858

EVERYDAY ELECTRONICS

JANUARY 1991

INCORPORATING ELECTRONICS MONTHLY

£1.50

NEW SERIES

GCSE PROJECT DEVELOPMENT

A GCSE Assessor gives some practical advice

FREE INSIDE

BULL ELECTRICAL CATALOGUE

ANALOGIC TEST PROBE

PCW SOUND GENERATOR

SPATIAL AUDIO POWER DISPLAY

ISSN 0262-3617

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The No.1 Magazine for Electronics & Computer Projects

REAL POWER AMPLIFIER For your car, it has 150 watts output. Frequency response 20HZ to 20 KHZ and a signal to noise ratio better than 60db. Has built in short circuit protection and adjustable input level to suit youe existing car stereo, so needs no pre-amp. Works into speakers ref 30P7 described below. A real bargain at only £57.00 Order ref 57P1.

REAL 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 30P7.

PERSONAL STEREOS Customer returns but complete with a pair of stereo headphones very good value at £3.00 ref 3P83. We also have customer returned units with a built in FM radio at £6.00 ref 6P34

2KV 500 WATT TRANSFORMERS. Suitable for high voltage experiments or as a spare for a microwave oven etc. 250v AC input. £10.00 ref 10P93

MICROWAVE CONTROL PANEL. Mains operated, with touch switches. Complete with 4 digit display, digital clock, and 2 relay outputs one for power and one for pulsed power (programmable). Ideal for all sorts of precision timer applications etc. £6.00 ref 6P18

FIBRE OPTIC CABLE. Stranded optical fibres sheathed in black PVC. Five metre length £7.00 ref 7P29

12V SOLAR CELL. 200mA output ideal for trickle charging etc. 300 mm square. Our price £15.00 ref 15P42

PASSIVE INFRA-RED MOTION SENSOR. Complete with daylight sensor, adjustable lights on timer (8 secs -15 mins), 50' range with a 90 deg coverage. Manual overide facility. Complete with wall brackets, bulb holders etc. Brand new and guaranteed. £25.00 ref 25P24. Pack of two PAR38 bulbs for above unit £12.00 ref 12P43

VIDEO SENDER UNIT. Transmit both audio and video signals from either a video camera, video recorder or computer to any standard TV set within a 100' range! (tune TV to a spare channel). 12v DC op. £15.00 ref 15P39 Suitable mains adaptor £5.00 ref 5P191

FM TRANSMITTER housed in a standard working 13A adapter (bug is mains driven). £18.00 ref 18P10

MINATURE RADIO TRANSCEIVERS. A pair of walkie talkies with a range of up to 2 kilometres. Units measure 22x52x155mm. Complete with cases. £30.00 ref 30P12

FM CORDLESS MICROPHONE. Small hand held unit with a 500' range! 2 transmit power levels reqs PP3 battery. Tuneable to any FM receiver. Our price £15 ref 15P42

10 BAND COMMUNICATIONS RECEIVER. 7 short bands, FM, AM and LW DX/local switch, tuning 'eye' mains or battery. Complete with shoulder strap and mains lead. £34.00 ref 34P1

WHISPER 2000 LISTENING AID. Enables you to hear sounds that would otherwise be inaudible! Complete with headphones. Cased. £5.00 ref 5P179.

CAR STEREO AND FM RADIO. Low cost stereo system giving 5 watts per channel. Signal to noise ratio better than 45db, wow and flutter less than .35%. Neg earth. £25.00 ref 25P21.

LOW COST WALKIE TALKIES. Pair of battery operated units with a range of about 150'. Our price £8.00 a pair ref 8P50

7 CHANNEL GRAPHIC EQUALIZER plus a 60 watt power ampl 20-21KHZ 4-8R 12-14v DC negative earth. Cased. £25 ref 25P14.

NICAD BATTERYS. Brand new top quality. 4 x AA's £4.00 ref 4P44. 2 x C's £4.00 ref 4P73, 4 x D's £9.00 ref 9P12, 1 x PP3 £6.00 ref 6P35

TOWERS INTERNATIONAL TRANSISTOR SELECTOR GUIDE. The ultimate equivalents book. Latest edition £20.00 ref 20P32.

CABLE TIES. 142mm x 3.2mm white nylon pack of 100 £3.00 ref 3P104. Bumper pack of 1,000 ties £14.00

BUILD AN IBM COMPATABLE PC !

AT 12 meg turbo 286 mother board.	£115.00	pc1
1 meg memory for above board.	£55.00	pc2
4 meg memory for above board.	£214.00	pc3
AT keyboard	£49.00	pc4
AT power supply and pc case (complete)	£115.00	pc5
AT controller card with 2 x serial, 1 x parallel Floppy and hard controller + mono Display driver.	£74.00	pc6
1.2 meg 3 1/2" disc drive.	£74.00	pc7
1.44 meg 5 1/4" drive.	£66.00	pc8
Amber monitor 12".	£99.00	pc9
40 meg hard disc.	£270.00	pc10
100 meg hard disc.	£595.00	pc11

minimum system consisting of mother board, 1 meg of memory , case, power supply, 1.44 meg floppy, interfaces, and monitor is £525.00 inc VAT (single drive mono 286) pc12
£795.00 inc VAT (40 meg + floppy + mono 286) pc13

1991 CATALOGUE AVAILABLE NOW IF YOU DO NOT HAVE A COPY PLEASE REQUEST ONE WHEN ORDERING OR SEND US A 6"X9" SAE FOR A FREE COPY.

GEIGER COUNTER KIT. Complete with tube, PCB and all components to build a battery operated geiger counter. £39.00 ref 39P1

FM BUG KIT. New design with PCB embedded coil. Transmits to any FM radio. 9v battery req'd. £5.00 ref 5P158

TV SOUND DECODER. Nicely cased unit, mains powered 8 channel will drive a small speaker directly or could be fed into HI FI etc. Our price £12.00 ref 12P22

COMPOSITE VIDEO KITS. These convert composite video into separate H sync, V sync and video. 12v DC. £8.00 ref 8P39.

SINCLAIR C5 MOTORS. 12v 29A (full load) 3300 rpm 6"x4" 1/4" O/P shaft. New. £20.00 ref 20P22.
As above but with fitted 4 to 1 inline reduction box (800rpm) and toothed nylon belt drive cog £40.00 ref 40P8.

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 6P20, 16" wheel £6.00 ref 6P21.

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 17P3.

SOLAR POWERED NICAD CHARGER. Charges 4 AA nicads in 8 hours. Brand new and cased £6.00 ref 6P3.

MOSFETS FOR POWER AMPLIFIERS ETC. 100 watt mosfet pair 2SJ99 and 2SK343 £4.00 a pair with pin out info ref 4P51. Also avaliable is a 2SK413 and a 2SJ118 at £4.00 ref 4P42.

10 MEMORY PUSH BUTTON TELEPHONES. These are 'customer returns' so they may need slight attention. BT approved. £6.00 each ref 6P16 or 2 for £10.00 ref 10P77.

12 VOLT BRUSHLESS FAN 4 1/2" square brand new ideal for boat, car, caravan etc. £8.00 each ref 8P26.

ACORN DATA RECORDER ALF503. Made for BBC computer but suitable for others. Includes mains adapter, leads and book. £15.00 ref 15P43

VIDEO TAPES. Three hour superior quality tapes made under licence from the famous JVC company. Pack of 10 tapes £20.00 ref 20P20.

ELECTRONIC SPACESHIP. Sound and impact controlled, responds to claps and shouts and reverses when it hits anything. Kit with complete assembly instructions £10.00 ref 10P81.

PHILIPS LASER. 2MW HELIUM NEON LASER TUBE. BRAND NEW FULL SPEC £40.00 REF 40P10. MAINS POWER SUPPLY KIT £20.00 REF 20P33 READY BUILT AND TESTED LASER IN ONE CASE £75.00 REF 75P4.

SWITCHED MODE POWER SUPPLY (Boshert) +5 at 15A, +12 at 3A, -12 at 2A, +24 at 2A. 220 or 110v input. Brand new £20.00 ref 20P30.

SOLDER 22SWG resin cored solder on a 1/2kg reel. Top quality. £4.00 a reel ref 4P70.

600 WATT HEATERS. Ideal for air or liquid, will not corrode, lasts for years. coil type construction 3"x2" mounted on a 4" dia metal plate for easy fixing. £3.00 ea ref 3P78 or 4 for £10.00 ref 10P76.

TIME AND TEMPERATURE MODULE. A clock, digital thermometer (Celcius and Farenheit (0-160 deg F) programmable too hot and too cold alarms. Runs for at least a year on one AA battery. £9.00 ref 9P5.
Remote temperature probe for above unit £3.00 ref 3P60.

GEARBOX KITS. Ideal for models etc. Contains 18 gears (2 of each size) 4x50mm axles and a powerful 9-12v motor. All the gears etc are push fit. £3.00 for complete kit ref 3P93.

ELECTRONIC TICKET MACHINES. These units contain a magnetic card reader, two matrix printers, motors, sensors and loads of electronic components etc. (12"x12"x7") Good value at £12.00 ref 12P28.

JOYSTICKS. Brand new with 2 fire buttons and suction feet these units can be modified for most computers by changing the connector etc. Price is 2 for £5.00 ref 5P174.

QUALITY PANEL METERS. 50uA movement with 3 different scales that can be brought into view with a lever! £3.00 each ref 3P81.

CAR IONIZER KIT. Improve the air in your car! clears smoke and helps to reduce fatigue. Case required. £12.00 ref 12P8.

METAL DETECTOR. Fun light weight device for buried treasure! 33" long with tune and fine tune controls. £10.00 ref 10P101.

6V 10AH LEAD ACID sealed battery by yuasha ex equipment but in excellent condition now only 2 for £10.00 ref 10P95.

12 TO 220V INVERTER KIT. As supplied it will handle up to about 15 w at 220v but with a larger transformer it will handle 100 watts. Basic kit £12.00 ref 12P17. Larger transformer £12.00 ref 12P41.

VERO EASI WIRE PROTOTYPING SYSTEM. Ideal for designing projects on etc. Complete with tools, wire and reusable board. Our price £6.00 ref 6P33.

MICROWAVE TURNTABLE MOTORS. Complete with weight sensing electronics that would have varied the cooking time. Ideal for window displays etc. £5.00 ref 5P165.

STC SWITCHED MODE POWER SUPPLY. 220v or 110v input giving 5v at 2A, +24v at 0.25A, +12v at 0.15A and +90v at 0.4A £12.00 ref 12P27.

CAMERA FLASH UNITS. Require a 3v DC supply to flash. £2.00 each ref 2P38 or 6 for £10.00 ref 10P101 (ideal multi-flash photography).

TELEPHONE AUTODIALLERS. These units, when triggered will automatically dial any telephone number. Originally made for alarm panels. BT approved. £12.00 ref 12P23 (please state telephone no req'd).

25 WATT STEREO AMPLIFIER ic. STK043. With the addition of a handful of components you can build a 25 watt amplifier. £4.00 ref 4P69 (Circuit dia included).

MINATURE DOT MATRIX PRINTER assembly 24 column 5v (similar to RS type). £10.00 each ref 10P92.

LINEAR POWER SUPPLY. Brand new 220v input +5 at 3A, +12 at 1A, -12 at 1A. Short circuit protected. £12.00 ref 12P21.

MAINS FANS. Snail type construction. Approx 4"x5" mounted on a metal plate for easy fixing. New £5.00 5P166.

POWERFUL IONIZER KIT. Generates 10 times more ions than commercial units! Complete kit including case £18.00 ref 18P2.

MINI RADIO MODULE. Only 2" square with ferrite aerial and tuner. Superhet. Req's PP3 battery. £1.00 ref BD716.

HIGH RESOLUTION MONITOR. 9" black and white Phillips tube in chassis made for OPD computer but may be suitable for others. £20.00 ref 20P26.

SURFACE MOUNT KIT. Makes a high gain snooping amplifier on a PCB less thanan an inch square!. £7.00 ref 7P15.

SURFACE MOUNT SOLDER. In easy to use tube. Ideal for above project £12.00 ref 12P18.

CB CONVERTORS. Converts a car radio into an AM CB receiver. Cased with circuit diagram. £4.00 ref 4P48.

FLOPPY DISCS. Pack of 15 31/2" DSDD £10.00 ref 10P88. Pack of 10 51/4" DSDD £5.00 ref 5P168.

SONIC CONTROLLED MOTOR. One click to start, two click to reverse direction, 3 click to stop! £3.00 each ref 3P137.

FRESNEL MAGNIFYING LENS. 83 x 52mm £1.00 ref BD827.

lcd display. 4 1/2 digits supplied with connection data £3.00 ref 3P77 or 5 for £10.00 ref 10P78.

