1b pin 6 (Fig. 3) are both at logic 1 can green l.e.d. D5 be turned on via IC2b and IC1d. In this instance, the logic 0 level output from IC2b pin 6 also holds IC2a pin 2 at logic 0. Consequently, IC2a output pin 3 will be at logic 1 and so IC2c output pin 11 will be at logic 0, thus yellow l.e.d. D4 will be turned off.

If, instead, the signal in the next track section is at red, a logic 0 level will be fed back from that section's IC2d pin 8 to this section's IC2b pin 5. Consequently, IC2b pin 6 will high, IC1d pin 8 will be low, and so green l.e.d. D5 will be off. The logic 1 output from IC2b pin 6, though, will allow IC2a output pin 3 to go low if IC2a pin 1 is also high. The inverted output from IC2c pin 11 will thus go high, and so yellow l.e.d. D4 will be turned on.

Resistor R3 provides common current limiting for all three l.e.d.s, D3 to D5.

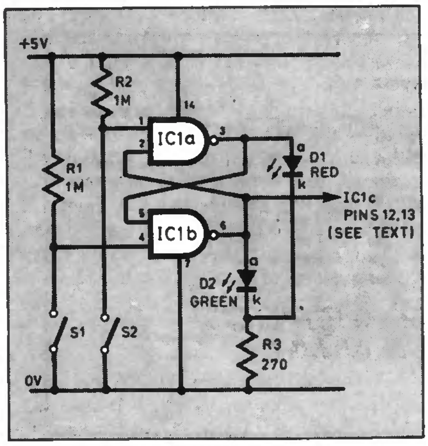


Fig. 3. 2-Aspect signal circuit diagram.

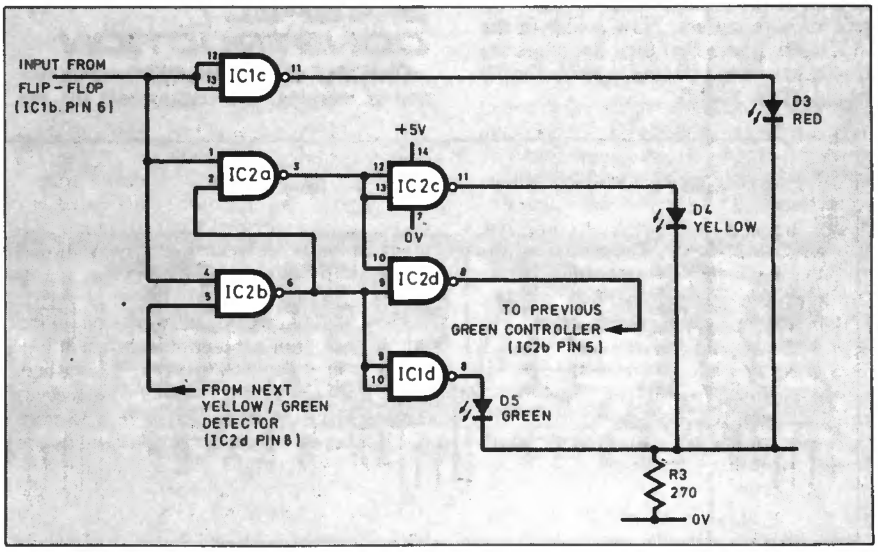


Fig. 4. Circuit diagram for the 3-Aspect signal extension to the circuit of Fig. 3.

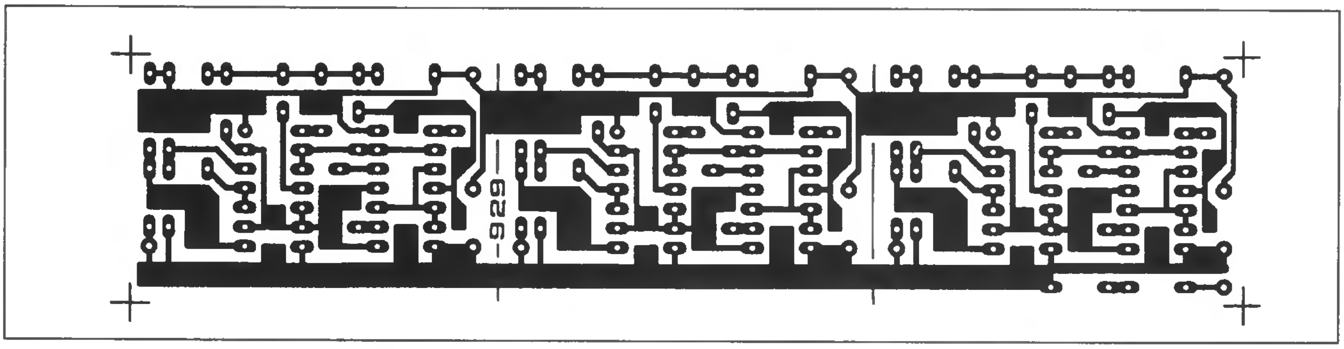


Fig. 5. Full size underside copper foil master track pattern for combined three-module p.c.b.

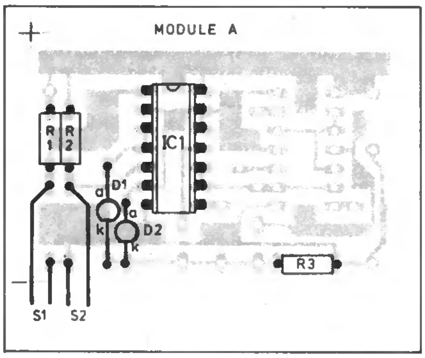


Fig. 6. Component layout for the 2-Aspect signal controller.

2-ASPECT CONSTRUCTION

The full size master foil track layout for the p.c.b. which is common to both the 2-Aspect and 3-Aspect signals controllers is shown in Fig. 5. This board holds three identical circuit assemblies and is available from the *EPE* PCB Service, code 929.

The component layout for the 2-Aspect signals controller on this p.c.b. is shown in Fig. 6.

For the 2-Aspect circuit, insert the d.i.l. (dual-in-line) chip socket for IC1 into its designated position on the board. Ensure that the notch in the socket is orientated as shown, and that the socket is pushed firmly down on the board. Unless you are using a p.c.b. assembly frame, you may find it helpful to solder one pin first and then check that the socket is still fully in position. Then solder the remaining socket pins.

Next insert and solder the resistors, and then trim off their excess lead lengths with a pair of wire cutters. Now solder in the l.e.d.s, making sure that their flat edges are correctly orientated (facing towards the 0V tracking on the board).

At this stage it is a good idea to temporarily use link wires in place of reed switches S1 and S2. On the prototype, the wires cut off the resistors were used.

Before connecting to a power supply, thoroughly check the assembly, looking for solder shorts across tracks, especially between the pins of the i.c. socket. Now carefully insert IC1, making sure that its legs are not bent under and that pin 1 is in the correct place, as shown.

Finally, a power supply should be connected. Although +5V d.c. is the ideal supply voltage, in practice four AA type batteries can be used, delivering about +6V (4 × 1·5V). Rechargeable AA batteries will probably deliver about +4·8V (4 × 1·2V). Do not use a supply which exceeds +6V d.c.

The a.c. supply from a model railway transformer **must not be used** to power the circuit directly. It may, however, be rectified and stabilised at +5V d.c. in the conventional fashion and then used as the power source.

2-ASPECT TESTING

To test the signals, simply short together the wires for reed switches S1 and S2 in turn. The two l.e.d.s, D1 and D2, should be seen to turn on and off alternately. If neither of the l.e.d.s turn on when the power supply is switched on check that they (and IC1) have been inserted the correct way round. If necessary, also recheck your soldering for missed joints and bridged tracks.

If the 2-Aspect signal is to be used on its own without the addition of the 3-Aspect components, it is necessary to also connect IC1 pins 9 and 10 to the 0V line.

