EVERYDAY ELECTRONICS

858

JUNE 1992

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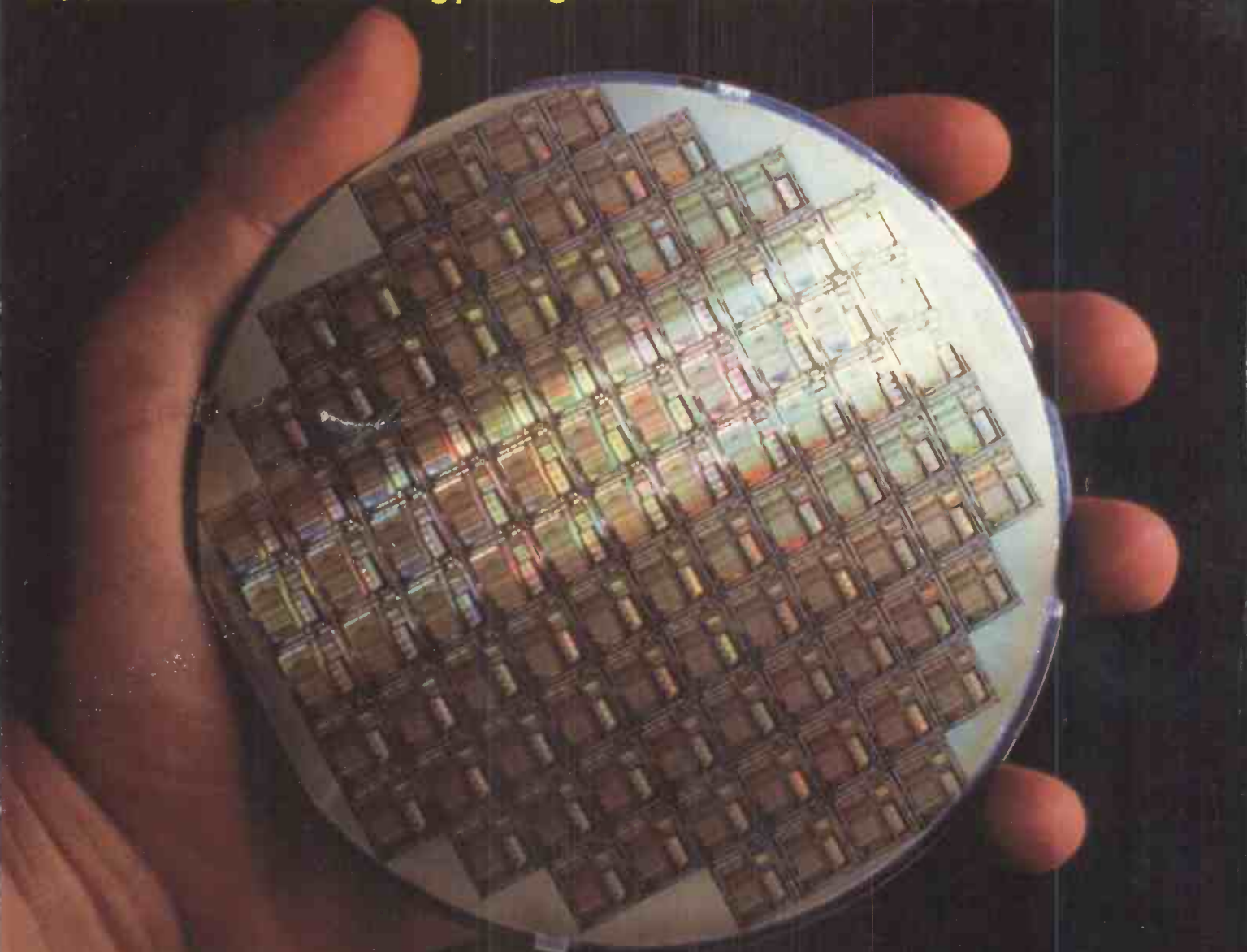

CCD REVERB UNIT

VEHICLE WATCHDOG

MAKING YOUR OWN P.C.B.s – 2

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

AMSTRAD PORTABLE PC'S FROM £149 (PPC1512SD). £179 (PPC1512DD). £179 (PPC1640SD). £209 (PPC1640DD). MODEMS £30 EXTRA.NO MANUALS OR PSU.

HIGH POWER CAR SPEAKERS. Stereo pair output 100w each. 4ohm impedance and consisting of 6 1/2" woofer 2" mid range and 1" tweeter. Ideal to work with the amplifier described above. Price per pair £30.00 Order ref 30P7R.

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12 BAND COMMUNICATIONS RECEIVER. 9 short bands, FM, AM and LW DX/local switch, tuning 'eye' mains or battery. Complete with shoulder strap and mains lead NOW ONLY £19.00!! REF 19P14R.

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FM BUG Built and tested superior 9v operation £14.00 ref 14P3R

COMPOSITE VIDEO KITS. These convert composite video into separate H sync, V sync and video. 12v DC. £8.00 ref 8P39R.

SINCLAIR C5 MOTORS 12v 29A (full load) 3300 rpm 6"x4" 1/4" O/P shaft. New. £20.00 ref 20P22R.

As above but with fitted 4 to 1 inline reduction box (800rpm) and toothed nylon belt drive cog £40.00 ref 40P8R.

SINCLAIR C5 WHEELS 13" or 16" dia including treaded tyre and inner tube. Wheels are black, spoked one piece poly carbonate. 13" wheel £6.00 ref 6P20R, 16" wheel £6.00 ref 6P21R.

ELECTRONIC SPEED CONTROL KIT for c5 motor. PCB and all components to build a speed controller (0-95% of speed). Uses pulse width modulation. £17.00 ref 17P3R.

SOLAR POWERED NICAD CHARGER. Charges 4 AA nicads in 8 hours. Brand new and cased £6.00 ref 6P3R.

12 VOLT BRUSHLESS FAN 4 1/2" square brand new ideal for boat, car, caravan etc. £5.00 ref 5P206.

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VIDEO TAPES. Three hour superior quality tapes made under licence from the famous JVC company. Pack of 5 tapes New low price £8.00 ref 8P161

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12 TO 220V INVERTER KITAs supplied it will handle up to about 15 w at 220v but with a larger transformer it will handle 80 watts. Basic kit £12.00 ref 12P17R. Larger transformer £12.00 ref 12P41R.

VERO EASI WIRE PROTOTYPING SYSTEM Ideal for designing projects on etc. Complete with tools, wire and reusable board. New low bargain price only £2.00 ref B2P1

HIGH RESOLUTION 12" AMBER MONITOR 12v 1.5A Hercules compatible (TTL input) new and cased £22.00 ref 22P2R

VGA PAPER WHITE MONO monitors new and cased 240v AC. £59.00 ref 59P4R

25 WATT STEREO AMPLIFIER c STK043. With the addition of a handful of components you can build a 25 watt amplifier. £4.00 ref 4P69R (Circuit dia included).

BARGAIN NICADS AAA SIZE 200MAH 1.2V PACK OF 10 £4.00 REF 4P92R, PACK OF 100 £30.00 REF 30P16R

FRESNEL MAGNIFYING LENS 83 x 52mm £1.00 ref BD827R.

ALARM TRANSMITTERS. No data avaliable but nicely made complex radio transmitters 9v operation. £4.00 each ref 4P81R.

12V 19A TRANSFORMER. Ex equipment but otherwise ok. Our price £20.00

GX4000 COMPUTERS. Customer returned games machines complete with plug in game, joysticks and power supply. Retail price is almost £100. Ours is £12.00 ref B12P1

ULTRASONIC ALARM SYSTEM. Once again in stock these units consist of a detector that plugs into a 13A socket in the area to protect. The receiver plugs into a 13A socket anywhere else on the same supply. Ideal for protecting garages, sheds etc. Complete system £25.00 ref B25P1 additional detectors £11.00 ref B11P1

IBM XT KEYBOARDS. Brand new 86 key keyboards £5.00 ref 5P612

IBM AT KEYBOARDS Brand new 86 key keyboards £15.00 ref 15P612

386 MOTHER BOARDS. Customer returned units without a cpu fitted. £22.00 ref A22P1

BSB SATELLITE SYSTEMS

BRAND NEW

REMOTE CONTROL

£49.00 REF F49P1

286 MOTHER BOARDS. Brand new but customer returns so may need attention. Complete with technical manual £20.00 ref A20P2

286 MOTHER BOARDS. Brand new and tested complete with technical manual. £49.00 ref A49P1

UNIVERSAL BATTERY CHARGER. Takes AA's, C's, D's and PP3 nicads. Holds up to 5 batteries at once. New and cased, mains operated. £6.00 ref 6P36R.

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CAPACITOR PACK [illegible]

MIRACOM WS4000 MODEMS

V21/23

AT COMAND SET

AUTODIAL/AUTOANSWER

FULL SOFTWARE CONTROL

TONE AND PULSE DIALLING

£29

IBM PRINTER LEAD. (D25 to centronics plug) 2 metre parallel. £5.00 ref 5P186R.

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50 METRES OF MAINS CABLE £3.00 2 core black precut in convenient 2 m lengths. Ideal for repairs and projects. ref 3P91R

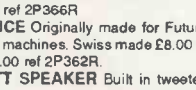
4 CORE SCREENED AUDIO CABLE 24 METRES £2.00 Precut into convenient 1.2 m lengths. Ref 2P365R

TWEETERS 2 1/4" DIA 8 ohm mounted on a smart metal plate for easy fixing £2.00 ref 2P366R

COMPUTER MICE Originally made for Future PC's but can be adapted for other machines. Swiss made £8.00 ref 8P57R. Atari ST conversion kit £2.00 ref 2P362R.

6 1/2" 20 WATT SPEAKER Built in tweeter 4 ohm £5.00 ref 5P205R

WINDUP SOLAR POWERED RADIO! FM/AM radio takes rechargeable batteries complete with hand charger and solar panel 14P200R



PC STYLE POWER SUPPLY Made by AZTEC 110v or 240v input. +5 @ 15A, +12 @ 5A, -12 @ .5A, -5 @ .3A. Fully cased with fan, on/off switch, IEC inlet and standard PC flyleads. £15.00 ref F15P4

ALARM PIR SENSORS Standard 12v alarm type sensor will interface to most alarm panels. £16.00 ref 16P200

ALARM PANELS 2 zone cased keypad entry, entry exit time delay etc. £18.00 ref 18P200

MODEMS FOR THREE POUNDS!!

Fully cased UK modems designed for dial up system (PSTN) no data or info but only £3.00 ref 3P145R

TELEPHONE HANDSETS

Bargain pack of 10 brand new handsets with mic and speaker only £3.00 ref 3P146R

BARGAIN STRIPPERS

Computer keyboards. Loads of switches and components excellent value at £1.00 ref CD40R

DATA RECORDERS

Customer returned mains battery units built in mic ideal for Computer or general purpose audio use. Price is £4.00 ref 4P100R

SPECTRUM JOYSTICK INTERFACE

Plugs into 48K Spectrum to provide a standard Atari type joystick port. Our price £4.00 ref 4P101R

ATARI JOYSTICKS

Ok for use with the above interface, our price £4.00 ref 4P102R

BENCH POWER SUPPLIES

Superbly made fully cased (metal) giving 12v at 2A plus a 6V supply. Fused and short circuit protected. For sale at less than the cost of the case! Our price is £4.00 ref 4P103R

SPEAKER WIRE

Brown twin core insulated cable 100 feet for £2.00 REF 2P79R

MAINS FANS

Brand new 5" x 3" complete with mounting plate quite powerfull and quite. Our price £1.00 ref CD41R

DISC DRIVES

Customer returned units mixed capacities (up to 1.44M) We have not sorted these so you just get the next one on the shelf. Price is only £7.00 ref 7P1R (worth it even as a stripper)

HEX KEYBOARDS

Brand new units approx 5" x 3" only £1.00 each ref CD42R

PROJECT BOX

51/2" x 31/2" x 1" black ABS with screw on lid. £1.00 ref CD43R

SCART TO SCART LEADS

Bargain price leads at 2 for £3.00 ref 3P147R

SCART TO D TYPE LEADS

Standard Scart on one end, Hi density D type on the other. Pack of ten leads only £7.00 ref 7P2R

OZONE FRIENDLY LATEX

250ml bottle of liquid rubber sets in 2 hours. Ideal for mounting PCB's fixing wires etc. £2.00 each ref 2P379R

QUICK SHOTS

Standard Atari compatible hand controller (same as joysticks) our price is 2 for £2.00 ref 2P380R

VIEWDATA SYSTEMS

Brand new units made by TANDATA complete with 1200/75 built in modem infra red remote controlled qwerty keyboard BT appproved Prestel compatible, Centronics printer port RGB colour and composite output (works with ordinary television) complete with power supply and fully cased. Our price is only £20.00 ref 20P1R

AC STEPDOWN CONVERTOR

Cased units that convert 240v to 110v 3" x 2" with mains input lead and 2 pin American output socket (suitable for resistive loads only) our price £2.00 ref 2P381R

SPECTRUM +2 LIGHT GUN PACK

complete with software and instructions £8.00 ref 8P58R/2

CURLY CABLE

Extends from 8" to 6 feet! D connector on one end, spade connectors on the other ideal for joysticks etc (6 core) £1.00 each ref CD44R

COMPUTER JOYSTICK BARGAIN

Pack of 2 joysticks only £2.00 ref 2P382R

BUGGING TAPE RECORDER

Small hand held cassette recorders that only operate when there is sound then turn off 6 seconds after so you could leave it in a room all day and just record any thing that was said. Price is £20.00 ref 20P3R

IEC MAINS LEADS

Complete with 13A plug our price is only £3.00 for TWO! ref 3P148R

NEW SOLAR ENERGY KIT

Contains 8 solar cells, motor, tools, fan etc plus educational booklet. Ideal for the budding enthusiast! Price is £12.00 ref 12P2R

286 AT PC

286 MOTHER BOARD WITH 640K RAM FULL SIZE METAL CASE, TECHNICAL MANUAL, KEYBOARD AND POWER SUPPLY £139 REF 139P1 (no i/o cards or drives included) Some metal work req'd phone for details.

35MM CAMERAS Customer returned units with built in flash and 28mm lens 2 for £8.00 ref 8P200

STEAM ENGINE Standard Mamod 1332 engine complete with boiler piston etc £30 ref 30P200

TALKING CLOCK

LCD display, alarm, battery operated. Clock will announce the time at the push of a button and when the alarm is due. The alarm is switchable from voice to a cock crowing! £14.00 ref 14P200.R

HANDHELD TONE DIALLERS

Small units that are designed to hold over the mouth piece of a telephone to send MF dialling tones. Ideal for the remote control of answer machines. £5.00 ref 5P209R

COMMODORE 64 MICRODRIVE SYSTEM

Complete cased brand new drives with cartridge and software 10 times faster than tape machines works with any Commodore 64 setup. The orginal price for these was £49.00 but we can offer them to you at only £25.00! Ref 25P1R

ATARI 2600 GAMES COMPUTER Brand new with joystick and 32 game cartridge (plugs into TV) £29.00 ref F29P1 also some with 1 game at £19.00 ref F19P2.

BEER PUMPS Mains operated with fluid detector and electronic timer standard connections. Ex equipment. £18.00 ref F18P1

90 WATT MAINS MOTORS Ex equipment but ok (as fitted to above pump) Good general pupose unit £9.00 ref F9P1

HI FI SPEAKER BARGAIN Originally made for TV sets they consist of a 4" 10 watt 4R speaker and a 2" 140R tweeter. If you want two of each plus 2 of our crossovers you can have the lot for £5.00 ref F5P2.

VIDEO TAPES E180 FIFTY TAPES FOR £70.00 REF F70P1

360K 5 1/4" Brand new drives white front. £20.00 Ref F20P1

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EVERYDAY ELECTRONICS
INCORPORATING ELECTRONICS MONTHLY
ABC

VOL. 21 No. 6 JUNE 1992

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

ISSN 0262 3617

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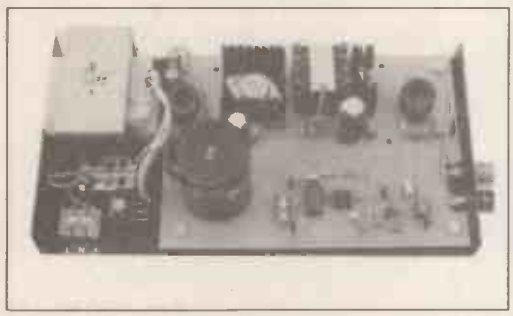
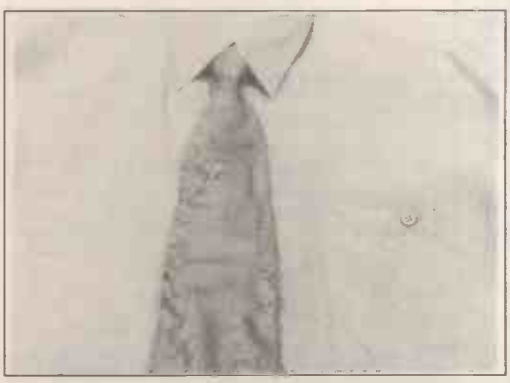
COMMENT . . . POPULAR FEATURES . . .





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Our July '92 Issue will be published on Friday, 5 June 1992. See page 331 for details.

2 x 220 watt MOSFET AMPLIFIER

A top-of-the-range performer that will satisfy the most demanding audio enthusiast. If you're looking for an amplifier to power your subwoofer, the **SPARKOMATIC** is all you'll need! Highly sophisticated MOS-FET technology dramatically extends frequency response, separate input sensitivity controls, built-in protection circuitry for overheat and short circuit with l.e.d. indication, output power: 2 x 220 watt maximum and 2 x 110 watt at 0.1% THD, Bridged 440 watt mono maximum and 220 watt mono at 0.5% THD.

£168.50 plus £3.50 p&p

100 watt x 4 CLASS A AMPLIFIER FOR CARS

Delivers 4 x 100 watt into 4 woofers or with the aid of its built in active cross over delivers 200 watt of Bass via sub-woofer output and 2 x 100 watt, full range into 2 speakers; thus giving you all the power you require to make even traffic jams a positive pleasure. SPECIFICATION 4 x 100W (4Ω), 2 x 200W Bridged, THD .08%, S/N RATIO: 7 90db, RESPONSE 10Hz-50kHz, LOW PASS FILTER SWITCHED 75Hz 150Hz, INPUT 4 x PHONO 100-3 Volts, INPUT x 4 HIGH LEVEL 20kΩ, SIZE 240mm x 50mm x 400mm.

£118.50 postage £4.50

80 watt CAR POWER AMPLIFIER

The AMP 7000 produces high power at low distortion. The amplifier accommodates low level, high level and high power radio speaker inputs. The response is linear and extends beyond the capability of all music sources. This compact unit mounts easily and its quick connect terminals accept RCA or straight wire input terminals. Power rating 2 x 40 watt per channel. MMP 2 x 20 watt at 10%. THD response 20Hz-20kHz. Size 160mm x 130mm x 45mm.

£32.95 plus £3.50 p&p

11 BAND COMPONENT GRAPHIC EQUALIZER FOR CARS

This neat unit connects between the line output of your car stereo and your power amplifiers so that you are able to adjust the sound as in a studio compensating for soft furnishing and sound reflections from glass, also it has a subwoofer output to drive a separate amplifier for that extra deep bass sound. FEATURES: 2 channel inputs 4 channel outputs via phono sockets, CD input via 3.5mm jack 11 band graphic. SPECIFICATION RANGE 20Hz-60kHz THD 0.05%, S/N RATIO 85dB. EQ FREQUENCIES 60Hz, 120Hz, 250Hz, 380Hz, 500Hz, 750Hz, 1kHz, 2kHz, 4kHz, 8kHz, 16kHz (boost cut of ±12dB) SIZE 178mm x 25mm x 140mm.

£32.70 postage £1.80

EMINENCE 4Ω PROFESSIONAL USA MADE IN CAR CHASSIS SPEAKERS

All units are fitted with big magents "Nomex" Voice coils NOT ALUMINIUM, "Nomex" is very light and can stand extremely high temperatures, this mixture makes for high efficiency and long lasting quality of sound.

V6 6½" 200W Max	Range 50Hz-3kHz £34.40
V6 8" 300W Max	Range 45Hz-3kHz £39.35
V10 10" 400W Max	Range 33Hz-4kHz £44.45
V12 12" 400W Max	Range 35Hz-3kHz £45.95
BOSS 15" 800W Max	Range 35Hz-4kHz £79.90
KING 18" 1200W Max	Range 20Hz-1kHz P.O.A.

Postage **£3.85** per speaker.

Build your own Bazooka sub woofer tube to suit Eminence car speakers. 10mm thick fibre supplied with grille and clamp terminals finished in black vinyl.

Eminence U10, Size 270mm x 700mm

£25.95 £3.50 p&p

Eminence U12 Size 320mm x 710mm

£29.95 £3.50 p&p

MAIL ORDER BARGAIN PACKS

No.	Qty.	per pack
MO20	1	30W dome tweeter by *Eagle/Japan Made* size 90mm x 66mm £1
MO21	1	60W Hifi tweeter made for *Jamo UK* size 90mm sq. £1
MO22	2	30 watt 8 ohm Hifi chassis speakers. *Made for Hitachi UK* midi systems, size 125mm sq. with large 70mm magnet £9.00 + £2.00 p&p
MO23	2	Pod Car Speakers. Moulded in black plastic with 15 watt 10cm *Goodmans* unit fitted £4.95 + £2.50 p&p
MO23A	1pr	40 watt Car Speakers made for Roadstar of Switzerland. Fitted with dual polypropylene cone and foam rubber surround. Big 70mm magent for good base response. Supplied with grills fixing screws and cable. Size 30cm, weight 1.5Kg £11.70 pair + £3.65 p&p or TWO pairs for £25.00 UK post paid
MO24	2	Audax JBL 40-100watt dome tweeters. High performance 10mm Ferrofluid cooled horn loaded unit for load distortion and high output. Supplied with 1st order crossover, spec. 40 watts at 3kHz, 100 watt at 8kHz; size 51mm x 51mm x 16.5mm. Ideal for car use £7.50 + £1 p&p
MO25	2	33000µF 10V d.c. can type computer grade quality electrolytic *UK made* £1
MO25A	1	47µF 385V d.c. can type electrolytic. Size 350mm x 250mm. *UK made by Phillips* £1.75
MO26	2	680µF 100V d.c. can type electrolytic size 45mm x 25mm £1
MO27	3	2200µF 25V d.c. can type electrolytic size 45mm x 25mm £1
MO28	1	15000µF 40V d.c. can type 23A electrolytic size 113mm x 50mm £1
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MO38	1	Dual VU meter 280µA f.s.d., size 80mm x 42mm x 15mm £1.50
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MO42	20	5 Pin Din 180°chassis mount sockets £1
MO43	6	Double phono sockets £1
MO44	5	6.35mm (¼") Stereo Jack sockets £1
MO45	4	6.35 (¼") Mono Jack Plugs £1
MO46	12	Coax Sockets chassis mount £1
MO47	2	Case handles plated U-shape, size 97mm x 50mm £1
MO48	30	Mixed control knobs £1
MO49	1	Cassette tape transport mechanism, belt-drive, top loading, six piano key operation with knobs, stereo record/replay erase heads, heavy fly-wheel £5.50 + £2.65 p&p
MO50	1	Hifi stereo pre-amp. module. Input for CD Tuner record player with diagram. *Made by Mullard* £1
MO51	2	AM/FM tuner head modules'. *Made by Mullard* £1
MO52	3	AM I.F. modules'. *Made by Mullard* £1
MO53	1	FM stereo decoder module with diagram. *Made by Mullard* £1
MO54	3	UHF Varicap tuned tuner heads unboxed, untested but complete. *Made by Mullard* £1
MO55	1	25V d.c. 150mA Mains adaptor in neat plastic box, size 80mm x 55mm x 47mm £1
MO55A	1	80mm Cooling Fan. Five bladed A.C. impedance corrected motor on a cast aluminium chassis. Size 80mm x 40mm. Voltage 115V a.c. working, 130mA. *Japanese made.* £5.95 + £1.40 p&p, TWO for £11.20 UK post paid
MO56	2	6V-0V-6V 4VA p.c.b. mount mains transformer 240V input, size 42mm x 33mm x 35mm. *UK Made* £1
MO57	25	4 Volt miniature wire-ended bulbs £1
MO57A	1	SRBP Copper Clad Printed Circuit Board. Size 410mm x 360mm x2mm £3.65 + 75 p&p
MO58	2	Mono cassette tape heads. *Japan Made* £1
MO59	2	Sonotone stereo cartridge with 78 and LP Styl. *Japan Made* £1
MO60	8	Bridge rectifiers 1 amp 24Volt £1
MO61	10	OC44 transistors. "Remove paint from top and it becomes a photo electric cell (ORP12) £1
MO62	30	Low signal transistors *npn* and *pnp* type £1
MO63	6	14 watt output transistors. Three complimentary pairs in T066 case (replacement for AD161 +162) £1
MO64	5	5 watt Audio i.c. No. TBA800 £1
MO65	5	Motor Speed Control i.c. £1
MO66	1	Digital DVM Meter i.c. *Made by Plessey*, with diagram £1
MO67	4	7-Segment 0.3in l.e.d. display (red) £1
MO68	1	Tape Deck i.c., with record replay switching. No. LM1818, with diagram £1
MO69	2	Ferrite Rod. High grade with LW, SW & MW coils, size 140mm x 10mm £1
MO70	1	Moving coil dynamic, handheld, ball microphone. *Ross Electronics* customers returns (*no warrantee*) £1
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MO72	1	WW II EX WD headphone, A BIT OF NOSTALGIA, low impedance £3.50 + £1.20 p&p
MO73	1	Koss Stereo Headphones on ear. Lightweight design, vari-fitting ear-cups with contour cushions, 36in. cord. 3.5mm + 6.35mm Jack plug adaptor £3.50 + £1 p&p
MO74	2	Tone dialling keypad, use services that require DTMF tone signals for a rotary dial pulse phone, size 90mm x 55mm 12mm £11.00 + 70p p&p
MO75	1	100 yard roll of single screened quick splice cable, good quality *British Made* £4.50 + £2 p&p
MO76	1	100 yard 3-core 3 amp cable, coded brown, blue and green/yellow £4.20 + £2 p&p
MO78	1	TV Aerial Amplifier housed in a neat plastic box, coax input and output sockets. Mains operated. Double the output signal of your aerial £6.50 + £1.50 p&p
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MO80	2	Solar Powered Wooden Kits. Easy to build aeroplane, with revolving propeller, and an old time gramophone with music chip. Supplied with glue, solar cells, electronics and pre-cut panels. One of each for £12.00 + £1.50 p&p
MO81	1	Bump and Go Space Ship Kit with motor, wheels, p.c.b. wire and diagram. An ideal introduction for youngsters into the world of electronics and mechanics; goes all the way to the moon on two AA batteries £8.95 + £1 p&p
MO82	1	Filofax Personal Organiser Radio/Calculator. This neat little unit simply fits inside your filofax so you can listen to AM Radio with earphone or use it as a solar powered 8-digit calculator. Punched with six holes to fit all personal organisers. *UK Made* under ½ price £8.95 + £1 p&p
MO83	1	Video Sender. With this handy unit you can transmit output of your home video, wideo camcorder or satelite equipment over the air to a receiving television within a range of 100ft. Simply connect the video and audio output of your equipment into this unit, and a 10-13.8V d.c. power supply – extra £3.75 £11.75 + £2 p&p
MO84	1	Multiband radio. Listen to air traffic control, aircraft, radar, public utilities VHF 54-176MHz + CB 1-80 with built in squelch control £17.95 + £2 p&p
MO85	2	AM, FM. LW Ross Pushbutton Radio. With this neat unit you can easily tune in to five pre-set stations of your choice without fiddling or fuss, runs off six C-cell batteries or 240V mains. Output 400mW, volume and tone control. Size 230mm x 150mm x 65mm £23.00 + £3.65 p&p
MO86	1	(As above) £15.00 + £2.80 p&p
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This unit is played on a "field" measuring 300mm × 230mm and accomodates a range of bowling speeds, provides various hit scores and the usual ways of getting someone out. You can also play whatever the weather!

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EVERYDAY ELECTRONICS

JULY ISSUE ON SALE FRIDAY 5TH JUNE 1992

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MTX Micro-miniature Room Transmitter
Best-selling micro-miniature Room Transmitter
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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 ★★★

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Complete System (2 kits).....£50.95
Individual Transmitter DLTX.....£19.95
Individual Receiver DLRX.....£37.95

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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

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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 catlogue). Size 20mm x 67mm. 9V operation. 1000m range.....£40.95

QLX180 Crystal Cointrolled 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

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Z5147 4700µF 100V 105 x 51mm dia. **£3.00; Box of 35 £70.00**; 100+ 1.50; 1k+ 1.20

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Z8956 These were the units screwed to various buildings throughout the UK which you stood next to whilst making a phone call with your incredibly useful handset! Too bad if you weren't in range (99.9% of the UK wasn't!) but it was a nice toy while it lasted. There was a lot of clever technology involved, and we're selling these at probably about 1% or 2% of their real cost! So what do you get for your money? Well, a lot of case for a start - in the outer steel case (a) 480 x 300 x 150mm with fibre glass aerial case on top (b) 250 x 160 x 75mm, there's another steel case (c) 325 x 245 x 130mm and inside there's a plastic box (d) 200 x 15 x 75mm. (a) contains a metal surfave mounting 13A socket and a BT line socket. (b) has 2 whip aerials 200mm long terminated in PL259 plugs. (c) contains 8V 3.8Ah sealed lead acid battery, mains transformer (10V 2A Sec), mains filter and a plethora of plugs and sockets mounted on top - 3 BNC and 2 x 9 pin 'D' type, also 2 fuse holders, a lead with 13A plug and another lead with BT plug, and a power on/ off toggle. Screwed to the inside of the lid is a PCB 250 x 160 with lots of nice bits - 64180 CPU, 27C256 EPROM, 5256 - 15 256K RAM x 3, LM2940, LM317T, BD680 x 2, 3.6V AA size lithium cell in holder, about 30 various linear/logic chips, 3 xtals etc, etc. (you're getting great value for money here !) (d) contains Tx/Rx panel 170 x 135mm. Lovely bit of kit, this, all surface mount - about 20 chips. inputs and outputs are taken to 2 min PCB sockets. There's another panel the same size in this box, with lots of hi - tech devices - 2 x TMS77C82, programmable 8 bit microcontroller , 77C01, TMS320MC10FNL. 16/32 bit signal processor, LM2984 triple 5V output regulator and another 10 chips, 4 'D' plugs/sockets and lots of other bits. And that's about it!

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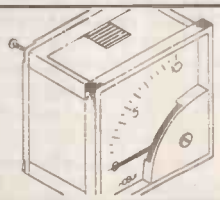

10 AMP METER

Panel meter by Hobut, 72 x 72mm. Scaled 0 - 10A AC. Moving iron.

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Z8973 A compact V21/v23 300 or 1200/75 baud modem, new, boxed and complete with power supply but without manual, but, data supplied. Plugs into standard BT socket and RS232 port on any computer. Tone/auto dialing last number re-dial. 205mm x 195mm x 30mm. Front panel has reset button, and 5 status LED's Excellent value for money - **£49.95**

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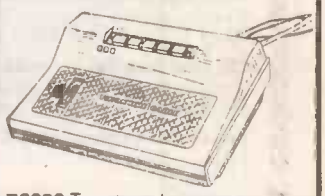

Z8939 Two tone brown case contains PCB 192 x 195mm with easily removed UHF modulator made by Labgear (Sound and Vision); video pre-amp; stabilised power supply and all the decoding circuitry (9 transistors and TBA673 chip). On the front of the case is a cable/off air switch and 5 push buttons (5 channels and on/off mains switch). There are 4 cables coming from the rear. The case can easily be utilised for other purposes - the dark brown inserts on the front are both easily removable, if required. Please note the low price we are asking in no way reflects their true worth - they're taking up a lot of space, so we need to shift them quickly!! Supplied with circuit diagram. **Price....£6.95** 100+ 3.50 1k+ 2.50

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EE Jan '92

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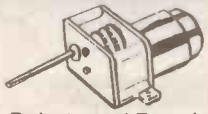

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724	SUPER SOUND ADAPTOR Aug 87	£43.86
722	FERMOSTAT July 87	£13.88
719	BUCCANEER I.B. METAL DETECTOR July 87	£30.22
718	3-BAND 1.6-30MHz RADIO Aug 87	£30.30
715	MINI DISCO LIGHTS June 87	£14.39
707	EQUALIZER (IONISER) May 87	£17.75

Ref		Price
700	ACTIVE I/R BURGLAR ALARM Mar 87	£40.74
584	SPECTRUM SPEECH SYNTH (no case) Feb 87	£23.90
581	VIDEO GUARD Feb 87	£9.59
569	CAR ALARM Dec 86	£14.24
561	LIGHT RIDER LAPEL BADGE Oct 86	£11.65
560	LIGHT RIDER DISCO VERSION Oct 86	£22.41
559	LIGHT RIDER 16 LED VERSION Oct 86	£15.58
556	INFRA-RED BEAM ALARM Sep 86	£32.39
544	TILT ALARM July 86	£8.94
542	PERSONAL RADIO June 86	£13.17
528	PA AMPLIFIER May 86	£30.60
523	STEREO REVERB Apr 86	£30.21
513	BBC MIDI INTERFACE Mar 86	£31.93
512	MAINS TESTER & FUSE FINDER Mar 86	£10.07
497	MUSICAL DOOR BELL Jan 86	£21.41
493	DIGITAL CAPACITANCE METER Dec 85	£49.95
481	SOLDERING IRON CONTROLLER Oct 85	£6.25
464	STEPPER MOTOR INTERFACE FOR THE BBC COMPUTER less case Aug 85	£9.60
	1D35 STEPPER MOTOR EXTRA	£9.15
	OPTIONAL POWER SUPPLY PARTS	£5.86
461	CONTINUITY TESTER July 85	£7.08
455	ELECTRONIC DOORBELL June 85	£8.63
444	INSULATION TESTER Apr 85	£22.37
392	BBC MICRO AUDIO STORAGE SCOPE INTERFACE Nov 84	£40.82
387	MAINS CABLE DETECTOR Oct 84	£6.31
386	DRILL SPEED CONTROLLER Oct 84	£9.91
362	VARICAP AM RADIO May 84	£15.02
337	BIOLOGICAL AMPLIFIER Jan 84	£27.59
263	BUZZ OFF Mar 83	£6.49
242	INTERCOM no case July 82	£6.50
240	EGG TIMER June 82	£7.85
108	IN SITU TRANSISTOR TESTER June 78	£10.76
106	WIERD SOUND EFFECTS GEN Mar 78	£8.94
101	ELECTRONIC DICE Mar 77	£7.15

EDUCATIONAL BOOKS & BOOK PROJECTS

ADVENTURES WITH ELECTRONICS

The classic Easy to Follow book suitable for all ages. ideal for beginners. No soldering, uses an S-DEC breadboard. Gives clear instructions with lots of pictures. 16 projects – including three radios, siren, metronome, organ, intercom, timer, etc. Helps you learn about electronic components and how circuits work. Component pack includes an S-DEC breadboard and all the components for the series.

Adventures with Electronics **£6.25**
Component Pack (less book) **£22.83**

FUN WITH ELECTRONICS

From the USBORNE Pocket Scientist series – an enjoyable introduction to electronics. Full of very clear full colour pictures accompanied by easy to follow text. Ideal for all beginners – children and adults. Only basic tools are needed. 64 full colour pages cover all aspects – soldering – fault finding – components (identification and how they work). Also full details of how to build 6 projects – burglar alarm, radio, games, etc. Requires soldering – 4 pages clearly show you how. The components supplied in our pack allows all the projects to be built and kept. The book is available separately.

Fun with Electronics Book **£2.95**
Component pack (less book) **£17.93**

30 SOLDERLESS BREADBOARD PROJECTS

A book of projects by R. A. Penfold covering a wide range of interests. All projects are built on a Verobloc breadboard. Full layout drawings and component identification diagrams enable the projects to be built by beginners. Each circuit can be dismantled and rebuilt several times using the same components. The component pack allows all projects in the book to be built one at a time. Projects covered include amplifiers, light actuated switches, timers, metronome, touch switch, sound activated switch, moisture detector, MW Radio, Fuzz unit, etc.

30 Solderless Breadboard Projects (Book 1) **£2.95**
Component Pack **£27.74**

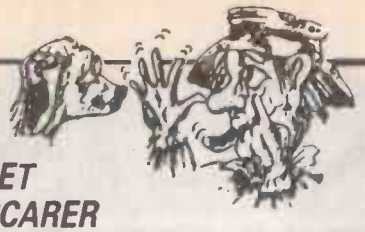
INSULATION TESTER

EE APRIL 85

A reliable electronic tester which checks insulation resistance of wiring 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. One of our own designs and extremely popular.

KIT REF 444 £22.37

PET SCARER



EE MAY 89

Produces high power ultrasound pulses. L.E.D. flashes to indicate power output and level. Battery powered (9V–12V or via Mains Adaptor).

KIT REF 812 £14.81

Mains Adaptor £2.02

DIGITAL LCD THERMOSTAT

EE MAY '91

A versatile thermostat with LCD read out. MIN/MAX temperature recording, clock and individually settable upper and lower switching points. Covers –10 to 110 degrees Celsius, accurate to within 0.1 degrees. Submersible probe on 3 meter lead. Kit includes punched and printed case. Save on energy bills by improved control of your hot water system. Also ideal for greenhouse soil temperature and aquarium control. Complete kit includes thermostat and probe, mains power supply and relay output, PCB's and punched and printed case.

KIT REF 841 £29.95

3 BAND SHORT WAVE RADIO

EE AUG 87

Covers 1.6–30 MHz in 3 bands using modern miniature coils. Audio output is via a built-in loudspeaker. Advanced design gives excellent stability, sensitivity and selectivity. Simple to build.

KIT REF 718 £30.30

DIGITAL COMBINATION LOCK

EE MAR '91

Digital combination lock with a 12 key keypad. 4 digit code operates 250V-16A SPCO relay. A special anti-tamper circuit allows the relay to be mounted remotely from the keypad without any loss of security. Can be operated in many modes (latching/unlatching, manual/automatic setting, continuous/momentary output, etc.). Article describes operation as Vehicle Immobilising security system. Low current drain. *Kit includes drilled case.*

KIT REF 840 £19.86

MOSFET VARIABLE BENCH 25V 2.5A POWER SUPPLY

EE FEB 88

A superb design giving 0.25V and 0-2.5A. Twin panel meters indicate Voltage and Current. Voltage is variable from zero to 25V. A Toroidal transformer MOSFET power output device, and Quad op-amp IC design give excellent performance.

KIT REF 769 £56.82

PORTABLE ULTRASONIC PEsT SCARER

EE AUG '91

A powerful 23kHz Ultrasonic generator in a compact hand-held case. A MOSFET output drives a weatherproof transducer at up to 300V peak to peak via a special tuned transformer. Sweeping frequency output requires no setting up or alignment. Kit includes all components, PCB, transducer and case.

KIT REF 842 £22.56

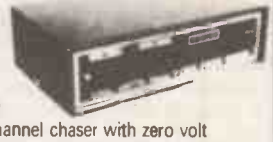
ACOUSTIC PROBE

EE NOV '87

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 REF 740 £20.01

4 CHANNEL LIGHT CHASER



EE Jan '90

A 1000W per channel chaser with zero volt switching, hard drive, inductive load capability, mic sound sensor and sophisticated 'beat' detector. Chase steps to music or auto when quiet. Variable speed and mic. sens. LED mimic on front panel. Switchable for 3 or 4 channels. P552 output. Ideal for rope lights, pin spots, disco and display lighting.

KIT REF 833 £32.13

EE EQUALISER

EE MAY '87

A mains powered loniser with an output of negative ions that give a refreshing feeling to the surrounding atmosphere. Negligible current consumption and all-insulated construction ensure that the unit is safe and economical in use. Easy to build on a simple PCB.

KIT REF 707 £17.75

MICROCONTROLLER LIGHT SEQUENCER

EE DEC '90

A superb kit with pre-drilled painted and silk screen printed case for a really professional finish. This kit uses a microcontroller I.C. to generate 8-channel light sequences.. Sequences are selected by keypad from over 100 stored in memory. Space for 10 user programmed sequences up to 16 steps long also available. 1000 watts per channel, zero volt switching, inductive load capability. Opto-isolated for total safety. Many other features. Complete kit includes case, PCBs, all components and hardware.

KIT REF 838 £57.17

EPROM ERASER

EE OCT '88

Safe low-cost unit capable of erasing up to four EPROM's simultaneously in less than twenty minutes. Operates from a 12V supply. Safety interlock. Convenient and simple to build and use.

KIT REF 790 £28.51

LIGHT RIDERS

EE OCT '86

Three projects under one title – all simulations of the Knight Rider lights from the TV series. The three are a lapel badge using six LEDs, a larger LED unit with 16 LEDs and a mains version capable of driving six main lamps totalling over 500 watts.

KIT REF 559 CHASER LIGHT	£15.58
KIT REF 560 DISCO LIGHTS	£22.41
KIT REF 561 LAPEL BADGE	£11.65

EE TREASURE HUNTER

EE AUG '89

A sensitive pulse induction Metal Detector. Picks up coins and rings etc., up to 20cms deep. Low "ground effect". Can be used with search-head underwater. Easy to use and build, kit includes search-head, handle, case, PCB and all parts as shown.

KIT REF 815

Including headphones £45.95

SUPERHET BROADCAST RECEIVER

EE MAR '90

At last, an easy to build SUPERHET A.M. radio kit . Covers Long and medium Wave bands. built in loudspeaker with 1 watt output. Excellent sensitivity and selectivity provided by ceramic I.F. filter. Simple alignment and tuning without special equipment. Kit available less case, or with pre-cut and drilled transparent plastic panels and dial for a striking see-through effect.