TRANSMITTER AND RECEIVER. These units were designed for nurse call systems and transmit any one of 16 different codes. The transmitter is cased and designed to hang round the neck. £12.00 a pair ref 12P26.

ALARM TRANSMITTERS. No data avaliable but nicely made complex transmitters 9v operation. £4.00 each ref 4P81.

100M REEL OF WHITE BELL WIRE. figure 8 pattern ideal for intercoms, door bells etc £3.00 a reel ref 3P107.

ULTRASONIC LIGHT. This battery operated unit is ideal for the shed etc as it detects movement and turns a light on for a preset time. (light included). Could be used as a sensor in an alarm system. £14.00 each ref 14P8.

CLAP LIGHT. This device turns on a lamp at a finger 'snap' etc. £4.00 each ref 4P82.

ELECTRONIC DIPSTICK KIT. Contains all you need to build an electronic device to give a 10 level liquid indicator. £5.00 (ex case) ref 5P194.

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 6P36.

ONE THOUSAND CABLE TIES! 75mm x 2.4mm white nylon cable ties only £5.00 ref 5P181.

HI-FI SPEAKER. Full range 131mm diameter 8 ohm 60 watt 63-20 khz excellent reproduction. £12.00 ref 12P33.

ASTEC SWITCHED MODE POWER SUPPLY. 80mm x 165mm (PCB size) gives +5 at 3.75A, +12 at 1.5A, -12 at 0.4A. Brand new £12.00 ref 12P39.

VENTILATED CASE FOR ABOVE PSU with IEC filtered socket and power switch. £5.00 ref 5P190.

IN CAR POWER SUPPLY. Plugs into cigar socket and gives 3,4.5,6,7.5,9, and 12v outputs at 800mA. Complete with universal spider plug. £5.00 ref 5P167.

CUSTOMER RETURNED switched mode power supplies. Mixed type, good for spares or repair. £2.00 each ref 2P292.

DRILL OPERATED PUMP. Fits any drill and is self priming. £3.00 ref 3P140.

PERSONAL ATTACK ALARM. Complete with built in torch and vanity mirror. Pocket sized, req's 3 AA batteries. £3.00 ref 3P135

POWERFUL SOLAR CELL 1AMP .45 VOLT! only £5.00 ref 5P192 (other sizes avaliable in catalogue).

SOLAR PROJECT KIT. Consists of a solar cell, special DC motor, plastic fan and turntables etc plus a 20 page book on solar energy! Price is £8.00 ref 8P51.

RESISTOR PACK. 10 x 50 values (500 resistors) all 1/4 watt 2% metal film. £5.00 ref 5P170.

CAPACITOR PACK 1. 100 assorted non electrolytic capacitors £2.00 ref 2P286.

CAPACITOR PACK 2. 40 assorted electrolytic capacitors £2.00 ref 2P287.

QUICK CUPPA? 12v immersion heater with lead and cigar lighter plug £3.00 ref 3P92.

LED PACK . 50 red leds, 50 green leds and 50 yellow leds all 5mm £8.00 ref 8P52

12 " HIGH RESOLUTION MONITOR. AMBER SCREEN BEAUTIFULLY CASED NEEDS 12V AT 1A TTL INPUT (SEP SYNCS). £22.00 REF 22P2.

RADIO CONTROLLED CAR. Sigle channel R/c buggy with forward reverse and turn controls, off road tyres and suspension. £12.00 ref 12P40.

FERRARI TESTAROSSA. A true 2 channel radio controlled car with forward, reverse, 2 gears plus turbo. Working headlights. £22.00 ref 22P6.

SUPER FAST NICAD CHARGER. Charges 4 AA nicad's in less than 2 hours! Plugs into standard 13A socket. Complete with 4 AA nicad batteries £16.00 ref 16P8.

ULTRASONIC WIRELESS ALARM SYSTEM. Two units, one a sensor which plugs into a 13A socket in the area you wish to protect. The other, a central alarm unit plugs into any other socket elsewere in the building. When the sensor is triggered (by body movement etc) the alarm sounds. Adjustable sensitivity. Price per pair £20.00 ref 20P34. Additional sensors (max 5 per alarm unit) £11.00 ref 11P6.

TOP QUALITY MICROPHONE. Unidirectional electret condenser mic 600 ohm sensitivity 16-18khz built in chime complete with magnetic microphone stand and mic clip. £12.00 ref 12P42.

WASHING MACHINE PUMP. Mains operated new pump. Not self priming £5.00 ref 5P18.

IBM PRINTER LEAD. (D25 to centronics plug) 2 metre parallel. £5.00 ref 5P186.

QUICK FIX MAINS CONNECTOR. Ideal for the fast connection of mains equipment. Neon indicator and colour coded connectors. £7.00 ref 7P18.

COPPER CLAD STRIP BOARD. 17" x 4" of .1" pitch "vero" board. £4.00 a sheet ref 4P62 or 2 sheets for £7.00 ref 7P22.

STRIP BOARD CUTTING TOOL. £2.00 ref 2P352.

3 1/2" disc drive. 720K capacity made by NEC £60.00 ref 60P2

TV LOUDSPEAKERS. 5 watt magnetically screened 4 ohm 55 x 125mm. £3.00 a pair ref 3P109.

TV LOUDSPEAKERS. 3 watt 8 ohm magnetically screened 70 x 50mm. £3.00 a pair ref 3P108.

TOROIDAL TRANSFORMER. 24v 5A encapsulated 4" dia £5.00 ref 5P34.

BULL ELECTRICAL

250 PORTLAND ROAD HOVE SUSSEX BN3 5QT DEPT EE

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ABC

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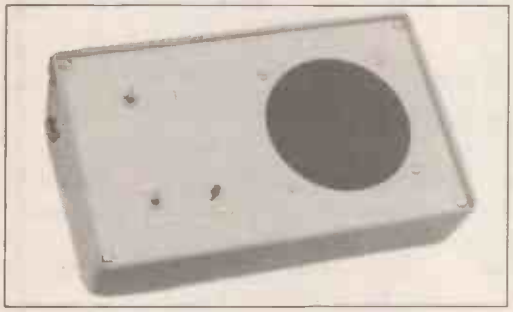
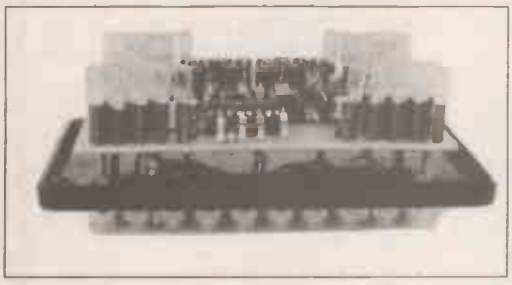
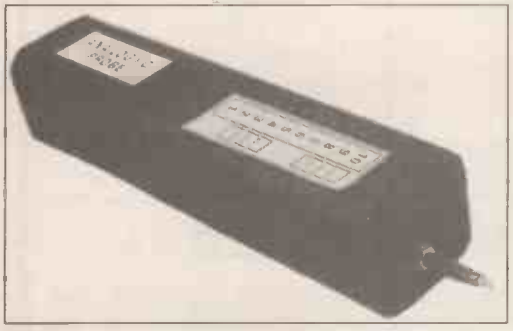
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .







Merry Christmas
to all our readers

Projects

Series

Features

FREE WITH THIS ISSUE

Bull Electrical Catalogue **between pages 36 and 37**

Our February '91 Issue will be published on Friday, 4 January 1991. See page 3 for details.

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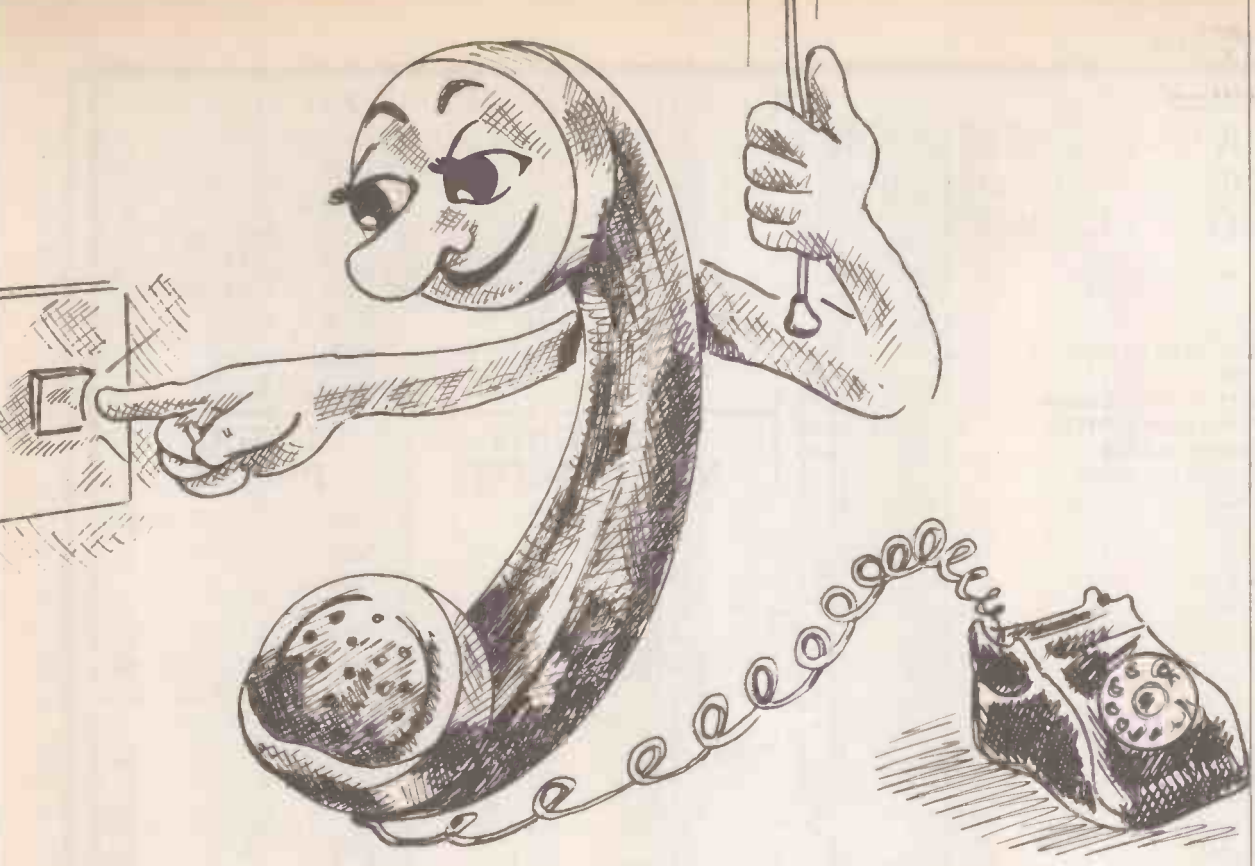

NEXT MONTH

MARC PHONE-IN

An "over the phone" data link. Designed to interface with our Mains Appliance Remote Control (EE June '90 to Sept '90) this project enables home appliances to be controlled via a 'phone link from just about anywhere in the world. It can also be simplified to interface to a computer.

This unit does not need any direct connection to the telephone system.

ELECTRIC BLANKET SHUT DOWN

A very useful device for the absent-minded. This project automatically switches off an electric blanket when anyone sits on the bed or gets into it. By preventing any resulting overheating the unit can thus reduce the risk of fire.

GINGERNUT 80m RECEIVER

The first ever EE project using surface mount devices. Designed around a chip mainly intended for m.w. reception, this little receiver gives amazing results on the 80 meter band.

If you want to try surface mount construction and/or if you are interested in amateur radio then this one is for you.