3-ASPECT CONSTRUCTION

Once the 2-Aspect signal controlling section is working, the components for the 3-Aspect section can be added. Basically, this only amounts to adding a socket for IC2, and adding l.e.d.s D3, D4 and D5. However, it is expected that railway modellers will want to use several identical 3-Aspect signal controllers and these should be constructed in the same way as the first one. The p.c.b. component positioning details for the three sections of the 3-Aspect controller are shown in Fig. 7. Once again, make sure that the components are correctly orientated and that the soldering of the connections is satisfactory.

3-ASPECT TESTING

For testing the triple series of 3-Aspect controllers it is probably easiest to link the switch connections as shown in Fig. 8.

Connect the power supply and two l.e.d.s should light on each module, one on the 2-Aspect side, and one on the 3-Aspect side, probably all the green l.e.d.s.

Short the left hand Module A point S2 to the battery 0V line. This should result in one 3-Aspect signal on red, one on yellow, and one on green. Next do the same for point S2 of Module B, and then for point S2 of Module C. The sequence of red, yellow and green should follow the shorting pattern. Do not operate the modules in the wrong order since this will create logical display errors.

It is probable that the complete modular set-up will work first time if the initial 2-Aspect section has first been tested and that component positioning and soldering has been correctly carried out.

If there is an unexpected sequencing of the light displays it is most likely that the link wires have been incorrectly connected.

In the component layout of Fig. 7 are shown resistor R4 and diodes D6 and D7, these components are optional and not shown in the circuit diagram of Fig. 4. They are intended to offer a safety factor to

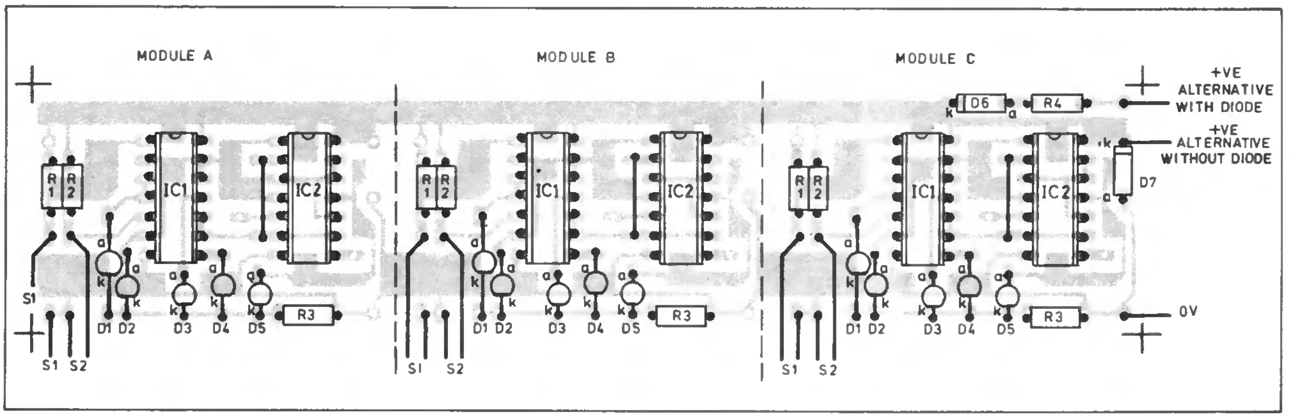


Fig. 7. Component layout for the complete triple-module 3-Aspect signals controller.

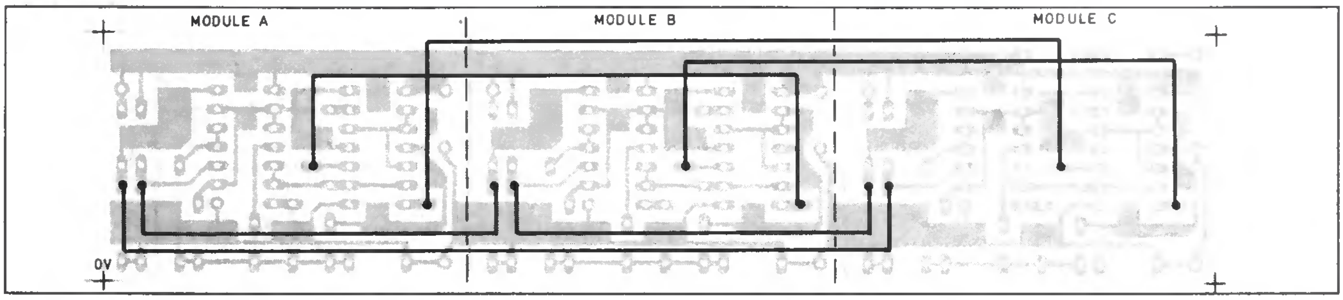


Fig. 8. Details of the wired interconnections between the three modules on one board.

prevent damage to the circuit from inadvertent wrong polarity connection of the power supply, or connection of a power supply in excess of the allowable +6V. A suggested value for R4 is 33Ω for a +9V DC supply, but this value may be changed if necessary, to suit supply sources.

RAILWAY CONNECTIONS

At this point there are many possibilities for practical circuit connections. It is essential, though, that any wires taken from the circuit to the railway are of sheathed (screened) cable, with the screening connected to the 0V points of the signals. This applies equally to the reed switch links and to the signal light links. (If the signals are intended to be used with clockwork or plastic push-along trains, then ordinary unscreened cable will be satisfactory.)

The reed switches need to be attached nearby or between the railway tracks. A 10n capacitor should also be soldered across each reed switch. Although the capacitor (C3) could be placed across the connections at the p.c.b. end, with the prototype it was found that the best results were obtained with the capacitor right across the reed switch as shown in Fig. 9. Operation of the reed switches is performed by a small magnet connected in a suitable place on the railway engine.

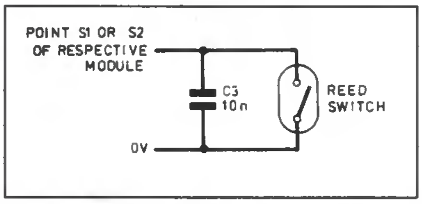
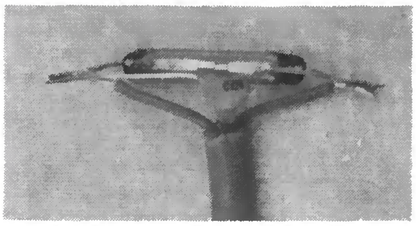


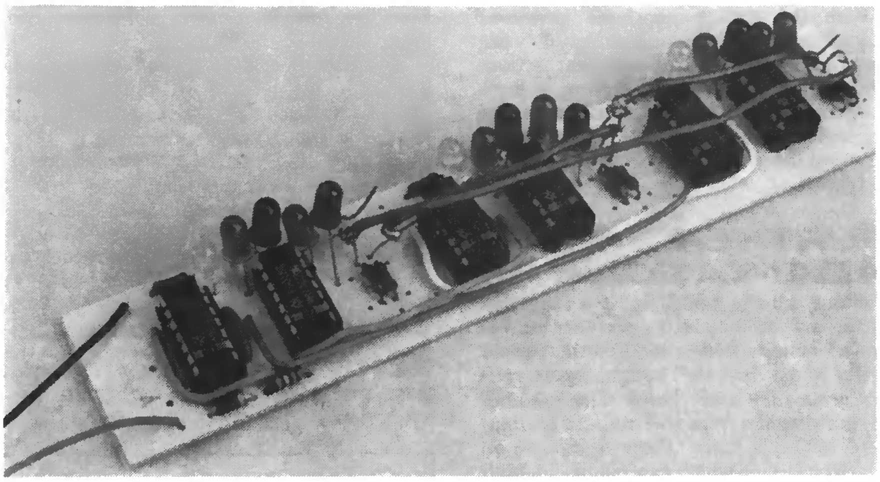
Fig. 9. Reed switch wiring detail.



Closeup detail showing reed relay, capacitor C3 and screened cable.

It is a matter of personal preference whether the l.e.d.s are left on the p.c.b. as a signal indicator board or mounted on small pieces of strip-board assembled into suitable housings to simulate trackside signal gantries. It is suggested that for "00" gauge railways 3mm or 5mm l.e.d.s are used.