KIT REF 835 £17.16

ESR ELECTRONIC COMPONENTS

Station Road, Cullercoats,
Tyne & Wear NE30 4PQ
Tel. 091 251 4363 Fax. 091 252 2296

PCB EQUIPMENT

UV EXPOSURE UNIT – 229 x 159mm working area, built in timer, 2 x 8w tubes £62.57
PHOTO RESIST BOARD – single sided pre-sensitised FR4 glass fibre board. 3 x 4 in. £0.86 4 x 6 in. £1.62 6 x 6 in. £2.41
PLASTIC DEVELOPING TRAY £1.35
FERRIC CHLORIDE (0.5Kg) £2.45
TIN PLATING POWDER (90g) £8.33
STRIPBOARD 0.1 pitch 64 x 127mm £1.30 64 x 431mm £4.03 95 x 127mm £1.52 95 x 95mm £1.33 95 x 431mm £5.27
BREADBOARD 81 x 60mm 390TP £2.98 175 x 42mm 640TP £3.40 175 x 67mm 840TP £5.34 *203 x 75mm 840TP £6.88
* inc plate & 4mm posts

KITS

Complete with screen printed & solder mask board, components and full instructions.
CAR ALARM voltage drop £12.99
200W CAR BOOSTER 12/24V CD/line/speaker input. inc housing. £91.88
ELECTRONIC DICE (dual) £9.15
SOUND GENERATOR 10 tunes, line & speaker output £19.11
2.5W UNIVERSAL AMPLIFIER £6.86
AF SIGNAL INJECTOR/TRACER adjustable o/p & i/p £8.39
DIGITAL CODE LOCK 4 digit code flip/flop or latch o/p £19.11
AC MOTOR/DRILL CONTROLLER carbon brush 24-240Vac 5A £15.28

D CONNECTORS

	Plug	Socket
9 pin	£0.29	£0.30
15 Pin	£0.39	£0.39
15 Pin H.D.	£0.81	£0.90
23 Pin	£0.40	£0.42
25 Pin	£0.48	£0.50
9 Way plastic cover		£0.30
15 Way plastic cover		£0.33
23 Way plastic cover		£0.36
25 Way plastic cover.		£0.36

CAPACITORS

Ceramic Disc 100V 10pF to 100nF £0.07
Ceramic Plate 100 & 63V 1.0pF to 12nF 1pF-1nF £0.06, 1n2-2n7 £0.09, 3n3-4n7 £0.12, 10n & 12n £0.06
Polystyrene 160V 5% 47pF to 10nF 47p-2n2 £0.09, 2n7-10n £0.12

SOLDERING IRONS

Antex Soldering irons
M 12 Watt £7.11
C 15Watt £7.11
G 18Watt £7.30
CS 17Watt £7.21
XS 25Watt £7.30
ST4 STAND £2.75
New PORTASOL HOBBY 35Watt gas iron £11.17
DESOLDER PUMP £3.00
ANTISTATIC PUMP £4.30
22SWG 0.5Kg Solder £7.40
18SWG 0.5Kg Solder £6.60
1mm 3 yds Solder £0.50

RESISTORS

0.25W 5% CF E12 Series	£0.60/100
0.5W 5% CF E12 Series	£0.95/100
0.25W 1% MF E24 Series	£1.72/100
POTS Log or Lin 470R – 1MO 25mm dia 0.25in shaft	£0.40
PRESETS Enclosed Horz or Vert 100R – 1MO 0.15W	£0.15
PRESETS Skeleton Horz or Vert 100R – 1MO 0.1W	£0.11

ELECTROLYTIC RADIAL CAPACITORS

uF	16V	25V	63V	100V
0.47	–	–	£0.05	£0.07
1.0	–	–	£0.05	£0.06
2.2	–	–	£0.05	£0.06
4.7	–	–	£0.05	£0.08
10	£0.05	£0.05	£0.06	£0.08
22	£0.05	£0.05	£0.09	–
47	£0.06	£0.06	£0.11	–
100	£0.06	£0.09	£0.11	–
220	£0.09	£0.12	£0.31	–
470	£0.15	£0.19	£0.57	–
1000	£0.22	£0.29	–	–
2200	£0.37	£0.57	–	–
4700	–	£1.11	–	–

HARDWARE

PCB Nylon Stand-offs clip into board, screw from base.
5mm spacing £0.24/10 £1.68/100
10mm spacing £0.26/10 £1.82/100
13mm spacing £0.30/10 £2.10/100
SELF TAPPING SCREWS Pan head
No 6 x 6.4mm £0.14/10 £0.88/100
No 6 x 9.5mm £0.12/10 £0.78/100
No 6 x 13mm £0.13/10 £0.85/100
No 6 x 19mm £0.16/10 £1.04/100
T2 Box 75 x 56 x 25mm £0.76
T3 Box 75 x 51 x 25mm £0.72
T4 Box 111 x 57 x 22mm £0.92
MB1 Box 79 x 61 x 40mm £1.36
MB2 Box 100 x 76 x 41mm £1.48
MB3 Box 118 x 98 x 45mm £1.72
MB5 Box 150 x 100 x 60mm £2.36

AUDIO CONNECTORS

PHONO PLUG inc strain relief, Red or Black £0.17
PHONO PLUG right angle, Red or Black £0.23
PHONO Chassis Socket £0.16
6.35mm Plastic Mono Plug with strain relief £0.25
As above but Stereo £0.45
6.35mm Chassis Socket, switched Mono £0.36, switched Stereo £0.49
3.5mm Mono Plug £0.17
3.5mm Stereo Plug £0.29
3.5mm Mono line skt £0.24
3.5mm Stereo line skt £0.29
PLASTIC DIN PLUGS 2 pin £0.15, 5/360 £0.27, 3 pin £0.24, 6 pin £0.30, 4 pin £0.29, 7 pin £0.33, 5/180 £0.26, 8 pin £0.45, 5/240 £0.30
XLR Chassis Socket £1.65
XLR Chassis Plug £1.32
XLR Line Socket £1.45
XLR Line Plug £1.36

BRIDGE RECTIFIERS

W005 1.5A 50V	£0.19
W02 1.5A 200V	£0.20
BR32 3A 200V	£0.36
BR62 6A 200V	£0.64
1004 10A 400V	£1.39

74LS Series

74LS00	£0.14
74LS01	£0.17
74LS02	£0.18
74LS03	£0.17
74LS04	£0.14
74LS05	£0.17
74LS08	£0.17
74LS09	£0.17
74LS10	£0.17
74LS11	£0.17
74LS12	£0.16
74LS20	£0.16
74LS21	£0.16
74LS26	£0.16
74LS30	£0.17
74LS32	£0.17
74LS37	£0.16
74LS42	£0.25
74LS51	£0.19
74LS86	£0.20
74LS92	£0.35
74LS93	£0.25
74LS107	£0.30
74LS109	£0.21
74LS123	£0.40
74LS125	£0.21
74LS133	£0.22
74LS138	£0.24
74LS153	£0.25
74LS154	£0.90
74LS157	£0.25
74LS164	£0.26
74LS165	£0.53
74LS175	£0.24
74LS191	£0.24
74LS193	£0.24
74LS367	£0.21
74LS374	£0.32

LINEAR ICs

TL061	£0.35
TL062	£0.42
TL064	£0.46
TL071CP	£0.32
TL072CP	£0.34
TL074CN	£0.48
TL081	£0.29
TL082CP	£0.34
TL084CN	£0.46
TBA120S	£0.77
LM301A	£0.25
CA311E	£0.28
CA324	£0.23
LM348N	£0.31
LF351N	£0.36
LM358N	£0.27
LM377	£2.57
LM380N	£1.12
LM381	£2.70
LM386	£0.48
LM387	£1.60
LM392N	£0.79
LM393N	£0.28
LM394	£3.98
ZN414Z	£1.04
NE531	£1.56
CA555	£0.22
NE556N	£0.36
NE567N	£0.36
UA733	£0.64
CA741CE	£0.18
CA747CE	£0.39
LM748CN	£0.31
TBA810S	£0.68
TBA820M	£0.39
LM1458	£0.26
ULN2004	£0.48
TDA2030	£1.35
CA3046	£0.37
CA3080	£0.72
CA3130	£0.98
CA3130E	£0.98
CA3140	£0.56
CA3240	£1.22
LM3900	£0.72
LM3914	£2.70
LM3915	£2.70
MC4558	£0.36
NE5532	£0.80
NE5534	£0.66
ICL7621	£1.70
ICM7555	£0.43
ICM7556	£0.96

AUDIBLE WARNING

400Hz 75dB 9-20V	£0.72
450Hz 80dB 9-12V	£1.14
4KHz 90dB 3-15V	£0.92
2.8KHz 100dB pulsed	£1.60
3.5KHz 75dB 240Vac	£1.22
4KHz 80dB 30V pk-pk	£0.58

VELLEMAN KITS

Stockists of the full range of Velleman kits. Catalogue available upon request.

SWITCHES

Miniature Toggle Switches
3amp 250v 6.4mm ϕ mounting
SPST Toggle £0.58
SPDT Toggle £0.54
SPDT CO Tog £0.62
DPDT Toggle £0.68
DPDT CO Toggle £0.74
DPDT CO Toggle (biased) £1.20
DPDT CO Toggle (biased 1 way) £1.20
DPDT mini slide £0.15
Rotary Wafer 1P-12W, 2P-6W, 3P-4W, 4P-3W £0.78
Key Switch SPST £2.70
Push to make £0.25
Push to break £0.24
Latching Push Sqr £0.58
PCB Tact 6 x 6mm £0.25

CONNECTORS

CROC CLIPS 33mm Red or Black £0.12
CROC CLIPS 45mm Red or Black £0.21
PP3 Battery Snap £0.10
PP9 Battery Snap £0.14
4mm BANANA PLUG Red or Black £0.09
4mm BUNCH PIN PLUG Red or Black £0.30
4mm BINDING POST Red or Black £0.54
SCART PLUG £0.60
SCART PCB Skt £0.78
SCART LINE Skt £1.35
IEC LINE SOCKET £0.78
IEC CHASSIS PLUG £0.72
IEC CHASSIS Skt £0.56
CAR AERIAL PLUG £0.19
CIGAR LIGHTER PLUG £0.30

DIL SOCKETS

8 Pin	£0.07
14 Pin	£0.11
16 Pin	£0.15
18 Pin	£0.15
20 Pin	£0.16
24 Pin	£0.19
28 Pin	£0.22
40 Pin	£0.25

TEST & MEASUREMENT

HM103S ANALOGUE METER
19 ranges (inc 10Adc), fuse & diode protection, battery test, shock resistant tilted case, mirrored scale, supplied with battery, leads & instructions. Dim. 154 x 77 x 43mm £11.47

HC2020S ANALOGUE METER
20 Ranges (inc 10Adc), fuse & diode protection, transistor & diode tester, polarity reverse switch, high impact shock resistant case. Supplied with battery, leads, stand & instructions. Dim. 150 x 102 x 45mm £18.45

HYT07 LOGIC PROBE
TTL & CMOS, displayed in light & sound, pulse enlargement, pulse detection down to 25nsec, max freq. 20MHz. Supplied with full instructions. £7.72

MX190 DIGITAL METER
19 ranges, 3.5 digit 12mm LCD, signal injector, diode test, fuse protection, auto polarity & zero, supplied with battery, leads & instruction manual. Dim. 126 x 70 x 24mm £14.73

M2315B DIGITAL METER
17 Ranges (inc 10Adc), 3.5 digit 12mm LCD, diode test, buzzer, auto polarity & zero, over-range & low bat indication, supplied with battery, leads & instructions. Dim. 130 x 72 x 33mm £23.40

TL34 DIGITAL METER
33 Ranges (inc 20A ac/dc) PTC & fuse protection, 5 capacitance ranges, transistor test. 3.5 digit large 24mm display. Heavy duty case with tilt stand. Supplied with battery, leads & instructions. Dim. 191 x 88 x 36mm £27.59

HC213 ANALOGUE METER
12 ranges, diode protection, mirrored scale, 2mm leads. Pocket sized, supplied with battery & instructions. Dim. 90 x 60 x 30mm £5.96

RF CONNECTORS

BNC Solder Plug	£0.85
BNC Crimp Plug	£0.68
BNC Solder Skt	£1.08
BNC Chassis Skt	£0.78
PL259 5.2mm	£0.58
PL259 11mm	£0.58
RND UHF socket	£0.63
SQR UHF socket	£0.40
F Plug RG58	£0.27
F Plug RG6	£0.27
N Plug RG8	£1.64

DIODES

Zener Diodes 2V7–33V BZY88 400mW	£0.08
BZX85 1.3W	£0.14
1N4001-1N4005	£0.07
1N4006-1N4007	£0.08
1N5400-1N5402	£0.09
1N5404-1N5406	£0.11
1N5407-1N5408	£0.15
1N4148 Signal	£0.05
OA47 Signal	£0.28
OA90 Signal	£0.07
OA91 Signal	£0.10

OPTO DEVICES

5mm Red LED	£0.09
5mm Green LED	£0.10
5mm Yellow LED	£0.10
5mm Orange LED	£0.10
3mm Red LED	£0.08
3mm Green LED	£0.12
3mm Yellow LED	£0.13
3mm Orange LED	£0.13
5mm Flashing Red	£0.50
5mm Flashing Green	£0.54
5mm Bi Colour	£0.36
5mm Tri Colour	£0.48
5mm Plastic Bezel	£0.04
3mm Plastic Bezel	£0.05
0.3" 7 Segment Display Red common anode	£1.14
common cathode	£1.14

RELAYS

6V SPDT 6A	£0.70
12V SPDT 6A	£0.70
6V DTDP 6A	£1.96

4000 Series

4000	£0.20
4001	£0.17
4002	£0.19
4006	£0.32
4007	£0.20
4008	£0.31
4010	£0.23
4011	£0.16
4013	£0.17
4014	£0.30
4015	£0.31
4016	£0.18
4017	£0.25
4018	£0.27
4020	£0.31
4022	£0.32
4024	£0.21
4025	£0.15
4026	£0.40
4027	£0.18
4029	£0.27
4030	£0.17
4033	£0.56
4035	£0.31
4040	£0.29
4043	£0.28
4042	£0.22
4046	£0.31
4047	£0.25
4049	£0.20
4051	£0.25
4052	£0.25
4053	£0.24
4055	£0.30
4060	£0.31
4063	£0.29
4066	£0.18
4069	£0.20
4070	£0.17
4071	£0.21
4072	£0.17
4075	£0.17
4076	£0.30
4077	£0.15
4081	£0.14
4082	£0.17
4089	£0.55
4093	£0.15
4094	£0.31
4095	£0.56
4098	£0.31
4510	£0.26
4511	£0.29
4514	£0.73
4515	£0.78
4516	£0.31
4518	£0.27
4520	£0.26
4521	£0.84
4534	£2.48
4538	£0.37
4541	£0.31
4543	£0.46
4572	£0.25
4584	£0.24
4585	£0.48
40106	£0.24
40174	£0.34

TRANSISTORS

BC107	£0.14
BC108A	£0.12
BC109C	£0.15
BC177	£0.16
BC178	£0.16
BC179	£0.16
BC182LB	£0.09
BC183LB	£0.09
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EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

VOL. 21 No. 6 **JUNE '92**

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TWICE AS GOOD

It's not our style to be brash or big headed about EE but sometimes it is hard to resist giving ourselves a little pat on the back! 1991 was a particularly difficult year for most UK businesses and the magazine industry found it tough. Many UK magazines suffered a drop in circulation.

The independent Audit Bureau of Circulation figures for the year December to January 1991 have recently been published and they show that EE now outsells all of its rivals by more than two to one in the UK. Last year EE sold an average of 19,655 copies in the UK each month, none of the competing independent monthly titles even sold half that number in the UK. They all have UK circulation figures which are less than 9,800 copies per month.

The two to one figures are very satisfying, however when you realise that one competitor has experienced a 30 per cent drop in UK circulation while EE's figure has barely moved (a fall of 0·7 per cent) during that difficult period, we, needless to say, are very pleased indeed.

EE is also sold to just about every other country around the world so, with the assistance of all our overseas readers, the magazine is read by a very substantial number of people interested in our hobby. Thanks goes to all our readers for your support, some of you since our first issue way back in November 1971. Thank you.

SPECIAL OFFER

In case any readers missed it last month can I point out the exceptional value of our subscription offer which is now on. If you are a regular reader we are presently offering 13 issues for our normal subscription price, plus a free gift, but both of these offers have strict time limits on them.

This is the first subscription offer we have carried in the last six years and it will not be repeated during this year – don't miss it! You will find the offer page with a special coupon on it elsewhere in this issue.

VIDEO

While pushing our sales can I also introduce a new range of videos that we are pleased to make available. We have for some time wanted to be able to supply instructional videos for our hobby, unfortunately this is not easy to achieve at a sensible price.

One of the major industrial distributors sells some electronics theory videos for £75 to £99 each! Our videos are retailing at £29.95 including VAT, which is considerably less and we feel realistic value for money. They are produced in the USA and provide excellent back up theory for any general electronics course – you will find a page advertising these near our Direct Book Service pages. We are sure they will prove valuable to schools, colleges, training departments and electronics clubs as well as hobbyists.

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Constructional Project

CCD REVERB UNIT

ROBERT PENFOLD

Only the bucket-brigade can bring that rich "big hall" sound to your instruments or recordings.

REVERBERATION is the sort of multiple echo that occurs when music is performed in a large hall. In addition to hearing the sounds direct from the instruments, you also hear them via reflections from the walls, ceiling, etc. These reflections take more round-about routes than the direct sounds, and are therefore delayed slightly relative to the direct sounds.

This effect occurs in practically any room, but it is more noticeable in concert halls or other large rooms, where the indirect sounds have to travel much further than the direct sounds, and are therefore delayed by a much greater amount. This gives a jumble of echoes that will sometimes persist for as much as a few seconds after the original sound has ceased.

A problem with making recordings direct from electronic instruments is that they are totally free from any natural reverberation. A small amount of reverberation will occur in the room where the recordings are played-back, but this will usually be so slight as to be unnoticeable. If you listen to the recordings via headphones, they will be totally reverberation-free.

Most people find that some added artificial reverberation gives a more pleasant sound than "raw" recordings from electronic instruments. Some instruments do now have built-in reverberation effects, but this is a far from universal feature.

TECHNIQUES

There are several methods of adding a reverberation effect to recordings, but these basically boil down to three methods. The best one is a digitally produced effect using a digital delay line having at least 16-bit resolution. Unfortunately, this remains a complex and expensive method which is beyond the scope of a reasonably simple do-it-yourself project. Even systems which use lower resolution tend to be quite complex and costly.

There are various mechanical methods, such as spring-line based units. These probably offer the best low cost results, but they are large, heavy, and suffer from problems with acoustic and magnetic feedback. Also, the spring-line units are becoming difficult to obtain these days.

The third approach, and the one utilized for this project, is to used a tapped c.c.d. (charge coupled device) delay line. These are analogue circuits which provide the delay using a series of f.e.t.s (field effect transistors) operating as electronic switches, plus capacitors to hold the sampled voltages.

BUCKET BRIGADES

The basic way in which these c.c.d. lines operate is to have the first capacitor connected to the input so that it samples the input voltage. This first capacitor is then connected to the second one in the chain via a buffer stage so that it passes on the sampled voltage. Next the first capacitor is connected back to the input so that a fresh sample voltage is taken. Meanwhile, the second capacitor passes its charge on to the third capacitor. Then the first capacitor is coupled to the second one again, and so on.

This process is repeated indefinitely, with a stream of input samples being taken and passed along the chain of capacitors. Of course, eventually the samples reach the last capacitor in the chain, where they provide the output signal before being discarded.

Delay lines which use this method are popularly known as "bucket brigade" devices. This term is derived from the fact that the way in which these circuits operate is roughly analogous to buckets of water being passed along a human chain (as in the old method of fire fighting). The capacitors are the "buckets", and the electricity stored in them is the "water".

DELAY

A c.c.d. delay line provides a delay because it takes a certain amount of time for each input sample to be passed along the chain of capacitors and to finally emerge at the output. The delay time is governed by two factors, which are the number of stages in the circuit, and the speed at which the samples are passed from one stage to the next.

In practice the rate at which samples are passed along the device is controlled by a clock oscillator. On the face of it, the delay time in seconds is equal to the number of stages divided by the clock frequency in Hertz. In reality it is only half this figure. This is due to the fact that the capacitors cannot simultaneously pass on their charge to the next stage and receive the charge from the previous stage.

Each capacitor first receives a sample, and then passes it on. This means that there are only half as many samples in the circuit as there are delaying stages.

SYSTEM OPERATION

Most c.c.d. delay lines are not suitable for use in reverberation circuits. The majority of c.c.d.s have around 500 stages, which is just about enough to give some sort of reverberation effect. It is not quite enough to give the rich "big hall" form of reverberation effect that we require in this case though. Also, for this effect we do not require a single delay time.

Reverberation is produced by sounds arriving at the listener's ear having taken several routes of different lengths. In order to produce a reverberation effect we must mix the direct signal with several delayed versions of itself. In order to give a good effect a fairly wide range of delay times are required, and apparently it is important that the longer times are not exact multiples of the shortest time.

This reverberation unit is based on a c.c.d. delay line that has been designed specifically for operation in reverberation circuits. It has tappings at stages 396/397, 662/663, 1194/1195, 1726/1727, 2790/2791, and 3328/3329. Note that the output signals are taken from two stages rather than one, so that one stage can maintain the output while the other collects a new sample from the previous stage. This gives stepped output waveforms instead of pulsed signals. With suitable lowpass filtering either type of signal can be smoothed to produce a proper audio output. However, much simpler filtering is adequate if the output signal is a stepped type.

BLOCK DIAGRAM

The block diagram for the reverberation unit is shown in Fig. 1. A buffer amplifier at the input provides a fairly high input impedance of about 47k, and ensures that the subsequent stage is fed from a suitably low source impedance. This second stage is a lowpass filter. It is important that high frequencies are not allowed to enter the delay line as they would generate a severe form of distortion known as "aliasing" distortion.

In this case high frequencies means anything above approximately half the clock frequency. The latter is at approximately 20kHz, which means that the filter must severely attenuate frequencies above about 10kHz.

The filter is a third order (18dB per octave) type having a cut-off frequency of about 6kHz. This means that the reverberation signal has something less than the full audio bandwidth, but a bandwidth of about 6kHz is sufficient to give a good effect. A wider bandwidth could be achieved at the expense of a shorter delay time, but this would not give such a good reverberation effect.

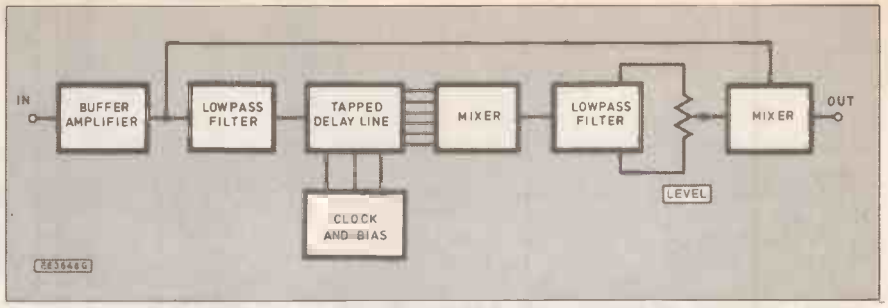


Fig. 1. Block diagram for the CCD Reverberation Unit.

The two-phase clock signal for the delay line is provided by a matching clock generator chip. This also generates a bias signal required by the delay line chip. With an operating frequency of about 20kHz, the clock circuit gives a delay time from the first tapping of about 10mS. This is the minimum that will give a reverberation effect.

The delay time from the final stage is around 85mS. This is adequate to give a good reverberation effect, but the unit cannot provide very long reverberation times of the type associated with spring-line reverberation units.

MIXER

A mixer stage combines the six output signals from the delay line into a single signal. This stage also provides a small amount of filtering. However, another three stage active lowpass filter provides the main filtering, and gives a step-free output signal. A second mixer stage combines the non-delayed signal with the reverberation signal. A level control permits the strength of the reverberation signal to be controlled.

Although many delay line effects make use of clock modulation to vary the delay time, this does not give good results in a reverberation unit. Significant variations in the delay time produce quite strong frequency modulation. This can give decidedly unmusical results if the unit is fed with a polyphonic signal. In fact it tends to generate some very discordant results.

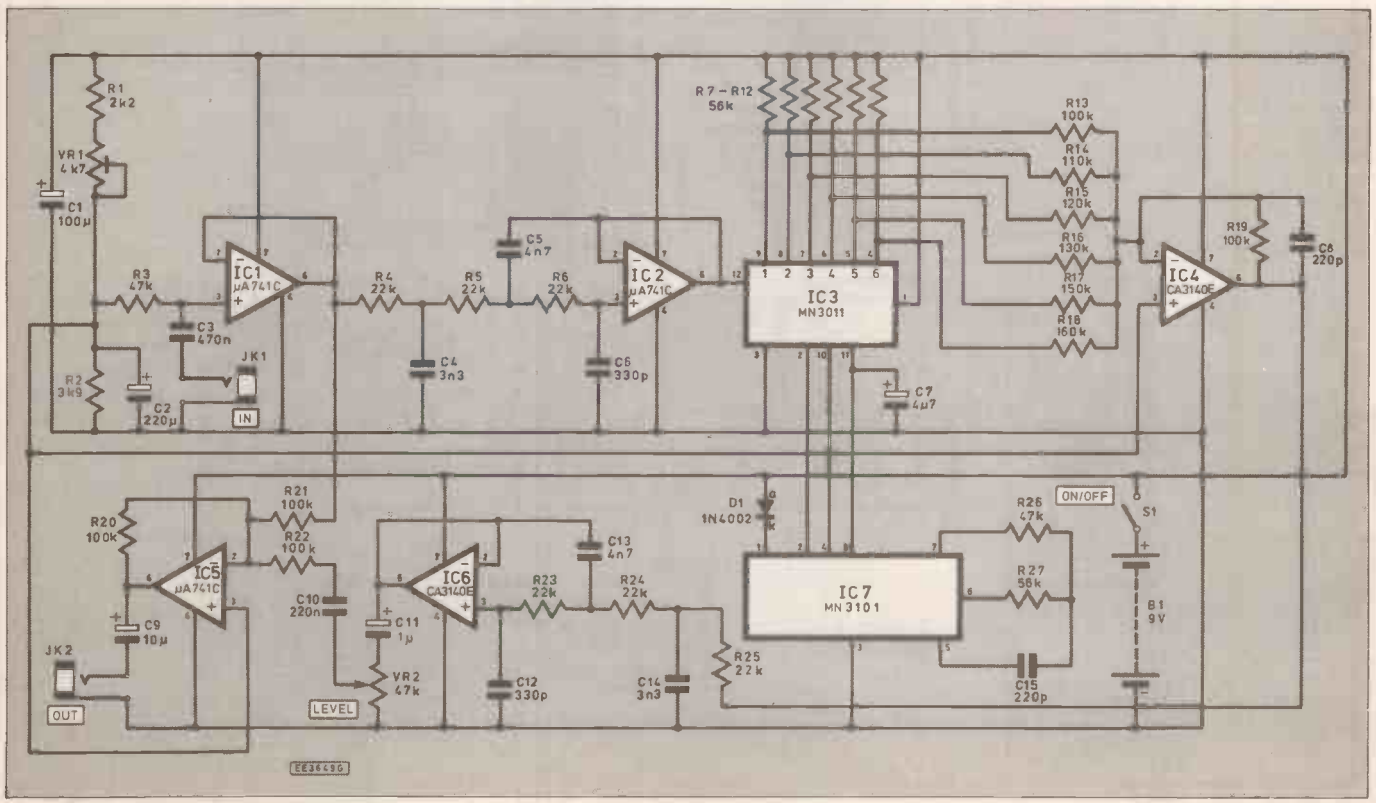
It is possible to obtain extended reverberation times by feeding some of the delayed signal back to the input of the unit. In practice this seems to give a rather poor effect though, and this feature has not been included in the final unit.

CIRCUIT OPERATION

The full circuit diagram for the CCD Reverberation Unit is shown in Fig. 2. IC1 acts as the input buffer stage, and it is a simple operational amplifier non-inverting mode circuit. Preset VR1 permits the bias voltage on IC1 to be varied. In fact the entire circuit is either directly or indirectly biased from this potential divider. VR1 is adjusted to optimise the large signal handling capability of the circuit. This is limited by the delay line chip, but signal levels of up to at least one volt r.m.s. can be accommodated.

IC2 is used as the buffer stage in the active lowpass filter ahead of the delay line. IC3 is the delay line chip, and this is a PMOS device. R7 to R12 are source load resistors for buffer stages in IC3. It seems to be the convention for c.c.d. delay line chips to have separate clock generators,

Fig. 2. Complete circuit diagram for the CCD Reverberation Unit.



and in this case IC7 provides both the two phase clock signal and a bias voltage for IC3.

A two-phase clock signal is merely an anti-phase type (i.e. as one signal goes low the other goes high, and vice versa). CCD delay lines tend to be fussy about the clock signal timing, but using the matching clock chip should avoid any problems.

IC4 operates as a conventional summing mode mixer which combines the six output signals of IC3. Capacitor C8 provides the first stage of lowpass filtering. With real reverberation the sounds that take the longest to arrive are the weakest. The input resistor values in the mixer circuit (R13-R18) have therefore been chosen to simulate this effect by giving progressively larger attenuation from

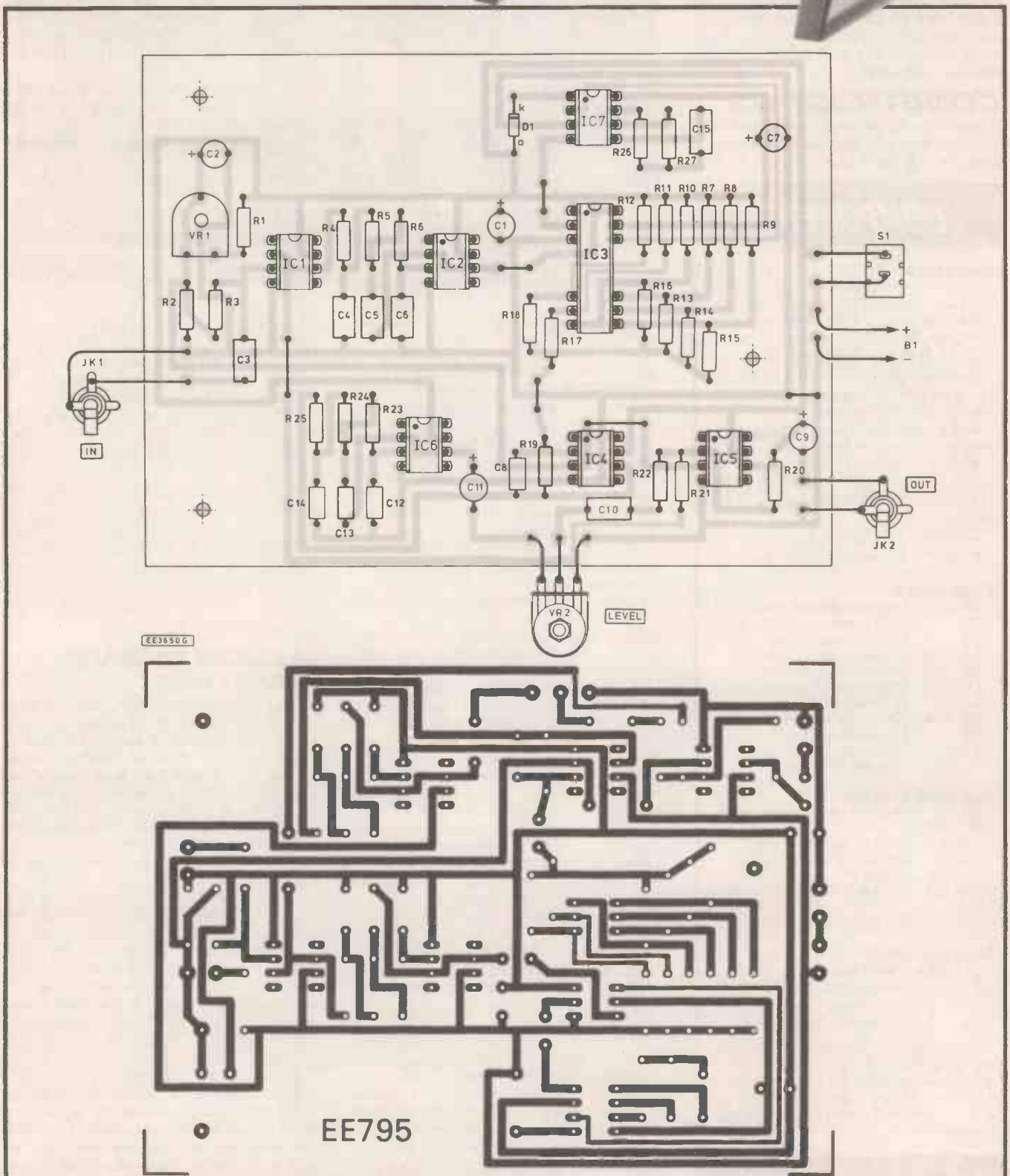


Fig. 3. Printed circuit board component layout, interwiring and full size copper foil master pattern for the Reverb.

tapping one through to tapping six on IC3.

IC6 is the buffer amplifier in the main output filter, and this is identical to the filter used at the input of the delay line. The output mixer is based on IC5, which is another summing mode circuit. The unit provides unity voltage gain on the straight-through signal. VR2 enables the reverberation level to be varied from zero, up to a maximum level which is comparable to that of the straight-through signal.

Power is provided by a 9 volt battery. The current consumption is about 10 milliamps, and a "high power" PP3 size battery is adequate. However, if the unit is likely to receive a great deal of use a higher capacity type (such as six HP7 size cells in a plastic holder) would probably be a more economic means of powering the unit.

CONSTRUCTION

Details of the printed circuit board are provided in Fig.3, this board is available from the *EE PCB Service*, code EE795.

COMPONENTS

Resistors

R1	2k2
R2	3k9
R3, R26	47k (2 off)
R4, R5, R6, R23, R24, R25	22k (6 off)
R7 to R12, R27	56k (7 off)
R13, R19, R20, R21, R22	100k (5 off)
R14	110k
R15	120k
R16	130k
R17	150k
R18	160k

All 0.25W 5% carbon film

See SHOP TALK Page

Potentiometers

VR1	4k7 sub-min hor. preset
VR2	47k rotary carbon, log

Capacitors

C1	100µ radial elect. 10V
C2	220µ radial elect. 10V
C3	470n polyester layer
C4, C14	3n3 polyester (2 off)
C5, C13	4n7 polyester (2 off)
C6, C12	330p ceramic plate (2 off)
C7	4µ7 elect. 63V
C8, C15	220p ceramic plate (2 off)
C9	10µ radial elect. 25V
C10	220n polyester
C11	1µ radial elect. 63V

Aemiconductors

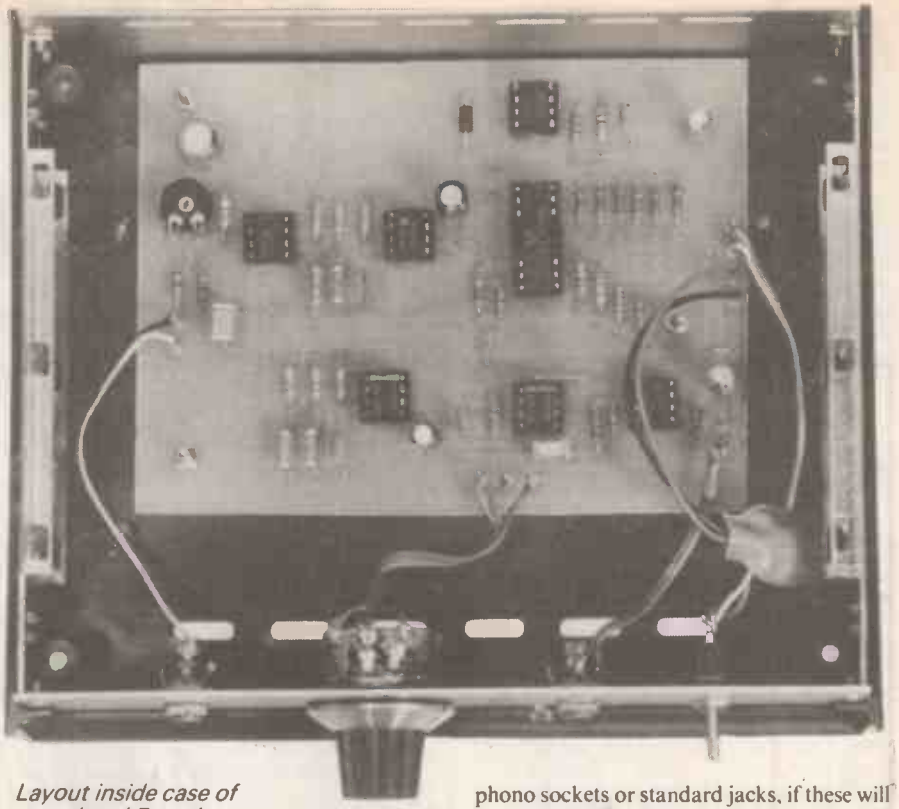
D1	1N4002 1A 100V rec. diode
IC1, IC2, IC5	µA741C op.amp. (3 off)
IC3	MN3011 bucket brigade delay line
IC4, IC6	CA3140E MOSFET op.amp. (2 off)
IC7	MN3101 clock/bias gen

Miscellaneous

JK1, JK2	3.5mm jack socket (2 off)
B1	9V (high power PP3) battery
S1	s.p.s.t. sub-min toggle switch

Printed circuit board available from the *EE PCB Service*, order code EE795; battery connector; case about 170mm x 145mm x 55mm; control knob; 18-pin d.i.l. i.c. socket; 8 pin d.i.l. socket (6 off); wire; solder, etc.

Approx cost guidance only **£40** *excl. case*



Layout inside case of completed Reverb.

The board is a single-sided design, but a few short link wires are required. Be careful not to overlook any of these (there are six of them).

Note that IC3, IC4, IC6, and IC7 are all MOS devices, and that they therefore require the normal anti-static handling precautions to be observed. Even if you do not normally bother too much about this type of thing, it is strongly urged that great care be taken when dealing with IC3. This is a complex device which would be expensive to replace.

Holders should be used for all the MOS devices and it is a good idea to use i.c. holders for the other three integrated circuits as well. Leave the i.c.s in their anti-static packing until the unit is finished in all other respects. They should then be plugged into their holders, handling them no more than is really necessary, and avoiding any obvious sources of static electricity.

There is a minor problem with IC3, which is its unusual 12-pin d.i.l. encapsulation. It is effectively just an ordinary 18-pin d.i.l. encapsulation, but with the middle six pins absent. This component can be fitted into an ordinary 18-pin d.i.l. holder, but it *must* have the middle six pins trimmed away before it will plug into the board.

In other respects construction of the board is quite straightforward. At this stage only fit pins to the board at the points where the connections to the off-board components will eventually be made.

CASE

A case having outside dimensions of about 160 by 140 by 50 millimetres or more is adequate to accommodate everything. The prototype was housed in a plastic instrument case having aluminium front and rear panels, but there are plenty of cases of about this size to choose from. The two controls and two sockets are mounted on the front panel. 3.5 millimetre jack sockets have been used for JK1 and JK2, but you can obviously use an alternative such as phono sockets or standard jacks, if these will fit in better with other equipment. The exact layout is not too important, but as with any project, try to avoid layouts that result in lots of long and crossed-over wiring.

The printed circuit board is mounted on the base panel of the case using either plastic stand-offs or 6BA bolts plus nuts and spacers. The board is mounted towards the rear of the case, leaving sufficient space for the battery in front of or to one side of the it. The battery can be held in place using a double-sided adhesive pad or a home-made aluminium fixing bracket. To complete the unit the small amount of point-to-point wiring is added, using multi-strand connecting wire or pieces of ribbon cable. This wiring is included in Fig.3.

ADJUSTMENT AND USE

This unit is intended for operation with high level input signals of around one volt r.m.s. With signals of about this level a signal to noise ratio of 70dB to 80dB should be obtained. Low level signals will give a lower (and almost certainly inadequate) signal to noise ratio. The unit can only be used successfully with low level inputs, such as microphones and low output guitar pick-ups if it is preceded by a suitable preamplifier.

Initially set VR1 at a roughly mid-setting. With an input signal connected to the unit and the output monitored using an amplifier/speaker or headphones, the effect will probably be very apparent with VR2 well advanced. It is most noticeable on any intermittent signal. If the effect is not present, or the unit is clearly malfunctioning in some way, switch off at once and recheck all the wiring.

If suitable test equipment is available, VR1 is adjusted for symmetrical clipping using the standard techniques. In the absence of suitable test gear, simply give VR1 a setting that provides low distortion at high signal levels. There will probably be a small range of settings that give satisfactory results. Set VR1 at roughly the middle of the range. □

Constructional Project

VEHICLE WATCHDOG

CHRIS WALKER

An ingenious easy-fit intruder deterrent. Will also complement existing security systems without the need to modify existing wiring.

DURING a conversation about car theft and security devices, a colleague recently expressed the opinion that a simple flashing light, such as a light emitting diode, placed inside the car would be sufficient to deter many opportunist thieves. Mounted in a conspicuous position and in a convincing enclosure, a would-be thief may not wish to risk a break-in for fear of attracting attention from an alarm system, even though no such system may exist.

BLUFF

One may wonder why it is necessary to fit such a "bluff" unit when a proper working alarm could be constructed for little extra outlay. There are, however, two good reasons for fitting a visual deterrent:

Many budget-priced car alarms have no visual indication that they are in operation and an additional flashing light could draw attention to this fact. Ordinary window stickers warning of the presence of an alarm are easily bought nowadays, and they are not very convincing. Secondly, a simple flasher could be made entirely independent of the car's electrical system thus being extremely quick and easy to install and requiring no modification of the existing vehicle's wiring.

It must be stressed that the Vehicle Watchdog is not a burglar alarm. It is merely intended as a very easy-to-fit deterrent which a car owner may use in place of an alarm or, as in the author's car, the unit can complement an existing security system which previously had no visual deterrent.

SPECIFICATIONS

Building a flashing l.e.d. circuit is one of those designs that sounds trivially easy until you stop to consider the design requirements for its application. It was decided that, in order to make the unit a worthwhile compromise to fitting a complete theft alarm, it must be independent and require no connection to the vehicle. Battery operation is, therefore, a logical requirement. However, current consumption must be kept sufficiently low to provide an acceptably long battery life.

Since the unit will be placed in a conspicuous position, the flashing light could be an annoying and dangerous distraction to the driver whilst the vehicle is in motion. Therefore, the l.e.d. must not flash when the car is being driven.

In order to meet these criteria, the Vehicle Watchdog performs as follows: providing the vehicle has been stationary for at least one minute, a 15mA current pulse will brightly light an l.e.d. for 0·02 seconds once every two seconds.

The flashing stops as soon as the car undergoes appreciable movement such as occurs during driving. Average current consumption is about 170µA which ensures a battery life in excess of twelve months if alkaline cells are used.

After over two years of use, the prototype Vehicle Watchdog has successfully fooled every passenger into believing that it is a passive infra-red detector mounted on the dashboard. It has also trained the designer to become a rather convincing fibber!

HOW IT WORKS

The block diagram of the unit is shown in Fig. 1. The vibration sensor is used to detect movement of the vehicle. This sensor consists of an ordinary mercury tilt switch mounted at an angle so that the small mercury bead encapsulated in the switch easily rolls on and off the contacts as the switch encounters movement. This "make and break" action causes the monostable to generate a brief pulse which resets the one minute timer.

Therefore, as long as the vehicle is in motion, the mercury switch repeatedly triggers the monostable which prevents the timer running for one minute. If the vehicle should become stationary, the timer is allowed to run and, after one minute, it switches on the flasher circuit to operate the l.e.d.

The monostable is an *edge-triggered* device which resets the timer every time the mercury rolls *onto* the switch contacts. So, even if the car is parked at an angle where the mercury switch is continuously closed, the timer will be allowed to operate providing the vehicle remains stationary.

MONOSTABLE AND TIMER

The circuit diagram of the Vehicle Watchdog is shown in Fig. 2. In the interest of low power consumption the device is designed around a CMOS integrated circuit type 4093 which is a versatile package containing four two-input NAND gates with Schmitt triggers on their inputs. Gates IC1c and IC1d make up the monostable along with timing capacitor C1 and resistor R2.

The output from the monostable (pin 10) is normally "high" (battery positive voltage, 4·5V), but as the vehicle encounters movement and mercury switch S1 closes pin 13 is pulled down to 0V causing the output from IC1d pin 11 to go high.

The voltage at pins 8 and 9 must instantaneously follow pin 11 and go high as well, but this voltage falls exponentially as capacitor C1 charges up. The result is that pin 10 goes low for a fixed period determined by the values of C1 and R2; approximately 0·1 seconds with the values given.

Capacitor C2 charges via resistor R4 such that the voltage at pin 5 of gate IC1b gradually rises from 0V, taking about 60 seconds to reach a level recognised as a logic 1 by the CMOS NAND gate IC1b. Every time the monostable output pulses low, transistor TR1 switches on and capacitor C2 loses a substantial amount of its charge via resistor R3 and down to 0V through the emitter of TR1. Thus the monostable essentially resets the one-minute timer back to zero.

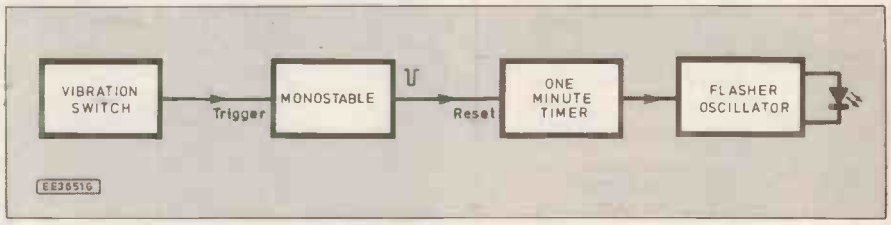


Fig. 1. Block diagram of the Vehicle Watchdog deterrent.

FLASHER CIRCUIT

When the voltage at pin 5 reaches a logic 1 level, gate IC1b acts as a relaxation oscillator. Fig. 3 shows the basic circuit of such an oscillator. Suppose the output of the Schmitt trigger inverter is initially high. Current will flow via resistor R to charge up capacitor C and the voltage V_C rises exponentially as shown. When V_C reaches the logic 1 input threshold (V+) the output of the inverter will go low and C will start to discharge. Therefore V_C falls until it reaches the lower logic 0 threshold (V−), upon which the output once more goes high and the cycle repeats.

The time period of one complete cycle of this oscillator is given by the formula:

$$T = 2RC \times \log_e(V+/V-)$$

where V+ and V− are the high and low switching thresholds of the Schmitt trigger input.

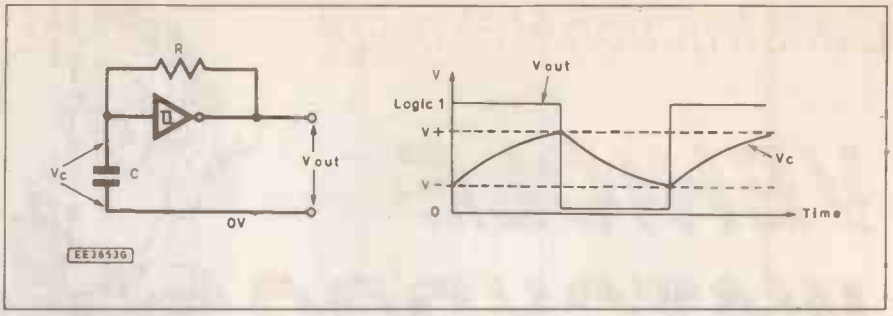


Fig. 3. Basic circuit and waveform of a relaxation oscillator.

In order to create a mark-to-space ratio greater than unity (i.e. output high/low times unequal) the resistor/diode arrangement shown in Fig. 4 is used. The capacitor now charges via R but when the output is low the forward-biased diode D allows a discharge current to pass through Rd as well as R. The discharge time (output low) is, therefore, much shorter.

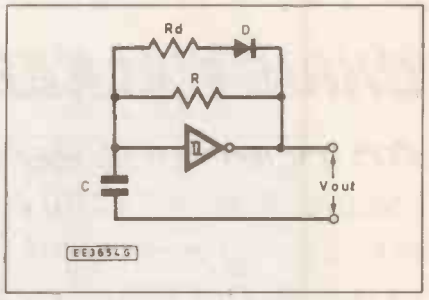


Fig. 4. Resistor/diode arrangement to create a mark-to-space ratio where the output high/low times are equal.