EVERYDAY ELECTRONICS

FEBRUARY ISSUE ON SALE FRIDAY 4TH JANUARY 1991

TRANSISTORS

AAY32	9p
AC107	40p
AC125	25p
AC126	25p
AC127	21p
AC128	21p
AC128K	26p
AC141K	30p
AC142K	30p
AC176	22p
AC176K	28p
AC187	21p
AC187K	28p
AC188	21p
ACY18	48p
ACY19	48p
AD149	60p
AF124	50p
AF125	50p
AF126	50p
AF127	50p
AF139	30p
AF239	30p
AF379	45p
BA145	10p
BA148	10p
BA154	6p
BA157	12p
BB105B	18p
BB205B	24p
BC107	8p
BC108	8p
BC109	8p
BC109C	10p
BC115	10p
BC118	11p
BC140	20p
BC141	20p
BC142	20p
BC143	20p
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BC637	20p
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BC640	20p
BCY32	200p
BCY33	200p
BCY34	200p
BCY70	16p
BCY71	16p
BCY72	16p
BD115	30p
BD124P	50p
BD124	110p
BD131	25p
BD132	25p
BD133	50p
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BD136	20p
BD137	20p
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BD711	50p
BD736	50p
BD826	50p
BD828	50p
BD875	50p
BD897	50p
BD899	50p
BD901	50p
BD977	50p
BDX32	100p
BDX33	60p
BDX53	60p
BDX65	80p
BOW23	55p
BDW24	55p
BDW93	50p
BDW94	50p
BDY20	100p
BDY92	100p
BF137	35p
BF154	25p
BF167	30p
BF173	40p
BF178	30p
BF180	16p
BF181	18p
BF183	20p
BF185	20p
BF194	7p
BF195	7p
BF196	8p
BF197	10p
BF198	10p
BF199	8p
BF200	16p
BF225	30p
BF240	16p
BF245	25p
BF254	15p
BF255	12p
BF256	18p
BF257	18p
BF258	18p
BF259	18p
BF262	25p
BF263	25p
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BF450	20p
BF455	14p
BF458	19p
BF459	19p
BF461	60p
BF462	62p
BF469	30p
BF470	28p
BF471	28p
BF472	28p
BF479	30p
BF493	18p
BF494	16p
BF495	16p
BF506	25p
BF595	16p
BF596	16p
BF615	30p
BF617	30p
BF757	40p
BF758	41p
BF759	40p
BF760	40p
BF763	40p
BF869	22p
BF870	22p
BF871	22p
BF872	23p
BF960	38p
BF961	35p
BF963	40p
BF964	38p
BF966	40p
BFR40	25p
BFR79	25p
BFR90	52p
BFR91	99p
BFT37	130p
BFT42	30p
BFT43	30p
BFT84	30p
BFW92	35p
BFX29	20p
BFX84	20p
BFX85	20p
BFX87	15p
BFX88	15p
BFX89	60p
BFY17	30p
BFY18	40p
BFY50	14p
BFY51	14p
BFY52	14p
BFY56	25p
BFY64	25p
BFY90	45p
BLY48	85p
BR100	14p
BR101	43p
BR103	37p
BR303	85p
BRY39	55p
BRY49	38p
BRY56	33p
BS574	33p
BSX20	15p
BSX26	18p
BSX29	19p
BT100A	70p
BT106	180p
BT109	90p
BT116	80p
BT119	100p
BT138	60p
BT146	99p
BT151	58p
BTY79	140p
BU100A	110p
BU104	100p
BU105	80p
BU108	100p
BU109	100p
BU110	110p
BU111	140p
BU124	60p
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BU180	150p
BU184	100p
BU204	75p
BU205	70p
BU206	100p
BU208	70p
BU208D	80p
BU209	140p
BU225	190p
BU226	190p
BU312	120p
BU325	55p
BU326	75p
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BU406D	95p
BU407	60p
BU407D	95p
BU408	85p
BU408D	95p
BU409	95p
BU426A	75p
BU500	110p
BU508A	85p
BU508D	90p
BU536	150p
BU526	80p
BU546	140p
BU608	150p
BU626	150p
BU636	150p
BU801	95p
BU806	80p
BU807	75p
BU902	130p
BU903	130p
BU920	130p
BU921	130p
BU922	130p
BU930	130p
BUT11A	90p
BUT56A	250p
BUX80	180p
BUX82	180p
BUX84	50p
BUX85	50p
BUY69A	200p
BUY71	300p
C106D	28p
MEO411	38p
MEO414	125p
ME3001	12p
ME4103	12p
ME6001	12p
ME6002	15p
ME8001	15p
ME9021	12p
MJ802	350p
MJ900	200p
MJ1000	200p
MJ1001	200p
MJ10012	300p
MJ15001	325p
MJ15002	300p
MJ15003	325p
MJ15004	370p
MJ15022	400p
MJ2501	110p
MJ2955	55p
MJ3000	115p
MJ3001	115p
MJE29A	30p
MJE30A	30p
MJE340	25p
MJE350	80p
MJE520	30p
MJE2955K	90p
MP8111	40p
MP8112	45p
MP8113	55p
MP8512	50p
MPS65781	20p
MPS9012	20p
MPS9013	20p
MPS9014	20p
MPS9015	20p
MPSA05	15p
MPSA06	15p
MPSA13	15p
MPSA20	15p
MPSA42	15p
MPSA43	15p
MPSA65	25p
MPSA66	25p
MPSA70	15p
MPSA92	20p
MPSA93	20p
MR510	35p
MR856	36p
OC28	250p
OC29	250p
OC35	250p
OC36	250p
OC45	50p
OC71	30p
OC72	50p
OC200	180p
OT121	120p
R2008B	100p
R2010B	100p
S2800D	52p
S2800M	72p
T2800D	52p
T2800M	72p
TIP29	15p
TIP29A	22p
TIP29C	25p
TIP30	25p
TIP30C	30p
TIP31A	24p
TIP31C	30p
TIP32	24p
TIP32A	24p
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TIP33	50p
TIP33C	60p
TIP34	60p
TIP34C	60p
TIP35C	65p
TIP36C	65p
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TIP110	47p
TIP111	50p
TIP112	40p
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TIP116	45p
TIP117	50p
TIP120	43p
TIP121	46p
TIP122	47p
TIP125	47p
TIP126	56p
TIP127	56p
TIP130	30p
TIP131	30p
TIP132	30p
TIP141	90p
TIP142	90p
TIP145	65p
TIP146	90p
TIP147	100p
TIP150	90p
TIP151	90p
TIP2955	42p
TIP3054	45p
TIP3055	42p
TIS44	40p
TIS61	15p
TIS90	15p
TIS91	18p
VK1010	88p
VN10KM	60p
VN66AF	100p
VN88AF	115p
ZTX107	11p
ZTX108	11p
ZTX109	12p
ZTX212	27p
ZTX300	13p
ZTX301	16p
ZTX302	16p
ZTX303	24p
ZTX304	17p
ZTX320	29p
ZTX500	13p
ZTX501	13p
ZTX502	18p
ZTX503	18p
ZTX504	25p
ZTX550	24p
ZN.696	26p
ZN.697	22p
ZN.698	40p
ZN.706	22p
ZN.708	22p
ZN.914	28p
2N.930	18p
2N.1131	28p
2N.1132	28p
2N.1613	24p
2N.1711	24p
2N.1893	30p
2N.2102	50p
2N.2218A	24p
2N.2219	24p
2N.2221	23p
2N.2222	23p
2N.2369	15p
2N.2484	20p
2N.2646	40p
2N.2904	20p
2N.2905	20p
2N.2906	18p
2N.2907	18p
2N.2926	8p
2N.3019	28p
2N.3053	18p
2N.3054	40p
2N.3055	38p
2N.3055H	50p
2N.3440	58p
2N.3442	85p
2N.3583	90p
2N.3585	120p
2N.3702	9p
2N.3703	9p
2N.3704	9p
2N.3705	9p
2N.3706	9p
2N.3707	9p
2N.3708	9p
2N.3710	12p
2N.3711	12p
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2N.3772	90p
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2N.3819	29p
2N.3866	68p
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2N.3904	11p
2N.3905	11p
2N.3906	11p
2N.4031	25p
2N.4036	25p
2N.4037	25p
2N.4062	12p
2N.4064	100p
2N.4401	12p
2N.4403	12p
2N.4443	76p
2N.5061	20p
2N.5088	20p
2N.5163	45p
2N.5192	50p
2N.5241	500p
2N.5245	45p
2N.5294	30p
2N.5296	30p
2N.5320	90p
2N.5321	60p
2N.5366	25p
2N.5401	12p
2N.5448	12p
2N.5496	80p
2N.6107	40p
2N.6109	40p
2N.6254	110p
2N.6292	40p
2N.6384	120p
2N.6385	120p
2N.6403	160p

DIODES RECTIFIER DIODES

BY100	40p
BY103	32p
BY126	6p
BY127	8p
BY133	8p
BY164	40p
BY179	35p
BY184	32p
BY196	20p
BY206	11p
BY207	11p
BY208	18p
BY210	22p
BY225	120p
BY226	18p
BY227	19p
BY228	32p
BY296	20p
BY298	26p
BY299	28p
BYX10	15p
BYX55/350	30p
BYX55/600	30p
BYX70/500	32p
BYX70/800	36p
OA91	8p
OA200	7p
OA202	7p
IN.914	2p
IN.4001	4p
IN.4002	4p
IN,4003	4p
IN.4004	4p
IN.4005	4p
IN.4006	4p
IN.4007	5p
IN,4148	2p
IN.5400	9p
IN.5401	10p
IN,5402	10p
IN,5403	11p
IN.5404	11p
IN.5405	12p
IN.5406	13p
IN.5407	13p
IN.5408	13p
SKE4F2/06	50p
SKE4F2/08	70p
SKE4F2/10	90p

I.C. SOCKETS

8 PIN	6p
14 PIN	8p
16 PIN	9p
18 PIN	12p
20 PIN	14p
22 PIN	16p
24 PIN	18p
28 PIN	20p
40 PIN	25p

ZENER

400 MV
BZY88 RANGE
2V7 TO 39V 6p
1.3W
BZX61 RANGE
2V7 TO 39V 12p

VOLTAGE REGULATORS

7805	35p
7806	35p
7808	35p
7812	35p
7815	35p
7818	35p
7824	35p
7905	35p
7906	40p
7908	40p
7912	40p
7915	40p
7918	40p
7924	40p
78L05	28p
78L08	28p
78L12	28p
78L15	28p
78L18	28p
78L24	28p
79L05	40p
79L08	40p
79L12	40p
79L15	40p
7818KC	100p
7824KC	100p
LM309K	100p
LM317K	220p
LM317T	180p
LM323K	420p
LM723	40p
78HGKC	570p
78H05KC	800p
78H12KC	700p
78GU1C	190p
79GU1C	215p
79HGKC	800p

L.E.D.'S

LED 3MM RED	5p
LED 3MM YELLOW	10p
LED 3MM GREEN	10p
LED 5MM RED	6p
LED 5MM YELLOW	10p
LED 5MM GREEN	10p

RECTANGULAR L.E.D.'S

RED	10p
GREEN	15p
YELLOW	15p

LINEAR IC's

LF-347	110p
LF-351	45p
LF-353	48p
LF-355	60p
LF-356	60p
LF-357	70p
LF-398	300p
LM-301	26p
LM-307	42p
LM-308CN	70p
LM-311	35p
LM-318	120p
LM-319	165p
LM-324	35p
LM-334Z	115p
LM-335Z	120p
LM-337	250p
LM-339	37p
LM-348	55p
LM-358	45p
LM-377	220p
LM-380	100p
LM-381	150p
LM-382	130p
LM-384	130p
LM-386	85p
LM-387	100p
LM-392	100p
LM-393	55p
LM-709DIL	30p
LM-710	45p
LM-711	85p
LM-723	40p
LM-733	60p
LM-741DIL	18p
LM741MET	45p
LM-747	58p
LM-748	35p
LM-1458	33p
LM-1889	400p
LM-3900	40p
LM-3909	80p
LM-3911	160p
LM-3914	250p
LM-3915	255p
LM-3916	290p
MB-3515	240p
MB-3614	180p
MB-3712	140p
MB-3713	130p
MB-3714	270p
MB-3715	250p
MB-3722	310p
MB-3730	200p
MB-3731	300p
MB-3756	230p
MB-3759	200p
MB-8719	360p
MC-1310P	130p
MC-1455	45p
MC-1458	33p
MC-1469	290p
MC-1488	65p
MC-1489	65p
MC-1496	65p
MC-3302	70p
MC-3401	45p
MC-3403	60p
MC-3423	75p
NE-531	115p
NE-544	170p
NE-555	20p
NE-556	40p
NE-565	110p
NE-566	130p
NE-567	115p
NE-570	360p
NE-571	290p
NE-592	85p
NE-5532P	140p
NE-5534P	110p

74 SERIES

7400	20p
7401	16p
7402	18p
7403	20p
7404	35p
7405	10p
7406	36p
7407	36p
7408	25p
7409	20p
7413	30p
7414	45p
7416	40p
7417	32p
7420	22p
7421	25p
7425	15p
7430	25p
7437	28p
7438	32p
7442	38p
7447	60p
7450	22p
7451	10p
7454	25p
7470	30p
7473	25p
7474	35p
7475	25p
7481	90p
7482	60p
7485	28p
7486	28p
7489	75p
7490	35p
7492	45p
7493	35p
7495	48p
7497	80p
74107	30p
74111	52p
74116	85p
74119	85p
74122	40p
74123	20p
74125	40p
74126	45p
74132	42p
74141	55p
74145	70p
74153	45p
74155	45p
74157	45p
74160	50p
74164	50p
74167	35p
74173	50p
74174	60p
74175	65p
74176	45p
74180	50p
74182	45p
74192	40p
74196	40p
74197	45p
74393	70p

74LS SERIES LOW POWER SCHOTTKY T.T.L.