The layout for a three module system which will suit many people is shown in Fig. 10. One reed switch per module is required and the logic is that the red signal is only turned on when the train is fully in the section.



Completed triple 3-aspect signal controller board, also showing interwiring as illustrated in Fig. 8.

COMPONENTS

2-ASPECT MODULE

Resistors
R1, R2 1M (2 off)
R3 270
All 0·25W 5% carbon film.

See SHOP TALK Page

Capacitors
C1, C2 10n ceramic (2 off)
C3 10n ceramic (see text)

Semiconductors
D1 l.e.d. red, 3mm or 5mm
D2 l.e.d. green, 3mm or 5mm
IC1 7400 quad NAND gate

Miscellaneous
S1, S2 s.p. normally open reed switches (2 off)

Printed circuit board available from the *EPE* PCB Service, code 929; 14-pin d.i.l. socket; 4×AA type battery holder, plus batteries and battery clip; 4-core screened cable (length to suit distance to signal displays); 2-core screened cable (length to suit distance to reed switches).

3-ASPECT MODULE

(In addition to components required for 2-Aspect section)

Resistor
R4 33 (see text)

Semiconductors
IC2 7400 quad NAND gate
D3 l.e.d. red, 3mm or 5mm
D4 l.e.d. green, 3mm or 5mm
D5 l.e.d. yellow, 3mm or 5mm
D6 1N4001 rectifier diode (see text)
D7 5V1 Zener diode (see text)

Miscellaneous
14-pin d.i.l. socket

Note that the p.c.b. is supplied as a 3-module strip and can hold three 2-Aspect circuits plus the additional components for three 3-Aspect circuit sections.

Approx cost three complete modules £18

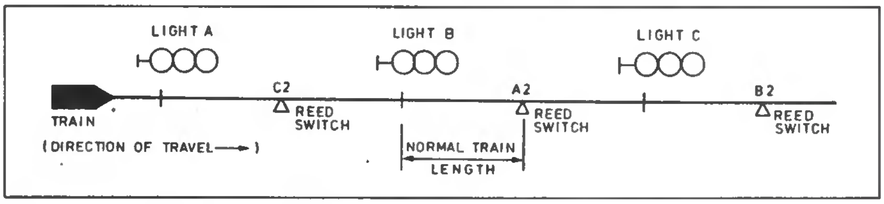


Fig. 10. Positioning of the reed switches to control three 3-Aspect signal light gantries.

In reality, of course, a train will often be in two sections at the same time because of its length. It is better, therefore, if the engine switches the next section to red as soon as it enters that section, while still leaving the previous section on red to protect the rear coaches. In this case, it will be necessary to remove the wires linking the switches on the p.c.b. and use six reed switches as shown in Fig. 11.

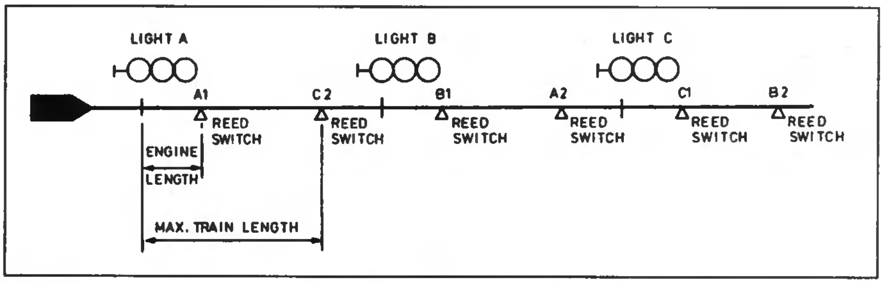


Fig. 11. Using six reed switches to control the signal gantries so that the rear of a train also determines the signalling logic.

With this arrangement one switch is placed just after the signals so that they are set to red when the train enters that section. The second switch in the section is positioned so that it is operated once the rear of the train is safely out of the last section, allowing the previous red signal to be reset to yellow.

FURTHER ADAPTATIONS

Some railway modellers have suggested to the author that l.e.d.s are two big for smaller gauge railways and that they would prefer to use "proper" bought signal units or "grain of wheat" bulbs. These cannot be run directly from the outputs of standard 7400 type chips. There is, though, an interface circuit which can readily be built which will enable the controller board to drive this type of lamp.

The interface circuit is shown in Fig. 12 and simply consists of several individual transistors each of which can drive one or more of the lamps, depending on the transistor's current rating. The circuit should be repeat-assembled for each of the l.e.d.s it replaces, i.e. three assemblies to replace three l.e.d.s.

The driver assemblies could be built on strip-board, as shown in Fig. 13, and then taped to the side of the controller p.c.b.

A smaller assembly could be achieved by using ULN2003 7-stage Darlington drivers, each of which contains seven Darlington transistors, as schematically shown in Fig. 14. No constructional details are offered for this alternative technique.

(It may be possible to use type 74HC00 chips in place of the standard 7400 devices. These are capable of sinking or sourcing about 25mA at each output pin. The maximum allowable power dissipation of the chip is about 750mW. Ed.)

ISOLATION HALT

Another facility suggested to the author by a railway buff is to allow the signal unit to cause a following train to stop at a red signal. For example, if an express train is catching up with a slow train, the express must stop if it meets a red signal. This is fairly easy to achieve by isolating about 150mm of track just before the red signal. The isolated section is then powered from the ordinary track supply via the normally-closed contacts of a relay.

The red signal is used to supply current to the base of a transistor which powers the relay coil. Thus, if the red signal is on, the closed contacts would open, so cutting power from that section of the track. In this way, the following train would stop at the red signal until the forward train has cleared the next section, setting the red to yellow and allowing the following train to proceed. Fig. 15 shows an example of how this system could be implemented. □

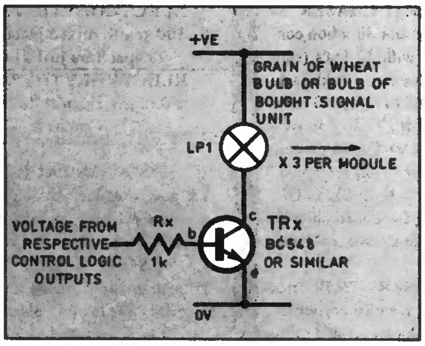


Fig. 12. Interfacing circuit which allows higher-wattage lamps to be switched.

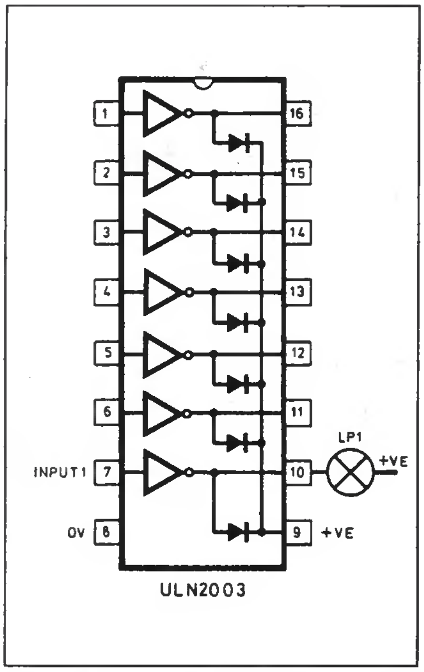


Fig. 14. Schematic diagram of the ULN2003 7-stage Darlington driver which could be used in place of seven circuits shown in Fig. 12.