Referring back to the main circuit diagram, Fig. 2, resistor R5 can be seen to be the charge resistor for capacitor C3, whilst a rapid discharge occurs predominantly through R6. The oscillator output is inverted by gate IC1a and then buffered by transistor TR2, to illuminate light emitting diode D2. Resistor R7 limits the current through D2 to 15mA.

The visibility of the flashing l.e.d. obviously depends on the level of ambient light in the car; it is most eye-catching at night. Constructors may, if they wish, use an "ultra bright" type of l.e.d, but beware; these devices achieve high illumination by narrowing down their angle-of-view, so the overall result may be to make the l.e.d. less conspicuous.

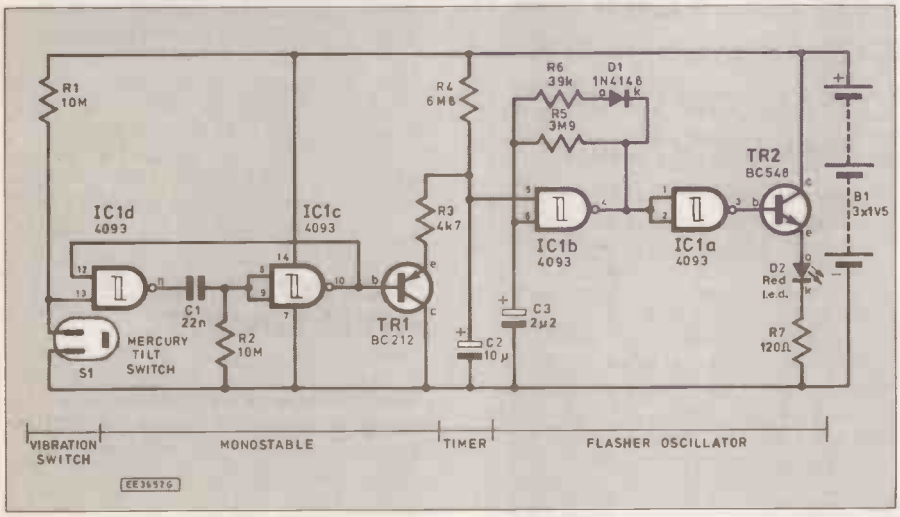


Fig. 2. Complete circuit diagram for the Vehicle Watchdog.

CONSTRUCTION

The prototype Watchdog is constructed in a plastic case measuring 112mm × 62mm × 31mm which houses the circuit board and three AA-size batteries. Only one hole needs drilling, 6·5mm diameter to accept a panel mounting clip for l.e.d. D2.

Before inserting the l.e.d. clip, clean the front panel with meths and take some time to create an impressive design using rub-down lettering and symbols. Remember that the success behind this unit relies on a convincing external appearance.

After the design is finished the transfers must be protected by a couple of thin coats of clear spray-on lacquer otherwise they will scratch off. Be sure to use a lacquer which will not lift the transfers off the panel. After an hour's careful work, the designer found (to his dismay) that one brand of lacquer caused all the lettering to lift off and float merrily across the case!

COMPONENTS

Resistors

R1, R2	10M (2 off)	
R3	4k7	
R4	6M8	
R5	3M9	
R6	39k	
R7	120	

See SHOP TALK Page

All 0.6W metal film or 0.25W carbon

Capacitors

C1	22n polyester layer
C2	10µ tantalum 16V
C3	2µ2 tantalum 35V

Semiconductors

D1	1N4148 signal diode
D2	5mm red l.e.d. with panel clip
IC1	4093 quad 2-input NAND Schmitt trigger
TR1	BC212 *pnp* silicon
TR2	BC548 *pnp* silicon

Miscellaneous

S1	Min. mercury tilt switch
B1	1·5V AA size battery (3 off)

Stripboard 0·1in. matrix, size 16 strips x 22 holes; plastic case, size 112mm x 62mm x 31mm; 14-pin d.i.l. socket; battery holder for 3 x AA cells; clip for battery holder; transfers for case; solid core wire for links; length of "dummy" wire.

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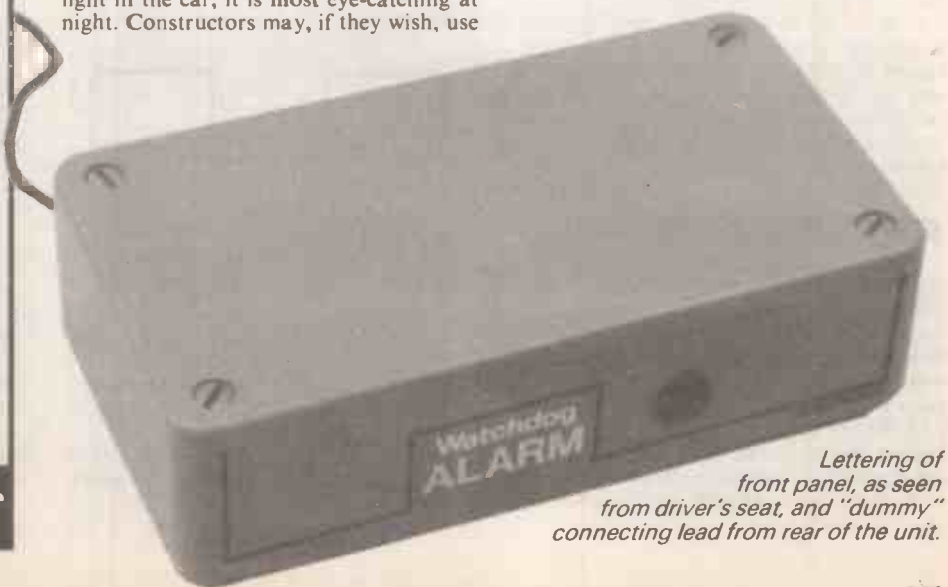
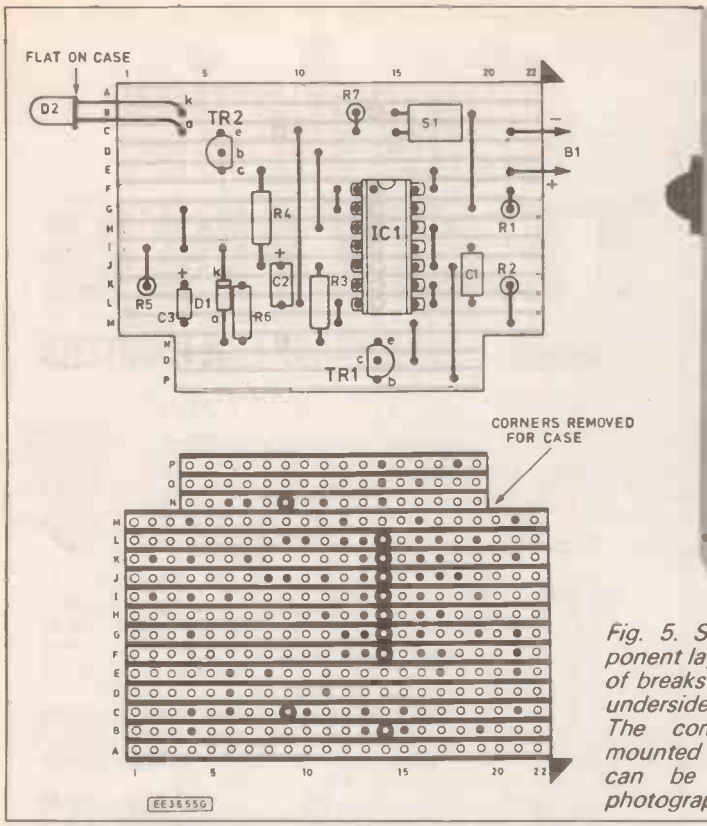


Lettering of front panel, as seen from driver's seat, and "dummy" connecting lead from rear of the unit.



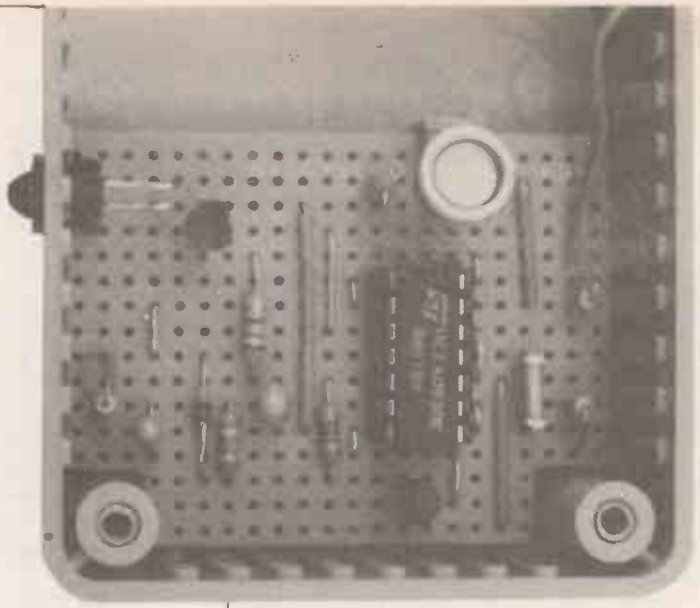


Fig. 5. Stripboard component layout and details of breaks required in the underside copper strips. The completed board mounted in its case can be seen in the photograph above.

CIRCUIT BOARD

Excluding the batteries, all components are mounted on a piece of 0·1in. matrix stripboard measuring 16 strips by 22 holes as shown in Fig. 5. Cut the board to size with a hacksaw and cut out two corners 8mm square to accommodate the corner pillars in the case. Next, using a cutting tool or a twist drill bit, make the ten breaks in the copper tracks according to the diagram.

Referring to the component layout diagram, Fig. 5, solder in a 14-pin d.i.l. socket for IC1 (but do not insert the integrated circuit just yet) and then solder eleven wire links onto the board, using tinned copper wire for this job.

The remainder of the components may now be soldered into place in any convenient order. Take care that the tantalum capacitors C2/C3, transistors TR1/TR2 and the diode D1 are inserted the correct way around as shown in the component layout. The semiconductor devices are all fairly sensitive to excess heat, so don't fry them during soldering! When mounting the mercury switch S1, position the switch body about 10mm above the board to allow it to be angled to adjust its sensitivity.

Before inserting l.e.d. D2 identify the cathode lead, it is the lead adjacent to the small flat edge on the l.e.d. body (the cathode is marked k on the diagram). Bend the l.e.d. leads through a right angle and solder it in place so that it will protrude through the panel mounting clip when the circuit board is placed in the case. Blu-tak can be used to hold the l.e.d. steady whilst soldering.

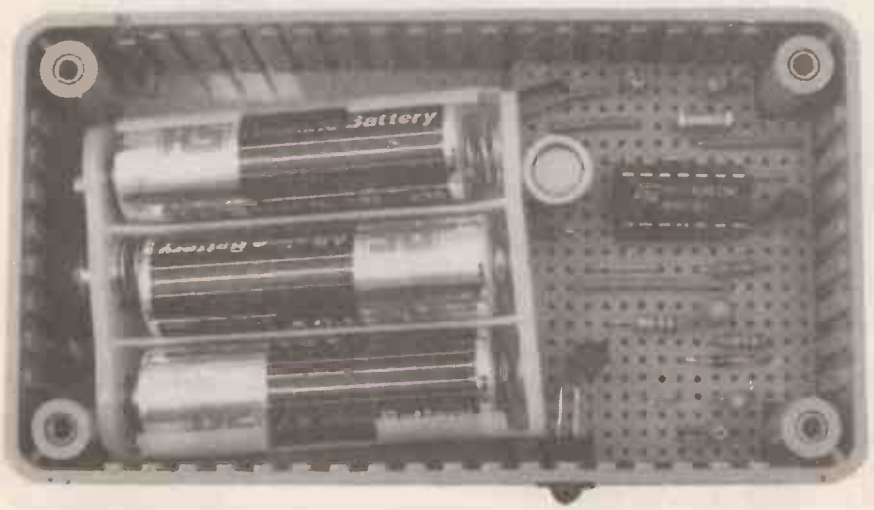
BATTERIES

The three AA-size batteries are held in a flat 3-cell battery box. Connections to these boxes are usually made via a PP3 style clip-on connector and the wires to this clip are soldered to the circuit board, red is positive, black is negative.

Due to the high resistance and small current involved in this circuit, and to preserve battery life, it is now beneficial to clean the copper side of the circuit board with a rag soaked in meths to remove finger grease which may otherwise cause leakage currents to flow.

The final stage of circuit board construction is to insert the integrated circuit IC1 with the identification notch next to the mercury switch. This is a CMOS technology device and, to some extent, prone to damage from static electricity which can build up on the human body. Discharge yourself by touching an earthed object before handling the i.c. and then try not to touch the pins.

Layout of components inside the case showing position of the battery pack.



TESTING AND INSTALLATION

Insert three fresh batteries and allow the circuit board to remain stationary for at least one minute. After this time D2 should start to flash once every two seconds. Give the board a good jolt and the l.e.d. should stop flashing for another minute.

If the unit fails to operate, check your construction. Pay particular attention to your soldering and make sure there are no solder blobs between adjacent tracks. Also ensure that all the components are correctly located.

Place the circuit board and batteries inside the case and clip the l.e.d. into its holder. It is quite important that the board does not move about as this will upset the sensitivity of the vibration detector. Secure the board if necessary.

Mount the case in a conspicuous position inside the vehicle. Double-sided adhesive pads are very useful for this purpose and are easily removed at a later date.

ADJUSTMENT

When the unit is in place, adjust the angle of the mercury switch S1 so that the gentle vibration experienced as the car is being driven causes the l.e.d. to stop flashing. Start with the switch at about 45 degrees to the horizontal and adjust as necessary.

When you are happy with the sensitivity of the unit, you can improve its authentic appearance by arranging for a short length of "bluff" wire to emerge from the case and disappear under the dashboard at a convenient location.

You can now forget about the Vehicle Watchdog as it will automatically switch itself on and off and the extensive battery life will ensure long and reliable service. □

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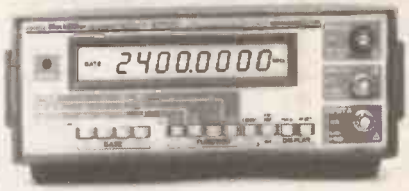

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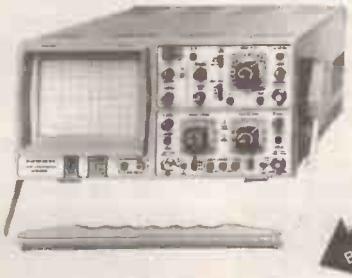

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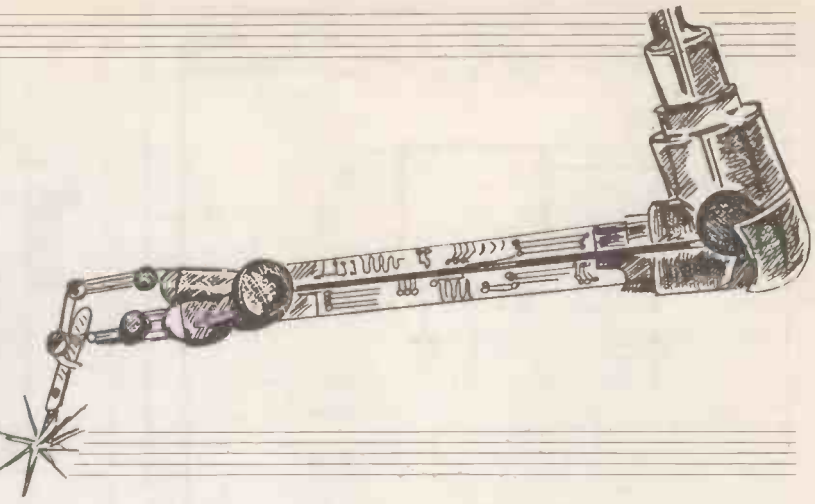

MIKE TOOLEY B.A.

Welcome again to Circuit Surgery, our regular clinic for readers' problems. In this month's Surgery we shall be describing a simple method of measuring unknown capacitors. We also have details of a low-battery indicator circuit which will provide warning of impending battery failure in portable equipment. We begin, however, with some points arising from an earlier Surgery:

Go/no-go transistor tester revisited

The simple go/no-go transistor tester described in April's EE seems to have been popular with quite a few of our readers and several of you have written with specific queries concerning the circuit used. Two of these are worthy of a wider audience and thus I make no apology for including them in this month's Surgery!

Firstly, ***Martin Coleman*** from High Wycombe has taken me to task for not including a power on/off switch in the circuit of Fig. 4 (April '92). Martin thinks that this was probably an oversight on my part and suggests that a simple s.p.s.t. toggle switch should be incorporated in the positive supply from the 9V battery.

In my defence, I should have pointed out that, provided the transistor under test (TR1) is removed from the tester, there will be virtually no current drain from the supply. The reason for this is simply that there is no d.c. path to ground in the oscillator stage and the d.c. amplifier stage (TR2) will consume only a minimal value of collector leakage current whilst the device is in the "off" state. There is thus no need for an on/off switch – just remember to unplug TR1!

Secondly, ***Joe Kendal*** has written from Otley, West Yorkshire, to ask if I can clarify some of the thinking behind the design of this circuit. In particular, Joe has asked if I can justify the values selected for the base resistors.

Taking the second (d.c. amplifier) stage first, TR2 is operated under saturated switching conditions. When TR2 is conducting its collector voltage will be approximately zero and the l.e.d., D3, will become illuminated as a consequence.

Now the voltage drop across a typical red l.e.d. will be about 2.2V when it is supplied with a normal value of forward current (in the range 10 to 18mA) and hence a voltage of about 6.8V (9-2.2V) will appear across R6. The current flowing in R6 can thus be determined from Ohm's Law. This current is also the collector current for TR2.

Hence, when switched "on", TR2 will operate with a collector current of 6.6V/470Ω = 14mA. The BC108 is rated with a minimum current gain of 150. Thus any base current in excess of 14mA/150 (93μA) will drive the transistor into saturation.

The value of R5 is actually not particularly critical; it just has to provide a *minimum* of 93μA to the base of TR2. The a.c. signal present at the collector of TR1 is typically in the range 2 to 4V pk-pk (under no circumstances can it exceed 9V pk-pk by virtue of the 9V d.c. supply). Consequently, the d.c. voltage (after rectification by D1 and D2) which appears at the junction of C5 and R5 will be typically between 1V and 2V (remember that we are using *half-wave* rectification).

At the other end of R5 (the base of TR2) we will need a voltage of 0.6V in order to forward bias the base-emitter junction and turn TR2 "on". Hence the voltage drop across R5 will be in the range 0.4V to 1.4V.

Taking the smallest of these values we could find the value of R5 that will produce a current of 93μA to the base of TR2. However, to be on the safe side, we will find the value of resistor that will yield at least *twice* this value.

Again, Ohm's Law comes to the rescue and we obtain a value of 0.4V/186μA or 2.15k. The nearest preferred value is 2.2k and hence this was the value specified.

A somewhat similar argument can be applied to the oscillator stage, TR1, except for two important additional considerations. Firstly, the base bias for TR1 is applied via R1 and R2 *in series*. However, these two resistors also form part of the phase shifting network within the Twin-T feedback network and are thus instrumental in determining the frequency of oscillation.

Secondly, TR1 operates under a.c. (rather than d.c. conditions). The mean value of collector voltage will be somewhere between 2V and 3.5V depending upon the current gain of the individual transistor used. The values of R1 and R2 must, therefore, represent something of a compromise between that required for correct d.c. bias and that required for a sensible frequency of oscillation!

Capacitance adapter

Most multimeters have ranges which are designed for measuring voltage, current and resistance. Only a few are versatile enough to permit measurement of capacitance. Following the two multimeter add-ons described in the last two instalments of Circuit Surgery, several readers have suggested that a simple device for directly measuring capacitance would be extremely useful. With this in mind, I set about designing a circuit which could be used with an existing meter (preferably a digital type).

The capacitance adapter can be highly recommended to anyone who needs a quick and effective means of measuring polyester, polystyrene and ceramic capacitors.

The complete circuit of the capacitance range extender is shown in Fig. 1. The circuit uses a single 555 timer connected as an astable oscillator which produces a square wave output at approximately 200Hz. The output of the oscillator is passed to the unknown capacitor and an integrating charge-pump detector arrangement is used to provide a direct current to operate the external multimeter (switched to the 2mA d.c. current range).

Assuming that a 3½ digit digital

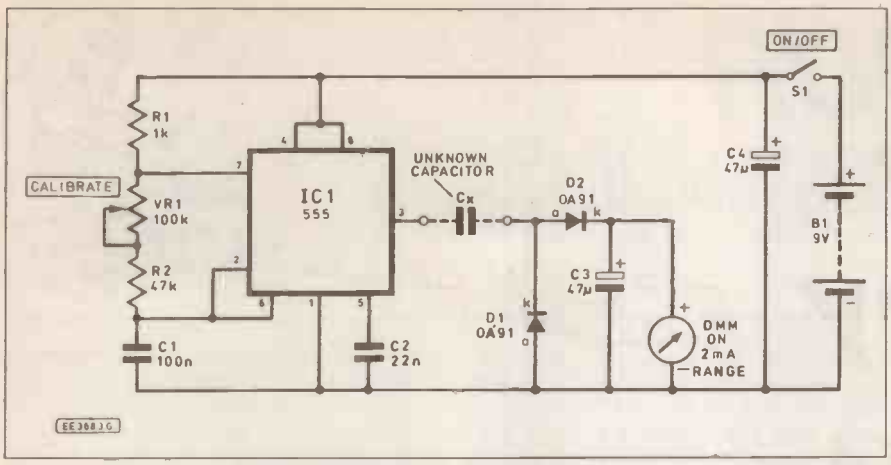

Fig. 1. Circuit of the capacitance adapter

multimeter is available, the instrument will provide readings over the range 1nF to 1.999µF. This is perfectly adequate for the majority of non-electrolytic capacitors including polystyrene, polyester and ceramic types.

To keep the instrument as simple as possible, no voltage regulator has been incorporated to keep the d.c. supply to IC1 at a constant level. It is, therefore, essential to calibrate the instrument *each time it is used* and this process will require a reasonably close-tolerance non-electrolytic capacitor of 1µF.

The multimeter should be switched to the 2mA d.c. range and the 1µF calibrating capacitor connected to the unknown capacitor terminals. VR1 should then be adjusted for a reading of exactly 1.000. The 1µF capacitor should then be removed and the instrument is now ready for use.

It must be said that this technique for measuring capacitance is not particularly new. However this particular design is novel in one respect; the secret in keeping the instrument linear lies with placing the calibrating resistor within the frequency determining circuitry rather than in series with the meter. This is a very real disadvantage of some other published designs. Hence, instead of introducing an additional variable resistance in series with the meter (and consequently suffering impaired linearity), our capacitance range adapter is calibrated by adjusting the *frequency* of the square wave source!

Low battery indicator

The terminal voltage of a battery usually remains reasonably constant during its normal discharge period but then falls dramatically at the end of its working life. Hence, some method of indicating the state of a battery can be extremely useful in any item of portable equipment. This is particularly true when the equipment in question is powered by nickel cadmium (NiCd) batteries.

With this in mind, ***Neal Taylor*** has written to me from South Devon with a request for a simple battery indicator. Neal writes:

"I have a portable transceiver which operates from a stack of nickel cadmium batteries. Depending on use, these will last for between 60 and 90 minutes of continuous operation. Unfortunately, I get little warning when they become exhausted – the set simply dies (often in the middle of a transmission)."

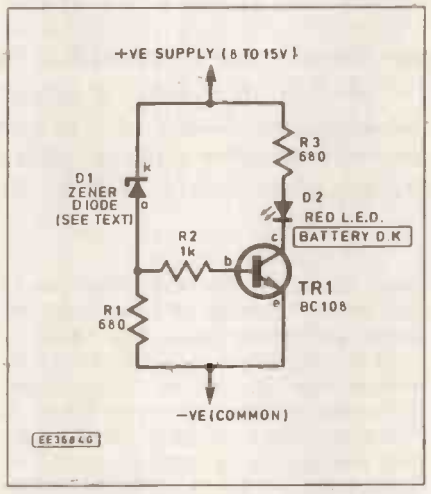

Fig. 2. Simple battery condition indicator.

Fortunately, the answer to Neal's problem is really quite simple. All that is required is an l.e.d., an n.p.n. transistor and an appropriately rated Zener diode connected as shown in Fig. 2. The Zener voltage should be chosen so that it is approximately 1V *less than* the nominal on-load battery voltage. As an example, assuming that Neal's transceiver uses an 8.4V d.c. supply, a Zener rated at 7.5V would be quite satisfactory. The l.e.d. will become illuminated when the battery condition is "good" and will become extinguished when the terminal voltage of the battery falls below about 8.1V. Neal will thus be alerted to the impending failure of his battery.

COMPONENTS

Resistors

R1	1k	
R2	47k	
¼W 5% carbon film		

See SHOP TALK Page

Potentiometer

VR1	100k linear

Capacitors

C1	100n polyester
C2	22n polyester
C3	47µ elect. 16V
C4	47µ elect. 16V

Semiconductors

D1	OA91 diode
D2	OA91 diode
IC1	555 timer

Miscellaneous

Small ABS case; Terminals (2 required); 8-pin low-profile d.i.l. socket; matrix board (aprox. 60mm x 40mm); snap-fit PP9 battery connector; s.p.s.t. miniature toggle switch; knob (to fit VR1)

Approx cost guidance only **£5**

Finally, if the required Zener voltage does not fall within the range of preferred values available, readers should remember that two (or more) Zener diodes can be connected in series to produce any desired voltage rating. As an example, a 6V Zener can be realised by simply connecting a 2.7V Zener in series with one rated at 3.3V!

Next month: In next month's Surgery we shall be describing a simple pulse repetition frequency comparator which can be used for synchronising the speed of two engines. We also provide details of a simple AM tuner which can be added to an audio system which only has an FM reception capability. For good measure, we have some information on the design of analogue to digital converters (ADC) and selecting basic logic gates to perform the standard AND, OR, NOT, NAND and NOR functions.

In the meantime, if you have any comments or suggestions for inclusion in Circuit Surgery, please drop me a line at: Faculty of Technology, Brooklands College, Heath Road, Weybridge, Surrey, KT13 8TT. Please note that I cannot undertake to reply to individual queries from readers however I will do my best to answer all questions from readers through the medium of this column.

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FOR YOUR ENTERTAINMENT

by Barry Fox

London Show

The annual absurdity of the spring "Brown Goods" trade show continues. (The name dates back to the days when all home electronics was a horrid brown colour – now it is an almost nasty black). Whereas all other countries stage annual, or biennial, exhibitions of new consumer electronics technology, either for the trade and press, or public, or both, Britain still clings to the crazy hotel system.

Rival manufacturers book suites in London hotels and galleries, and display their wares to the trade. This year over 40 exhibitors spread themselves between a score of hotels and venues, apparently selected on the basis of being as far apart as possible.

Philips had a marquee in Battersea Park. Nokia was at the Imagination Gallery off Tottenham Court Road. Toshiba was at the Institute of Directors in Pall Mall. Several firms had booked hotel suites in the Park Lane and Marble Arch areas and Sony had leased three floors in Landmark House in Euston Road. Sharp even split its exhibit between two venues, the company's showrooms in Vere Street near Oxford Circus and a hotel near Marble Arch.

"It's all a bit evolutionary" said one jaded visitor. What he meant was that you had to cover a lot of ground to find anything newsworthy.

Widescreen Demo

Perhaps the most significant event of the London trade shows was the last minute decision by satellite broadcaster BSkyB, to transmit excerpts from feature films in 16:9 wide screen D2-MAC. Agreement was reached only a couple of days before the show, after negotiations between BSkyB, Astra, Philips, the Eureka project handling HDTV and UK satellite receiver manufacturer Pace.

Although the parties are guarded about details of the deal, it seems that Astra loaned Channel 29 for the occasion, BSkyB provided the movie material, the EC chipped in some money and Philips did deals with Pace to produce wide screen decoders. This was necessary because BSkyB scrambled the material using Videoguard, a new scrambling system which appears to be halfway between VideoCrypt and EuroCrypt.

Both Philips and Nokia were demonstrating wide screen pictures live from the satellite source. The event is a watershed, because it shows a degree of commitment to wide screen TV from BSkyB never previously seen.

The demonstrations were important too because they included sets with 28in. screens. So far 36in. has been the only 16:9 size. Nokia had three 16:9 wide screen TV sets running side by side, under domestic viewing conditions; a 36in. 16x9 at £2150, 32in. at £1400 and 28in. at £1100. Each could be switched to demonstrate 4x3 pictures zoomed to wide screen format.

This, of course, reduces the number of scanning lines available for the displayed picture. On the 36in. and 32in. screens the zoomed format made the pictures look very coarse. But on the 28in., the picture looked clean and crisp.

This suggests that the 28in. screen size may well be the break point between acceptable and unacceptable viewing when the picture is zoomed.

Also, whereas 36in. and 32in. sets are still too large for most living-rooms, the 28in. is of manageable size, and weight. The visual impact of wide screen viewing still carries through on a 28in. screen, although it is unlikely that the benefit of wide screen would come through on smaller screens.

Dual Standards

For me, by far the most exciting innovation at this year's show was a new VCR from Aiwa, a subsidiary of Sony. To be strictly accurate there are two new VCRs, each costing under £400. Both play a very clever trick which will answer the prayers of video users all round the world. There will also be a "stand-alone" box, costing around £250, which connects to existing VCRs.

The trick is this. The VCR can play a tape of one standard, either NTSC or PAL, display it on any PAL or NSTC TV set, and make a copy onto any other VCR in either PAL or NTSC. The only other VCR on the market which can do this is made by Panasonic and costs £1800. Most people who want to watch tapes from abroad must pay a video or photographic shop at least 25 pounds to transfer just half an hour's viewing.

The NTSC TV system used in the US and Japan builds its pictures from 525 lines, transmitted as half pictures or fields, each with 262·5 lines. The fields interlace on screen to create the illusion of full pictures.

The European PAL system works in the same way, but with 625 lines, 312·5 per field. NTSC displays 60 fields a second. PAL uses 50. This is why VCR and TV sets of one standard will not normally play tapes of another standard.

Several manufacturers, including Pioneer, Panasonic and Mitsubishi, now sell video disc players and VCRs which can play NTSC tapes through *some* PAL sets. They do this by modifying the NTSC colour signal to mimic PAL, and relying on the fact that many modern PAL TV sets can by good fortune cope with 525 lines and a 60Hz field rate.

But these systems are rogues because they do not convert the NTSC signal into PAL, so it is not possible to make a PAL copy of an NTSC original. Also some TV sets are confused by the fudged signal and display pictures which are either too small or unstable.

By Memory

The Aiwa VCR contains a solid state memory which stores each TV field as it is read off tape. It then reads the field from the memory and out to a TV set or other VCR. While reading an NTSC signal out to a PAL TV or VCR, the memory reads 50 of the stored lines twice over to build the 262·5 line scanning structure up to 321·5 lines.

The memory also skips every sixth field that is stored, thereby converting a 60Hz sequence into a 50Hz sequence. The VCR also converts the colour coding system from NTSC to PAL, by changing the frequency at which the colour information is carried piggy-back on the black and white information. So the VCR delivers a true PAL Signal.

To convert PAL to NTSC, the memory reads out every sixth field twice, to increase the field rate from 50Hz to 60Hz. At the same time it converts the colour coding frequencies from PAL to NTSC and combines 50 lines of each field to reduce the scanning pattern from 312·5 lines to 262·5 lines.

The picture delivered to a PAL screen from an NTSC tape are not as good as the original, but they will be quite good enough for most viewers wanting to watch family tapes from abroad. They will also let people buy tapes on holiday and either watch or copy them back home. This is likely to distress the movie industry which has relied on the NTSC/PAL standards barrier to police its copyright deals with different countries.

Professional converters, as used by broadcasters to screen US tapes in Europe, give better quality. They store up to eight fields at a time, and use computer intelligence to average and interpolate the picture information that is added or subtracted. But these systems cost tens of thousands of pounds – in the early days of TV broadcasting, they cost hundreds of thousands!

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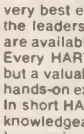

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INTERFACE

Robert Penfold

As promised last month, this article includes the train controller listing (see also April issue). This is written in QBASIC (as supplied with MSDOS 5), but it will also run as a Quick BASIC program. It should be possible to convert it to other BASICs without too much difficulty.

It is written on the assumption that the digital to analogue converter is at address &H300, and that the direction is controlled by bit 0 at address &H308. If different addresses are used, these must be substituted in the appropriate program lines. Also, some modification to the program will be needed if one address is used for both speed and direction control, as discussed in a previous *Interface* article. Details of how to use the program will not be given here, as it is very easy to use, and provides on-screen prompts.

Keyboard Control

The basic method of keyboard control used in the original program was to have the train accelerate while the appropriate key was held down, and brake while another key was operated. This type of control works well with most 8-bit computers where the keyboard is monitored by input ports, and direct reading of each key (or something close to it) is possible.

It does not seem to work well with some 16 bit computers as they have quite complex keyboard electronics, and rather indirect means of reading the keys. With both the Atari ST and the PCs there is a micro-controller to read the keyboard, with a serial link to the main processor. This removes a lot of work from the main processor which no longer has to bother with keyboard scanning, buffering, etc. On the other hand, it can be difficult to reliably monitor keys on an "up" or "down" basis.

The keyboard circuits are designed to detect the order of key presses rather than the duration of each key press. It seems to be more practical to opt for control on some form of "toggling" basis, which is the method of control used in this program.

Joystick

If you have a joystick and a games port for your PC it might be interesting to try this as the input device for a train controller. The "firebutton" could be used for direction control, with the "stick" being used to control the speed. Alternatively, the "stick" could be used for both functions, with the spring-loaded central position being used as the "off" setting. This would leave the "firebutton" free to operate as a brake.

Remember that the values read from the games port can be mathematically manipulated before being sent to the controller circuit. This feature can be used to provide simulated inertia and momentum. Some BASICs provide easy access to the games port (usually in the form of STICK and STRIG functions), and with a suitable language this method of control should be well worth investigating.

Languages

In last month's *Interface* article I should have mentioned that the FST Modula 2 program is available from PDSL, Winscombe House, Beacon Road, Crowborough, Sussex, TN6 1UL (Tel. 0892 663298, Fax 0892 667473). This program is on three disks which have catalogue numbers 2033A/B/C. It is a popular

Train Controller Programme

```
DEFINT A-Z
'Declare state variable and constants

DIM SHARED State
CONST Still = 0, Accel = 1, Brake =
2, EBrake = 3, Cruise = 5

State = Still

'Declare global variable for speed factor
DIM SHARED CurrentSpeed
CurrentSpeed = 0

'Set up screen

SCREEN 0, 1
CLS
LOCATE 4, 32
PRINT "Train Controller"
LOCATE 6, 35
PRINT "Speed: "
LOCATE 6, 42
PRINT CurrentSpeed / 3
LOCATE 10, 5
PRINT "A - Accelerate"
LOCATE 12, 5
PRINT "B - Brake"
LOCATE 14, 5
PRINT "E - Emergency Brake"
LOCATE 16, 5
PRINT "Spacebar - Cruise"
LOCATE 18, 5
PRINT "F - Forward, R - Reverse (Stationary only)"
LOCATE 22, 5
PRINT "Esc - Quit program."

'Main program loop
WHILE 1
   Choice$ = UCASE$(INKEY$)
   SELECT CASE Choice$
      CASE "A"
         State = Accel
      CASE "B"
         State = Brake
      CASE "E"
         State = EBrake
      CASE "F"
         IF State = Still THEN OUT
         &H308, 1
      CASE "R"
         IF State = Still THEN OUT
         &H308, 0
      CASE CHR$(32)
         IF State <> Still THEN
         State = Cruise
      CASE CHR$(27)
         END
   END SELECT
   SELECT CASE State
      CASE Accel
   CurrentSpeed = CurrentSpeed + 3
      IF CurrentSpeed > 255 THEN
         CurrentSpeed = 255
            State = Cruise
         END IF
      CASE Brake
   CurrentSpeed = CurrentSpeed - 3
      IF CurrentSpeed < 0 THEN
         CurrentSpeed = 0
            State = Still
         END IF
      CASE EBrake
   CurrentSpeed = CurrentSpeed - 12
      IF CurrentSpeed < 0 THEN
         CurrentSpeed = 0
            State = Still
         END IF
   END SELECT

   LOCATE 6, 42
   PRINT CurrentSpeed \ 3
   OUT &H300, CurrentSpeed
   SLEEP 1
WEND
```

program which should be available from other PC shareware companies, but not under these catalogue numbers.

It is worth mentioning that with PDSL disks you are guaranteed the latest available version of any program. You need to be wary of PC shareware companies that offer very cheap disks, as these often contain versions of programs that are literally years out of date. Not so long ago I obtained some cheap PD/shareware disks where some of the programs were of 1986 and 1987 vintage! None of the disks contained up-to-date programs.

There are quite a range of PC shareware languages available these days. Some of these are quite interesting to try out, but in many cases the cost of registering is not very competitive with commercial software. Competition amongst producers of commercial PC software has made it difficult for shareware authors to significantly undercut them and still charge a worthwhile amount for their products.

The A86/D86 assembler and debugger is a popular program, and is now available in an updated form on disk No.1930. There are a couple of interesting C compilers on disks 1199 ("Small C Compiler") and 1489 ("Personal C Compiler"). There is an interesting public domain version of Prolog 2 on disk 2547. I think that I am correct in saying that the two original high level computer languages were Cobol and Prolog, which were for developing business and general/scientific applications respectively. This version of Prolog is public domain, so there are no registration fees. However, there is little on-disk documentation, and you will probably need a book on Prolog in order to use the program.

Reliability

Anyone involved with PCs can hardly have failed to notice the dramatic price reductions in PCs over the last year. New 8088 based computers have virtually disappeared from the scene, and now 80286 based PCs seem to be going the same way. They simply have no significant cost advantage over 80386SX computers. Even 33MHz 80486 based computers are becoming affordable. So what is the catch?

My recent PC buying experiences, and those of several PC owning friends, would suggest that the problem with many of the bargain PCs currently on offer is that they are not very reliable. To be strictly accurate about it, they are mostly very reliable once they are up and running properly.

The problem is that many of the PCs currently on offer have not been thoroughly tested prior to despatch, and come complete with one or more faults. These vary from things like ports that do not work because the sockets do not connect to their expansion card, to obscure faults such as motherboards which only work when the weather is hot. Some are simply not set up correctly.

Now would seem to be a good time to buy PCs, but there could well be a certain amount of hassle before your new wonder computer is up and running properly.

Next month we will return to general computer hardware matters, with a look at some simple pieces of hardware to read bar codes.

SHOP TALK

with David Barrington

Switch-Mode Power Supply

There are a number of factors to be considered if you wish to get the best from the *Switch-Mode Power Supply*.

Transistor TR2 needs to have an h_{fe} of at least 500 or greater and a BC109C was chosen here. The BC109C was selected as it claims to have a spread from 380 to 800 at 2mA and is more likely to be within the spec we require. The standard BC109 quotes a range of 180 to 800 and you are less likely to find you have a suitable device. The device with the suffix "B" only quotes 180 to 480 and does not attain the level we want.

Only good quality capacitors should be used in this project. The filter electrolytics C3 and C5 must have a low ESR ("effective series resistance) for the reasons mentioned in the article. These should be available from most good component suppliers and are certainly listed in the Maplin catalogue.

The large main smoothing electrolytic C1 must be rated at about 5A ripple current. The one used in the model is listed as 4·9A ripple and is a five terminal, long life, p.c.b. mounting device purchased from **Electromail** (☎ *0536 204555*), code 104-382. This capacitor seems fairly expensive and other types can be used, but they must be able to sit on the p.c.b. and have almost identical ratings.

The "flyback diode" D1 must be a fast recovery type and be capable of carrying the peak inductor current. The BYW29/100 type is listed by **Cricklewood Electronics** and the BYW80/150 device by Maplin, code UK63T.

The bridge rectifier should be one rated at 6A and may be difficult to find in a d.i.l. configuration. As the bridge is not mounted on the board but the metal chassis plate, the standard "square" type can be used. The square bridge is the most common type stocked and the 6A version is usually rated from about 200V p.i.v. to 600V p.i.v.

The low ohm, high wattage resistors used are wirewound types and should be available generally. However the 6W type seems scarce, so its a case of using 3W (doubling up where indicated) or a 7W type.

The Darlington transistor and thyristor should be widely available and not cause concern. They are certainly listed in the *Free* Cricklewood components catalogue. The two heatsinks for the Darlington transistor and diode D1 should also be readly available. If you do experience problems they are stocked by Maplin, codes FG51F and JW27E.

Now for the inductors. The Feroxcube core and former were purchased from Electromail, code 228-270 and the DT2534 bobbins from Maplin HX10L.

Suitable 80VA mains transformers should be stocked by most of our components advertisers. Transformer specialists, such as **Jaytee Electronic Services** (☎ *0227 375254*), may even be able to supply one with 22V secondaries as mentioned in the article. The transformer used by the author was purchased from Trent Coil Winding Co., Dept **EE**, 26 Derby Road, Long Eaton, Notts. You could try winding your own from one of the kits available. A torriod transformer, such as the Maplin YK18U, could also be used.

Finally, the printed circuit board is available from the *EE PCB Service*, code **EE796** (see page 395).

Digital Servo Interface

Several items called for in the *Digital Servo Interface* are "specials" and will not be available locally.

The pre-programmed controller IC1 is only available from one source. The programmed PIC 16C54 Opt/Servo can be purchased (£12.50 inclusive) from **Nikam Electronics Ltd, Dept EE, West End Gardens, Fairford, Glos. GL7 4JB**.

Suitable RC servo motors should be available from model shops. Maplin stock a suitable motor listed as type 626T, code FS35Q. Note that there does not appear to be a standard configuration for servo motor connections and on some older motors the supply connections may have to be reversed.

The block connector and servo mechanics for the prototype model were obtained from: **SLM (Model) Engineers Ltd**, (☎ *0242 525488*).

The small printed circuit board is obtainable from the *EE PCB Service*, code EE791.

CCD Reverb

The only sources we have been able to locate for the MN3011 bucket brigade delay line i.c. and the companion clock generator/driver i.c. MN3101 are from **Maplin** (☎ *0702 554161*), **Farnell Electronic Components** (☎ *0532 636311*) and **Electromail** (☎ *0536 204555*). The Maplin order codes are: UM65V (MN3011) and UM66W (MN3103). The delay line i.c. is an expensive device and should only be removed from it's packing when all construction has been completed and checked.

The rest of the components for the Reverb are standard lines and should not cause any problems. Remember to use a "High Power" battery in the model.

The printed circuit board is available from the *EE PCB Service*, code **EE795** (see page 395).

Vehicle Watchdog

We do not expect any component buying problem to be encountered by constructors of the *Vehicle Watchdog*. The mercury tilt switch should be available generally, however, if problems do arise, the one in the model was purchased from Electromail, code 337-289.

These switches are sometimes listed as vibration type. The switch finally used must be the metal cased type not the glass envelope type. *Warning:* Mercury is very toxic and the switch *must not* be cut open in any circumstances.

The BC212L transistor used must be the one with the letter L suffix, other types have different pinout arrangements.

Tie Pulser

The miniature microphone insert used in the *Tie Pulser* project is the EM-4 omnidirectional electret condenser type and should be avaiable from numerous sources. A suitable type is certainly carried by Omni, Greenweld, Maplin, Marco, Cricklewood and Electrovalue.

The l.e.d.s used for the tie display are the low current 2mA type, with maximum current of 20mA. As twenty are required it might pay to ask your supplier for a "bulk discount".

The small printed circuit board is available from the **EE** PCB Service, code **EE794** (see page 395).

EVERYDAY NEWS

TALKING MOBILE

Keep your eyes on your driving, keep your hands on the wheel

FOR the man or woman in the fast lane, keeping in touch while you're on the move is safer and simpler than ever before with the new British Telecom's Azure cellpone. In fact, it's as easy as 1,2,3, – or any other convenient number code you choose to programme into the carphone's memory.

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Voice Commands

They synthesised female voice that responds to your commands and verifies that is has heard them correctly is amiable enough, though clearly not to be trifled with. She can, for example, remember a total of 130 numbers for fast, accurate dialling.

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Another holds 24 numbers tagged with the names of your business contacts. Just say the name and your invisible assistant will call their office.

She will also, it is claimed, answer the phone automatically, so you don't need to move a hand off the wheel to take an incoming call.

The BT Azure has a security lock, a hand-signal strength indicator and a dual-function timer, to help you keep tabs on individual calls and your total calling time. For those who need the ability to carry the phone with them wherever they go, it is also available with an optional transmobile kit that turns it into a transportable cellphone.

Apart from the safety aspects, most people will go for the Azure because the voicedial command system makes this unique phone both easy and fun to use. The price, £295 plus VAT, is pretty sharp for a good all-round carphone with the bonus of speech-recognition technology.

PC 'SCOPE/VOLTMETER

The neat and easy to use plug-in module shown will transform your PC into a 'scope and a voltmeter. The ADC-10 comes from Pico Technology together with a 24-page user manual and software on disc. The electronics have been very neatly incorporated inside a connector hood with a BNC socket for input lead connection. The unit plugs into the parallel printer port of a PC and takes its supply from the computer.