74LS00	12p
74LS01	12p
74LS02	12p
74LS03	12p
74LS04	12p
74LS05	12p
74LS08	12p
74LS09	14p
74LS10	12p
74LS11	12p
74LS12	12p
74LS13	20p
74LS14	24p
74LS15	14p
74LS20	14p
74LS21	14p
74LS22	14p
74LS24	35p
74LS26	14p
74LS27	14p
74LS28	14p
74LS30	14p
74LS32	15p
74LS33	15p
74LS31	15p
74LS38	15p
74LS40	15p
74LS42	25p
74LS47	52p
74LS48	48p
74LS51	13p
74LS54	13P
74LS55	15p
74LS73	24p
74LS74	18p
74LS75	24p
74LS76	24p
74LS78	24p
74LS83	37p
74LS85	37p
74LS86	25p
74LS90	26p
74LS91	55p
74LS92	32p
74LS93	26p
74LS95	41p
74LS96	52p
74LS107	28p
74LS109	28p
74LS112	28p
74LS113	28P
74LS114	28p
74LS122	35p
74LS123	35p
74LS124	85p
74LS125	30p
74LS126	30p
74LS132	30p
74LS133	30p
74LS136	30p
74LS138	28p
74LS139	28p
74LS145	65p
74LS147	90p
74LS148	75p
74LS151	27p
74LS153	31p
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74LS170	68p
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74LS191	43p
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74LS197	42p
74LS221	45p
74LS240	45p
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74LS266	22p
74LS273	44p
74LS279	33p
74LS280	88p
74LS283	51p
74LS290	26p
74LS293	26p
74LS365	26p
74LS366	31p
74LS367	28p
74LS368	30p
74LS373	45p
74LS374	45p
74LS375	46p
74LS390	42p
74LS393	37p
74LS399	68p
74LS629	95p
74LS641	88p
74LS642	105p
74LS644	105p
74LS645	105p
74LS670	62p
74LS674	310p
74LS687	250p

COMPUTER IC'S

2114	200p
2532	330p
2716	200p
2732	280p
2732A	300p
2764	240p
27C64	550p
27128	310p
27256-25	400p
41256-15	240p
4116	75p
4164-15	150p
6116	150p
6264-12	300p
6502	300p
6502A	400p
65C02	930p
6503	570p
6520	170p
6522	330p
6532	460p
6545	880p
6551	530p
6800	210p
6802	220p
6803	800p
6808	500p
6809	600p
6810	150p
6818	380p
6820	140p
6821	140p
6840	310p
6845	620p
6850	110p
8080A	400p
8085A	300p
8086	500p
8088	500p
8155	360p
8156	300p
81LS95	120p
81LS96	130p
81LS97	130p
81LS98	130p
8224	240p
8226	240p
8243	250p
8250	850p
8251	270p
8253	230p
8255	200p
8256	1200p
8257	220p
8259	280p
8271	3400p
8279	270p
8284	440p
8288	650p
8748	1100p
8755	1400p
AY3-1015	290p
SP0256AL2	500p
Z80ACPU	150p
Z80BCPU	400p
Z80ADMA	500p
Z80AP10	220p
Z80BP10	340p
Z80ACTC	200p
Z80BCTC	320p
Z80AS10	460p
Z80AS10-1	580p
Z80AS10-2	580p
Z80ADART	500p

SPECIAL OFFER DRAMS

4164-15	150p
4164-12	175p
41256-10	260p
41256-12	240p
41256-15	220p
41464-12	360p
41464-10	430p
256KX4	1000p
1MBRAM-8	1080p
1MBRAM-10	1000p

SIPP

256KX9-10	3000p
256KX9-8	3800p
256KX9-7	5200p
256KX9-6	6500p

SRAMS

6264LP15	250p
6264LP12	280p
6264LP10	300p
32KX8-12	800p
62256-12	800p
27512	580p

SIMMS

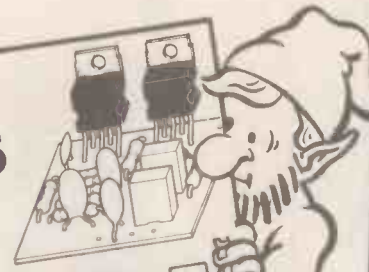
1MX9-10	9500p
1MX9-8	9800p
1MX9-7	10500p
2MX9-10	39000p
4MX9-80	78000p

PLEASE PHONE US FOR TYPE NOT LISTED HERE AS WE ARE HOLDING 5000 ITEMS AND QUOTATIONS ARE GIVEN FOR LARGE QUANTITIES.

Please send £1.00 p&p and VAT at 15%. Govt, Colleges, etc. Orders accepted. Quotations given for large quantities. All brand-new Components. prices quoted are subject to stock availability and may be changed without notice.

Special CHRISTMAS OFFERS from Specialist SEMICONDUCTORS

MATCHBOX AMPLIFIERS



Amazingly powerful amplifier modules – small enough to fit in a matchbox!

50W amplifier ~~£11.27~~ £8.95 ☐

20W amplifier ~~£7.59~~ £5.95 ☐

BIO-FEEDBACK MONITOR

Measures your stress level. Take life easy!

~~£19.32~~ £12.65 ☐

FREE

with every order received by December 10th

100 mixed high grade components ☐

OR

Mini bio-feedback kit ☐

Please tick box for the gift you would like.

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TACHO/DWELL METER

Essential for the motoring enthusiast

~~£18.86~~ £14.85 ☐

CREDIT CARD CASINO

with five extra games FREE!

The tiny pocket gambling machine

~~£6.78~~ £5.25 ☐

MAINS CONTROLLER

For the expert. Control mains powered equipment from your logic circuits

~~£7.13~~ £5.95 ☐

BURGLAR BUSTER

Protect your home and valuables

~~£14.72~~ £10.95 ☐

IONISER

Get healthy without pills, drugs or jogging!

Black Ioniser ~~£14.49~~ £10.95 ☐

White Ioniser ~~£14.72~~ £11.25 ☐

Please tick the boxes for the kits you would like and return the entire list to us. All prices include VAT, but please don't forget to add £1.20 for postage and packing. No orders accepted at these prices after 20th December 1990.

Please debit my ACCESS card no. ..... I enclose cheque for £.....

Name .....

Address .....

.....

SPECIALIST SEMICONDUCTORS LTD, FOUNDERS HOUSE, REDBROOK, MONMOUTH, GWENT NP5 4LU. Tel: 0600 3715

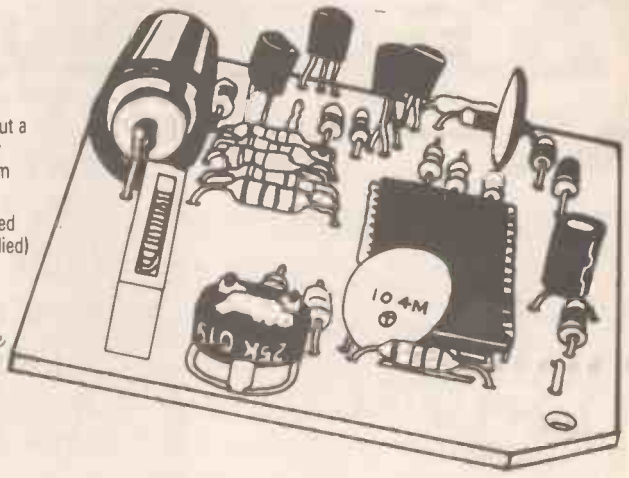
Welcome to the 1990 Christmas list! Whether you intend to make somebody an original Christmas present or to treat yourself to a project for the holidays, there's just so much to choose from. To be sure of getting your products for Christmas, please allow enough time for postal delays in both directions and for our staff (who are very busy at this time of year, bless 'em) to pack your order. If you have an ACCESS card, you can speed things up by phoning in your order on 0600 3715, and we'll post your projects the very same day.

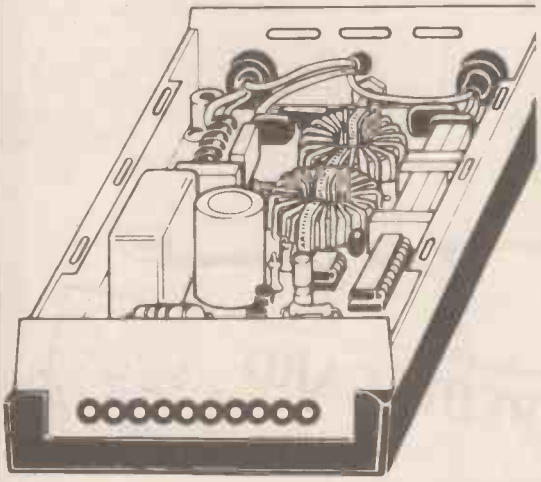
SOUND FX COMPUTER ▷

This super project will make the most outrageously realistic sounds you've ever heard! How about a motor rally complete with revving engines and gear changes? Or a ship hooting its moumful way through the fog? Or a fly so realistic it'll have you running for the swat! Sirens, helicopters, steam trains, aliens – you name it, it's in there. In one mode you can even play it like a synthesizer!

The computer is ready built and programmed, and has its own audio amplifier built in. All you need to do is to connect up the speaker (supplied), wire together the 13 programming switches (supplied) and you're ready for action! What a Christmas present!

~~£14.72~~ **£10.95** ☐





◁ POWER CONDITIONER

You don't have to be a hi-fi nut to notice the huge improvement in sound quality when you run your music system from a clean mains supply. How do you describe the difference? It's as if all this time your favourite artists have been playing and singing inside a wardrobe . . . and someone has just opened the door and let them out. You could spend 20 times as much on special cables, plugs, mats and stuff without achieving a tenth of the difference. But don't take my word for it, Try it for yourself.

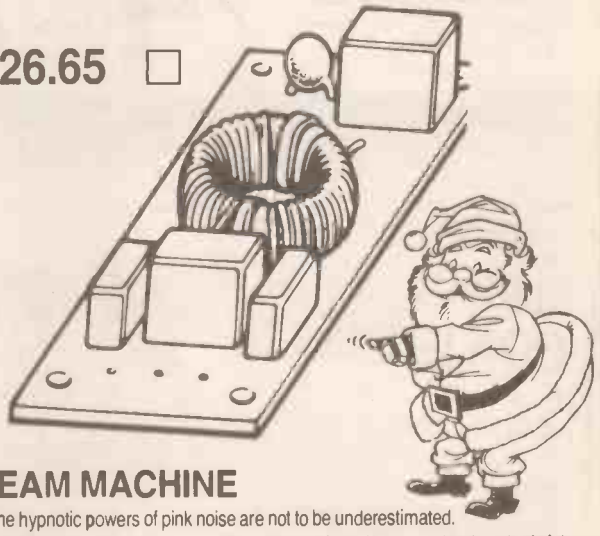
The sophisticated circuitry of the Power Conditioner begins with a bank of six VDRs to eliminate impulsive spikes. Then comes a massive filter with thirteen capacitors and two current-balanced inductors to smooth away every trace of noise and interference, A ten LED logarithmic display flicks up and down as each spike is eliminated, and gives a second by second account of the interference removed. Maximum load 1.5kW.

~~£34.27~~ **£26.65** ☐

MAINS CONDITIONER ▷

If the budget won't stretch to the full Power Conditioner, its smaller brother the Mains Conditioner will give you a taste for the clear sounds. Just the thing for computer supplies too – it catches the spikes before they can do any harm.

~~£6.21~~ **£5.65** ☐ Rugged plastic case **£2.07** ☐



◁ THE DREAM MACHINE

What a project this is! The hypnotic powers of pink noise are not to be underestimated.

Legend has it that a New York dentist used to pull patients' teeth with only the gentle whoosh of pink sound to soothe them. No anaesthetic! Not something I'd care to try myself, but having experienced the effects of the Dream Machine I can well believe it.

The main function of the project is to give a truly refreshing sleep. One that leaves you feeling alert and ready for anything, not half dead until the third cup of coffee. For babies and young children it's just the thing. They drift into sleep quickly and are far less likely to wake in the middle of the night.

As for me, I enjoy experimenting with lucid dreams – ones where I'm completely in control of the action. The night time can be more exciting than the day!

~~£22.77~~ **£16.95** ☐

SILVER SOLUTION

We stock this for plating the electrodes on our Brainwave Monitor, but it's such fascinating stuff I just had to add it to the Christmas list. Just run a little onto any metal surface – coins, ornaments, PCB tracks – and a silver coating appears. This is real silver, bonded just as thoroughly to the metal as if it has been silver plated. Amazing stuff! Have a bottle for yourself and a few to give away as presents.