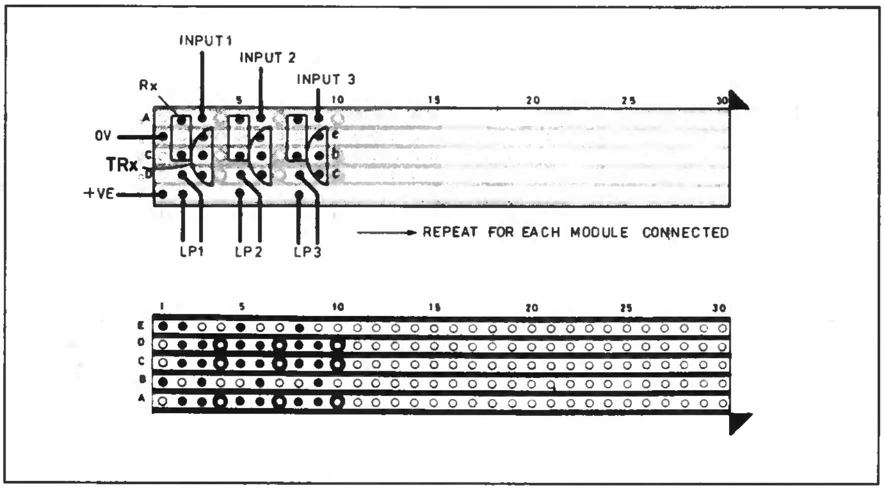


Fig. 13. Layout of three circuits as in Fig. 12 assembled on strip-board.

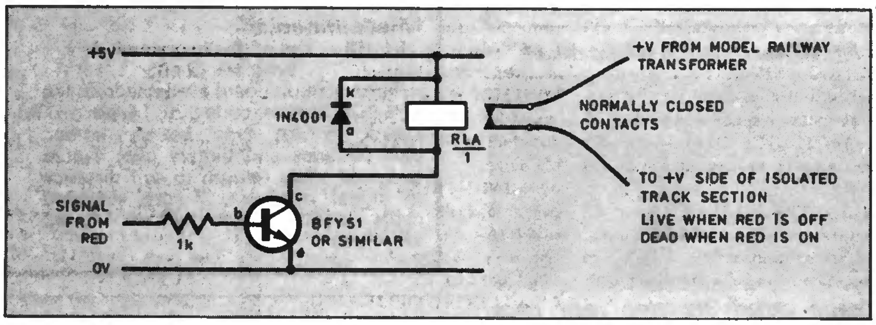
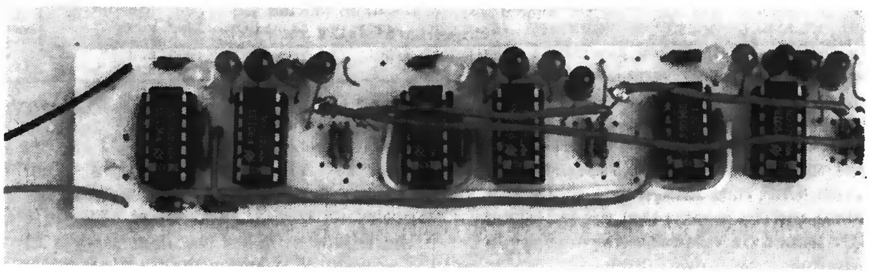


Fig. 15. Suggested circuit which provides track isolation in order to prevent two trains colliding front to rear.



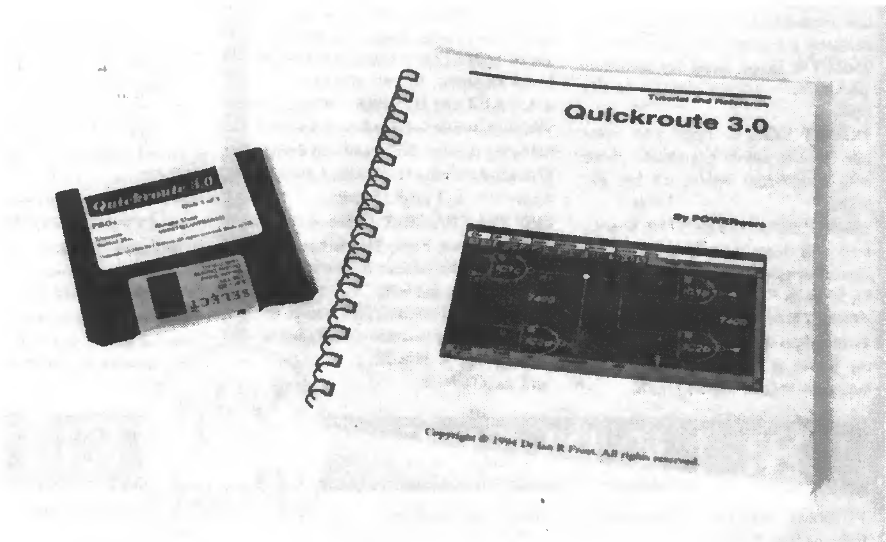
QUICKROUTE 3.0 REVIEW

ROBERT PENFOLD

For some time Quickroute has been one of the leading PCB CAD software packages. The latest Windows version is well worth examining.

QUICKROUTE *2.0 Professional Edition* was reviewed in the *Interface* article that appeared in the December 1993 issue of *EPE*. *Quickroute 3.0* in its most advanced version is a direct descendant of the earlier program. Like its predecessor, it is available in somewhat simplified and lower cost forms, but there is no longer a DOS variant. All four of the current versions run under *Windows 3.1*.

A fairly powerful PC is needed in order to run *Quickroute 3.0*. The minimum recommended system is an 80386 based PC having two megabytes of memory and at least three megabytes of vacant hard disk space, plus a *Windows* compatible mouse. A VGA or super VGA colour display plus a maths co-processor are also "strongly recommended". In order to make real use of the program it is necessary to have some means of providing good quality hard copy. Ideally a laser printer would be used, but it should be possible to utilize any *Windows* supported output device.



GETTING STARTED

Going against the modern trend, this program is supplied on a single 3·5 inch 720K disk. However, the files are mostly in compressed form, and once installed onto a hard disk they occupy nearly two megabytes. Installation is very simple, and surprisingly fast. The installation program is run from within *Windows*, and it takes only about three minutes to get the program loaded onto the hard disk.

You have to enter a serial number before the installation will proceed, but there is no other form of copy protection. The program is automatically installed into its own *Windows* group, and you simply "click" on the appropriate icon in order to run the program.

There is a definite advantage in using the *Windows* environment in that it avoids the need for lengthy setting up procedures in order to get the program to work with your particular hardware. If your screen, printer, etc. work with *Windows*, then they should work with *Quickroute 3.0*. The only problem encountered was when using a high resolution (1024 x 768) super VGA screen. A band down the right hand side of the screen failed to redraw when using the vertical scroll-bar. This problem does not seem to occur at lower screen resolutions.

A drawback of using the *Windows* environment is that it is not particularly fast. Using a 33MHz 80386 based PC fitted with a maths co-processor gave an acceptable operating speed with small to medium size designs, but results were rather slow with a large design loaded.

The problem is made worse by the program performing complete screen redraws each time even a minor piece of editing is undertaken (deleting a single pad or track for example). This method ensures that the on-screen representation of the design is always up-to-date, but it makes *Quickroute 3.0* much slower than most of the competition. The situation can be eased by using the "Turbodraw" option, which speeds up screen redraws by representing pads and tracks in outline form.

IN USE

The program is "driven" in much the same way as the earlier versions, and the original screen layout is largely retained. There are the usual *Windows* header and menu bars at the top of the screen, and below these there is a toolbar. The menu options are mainly used for general tasks such as saving and loading files, and switching the on-screen grid on and off. Most of the drawing and some of the editing is undertaken using the toolbar.

The first three icons in the toolbar give access to three pads of preselected size and shape. To use a pad it is merely necessary to "click" on its icon and then "click" again in the main (drawing) area of the screen at each point a pad is needed.

To alter the selected pad size/shape the right hand mouse button is "clicked" on the icon, which brings up a window showing sixteen alternatives. It is possible to select several further "pages" of sixteen pad sizes and types using arrow icons. Circular, square, and oval pads are available, and each type can be plain or with a centre hole. The size of any pad can be altered by the user, as can the hole size (where appropriate).

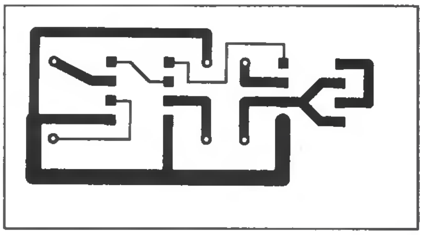


Fig. 1. Example of simple p.c.b. created using Quickroute 3.0.