ADC-10 is an 8-bit A to D converter with an input voltage range of 0 to 5V. The software supplied allows various options such as Oscilloscope; Digital Voltmeter; Multimeter; ADC Readings etc., and also allows the parameters within each option to be changed e.g. triggering and timebase settings for the 'scope.

Additionally the ADC-10 can perform many functions that are only currently available on expensive digital storage oscilloscope such as saving waveforms to disk, or sending them to a printer. It is particularly suitable for displaying very low frequency trends (such as a battery discharge) which cannot be displayed on an oscilloscope due to the limitations of a CRT.

Typical examples of its use are in data acquistion (monitoring temperature, pressure and strain gauges) and digital audio sampling. It is claimed to be particularly useful for field engineers since it's small size makes it ideal for use with portable computers.

Principles of operation are described so that users can develop their own driver software if they wish. The complete package cost £49 plus VAT and is available from **Pico Technology Ltd., Dept EE, Broadway House, 149-151 St. Neots Road, Hardwick, Cambridge CB3 72J. Tel. 0954 211716. Fax: 0954 211880.**

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The TSA250 Spectrum Analyser adaptor costs £405.38, inclusive VAT, and is available from: **B.K. Electronics, Dept. EE, Units 1 and 5 Comet Way, Southend-On-Sea, Essex SS2 6TR. Tel: 0702-527572. Fax: 0702-420243.**

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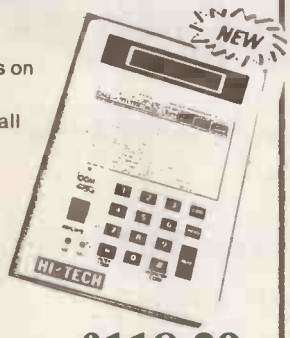

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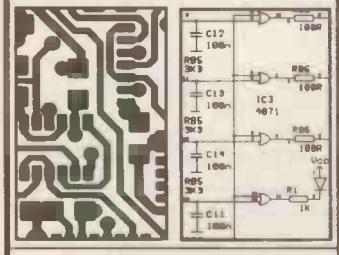	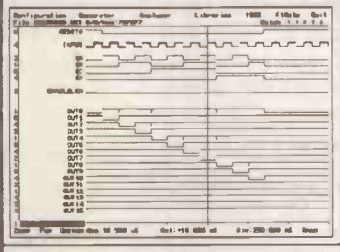	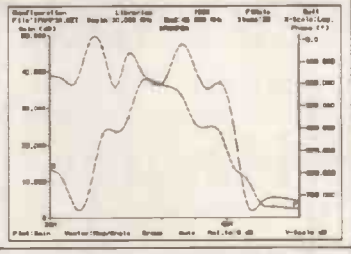	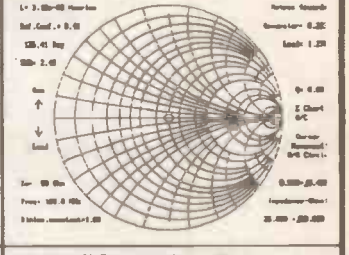
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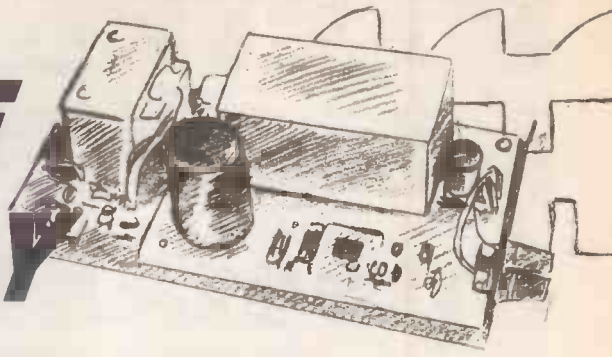
SWITCH-MODE POWER SUPPLY



STEVE KNIGHT

A DIY design that will give a 5V to 15V supply, with a maximum output current of 5A

A COUPLE of years ago I had a short series published in *Everday Electronics* covering the design of regulated power units. In the theory which accompanied this series it was shown that the function of regulated systems was to convert a "rough" d.c. input voltage into a stable d.c. output voltage which would be maintained over a wide range of load current requirements as well as input voltage variations.

The general block diagrams of such systems are shown in Fig. 1 and Fig. 2. Designs based on these principles are known as *linear* voltage regulators to distinguish them from the kind of regulator we are going to investigate in this article.

LINEAR SYSTEM

The circuit system in which a "control element" is placed in series with the positive rail of the supply is illustrated in Fig. 1. Current flowing from the rectified input supply to the load terminals passes through this control element, which is usually a power transistor acting as a variable resistance, R_S.

This resistance is controlled in effective value by an error amplifier which takes a signal from an error detector and compares it with a stable reference voltage, often derived from a Zener diode or a band-gap device. The error detector is, in turn, controlled by a voltage adjustment control which sets the desired output voltage V_0.

Once this level is set, any change in the output voltage, rise or fall, due to a variation in the load current, for instance, is sensed by the error detector which then causes the error amplifier input to deviate from the reference level, and the resulting output adjusts the series control element resistance in such a direction as to compensate for the initial change. Hence the output voltage, within the design limits, remains constant over a wide range of current and input voltage variations.

Series regulators are simple and inexpensive design features but under high current, low voltage output conditions there is a considerable voltage drop across the control element resulting in wasteful power dissipation and a consequent loss in efficiency.

Some linear systems have the control element connected in shunt rather than in series with the supply, see Fig. 2. In a sense, the shunt element behaves in its stabilising work rather as a Zener diode behaves, but the analogy must not be pressed too far.

The current flowing through the shunt is again controlled by an error detecting system in much the same way as it did in the series case, though the sense of the control has the opposite sign. This means that as the load current I_L increases, say, the current through the shunt is reduced, to adjust the voltage drop across a series resistor R, and maintain the output constant.

Again at high currents, there is wasteful power dissipation in R, and additionally in the control element itself, so that the shunt regulator on the whole is not so efficient, under like circumstances, as the series model. It has, however, some advantages under certain operating conditions.

An alternative approach which has a number of advantages over linear control systems, is the switching regulator, or as it is more usually known, the "switch-mode power supply". This is the method used in the project to be described in this article.

SWITCH-MODE PRINCIPLES

As long as patience and care are applied, making up a switch-mode power unit is no more difficult than any other sort. Integrated circuits are available in which everything except the switching control transistor, smoothing capacitors and the necessary inductances are built in, and a supply can be fabricated by a dozen or so connections to the chip.

The design we are going to talk about is a DIY design in that, apart from a 555 timer and 4001 NOR gate chip, discretes are used to carry out the various circuit operations and the system is capable of being modified for those who like a starting point and then like to experiment. It gives scope for the hobby-electronics enthusiast to try out his own ideas, and for those who don't, the

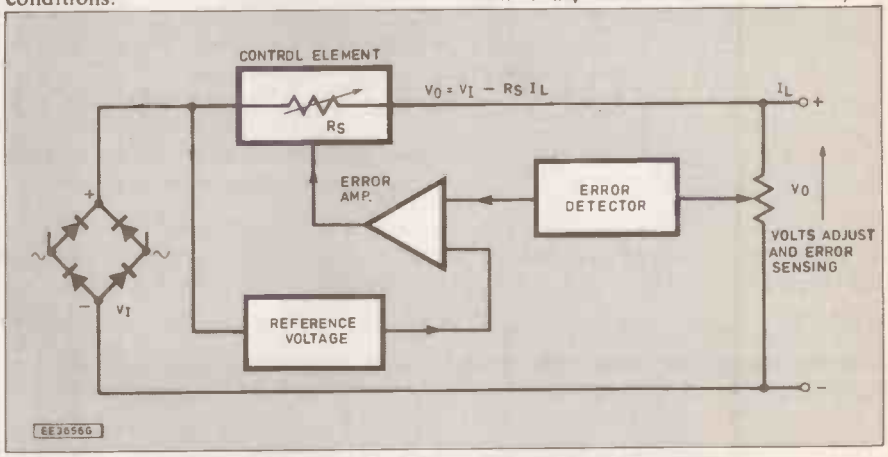
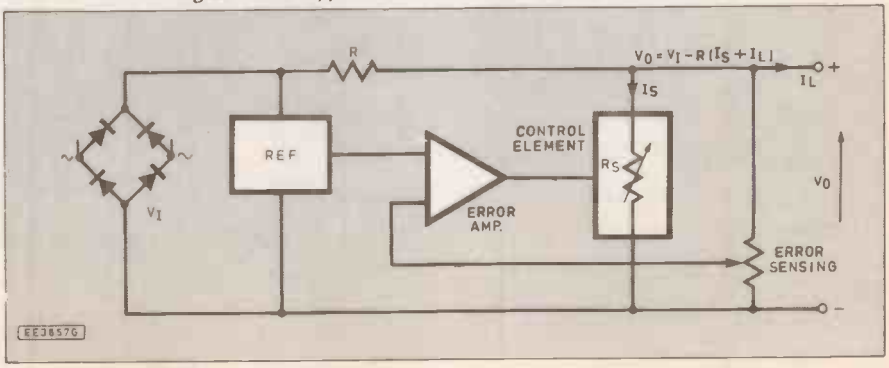


Fig.1. Linear type series controlled voltage regulator.

Fig.2. Linear type shunt controlled voltage regulator.



design as it stands provides a useful power supply unit.

The principle of a switch-mode regulator is shown in Fig. 3. A source of d.c. voltage is obtained from a bridge rectifier and initially smoothed by a capacitor C1 in the conventional manner. This unregulated d.c. now passes through an electronic switch *S* which turns on and off at a relatively high frequency; this might well lie within the range 15kHz to 100kHz, sometimes more.

The voltage at the output of this switch alternates as a rectangular wave between the source level and zero, and this in turn is fed into an *LC* filter network consisting of inductor L1 and capacitor C2, plus a "flyback" diode D1. The basic purpose of this filter is to smooth out the chopped waveform appearing from the switch and so provide a steady output voltage across a load resistance R_L, though it does this job in an unconventional way.

The advantage of using a switch which is either *completely off* or *completely on* over any form of variable resistance as in linear supplies, is that *no power* is dissipated in this sort of control element, whatever the load requirements are or whatever the voltage developed across the switch happens to be. When the switch is open, the current through it is zero, hence the power product *VI* is zero. When the switch is closed, the full available current flows through it to the load but again no power is dissipated in the switch since the voltage across it is zero.

We are, of course, assuming that we are using an ideal switch which doesn't exist in real life, but the point being made is that a switching system will be a lot more efficient than any resistive control element where dissipation is invariably relatively large.

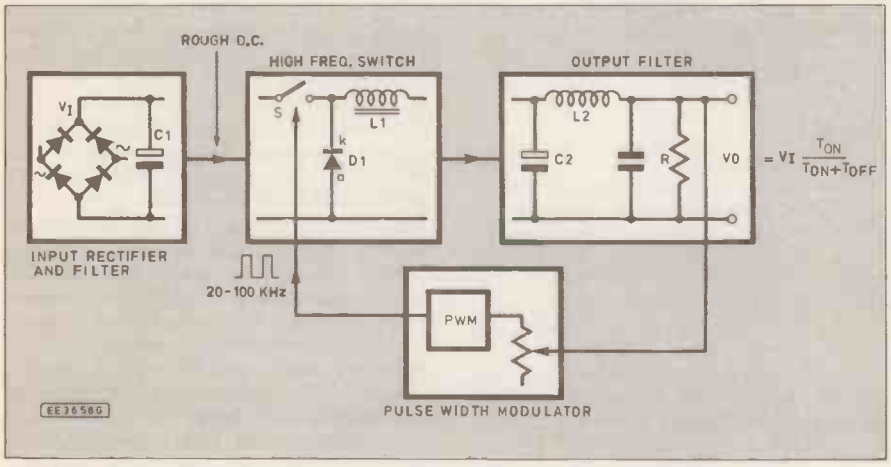


Fig3. Block diagram of a switch-mode type regulator system.

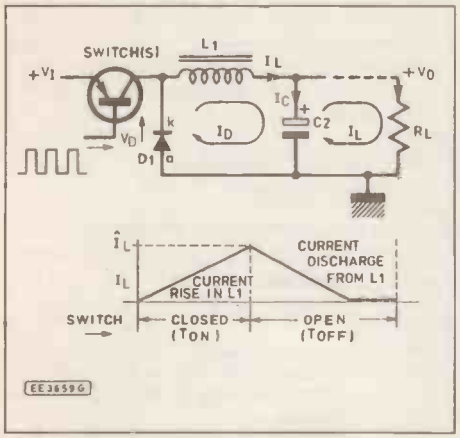


Fig.4. Operating cycle of the filter circuit showing the inductor current waveform.

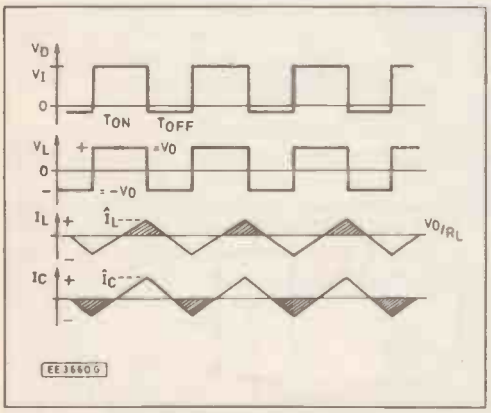


Fig.5. Idealised waveforms found at the various points in the filter network.

FILTER CIRCUIT

At first sight, the filter circuit may appear conventional but the presence of the diode D1 is unconventional and it seems as though it is going to be switched off all the time anyway, the anode (*a*) always being at zero potential. We can study the circuit in rather more detail if we look at Fig. 4.

When the transistor switch *S* "closes" the full d.c. input voltage is applied across the filter and current flows through the inductor to charge capacitor C2 and provide the needs of the load (R_L). The diode D1 *is* reverse biased during this period and plays no part in the action.

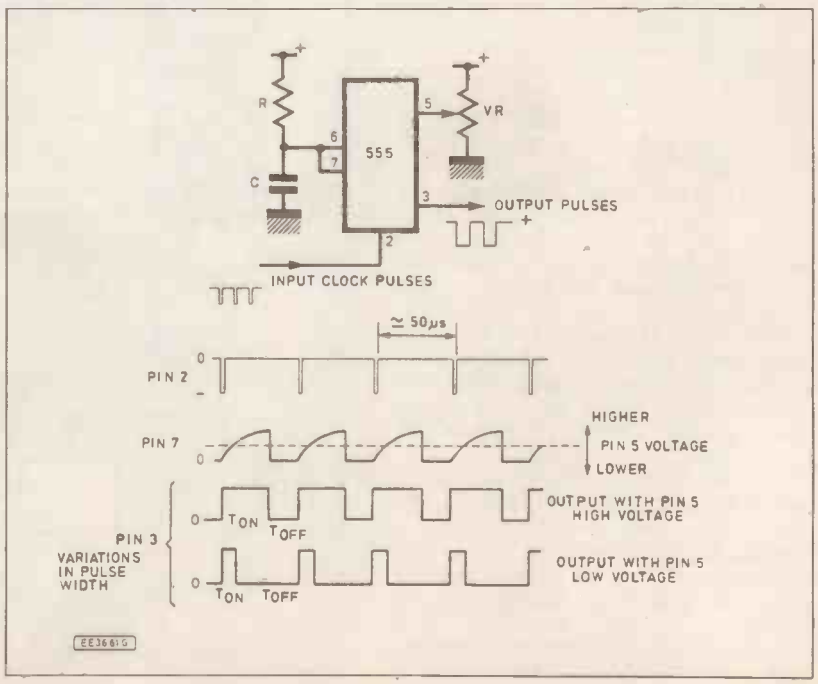
Although the switching action is abrupt, the current in L1 and the voltage across C2 cannot, however, follow the steep rise of the switch output but builds up relatively slowly. That is, the effect of the inductance, as always, is to oppose an increase in current. Under the impressed constant voltage, the inductor current raises linearly to a peak magnitude $\hat{I}_L$ (if saturation is avoided) which is dependent upon the value of L1 and the time T_{ON} during which the switch remains closed.

At the instant the switch opens, the current through the inductor is at its peak value; this current cannot fall to zero instantaneously any more than it could rise instantaneously, and a back e.m.f. is developed across the inductor to oppose the fall. The diode D1 now comes into the action by being suddenly forward biased, so providing a path for the current from the inductor to flow around the loop into the filter capacitor and the load. Hence current continues to flow into the load even when the switch is open. Fig. 4 illustrates the effect of current discharge from inductor to capacitor and load.

If the output voltage is to remain constant, the effectual *net* charge delivered to the filter capacitor must be zero; this means that the charge provided by the inductor must be dissipated in the load. For a constant value of T_{ON}, the time required by the load requirement; control of T_{ON} therefore determines the output capability of the supply.

The waveforms of Fig. 5 illustrate this action in more detail. The voltage across the diode, V_D, follows that from the output of the switch, that is, very closely equal to V_I assuming an ideal switch, during the period T_{ON}; when the switch opens, the

Fig.6. Principle of the 555 timer used as a pulse width modulator (PWM) and the associated waveforms. Pin 3 waveforms are inverted before being applied to the switching transistor (TR1).



back e.m.f. inversion across the inductor allows current I_D to pass through the diode, this current being in the *same* direction inductor-wise as before but now decreasing.

Current which is over and above that required by the load is represented on the waveform for I_L by the cross-hatched area. This excess flows into the capacitor where it is stored until the load requirement demands it, the un-hatched current passing into the load.

When the inductor current is less than that needed by the load, the capacitor sheds some of its stored energy and provides the required additional current. The waveform for capacitor current I_C shows this provision as the cross-hatched area. If everything is properly proportioned, therefore, a steady supply of current is available for the loading.

FILTER COMPONENTS

The a.c. ripple frequency fed into the filter is obviously high. This gives an advantage over conventional 100Hz ripple-smoothing filters used in linear power systems in that the values of both L and C can be relatively small but still provide a high a.c. ripple reduction. The attenuation is, in fact, proportional to the reciprocal of $2\pi f^2LC$ assuming that this is large compared to 1, hence the higher the switching rate the smaller the filter components may be.

The requirements of both the filter capacitor and the "flyback" diode are fairly critical in this kind of application. The value of the capacitor must be selected in conjunction with the value of the inductor so that the output ripple requirement is met; as an electrolytic will almost certainly be used, the Effective Series Resistance (ESR) and the self inductance are the important parameters.

For effective filtering, the ripple frequency must be very much lower than the frequency at which the series inductance becomes troublesome, and ideally the ESR must be less than the ratio of the specified ripple voltage to the ripple current. Suitable capacitors are available and should be used in this position.

The diode used must be capable of carrying the peak inductor current; in addition, it must be able to recover from its conducting state to its blocking state in a very short space of time. If this does not happen, current from the switch could be passed to "earth" for part of the cycle, resulting in possibly a damaging loading on the switching device and overheating with loss of efficiency. A fast recovery diode must therefore by used.

There remains now only the problem of providing a suitable Pulse Width Modulating (PWM) signal to control the on-off periods of the switching device to begin getting our power unit into shape. This is achieved by the use of a simple 555 timer circuit.

MODULATING SIGNAL

If the electronic switch (S) depicted in Fig. 3 and Fig. 4 was on all the time, the input and output voltages would be identical. If the switch was off all the time, the output would be zero.

The actual output when the switch is alternately on and off is therefore clearly an average value somewhere between these two extremes; or, in an ideal world, the output is a function of the ratio of T_{ON} to T_{OFF}. That is, a function of the duty cycle of the switching waveform, or:

$$V_0 = V_I \frac{T_{ON}}{T_{ON} + T_{OFF}}$$

Ignoring any voltage drop across the filter, the average output voltage will be the same as that applied to the filter input. From this, it is clear that the output voltage can be varied by altering the duty cycle.

So, in theory at least, a 100 per cent variation in duty cycle will change the output voltage from zero to its maximum of V_I. This is not all; for if any *unwanted* change in the output occurs and this change can be fed back to modify the duty cycle ratio in the proper sense, the output can be stabilized at some desired value, any deviation from that value being automatically corrected.

There are a number of methods of varying the duty cycle ratio of a rectangular pulse train. Some of these are highly sophisticated and provide almost complete control of the duty cycle over a 100 per cent variation. Our purpose is less exacting and a simple application using the familiar 555 timer gives us an effective PWM with a minimum of components and a duty cycle variation from about 20 per cent to 70 per cent.

The basic method is shown in Fig. 6. Here the 555 timer i.c. is used in conventional monostable mode but with a control voltage applied to pin 5.

In the monostable mode the output at pin 3 is "low" until a clock pulse is applied to pin 2. At that time the output goes "high" for a period determined (with control pin 5 disconnected) by the value of capacitor C and resistor R. Capacitor C charges through resistor R until it reaches two-thirds of the supply voltage, the timer then resets and C is discharged through pin 7.

If, however, pin 5 is returned to a positive voltage level, determined by the setting of the potentiometer VR, the point at which the timer resets is altered. This means that the output at pin 3 is a positive-going pulse whose duration for a given C and R depends upon the potential at pin 5.

Notice that the *frequency* of the output wave is unaffected, this remaining the same as the frequency of the input clock pulses. What changes is simply the mark-space ratio or the duty cycle. It is possible to use *variable* frequency regulation in which the on time is fixed and regulation is achieved by increasing or decreasing the switching frequency, but such systems lead to difficult filtering problems.

If the variable duty cycle waveform is applied to act as the control parameter of the switching regulator of Fig. 4, then the voltage will be controllable over a wide range and provide an adjustable and stabilised output.

PRACTICAL CIRCUIT

The design aim at the beginning of this project was to have a power supply adjustable over a range of about 5V to 15V which regulated well with a maximum current output of about 5A. This was a tall order for a system based on discretes and a simplified circuitry which would be easy for home construction (and to set up) without critical adjustments.

The problem was compounded by the requirement of a voltage output range which led to a compromise over the values of certain components, particularly those in the filter section. With the circuit values chosen, the system is optimized at about 5V where good regulation up to the design current of 5A is obtained.

There is a slight deterioration as the voltage rises and the current limit (with tight regulation) is about 3A at the 15V end of the scale. This was accepted as a small price to pay for having the wide range of voltage output, and unless a load situation arises which takes a rapidly fluctuating current from some low value up to beyond 3A at the 15V point, the performance of the unit is quite satisfactory.

CIRCUIT DESCRIPTION

The complete circuit diagram for the Switch-Mode Power Supply is shown in

Early prototype version of the circuit board showing the filter coil mounting clamp and the two finned heatsinks.

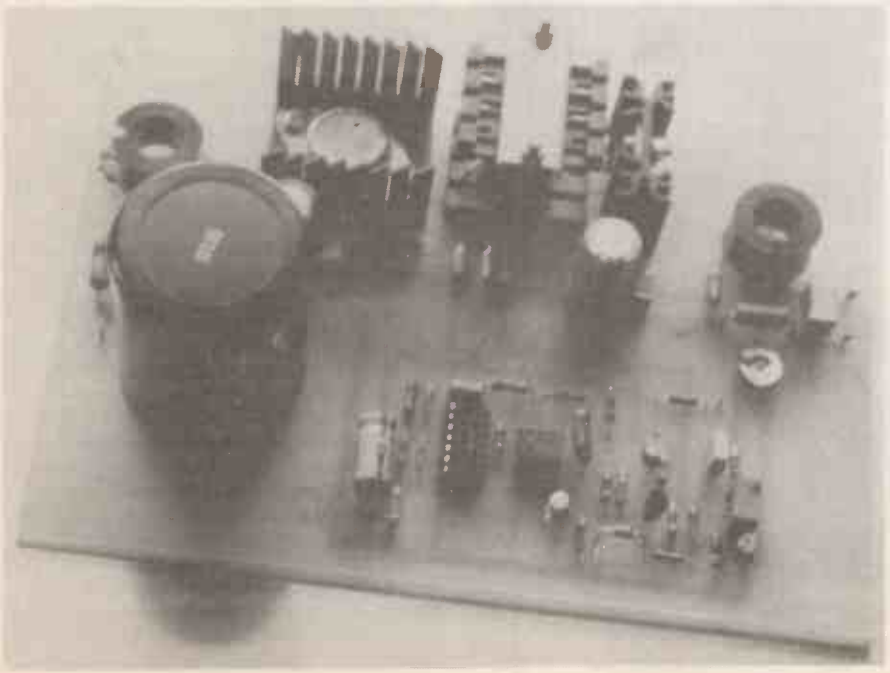


Fig. 7. Dealing first with the control side of things, the clock pulses are generated by IC1, a simple CMOS astable using a 4001B quad NOR gate i.c. Three of the gates are used, the first pair, IC1a, IC1b, generating a series of positive pulses at a frequency of about 20kHz, with the third gate, IC1c, acting simply as an inverter to provide negative-going triggers to pin 2 of IC2, the 555 monostable.

The arrival of a pulse sends the output at IC2 pin 3 high and the timing capacitor C9 begins to charge through resistor R10. When the voltage across C9 reaches a level determined by the potential on pin 5, pin 3 goes low and C9 discharges through pin 7. The cycle repeats on the arrival of the following trigger pulse.

In this way, the period between the pulses is the same as that of the clock while the actual pulse width is fixed by the charge rate of capacitor C9 and the voltage on control pin 5. With C9 and R10 constant, the charge rate is constant and the pulse width at pin 3 increases as the potential on pin 5 increases. This, then, is our pulse width modulator.

The actual control of the level at pin 5 is accomplished by transistor TR2 whose base (*b*) is fed from the potential divider chain of resistor R20 preset VR1 and resistor R21 connected directly across the output terminals. As the base potential rises, the voltage at the collector and on IC2 pin 5 falls, and conversely. Hence the duty cycle at IC2 pin 3 is varied and the output voltage which is controlled by the duty cycle value becomes adjustable by the use of preset VR1.

Regulation is also controlled by this method. The controlling pulses from IC2 pin 3 are fed, via resistors R14 and R15, to the base of transistor TR4 where, after inversion, they are passed to the base of the Darlington switching transistor TR1.

The MJ2501 is a *pnp* power Darlington which simplified things a little from the assembly point of view although there is a small sacrifice in switching and saturation losses. An *npn* Darlington MJ3001 was tried originally, fed directly from pin 3 of the 555 but the performance was inferior to the present arrangement because of the difficulty of getting sufficient drive.

Now, for any particular setting of preset VR1, should the output voltage decrease for any reason, the voltage on the slider of VR1 decreases proportionally and backs off transistor TR2. The control voltage at pin 5 consequently increases, the ON time of TR1 increases, and the output voltage rises, compensating for the original fall. The same correcting action takes place when the output voltage tends to rise, the ON time of TR1 decreasing.

What in effect happens is that the system stabilizes in such a way that the slider of potentiometer VR1 is maintained at a constant level. When the slider potential moves towards resistor R20 the output voltage *falls* to keep the slider at its original level. When the slider potential moves towards R21 the output voltage *rises* to maintain the same state of equilibrium.

Transistor TR2 needs to have a very high h_{fe}, which is why a BC109C is specified. This should have a h_{fe} of at least 500, higher if a selection can be made.

INTERFERENCE

The operation of the switching system and the filter network has already been explained. Because of the high frequency of operation, there can be considerable r.f. radiation from this part of the circuit and for that reason those components involved, shown in the broken lines on the circuit diagram, are screened under a diecast aluminium box which eliminates most of the RFI (radio frequency interference).

The inductors L1 and L3, nominal 15µH coils, are additional suppressors preventing interference getting out of the circuit along the connecting wires.

PROTECTION

Some sort of protection is needed against excessive load currents or short-circuited output conditions. The fuse at the input to the switching circuit, rated at 10A, provides some protection, but fuses even of the fast-blow sort sometimes prove too slow to prevent damage to semiconductor devices. Here the fuse is used as a back up to the protection afforded by thyristor CSR1 aided and abetted by transistor TR3.

Resistor R22 is a current sensor which develops the triggering voltage (nominally 0·8V) for the thyristor, CSR1, when the output current exceeds 8A. When the thyristor triggers into conduction it presents a virtual short-circuit across Zener diode D4 (which has held the base voltage of the *pnp* transistor TR3 at a cutoff level of 3·3V) and so pulls the base down sufficiently to switch TR3 on. This action brings pin 3 of IC2 down to near zero and shuts off the drive to the switching transistor TR1.

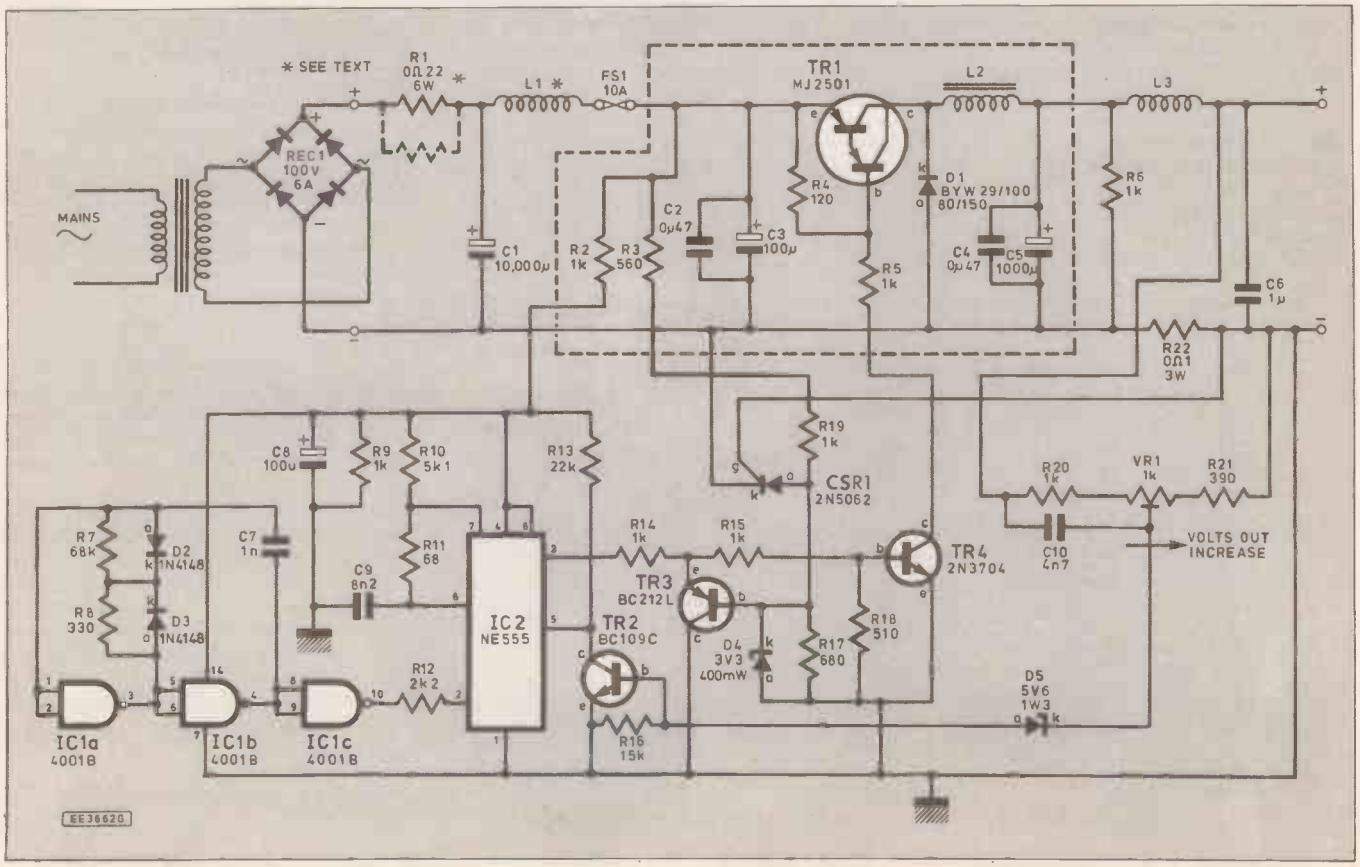
The circuit can be reset by momentarily switching the unit off. Those who wish to do so might incorporate a reset switch (of suitable rating) in the positive lead between R1 and L1 or in place of the 10A fuse. This is momentarily opened to reset the circuit after shut-down.

CONSTRUCTION

Construction of this project is relatively easy as all the parts, excepting the mains transformer and bridge rectifier, are assembled on a single printed circuit board. This board is available from the EE PCB Service, code EE796.

There are a few preliminaries to be seen

Fig. 7. Complete circuit diagram for the Switch-Mode Power Supply. The area within the dotted lines generates considerable r.f. radiation and is screened from the rest of the circuit under a diecast aluminium box, see photographs.



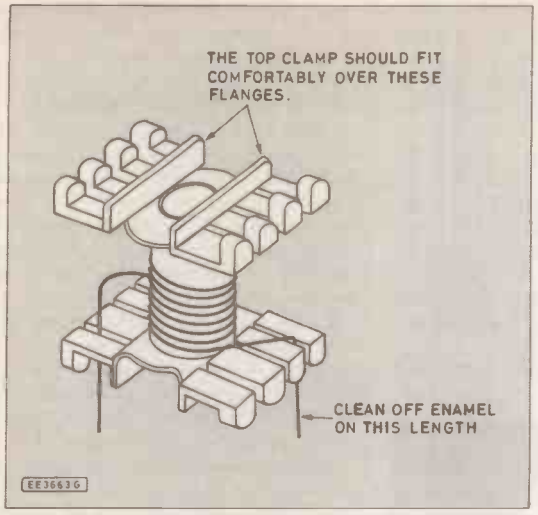


Fig.8 (above). The wound bobbin for the filter inductor L2 showing the coil ends positioned for connecting to the p.c.b. foil pads.

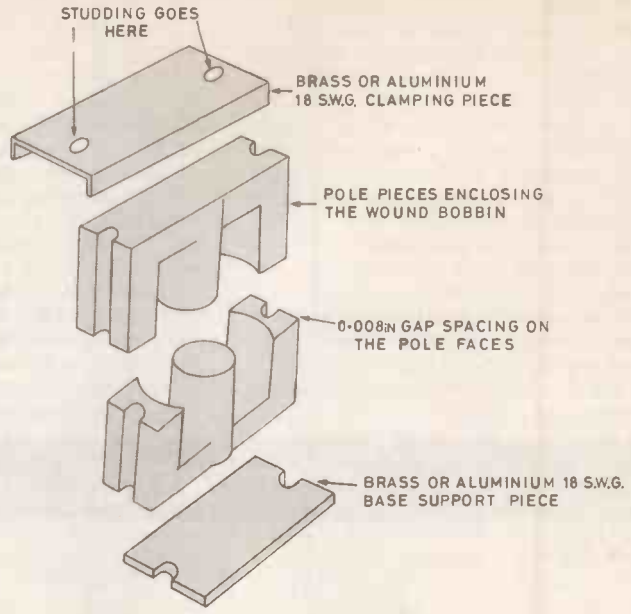


Fig.9 (right). Exploded view showing the mounting method for inductor coil L2. There has to be a gap of 0·008in. between the two E-coes and this is achieved by using two layers of drafting tape, paper or layers of Sellotape. Note the "ali" or brass clamping bar and base plate.

to before the construction can begin; these are the winding of inductors L1, L2, L3 and the mounting details of the switching transistor TR1 and the flyback diode D1 on small heatsinks which attach directly to the board. Large heatsinks are not required as the dissipations in the Darlington switch and the diode are very small.

COIL WINDING

Inductors L1 and L3 are simple RFI suppressor coils and are not critical in winding. They are nominally of 15µH indutance and are wound with 28-turns of 20s.w.g. enamelled wire on DT2534 bobbins.

Wind the wire on neatly in layers and bring the ends out *between* the pins on each side of the bobbin. These pins are used to hold the coils on the board; snip off the odd pin on that side of the bobbin which has three pins. The wire ends, suitably cleaned of enamel, then go through the board along with the pins and are soldered into place where indicated.

Coil L2 has an inductance of about 170µH and is wound on a Ferroxcube FX3720 bobbin which is supplied with two E-cores in grade 3C8 material. *Great care must be exercised with these core pieces as the material is as brittle as glass and easily broken by careless handling and assembly.*

Wind the bobbin with 24-turns of 18s.w.g. enamelled wire, keeping it neatly in layers (there are about 1½ layers involved) and bring out the wire ends down through the bobbin slots in the positions shown in Fig. 8. These coil ends, suitably cleaned of enamel, are later pushed through the "D" holes on he board and soldered to the foil. Make sure that the winding is tight and when completed, tape it to prevent any possibility of the coil vibrating or "singing" as the current varies.

There has to be a gap of about 0.008in. in the magnetic circuit and this is best introduced by sticking a double thickness of ordinary drafting tape to the pole faces of one of the E-cores. You can use paper of similar thickness but unless you stick it in some way to the faces it is difficult to keep it in position when assembling the cores into the bobbin and bolting it down to the board. Trim the paper to the shape of the faces with a sharp craft knife.

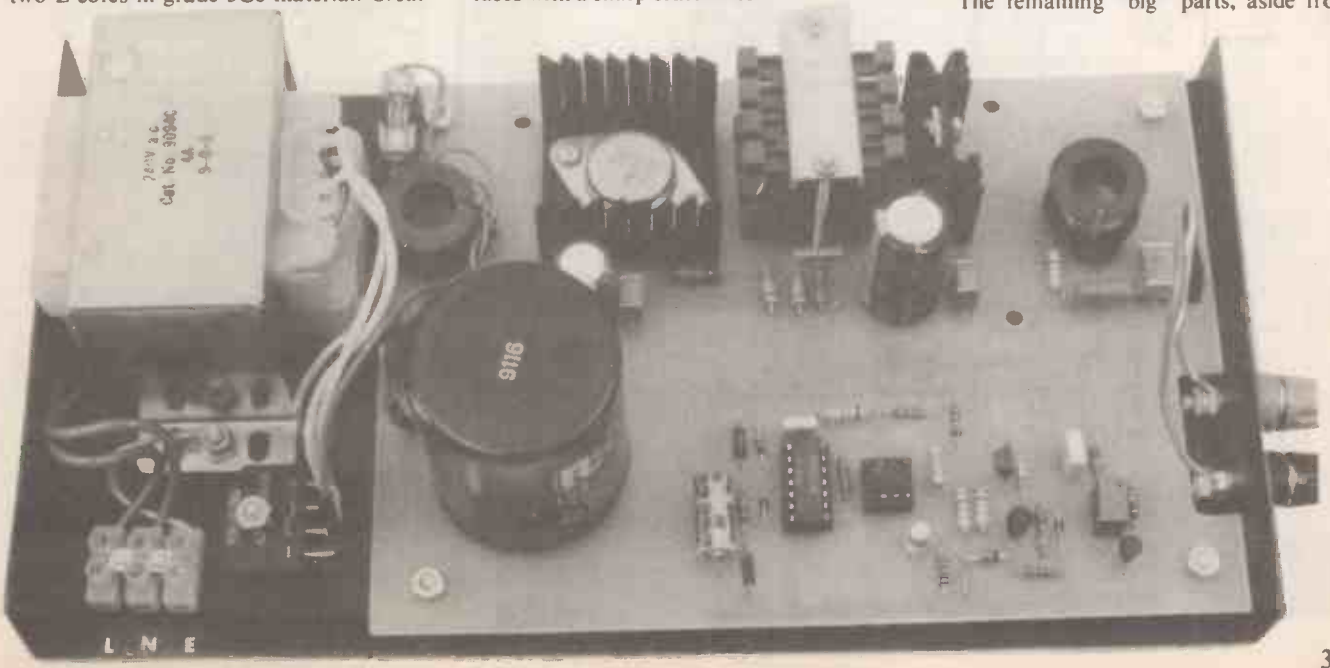
When the two E-cores are assembled in the bobbin, the inductor is mounted on the board by M2 or 6BA *brass* studding (or any *non-magnetic* screws of suitable length) by way of the holes "C-C". A clamping bar of aluminium or brass i needed across the top of the assembly to ensure that the clamping force is uniformly distributed over the cross-section of the outer limbs and another at the bottom, though this can be a simple flat strip of brass or aluminium. The exploded view of Fig. 9 shows the method.

Tighten the upper nuts firmly but do not overtighten – the ferrite material, as mentioned above, breaks easily. If you break a piece, replace it; do not try to use the broken pieces or glue them together, the magnetic circuit properties will be affected.

COMPLETING THE BOARD

The printed board component layout and full size copper foil master pattern is shown in Fig. 10. The assembly of this, used in conjunction with the circuit diagram, should give no problems.

The remaining "big" parts, aside from



the three inductors already covered, are the switching transistor TR1 and the flyback diode D1. These are mounted on small heatsinks in the positions shown in Fig. 10.

Transistor TR1 together with the twisted vane heatsink, which is already drilled to accept the TO3 pin configuration, are bolted to the board at holes "B-B" with 6BA screws. Use fibre or brass washers between the sink and the board to keep the sink about 2mm clear of the board surface.

The right-hand "B" hole is also the collector connection and contact with the underside board copper foil must be ensured, use washers on the foil side under the nut. The base and emitter pins of the transistor go through the board holes where shown and are soldered to the foil.

Diode D1 is also mounted on a small heatsink so that its two pins go through to the appropriate foil points and the 'sink itself, which has solderable pins, is mounted vertically and fitted to the holes "E-E".

All the small components can now be fitted in the positions indicated, taking the usual care where tracks are close together to avoid solder bridges. Capacitor C1 will *only* fit to the board layout if it is the type specified in the parts list. The five tag holes should be drilled out 2mm and the three unused positions should be left floating as the diagram indicates.

You can, of course, use an alternative type electrolytic capacitor if you wish but you will have to adjust the mounting position accordingly. Any alternative must be rated *at least* 40V working and have *minimum* ripple current rating of 5A. Capacitors greater than 10,000μF) are OK and may be used in this position.

Capacitors C3 and C5 must be low ESR types, but C8 is an "ordinary" electrolytic. Resistor R1 is shown as two 0·47ohms 3W types "wired" in parallel, but a single 0·22ohms resistor of 6W rating may be used instead. Resistors R1 and R22 should be mounted 3mm clear of the board.

As TR1 and D1 are not isolated from their heatsinks, these 'sinks *must NOT touch* the diecast screening box when it is finally fitted over them. Check that this is so, though if the hole positions are correctly made, there is no danger of this.

The screening box contacts, by way of its two lower fixing screws at points "A", the common negative line of the supply which effectually Earths it. Don't fit the box until the unit has been finally tested.

You don't have to, but it is convenient to put solder pins at the input and output terminations; it makes disconnection easier if this becomes necessary when fitting the unit into a case.

COMPONENTS

Resistors

R1	0Ω22 6W (or two off 0Ω47 3W in parallel)
R2, R19	1k 0.5W (2 off)
R3	560
R4	120
R5, R6, R9, R14, R15, R20	1k (6 off)
R7	68k
R8	330
R10	5k1
R11	68
R12	2k2
R13	22k
R16	15k
R17	680
R18	510
R21	390
R22	0Ω1 3W

All 0.25W 5% carbon, except where indicated.

See SHOP TALK Page

Potentiometer

VR1	1k 25-turn ceramic 3/8in. square preset, 0·5W.

Capacitors

C1	10,000μ. radial elect., 40V. Min. 5A ripple
C2, C4	0μ47 polyester layer, 100V 5% (2 off)
C3	100μ. radial elect., 35V Low ESR
C5	1000μ. radial elect., 25V Low ESR
C6	1μ. polyester layer, 100V 5%
C7	1n polycarbonate, 100V 5%
C8	100μ. axial elect., 25V
C9	8n2 polycarbonate, 100V 5%
C10	4n7 polycarbonate, 100V 5%

Semiconductor

D1	BYW29/100 or BYW80/150 8A fast recovery rectifier diode, 150V
D2, D3	1N4148 signal diode (2 off)
D4	3V3 400mW Zener diode
D5	5V6 1W3 Zener diode
TR1	MJ2501 *pnp* Darlington power transistor
TR2	BC109C (h_{fe} > 500) *npn* silicon transistor
TR3	BC212L *pnp* silicon transistor
TR4	2N3704 *npn* silicon transistor
IC1	4001B quad 2-input NOR gate
IC2	NE555 timer
REC.1	100V 6A bridge rectifier
CSR1	2N5062 100V 225mA thyristor

Miscellaneous

T1	80VA mains transformer, with 20V secondary winding (see text).
L1, L3	15μH suppression coil; 28-turns 20 s.w.g. enamelled wire on DT2534 bobbin (2 off) – see text.
L2	170μH filter coil; 24-turns 18 s.w.g. enamelled wire on 50W Ferroxcube FX 3720 bobbin, with two, grade 3C8 material, E-cores – see text.

Diecast screening box, size 114mm x 64mm x 55mm; 8-pin d.i.l. socket; 14-pin d.i.l. socket; twisted-vane heatsink, with TO3 drilled outline; vertical mounting solderable heatsink, drilled for TO220 outline; 1oz. 18 s.w.g. enamelled wire; 1oz. 20 s.w.g. enamelled wire; 6in. length brass M2 (or 6BA) studding; connecting wire; solder pins; solder etc.

Printed circuit board available from the *EE PCB Service*, code EE796.