Silver solution **£4.37** ☐ Three bottles of Silver Solution **£11.95** ☐

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9-2 Saturday
Official orders welcome

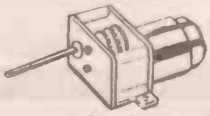
Add £2 p&p to all orders

MICROCONTROLLER LIGHT SEQUENCER

EE DEC '90 KIT REF 838

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.
As published in EE Dec '90 **£55.95**

D.C. MOTOR GEARBOXES



Ideal for Robots and Buggies. A miniature plastic reduction gearbox coupled with a 1·5-4·5 Volt mini motor. Variable gearbox reduction ratios are obtained by fitting from 1 to 6 gearwheels (supplied). Two types available:

SMALL UNIT TYPE MGS **£3.99**
Speed range 3-2200 rpm. Size 37x43x25mm

LARGE UNIT TYPE MGL **£4.55**
Speed range 2-1150 rpm. Size 57x43x29mm

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STEPPING MOTORS

A range of top quality stepping motors suitable for driving a wide range of mechanisms under computer control using simple interfacing techniques.

ID35 PERMANENT MAGNET MOTOR — 48 steps per rev. **£16.50**

MD200 HYBRID MOTOR — 200 steps per rev. **£16.80**

MD35 ¼ PERMANENT MAGNET MOTOR — 48 steps per rev. **£12.70**

MD38 PERMANENT MAGNET MOTOR — 48 steps per rev. **£8.95**

HAMEG HM 203-7 OSCILLOSCOPE

New model just arrived. High quality reliable instrument made in W. Germany. Outstanding performance.
Full two year parts and labour warranty.
20MHz-2 channels 1mV sensitivity
Easy to operate and high performance
£338 + £50.70 VAT
Next Day Delivery £5.00

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 £5.25
COMPONENT PACK (less book) £22.35

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 & how they work). Also full details of how to build 6 projects — burglar alarm, radio, game, 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) £17.55

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, M.W. Radio, Fuzz unit, etc.

30 SOLDERLESS BREADBOARD PROJECTS Book 1 £2.95
COMPONENT PACK £27.15

ENJOYING ELECTRONICS

A more advanced book which introduces some arithmetic and calculations to electronic circuits. 48 chapters covering elements of electronics such as current, transistor switches, flip-flops, oscillators, charge, pulses, etc. An excellent follow-up to Teach-in or any other of our series. Extremely well explained by Owen Bishop who has written many excellent beginners' articles in numerous electronics magazines.

ENJOYING ELECTRONICS Book £3.60
COMPONENT PACK £14.31

Note – A simple multimeter is needed to fully follow this book. The M102 BZ is ideal. £13.98

A FIRST ELECTRONICS COURSE

A copiously illustrated book that explains the principles of electronics by relating them to everyday objects. At the end of each chapter a set of questions and word puzzles allow progress to be checked in an entertaining way. An S-DEC breadboard is used for this series – soldering is not required.

A FIRST ELECTRONIC COURSE BOOK £4.50
PACK £22.35

EVERYDAY ELECTRONICS KIT PROJECTS

ALL KITS HERE HAVE BEEN FEATURED IN EE AND ARE SUPPLIED WITH MAGAZINE ARTICLE REPRINTS. SEPARATE REPRINTS ALSO AVAILABLE PRICE 80p EACH INCLUSIVE P&P. KITS INCLUDE CASES, PCB's HARDWARE AND ALL COMPONENTS (UNLESS STATED OTHERWISE) CASES ARE NOT DRILLED OR LABELS SUPPLIED UNLESS STATED.

Ref		Price
839	ANALOGIC TEST PROBE Jan 91 with drilled case	£12.95
838	MICROCONTROLLER LIGHT SEQUENCER Dec 90. With drilled and labelled case	£55.95
835	SUPERHET BROADCAST RECEIVER Mar 90 With drilled panels and dial	£16.79
	Without above	£13.64
834	QUICK CAP TESTER Feb 90	£10.17
833	EE 4 CHANNEL LIGHT CHASER Jan 90	£31.45
815	EE TREASURE HUNTER Aug 89 Full Kit	£41.95
814	BAT DETECTOR June 89	£20.98
812	ULTRASONIC PET SCARER May 89	£14.49
800	SPECTRUM EPROM PROGRAMMER Dec 88	£29.95
796	SEASHELL SYNTHESISER Nov 88	£27.94
790	EPROM ERASER Oct 88	£27.90
769	VARIABLE 25V-2A BENCH POWER SUPPLY Feb 88	£55.61
763	AUDIO SIGNAL GENERATOR Dec 87	£15.66
739	ACCENTED BEAT METRONOME Nov 87	£23.43
740	ACCOUSTIC PROBE Nov 87 (less bolt & probe)	£19.58
744	VIDEO CONTROLLER Oct 87	£32.58
734	AUTOMATIC PORCH LIGHT Oct 87	£19.20
728	PERSONAL STEREO AMP Sep 87	£15.99
730	BURST-FIRE MAINS CONTROLLER Sep 87	£15.17
724	SUPER SOUND ADAPTOR Aug 87	£42.93
718	3-BAND 1.6-30MHz RADIO Aug 87	£29.66
719	BUCCANEER I.B. METAL DETECTOR July 87 Inc coils, and case, less handle and hardware	£29.58
722	FERMOSTAT July 87	£13.58
715	MINI DISCO LIGHTS June 87	£14.08
707	EQUALIZER (IONISER) May 87	£17.37
700	ACTIVE I/R BURGLAR ALARM Mar 87	£39.87
581	VIDEO GUARD Feb 87	£9.39
584	SPECTRUM SPEECH SYNTH (no case) Feb 87	£23.39
578	SPECTRUM I/O PORT less case Feb 87	£10.55
569	CAR ALARM Dec 86	£13.94
563	200MHz DIG. FREQUENCY METER Nov 86	£69.95
561	LIGHT RIDER LAPEL BADGE Oct 86	£11.40
560	LIGHT RIDER DISCO VERSION	£21.93
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556	INFRA-RED BEAM ALARM Sep 86	£31.70
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513	BBC MIDI INTERFACE Mar 86	£31.25
512	MAINS TESTER & FUSE FINDER Mar 86	£9.86
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	1D35 STEPPER MOTOR EXTRA	£8.95
	OPTIONAL POWER SUPPLY PARTS	£5.74
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444	INSULATION TESTER Apr 85	£21.89
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386	DRILL SPEED CONTROLLER Oct 84	£9.70
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337	BIOLOGICAL AMPLIFIER Jan 84	£27.00
263	BUZZ OFF Mar 83	£6.35
242	INTERCOM no case July 82	£6.36
240	EGG TIMER June 82	£7.68
108	IN SITU TRANSISTOR TESTER June 78	£10.53
106	WIERD SOUND EFFECTS GEN Mar 78	£8.75
101	ELECTRONIC DICE Mar 77	£7.00

TEACH-IN PROJECT 1

591	REGULATOR UNIT & SAFE POWER SUPPLY	£29.95
592	UNIVERSAL LCR BRIDGE	£28.89
593	DIODE/TRANSISTOR TESTER	£21.22
594	AUDIO SIGNAL TRACER	£18.73
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596	R.F. SIGNAL GENERATOR	£27.37
597	FET VOLTMETER	£24.02
598	DIGITAL PULSE GENERATOR	£18.65

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 £21.89

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 £14.49

Mains Adaptor £1.98

DIGITAL CAPACITANCE METER

EE DEC 85

Simple and accurate (1%) measurement of capacitors from a few pF up to 1,000 μF. Clear 5-digit LED display indicates exact value. Three ranges – pF, nF, and μF. Just connect the capacitor, press the button and read the value.

KIT REF 493 £46.46

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 £29.66

DIGITAL FREQUENCY 200 MHz METER

EE NOV 86

An 8 digit meter reading from AF up to 200 MHz in two ranges. Large 0.5" Red LED display. Ideal for AF and RF measurements. Amateur and C.B. frequencies.

KIT REF 563 £69.95

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 £55.61

MINI STROBE

EE MAY '86

A hand held stroboscope which uses 6 "ultra bright" LEDs as the light source. Designed to demonstrate the principles of stroboscope examination, the unit is also suitable for measuring the speed of moving shafts etc. The flash rate control covers 170–20,000 RPM in two ranges.

KIT REF 529 £15.50

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 £19.58

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 £31.45

EE EQUALISER

EE MAY '87

A mains powered Ioniser 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 £17.37

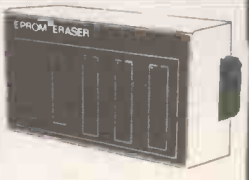
MUSICAL DOORBELL

EE JAN '86

This project uses a special I.C. pre-programmed with 25 tunes and 3 chimes. A Magenta design, the circuit is battery powered and only draws current whilst producing sounds. Two rotary switches select the tune required. Provision is made for three bell pushes, each of which sounds a different tune, so that three points of entry can be identified.

KIT REF 497 £20.95

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 £27.90

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	£15.25
KIT REF 560 DISCO LIGHTS	£21.93
KIT REF 561 LAPEL BADGE	£11.40

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 £41.95

Headphones £1.99

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 £16.79

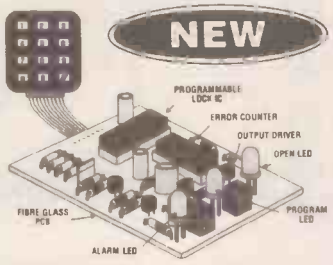
TK FOR KITS

GUARD DOG KIT

One of the best burglar deterrents is a guard dog and this kit provides the barking without the bite! Can be connected to a doorbell, pressure mat or any other intruder detector and produces random threatening barks. Includes mains supply and horn speaker.

XK125 **£21.95**

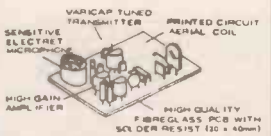
PROGRAMMABLE ELECTRONIC LOCK KIT



Keys could be a thing of the past with this new high security lock. Secure doors to sheds, garages, even your home or prevent the unauthorised use of computers, burglar alarms or cars. One 4–digit sequence will operate the lock while incorrect entries will sound an alarm. The number of incorrect entries allowed before the alarm is triggered is selected by you. Further entries will be ignored for a time also set by you. Only the correct sequence will open the lock and switch off the alarm. The sequence may easily be changed by entering a special number and code on the supplied keyboard. Kit includes; keyboard, alarm buzzer, high quality PCB and all electronic components. Supply 5–15V DC. Will drive our Latch Mechanism (701 150 @ £18.98) or relay directly.

XK131 **£19.95**

SUPER–SENSITIVE MICROBUG



Only 45x25x15mm, including built–in mic. 88–100MHz (standard FM radio). Range approx. 300m depending on terrain. Powered by 9V PP3 (7mA). Ideal for surveillance, baby alarm etc. **XK128** **£6.35**

DISCO LIGHTING KITS

DL8000K 8–way sequencer kit with built–in opto–isolated sound to light input. Only requires a box and control knob to complete **£39.95**

DL1000K 4–way chaser features bi–directional sequence and dimming 1kW per channel ..**£23.95**

DLA/1 (for DZ1000K)
Optional op-to input allowing audio beat/light response.....**95p**

DL3000K 3–channel sound to light kit, zero voltage switching, automatic level control and built–in mic. 1kW per channel **£19.55**

XK139 Uni-directional chaser. Zero switching and built-in audio input.....**£12.95**

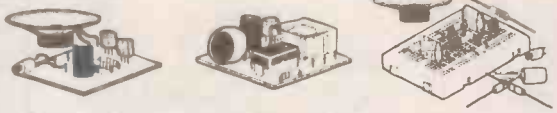
POWER STROBE KIT

Produces an intense light pulse at a variable frequency of 1 to 15Hz. Includes high quality PCB, components, connectors, 5Ws strobe tube and assembly instructions. Supply: 240V ac. Size: 80x50x45.

XK124 STROBOSCOPE KIT. **£17.25**

SIMPLE KITS FOR BEGINNERS

Especially aimed at the beginner. Have fun with your project even after you have built it and also learn a little from building it. These kits include high quality solder resist printed circuit boards, all electronic components (including speaker where used) and full construction instructions with circuit description.