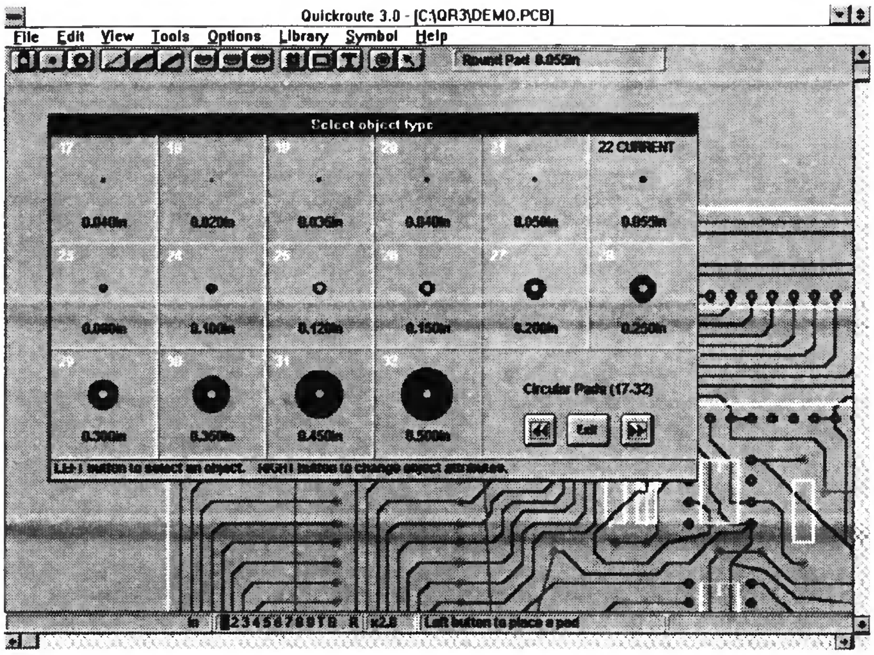


Fig. 2. Quickroute 3.0 pad selection window.

Tracks are selected using the next three "buttons", and these are used in the same basic manner as the pad icons. A wide range of track widths are available. There is a useful "polygon" option available from the menu bar, and this enables an irregular shape to be outlined and then filled.

The next three icons in the toolbar give access to a range of predrawn symbols (transistors, resistors, capacitors, etc.), and the fourth icon is used for d.i.l. integrated circuits having from eight to 28 pins. There is no rotation option for integrated circuits, so each d.i.l. integrated circuit symbol is included in vertical and horizontal formats.

The symbols are selected and used in much the same way as tracks and pads, but there are no user selectable characteristics. However, they can be rotated through 90, 180, or 270 degrees via a sub-menu of the main menu bar. This sub-menu also permits symbols to be mirrored in the X and (or) Y planes, and also permits separate X and Y scaling with a high degree of resolution. Users can generate their own symbols, and edit existing symbols.

Using the eleventh icon it is possible to produce a rectangle, an ellipse, or an arc, or filled versions of these. Icon number twelve provides access to two types of text. One is normal *Windows* text, and the other is the program's own vector text. The four sizes of vector text are made up from pieces of track. This gives relatively crude results, but it permits the text to be manipulated in ways that are not possible with *Windows* text. Vector text can also be produced by an output device which does not have a driver that supports *Windows* fonts.

SCHEMATIC CAPTURE

"Pins" can be inserted into a design when the thirteenth icon button is selected. This button does not actually do anything on the more basic versions of the program, but on the versions that have schematic capture it is used as a means of identifying connection points. *Quickroute 3.0* can be used to produce circuit diagrams ("schematics"), and on the more sophisticated versions of the program a list of interconnections can be taken from a schematic and carried on through a printed circuit layout.

This is one of those things that seems quite simple in principle, but which tends to get very involved in practice. Each circuit symbol must be twinned with a physical symbol for use in the printed circuit layout. Every pin of every component must be identified by a pin number, and the pin numbering must be the same for the circuit and physical symbols. The set of interconnections in the circuit will then be carried forward correctly to the printed circuit layout.

The *Quickroute 3.0* schematic capture facility is easier to use than the similar facilities I have encountered on other programs. I have not tested it extensively, but on a quick test it seemed to work flawlessly. It is in many ways fairly basic though, and it cannot handle modifications to a circuit and board layout quite as easily as some other schematic capture facilities.

Many professional printed circuit designers favour the use of netlists, which is simply a text file containing a list of the components in the circuit, plus a list giving details of every interconnection. The more advanced versions of *Quickroute 3.0* can export a netlist generated by the program, but there seems to be no netlist import facility. Of course, you do not have to use the schematic capture and netlists, and any version of the program can be used as a sort of electronic drawing board. When dealing with relatively simple designs this is probably the best way of working.

EDITING

The final "button" of the toolbar sets the program into its editing mode. This enables single objects or groups of objects to be selected, and then deleted, moved, copied, etc. Deleting, adding, and moving track nodes is very simple and straightforward. For example, to move a node you simply place the cursor over it, press and hold down the left mouse button, and then move the cursor to the new position for the node. The editing facilities are somewhat improved on the earlier versions of *Quickroute*, but there still seems to be no block move command that preserves the interconnections between the objects inside and outside the box.

Next to the toolbar there is a text bar that gives details of the "tool" currently selected (track size, pad size, symbol, or whatever). The co-ordinate display which formerly occupied this space is relegated to the status line at the bottom of the screen. This also gives other information, such as the zoom factor and the current layer.

The pop-down menus give access to the usual file utilities, help facility, etc. Several preset zoom factors are available, or a custom zoom factor can be entered. It is possible to scroll around a design with the aid of the usual scroll bars, or "clicking" the right hand mouse button will cause the screen to be redrawn with the current cursor position being used as the centre of the display. The cursor can be "snapped" to an invisible grid, and a separate grid of on-screen dots can be activated to make it easier to place objects accurately.

AUTO-ROUTER

All versions of "Quickroute" now include an auto-router, but the more expen-

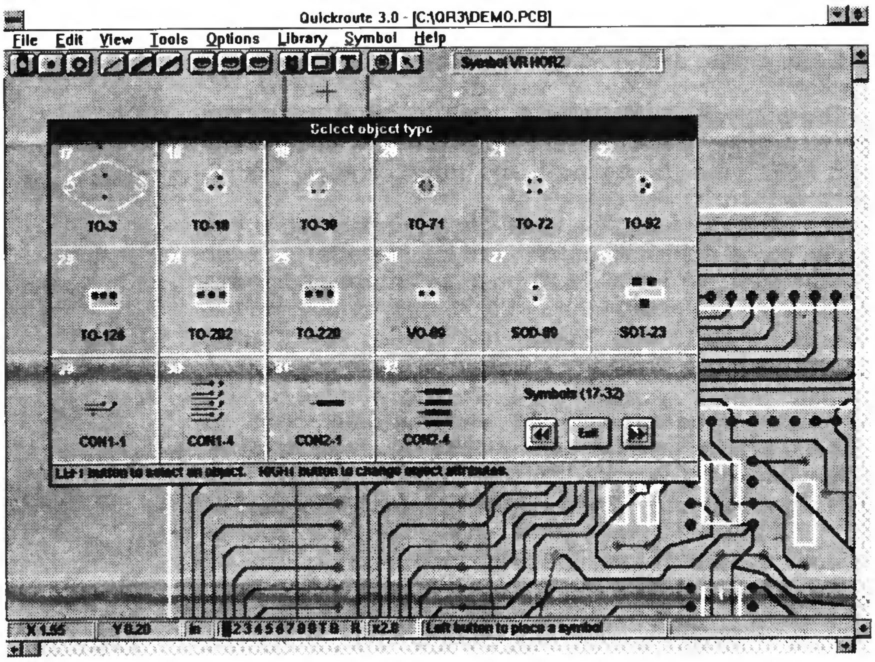


Fig. 3. Quickroute 3.0 symbol selection window.

sive versions have faster and more sophisticated auto-routers. A "rats nest" must first be entered, either manually, or via the schematic capture facility. The "rats nest" is simply a set of interconnections going straight from pin-to-pin, with each net line often crossing several pads and other net lines on the way. The auto-router tries to route each net line so that pads and other tracks are avoided, but in common with other low cost routers, it is not usually successful in routing all the tracks.