Approx cost guidance only **£40**

POWER SUPPLY

The input to the board from the bridge rectifier, Rec. 1, needs to be 28V to 30V d.c. if the output range of 5V to 15V is to be achieved. This means that the a.c. input to the rectifier bridge should be in the range of 20V to 22V r.m.s. Unless you have a transformer made or wind one yourself, it is unlikely that you will find a 22V secondary, but a 20V type is quite satisfactory.

The *average* rectifier current is given by V_0I_0/V_1 and this works out , taking the highest voltage output as 15V at 3A, at $15 \times 3/30 = 23$ 1·5A. Hence we could just get away with a 50VA transformer. However, assuming a 70 per cent efficiency we can take this as 3A, and this calls for a 80VA transformer and a 6A rectifier to be on the side of "belt *and* braces".

Transformers are readily available with 20V secondaries and of 80VA rating, both standard and toroidal. Two separate secondaries are commonly provided and these can be parallelled to supply the total 3A current required, which is only 1·5A per winding. On the prototype a 100VA transformer, which was unnecessarily big, but because it happened to be standing on the shelf, was used. If you happen to have anything like this, by all means use it.

A bridge doesn't have to be used; if you have a centre-tapped secondary, 20V-0V-20V, for instance rated at 3A (or more) use a biphase circuit instead of a bridge. The circuit is shown in Fig. 11. The diodes can be 6A individual types.

TESTING

A unit can be tested by hooking the transformer and bridge rectifier temporarily on to the input terminals; neither the board nor these components need be mounted on any sort of chassis. Switch on and check that you have 28V to 30V at the rectifier output, about 9V across capacitor C8 and something at the output terminals. If there is no output of any sort, the pulse generator IC1 probably isn't working and TR1 is shut down.

If all seems well up to this point, put some sort of load which draws, say, 1A on average across the output terminals i.e. a "watty" resistor of perhaps 10 to 15 ohms.

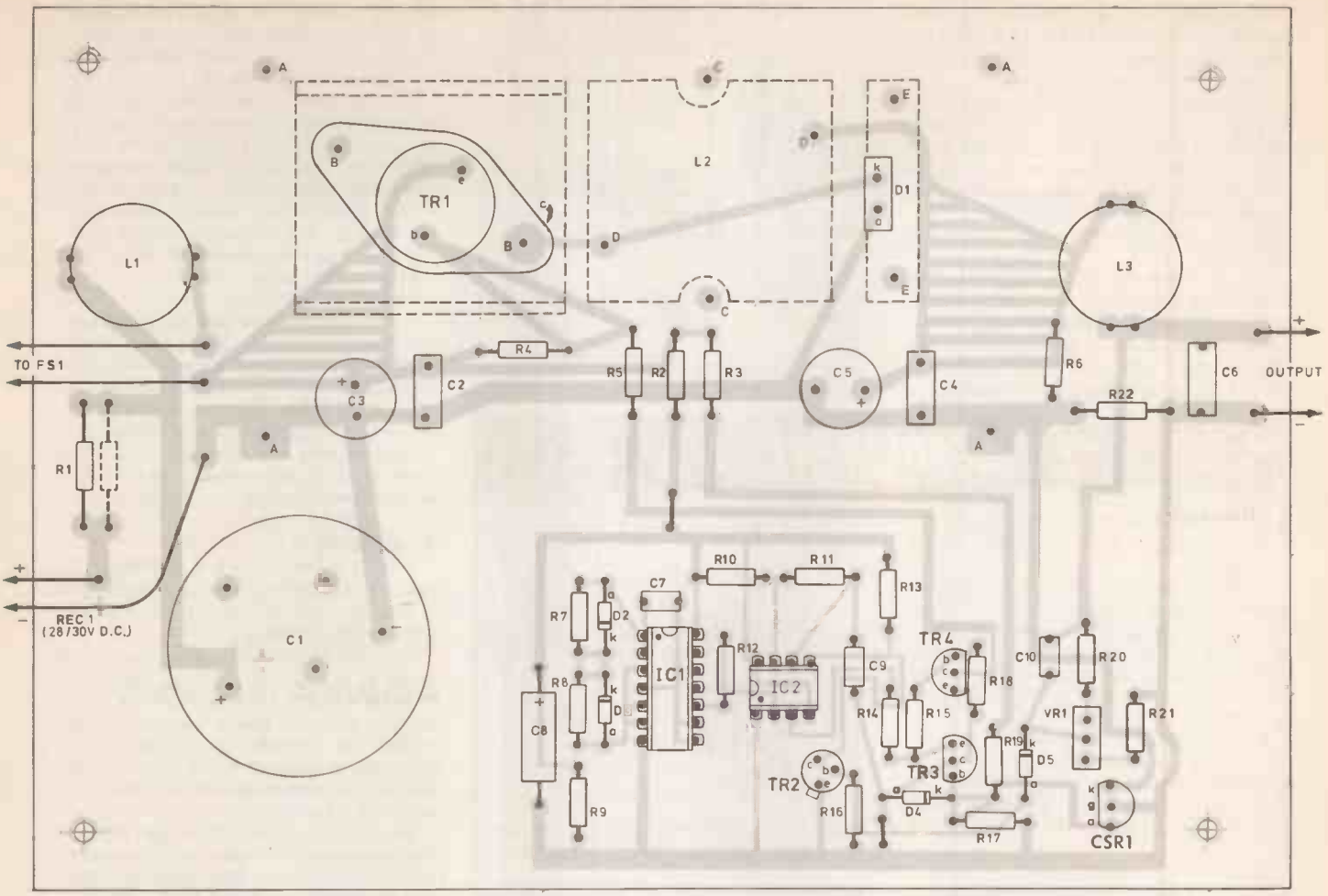


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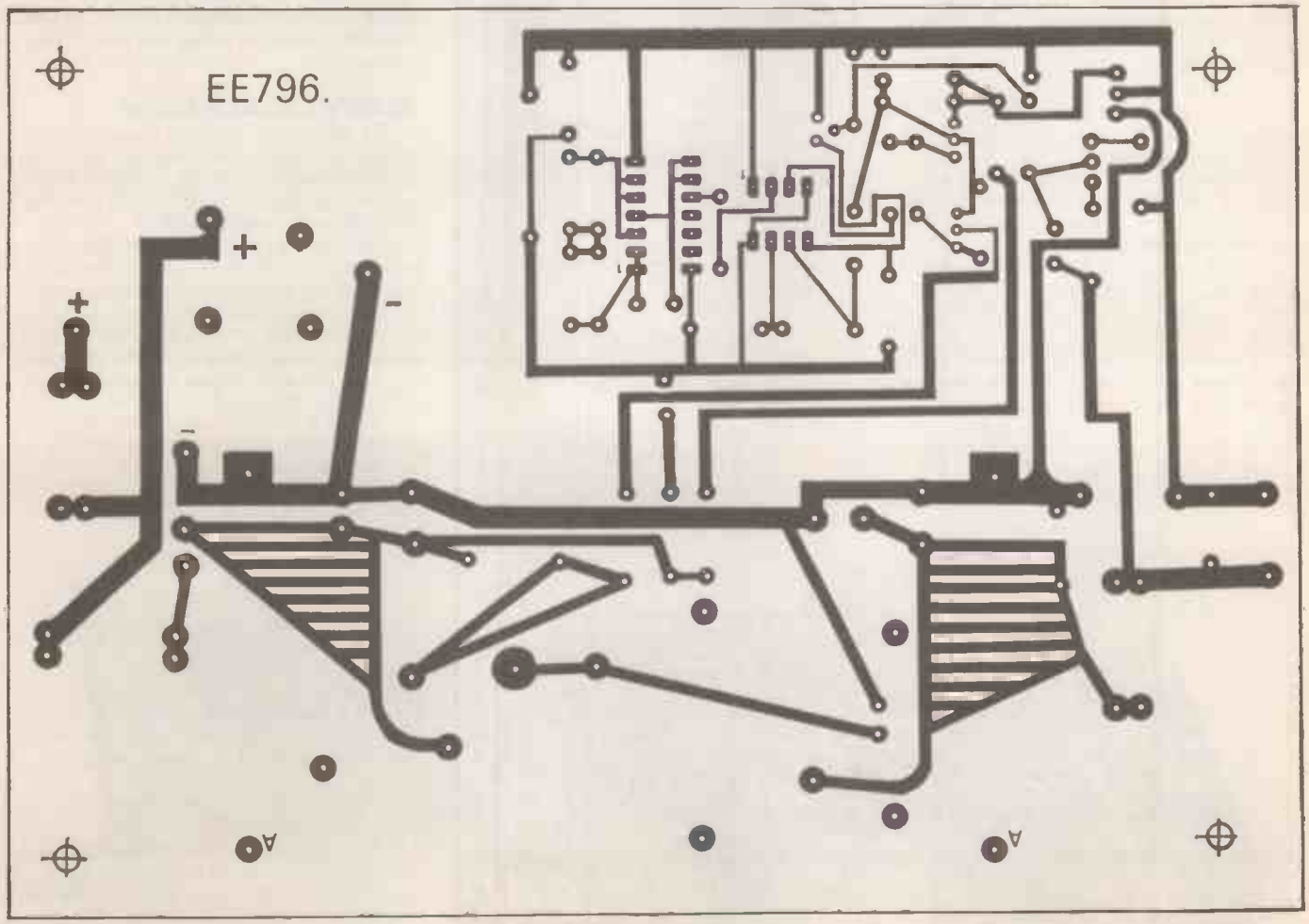
Fig. 10. Complete p.c.b. layout and wiring details for the Switch-Mode Power Supply



Now adjust preset VR1 either way to check that you get a range of 5V to 15V; you may find you can actually go a bit beyond these limits but this is not of importance.

The inductor L2 should not "sing", if it does you may need a fraction more tightness on the studding nuts holding it in place, but do this with *extreme* care. If you experience a short "buzz" at some particular point along the adjustment of VR1, ignore it; it is probably a local resonance effect.

Check that nothing is getting hot. The Darlington transistor TR1 will get *slightly* warm, particularly at higher load currents, as will R1 and R22, but otherwise there should be contentment. These two resistors should stand 3mm clear of the board.

If you have a frequency meter of any sort, check at pin 10 of IC1 to see that the frequency is between 20kHz to 25kHz; this might seem a big variation but the design works over this range. The frequency can be increased by reducing the value of resistor R7 or decreased by increasing it.

Although the design target was 20kHz to 22kHz, tolerance around IC1 give a spread but this is not critical in any way; three prototype models gave figures of 21·7kHz, 23·5kHz and (the last one) 22·5kHz respectively. There is no point in calling for tight tolerance components here.

Regulation curves for three typical output voltage levels are shown in Fig. 12; these were taken from the final prototype. The output impedance is about 0·02 ohm at the 5V end and 0·1ohm at the 15V end of the range.

MODIFICATIONS

Strictly, a switch-mode p.s.u. can be precisely designed for a particular output voltage at some stated current; if that design voltage is altered by some means, the performance deteriorates. This is why commercial units generally have fixed outputs. This project has been called a DIY design as it is open to certain modifications to suit particular whims.

Some constructors might not like the idea of the control potentiometer VR1 being mounted on the board and so, when the unit is boxed up, inaccessible to adjustment. The control was actually mounted where it is in anticipation that the unit might be used at a fixed voltage output for a particular purpose.

If, however, continuous variation is required, this preset can be omitted from the board and three wires taken from the relevant board points up to a conventional 1k rotary potentiometer mounted on a front panel, along with any metering. Only light gauge wire is needed.

Alternatively, you might like to have distinct switched positions giving outputs of, say, 5V, 9V, 10V, 12V and 15V. An external 2-pole 5-way switch will then be needed and the circuit shown in Fig. 13 built up on a small board. This board can be mounted on the rear of the front panel next to the "range" switch or even possibly directly on the rear of the switch.

The wiper contacts of the presets should be "commoned" together and a lead taken from this point and soldered to the centre copper pad on the main p.c.b. which is earmarked for VR1. The two outer pads take leads from the two pole contacts (tags) of the range switch. The five presets, mounted on the small "range" board, can now be adjusted in turn to give the five voltage ranges desired.

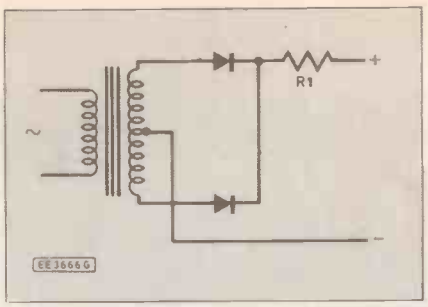


Fig.11. Alternative rectifier circuit diagram to suit centre-tapped transformers.

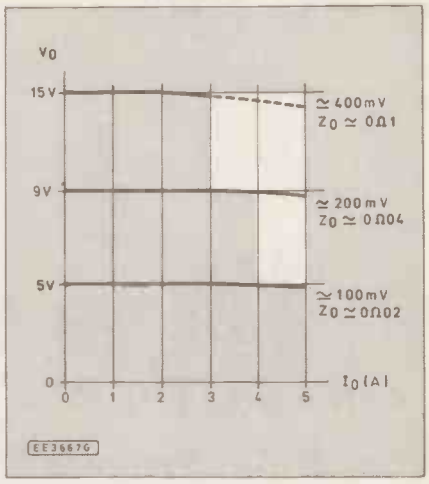


Fig.12. Resolution curve for three typical output voltages versus load current.

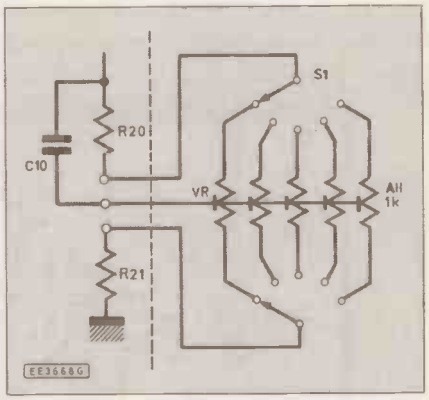


Fig.13. Method of switching a number of fixed output voltages using a two-pole rotary switch and five preset potentiometers.

CASE

A front panel has been talked about but nothing practical has been mentioned. This is because the casing of the unit has been left to individual choice.

As can be seen from the photographs, the board is spaced off a sheet of aluminium forming a base "chassis" using 6mm spacers, and the mains transformer and rectifier are mounted on the sheet at the input end. A case can be fabricated around this chassis without too much difficulty (or one might be bought).

On the front panel of the selected case can be mounted the main On-Off switch, a neon indicator lamp, the "volts out" control (or switch system) and the output terminals. Also, the fuse and a voltmeter (0-15V) and an ammeter (0-5A), or a switched combination of these last two items, can be included to produce a neat and versatile instrument.

CONCLUSION

One final observation: It is possible, although I couldn't reproduce the effect on the three models made, that a switch-mode power system may oscillate or be unstable on open or very light loads.

This problem, if it arises, can usually be cured by drawing a minimum current at all times (or by elaborate internal loading circuitry which operates when the regulator is off). Connecting a 47ohm 6W resistor across the output terminals will clear the trouble, although I think it is unlikely to occur in this design. □

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It's easy if you have the right chemistry

Part Two: Ultra-Violet Processing Techniques

AS WE mentioned last month, applying the "original" etch-resist directly to the copper foil prior to etching is fine for quicker one-off printed circuit boards (p.c.b.s), but there is the drawback of actually having to destroy the etch-resist after etching, in order to reveal the copper tracks underneath. With more complex circuits, having to remove the transfers after taking all that time to lay them down in the first place, is wasteful.

In many circumstances this might not be a problem, but if you are at all keen on the subject and a little more experienced in circuit design and assembly, you may well wish to make another board or perhaps modify the circuit (and probably the p.c.b. layout) at a later date. It then becomes rather a chore having to re-apply those etch-resist transfers all over again.

Sensitive Approach

Fortunately it is possible to produce printed circuit boards using a readily available light-sensitive process. This permits you to design the copper track layout on paper at leisure, changing it around at will before finally committing it to etching.

This more advanced system uses an etch-resist coating on the copper foil of the p.c.b. which is sensitive to ultra-violet light (UV). Basically, the p.c.b. artwork "positive" is translated onto *clear* film which has the design of the copper track layout printed onto it, with black areas representing the copper conductors – just like the artwork shown in the published design.

The artwork film "master" is then placed against the UV sensitive coating of the blank board, and UV light is shone through the positive master onto the etch resist coating. The board is exposed to UV light for a period of up to 20 minutes or so.

Afterwards, the exposed board is processed with a readily-available developer which will wash away all the etch-resist that was exposed to UV light. Hence, those areas of resist which were masked from the UV light by the artwork will remain on the board.

The result is a perfect reproduction of your artwork in etch-resistant ink on your p.c.b., which can then be etched as normal. What's more, you can keep the artwork for re-use at a later date!

It should be noted that the etch-resist is sensitive to ultra-violet light only, and processing indoors in a subdued light should not cause any problems. It isn't normally necessary to operate in a darkroom.

Normal sunlight, of course, contains a proportion of UV which may be enough to turn the etch-resist. Indoors, though, ordinary window glass generally filters out some of the UV content of sunlight, and the author has never experienced any difficulties of daylight interfering with end results.

This system may require some initial experimentation to familiarise oneself with exposure times, chemical strengths etc., but it is much more convenient in many respects, especially if you are involved with designing/prototyping as well as routine project building. Once you have got the hang of it, you will find it much simpler, more accurate and more enjoyable to create p.c.b. artwork on a film, changing it as required, rather than scratching away on a piece of copper clad board! It's certainly the best way to produce more complicated boards.

To illustrate a typical method of producing a single-sided printed circuit board, the methods of creating artwork and utilising the UV system will be now described, and later we will look at means of designing your own artwork.

Producing A Masterpiece

The initial step involves the preparation of the master artwork. If you are copying artwork from a magazine article, half of the work (i.e. designing the track layout itself) is already done for you, and all you need to do is reproduce the given copper track layout onto a suitable medium.

Polyester drafting film is generally used, which is translucent white and quite strong. Other films can be used such as acetate or overhead-projector film but polyester is better able to withstand the rigours of handling whereas other types may tear easily. It can be bought in A4 sized sheets.

In order to copy existing artwork onto film, cut some drafting film to size (allowing plenty of room as a border) and place it over the artwork to be copied, perhaps Sellotaping it in place over the page.

Next, mark the outline of the board onto the film and then lay down the positions of the copper pads to act as a reference, just as we did in the "direct etch" method last month. Again, rub-down dry transfers can be used – etch-resist transfers are adequate (which are say 10 microns thick).

You may occasionally see precision artwork transfers available which are thicker (25 microns). These thicker transfers are preferable because they are less likely to let UV light through, but perfectly acceptable results have been obtained using standard etch-resist transfers.

Continue to copy the artwork by filling in the routes of the copper conductors, using the same technique (tape or special ink pen) described last month. Make sure that lines do not inadvertently

Photo 1. Materials for preparing boards using the ultra-violet system: positive artwork, UV aerosol resist (2 types shown), developer, Dalo "Red" Pen (opaque to UV), copper clad board and pre-coated board.

Photo 3. Aligning the sensitive p.c.b. with the artwork, on an ultra-violet light unit. The EE UV Exposure Timer, to be described next month, is adjacent.

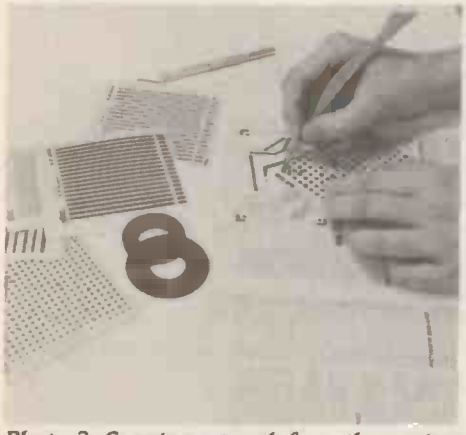

Photo 2. Copying artwork from the project details onto polyester film. Note the crepe paper tape which can be used to lay down lines of various widths.

Photo 4. Developing the exposed p.c.b. – Caustic Soda solution can be used (see text) or a proprietary developer may be employed for more consistent results.

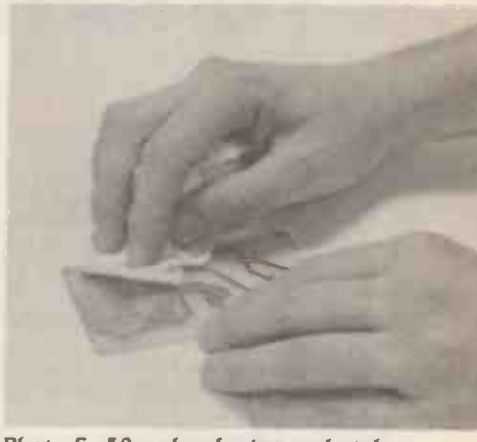

Photo 5. After developing and etching, the etch-resist can be removed with acetone (nail varnish remover). The board can now be drilled.

touch each other, or this will result in short-circuits on the finished board.

Some boards may have areas of copper which form large "islands" on the copper track layout. To copy these onto your artwork, draw the outline of the area in tape or dry transfer lines, and then fill in the middle with either wide dry transfer lines cut to size or use two coats of matt black enamel paint applied with a fine brush, and allow to dry.

Occasionally you may make an error on the artwork, and these can be corrected by scraping off the transfer with a scalpel blade. Larger areas of track can be lifted off by applying Sellotape, pressing down firmly onto the offending artwork, and then lifting off sharply. *It is extremely important that ALL traces of incorrect transfers etc. are removed, or these will be reproduced on the finished board.*

Crepe Tape

One alternative to rub-down transfers which is preferred by many designers is the use of crepe-paper tapes. They are much thicker (100 microns plus) than dry transfers and are completely opaque. Adhesive circles and lines are available on a reel and these are simply stuck down onto the film as required.

The lines particularly can be more convenient than transfers because you can simply follow the original artwork like following a map, unwinding from the reel and sticking it down onto the film as you go along – though it can be fiddly on dense or complicated boards. Cut the tape from the reel using a scalpel whilst attempting not to cut through the film, lifting off any excess tape from the drafting film. You will still require transfer film decals for dual-in-line pads, edge connectors etc., but crepe tapes lend themselves especially to designing your own artwork.

Having reproduced the artwork onto polyester film, the next step is to label the artwork clearly, so that you know which side is the copper foil layout. It is not difficult to expose the board back to front! Use an adhesive label and mark clearly "This side copper track view", plus the project title. The other side of the artwork would represent an X-Ray of the copper layout, seen from the component side of the board.

On Board

The next step is to prepare the UV sensitive board itself. There are two choices available in this respect. Either buy "pre-sensitised" copper-clad board, or apply the light-sensitive coating yourself.

Pre-sensitised board is available in standard sizes just like plain copper-clad board, and the manufacturer treats the copper with a UV sensitive etch-resist ink and generally protects this with a peel-off paper sheet, see Fig. 1. It is more convenient to purchase pre-sensitised boards which are then cut to the required size, but *DO NOT* remove the protective film until you are ready to expose the board to ultra-violet light.

Alternatively you can try to apply the sensitive etch-resist ink yourself, and special positive-working aerosols are available for this purpose. In this case, cut the circuit board from standard plain copper-clad board, file the edges and clean up the copper with an abrasive block, ensuring that the board is then completely clean and grease-free. Often, a domestic detergent is also used, in order to ensure that no greasy marks remain on the board, which must be "wettable" to accept the etch-resist lacquer.

The use of aerosol etch-resist undoubtedly requires some initial trial and error. From experience, it can be difficult to apply a

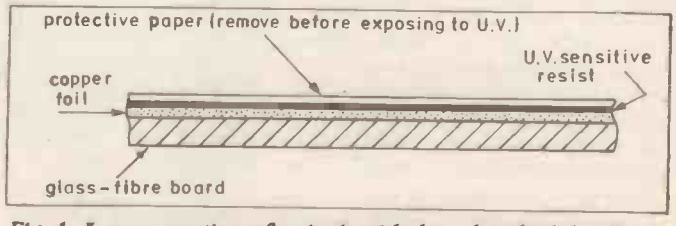

Fig. 1. A cross-section of a single-sided p.c.b. which has been coated with an ultra-violet light resistant lacquer or "resist".

coating of uniform thickness on the copper, depending on the quality and uniformity of the aerosol spray cone. Sometimes the wet ink which is sprayed on to a horizontal board can spread out sideways, which results in a reasonably-uniform layer in the middle of the board, but an excessively thick border of ink around the edges of the board. In this case, too much spray has probably been applied, and this will require a longer UV exposure period (see later).

Airborne dust particles are another hazard, as any impurities that settle on the ink coating during drying results in unwanted reproduction in the etch-resist.

After spraying on the etch-resist, it can be left to dry in subdued light at room temperature which could take up to 24 hours but can be accelerated by warming the board in a low oven (not a fan-assisted type) at about 70 degrees maximum. Do not be tempted to use a hair drier, for instance, as this will simply blow dust onto the board and also create unevenness in the lacquer.

Exposure Time

So having prepared a board with the UV sensitive etch-resist lacquer, the next stage is to expose the board to ultra-violet light through the positive artwork, see Fig. 2. For this, a special UV light box is used which contain two or more small fluorescent UV tubes. More expensive versions include a timer so that the light source switches off after a preset period.

The artwork is placed down onto the UV light box so that the "Copper Track View" of the artwork is downwards, towards the light source. Then remove the protective paper (if any) of the sensitised board and place this, etch-resist side down, onto the artwork, carefully lining it up on the artwork. Double-check you have got everything the right way round so that the artwork is not back to front, then close up the UV light box and switch on.

The exposure time depends on the following factors:–

1. The thickness of the etch-resist coating: Pre-sensitised boards will generally not have as thick a coating as etch-resist applied by an aerosol.
2. Whether the drafting film is clear or translucent: Polyester drafting film may reduce the UV light getting through to the etch-resist, so longer exposure may be necessary.
3. The UV content and power output of the UV tubes (itself related to how far away the tubes are from the board).

When exposing the board to ultra-violet light, we are attempting to "turn" the etch-resist throughout the depth of the layer of the ink. It takes time for UV to penetrate all the way through the etch-resist, so a thicker coating of sprayed-on resist will require a longer period of UV exposure. Using some scraps of board, it is worth experimenting with exposure times to optimise the UV time period.

Note that UV light can be *harmful to the eyes* and it is important that the lid of the UV light box is kept firmly closed when the light source is switched on. A UV Exposure Timer construction project, which permits you to set and forget the UV light source so that you can pay attention to other tasks, will be described next month.

Rule-Of-Thumb

As a rule of thumb, a pre-sensitised board can be exposed for between 5 and 10 minutes using an ordinary UV light box. It has been found that boards with a sprayed-on coating of etch-resist lacquer may require up to 15 or 20 minutes. These times may vary considerably depending on the sensitivity and thickness of the etch-resist.

Can you damage a board by over-exposing it? In extreme cases, if the dark areas of the artwork are not perfectly opaque (say you used ink instead of dry transfers or crepe tape) the UV light could pass through this and excessive exposure will affect the etch-resist varnish under the artwork – and the result can be that the whole of the etch-resist ink will be exposed, so that the foil pattern does not develop.

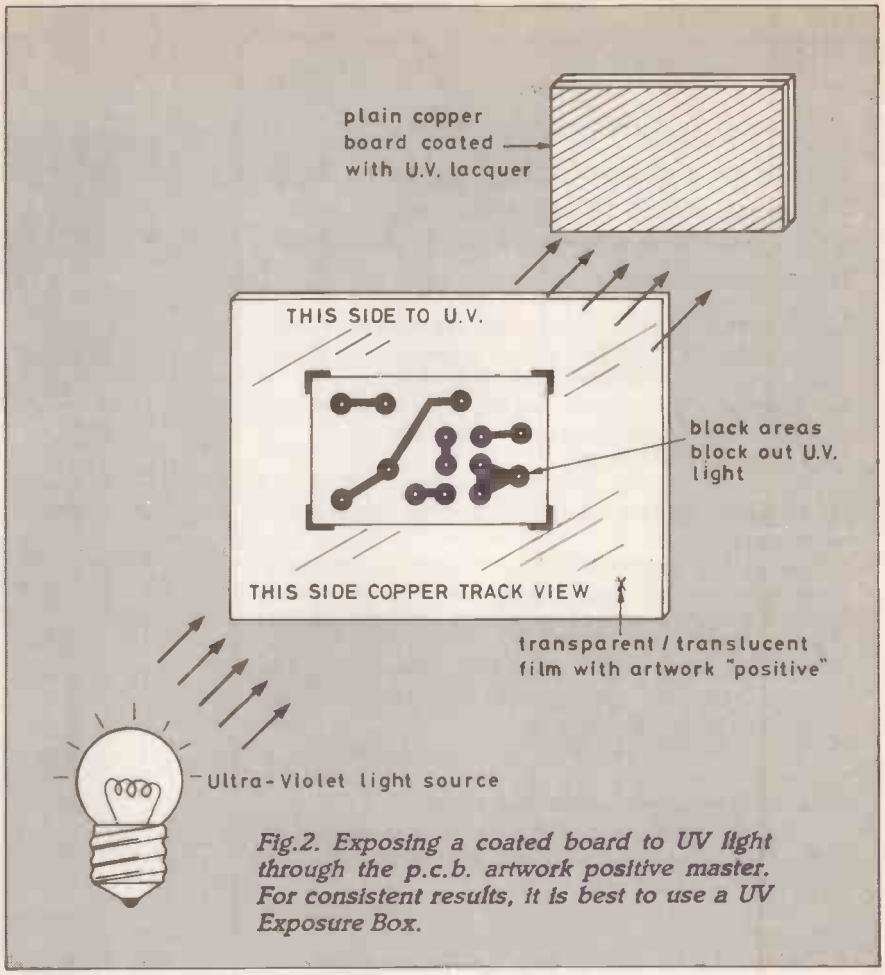

Fig.2. Exposing a coated board to UV light through the p.c.b. artwork positive master. For consistent results, it is best to use a UV Exposure Box.

On the other hand, under-exposure causes problems which will be apparent when you come to develop the exposed board, which is the next stage of processing.

Developing A Solution

The exposure and developing of the etch-resist pattern in order to remove the unwanted areas of etch-resist are probably the most tricky aspects of making the board until you have some experience. Normally, Sodium Hydroxide – Caustic Soda (NaOH) – solution is used as a developing agent, and this can easily be made up at home. Ready-mixed developers are also available (some require diluting) which take out most of the guesswork of developing the board.

Caustic Soda is sold by chemists and DIY stores in, say, 2kg. tins for use at home in clearing blocked drains (!) and a solution can be made up as follows:

Wearing gloves; fill a plastic bottle with one litre of warm water, and using a *plastic spoon*, pour a dessertspoonful (two teaspoons) of Caustic Soda crystals into the water. (The recommended formula is actually seven grammes per litre of water.) Replace the bottle stopper and shake the solution thoroughly. Empty the developer into a plastic tray.

Place the exposed board into the tray of developer using plastic *tweezers* or *tongs* and agitate the board gently. The exposed areas of resist will soften and then should wash off the board leaving, we hope, the copper track artwork on the board, see Fig. 3.

It sometimes helps to very gently swab the board in the developer tray with a cotton wool pad held between tongs or plastic tweezers. It should take only two or three minutes to fully develop the board in this manner, and the board is then rinsed with water and dried carefully.

If *all* the etch-resist is completely stripped away in a short period of time, then perhaps the whole board has been exposed at some stage to too much UV light. Another reason may be that the developer solution may be far too hot or concentrated. Either way, you will have to start again!

If on the other hand the board does not fully and cleanly develop after a couple of minutes, then the board has not been exposed to UV light for long enough. Remember that only the resist which was subjected to UV light will be stripped by the developer.

If the resist is not exposed for a long enough period, it will not develop fully and so some traces will remain on the board. Another

Fault Finding

Here is a fault-finding guide to help locate any problems that might arise when producing boards with the ultra-violet technique.

Develops O.K. but excessive exposure time required.
Artwork drafting film is too opaque – use appropriate clear/ translucent film.
Aerosol resist coating too thick: – increase exposure time or use spray more sparingly.
UV tubes need replacing.

Very long developing time, or resist does not develop fully or at all.
Resist is underexposed to UV light: – increase exposure period accordingly (only areas which have been thoroughly exposed to UV light will be developed).
Resist may also be too thick or artwork film too opaque, and has not been thoroughly activated by the UV light – see above.
Developer cold, weak or exhausted. Renew.

Image is developed but then disappears.
PCB has been over-exposed. Reduce exposure time. (Applies especially to good quality sensitive pre-coated boards.)
Artwork layout is not opaque to UV light, permitting UV to pass through transfers etc.
Board has been left in developer for too long.

All of the etch-resist disappears when developing.
Developer could be too hot or concentrated.
The whole board has previously been exposed to UV light. (e.g. sunlight).

Unwanted copper is left on the p.c.b. when etching.
Unwanted etch-resist left on board, due to under-exposure or under-development. Try removing excess resist with a cotton-bud dipped in acetone, then re-immerse in etchant.

Excessive etching time.
Etchant may be exhausted: – dispose of safely and renew.

Narrower tracks are etched away.
Over-exposure to UV may affect very narrow etch-resist tracks which will be removed/ reduced in width by etchant.
Developer or etchant may be too strong, undermining narrow sections.

Copper pads lift off when soldering.
Excessive heat applied during soldering.
Diameter of pads too small.
Diameter of the drilled hole too large!
If conductor is intact, repair by applying Super Glue Gel to the affected area, to encapsulate the lifted pad in resin.

Breaks in copper track.
Flaws in etch-resist coating or artwork.
Extremely thin conductors may be undermined by excessive etching time, resulting in the tracks being etched through.
Repair with silver-loaded paint or solder in a jumper wire.

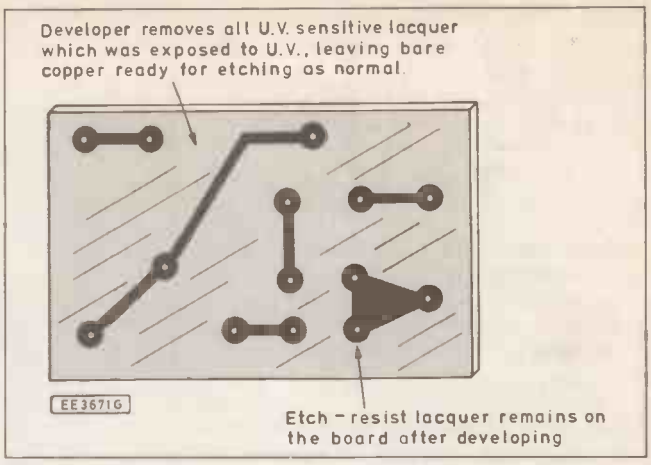

Fig. 3. After exposure to UV light, the coated board is developed in a Caustic Soda solution or proprietary developer. The sensitive lacquer which was subjected to UV light is washed away, leaving the artwork positive reproduced in etch-resist on the board.

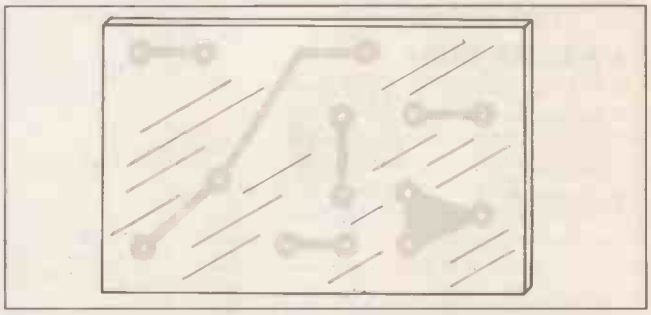

Fig. 4. The etched p.c.b. with resist removed (solvent or abrasive cleaning block) and drilled. Compare with Fig. 3.

possible cause is that the polyester film is too opaque and blocked the ultra-violet light: longer exposure is necessary with translucent drafting films.

Start Again

The only option is to rinse the board in water, dry it carefully and try to line it up again on the artwork, re-exposing it for a few more minutes. It is very difficult to do this without producing a "blurred-vision" effect in the resist – so you may well have to scrap that attempt, recoat the board with resist and start all over again.

A comprehensive trouble-shooting guide is given opposite which summarises most problems that arise. But don't be put off by any early setbacks because some simple experimentation will soon determine the best way of producing boards with this technique.

After use the developer solution can be thrown away. The product is, of course, caustic and any spills or splashes must be rinsed with plenty of water.

It is now only necessary to inspect the etch-resist artwork on the p.c.b. prior to etching it as described previously. Look for any spots of etch-resist which are unwanted: these can be removed by wiping them off with a cotton bud dipped in acetone (nail varnish remover). Keep the acetone away from the rest of the etch-resist layout!

Additionally, examine the continuity of the etch-resist, making sure that there aren't any flaws in the resist pattern. Any problem areas can be touched up manually with a Dalo Etch-Resist pen.

Etching

When you are happy that the etch resist pattern is as required, the board can then be etched in Ferric Chloride in the usual manner in either an open tray of etchant or using the Seno GS sealed system described last month.

When etching has been satisfactorily completed, the etch-resist ink can be removed from the board with an abrasive Polyfix block, or Isopropanol or acetone dabbed onto a cotton wool pad will dissolve the ink effectively. The board is then ready for drilling and tinning (if required) before soldering in the components. (Compare Fig. 3 with Fig. 4).

In part three next month, we suggest ways of originating your own artwork so that you can design your very own printed circuit boards. Construction of a UV Eposure Timer will also be undertaken.

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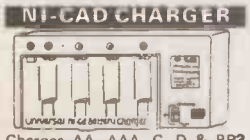

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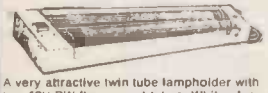

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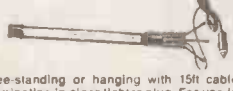

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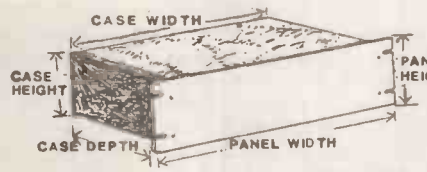

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Audio harmonic distortion	less than 0.5%
Power	220/240V ac 50Hz or 12V dc via external adaptor (not supplied)
Dimensions	190 x 54 x 200mm

Transmitter

Transmitting frequencies	173.8MHz, 174.1MHz, 174.5MHz, 174.8MHz or 175.0MHz
Frequency stability	0.005%
Modulation system	Crystal controlled FM
Harmonic and spurious output power	Less than –45dB below carrier level
Pre-emphasis	75μS
Max frequency deviation	± 50kHz
Frequency response	70Hz-12000Hz
Distortion	Less than 0.5%
S/N ratio	Better than 87dB
Ambient termperature range	0°C – 40°C
Operating voltage range	3.8V to 4.5V dc

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- ★ 2 x 1 Internal Passive I.R.
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ACTUALLY DOING IT!

by Robert Penfold

I THINK it is fair to say that every hobby has its frustrations, and that there is no pastime that is genuinely "roses all the way". Electronic project construction is probably less troubled by this type of thing than many others, perhaps due to the fact that it is an indoor pursuit which is not dependent on the weather.

It is not a totally frustration-free hobby though, and there are two main problem areas. One is the occasional project that refuses to work (although some consider that this is where the fun really starts), and the other is waiting for "out of stock" components to arrive. It is this second problem, plus some related topics, that we will consider in this article.

GOLDEN OLDIES

One point that has to be made straight away, is that it is not a good idea to start buying the components for a project published some time ago unless you are certain that *all* the components are still available (even up-to-the-minute designs can suffer from supply problems with components – see *Everyday Readout* in this issue). Ironically perhaps, supplies of some semiconductors which were popular only a few years ago seem to have completely dried up, whereas most valves of around 50 years ago are still available.

While semiconductors are the main offenders, there are other items which might cause problems. These include such things as transformers, r.f. coils, crystals/resonators, photocells and other sensor devices. If an old project uses any component that is even slightly out of the ordinary it would be advisable to check that it is still available before starting to buy the components.

It is very difficult to come up with a sensible definition of what constitutes an "old project". The Everyday Electronics official policy is that anything published more than five years ago is "old", which I suppose is about right. No doubt there are many projects much older than this that use only standard "off the shelf" items, and which are still quite buildable. On the other hand, there are certainly some projects which are less than five years old, but where there are some components which are likely to prove unobtainable.

It is a matter of carefully considering components used in each project, and using a little common sense. The safest way to proceed with a project that uses any unusual components is to buy these components first, and to only go on to buy the remaining components once you actually have the "hard to find" items in your possession.

Probably the best advice is to be wary of any project that is more than a couple of years old, and to be extremely wary of any that were published more than five years ago. With projects that are more than ten years old you should give a lot of thought to the problems involved, and then decide to build something from the current issue of *Everyday Electronics* instead!

STOCK TAKING

One way to reduce the problem of waiting for elusive components to arrive is to build up a stock of components. At one time quite a modest stock of components would enable you to build practically anything that came along in the electronics press, although the cost of the components would have been very high by today's standards.

These days there is no point in trying to accumulate a cache of components that will accommodate any project that takes your fancy. A glance through any of the larger component catalogues will show that the number of different components currently in use is so large that even if you could afford to buy one or two of everything, you would need a warehouse to store it all. If you look through the components lists of a few recent projects you will no doubt find some that only use common components, but most seem to use at least one or two "specials".

It is still worthwhile building up a stock of components though, and most electronics hobbyists end up with quite a large store of components after a few years. A stock of "standard" components will not help when an unusual item is "out of stock", and with these you just have to accept that you are at the mercy of the suppliers.

On the other hand, a stock of components can avoid the frustration of being held up on a project because a mundane integrated circuit is temporarily unavailable, or because you have managed to break one lead away from a 10n capacitor. You need to be sensible about buying components for stock though, or you will probably just waste a lot of money.

JUNK BOX

The old approach to the problem was to raid discarded or inexpensive pieces of surplus equipment for any components that could be removed intact. These went into what was known as the "junk box". The "junk box" approach is a less practical proposition these days, although there are plenty of surplus printed circuit boards etc. available. The main problem is that the cost of most new resistors and capacitors is now so low that it is barely worthwhile going to the trouble of removing and testing them.

Also, bear in mind that the components removed from circuit boards are likely to have very short leadouts that might prevent them from fitting into the component layouts of your projects. Surplus component boards etc. are most useful if they contain expensive semiconductors, and are probably something that are best left to those who have a few years experience of electronics behind them.

The same is probably also true of "untested bargain packs". These can actually be a very good source of low cost resistors, capacitors, diodes, etc., but only if you know what you are doing, and you have the necessary test equipment to sort out the good components from the "duds". Unless you are careful, your "junk box" will live up to its name. The likely consequence of this is that project after project will fail to work because you have used one or more faulty or otherwise unsuitable components.

TRIED AND TESTED

Packs of tested components are a different matter, and these represent the best way for beginners to obtain a useful stock of components for a modest outlay. These usually contain something along the lines of ten of each value for a particular type of component. For example, a resistor pack might contain ten of each value in the E12 series from 10 ohms to 10M.

Sometimes the quantity of each value is weighted according to the popularity of that particular value. Thus there might be 25 per pack of popular values such as 10k and 100k, but only five of less well used values such as 82 ohms and 1k2. This seems to be a very good way of doing things.

It is not really a good idea to buy a few packs at random in the hope that these will be the type of thing you need. Initially at any rate, it is best to choose packs that contain the types of component which can be found in practically every project.

The obvious first buy is a pack of small resistors, such 0.25 watt 5 per cent types. A pack of around 1000 resistors can be had for well under £10, which is clearly under 1p per resistor. Even if a few of the resistors are never used, this still represents a very cheap and easy way to buy resistors. It is the way I obtain most of my resistors incidentally.

Other types of component which definitely merit the pack treatment are radial electrolytic capacitors, ceramic capacitors, polyester capacitors, and miniature horizontal preset resistors. These are all reasonably inexpensive in pack form, and are used a great deal in electronic projects.

It might also be worthwhile buying packs of d.i.l. integrated circuit holders, or bulk buying the smaller types. I seem to use these up at a surprisingly high rate these days (particularly the 8 pin type), but I suppose that practically every project is based on d.i.l. integrated circuits these days.

SEMICONDUCTORS

With a few possible exceptions, it is not worthwhile stocking up with other

components in large numbers because it would either be too costly, or it would take years to use them all up. Packs of Zener diodes can be had at reasonable prices, but as these components do not feature in many projects these days, you could well be buying a two hundred year supply! At most I would only buy one each of the values up to 15 volts.

It is worthwhile having a few 3 and 5 millimetre red l.e.d.s plus matching panel holders in stock. Packs of l.e.d.s and holders are sometimes available at quite attractive prices, and it is probably worthwhile investing in one of these if you can find a suitable pack.

Modern circuits seem to be liberally scattered with general purpose silicon diodes such as 1N914s and 1N4148s. I generally buy these in packs of one hundred or more, which usually results in a massive discount on the one off price. I soon seem to use them all up.

Most other components simply are not offered in tested packs, or if they are, the cost is likely to be too high for most of us to be able to give them serious consideration. However, there are some commonly used components where it is worthwhile having two or three of each in stock, and this is my list of suggested buys.