SK1 DOOR CHIME plays a tune when activated by a pushbutton **£4.50**

SK2 WHISTLE SWITCH switches a relay on and off in response to whistle command **£4.50**

SK3 SOUND GENERATOR produces FOUR different sounds, including police/ambulance/fire–engine siren and machine gun **£4.50**

XK118 TEN EXCITING PROJECTS FOR BEGINNERS this kit contains a solderless breadboard, components and a booklet with instructions to enable the absolute novice to build ten fascinating projects including a light operated switch, intercom, burglar alarm and electronic lock. Each project includes a circuit diagram, description of operation and an easy to follow layout diagram. A section component identification and function is included, enabling the beginner to build the circuits with confidence **£17.25**

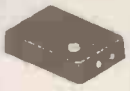
NEW

REMOTE CONTROL DIMMER KIT

Imagine controlling the brightness of your lights or switching them on or off from the comfort of your armchair! This kit contains all the components from front panel to the last screw to enable you to do just that and fit the shallowest wall boxes. Max power 300W (not fluorescents).

XK132.....**£19.95**

IR TRANSMITTER KIT



Designed for use with the XK132 and comes complete with a pre-drilled box. A PP3 9 volt battery is required.

MK 6.....**£4.95**

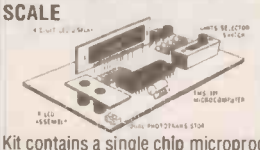
XK136 TOUCH DIMMER KIT.....**£12.95**

VERSATILE REMOTE CONTROL SYSTEM

These kits can switch up to 16 pieces of equipment on and off or control 16 functions depending on the keyboard selected for the MK18 transmitter. MK12 receiver has 16 logic outputs and operates from 12 to 24V d.c. or 240V a.c. via the transformer supplied. The MK18 requires a 9V battery and keyboard. Great for controlling lights, TVs, garage doors etc.

MK12 IR Receiver.....**£19.55**
MK18 Transmitter.....**£8.95**
MK 9 4-way Keyboard.....**£2.75**
MK10 16-way Keyboard.....**£7.95**
601 133 Box for transmitter.....**£2.95**

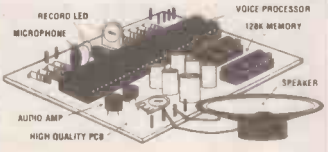
ELECTRONIC WEIGHING SCALE



Kit contains a single chip microprocessor. PCB, displays and all electronics to produce a digfital LED readout of weight in Kgs or Sts/Lbs. A PCB link selects the scale-bathroom/two types of kitchen scales. A low cost digital ruler could also be made.

ES1 **£8.25**

VOICE RECORD/ PLAYBACK KIT



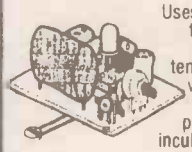
This simple to construct and even simpler to operate kit will record and playback short messages or tunes. It has many uses – seatbelt or light reminder in the car, welcome messages to visitors at home or at work, warning messages in factories and public places. In fact anywhere where a spoken message is announced and which needs to be changed from time to time. Also suitable for toys – why not convert your daugher's £8 doll to an £80 taking doll!!

Size ..... 76 x 60 x 15mm

Message time ..... 1–5 secs normal speed, 2–10 secs slow speed

XK129 **£25.95**

PROPORTIONAL TEMPERATURE CONTROLLER KIT



Uses "burst fire" technique to maintain temperature to within 0.5°C. Ideal for photography, incubators, wine making, etc. Maximum load 3kW (240V AC). Temperature range up to 60°C. Size 50x40x25mm. **XK140**.....**£8.95**

TK ELECTRONICS

TK ELECTRONICS

13 Boston Road
London W7 3SJ
Tel: 081-579 9794
Fax: 081-566 1916

ORDERING INFORMATION All prices INCLUDE VAT. Free P & P on orders over £60 (UK only), otherwise add £1.15. Overseas Customers divide total order by 1.15 then add P & P: Europe £3.50, elsewhere £10.00. Send cheque/PO/Visa/Access No. with order. Giro No. 529314002. Local Authority and educational institutions orders welcome. Shop Open: Tuesday–Thursday 10 am – 5 pm. Saturday 10 am – 4 pm.

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INCORPORATING ELECTRONICS MONTHLY

The No.1 Magazine for Electronic & Computer Projects

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GCSE PROJECTS

Help! Please, teachers, parents, students help us and help yourselves. Almost everyday my postbag carries letters from GCSE students working on crazy projects. Our new series *Project Development for GCSE* has been written by a GCSE assessor and hopefully the series will go a long way in helping to sort out the basic problems which arise time and time again. I know it would be great to be able to build a radio link and p.a. system to contact the whole school, but it is not a practical project.

IMPORTANT

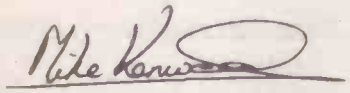
Can I say that in my opinion no student should be allowed to even consider anything that involves a radio link of any sort. First of all such a project could not be legally used in the UK and secondly, working at radio frequencies requires specialist knowledge and equipment that is not available at secondary school level.

Sensing objects/people at a distance is equally fraught, it would for instance be necessary to use radar or a laser to measure the distance between two cars travelling at speed. It seems like a good idea to build a "keep your distance" device but it is well outside the capabilities of GCSE students and teachers (and many professional engineers too).

GCSE assessors are not very concerned about the complexity of the project – try something very complex and it is likely to end in dismal failure. Make sure you have plenty of time to consider just how difficult a particular project might be *before* you commit yourself to it. Discuss it with teachers, parents, someone who works in the electronics industry, anyone who can provide some realistic idea of just what might be involved in realising a working project.

DIFFICULT

I find it very hard to reply to students' letters telling them that they should not be undertaking their chosen project – particularly if they have already spent a lot of time and effort searching for possible solutions. Please read our new series – I believe it will help everyone to get more students achieving Grade C marks or better.



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All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot however guarantee it and we cannot accept legal responsibility for it.

COMPONENT SUPPLIES

We **do not supply electronic components or kits** for building the projects featured, these can be supplied by advertisers.

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

We regret that we **cannot provide data or answer queries on projects that are more than five years old.**

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We would like to advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the U.K. Readers should check the law before using any transmitting or telephone equipment as a fine, confiscation of equipment and/or imprisonment can result from illegal use. The laws vary from country to country; overseas readers should check local laws.

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BACK ISSUES

Certain back issues of EVERYDAY ELECTRONICS are available price £1.70 (£2.20 overseas surface mail) – **£ sterling only please** – inclusive of postage and packing per copy. Enquiries with remittance, made payable to Everyday Electronics, should be sent to Post Sales Department, Everyday Electronics, 6 Church Street, Wimborne, Dorset BH21 1JH. In the event of non-availability one article can be photostatted for the same price. *Normally sent within seven days but please allow 28 days for delivery.* **We have sold out of Sept., Oct. & Dec. 85, April, May, Oct. & Dec. 86, Jan., April, May & Nov. 87, Jan., March, April, June & Oct. 88, & March** 90.

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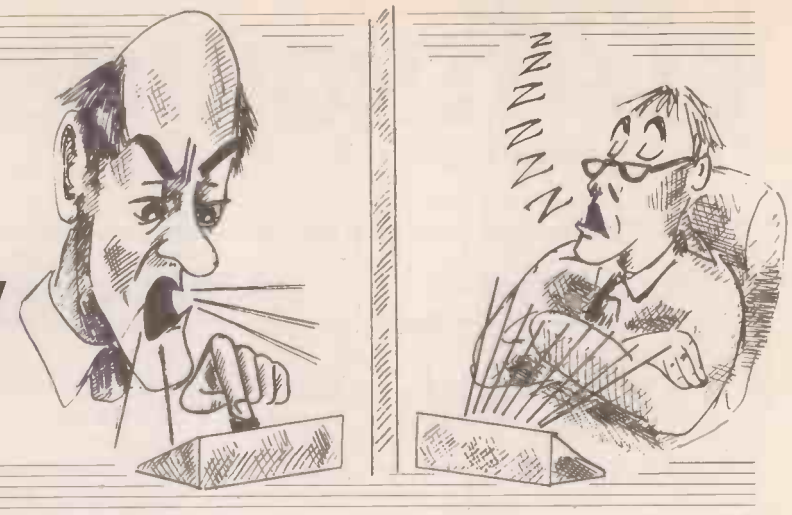
Teach-In '91 Project

SIMPLE INTERCOM



MIKE TOOLEY BA

The second constructional project to accompany our Design Your Own Circuits series takes the form of a Simple Intercom. This unit provides two-way communication over a simple two-wire circuit and, as with all of the practical constructional projects in this series, a number of modifications are suggested so that the more intrepid constructor can customise the unit to his or her own particular requirements.

A SIMPLE intercom can prove to be an asset in almost every home. Such a unit can provide an instant and effective means of two-way communications between nursery and lounge, kitchen and workshop, or wherever else it may be needed. All that is required is a medium gain amplifier and a low-power output stage connected along the lines shown in Fig. 1. A simple oscillator circuit can be added to provide a tone-call facility, as shown in Fig. 2(a). Remote tone calling can be achieved by a.c. coupling the remote speaker/microphone and switching the d.c. path to the remote station, as in Fig. 2(b).

Our simple intercom has been designed to satisfy the need for a low-cost system which can be readily expanded to permit the connection of extra stations. It also provides a useful practical application of the circuit design techniques described in Part Two of our series.

Circuit description

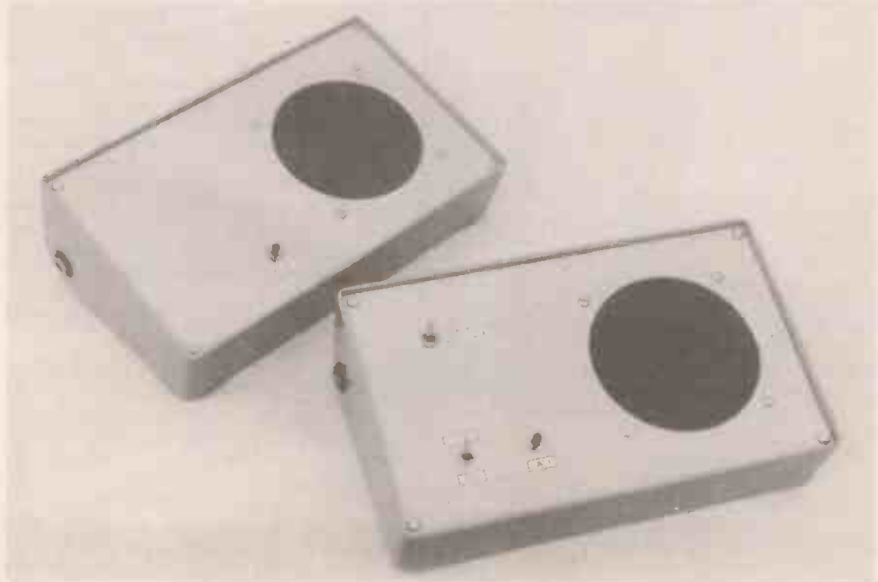
The complete circuit of the Simple Intercom is shown in Fig. 3. The circuit is based on a single operational amplifier stage, IC1, which provides a voltage gain of several hundred (determined by the ratio of R7 to R4). The operational amplifier stage operates in conjunction with a complementary transistor output stage, TR2 and TR3. This stage provides the additional current gain required to drive a 35ohm impedance loudspeaker, LS1.

A single +9V supply rail is used and hence, to provide the symmetrical positive and negative supply rails required by IC1, R5 and R6 form a potential divider to set the voltage at the non-inverting input of IC1 at 4.5V (i.e. the "half rail voltage"). This also fixes the quiescent voltage at the output of IC1 and at the junction of R8 and R9 at 4.5V. C2 provides decoupling of the half-supply voltage rail.

Transistors TR4 and TR5 are arranged as an astable oscillator (the frequency of which is determined by R13, R14, C7 and C8. R10 and C6 constitute a simple low-pass filter to shape the square wave oscillator output signal before it is applied to the input of the amplifier circuit. The supply to the oscillator circuit is switched on and off by means of TR1. This transistor operates as a "saturated switch"; TR1 will conduct when either S2 (a normally open push-button switch) is operated or the remote call-button places a short circuit across the intercom cable. When TR1 conducts, the d.c. supply to TR4 and TR5 is enabled and oscillation commences.

Switch S3 acts as a "talk/listen" switch. This switch (a double-pole double-throw miniature toggle switch) changes over the internal and remote loudspeakers so that communications can take place in both directions.