The most sophisticated of the *Quickroute* auto-routers is quite good at finding suitable routes, even when the only available route is a rather tortuous one. It is also reasonably fast. Unusually for a low cost auto-router, it can attempt single-sided boards, and makes a reasonable job of it. The only real shortcoming is that it is apt to "paint itself into a corner", making it necessary to do some manual editing before the last few nets can be routed manually. This problem seems to be a common one amongst inexpensive auto-routers.

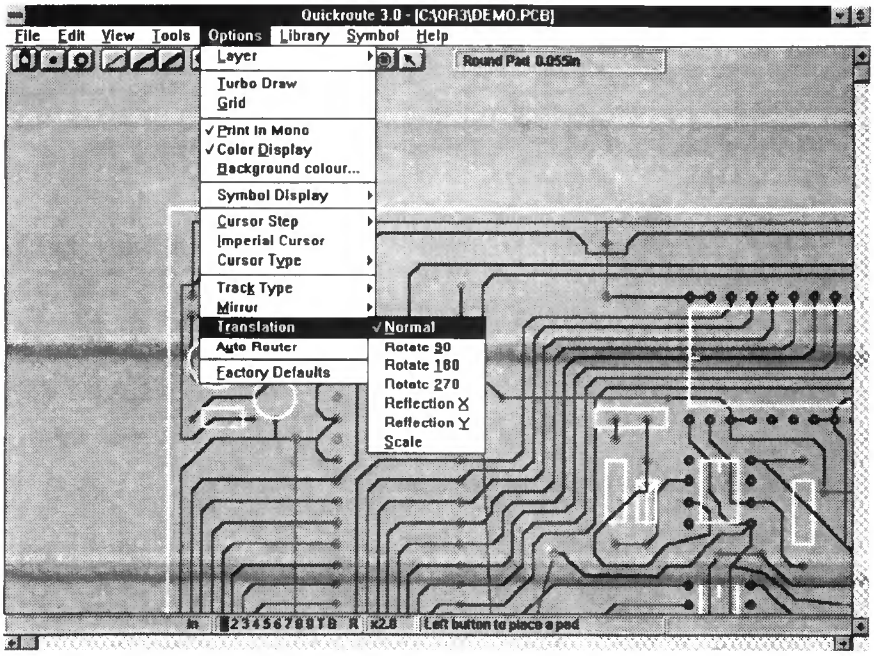


Fig. 3. Symbols can be rotated, mirrored and scaled via one of the Quickroute 3.0 drop down sub-menus.

CONCLUSIONS

The quality of the hard copy is very good provided you have a *Windows* compatible printer that is up to the task. The scaling of printouts is controlled by the screen zoom factor, making it easy to obtain practically any scaling factor. The program originally submitted for review tended to block up the holes in pads with the ends of tracks (both on-screen and in printouts). The previous version of the program automatically kept holes in pads clear of obstructions.

Fortunately, the latest version of the program now includes a "sort pads" option which clears the holes when the screen is redrawn. Subsequent printouts show the pads correctly, complete with the hole in the middle. The printing speed with an HP compatible laser is impressively fast.

Learning to use the program is quite quick and easy, especially if you are familiar with other *Windows* applications software. The 110 page A5 ring bound manual is perfectly adequate, and includes a useful index.

"Designer" is the cheapest version of the program, and it costs £99 (excluding postage and VAT). This version has an auto-router that is restricted to two layers, and it has no Gerber import or export facilities. Board designs can have up to 10,000 nodes. The version reviewed here is "PRO+", and it sells at £299 (again excluding postage and VAT). This has an eight layer fast auto-router, schematic capture, Gerber import and export, and can handle designs with up to 40,000 nodes.

At these prices *Quickroute 3.0* is in direct competition with well established printed circuit design programs such as *Easy-PC* and *Boardmaker*. It compares well with the competition, particularly in its cheapest form. I think I could use it quite happily to produce quite large board designs.

However, the best program for the job depends on personal preferences, the type of boards you will be designing, and the hardware you have available. If you have a PC that will run *Quickroute 3.0*, and you are in the market for this type of software, it is certainly a program you should give a trial (a demo disk is available from the manufacturer).

Quickroute 3.0 is produced by: POWERware, (Dept. EPE), 14 Ley Lane, Marple Bridge, Stockport, SK6 5DD. Tel/Fax 061 449 7101. □

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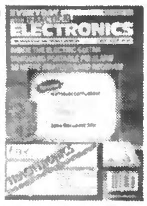

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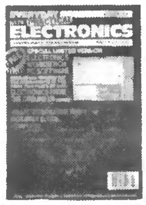

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Alan Winstanley and Keith Dye B.Eng(Tech)AMIEE
The highly acclaimed *Teach-In '92* series, which included the construction and use of the *Mini Lab* and *Micro Lab* test and development units, has been put together in book form. Additionally EPT Educational Software have developed a GCSE Electronics software program to compliment the course and a FREE DISC covering the first two parts of the course is included with the book.
An interesting and thorough tutorial series aimed specifically at the novice or complete beginner in electronics. The series is designed to support those undertaking either GCSE Electronics or GCE Advanced Levels, and starts with fundamental principles.
If you are taking electronics or technology at school or college, this book is for you. If you just want to learn the basics of electronics then this book is for you. If you are teaching electronics or technology you must make sure you see it. *Teach-In No. 7* will be invaluable if you are considering a career in electronics or even if you are already training in one. The Mini Lab and software enable the construction and testing of both demonstration and development circuits. These learning aids bring electronics to life in an enjoyable and interesting way: you will both see and hear the electron in action! The Micro Lab microprocessor add-on system will appeal to higher level students and those developing microprocessor projects.

Computers and Computing

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D. Weale
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This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!
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This guide is written with the non-expert, busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nonetheless, the guide is also designed to be circular, which means that you don't have to start at the beginning and go to the end. The more experienced user can start from any section.
The guide covers versions 3.0, 3.1 and 3.2 of both PC-DOS and MS-DOS as implemented by IBM and other manufacturers of "compatible" microcomputers.
64 pages **Order code BP232** **£2.95**

MAKING MS-DOS WORK FOR YOU (covers version 6.2)
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The book explains: How to write customised batch files which allow you to display what you want on your screen, and in the form and order you want it, instead of being forced to use the DOS prompt on a blank screen. How to design and set up a fast interactive and professional looking menu system, so that you or anyone else can run utility applications or commercial software packages easily. How the ANSI.SYS display and keyboard commands can be used to position the cursor on any part of the screen, change the intensity of the displayed characters or change their colour. How the Edit screen editor or the Edlin line editor can be used to enter ESCape (ANSI.SYS) commands into simple ASCII files to allow control of both your screen display and your printer. How to control the operation of the two main types of printers in use today, Epson compatible dot matrix and HP compatible laser printers. How to use several useful routines, such as moving and finding files, protecting files from accidental erasure, a simplified backup process, a screen saver, and a disc cataloguing system.
The Debug program and how it can be used to create, see and change the contents of any file, including those of programs written in assembler code. This includes how to find your way around the names and tasks of the CPU registers and the meaning of some simple assembler mnemonics.
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Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving acoustics. Some microphones are prone to feedback while others are not. Certain loudspeaker systems are much better than others, and the way the units are positioned can produce or reduce feedback. All these matters are fully explored as well as electronic aids such as equalizers, frequency-shifters and notch filters.

The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

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PRACTICAL MIDI HANDBOOK
R. A. Penfold

The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding, and many of the user manuals that accompany MIDI equipment are quite incomprehensible to the reader.