- µA741C op. amp.
- LF351N or similar bifet op. amp.
- CMOS 4001 and CMOS 4011 gates
- BC547, BC549, and BC559 (or similar) transistors
- S.P.S.T. and d.p.d.t. min. toggle switches
- OA91 germanium diodes
- 3-way 4-pole and 4-way 3-pole rotary switches
- Rotary on/off switch
- PP3 battery connector
- Some 0·1 inch pitch stripboard
- Some 6BA nuts, bolts, and spacers

INSTALMENT PLAN

In the early days of *Everyday Electronics* it was often suggested that it was a good idea to double-up on the cheaper components when buying a set of components for a project. This does not add much to the cost of the order, and over a period of time the extra components build up into a useful stock of parts. Furthermore, you automatically get more of the popular components, and fewer of those that are infrequently used.

This remains a good way of doing things, and must be the most pain-free way of building up a stock of components. Its main drawback is that you will be paying significantly more for your components, as you will not be getting the benefits of bulk buying. Also, with bulk buying you save a lot of time by not having to order each resistor and capacitor individually.

STORAGE

If you are going to have a large stock of components you must store them sensibly. Simply putting them all into a large box is a totally impractical approach. Rummaging through hundreds or thousands of components for each part you require will take a great deal of time. Worse than this, it will tend to rub the identification markings off the components, and could eventually result in more serious damage, such as detached leads.

Some sort of multi-compartment box is required, or if you have a lot of components to store it may be necessary to have several of these boxes. Each compartment can be used to hold a particular type of component over a limited range of values. For example, with resistors I have one compartment for the resistors having a black multiplier band, another for the resistors having a red multiplier, another for those with an orange multiplier code, and so on. By having a very limited range of values in each compartment you can quickly locate the components you require, with minimal wear on the components.

Small plastic chests of draws are ideal for component storage. You will probably find these locally in Woolworths etc., as well as in any of the larger electronic component catalogues. From the same sources you can also obtain compartment boxes, and trays made from transparent plastic, both of which are ideal for component storage. Some of these boxes have quite small compartments, making them unsuitable for resistors and some other components. They are perfect for the smaller components though, such as most capacitors, transistors, etc.

FINALLY

What is definitely not the right way to build up a stock of components is to buy sets of components for projects, and to never quite get around to building them. Making projects is far more fun than component collecting!

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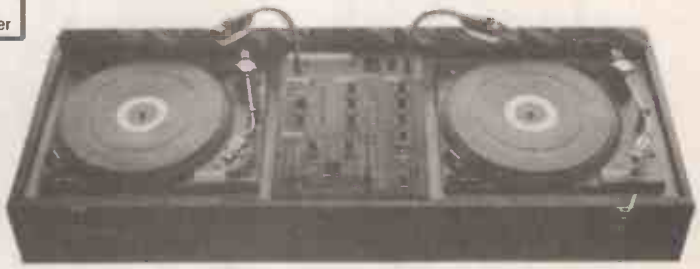

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Constructional Project

TIE PULSER

MAX HORSEY

Is this the comeback of the 70's "disco" tie? Sound activated, it will soon send out "good vibrations" to the rest of the groovers.

DESIGNED for disco's and parties, not to mention Red-Nose Day, the Tie-Pulser consists of a set of 20 l.e.d.s fastened to the front of a tie. An electronic circuit, complete with microphone and battery are concealed within the tie, which for ease of use should be a clip-on type. Sound causes the l.e.d. array to pulse, like the l.e.d. VU display fitted to some tape recorders.

HOW IT WORKS

The block diagram for the Tie Pulser is shown in Fig.1. The circuit is based around the LM3914N dot/bar driver i.c., with a simple 741 op.amp microphone amplifier.

The microphone picks up the surrounding sounds and feeds them to the amplifier. The audio signals (a.c.) are then passed, via the gain control, to the display driver i.c.

The LM3914N is a device which responds to inputs in a "linear" fashion. A LM3915N i.c. with a "log." response normally associated with sound level applications is also available, but in tests the LM3914N was found to be more satisfactory in this instance.

The i.c. contains a number of amplifiers whose non-inverting (+) inputs are controlled from a resistor or potential divider chain, see Fig.2. Each non-inverting input voltage is held at a different level, the connection nearest pin 4 being the lowest voltage, and the connection nearest pin 6 being the highest.

The signal (pin 5) is fed via a buffer amplifier to all the inverting (−) inputs. As the voltage at pin 5 rises, output 1 will become negative, followed by output 2 etc.

The i.c. also contains a regulator to provide a reference voltage. This may be used to set the voltage at pin 6, with pin 4 connected to 0V. The mode select input (pin 9) determines whether the display will be in dot or bar mode. If pin 9 is left open circuit, the display will be in dot mode, and if pin 9 is connected to the positive rail a bar mode display is produced.

The outputs may be used to drive l.e.d.s directly, and are "active low". In other words, with single l.e.d.s, each l.e.d. anode (a) must be connected to the positive supply rail, and each cathode (k) to a respective output as shown in Fig.3. The current flowing through the l.e.d. is regulated by the i.c. and can be set by means of a single resistor, R8.

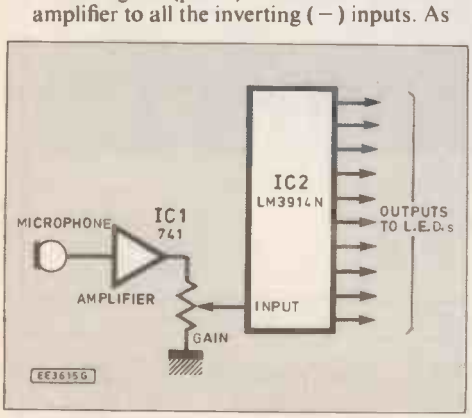


Fig. 1. Block diagram for the Tie Pulser.

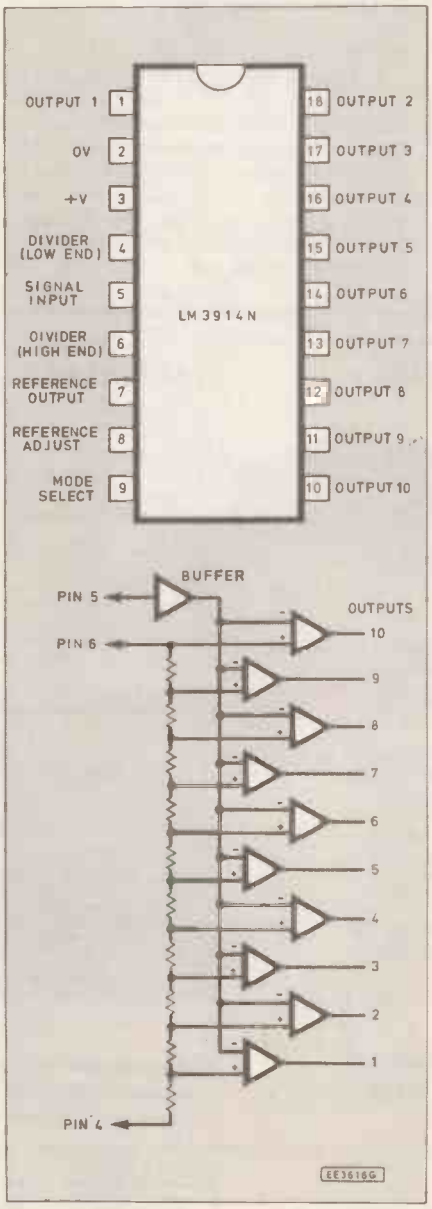


Fig. 2. Pinout information and part of the internal circuit of the LM3914N linear bargraph display driver i.c.

CIRCUIT DESCRIPTION

The full circuit diagram for the Tie Pulser is shown in Fig.4. The 741 op.amp IC1 is connected in its non-inverting mode. The microphone is an electret insert type EM-4 or similar, and costs less than £1. This type of microphone is very small and very sensitive, but requires a d.c. supply which in this circuit is provided by resistor R1.

The small alternating signal from the microphone passes via capacitor C1 into the non-inverting input (pin 3) of IC1. The purpose of C1 is to allow the flow of a.c. (i.e. the audio signal), but block the flow of d.c., which would upset the voltage at pin 3. This must be held at half the supply voltage, and is achieved by using two resistors R2 and R3 of equal value.

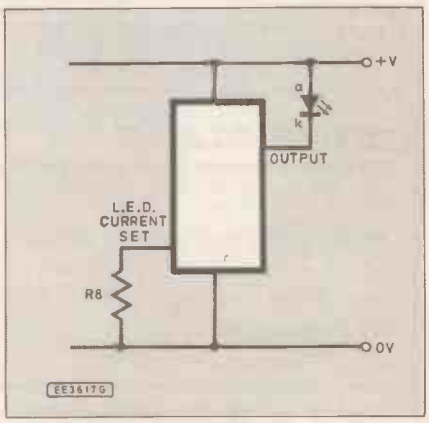


Fig. 3. The outputs of the LM3914N i.c. can drive l.e.d.s directly. Only one output is shown; the other nine outputs are connected in the same way.

The inverting input (pin 2) is connected to output pin 6 via resistor R4. Since there will be virtually no current flowing through R4, there will be virtually no voltage drop across it and the voltage at pin 2 will be equal to that at pin 6.

Remembering that pin 2 is an *inverting* input, any rise in its voltage will cause a corresponding fall in voltage at pin 6, and vice-versa. Thus the output voltage will be held at a voltage equal to that at pin 3.

The d.c. link between output pin 6 and inverting input pin 2 is known as "negative feedback". An alternating audio signal is required from pin 6, and a means must be found of preventing this "feeding back" to pin 2 and cancelling itself out.

This is achieved by capacitor C3, which whilst blocking the flow of d.c., allows the a.c. audio signal at the lower end of resistor R4 to flow to 0V. Resistor R5 reduces this flow a little, so that a small percentage is fed back to pin 2 to reduce the a.c. gain of the op.amp.

The ratio of R4 to R5 sets the approximate gain of the amplifier. The gain required is rather high, and the circuit can easily become unstable, especially when close to the high currents flowing via IC2. Any small voltage fluctuations on the supply rails will adversely affect the amplifier, causing it to oscillate (i.e. give out a signal, even when no sound is directed at the microphone).

Resistor R6 is a simple means of preventing these voltage fluctuations reaching the sensitive amplifier circuit. Used in conjunction with capacitor C2, the supply rails are "decoupled" i.e. the voltage level is maintained at a constant level.

DIODE PUMP

The amplified output from pin 6 of IC1 is fed to gain control VR1 via capacitor C4. This again allows the a.c. signal to pass, whilst preventing the flow of d.c. from pin 6. VR1 is a preset potentiometer, used as a level control, to adjust for loud or quiet sounds.

The a.c. signal passes via capacitor C5, with the right hand "plate" (as in the diagram) alternating between positive and negative. Each time this plate is positive, current flows via diode D2, and charges capacitor C7.

When the right hand plate of C5 is negative, the 0V rail appears to be positive by comparison, and current flows from 0V via diode D1. An imperfect analogy is to think of D1 and D2 acting as one way water valves, with C5 as a piston. The water is "sucked up" via D1, and pushed out through D2. This arrangement is often referred to as a "diode pump" network.

In practice the voltage obtained will be less than expected, since diodes (especially silicon ones) cause a voltage drop. The use of germanium diodes would improve the situation, but they are more expensive, and the circuit sensitivity is more than adequate anyway.

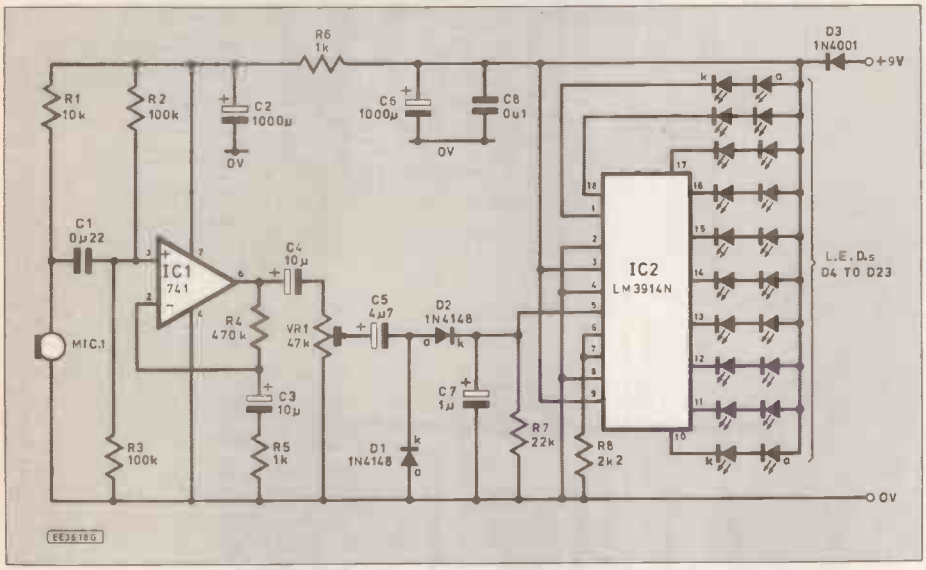


Fig. 4. Complete circuit diagram for the Tie Pulser.

DOT/BAR DRIVER LM3914N

The input signal is delivered to pin 5 of the display driver, IC2. Capacitor C7 stores the separate d.c. pulses received from diode D2, so that a more steady d.c. voltage level is presented to pin 5. Resistor R7 discharges C7 rapidly when the train of pulses stops. This ensures that the display falls rapidly when the sound stops.

Resistor R8 sets the output current from IC2. The value of 2.2 kilohms allows an output current of about 7mA. Pin 3 is the i.c.'s positive supply, and pin 2 is connected to 0V. It is important to also connect pins 4 and 8 to 0V, to ensure correct operation.

The ten outputs are from pin 1 (lowest sound level), followed by pins 18, 17, 16, etc. to pin 10, (the highest sound level). A rising voltage at the input pin (5) causes pin one to go 'low' (towards 0V), then pin

COMPONENTS

See SHOP TALK Page

Resistors

R1	10k
R2, R3	100k (2 off)
R4	470k
R5, R6	1k (2 off)
R7	22k
R8	2k2

All 0.25W 5% carbon film

Potentiometer

VR1	47k sub-min enclosed preset, horiz.

Capacitors

C1	0µ22 disc ceramic
C2	1000µ axial elect. 10V
C3	10µ axial elect. 16V or more
C4	10µ axial elect. 16V or more
C5	4µ7 axial elect. 16V or more
C6	1000µ axial elect. 10V
C7	1µ axial elect. 16V or more
C8	0µ1 disc ceramic

Semiconductors

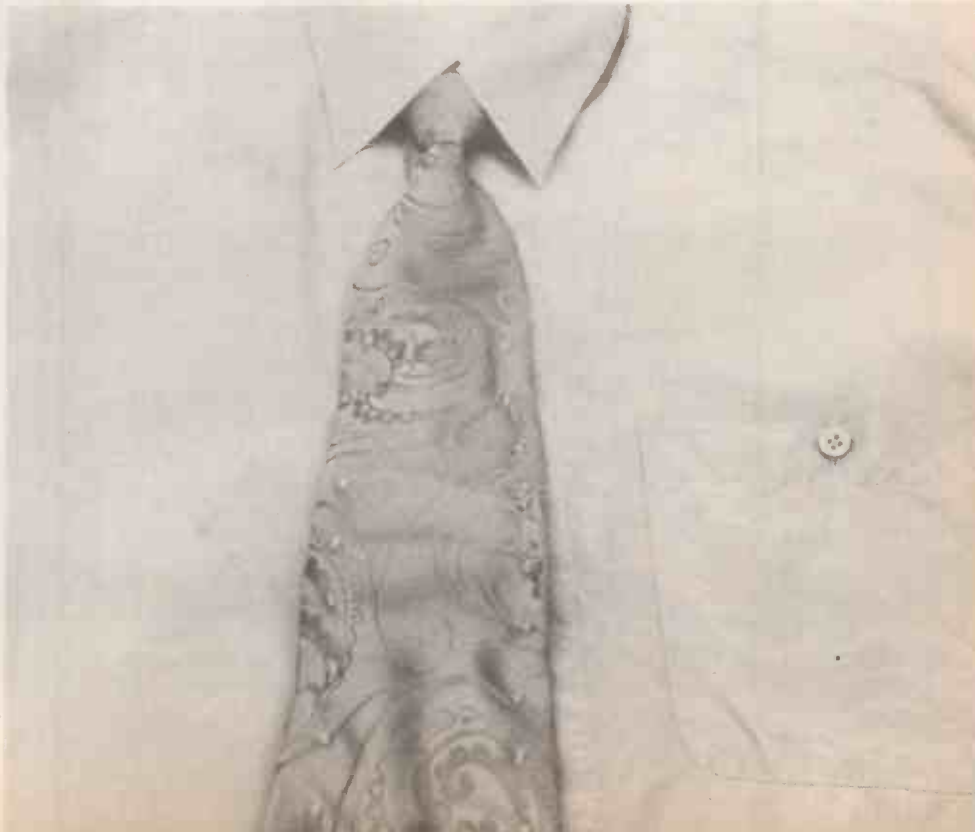
D1, D2	1N4148 signal diode (2 off)
D3	1N4001 1A 50V rect. diode
D4-D23	3mm red low current (2mA) l.e.d. (20 off)
IC1	741 op.amp
IC2	LM3914N bargraph display driver, linear

Miscellaneous

MIC.1	Sub-min. omnidirectional electret microphone insert (EM-4)

Printed circuit board available from *EE PCB Service,* code EE794; 8-pin d.i.l. socket; 18-pin d.i.l. socket; PP3 9V battery and connector clips; clip-on tie; connecting wire, solder etc.

Approx cost guidance only **£16** *plus tie*



18, 17 etc. The outputs are used to directly drive an l.e.d. display, with the l.e.d.s arranged in series pairs as shown.

CONSTRUCTION

All the components, with the exception of the 20 display l.e.d.s, are mounted on a small single-sided printed circuit board (p.c.b.). The component layout and full size copper foil master pattern is shown in Fig.5. This board is available from the *EE PCB Service*, code EE794.

Solder in the i.c. holders and small components such as resistors. Take care to fit the diodes and electrolytic capacitors the correct way round. The electet microphone insert can be purchased with a screened cable already attached, otherwise connect wires to the pads of the insert very carefully, taking care to observe the correct polarity. The pad which is already joined to the metal insert case is the negative side.

Screened wire should be used, but if the wires are kept very short ordinary wires can be employed. The mic insert case should be insulated with tape to prevent short-circuits, so that it may be left in any convenient position inside the tie. Connect all the wire leads required, and finally insert the i.c.s into their sockets ensuring that their notches are towards the top.

CHOICE OF LEDs

A very wide range of l.e.d.s is now available, and after some experimentation the l.e.d. chosen for the prototype was a red 3mm *low-current* type. The type obtained can be operated on 2mA, with a maximum current of 20mA. At 6mA or 7mA the l.e.d.s were far brighter than standard types, and well worth the few extra pence each.

BUILDING THE DISPLAY

A clip-on tie is ideal for accommodating the display l.e.d.s, although talented sowers may be able to modify ordinary ties. Begin by cutting the stitches at the rear of the tie so that it may be "opened". Mark the positions of the 20 l.e.d.s on the front of the tie using a pen.

Next cut the tips of the l.e.d. leads at an angle using side cutters so that each lead ends in a sharp point. Carefully check that each l.e.d. is inserted with its anode lead (longest) the side shown in Fig.6. The l.e.d.s may now be pushed through the front of the tie, the sharp leads piercing the fabric like a needle. They should now be secured by carefully bending their leads, using long-nosed pliers, at right angles as shown.

Soldering must be carried out with great care, noting that most ties will melt instantly if touched by a soldering iron or molten solder. Constructors with shaky hands are advised to place thin card between each pair of leads being soldered and the fabric.

When viewed from the rear (Fig. 6.), all the left hand l.e.d. (anode) leads are connected to each other, using bare wire if necessary. Each cathode (k) lead of the left hand line of l.e.d.s is connected to the anode (a) lead of the right hand l.e.d.s.

Finally, all the cathode leads of the right hand line are connected to the p.c.b., with the

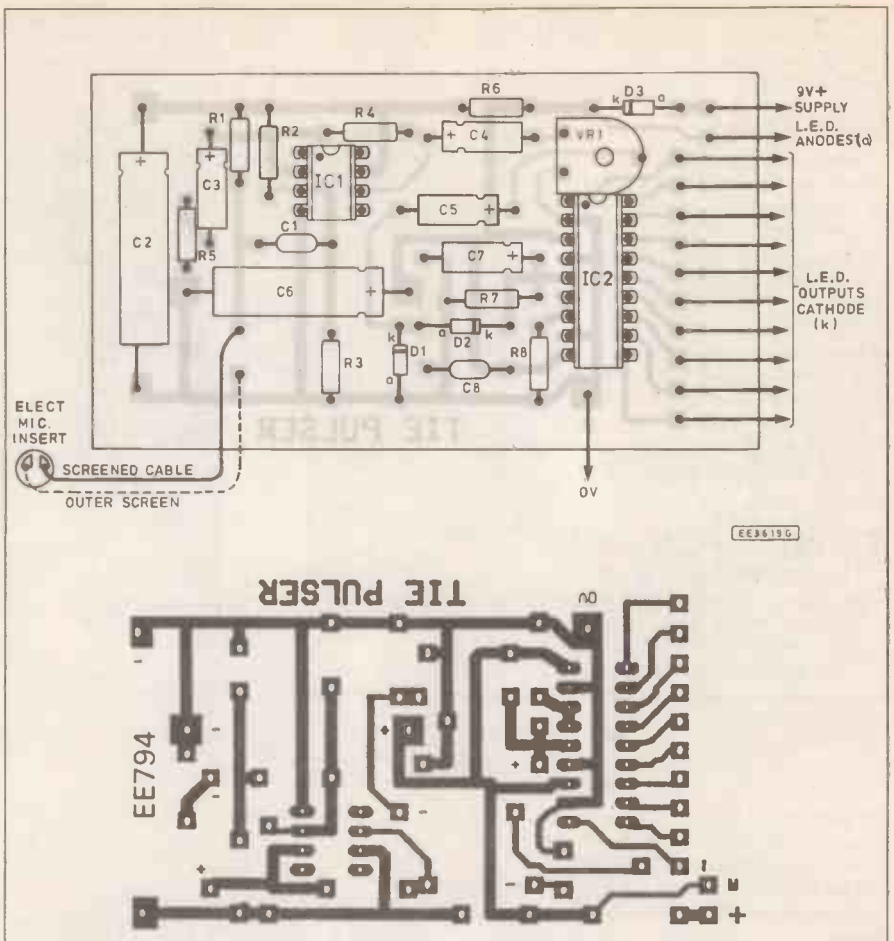


Fig. 5. Printed circuit board component layout and full size copper foil master pattern for the Tie Pulser.

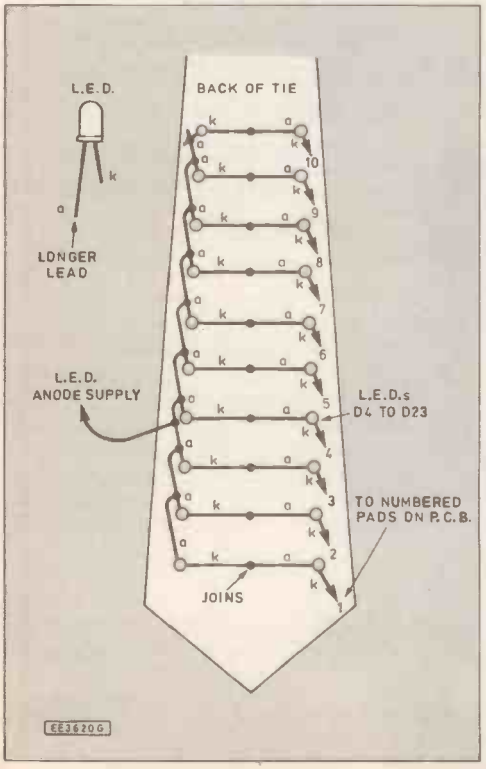


Fig. 6. Wiring to the display l.e.d.s and pin identification diagram.

lowest l.e.d. to copper pad 1, the next to pad 2 etc. Insulated wires should be used for this purpose, and colour coding will avoid confusion.

SETTING UP

Note that when power is first applied to the circuit, there will be a slight delay before the amplifier begins to work. This is due to the time taken to charge capacitor C3 via the high value resistor R4.

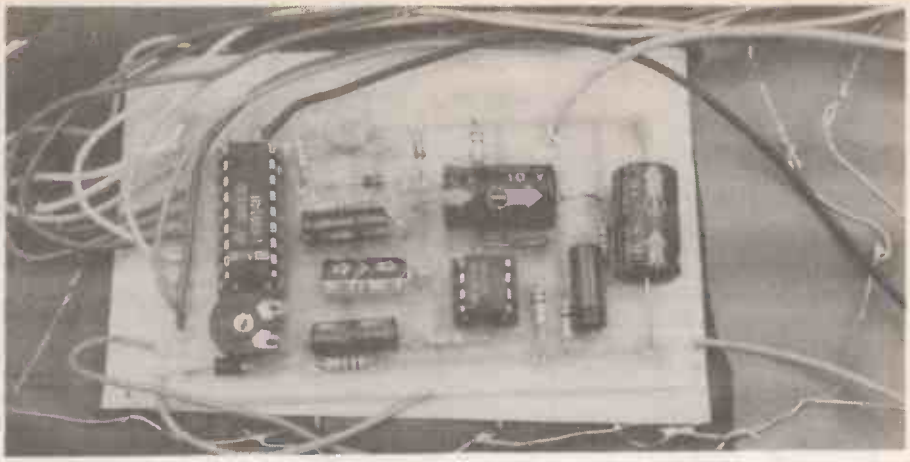
Commence the setting up procedure by adjusting preset VR1 to its highest gain setting. When a sound is directed at the microphone, some or all of the l.e.d.s should flash. Check that the l.e.d.s connected to the lowest outputs flash first and that the display rapidly "decays" when the sound stops. If, after a minute, the circuit fails to work, some simple tests should locate the fault.

FAULT FINDING

It is useful to first establish which part of the circuit is failing. If an oscilloscope is available, check that a signal is reaching pin 3 of IC1 when a sound is directed into the microphone. Check that a much higher signal is reaching preset VR1, and then capacitor C5.

Try linking the signal input (pin 5) of IC2 directly to positive. *Take great care not to connect any other pin by mistake.* A safer test position is the right hand side of R7. When this is made positive, all the l.e.d.s should light. Failure of this test would indicate a problem around IC2, or the l.e.d.s.

Voltmeter readings around IC2 should produce the following results, assuming that the negative lead of the voltmeter is connected to 0V.



Pins 2, 4, 8 = 0V
Pins 3 and 9 = 8V approx.
Pins 6 and 7 = about 1.2V

TESTING THE OP.AMP

Assuming the absence of a signal from capacitor C4 (as revealed by the oscillocope test earlier, or the correct functioning of the circuit around IC2), check that the d.c. voltages on the op.amp IC1 pins are as follows:

Pins 2, 3, 6 = about 3.5V
Pin 7 = about 7V
Pin 4 = 0V.

Note that a good quality (high resistance) meter is necessary to obtain the correct reading on pin 3, and in particular, pin 2.

If any strange readings are obtained around either i.c. check the board carefully for dry solder joints (i.e. joints not making correct contact), or solder bridges across adjacent tracks, or hairline cracks in a copper strip.

ON DISPLAY

A small PP3 battery should provide enough power for several hours use. In the prototype, the battery was housed by folding the tie lining around it, and fastening with a staple. No on/off switch was included, since it is very easy to unclip the battery; however, a switch could be included if preferred.

The fabric back of the tie was neatly refastened with strips of insulating tape, to enable easy servicing and adjustment of the preset. When "dancing" with the tie on, it is advisable to fasten the lower part to the shirt with a tie clip or safety pin, otherwise the weight of the battery may cause the tie to fly off and strike some unsuspecting person! □

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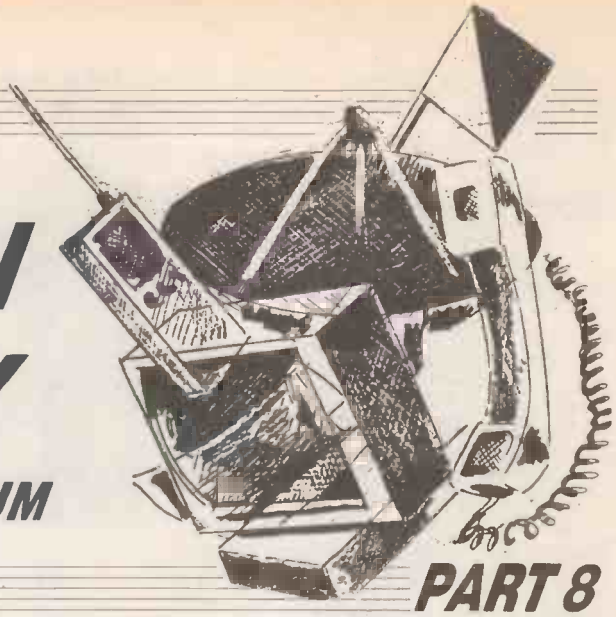

INFORMATION TECHNOLOGY AND THE NATIONAL CURRICULUM

T. R. de VAUX BALBIRNIE

PART 8

THIS IS the eighth in a 12-part series concerning information technology, communication systems and related matters in the Science National Curriculum. Readers are reminded that there is far more material given here than is needed for any particular scheme of study. The intention, as always, is that sections should be drawn on as required.

Those who have not been following the series are advised to read Part 1 (November, 1991 issue) since this gives certain background information about the National Curriculum and about this month's topic which is information-transmission systems.

TELECOMMUNICATIONS

Telecommunications – that is *communication at a distance* – is a large and ever-growing topic. Telecommunication devices include the telephone, radio, television (including teletext), fax (facsimile transmission) and telex. In a given situation, more than one of these may be used – for example, fax signals being passed along a telephone line or telephone messages being sent using radio techniques as in a car telephone, cordless telephone or ship-to-shore link. Now, satellites form part of the picture and their use will be discussed in detail in a later part of the series.

Here we will consider the traditional method of using analogue electrical signals in copper wires, analogue and digital light signals passed along optical fibres and the use of radio links. Information may represent two-way private conversations, radio or television information for mass entertainment, still pictures and printed documents, or binary data being interchanged between computers.

Whatever type of communication system we use, we can break it down into the following parts: (a) a source of information (b) a device which converts the information into a suitable form for transmission (c) the means of communication (channel of communication) itself (d) perhaps some form of processing circuit(s) at intervals along the way (e) a destination for the signal and its conversion into a suitable form (which is normally that of the original) and, finally, (f) the receiver of the information. This is shown as a block diagram in Fig. 1.

TRADITIONAL TELEPHONE SYSTEM

Let us illustrate the above by considering a traditional telephone system. The source of information is the *person speaking*. The device which converts the information into a suitable form is the *microphone* – this produces an analogue electrical copy of the variations in the human voice. The channel of communication is the *copper wire* which carries the electrical signals and runs to the distant end.

Some form of processing (amplifiers) will be used in a long-distance system to "boost" the signal level every so often to make up for losses before it is sent on its way again. At the distant end, the conversion from electrical signals to sound is carried out by the *earpiece* and the *listener* receives the information.

Such telephone systems are still widely used today. A similar system could be used where the channel of communication is *radio waves* rather than electrical signals along copper wire.

ANALOGUE TELEPHONE EXPERIMENT

This experiment uses a pair of old-type telephone handsets to set up a two-way analogue communication link over copper wires between two points which may be several hundred metres apart. You will need the handsets from a pair of traditional telephones having carbon granule microphones.

Complete telephones are available in used condition quite cheaply from mail order suppliers. In addition to the telephones, you will need a 9V battery and connector also some light-duty twin wire such as "bell" wire and some 3 amp (light-duty) screw terminal block.

You only need the handset, so if complete telephone instruments have been bought, you will need to do some minor dismantling to disconnect the handset wires from the terminals inside. When this has been done, unscrew the microphone and earpiece covers to identify the colours of the wires.

The two microphones and earpieces are then connected together in series with the battery as shown in Fig. 2. The wires on telephones are of a type to which it is difficult to make connections but there should be no difficulty if the pieces of screw terminal block are used as shown.

This system may be used for two-way conversation. Clear results are obtained providing the distance between the two stations is not too great. This experiment illustrates how, in practice, a simple analogue system can provide good results over relatively short distances.

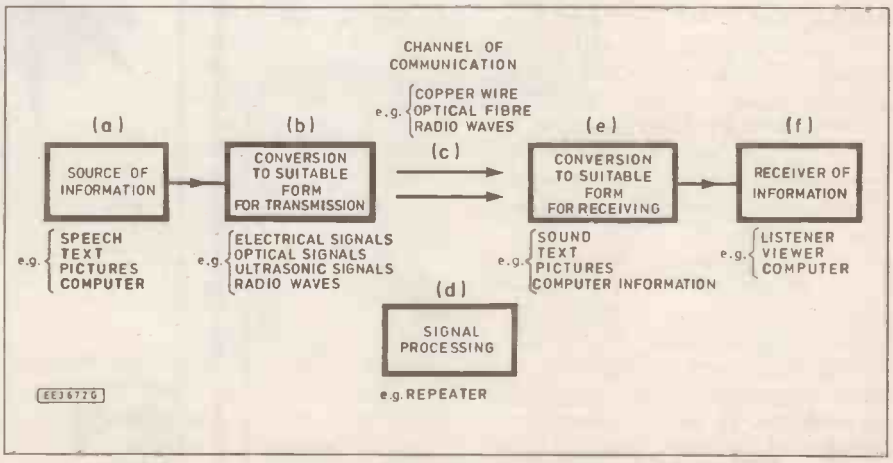

Fig. 1. Basic parts of a communication system.

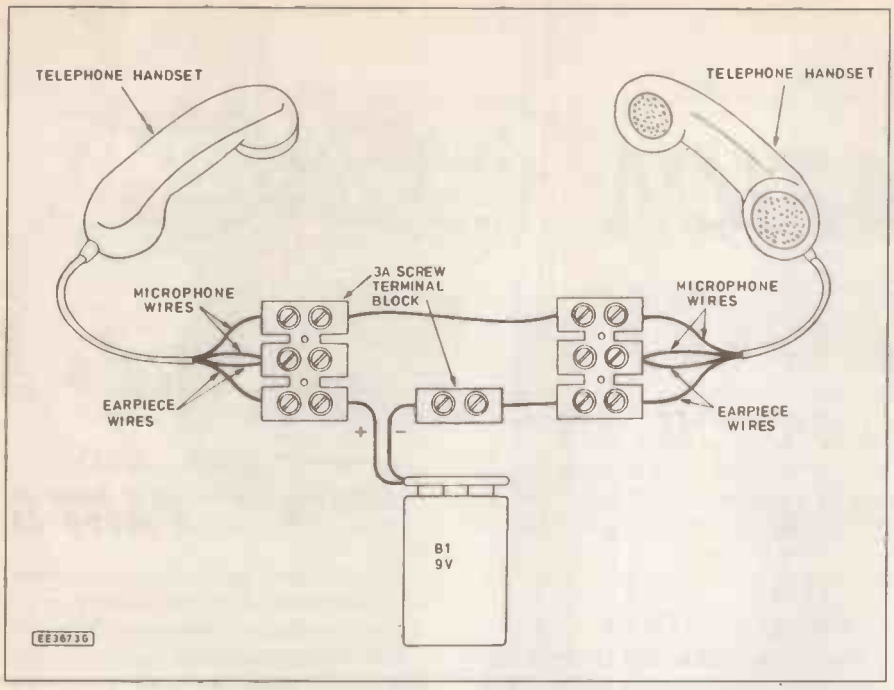

Fig. 2. Analogue telephone link.

One interesting point is that signals for both directions pass through *both* microphones and *both* earpieces. This makes it possible to set up a two-way conversation using only one pair of wires. It also means that the speaker hears his or her own voice and this acts as a check that the system is working. It would be a good exercise to compare this electrical system with the purely acoustic *string telephone* in Part 1 (November, 1991 issue).

Over very long distances, the signal in the system above would weaken and booster amplifiers (called repeaters) would be needed every so often along the line. These would inevitably introduce distortion, noise and hiss and the signal would gradually become degraded to the point where it became unintelligible. Another disadvantage of this type of system is that where several copper wires carrying different signals lie close to one another, current tends to be induced from one wire to adjacent ones. Other conversations will then be heard in the background. This effect is called *cross-talk* and can be a great nuisance and embarrassment.

ANALOGUE RADIO LINKS

Experiments using radio links are a problem in the UK because, although easy to do, it would be illegal to make and use the necessary apparatus. One way out is to use very low-power "toy" walkie-talkies, licensed CB (citizens band) transceivers or a cordless telephone as the basis of experiments.

The whole point of radio communications is the very versatility and freedom associated with its use. It needs no physical medium between the two stations (so-called *wireless* communication). The channel of communication is *radio waves* which are modulated to carry the analogue information of the voice (more will be said about radio waves and methods of modulation in a future article).

The waves spread out through space from the aerial (antenna) on the transmitter. An aerial on the distant receiver then picks them up and converts the information firstly into electrical signals then into sound which is reproduced by the loudspeaker.

Since the waves are not usually channelled in any particular direction, the signal strength becomes weaker the further the receiver is from the transmitter – in fact, when the distance between transmitter and receiver is doubled, the signal strength is *quartered*. It will be clear that the range will be short unless a powerful transmitter is used or the waves are directed to the listener in some way.

"Beaming" the signal is possible using certain high-frequency radio waves but this is only useful if you know where the receiving station happens to be. In many applications, such directional techniques are inappropriate. One disadvantage of radio communication is that it is not secure – that is, anyone with a suitable receiver can listen in on the conversation – users of cordless telephones beware! This should be compared with systems in which the signal is sent *direct* to the receiver for example, along a copper wire.

The students could investigate the range of radio equipment both in the open air and with various objects such as concrete and steel structures in between. They could investigate the performance at the limits of the range and find out exactly what eventually makes the sound unintelligible.

ANALOGUE TO DIGITAL CONVERSION

Last month we discussed analogue to digital conversion and the reverse process. In a modern telecommunications system, the analogue signal is converted to digital form using an *analogue to digital (A-D) converter*. The digital signal is then transmitted along the channel of communication to the distant end. A *digital to analogue (D-A) converter* then turns the signal back into its original form.

Using such digital techniques, although technically difficult to do, provides better quality with no degradation of the signal with distance or repeated amplifying. Sending such digital signals lends itself well to using *light* along *optical fibres* rather than electrical signals along copper wires. This is a fairly recent advance having many advantages over the traditional method.

OPTICAL COMMUNICATION

In an optical system, the information to be conveyed is converted into *light signals* rather than electrical ones. These may be analogue or digital in nature. Let us discuss an analogue system first. Here the speech, music or other information makes a light source "flash" with a brightness which follows all the changes in the sound pattern. The flashing light is then picked up by a sensor at the distant end and the information converted first into a corresponding electrical pattern then into sound using an earpiece or loudspeaker.

In practice, *infra-red* is often used rather than visible light. Infra-red may be regarded as a form of light to which the human eye is insensitive – that is, it cannot be seen but otherwise behaves in practically the same way.

It is wasteful simply to flash the light into the air and hope to pick it up some distance away since most of the light spreads out in space (compare this with radio communication) – although this method does have its uses over very short-distances.

An example is the remote control system used with many modern television sets, videocassette recorders, audio systems, etc. Here, an infra-red source in the handset sends a digital code according to which button is pressed. These codes consist of a string of binary numbers in the form of on-off states. The infra-red signal, carrying the digital code, is received by a sensor in the television set, video recorder or other piece of equipment. It is then decoded and made to change channels, turning up the volume, alter the brightness, mute the sound, or whatever other job is required.

The codes are unique and it is extremely unlikely that a "false" signal could be given or received. Unfortunately, different manufacturers use different codes so there is no compatibility between different systems. Note that no A-D converter is needed here because the data is already digital.

Some readers will be familiar with certain "wireless" audio systems. These allow headphone listening while walking around the room. The system consists of two parts: a transmitter which is plugged into the main audio system and a receiver which is carried around by the person. In the transmitter, infra-red is modulated to carry the analogue sound information which then fills the room. A sensor on a

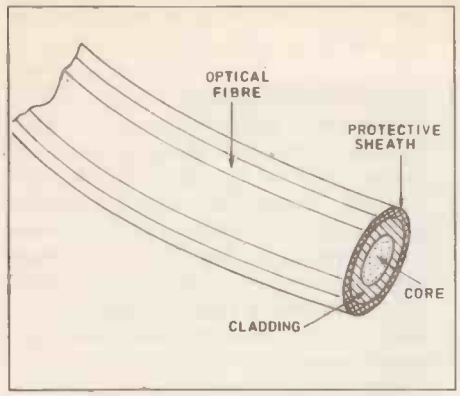

Fig. 3. Optical fibre construction.

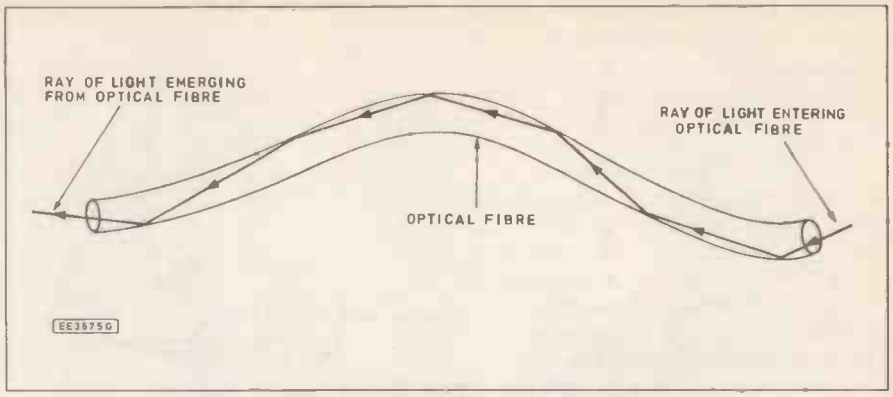

Fig. 4. Path of light ray along an optical fibre.

receiver picks this up and re-converts it first into electrical information then into sound.

OPTICAL FIBRE

For a greater range of communication, it is more efficient to channel the light signal along an *optical fibre*. This will prevent the signal from spreading out through space. An optical fibre has a core (made from glass or clear plastic) and a cladding all encased in a tough protective plastic sheath. Fig. 3 shows the general construction although optical fibres will differ in detail according to type and the precise use for which they are designed.

It is not the purpose here to explain exactly how an optical fibre works in terms of total internal reflection. Anyone interested in this type of detail should consult a standard physics textbook on light. However, it is good enough to say that light entering one end of the fibre will reflect repeatedly along its length and eventually emerge at the other end (see Fig. 4).

In theory, the light could travel any distance along the fibre. This, however, assumes that the material is absolutely transparent and no losses occur. In practice, this cannot be so. It is therefore necessary to pick up the optical signals, convert them into electrical signals, amplify them using a repeater and re-convert them into optical signals every so often along the way.

DIGITAL COMMUNICATION

Optical communications systems can work with advantage using *digital* signals rather than analogue ones. With a digital signal, the sound or other analogue information is converted into binary data using an analogue-to-digital converter (see Part 7 last month). The light source is then only required to flash on (for a 1) or remain off (for a 0) and does not need to follow every smooth change in the analogue pattern of the information. This it can do very well.

The pulsing light is picked up by a sensor at the distant end, converted into on-off electrical signals, amplified, fed to an digital-to-analogue converter and the information used to operate an earpiece, loudspeaker or other output device. As with an analogue signal, if the distance involved is very great it will need to be processed by a repeater every so often. However, with an analogue signal, distortion and noise which are inevitably introduced by the repeater would be amplified by the next one together with the signal itself. Thus, the signal degrades and, eventually, becomes unintelligible – that is, the information it carries will fail to be information at all.

With a digital signal, it is very difficult for distortion to occur since so long as a 1 remains a 1 and 0 remains a 0 the signal will continue to carry all the information and the data stream will be as pure at the end as it was at the beginning. This will be so no matter how many repeaters are used. If for some reason the 1's and 0's become a little distorted (yet still preserving their identity) they are easily cleaned up again by circuits in the repeater so the pulses are perfectly re-created.

LIGHT SOURCE

In a communications system, the source of infra-red radiation may be an infra-red l.e.d. or a laser. For fairly short distances l.e.d.'s are quite satisfactory. A laser is an exceptionally bright source of light so the light can travel much further between successive repeaters.

Note that a filament lamp is practically useless as a light source for optical communication. This is because to convey all the information – whether by analogue or digital means – it must be able to flash at great speed. The working part of a filament lamp is a metal coil which glows

An example of a high capacity optical fibre cable (courtesy British Telecom).

Optical fibre cables being laid between the Isle of Wight and mainland Britain (courtesy British Telecom).

white hot. Since it takes a certain time to reach its working temperature and cool down again, it would not be able to follow the changes satisfactorily. By contrast, lasers and l.e.d.'s can operate at great speed.

Using optical fibres instead of copper wire has several advantages. The material used is cheaper, lighter, thinner and easier to lay. Cross-talk does not occur – the signals remain confined to their own channel even where many fibres lie bundled together. It also turns out that a single fibre can carry many signals at the same time (more will be said about this in Part 10). This means that a single fibre bundle can carry an enormous amount of information.