The circuit diagram of the remote station is shown in Fig. 4. This circuit requires



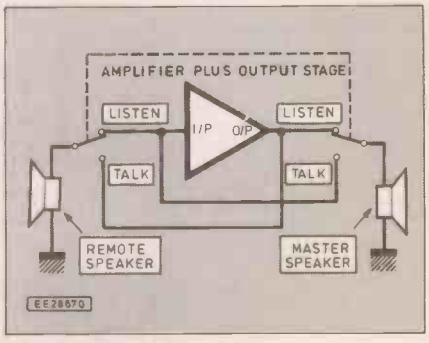


Fig. 1. Block diagram of a basic intercom

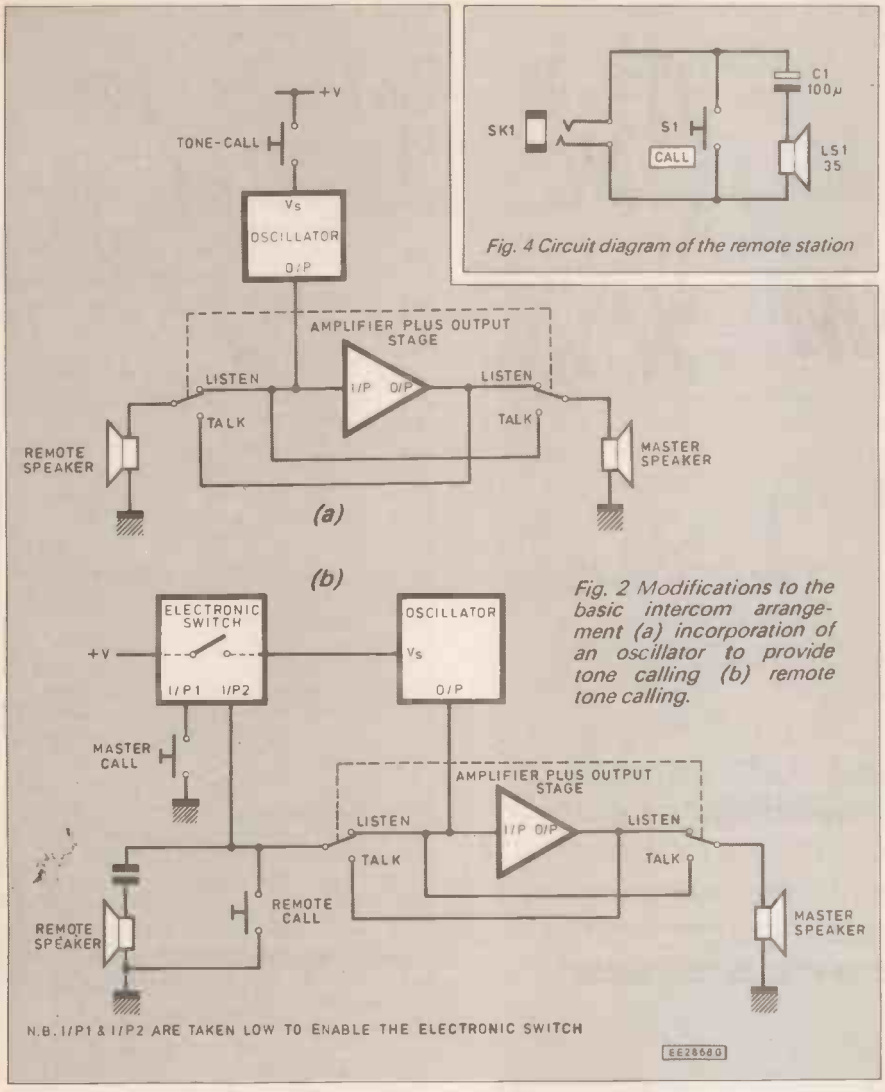


Fig. 2 Modifications to the basic intercom arrangement (a) incorporation of an oscillator to provide tone calling (b) remote tone calling.

Fig. 4 Circuit diagram of the remote station

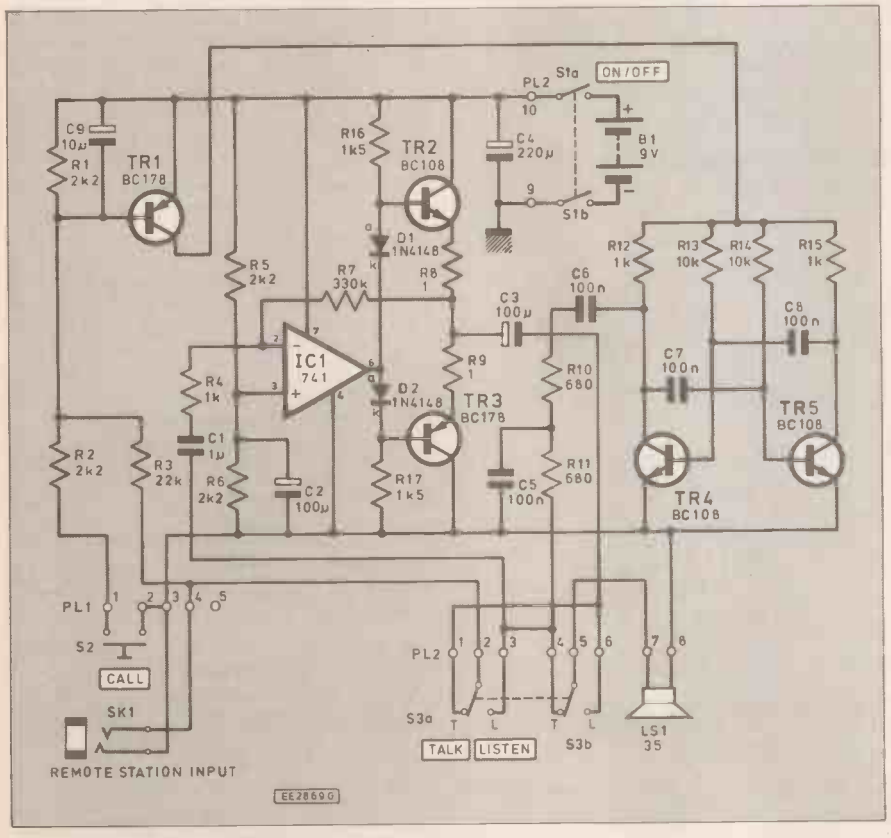


Fig. 3. Complete circuit diagram of the simple intercom.

little comment other than that S1 (a normally open push button switch) places a short-circuit across the line whenever it is operated. Such a short-circuit causes TR1 to conduct and thus enables the d.c. supply to the tone oscillator circuit of TR4 and TR5.

CONSTRUCTION

Construction is very straightforward and the vast majority of the components for the simple intercom are assembled on a single-sided printed circuit board measuring approximately 50 × 100mm. The layout of the printed circuit board is shown in Fig. 5.

Components should be assembled on the printed circuit board in the following sequence: p.c.b. headers, d.i.l. socket, resis-

COMPONENTS

See SHOP TALK Page

Resistors

R1, R2, R5, R6	2k2 (4 off)
R3	22k
R4, R12, R15	1k (3 off)
R7	330k
R8,R9	1 metal film 0.5W (2 off)
R10,R11	680 (2 off)
R13,R14	10k (2 off)

All resistors with the exception of R8 and R9 are 0.25W 5%

Capacitors

C1	1µ 100V min. polyester
C2,C3	100µ radial elect. 16V (2 off)
C4	220µ radial elect. 35V
C5,C6	100n 100V polyester (2 off)
C7,C8	100n 50V disc ceramic (2 off)
C9	10µ radial elect. 16V

Semiconductors

TR1,TR3	BC178 (2 off)
TR2,TR4, TR5	BC108 (3 off)
IC1	741
D1,D2	1N4148 (2 off)

Miscellaneous

S1	DPDT miniature toggle switch
S2	Miniature normally-open push-button
S3	DPDT miniature toggle switch
LS1	35ohm 4 inch speaker
PL1	5-way straight p.c.b. header (0.1 inch pitch)
PL2	10-way straight p.c.b. header (0.1 inch pitch)
SK1	Standard 0.25 inch jack socket

Printed circuit board available from the *EE PCB Service*, order code EE719: plastic p.c.b. fixing pillars with self-tapping No. 6 fixing screws (3 off); snap-fit PP3-type battery connector; 8-pin low-profile d.i.l. connector; sloping front ABS enclosure approx. 215 x 130 x 73mm (see text).

REMOTE STATION

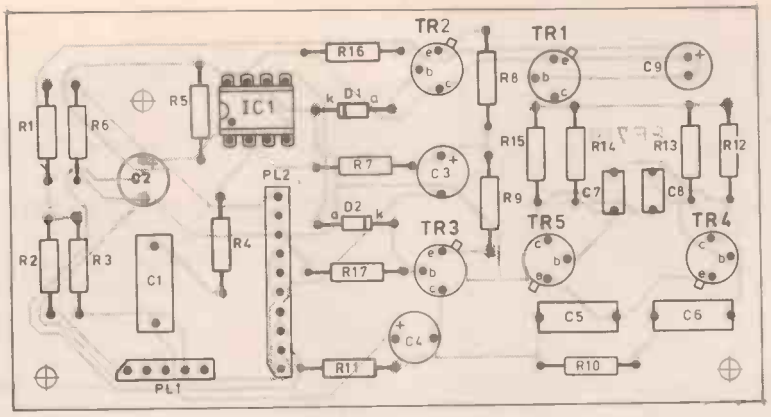
Capacitor

C1	100µ axial elect. 25V

Miscellaneous

S1	Min. normally-open push-button
LS1	35ohm 4 inch speaker
SK1	Standard open 0.25 inch jack socket; ABS enclosure (see text).

Approx cost guidance only **£22** *plus case*



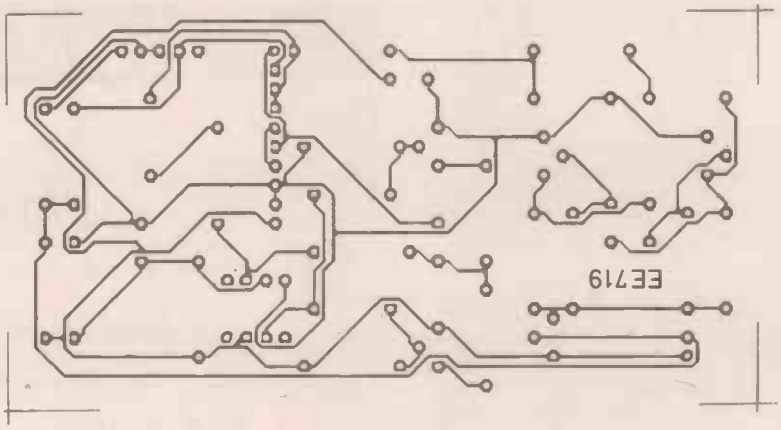


Fig. 5. P.C.B. layout for the simple intercom.

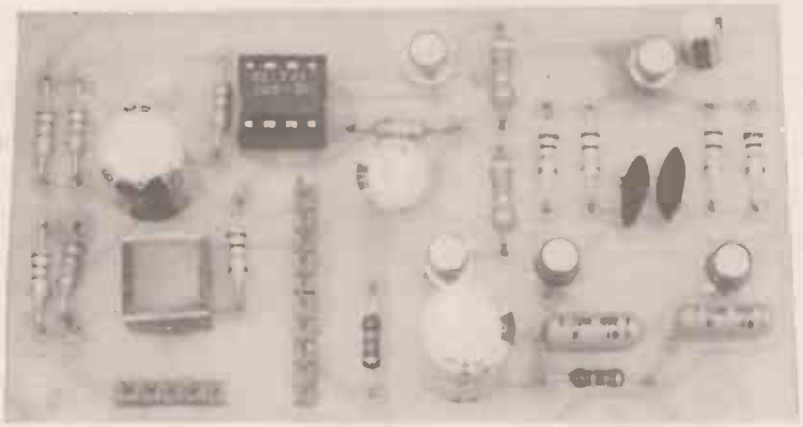


Fig. 6. Internal wiring of the simple intercom.

tors, capacitors, diodes and transistors. As with all of our projects, it is important to ensure that all of the components are correctly located. Furthermore, in the case of the polarised components (such as electrolytic capacitors, diodes and transistors) it is absolutely essential to ensure that each component is correctly orientated.

When construction of the printed circuit board has been completed (and before inserting IC1 into its socket) it is well worth carrying out a careful visual check of both the upper and lower sides of the board. The upper (component) side of the printed circuit board should be examined to ensure that the components have been correctly located whilst the lower (copper track) side of the board should be checked to ensure that there are no dry joints or solder bridges between adjacent tracks. This precaution will only take a few minutes to carry out but can be instrumental in preventing much heartache at a later stage!

When assembly of the printed circuit board has been completed, IC1 should be inserted into its socket (taking care to observe the correct orientation) and the board should then be mounted in the base of the plastic enclosure by means of three short snap-fit p.c.b. mounting pillars.