The Practical MIDI Handbook is aimed primarily at musicians, enthusiasts and technicians who want to exploit the vast capabilities of MIDI, but who have no previous knowledge of electronics or computing. The majority of the book is devoted to an explanation of what MIDI can do and how to exploit it to the full, with practical advice on connecting up a MIDI system and getting it to work, as well as deciphering the technical information in those manuals.

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R. A. Penfold

This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases).

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Other circuits include:– Audio limiter to prevent overloading of power amplifiers. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Audio mixers. Volume and balance controls

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V. Capel

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.

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This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.

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This book is in effect more than just a dictionary of practical electronics terms, it goes a stage further in also getting down to fundamentals. Accordingly the number of terms may be limited but the explanations of the many which are included are designed to leave the reader more competent and satisfied – and this is without the use of complicated mathematics which often on first reading can even be confusing.

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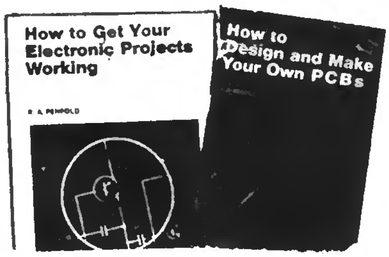

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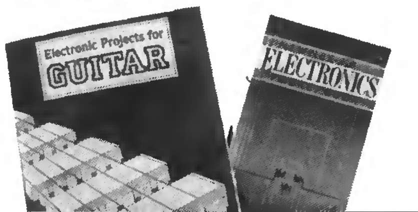

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The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.
Contains everything you need to know in order to get started in this absorbing hobby.
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A. Pickford
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There are a large number of amateur communications satellites in orbit around the world, traversing the globe continuously and they can be tracked and their signals received with relatively inexpensive equipment. This equipment can be connected to a home computer such as the BBC Micro or IBM compatible PCs, for the decoding of received signals.
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REPORTING AMATEUR RADIO

Tony Smith G4FAI

IARU NO CHANGE ON MORSE

In a recent issue it was reported that the IARU Administrative Council had appointed a special sub-committee to examine the issues related to the amateur Morse test, and to propose the position the IARU should take on this controversial matter.

Following the AC's meeting in Singapore on 10 to 12 September 1994, a press release included the following statement:

"A resolution concerning the requirements in the Radio Regulations for a demonstration of Morse code ability for operators licensed to use amateur frequencies below 30 MHz was adopted.

Consistent with the views of the member societies as expressed through the regional organisations, the IARU will neither propose nor support a change in the requirement at this time."

RA ANNUAL REPORT

The Annual Report of the Radiocommunications Agency, 1993/94, shows that as at 31 March 1994 the number of amateur radio licences on issue was 63,033. This is an increase of 3,790 over 1992/93, more than making up for the reduction of 2,200 recorded in that year.

Compared with 1992/93, there were 593 fewer class A licences, showing a continuing slow decline in this type of licence. There were, however, increases in all other types of licence, i.e., class B +3926, Novice A +33, and Novice B +425. The actual figures were: A – 31,817; B – 29,717; Novice A – 139; Novice B – 1360.

The Agency reports that it maintains an active dialogue with the Radio Society of Great Britain on a wide variety of issues affecting the amateur radio community, and the national and international arrangements that govern the use of the amateur radio spectrum.

It has continued, it says, to support the efforts of the RSGB and others to promote amateur radio as a rewarding hobby, especially among young people, and continues to give its backing to the Young Amateur of the Year Award.

CB UNDER STRESS

It is also reported that CB licences have continued their downward plunge, dropping a further 3,222 to 50,704 as at 31.3.94. The Agency accepted proposals from the CB community for a relaxation of current antenna restrictions and, says the Report, would be changing the licence rules in the near future.

This change will allow the use of half-wave and 5/8 wavelength antennas which are capable of greatly improved performance compared with the compulsorily attenuated antennas previously permitted. (The change rules came into effect on 2 August 1994 but the RA stress that beam antennas are still not permitted in CB operation.)

The RA has been monitoring discussions in the European Telecommunications Standards Institute about a specification for AM/SSB CB equipment. Such equipment is not permitted in the UK says the Report, because of the potential for interference, and there are no plans at present for the introduction of an AM/SSB CB service even if the ETSI standard is published.

LITTLE LEO

In the USA, the FCC has granted the first v.h.f. low-earth orbit (LEO) satellite license. The new Non-voice Non-Geostationary (NVNG) Service, is popularly known as *Little LEO*.

The first licensee, Orbital Communications Corp. (Orbcomm), plans to provide global E-mail, equipment monitoring, position-location and paging services through a network that will eventually grow to 36 satellites.

They will provide one-way and two-way data communications to pocket-size communicators costing as little as $50. Orbcomm transceivers will connect to laptop computers for E-mail. Early users of the system will include shipping companies tracking the location of trailers and containers or monitoring conditions such as container temperature, and oil and gas companies monitoring remote pipelines.

At the Orbcomm control room arrays of Unix workstations, running tracking software, monitor and predict spacecraft position and status. The highly automated system can be operated by two controllers, a far cry from the massive Mission Control facilities required by satellites of old.

The NVNG Service is the first fully-commercial descendant of the Amateur Satellite Service pioneered by radio amateurs since the 1960's. *(W5YI Report).*

STELAR SUCCESS

AMRED (Amateur Radio in Education), journal of STELAR (Science & Technology through Educational Links with Amateur Radio), reports good results from the Easter '94 crash Radio Amateur Examination course for teachers from schools with no current amateur radio programme. There was 100 per cent success on paper one, and three retakes of paper two were planned for December.

Applications are now invited for next Easter's course (sponsored by Kenwood UK) from teachers from schools with no RAE qualified staff (or where the licensed teacher is about to move on).

Those selected will receive four days of tuition, course materials, meals and hotel accommodation free of charge. Their only financial obligation will be travel to and from Rickmansworth, plus registration and exam fees at their local City & Guilds examination centre for the May 1995 RAE. There are twenty places available and early application is recommended.

Teachers interested should send a brief letter stating their interest to: *Richard Horton G3XWH, Harrogate Ladies College, Clarence Drive, Harrogate, North Yorkshire HG1 2QG.* Please mention that you read about STELAR in EPE.

UNIVERSAL LICENCE?

According to the *W5YI Report,* the United States is considering International Amateur Radio Licensing. There is already an international agreement whereby some 20 countries, including the UK, participating in the Conference of European Postal and Telecommunications Administrations (CEPT), have a Common Amateur Radio Licence arrangement. Last year New Zealand was the first country outside Europe to join in the scheme, and now the State Department is discussing with representatives of the CEPT the possibility of the CEPT Common Licence being recognised by the United States and vice versa.

The FCC, the U.S. licensing authority, is also working on an international amateur radio operating permit for certain countries in North, Central and South America. Unlike the CEPT arrangement, which still requires some formality, the Americas licence would be something like an international driving licence, valid in all participating countries.

The way things are going, perhaps it's not too fanciful to suggest that there will come a time when amateur licences issued nationally will be universally recognised around the world!

GB2SM TO CONTINUE?

Following an announcement by the *Science Museum* in London that its radio station, GB2SM, was closing on 7 November 1994, amateurs around the world have expressed dismay at the loss of this famous station after nearly forty years of operation.

Happily, the museum has agreed to enter into discussions with the Radio Society of Great Britain with a view to their providing the museum with a state-of-the-art hands-on amateur radio exhibit to replace the old station.

In the meantime, the RSGB is hoping to devise some means of keeping the GB2SM callsign on the air until the replacement exhibit is in place.

CORRECTION!

In the November column, reporting on the new power level for Top Band, it was indicated that this extended across the whole band. In fact, 26dBW is only permitted over the sub-band 1·810MHz to 1·850MHz. For the rest of the band, up to 2·000MHz, the limit is still 15dBW.

My thanks to reader Les Caine, G4XVQ, for writing to me about this "slip of the pen" as he so tactfully described it!