Experimental cars are being developed where the rear lights are controlled by a digital code sent from a circuit at the front along an optical fibre. The advantage is that just one fibre can convey all the information to operate the correct lights. Only one copper wire is needed to carry the current required for any bulb switched on in this way so there is a saving in terms of cost and weight. Such systems may become commonplace in the future.

OPTICAL FIBRE EXPERIMENTS

The following experiment illustrates analogue communication using an optical fibre. It does involve some careful circuit-building but anyone who has been following the series and has managed up to now will be able to build this system successfully. A personal stereo (Walkman) or, possibly, a battery-operated radio having a headphone socket is needed – this will be used as the source of speech or music.

You will need two Vero Plugblocks if using this method of construction – one for the transmitter and one for the receiver. You will also need a length of optical fibre. This is available from mail order suppliers fairly cheaply. The

A copper cable and optical fibre cable of similar message capacity (courtesy British Telecom).

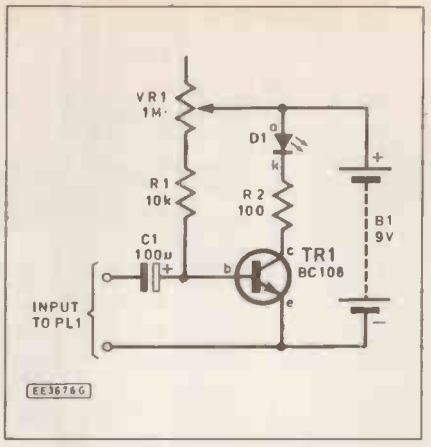

Fig. 5. Optical communication – transmitter.

prototype unit used a length of 5m but you may find that a greater range can be achieved.

It is interesting to examine the optical fibre before using it in the communications system. If someone shines a small torch at one end, the light may be clearly seen to emerge from the other. You will find that the experiments work best when the ends are cut cleanly using a sharp blade then, if possible, polished. However, good results were obtained in the prototype circuit without any special precautions.

Optical fibre can be used to inject light into places which would otherwise be impossible – into a person's body for example to enable photographs to be taken of the internal organs.

CIRCUITS

It is not essential to understand the transmitter and receiver circuits in order to build them. However, an explanation follows for those who are interested. Readers simply wanting to get the system working should disregard the next four paragraphs.

The transmitter circuit is shown in Fig. 5. The working part is the l.e.d., D1. Note that a *red* l.e.d. is used rather than an *infra-red* one. This works well, is inexpensive and has the advantage that the light can be seen. This acts as a check on operation, gives a better insight into the operation of the circuit and simplifies the setting-up procedure.

An l.e.d. requires 2V approximately between its ends to make it work and the output from the stereo would hardly achieve this or might only do so intermittently with loud sounds. It would therefore not work satisfactorily if connected direct to the stereo unit output. To overcome this problem, the l.e.d. is placed in the collector circuit of transistor, TR1. A bias current is allowed to flow into the base via VR1 and R1. This produces a steady collector current which operates the l.e.d.

The base current is adjustable by means of potentiometer, VR1 and this will set the steady brightness level at the end of construction. Resistor, R2, limits the current so that in the event of a circuit failure, the l.e.d. will not be destroyed by excessive current as would otherwise be the case. In use, VR1 will be adjusted so that with no music playing, the l.e.d. glows with about half its normal brightness.

The signal from the personal stereo or radio is applied to TR1 base via capacitor,

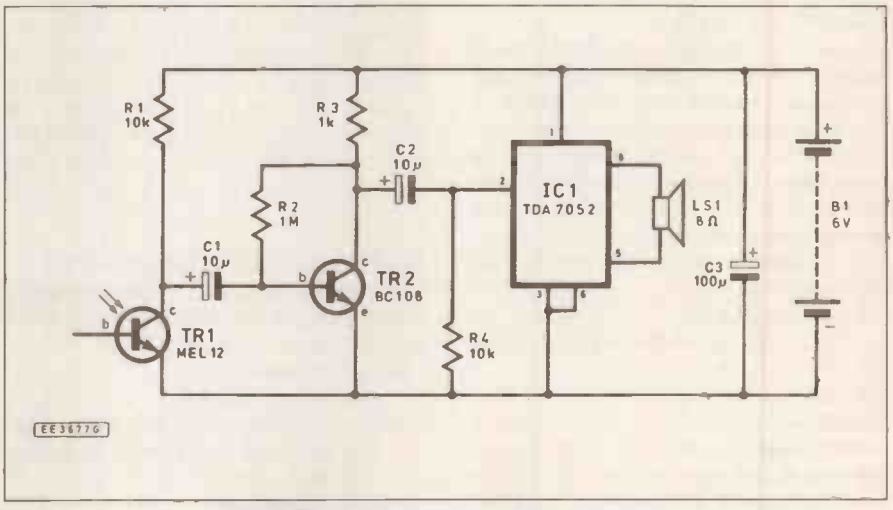

Fig. 6. Optical communications – receiver.

C1. This modulates the steady current already flowing here. The l.e.d. therefore flashes in sympathy with the music above and below its steady brightness level. This simple transmitter has been shown in tests to work surprisingly well.

The receiver circuit diagram is shown in Fig. 6. This consists of a sensitive phototransistor, TR1, a preamplifier centred on transistor TR2 and a high-gain power amplifier IC1. The power amplifier itself is almost totally preformed on the chip and this makes construction very straightforward.

The phototransistor picks up the light emitted by the l.e.d. in the transmitter section and converts it into an analogue electrical signal. This is amplified by transistor, TR2, and applied to the input (pin 2) of power amplifier, IC1. This in turn operates the loudspeaker, LS1 connected to the output pins 5 and 8.

The energy changes are as follows:

TRANSMITTER SECTION	RECEIVER SECTION

SOUND→ELECTRICITY→LIGHT→ELECTRICITY→SOUND

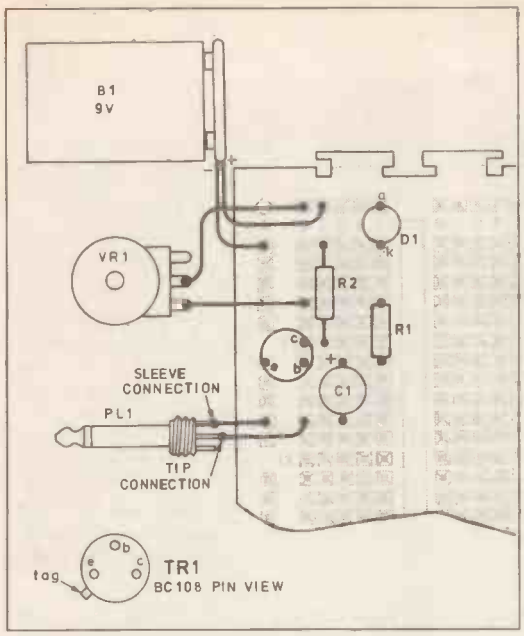

Fig. 7. Construction of the optical transmitter.

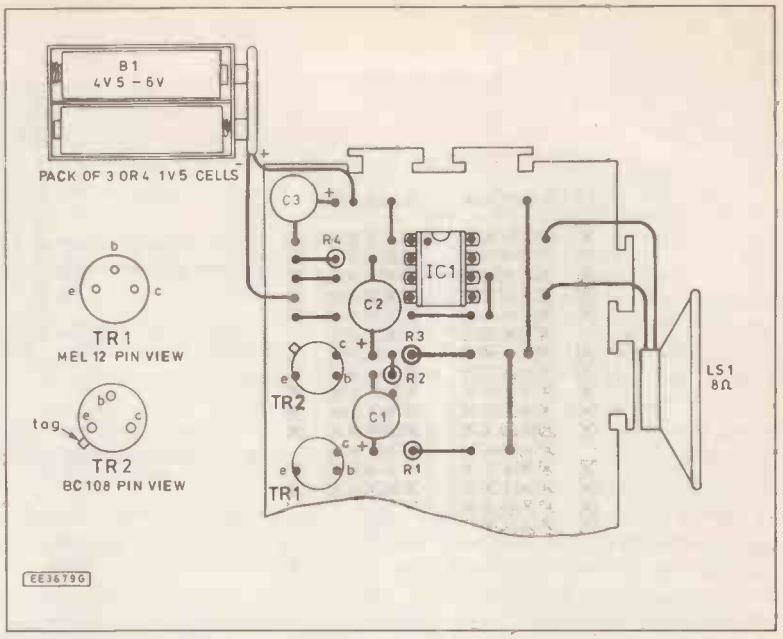

Fig. 8. Construction of the optical receiver.

BUILDING THE TRANSMITTER

As well as the personal stereo mentioned earlier, you will need the following components to make the transmitter. If you have been following the series, the starred items will already be part of your components kit so check before ordering. Note the use of a *hyperbright* l.e.d. in a clear package. In tests, this gave much better results than a standard one in a red encapsulation.

★ Vero Plugblock
5mm red hyperbright light emitting diode (l.e.d.)
★ 100 resistor
★ 10k resistor
★ 1M potentiometer
★ BC108 transistor
★ PP3 battery and connector
★ 100µ 10V electrolytic capacitor – radial leads.
5m 1mm optical fibre
Stereo jack plug to fit headphone socket on stereo.
Light-duty twin wire

The Plugblock layout for the transmitter is shown in Fig. 7. The 1M potentiometer should be prepared by attaching short wires to the centre and one of its outer terminals. This may be done by tight twisting, using small crocodile clips, or by soldering. Note that the 100µ capacitor is of the *electrolytic* type so must be connected the correct way round – the body is marked with a "–" sign and this identifies the orientation. Make up the jack plug lead as shown in Fig. 7. Note that only one stereo channel is used – it doesn't matter which.

After building the circuit check it as follows. Turn the sliding contact of the potentiometer to approximately mid-position. Connect the battery. Adjust the potentiometer so that the light is fairly weak. Insert the jack plug into the stereo unit earphone socket and turn the volume control to a low level. Now play some music and observe the l.e.d. – it should be seen to be varying in brightness gently with the music. If it does not vary at all, increase the volume a little. If it flashes heavily, turn it down. If this works correctly, all is well and attention may be given to building the receiver. If the l.e.d. does not light, it has probably been inserted the wrong way round in the circuit – reverse its leads and try again.

BUILDING THE RECEIVER

The Plugblock layout for the receiver is shown in Fig. 8. To build it, you will need the following components.

★ Vero Plugblock
TDA7052 i.c. amplifier
★ 100µ 10V radial electrolytic capacitor
10µ 10V radial electrolytic capacitor (2 off)
BC108 transistor
MEL12 photo-Darlington transistor
4·5V or 6V battery (3 or 4 off 1·5V cells)
Holder and connector for above
8 ohm loudspeaker (this could be borrowed from a stereo unit)

The receiver section needs a lot of connections so proceed carefully. Make sure the three electrolytic capacitors are connected the correct way round as shown. Note that the circuit works best from 4·5V or 6V battery (three 1·5V cells were used in a suitable holder for the prototype unit). Note also that an 8 ohm loudspeaker is needed. The high resistance speaker used in previous experiments would not be satisfactory. A suitable speaker could possibly be borrowed from an audio system.

TESTING

The system may be checked without using the optical fibre for the moment. Connect the loudspeaker and battery. If the phototransistor detector is picking up mains lights – especially from a fluorescent tube – there may be a buzzing sound from the loudspeaker and it would be necessary to shield it from the light to prevent this from happening. A gentle hiss should now be heard.

The transmitter should now be operated and the l.e.d. held pointing downwards approximately 10cm away from the top of the phototransistor on the receiver unit. Note that both the l.e.d. and phototransistor are very directional – the tops are the sensitive surfaces. If necessary, use a shield to prevent stray light from reaching the detector. The music should be heard clearly from the loudspeaker. This is quite exciting in itself.

If too great a volume is produced for the i.c. to handle it shuts down automatically but will come on again when correct conditions are restored. Adjustments should be made to the Walkman volume control and to VR1 on the transmitter unit to provide the clearest results. If the l.e.d. is over-modulated (that is, by advancing VR1 too far) the sound will be distorted. If under-modulated, there will be a lot of background noise and weak results. You will find that the modulation is approximately correct when the flashing can only just be seen over the steady glow.

Try to find the maximum range of the device in free air. This is limited because the light from the l.e.d. spreads out and only a fraction of it falls on the detector. Meanwhile the detector picks up hum from mains lighting and clicks are likely to occur whenever a flashing light is detected from whatever source. This illustrates the drawbacks of an analogue system. The range could be extended by several meters by using a glass or plastic lens to focus the light from the l.e.d. into a parallel beam then back into a spot on the sensitive area of the phototransistor using another lens.

ADDING THE FIBRE

After these initial experiments have been explored, performance may be improved and the range greatly extended by channell-

ing the light from the l.e.d. through the optical fibre. One student holds an end of the optical fibre on top of the l.e.d. in the transmitter and another holds the distant end on the top of the phototransistor. The exact positions are very critical and results depend very much on exactly where the ends are held. When the best signal is obtained, the optical fibre could be secured at each end using PVC tape.

Specially designed fibre optic infra-red l.e.d's and matching detectors are available from some suppliers. These are mounted in holders which secure the optical fibre in the optimum position. However, for reasons previously stated these have not been used in the present design. The performance of the system should be investigated and an evaluation of an analogue system made.

Unfortunately, it would not be an easy matter to construct a home-made optical system using *digital* signals so that this technique could be compared with the analogue one. However, if we examine the drawbacks of the analogue system, the advantages of using a digital one should be clear.

ULTRASONIC LINKS

Before finishing for this month, we shall look at one further method of short range communication; This involves *ultrasonics*. Ultrasonic waves are sound waves but of a higher frequency (pitch) than the human ear can hear. They are quite unlike radio waves since radio waves can travel in empty space and move at the speed of light (300 million metres per second – equivalent to approximately seven circuits of the earth in one second). Such waves are called *electromagnetic waves*.

By contrast, ultrasonic waves travel relatively slowly – 300 metres per second approximately – and need a medium such as air to travel through. Bats use ultrasonics for their guidance system.

Ultrasonic signals may be used for short-range control purposes. Unfortunately, the technique is limited because the system is easily deceived by false pick-up. The reason is that many everyday sounds – such as keys being dropped on the floor – contain ultrasonic frequencies and these can cause spurious operation.

Before infra-red control became popular, ultrasonic remote control was often used in television sets for simple on-off switching. A handset would contain an ultrasonic transmitter and the television fitted with a matching receiver. However, for the reason stated above, the television could be turned on if someone broke a glass or even whistled sharply!

Ultrasonics technology is used in certain burglar alarm systems which trigger on detecting the sound of breaking glass. Another use is to produce pictures of an unborn baby by reflecting ultrasonic waves off its body. This is believed to be harmless unlike the use of X-rays which could be damaging.

Readers interested in doing experiments involving ultrasonics can buy the basic matching transmitters and receivers quite cheaply but they will need to look up or develop the circuits needed to make them work.

That completes the work for this month. Next time we shall look at bistable circuits and the use of IT devices to monitor and control experiments.

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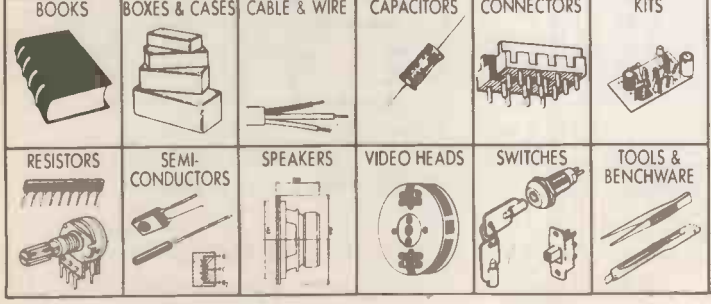

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THE ABC OF R.I.A.A.

W. F. HARMS

DESPITE the advent of cassettes and CDs the analogue record is likely to be with us for some time yet, and in every amplifier used for playing them is an equaliser to modify the signal derived from the pick-up cartridge. Equaliser circuits for this purpose are available in handbooks, journals etc. but it is most unfortunate that many of the designs, even those in quite expensive equipment, are inaccurate.

These are then innocently repeated and alas, the accurate circuits are forgotten, and yet it costs no more to be correct. It is, therefore, worth taking a little time and trouble to understand how this can be attained and is the purpose of this short article.

CONSTANT VELOCITY

From the earliest days of electrical recording, a constant velocity system was used to suit the velocity sensitive moving-iron cartridge normally used. If this were to be applied unmodified, since the displacement of the stylus varies *inversely* with frequency, the amplitude of the waveform cut in the disc at low frequencies would be very large.

There is an economic limit for the groove width and since the amplitude has to be reduced accordingly, the system is changed to "constant amplitude" in this region. This of course, necessitates a correcting network on replay.

Correspondingly, the higher the frequency the smaller the amplitude, and with the introduction of wide frequency range recording, surface noise became more significant. The system is therefore changed during reception of the treble on "top" content to constant amplitude which enhances the amplitude with frequency.

On replay with a correcting network, the signal is normalised and at the same time, the signal to noise ratio is improved. Finally, so as to limit the range of the compensation over the useful audible range to about 40dB, the system reverts to constant velocity for the lowest frequencies, with a benefit as regards possible "rumble" as a bonus.

R.I.A.A. Agreement

Record manufacturers formerly pleased themselves as to the degree of attenuation or enhancement used and in the early '50s, an amplifier might have several switched replay positions whilst another provided plug-in networks to suit records and cartridges. Ultimately, this chaos was rationalised by agreement . . . British Standard 1928 (dated 1955 and re-issued 1965 unchanged) is similar to CCIR (Comite Consultatif International des Radiocommunications) in Europe and R.I.A.A. (Recording Industries Association of America) in America, and the latter title generally prevails.

The R.I.A.A. specifies a "Recording Characteristic" and recommends the replay characteristic be the complement of this using a velocity sensitive cartridge, whilst the British Standard specifies both recording and replay characteristics. Although using different wording, the end result is identical.

SPECIFICATION

The replay characteristic is defined by the combination of three separate curves, individually the plot of a resistance/capacity combination of time constants $t_1 = 75\mu$ secs, $t_2 = 318\mu$ secs and $t_3 = 3180\mu$ secs which, when combined, give the curve in Fig. 1. The dotted lines are the asymptotes to the curves and the "turn over" frequencies can be identified $\left(f = \frac{1}{2\pi t}\right)$ as 2122Hz, 505·5Hz and 50·05Hz respectively.

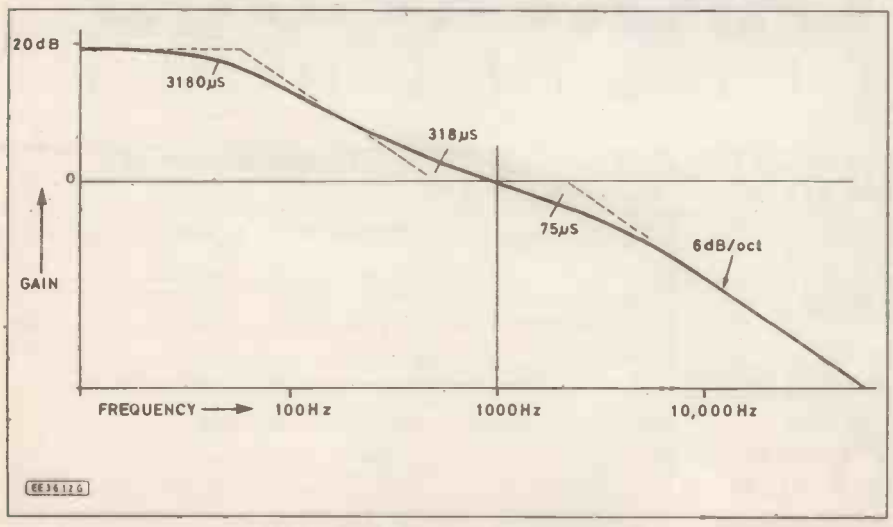

Fig. 1. R.I.A.A. replay characteristic.

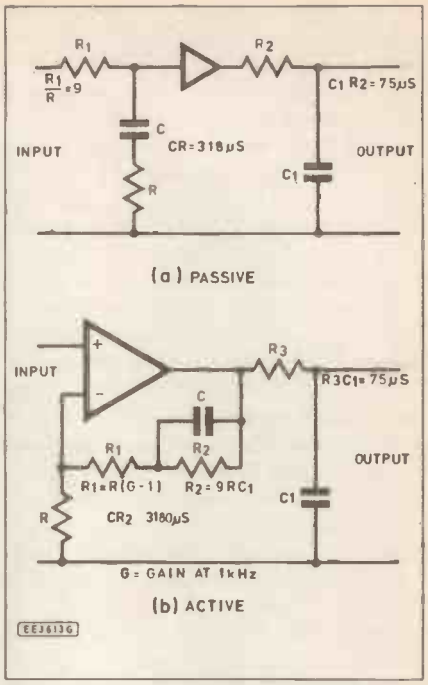

Fig. 2. Replay circuits in which two time constants are combined.

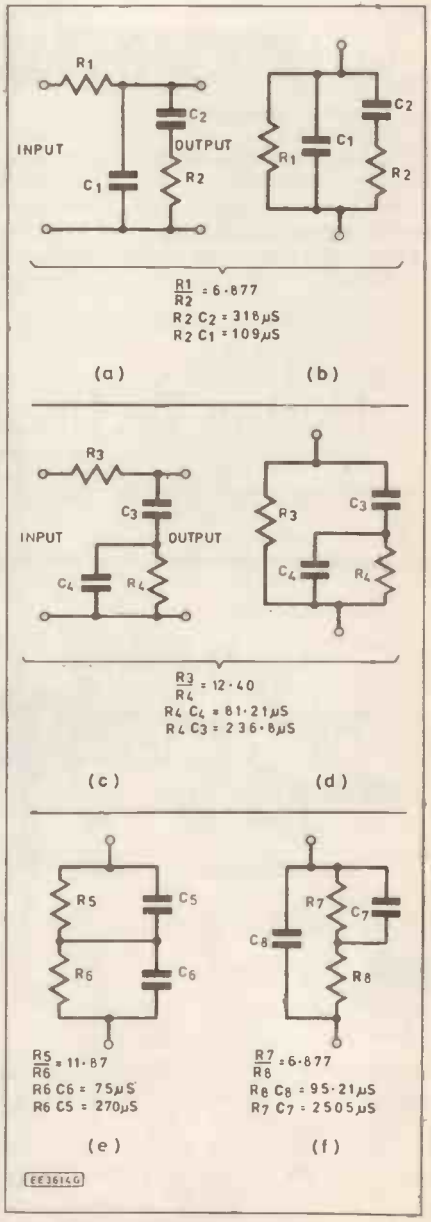

Fig. 3. R.I.A.A. replay networks.

The slope does not exceed 6dB/oct. The response is usually related to that at 1kHz; this is 10.103 per cent of the maximum and not 10 per cent as might be presumed.

Realising the response can be achieved in three separate stages but this is not recommended. A better way is to combine t_2 and t_3 in a passive or active form as shown in Fig. 2.

However, the usual arrangement is to combine the three time constants in a single network and the alternative types are shown in Fig. 3, two of which are suitable for a passive circuit whilst the others can be used in a feedback circuit because their impedance overall varies in accordance with the R.I.A.A. requirements.

COMPONENT VALUES

Because of interaction, component values cannot be determined by a simple "rule of thumb" and it is necessary to equate the response in terms of impedances with that in terms of time constants. Although a little involved but not difficult (ordinary algebra), fortunately this is not necessary for the data was made available over thirty years ago. In the late 50's E.M.I. advertisements often included the networks with values whilst in more detail, they were given in 1957 by W. H. Livy of E.M.I. in the *Wireless World* magazine.

The component ratios are shown in Fig. 3. By their prudent use, an accurate R.I.A.A. network is assured but the precise design depends upon the circuit as a whole in which it is to be used and particularly upon the impedances associated with it.

However, in a feedback circuit, if the 1kHz gain is set low, say 30, or if the "open loop gain" of the circuit is limited (as opposed to very high), inaccuracies can creep in beyond the usual tolerances, and special consideration may then be necessary. In any event, the need to use "preferred values" can be frustrating but with careful adjustment, the errors can be kept within 0.2dB, and this should be the aim. □

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Constructional Project

DIGITAL SERVO INTERFACE

MIKE MEAKIN

From Victroiana automata to Star Wars robots, this 8-channel serial port interface will allow you to control their actions through your home computer.

SOME years ago an enterprising manufacturer of home computer "add-ons" produced a low cost robot arm that used standard model radio control servos to produce the motive power. A small machine code programme was tucked away in the computer and when called upon would produce the necessary signals to drive the servos via the "user port" and an interface box.

This was ideal for those hobbyist and experimenters who derived much fun an pleasure from making their computers "sing and dance" in the real world. The interface was applicable not only to robot arms but to buggies and those interested in making "high-tech" versions of Victorian "automata" or animated models.

ANIMATRONICS

Since those early days of "home robotics" this combination of science and art has been given the name "animatronics". A very good example of the craft is seen in the almost human mannequins used in the "Royal" exhibition at Windsor. As Queen Victoria rises from her throne to address the audience it is hard to believe that it is not real flesh and blood!

Whilst these professional "robots" use penumatics, the same effect can be achieved, on a more modest scale, with the humble radio control servo. These very same servo mechanisms can be found within popular animated toys and it was whilst repairing my daughters "Teddy Ruxpin" that the seeds of this project were sown.

A wide range of servos are available from almost any model shop. The smallest being the size of a box of matches to the largest which are capable of winching a 40lb load. In addition speed controllers capable of driving d.c. motors are available too.

In recent years, due mainly to the vast market for model off-road vehicles, the price of these servos has tumbled, with a good quality servo now costing less than ten pounds. It is also possible to buy both the mechanics and the electronics for model servos in kit form from specialist suppliers. Whilst the cost saving in building from a kit is not enormous there is a certain satisfaction to be derived especially if a custom built solution is required.

MISSING LINK

The only "missing link" is the interface between the computer and the servos. The manufacturers of the robot arm have not advertised in the hobby electronics press for a long time and a disadvantage of their interface was that both software and hardware were designed specifically for the BBC computer.

The BBC Model B was, and probably still is, one of the best equipped home computers for experimenters and "interfacers". Sadly, manufacturers of more modern machines save themselves a few pennies and if it is "user ports" or analogue to digital converters that are required then the customer must dig even more deeply into his or her pocket!

The only interfaces that are almost universally supplied as standard are the parallel port and the serial port. The parallel port is usually fully employed driving a printer and therefore it would be more convenient if the serial port could be used.

SERVO OPERATION

Before the Digital Servo Interface is described it may be worth looking at the principles of operation of these model servos. They are based on the classic "closed loop feedback" system where the desired position is compared with the actual position and if there is a difference, an error signal is generated that drives the output closer to the desired position. Rather than using analogue voltages the servos operate with digital pulses of varying width to form a pulse width locked loop.

A typical servo in block diagram form is shown in Fig. 1. Input pulses trigger a monostable whose time period is determined by the wiper (moving contact) position of a potentiometer connected to the output shaft of the servo.

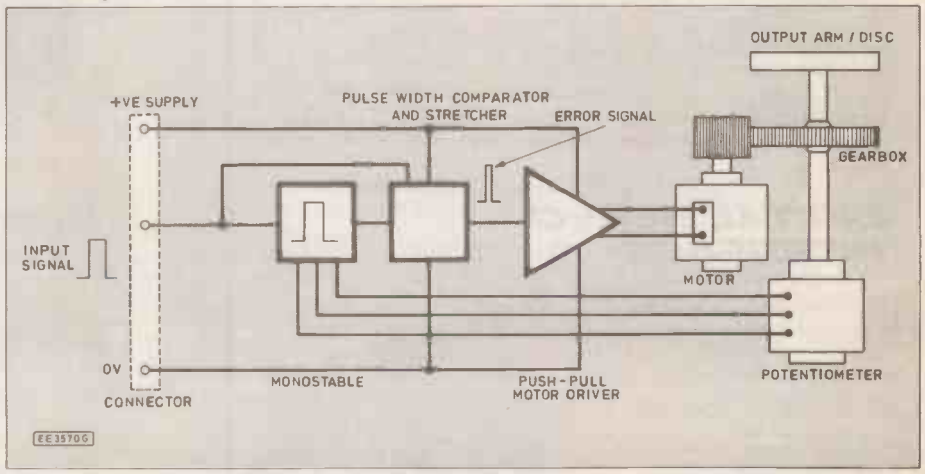


Fig. 1. Block diagram of a typical servo system. Input pulses trigger the monostable whose time period is determined by the position of the "pot" spindle coupled to the servo output shaft.

If this time period is greater than the input pulse width, the motor is driven in one direction whilst if it is less than the input pulse width, the motor is driven in the opposite direction. The comparison and generation of these error signals is illustrated in Fig. 2.

The motor will therefore drive the output shaft to a position where the monostable time period exactly matches that of the input pulse width. The input pulse width is thus accurately translated into output shaft position.

As the monostable time period and the input pulse width approach each other, the error pulse must be "stretched" to ensure

that there is sufficient power to drive the motor. This continues until the pulse widths are within about one per cent of each other. This "deadband" prevents the servo from "hunting" and allows for the inevitable backlash, friction and inertia of the gearbox and motor.

The repetition rate of the input pulses is, up to certain limits, non-critical and usually between 18mS and 50mS. In radio control parlance this is called the frame rate and determines how rapidly and smoothly the servo position can be updated.

SERVO AMP

Fortunately all of the electronics for the servo amplifier is usually contained within custom designed integrated circuits and interested readers should refer to the data sheets and application notes for the Signetics NE 544, the Plessey ZN 409 and the Exar XR-2264 for further information.

The servo amplifier circuitry is mounted on a small printed circuit board that fits within the case of the servo mechanics and the user is presented with three colour coded wires that terminate at a miniature plug or socket. These wires comprise positive supply, 0V and signal input.

A typical radio control system operates from a supply voltage of 4.8V to 6V derived from either four NiCad rechargeable cells or four 1.5V dry pen cells. As each servo may consume up to 1A when driving to a new position it is important that the supply has a very low output impedance and NiCad batteries are usually recommended for multi-servo systems.

There has been some standardisation on input pulse widths and in general, pulse widths of 0.75mS to 2.2mS will produce an output shaft rotation of about 180 degrees. The neutral or mid-position varies from manufacturer to manufacturer but as the output arm is usually attached to a splined output shaft it can be easily adjusted. Care must be taken when using these servos to avoid stalling them against the end-stops as large currents will be drawn by the servo amplifier that may eventually cause permanent damage.

DIGITAL SERVO INTERFACE

In order to drive the model servos from the serial port of a computer a protocol converter is required to translate messages squirted out of the port into pulses that the servos can understand. This is achieved by the Digital Servo Interface which, for elegance and simplicity, uses a single chip, pre-porgrammed i.c. (see Fig. 3) to both generate the variable pulse width signals for the servos and decode commands from the host computer.

The device used is an eight bit CMOS microcontroller in an 18-pin plastic d.i.l. package. It is embedded with some of the intelligence but not necessarily the wit of the author!

It can drive up to eight servos and operates from the 4.8V to 6V servo supply. Timing is derived from a low cost 4MHz ceramic resonator so that no trims or "tweaks" are required.

The most common serial port format is RS232 and, already, the sighs and groans can be heard as its mere mention can bring apoplexy to even the most experienced engineer. This despair may be deserved when whole books have to be written on the subject of connecting two pieces of electronic equipment together. However, with some simplication and the elimination of multiple choice, success can be achieved in the majority of cases first time around.

The interface could be classified as a Data Communications Equipment (DCE) and is thus similar to a serial printer in operation. The serial interface consists of a RX data input and a CTS (Clear To Send) output only.

CIRCUIT

The full circuit diagram for the Digital Servo Interface is shown in Fig. 3. In order to minimize cost and keep things simple, the signal levels are non-standard. IC1 is protected against damage by resistor diode networks that clamp the RS232 input and output to the supply rails.

The RX data input is clamped to the supply rails by diodes (D2, D4) to clamp the RS232 voltage levels to 5V logic levels, whilst the CTS output is a 5V logic level swing rather than the specified RS232 minimum +/−3V signal. This output is also protected by clamp diodes (D1, D3) to prevent damage should inputs and outputs be reversed.

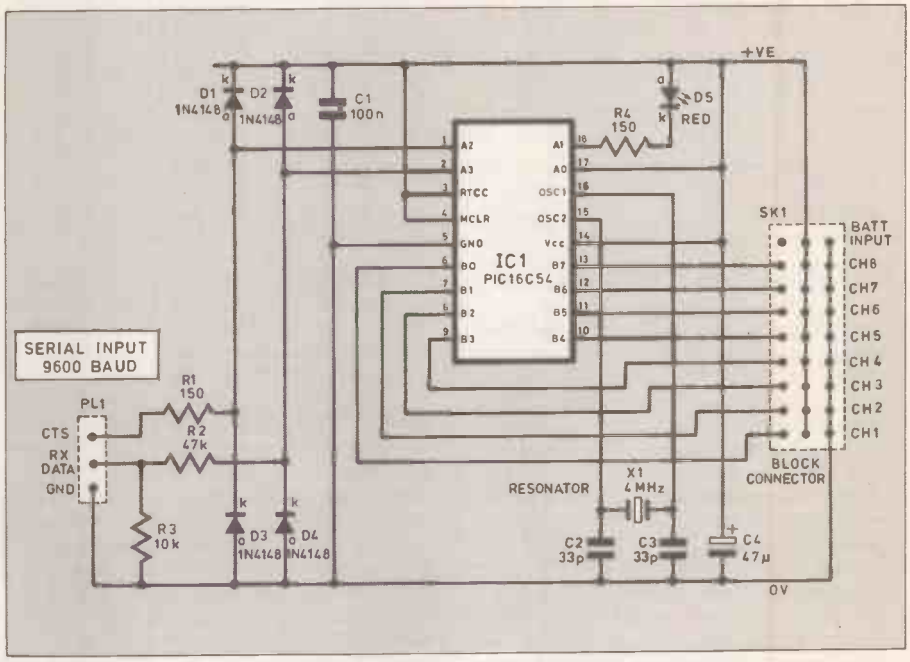


Fig. 3. Complete circuit diagram for the 8-channel Digital Servo Interface. Capacitor C4 should be a tantalum type.

Most modern computers will function perfectly well over short cable lengths at these reduced signal levels. The interface has been tested with the BBC RS423 port, the Cambridge Computers Z88 and both the Amstrad PC 1640 and PPC 512 computers.

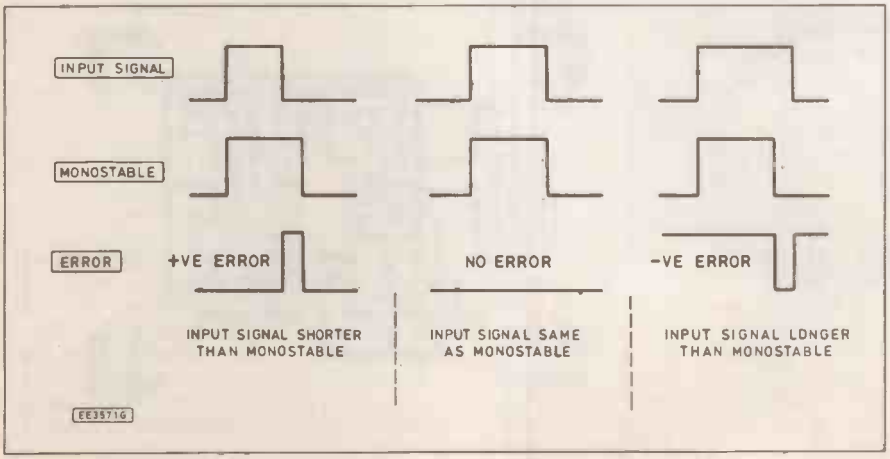
For the purist, or long distance servo driver the input/output levels could be buffered by a MAX232 or similar RS232 transmitter/receiver. It should be noted that most RS232 level converters are inverting, so additional inverters should buffer the input and output to restore the correct polarity.

The pre-programmed "processor" IC1 contains all the active circuitry with a low cost 4MHz resonator driven by an internal oscillator providing the timing. An l.e.d. (D5) can be optionally fitted to the board and merely indicates that characters are being received at the RS232 input.

IN COMMAND

The baud rate is fixed at 9600 bits per second and the data format is one start bit, eight data bits and one stop bit. Commands consist of a channel address and pulse width information sent in a string of printable hexadecimal ASCII characters and terminated by a carriage return.

Fig. 2. Comparison of input signal and monostable pulse width.



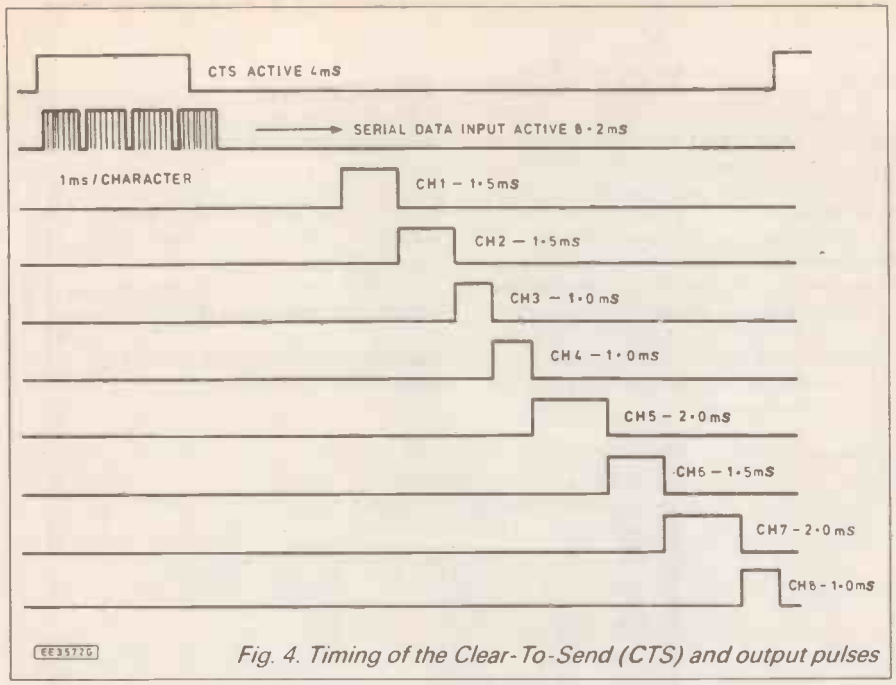


Fig. 4. Timing of the Clear-To-Send (CTS) and output pulses

The microcontroller sequentially generates the eight channel output pulses and then raises the CTS (Clear to Send) line high for 4.2mS during which time, data can be sent from the host computer. (See timing diagram, Fig. 4). It was noted in the course of development that some computers continued to send characters after the CTS input was taken low.

This is not unreasonable as CTS is usually used as a signal from a printer to indicate that the input buffer of the printer is getting nearly full. In order to cater for this anomaly the microcontroller will continue to recognize characters for a further 4mS by which time the host computer should have ceased sending characters.

If all outputs are set top the minimum pulse width of 0.75mS, the frame rate will be 14.2mS (8 × 0.75mS + 8.2mS) whilst if all outputs are set to the maximum pulse width of 2.25mS the frame rate will be 26.2mS (8 × 2.25mS + 8.2mS). This ideally matches the requirements of the servos and ensures a smooth and rapid response.

With the chosen baud rate and data format each character is approximately 1.04mS in duration. This allows one complete message command of four characters to be sent each frame and at the minimum frame rate allows up-dating the channel pulse width settings some forty times every second.

The channel address must have a numeric value between 1 and 8 with the output pulse width being defined by the decimal value (× 10μS) of the following two hex characters. For example, sending "1 64 (Return)" will set channel 1 output pulse width to 1.00mS. (64 Hex = 100 decimal × 10μS = 1.00mS).

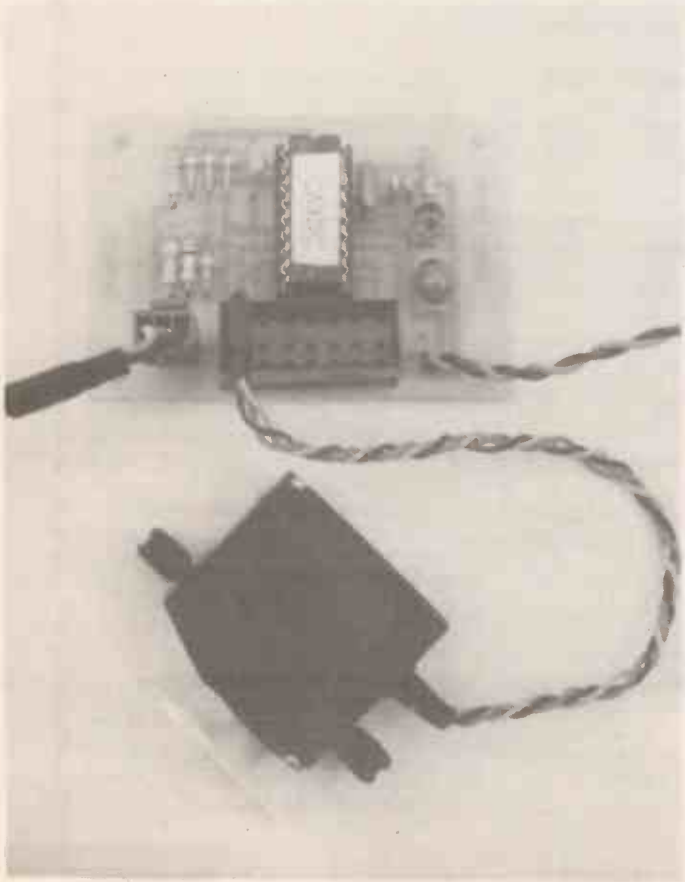
Although using hex characters may seem a little inconvenient when manually sending commands direct from the keyboard, it gives a resolution of 1 part in 255 against 1 part in 100 if two decimal characters were used. In order to prevent damage to the servos, any commands that request a value of less than 0.75mS (Hex 4B) or greater than 2.25mS (Hex E1) are ignored.

Characters must be upper case only and whilst a space, or non-hex character, may be optionally used to separate channel address and data, no space must precede the channel address. A message may only consist of one command containing a maximum of three valid characters and must be terminated by a carriage return character (Hex 0D). On power-up, all outputs are initialized to give a pulse width of 1.5mS. A special character, "Ctrl-R" (Hex 12) sent as any part of a message will re-initialize all the outputs to this value.

Some example programmes written in BBC BASIC and GW BASIC demonstrate the practical ease of sending commands both from the keyboard or automatically under programme control. These demonstration listings are shown in the "Programming Notes" panel.

CONSTRUCTION

A printed circuit board (p.c.b.) layout and full size copper foil master pattern is given in Fig. 5 but as the circuitry is so simple, some constructors may choose to build the interface on stripboard. There are no critical layout requirements although it is suggested that the decoupling capacitor,



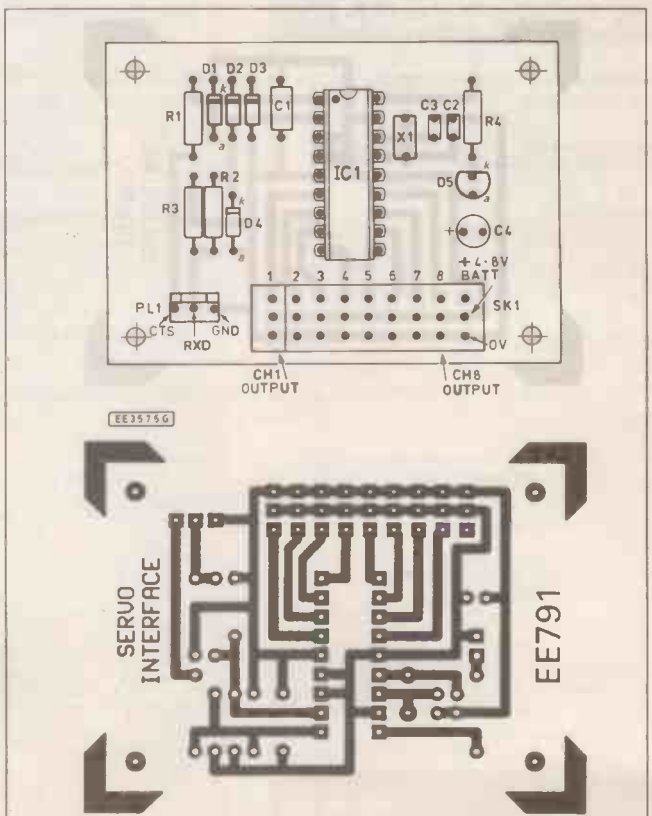


Fig. 5. Full size copper foil master pattern and circuit board topside component layout.

Digital Servo Interface

Programming Notes and Examples

Serial data format it 9600 Baud, 1 start, 8 data and 1 stop bit. The interface will only recognize upper case Hex characters (0 to F), carriage return (Hex 0D) and Ctrl-R (Hex 12). Commands consist of a channel number (1 to 8) followed by the Hex value of the desired pulse width in tens of µS (75 to 225) and terminated by a carriage return.

These programmes enable the servo interface board to be tested and exercised and demonstrate a method by which commands can be sent to the board. They are by no means definitive and merely form the basis for experimentation.