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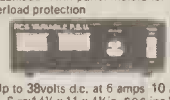

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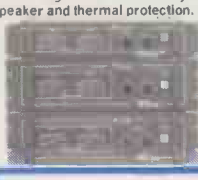

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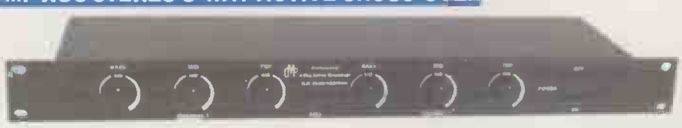

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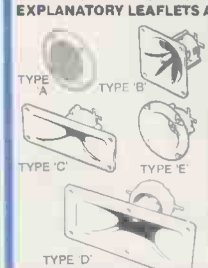

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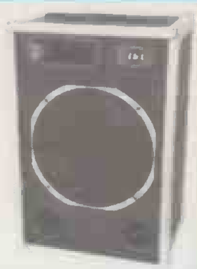

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THREE SUPERB HIGH POWER CAR STEREO BOOSTER AMPLIFIERS
150 WATTS (75 + 75) Stereo, 150W Bridged Mono
250 WATTS (125 + 125) Stereo, 250W Bridged Mono
400 WATTS (200 + 200) Stereo, 400W Bridged Mono
ALL POWERS INTO 4 OHMS
Features:
★ Stereo, bridgable mono ★ Choice of high & low level inputs ★ L & R level controls ★ Remote on-off ★ Speaker & thermal protection.

PRICES: 150W £49.99 250W £99.99
400W £109.95 P&P £2.00 EACH

OMP MOS-FET POWER AMPLIFIER MODULES

SUPPLIED READY BUILT AND TESTED.

These modules now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models are available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE that all models include toroidal power supply, integral heat sink, glass fibre P.C.B. and drive circuits to power a compatible Vu meter. All models are open and short circuit proof.

THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 123 x 60mm.
PRICE £40.85 + £3.50 P&P

OMP/MF 200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 155 x 100mm.
PRICE £64.35 + £4.00 P&P

OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 330 x 175 x 100mm.
PRICE £81.75 + £5.00 P&P

OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
PRICE £132.85 + £5.00 P&P

OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
PRICE £259.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

LOUDSPEAKERS

LARGE SELECTION OF SPECIALIST LOUDSPEAKERS AVAILABLE, INCLUDING CABINET FITTINGS, SPEAKER GRILLES, CROSS-OVERS AND HIGH POWER, HIGH FREQUENCY BULLETS AND HORNS, LARGE (A4) S.A.E. (60p STAMPED) FOR COMPLETE LIST.

McKenzie and Fane Loudspeakers are also available.

EMINENCE:- INSTRUMENTS, P.A., DISCO, ETC

ALL EMINENCE UNITS 8 OHMS IMPEDANCE

8" 100 WATT R.M.S. ME8-100 GEN. PURPOSE, LEAD GUITAR, EXCELLENT MID, DISCO.
RES. FREQ. 72Hz, FREQ. RESP. TO 4KHz, SENS 97dB. PRICE £32.71 + £2.00 P&P
10" 100 WATT R.M.S. ME10-100 GUITAR, VOCAL, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 71Hz, FREQ. RESP. TO 7KHz, SENS97dB. PRICE £33.74 + £2.50 P&P
10" 200 WATT R.M.S. ME10-200 GUITAR, KEYB'D, DISCO, VOCAL, EXCELLENT HIGH POWER MID.
RES. FREQ. 65Hz, FREQ. RESP. TO 3.5KHz, SENS 99dB. PRICE £43.47 + £2.50 P&P
12" 100 WATT R.M.S. ME12-100LE GEN. PURPOSE, LEAD GUITAR, DISCO, STAGE MONITOR.
RES.FREQ. 49Hz, FREQ. RESP. TO 6KHz, SENS 100dB. PRICE £35.64 + £3.50 P&P
12" 100 WATT R.M.S. ME12-100LT (TWIN CONE) WIDE RESPONSE, P.A., VOCAL, STAGE MONITOR. RES. FREQ 42Hz, FREQ. RESP. TO 10KHz, SENS 98dB. PRICE £36.67 + £3.50 P&P
12" 200 WATT R.M.S. ME12-200 GEN. PURPOSE, GUITAR, DISCO, VOCAL, EXCELLENT MID.
RES. FREQ. 58Hz, FREQ. RESP. TO 6KHz, SENS 98dB. PRICE £46.71 + £3.50 P&P
12" 300 WATT R.M.S ME12-300GP HIGH POWER BASS, LEAD GUITAR, KEYBOARD, DISCO ETC.
RES. FREQ. 47Hz, FREQ. RESP. TO 5KHz, SENS 103dB. PRICE £70.19 + £3.50 P&P
15" 200 WATT R.M.S. ME15-200 GEN. PURPOSE BASS, INCLUDING BASS GUITAR.
RES. FREQ. 46Hz, FREQ. RESP. TO 5KHz, SENS 99dB. PRICE £50.72 + £4.00 P&P
15" 300 WATT R.M.S. ME15-300 HIGH POWER BASS, INCLUDING BASS GUITAR.
RES. FREQ. 39Hz, FREQ. RESP. TO 3KHz, SENS 103dB. PRICE £73.34 + £4.00 P&P

EARBENDERS:- HI-FI, STUDIO, IN-CAR, ETC

ALL EARBENDER UNITS 8 OHMS (Except EB8-50 & EB10-50 which are dual impedance tapped @ 4 & 8 ohm)
BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED SURROUND
8" 50watt EB8-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 7KHz SENS 97dB. PRICE £8.90 + £2.00 P&P
10" 50WATT EB10-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 5KHz, SENS. 99dB. PRICE £13.65 + £2.50 P&P
10" 100WATT EB10-100 BASS, HI-FI, STUDIO.
RES. FREQ. 35Hz, FREQ. RESP. TO 3KHz, SENS 96dB. PRICE £30.39 + £3.50 P&P
12" 100WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO.
RES. FREQ. 26Hz, FREQ. RESP. TO 3 KHz, SENS 93dB. PRICE £42.12 + £3.50 P&P
FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND
5¼" 60WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 63Hz, FREQ. RESP. TO 20KHz, SENS 92dB. PRICE £9.99 + £1.50 P&P
6½" 60WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 38Hz, FREQ. RESP. TO 20KHz, SENS 94dB. PRICE £10.99 + 1.50 P&P
8" 60WATT EB8-60TC (TWIN CONE) HI-FI, MILTI-ARRAY DISCO ETC.
RES. FREQ. 40Hz, FREQ. RESP. TO 18KHz, SENS 89dB. PRICE £12.99 + £1.50 P&P
10" 60WATT EB10-60TC (TWIN CONE) HI-FI, MULTI ARRAY DISCO ETC.
RES. FREQ. 35Hz, FREQ. RESP. TO 12KHz, SENS 98dB. PRICE £16.49 + £2.00 P&P

TRANSMITTER HOBBY KITS

PROVEN TRANSMITTER DESIGNS INCLUDING GLASS FIBRE PRINTED CIRCUIT BOARD AND HIGH QUALITY COMPONENTS COMPLETE WITH CIRCUIT AND INSTRUCTIONS

3W TRANSMITTER 80-108MHz, VARICAP CONTROLLED PROFESSIONAL PERFORMANCE, RANGE UP TO 3 MILES, SIZE 38 x 123mm, SUPPLY 12V @ 0.5AMP.
PRICE £14.85 + £1.00 P&P

FM MICRO TRANSMITTER 100-108MHz, VARICAP TUNED, COMPLETE WITH VERY SENS FET MIC, RANGE 100-300m, SIZE 56 x 46mm, SUPPLY 9V BATTERY.
PRICE £8.80 + £1.00 P&P

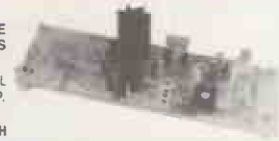

PHOTO: 3W FM TRANSMITTER

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