The following programme, written in BBC Basic, will ramp each channel from minimum to maximum pulse width.

```
10 REM SERVO DRIVER
20 REM TRANSMIT 9600 BAUD
30  *FX8,7
40 REM SELECT SERIAL PORT
50  *FX5,2
60 REM SUPRESS LINE FEEDS
70  *FX6,10
80
90 FOR PW%=75 TO 225
95 FOR CH%=1 TO 8
100
110 VDU2:REM ENABLE PORT
120 PRINT CH%;~PW%
130 VDU3: REM DISABLE PORT
140
155 NEXT CH%
160 NEXT PW%
170 GOTO 90
```

The channel number is defined by the variable CH% and the pulse width by PW%. This data is sent to the interface by re-directing output to the serial port. The "~" symbol converts the decimal value of PW% to Hex. In order to maximize speed the line feed character sent during a Print command is suppressed.

This programme can be translated into GW Basic and can be run on any IBM PC or compatible.

```
10 REM SERVO DRIVER FOR IBM PC
20 REM SET UP SERIAL PORT
30 OPEN "COM1:9600,N,8,1" AS #1
40 REM
50 FOR PW=75 TO 225 : FOR CH=1 TO 8
60 REM
70 PRINT #1,HEX$(CH);HEX$(PW)
80 REM
90 NEXT CH : NEXT PW
100 GOTO 50
```

The serial output is directed to COM1 and the data format is set to 9600 baud, no parity bit, 8 data bits and 1 stop bit. The command PRINT HEX$(X) prints the numeric variable X as a string of hex characters.

The next programme requests data for both channel and pulse width to be entered directly from the keyboard and displays the last command sent. It is written in BBC Basic but can be similarly translated to GW Basic.

```
10 REM SERVO INTERFACE TESTER
20 REM TRANSMIT 9600 BAUD
30  *FX8,7
40 REM SELECT SERIAL PORT
50  *FX5,2
60 REM SUPRESS LINE FEEDS
70  *FX6,10
80
90 CH%=0:PW%=0
100
110 CLS:PRINT"SERVO INTERFACE TESTER"
120 PRINT TAB(0,2)"CHANNEL ";CH%;" SET TO ";PW%*10;" uS"
130
140 REPEAT
150 PRINT TAB(0,4)"                                    "
160 INPUT TAB(0,4)"ENTER CHANNEL NO. (1-8)     :"CH%
170 UNTIL CH%>0 AND CH%<9
180
190 REPEAT
200 PRINT TAB(0,6)"                                    "
210 INPUT TAB(0,6)"ENTER PULSE WIDTH (750-2250) :"PW%
220 UNTIL PW%>749 AND PW%<2251
230 PW%=PW% DIV 10
240
250 VDU2:REM ENABLE PORT
260 PRINT CH%;~PW%
270 VDU3: REM DISABLE PORT
280
290 GOTO 110
```

COMPONENTS

Resistors

R1, R4	150
R2	47k
R3	10k

All 0.25W 5% carbon

See SHOP TALK Page

Capacitors

C1	100n disc or multilayer ceramic
C2, C3	33p ceramic plate
C4	47µF tantalum, 16V

Semiconductors

IC1	PIC 16C54 OTP/SERVO (preprogrammed – see *Shoptalk*)
D1, D2, D3, D4	1N4148 signal diode (4 off)
D5	5mm red l.e.d.

Miscellaneous

X1	4MHz Ceramic Resonator
PL1	3-way Molex plug
SK1	9-way servo block (to suit servos)

Printed circuit board available from *EE PCB Service*, code EE791; 18-pin d.i.l. socket; RC servo; multistrand connecting wire; solder etc.

Approx cost guidance only **£32** *including RC Servo*

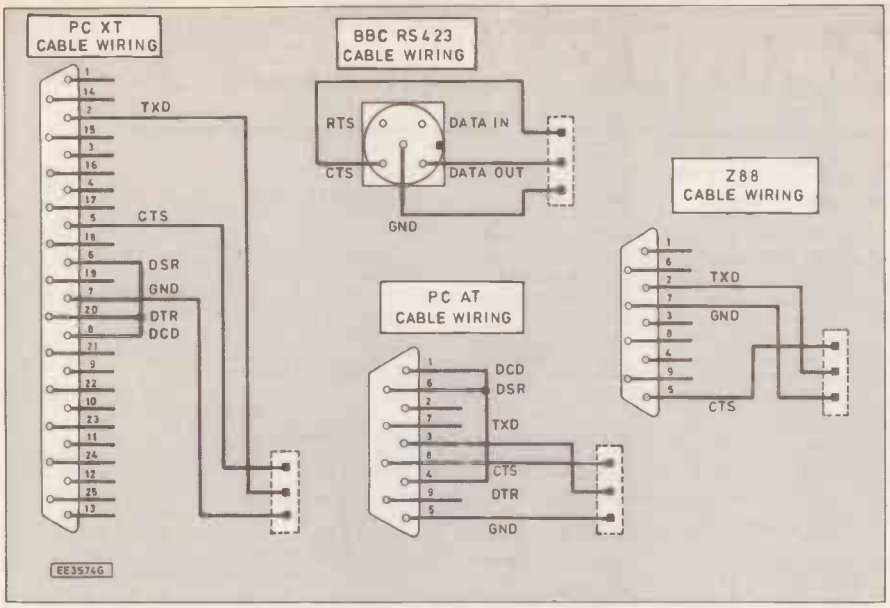


Fig. 6. Cable wiring connections to both BBC and PC type serial ports.

C1, be placed close to the supply pins of the microcontroller IC1.

The microcontroller is a CMOS device and normal anti-static handling procedures should be followed. The usual precautions of observing the polarity of the diodes and the electrolytic capacitor will bring the reward of first time success.

The board is de-coupled by a capacitor C4. As the servos move to new positions, large "chunks" of current are taken from the battery supply and it is recommended that a tantalum capacitor be used in this position.

For this same reason, NiCad batteries should be used in preference to dry cells when more than two servos are being driven by the board. If a mains power supply is used, ensure that an additional decoupling capacitor of several thousand microfarads (μF) is placed across the output. Semiconductor regulators are unable to provide the peak current requirements of the servos and will current limit and thus drop out of regulation.

A Molex 3-pin connector is used to terminate the RS232 cable and Fig. 6 shows the connections to both BBC and PC type serial ports.

Outputs are terminated in a row of p.c.b. pads that provide connections for the servos and the power supply. A "block" type connector may be fitted to the board and pad spacing will suit either the older Futaba or SLM sockets or the latest 3-pin headers.

Alternatively, servo extension leads can be "cannibalised" to provide the required plugs or sockets. These again are available from good model shops. Note that no universal standard exists for the servo connections and on some older servos the supply connections may be reversed.

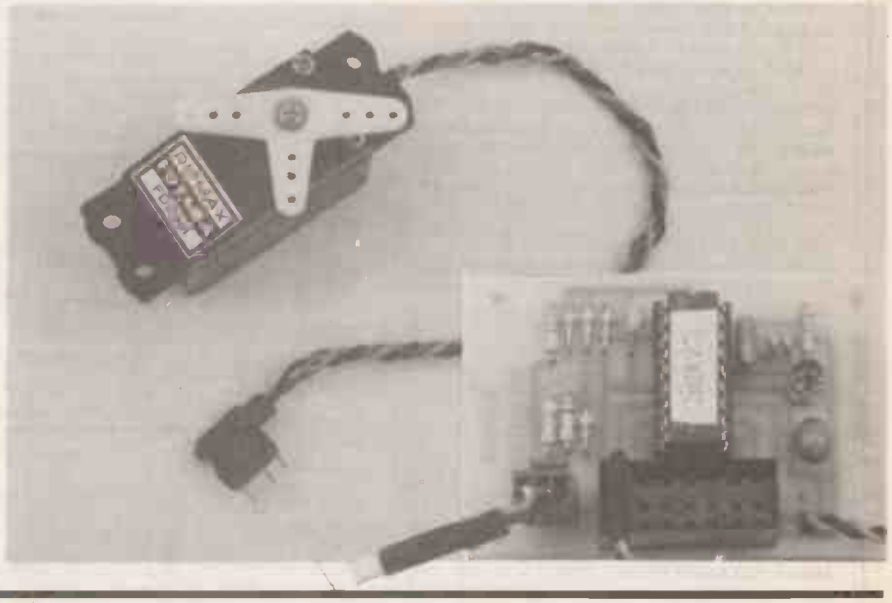
They say that cleanliness is a virtue and careful cleaning of the PCB after assembly with cellulose thinners and a stiff brush will reveal any poor solder joints and is well worth the modest effort.

TESTING

Testing is limited to checking the correct supply polarity and applying power to the board. If servos are connected to the outputs, they should immediately drive to the neutral position.

The interface should then be connected to the serial port of the host computer and the demo software listing loaded. When this is run the servos should faithfully follow the input commands. □

Model control servo with the three-lead output wires connected to a miniature plug. This plug is inserted in the "block" connector – see inset and previous photographs.



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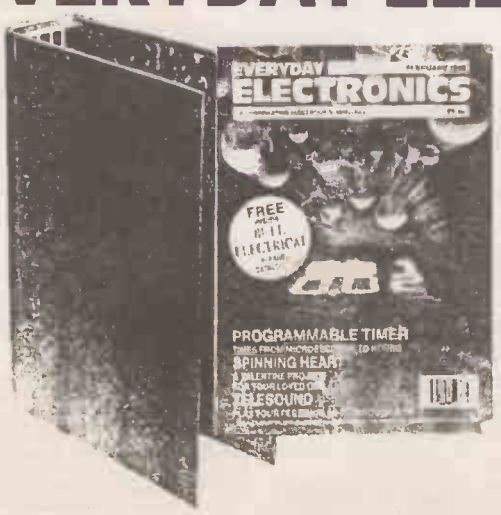

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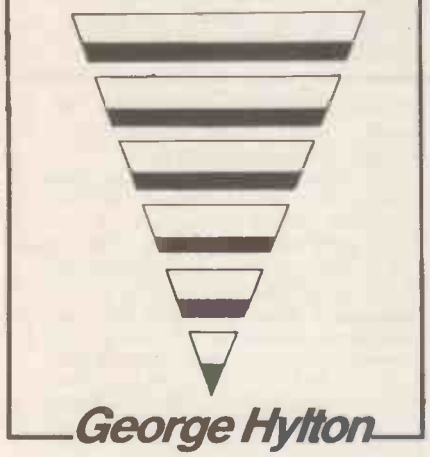

George Hylton

Battery Substitutes

Batteries seem to have become very expensive – especially large 9V types for the older generation of portable radios. Sooner or later it occurs to the owner that, for the price of two or three battery changes, it should be possible to make a transformer-rectifier unit capable of acting as a permanent substitute for the battery. As usual, however, there are problems, and help in solving them can be had by making a few simple measurements.

Transformer Ratings

If a mains transformer has a secondary rated at 9V, 100mA, does this refer to the a.c. output or the d.c. after rectification? The distinction is important because with a typical rectifier circuit with reservoir capacitor (Fig. 1), the d.c. output voltage is significantly greater than the a.c. This increased voltage means that, for the same current, the d.c. power is typically about 1.4 times the a.c. power.

Over the years it has become usual to rate small transformers for this sort of application in terms of rectified and smoothed d.c. outputs, but you can't always be sure of this and caution is advisable.

Practical Transformers

Another problem is that the output voltage of transformers seldom correspond exactly to the rated voltage. The main reason is that as current is drawn the resistance of the windings absorbs some voltage.

The manufacturer allows for this by upping the voltage. This means that the voltage delivered at low output currents is greater than the rated voltage. This can be worrying in a practical case (Fig. 2) where the output of a transformer/rectifier unit is connected to the battery terminals of a radio.

The radio's on-off switch disconnects the *output* of the substitute "battery". The *input* of the substitute is left energised by the mains even when the radio is switched off. The reservoir capacitor (C1 in Fig. 1) then charges to the full off-load voltage, which as we have seen is considerably in excess of the rated voltage. When the radio is switched on, this voltage, stored on C1, is temporarily let loose on the circuitry, where it could conceivably do some damage.

After a moment, of course, the voltage subsides to its on-load value, which is smaller. But we all know that a moment's overload, may wreak havoc. If there is a large capacitance inside the receiver, across the battery terminals, this absorbs much of the switch-on surge and reduces the risk.

Practical Example

Recently, through the advertising pages of EE, I discovered a source of cheap transformers rated at "9V-0V-9V, 75mA". When connected as in Fig. 1 the off-load d.c. output voltage was a shade over 15V. Even at 75mA d.c. output it was still well over 9V.

At first I suspected that the local mains voltage (nominally 240V) must be high, but in fact it measured only 234V on an accurate digital voltmeter. So that wasn't the answer: the transformer output voltage really was too high. (I suspect that the primary is wound for 220V continental mains, not 240V as indicated on the box).

What can be done about it? Inserting a simple voltage-dropping resistance is useless. It has little effect at low currents but severely reduces voltage at high currents.

To tackle the problem I needed more detailed information about the behaviour of the transformer-rectifier circuit, so I measured its d.c. output voltage at various currents and plotted the results on a graph (Fig. 3). This shows that the voltage delivered at the maximum rated current (75mA) is still more than 9V. However, a fresh 9V battery is likely to deliver something approaching 10V, so a small over-voltage is tolerable.

It's the large over-voltage at no load and small loads that is the problem. One could simply risk it. Better, fit a true mains switch (e.g. a cord switch on the primary side of the transformer) and hope that people will use it instead of the on-off switch on the radio. This is a good idea anyway, for the sake of safety. Or one could regulate the output voltage in some way. There isn't enough excess voltage to permit the use of an ordinary i.c. stabilizer unless one of the new low-voltage-drop kinds is available. So what are the alternatives?

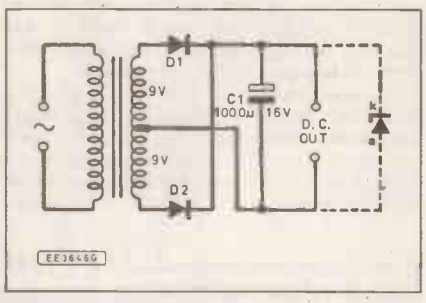

Fig. 1. Typical transformer-rectifier circuit.

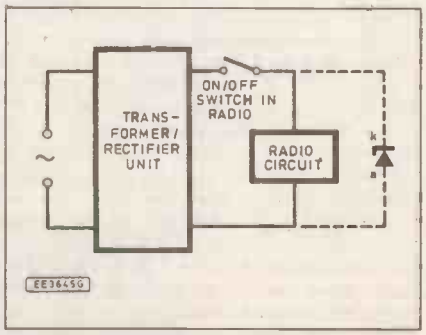

Fig. 2. Usual arrangement when a battery substitute is used to power a battery radio.

Zener Diode

If a Zener diode is connected across the d.c. output (as shown dotted in Fig. 1) then the voltage can't exceed the Zener voltage. The user must ensure that the permissible Zener dissipation is not exceeded. The voltage-current curves help.

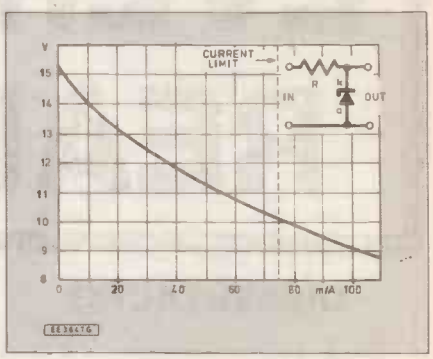

Fig. 3. Voltage-current curve for Fig. 1. A series resistance and shunt Zener can limit voltage and current output.

If the radio is off but the mains still connected to the transformer then the Zener must absorb all the output current. The nearest standard Zener diode voltage to 9V is 9.1V. The curves show that at 9.1V the current is 100mA. This exceeds the transformer current rating. At 75mA, the voltages is 10.1V. The extra 1V could be lost in a series resistance, as shown inset in Fig. 3. The required resistance is 13.33 ohms and it must dissipate 75 × 1 = 75mW. The Zener must now dissipate 9.1V × 75mA = 683mW.

My useful Cricklewood Electronics catalogue (supplied Free with EE) lists Zeners with power ratings of 400mW, 1.3W and 5W. In the present case 400mW is too low but 1.3W is well within ratings, even allowing for Zener tolerances and a possible mains surge of 10 per cent.

In some cases, it can happen that the correct voltage is obtainable simply by connecting a Zener across the output. In the present case, the transformer can safely deliver 12V d.c. at 38mA, so is usable if a 12V supply at up to 38mA is needed. With no load, a 12V Zener must then dissipate 456mW (=12V d.c. at 38mA) so a 1.3W Zener would do nicely.

At 75mA output the circuit delivers 10.1V, so it is possible, in theory, to connect a 10.1V Zener (power dissipation 10.1 × 75 = 758mW) across the output. Of course, 10.1V is not a standard voltage. You could either buy a lot of 10V, 5 per cent Zeners and sort out one with the right voltage (up to 10.5V is possible at 5 per cent tolerance), or you could use a 9.1V Zener in series with two high-current silicon rectifiers, which will drop about 0.5V each. Or

you could be sensible and stop trying to squeeze the last drop of current from the transformer!

Switching

The fact that the d.c. supply may remain on when the receiver is turned off at its own switch (usually ganged to the Volume control) is a worry. The transformer unit, when Zener stabilized, goes on dissipating full power. It's tempting, when fitting a permanent substitute for the battery, to rewire the existing on-off switch so that it operates on the mains supply to the transformer primary. This can only be contemplated if the switch is rated to handle the full mains voltage (which is unlikely).

If the rating is not marked on the switch or volume control it isn't worth the risk. Use a separate mains switch of adequate rating.

A less good alternative is to connect the Zener across the battery terminals of the radio, on the circuit side of the on-off switch (as shown dotted in Fig. 2). The Zener then gets a kick when the radio is turned on and capacitor C1 partially discharges through it.

To be on the safe side use a Zener of higher power than is needed. With this arrangement the standby power consumption (radio off) is low. Ideally, C1 should also be connected on the radio-circuit side of the on-off switch, but this may be difficult mechanically.

EVERYDAY READOUT

DIESEL TACHO

Dear Ed.,

Mr Pike has asked for details of a diesel tacho in your April issue.

The 30HP Watermota diesel on my boat was fitted with a pickoff from one phase of the Lucas car alternator using nine rectifiers.

An 0-270° Cirscale meter measured frequency and was scaled to correct belt drive step up displaying Engine RPM.

The tap was soldered very close to a rectifier and is not an easy job. It must be fused as an insulation failure would burnout the alternator.

The elapsed time recorder (engine hours) was mechanical, driven by diesel knock. A possible pickoff might use a small moving coil speaker clamped to the engine with the diaphragm loaded with a small metal weight.

W. M. Colles
Havant

Dear Ed.,

In reply to Mr Pikes letter *(EE April '92)* I have some information which may be of some use. The vast majority of vehicle alternators are three phase and the 'W' terminal is connected to one phase. This gives 7 to 8 volts pulsating dc.(i.e. half wave rectified ac). The number of pulses per second depends on the number of pole pairs and the rotational speed of the alternator. I found the following equation from which you can determine the frequency (pulses per second).

$$f = \frac{p\,n}{60}$$

f = frequency
p = number of pole pairs
n = alternator speed (r.p.m.).

As I work as a mechanic on diesel engines I had the opportunity of testing the output of the 'W' terminal, and it was, as the text books said, 7 to 8 volts. But the output started at 8 volts at about 800 r.pm. and fell to 7 volts at 2800 r.p.m. (max r.p.m. for the engine under test). Perhaps the connection of a 'scope would show a rise in frequency.

The other device I saw some time ago was a timing light for diesels, this obtained its triggering pulse from a sensor clipped to no.1 injector pipe. When diesel is injected in to the engine via the injector at about 2800 p.s.i. there is a shock wave in the pipe, it's this shock wave or pulse which triggers the timing light. How the sensor transmits the pulse into a useable driver for a tacho I do not know.

A problem I have which I hope you can solve is that I wish to build a ammeter to test alternator outputs. I need to be able to read outputs of a maximum of 100A (this may seem high but in my work you come across this sort of output).

P. M. J. Young
Hatfield

AUDIO TELESCOPE

Dear Ed.,

On reading R. Penfold's article in the April '92 issue of *Everyday Electronics*, I had a similar query in my mind to that of Mr G. I. Smith *(Everyday Readout May '92)*. I also have severe loss of hearing in both ears and wear two hearing aids.

I appreciate this difficulty with hearing in debates, church etc and conversation among groups of people, but my particular complaint is the loss of sound location out of doors mainly, but also in the home. The idea of using two microphones appeals to me because it could simulate two ears. I maintain that bilateral hearing is essential for sound location – as two eyes are for stereovision.

However the Audio Telescope is designed to amplify low sounds for *headphone* listening. Headphones are not practicable for hearing aid wearers because the proximity of the headphone causes acoustic feedback in the aids. To reduce this the hearing aid wearer will turn down the volume of his aid, and would therefore lose the amplification he had gained from the Audio Telescope.

My suggestion is that the Audio Telescope output (with two microphones) could be coupled to a meter which would show by its maximum reading the direction of the sound.

I am afraid that this does not answer G. I. Smith's predicament. I can only suggest that he considers Inductive Hearing with one small microphone and an amplifier. I have an instrument like this for listening to the TV.

Dr R. G. Tickhurst
Middleton

Dear Ed.,

Going to Maplins shop in Bristol to purchase components to build the *Audio Telescope* in your April issue I am informed that the Electret insert mic. is not available, a discontinued item.

Also the type of medium impedance headphone is not available for this same project.

I have gone through all the main component stockist catalogues, but the two items seem to be rare.

Could you please inform me of any stockists addresses, so that I can purchase the 'mic.' and the phones.

R. E. Whitchurch
Bristol

As many readers have discovered the supply of the specified unidirectional microphones for this project has dried up – apparently they are no longer being made. The following item from Robert Penfold gives information on an alternative microphone available from Maplin; order code FK44A.

One or two readers have also queried the headphones used. These are 32Ω stereo headphones but no conection is made to the common (outer) jack socket terminal thus placing the two phones in series in this circuit. No alteration is necessary to the phones or their plug so they can be used with other equipment as normal.

Please also note that two C1's are shown in the components list – the second one should be in C2. – Ed.

ALTERNATIVE MICROPHONES

The Maplin unidirectional electret microphone insert specified for this popular project has now sold out, and further supplies are unlikely to be available. The Maplin dynamic undirectional insert is suitable for use in this unit, but gives slightly lower sensitivity. It has only two terminals which connect to "OV" and "OUT" in Fig. 4. The insert can be connected either way round. The "V+" terminal is left unconnected. R1 and C1 become superflous and can be omitted.

It is possible to compensate to some extent for the lower sensitivity by reducing R2 to 470Ω in value. Making R2 any lower in value will simply increase the noise level as well as the wanted signal, and will probably not improve performance. The dynamic insert is much larger than the electret type (about double the diameter). It is therefore advisable to mount it closer to the lid of the case so that there is sufficient space for the circuit board to fit beneath it.

Complete each connection to the insert fairly swiftly, or you might desolder an internal connection (which will result in zero output from the insert). The dynamic insert might pick-up a certain amount of "hum" and other electrical noise if the unit is operated close to a television set, mains wiring, etc. However, the unit is intended for use out-of-doors when it should provide "hum-free" operation.

Optimum results seem to be produced using a separate dynamic or electret stick microphone. In general, electret types provide significantly better sensitivity than dynamic types. The only drawback of this method is that the price of a cheap electret stick microphone seems to be about double the cost of the other components! If you already have a suitable microphone it is well worth trying though. The screen of the microphone cable connects to "OV", and the inner conductor connects to "OUT".

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Michael J. Cockcroft
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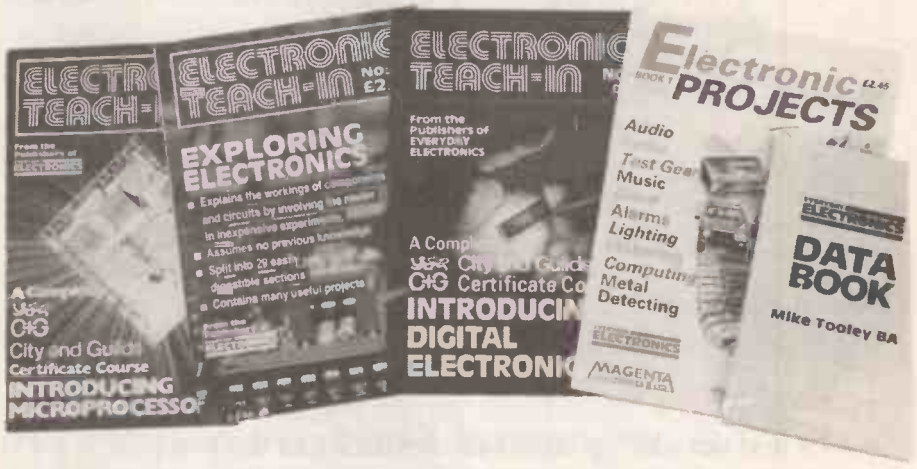

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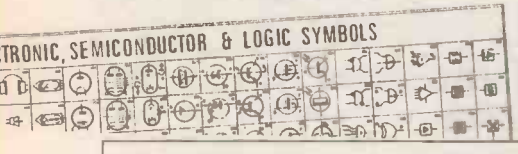

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The vast majority of modern electronic systems rely heavily on the application of digital electronics, and the *Practical Digital Electronics Handbook* aims to provide readers with a practically based introduction to this subject. The book will prove invaluable to anyone involved with the design, manufacture or servicing of digital circuitry, as well as to those wishing to update their knowledge of modern digital devices and techniques. Contents: Introduction to integrated circuits; basic logic gates; monostable and bistable devices; timers; microprocessors; memories; input and output devices; interfaces; microprocessor buses. Appendix 1: Data. Appendix 2: Digital test gear projects; tools and text equipment; regulated bench power supply; logic pulser; verstaile pulse generator; digital IC tester, current tracer, audio logic tracer; RS-232C breakout box; versatile digital counter/frequency meter. Appendix 3: The oscilloscope. Appendix 4: Suggested reading. Appendix 5: Further study.
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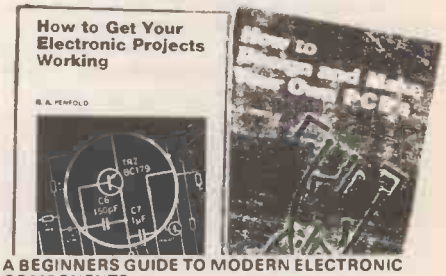

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A. Pickford
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There are a large number of amateur communications satellites in orbit around the world, traversing the globe continuously and they can be tracked and their signals received with relatively 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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R. A. Penfold
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Waveform Generator (Teach-In '91 Project 4)		735	£4.72
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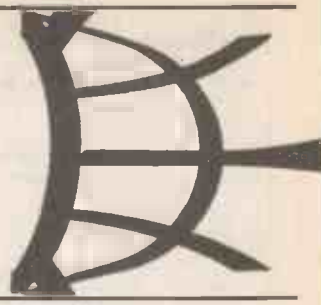

Tony Smith G4FAI

At the World Administrative Radio Conference (WARC) at Torremolinos, which ended on 3rd March, the main amateur interest related to allocations for the 7MHz band. In some countries, including North America, this band covers 7.00 to 7.30MHz (ie, 300kHz), while in others, including the UK and Europe, it is only 7.00 to 7.10MHz (100kHz).

In the face of possible threats to the full 300kHz band from broadcast expansion, European amateurs had hoped that what might emerge was a worldwide common 200kHz band, although the International Amateur Radio Union felt the amateur service should not relinquish any of its full 300kHz where currently allocated.

In the event, less broadcasting expansion was agreed than was expected and the 40m amateur allocations remained unchanged. To ensure formal consideration on a future agenda, a recommendation by Mexico was adopted calling for exclusive allocations for both amateur and broadcasting services around 7MHz which, it is hoped, could eventually result in a common worldwide amateur 40m band.

The WARC was attended by over 1,400 delegates from 127 countries and 31 international and regional organisations. Many observers from national radio societies were attached to official delegations and, according to the *W5YI Report*, more than 100 radio amateurs from about 40 countries were among the delegates, clearly demonstrating how an early interest in amateur radio can lead to success in a telecommunications career.

BROADCAST BAND EXPANSION

The WARC agreed that ten new international broadcasting bands would become available on April 1st, 2007, as follows:

5900-5950; 7300-7350; 9400-9500; 11600-11650; 12050-12100; 13570-13600; 13800-13870; 15600-15800; 17480-17550; 18900-19020kHz, all to use limited single-sideband transmissions.

As these allocations fell short of what had been proposed, the USA filed a "reservation", expressing the view that the conference had failed to make adequate provision for the h.f. needs of the broadcasting service, particularly below 10MHz and reserving the right of the US "to take the necessary steps to meet the h.f. needs of its broadcasting service."

YOUNG AMATEUR OF THE YEAR

Once again, the Young Amateur of the Year Award is sponsored jointly by the DTI's Radiocommunications Agency and the Radio Society of Great Britain. This award is open to any radio amateur under 18 years involved in such activities as DIY amateur radio construction, operating radios, community radio (for example emergency communication networks), encouraging others to become interested in amateur radio, or appropriate school projects.

The award will be made for the most outstanding achievement between 1st August 1991 and 31st July 1992, and will be presented at the RSGB's annual convention in September. In addition to a cash prize, all entrants will receive a copy of the RSGB's amateur radio log book and the winner and runners-up will be invited to visit the Agency's radio monitoring station at Baldock in Hertfordshire.

Further information is available from the RSGB. Applications or nominations for the award should be sent to: Young Amateur of the Year Award 1992, Radio Society of Great Britain, Lambda House, Cranborne Road, Potters Bar, EN6 3JE, by 31st July, 1992.

DUTCH EU BROADCASTS SAVED

A last minute decision by Radio Netherlands' management has averted the proposed close-down of their popular shortwave transmissions to Europe scheduled for 29th March. So many letters of protest were received from listeners that it was decided to retain one transmission to Europe, at 1230 UTC each day on 9855kHz in the 31m band.

For more than 25 years the only English transmission from Holland on Sundays has been "The Happy Station" programme, the longest running radio show in the world which started in 1928, and this continues in the new Sunday slot for Europe. A new programme, "East of Edam" is also now broadcast on Sundays to countries outside Europe, and all Sunday transmissions now begin with a five-minute news bulletin.

A full programme schedule, including transmissions not intended for Europe but which can be heard in the UK, can be obtained from Radio Netherlands, PO Box 222, NL-1200 JG Hilversum, Holland.

ANOTHER NEW COUNTRY

I am continually amazed at the efforts made by individuals to establish "new country" status for remote parts of the world. This involves formal recognition by the American Radio Relay League which administers the prestigious DX Century Club awards for contacts with over 320 "recognised" countries.

A recent addition to the list is the Penguin Islands lying off the coast of Namibia and owned by South Africa. One of the rules defining separate country status for DXCC purposes is "separation by another DXCC country". Namibia lies between South Africa and the Penguins but it was essential for recognition to know that Namibia had no claim on the islands.

It was not felt appropriate to raise this as a direct question to the authorities so an application was made to Namibia for an amateur radio licence for a Dxpedition to the Penguins. In reply the Namibian authorities stated they could not grant a licence as the islands were South African territory, thus indirectly providing the information required!

Even this was not sufficient however, and before recognition was confirmed large scale maps had to be sent to the US to confirm that other islands, rocks, etc, along the Namibian coast were not under South African control, possibly negating the "separation" contention.

Now that the Penguin Islands represent a new DXCC country, Dxpeditioners will not find it particularly easy or pleasant to operate from them. To embark for the islands they will need Namibian permission to pass through a restricted coastal diamond area, risking being shot on sight for straying from the road! South African permission is also required to land on the islands which are nature reserves. High winds and steep rocks make landing hazardous, and the smell of guano deposits can be significant!

With such problems and difficulties to overcome one wonders why anyone bothers. Certainly when they appear on the air using exotic callsigns Dxpeditions enable other, less adventurous, amateurs to share in their activities and that is perhaps one of the significant features of the hobby. Whenever someone undertakes interesting experiments or activities on the air it is open to other operators around the world to find out what is happening, join in, and make some contribution themselves.

RADIO AT DUXFORD

The Duxford Radio Society was recently re-inaugurated to support an international interest in the history of military radio, including all armed forces, para-military and clandestine (Resistance) groups; to assist in the provision of an exhibition of radio equipment at the Imperial War Museum's Duxford airfield; and to operate an amateur radio station at Duxford, using both modern and historic equipment.

Specially adapted accommodation will house a permanent exhibition of equipment later this year and an amateur station GB2IWM (or other call as appropriate for special events) will operate every Sunday during the main visitors season.

The purpose of the exhibition and station is to increase public awareness of the role played by radio in war-time operations and, hopefully, to make contact with many people, whether radio amateurs or not, who can help in achieving the aims of the Society either from personal experience and knowledge of historic equipment or from a special interest in the subject.

Further information about all aspects of the Society, including classes of membership, which effectively range from active to corresponding, can be obtained from the Secretary, Mrs B.I. Pope, 95 Northolt Avenue, Bishop's Stortford, Herts CM23 5DS.

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Code Selection	Solder Trace
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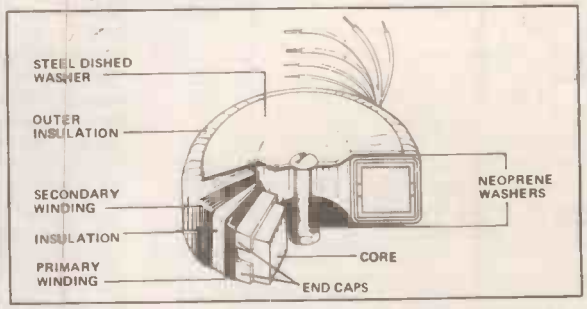

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RESISTOR PACKS – 0.25W C.Film		
RP3	5 each value – total 365	£2.30
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Catalogue – price £1
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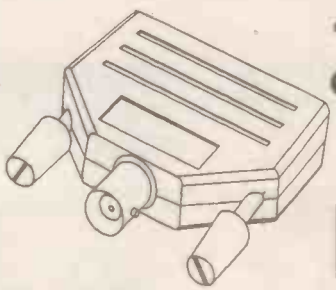
SHERWOOD ELECTRONICS

PICO ADC-10

8-bit Analog to Digital Convertor for IBM PCs & compatibles

- 10-25 kHz typical sampling speed
- 0-5 v input range



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Access VISA

- Plugs directly into parallel printer port
- Requires no external power or expansion slots
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- Supplied with software to use as a voltmeter & oscilloscope, plus Turbo C and Pascal drivers

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OMP POWER AMPLIFIER MODULES-TURNTABLES-DIMMERS-LOUDSPEAKERS-19 INCH STEREO RACK AMPLIFIERS

★ PRICES INCLUDE V.A.T. ★ PROMPT DELIVERIES ★ FRIENDLY SERVICE ★ LARGE (A4) S.A.E. 50p STAMPED FOR CATALOGUE ★

OMP MOS-FET POWER AMPLIFIERS HIGH POWER, TWO CHANNEL 19 INCH RACK

THOUSANDS PURCHASED BY PROFESSIONAL USERS

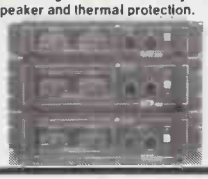
THE RENOWNED MXF SERIES OF POWER AMPLIFIERS

FOUR MODELS:- **MXF200** (100W + 100W) **MXF400** (200W + 200W) **MXF600** (300W + 300W) **MXF900** (450W + 450W)

ALL POWER RATINGS R.M.S. INTO 4 OHMS, BOTH CHANNELS DRIVEN

FEATURES: ★Independent power supplies with two toroidal transformers ★ Twin L.E.D. Vu meters ★ Level controls ★ Illuminated on/off switch ★ XLR connectors ★ Standard 775mV inputs ★ Open and short circuit proof ★ Latest Mos-Fets for stress free power delivery into virtually any load ★ High slew rate ★ Very low distortion ★ Aluminium cases ★ MXF600 & MXF900 fan cooled with D.C. loudspeaker and thermal protection.

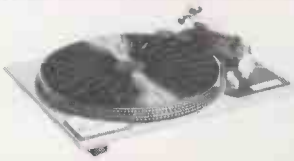
USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC.



SIZES:- MXF200 W19"xH3½" (2U)xD11"
MXF400 W19"xH5¼" (3U)xD12"
MXF600 W19"xH5¼" (3U)xD13"
MXF900 W19"xH5¼" (3U)xD14¾"

PRICES:- MXF200 £175.00 MXF400 £233.85
MXF600 £329.00 MXF900 £449.15
SPECIALIST CARRIER DEL. £12.50 EACH

OMP VARISPEED TURNTABLE CHASSIS



★ Manual arm ★ Steel chassis ★ Electronic speed control 33 & 45 R.P.M. ★ Vari pitch control ★ High torque servo driven DC motor ★ Transit screws ★ 12" die cast platter ★ Neon strobe ★ Calibrated balance weight ★ Removable head shell ★ ½" cartridge fixings ★ Cue lever★ 220/240V 50/60Hz ★ 390x305mm ★ Supplied with mounting cut-out template.

PRICE £61.30 + £3.70 P&P

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STEREO DISCO MIXER DJ6500

★ WITH ECHO ★

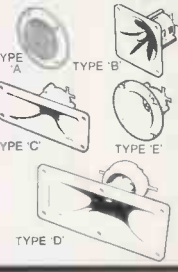
STEREO DISCO MIXER with 2 x 7 band L & R graphic equalisers with bar graph LED Vu meters. **MANY OUTSTANDING FEATURES:- including Echo with repeat & speed control, DJ Mic with tone control & talk-over switch, 7 Channels with individual faders plus cross fade, Cue & headphone Monitor. Useful combination of the following inputs:- 3 turntables (mag), 3 mics, 5 Line for CD, Tape, Video etc.**

Price £134.99 + £5.00 P&P

SIZE: 482 x 240 x 120mm

PIEZO ELECTRIC TWEETERS - MOTOROLA

Join the Piezo revolution! The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if two are put in series. **FREE EXPLANATORY LEAFLETS ARE SUPPLIED WITH EACH TWEETER.**



TYPE 'A' (KSN1036A) 3" round with protective wire mesh. Ideal for bookshelf and medium sized Hi-Fi apeakers. **Price £4.90 + 50p P&P.**
TYPE 'B' (KSN1005A) 3½" super horn for general purpose speakers, disco and P.A. systems etc. **Price £5.99 + 50p P&P.**
TYPE 'C' (KSN1016A) 2"x5" wide dispersion horn for quality Hi-Fi systems and quality discos etc. **Price £6.99 + 50p P&P.**
TYPE 'D' (KSN1025A) 2"x6" wide dispersion horn. Upper frequency response retained extending down to mid-range (2KHz). Suitable for high quality Hi-Fi systems and quality discos. **Price £9.99 + 50p P&P.**
TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-Fi monitor systems etc. **Price £5.99 + 50p P&P.**
LEVEL CONTROL Combines, on a recessed mounting plate, level control and cabinet input jack socket. 85x85mm. **Price £4.10 + 50p P&P.**

OMP LINNET LOUDSPEAKERS

THE VERY BEST IN QUALITY AND VALUE

Made especially to suit today's need for compactness with high output sound levels, finished in hard wearing black vynide with protective corners, grille and carrying handle. Each unit incorporates a 12" driver plus high frequency horn for a full frequency range of 45Hz-20KHz. Both models are 8 Ohm impedance. Size: H20" x W15" x D12".

CHOICE OF TWO MODELS

POWER RATINGS QUOTED IN WATTS RMS FOR EACH CABINET

OMP 12-100WATTS (100dB) PRICE £163.50 PER PAIR
OMP 12-200WATTS (200dB) PRICE £214.55 PER PAIR

SPECIALIST CARRIER DEL. £12.50 PER PAIR

IN-CAR STEREO BOOSTER AMPS

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

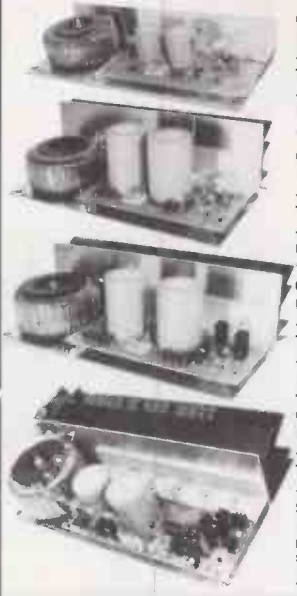
PRICES: 150W £49.99 250W £99.99
400W £109.95 P&P £2.00 EACH

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
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.

Vu METER Compatible with our four amplifiers detailed above. A very accurate visual display employing 11 L.E.D.s (7 green, 4 red) plus an additional on/off indicator. Sophisticated logic control for very fast rise and decay times. Tough moulded plastic case, with acrylic tinted front. Size 84 x 27 x 45mm.
PRICE £8.70 + 50p P&P

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. (50p STAMPED) FOR COMPLETE LIST.

P - From McKenzie Professional Series
S - From McKenzie Studio Series

McKENZIE:- INSTRUMENTS, P.A., DISCO, ETC

ALL McKENZIE UNITS 8 OHMS IMPEDANCE

8" 100 WATT P C8-100GP GEN. PURPOSE, LEAD GUITAR, EXCELLENT MID, DISCO.
RES. FREQ. 80Hz, FREQ. RESP. TO 7KHz, SENS 96dB. PRICE £31.45 + £2.00 P&P

10" 100WATT S C10-100GP GUITAR, VOICE, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 72Hz, FREQ. RESP. TO 6KHz, SENS97dB. PRICE £38.89 + £2.50 P&P

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RES. FREQ. 69Hz, FREQ. RESP. TO 5KHz, SENS 97dB. PRICE £53.21 + £2.50 P&P

12" 100WATT P C12-100GP HIGH POWER GEN. PURPOSE, LEAD GUITAR, DISCO.
RES.FREQ. 49Hz, FREQ. RESP. TO 7KHz, SENS 98dB. PRICE £40.35 + £3.50 P&P

12" 100WATT P C12-100TC (TWIN CONE) HIGH POWER, WIDE RESPONSE, P.A., VOICE, DISCO.
RES. FREQ 45Hz, FREQ. RESP. TO 12KHz, SENS 97dB. PRICE £41.39 + £3.50 P&P

12" 200WATT S C12-200B HIGH POWER BASS, KEYBOARDS, DISCO, P.A.
RES. FREQ. 45Hz, FREQ. RESP. TO 5KHz, SENS 99dB. PRICE £71.91 + £3.50 P&P

12" 300WATT S C12-300GP HIGH POWER BASS, LEAD GUITAR, KEYBOARDS, DISCO ETC.
RES. FREQ. 49Hz, FREQ. RESP. TO 7KHz, SENS 100dB. PRICE £95.66 + £3.50 P&P

15" 100WATT P C15-100BS BASS GUITAR, LOW FREQUENCY, P.A., DISCO.
RES. FREQ. 40Hz, FREQ. RESP. TO 5KHz, SENS 98dB. PRICE £ 59.05 + £4.00 P&P

15" 200WATT P C15-200BS VERY HIGH POWER BASS.
RES. FREQ. 40Hz, FREQ. RESP. TO 3KHz, SENS 98dB. PRICE £80.57 + £4.00 P&P

15" 250WATT S C15-250BS VERY HIGH POWER BASS.
RES. FREQ. 39Hz, FREQ. RESP. TO 4KHz, SENS 99dB. PRICE £90.23 + £4.50 P&P

15" 400WATT S C15-400BS VERY HIGH POWER, LOW FREQUENCY BASS.
RES. FREQ. 40Hz, FREQ. RESP. TO 4 KHz, SENS 100dB. PRICE £105.46 + £4.50 P&P

18" 500WATT S C18-500BS EXTREMELY HIGH POWER, LOW FREQUENCY BASS.
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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

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3W TRANSMITTER 80-108MHz, VARICAP CONTROLLED PROFESSIONAL PERFORMANCE, RANGE UP TO 3 MILES, SIZE 38 x 123mm, SUPPLY 12V @ 0.5AMP.
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PHOTO: 3W FM TRANSMITTER

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THE VELLEMAN K4000.
GUTSY & GOOD LOOKING.
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BEST VALUE, BEST
SOUNDING, BEST LOOKING,
STATE-OF-THE-ART,
VALVE POWER AMPLIFIER
KIT THAT'S AVAILABLE.
VELLEMAN,
SIMPLY THE BEST!

The Velleman name stands for quality, and the K4000 valve amplifier is supplied with everything you'll need to build it, including a 'Get-You-Working' back-up service.

Delivering 95 watts in class A/B1, the K4000 is, without doubt, price for price, the best sounding, 'gutsiest', most handsome valve power amplifier kit available anywhere.

A smooth top end, open mid range and deceptively powerful bass, give a tangible holographic sound stage. The massive, wide dynamic swing and overall sound quality means this amplifier loves music! – Any music!!

The full range of Velleman kits is available from Maplin Electronics, official appointed U.K. agents, including the Velleman K4000 (VE99H £499.95 [H]), high performance valve power amplifier, (featured above). Prices of Velleman kits start from as low as £7.45 and all kits are manufactured to the same high standards and quality.

See the full range of Velleman kits in the 1992 Maplin Catalogue £2.75, or by post £2.95 (CA09K), or visit your local Maplin store. Credit Card Hotline 0702 554161. Mail Order to: P.O. Box 3, Rayleigh, Essex SS6 8LR.

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