CASES

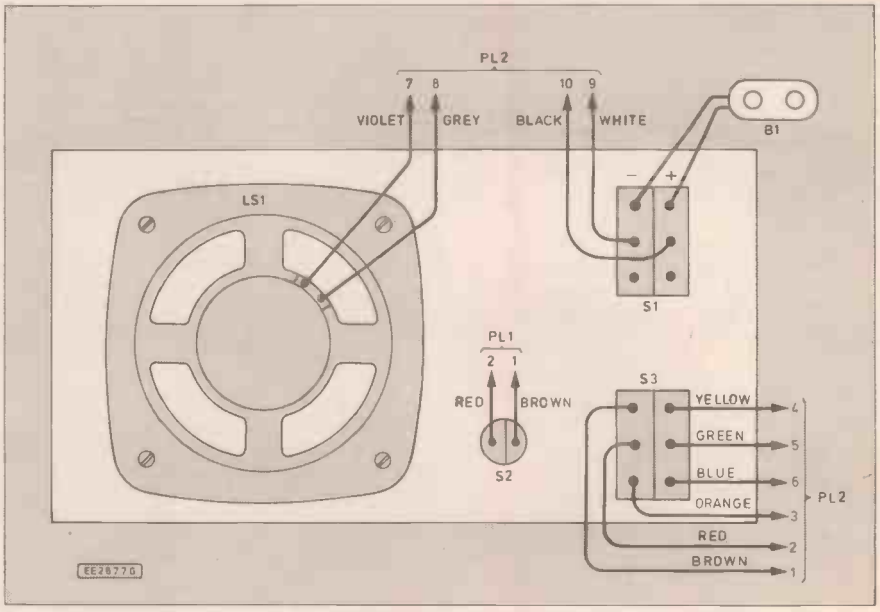
Both master and remote station units are housed in sloping front ABS enclosures (measuring 215 × 130 × 43mm min., 73mm max.). Such enclosures generally have a removable aluminium front panel which can be drilled and cut to accommodate the switches (S1, S2 and S3) and the loudspeaker, LS1.

Use of a loudspeaker of relatively large size (i.e. 4 inch diameter) is highly recommended since, in the author's experience, smaller units are rarely satisfactory on the grounds of both sensitivity and sound quality. In addition, medium impedance 35 ohm units should be used (not the more usual 8 ohm units). The remote station is connected by means of a standard 0.25 inch jack connector which is mounted at the lower left-hand side of the enclosure. A battery holder (for a PP3 9V battery) can consist of a simple L-shaped aluminium bracket secured to the base of the case.

The front panel should be carefully marked out before drilling and cutting takes place. As usual, there is nothing particularly critical about the layout of the unit and constructors may wish to experiment with the location of the loudspeaker and front panel controls.

The loudspeaker will require a round hole of suitable diameter (80mm on the prototype). Such an aperture may be cut by means of a tension file and then filed (using a half-round file) to an exact circular profile. Alternatively, an adjustable tank-cutter can be used (such a tool was used in the construction of the prototype). The same procedure should be adopted for the remote station.

Connections to the printed circuit board are made using two 0.1 inch pitch printed circuit board headers. A five-way header (PL1) is used for the master station call-button and the remote station jack connector whilst a 10-way header (PL2) is used for the talk/listen switch (S3), loudspeaker and supply connections (via S1). The procedure for terminating the female connectors which mate with the headers was described



in the first of our constructional projects which appeared last month.

Coloured stranded 0.1 inch pitch ribbon cable is used to make connections to the front and rear panels. The following colour coding is recommended:

PL1

Pin	Colour	Connection to:
1	Brown	S2 (master call button)
2	Red	S2 (master call button)
3	Orange	Jack connector (outer/ sleeve)
4	Yellow	Jack connector (inner/tip)
5		Not connected

PL2

Pin	Colour	Connection to:
1	Brown	S3a (master talk position)
2	Red	S3a (selector)
3	Orange	S3a (master listen position)
4	Yellow	S3b (master talk position)
5	Green	S3b (selector)
6	Blue	S3b (master listen position)
7	Violet	LS (loudspeaker)
8	Grey	LS (loudspeaker)
9	White	S1a (supply negative)
10	Black	S1b (supply positive)

The internal wiring of the simple intercom is shown in Fig. 6.

TESTING

Before testing the simple intercom, carefully check the wiring of the p.c.b. and front panel mounted components. The remote station should be connected to the master station by means of a length of two-core flex of appropriate length terminated with standard 0.25 inch jacks (it is important to ensure that the outer/sleeve connections are connected together).

Connect a PP3 battery to the battery connector and insert a milliammeter in one lead to the battery in order to measure the supply current to the unit. Now switch the unit on and measure the supply current. This should be in the range 5mA to 15mA. If this is not the case, disconnect the supply and carefully check the wiring and p.c.b.

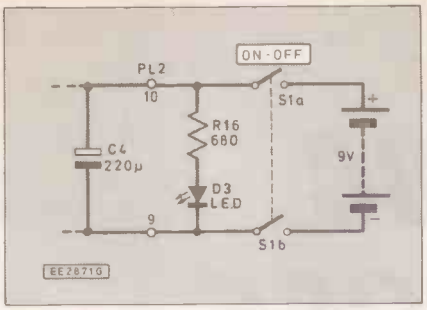


Fig. 7. Adding an l.e.d. indicator.

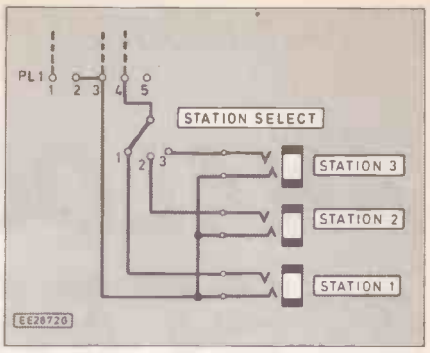


Fig. 8. Adding further remote stations.

If the supply current is correct, switch the unit to the "master talk" position and check that a signal appears at the remote unit. Depress the master call button (S2) and check that a loud tone is heard at the remote station. Switch to the "master listen" position and check communications in the reverse direction in a similar fashion. If either direction of communication is missing, check the wiring to S3. If the tone-call facility is not operating, check the connection of TR1 and the circuit around TR4 and TR5.

MODIFICATIONS

A number of useful modifications may be made to enhance the performance of the basic intercom circuit. The suggestions made here are provided as "food for thought" and should make a starting point for further development. Constructors are invited to report their own modifications to be incorporated in the *Readers' Feedback* which will appear in the final part of our Design series.

Adding an l.e.d. indicator

An l.e.d. indicator can very easily be added in order to provide the user with a visual warning that the unit is switched on and is "live". Fig. 7 shows the necessary circuit modifications.

Additional stations

Further remote stations can be added quite easily by means of an additional "station selector" switch and extra jack sockets (one for each additional remote station). Fig. 8 shows the modification required for a single-master/three- remote station system. The station selector switch can be a simple rotary switch (e.g. 1P 12W with the rotation stop suitably adjusted).

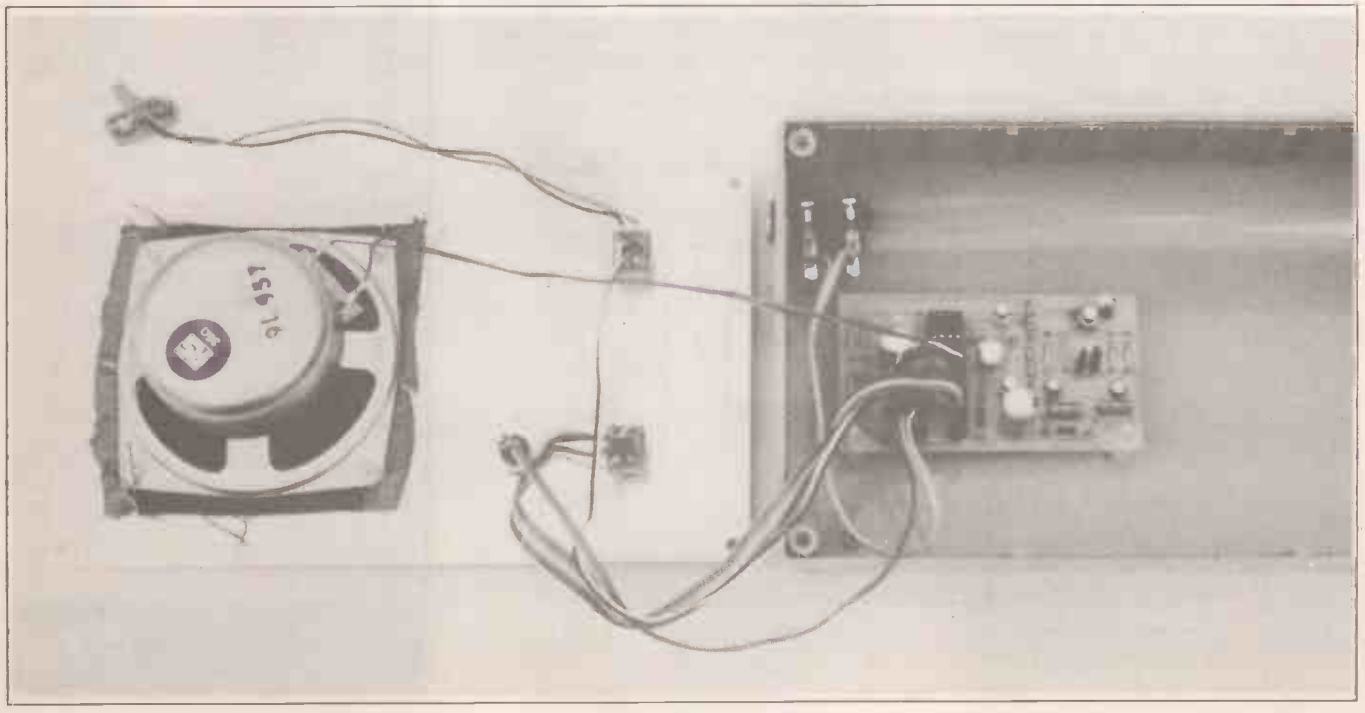
Increased output power

In some situations (e.g. in a noisy environment) it may be necessary to provide extra audio output from the intercom. This can easily be achieved by increasing the supply voltage to 18V by connecting two PP3 batteries in series. The following component changes should be made:

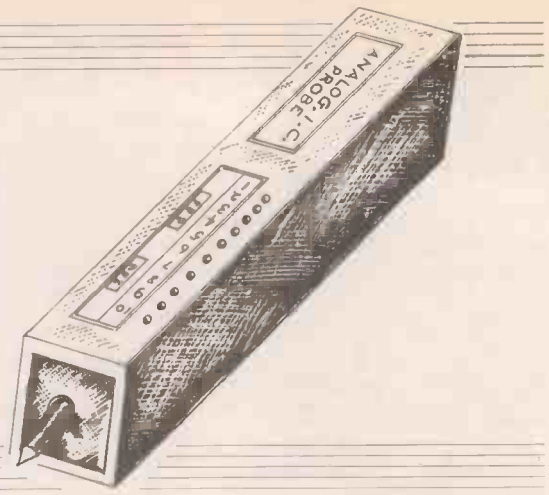
COMPONENT	Standard version	Higher power version
TR2	BC108	BC142
TR3	BC178	BC143
R16	1k5	3k9
R17	1k5	3k9
R3	22k	47k
C3	100µ 16V	100µ 35V

SPECIFICATIONS

Output power:	300mW r.m.s. max.
Voltage gain:	250 approx.
Number of stations:	1 master, 1 slave (may be easily expanded)
Call tone:	720Hz (approx.)
Supply voltage:	9V (PP3 battery)
Supply current:	7mA (standby) 50mA (tone call)



ANALOGIC TEST PROBE



MARK STUART

A very versatile test probe that measures voltage and indicates a.c. waveforms

THE idea for this project came about whilst trying to find a fault in an EE project. David, our new YTS, was using a logic probe to sort out the 16 l.e.d. Chaser Light project (EE Oct 86) and getting some curious results.

The Chaser Light circuit consists of a CMOS two gate oscillator driving a binary up/down counter, the outputs of which drive 16 l.e.d.s via a 4-to-16 line decoder. Normally the outputs and inputs of the logic i.c.s in these circuits are either at full supply or ground and spend little time in between.

The logic probe is fine in these circumstances and often leads directly to the fault. This circuit was different, because there was a voltage on one pin which was hovering around half of the supply. The logic probe read this as a 1 (high) but the i.c. was reading it as a 0 (low).

After some thought a multimeter came to the rescue and the fault was soon sorted out. It was apparent that if a probe with some type of continuous voltage indication had been available the fault would have been found much more easily.

Such a probe would also be useful in most other types of circuit, especially if it could read higher voltages and discriminate between a.c. and d.c. The circuit finally produced (in its original crude stripboard form) has been used on many circuits with success and has now been refined to make a simple useful and interesting project.

DISPLAY

The type of display required for a probe needs to be compact, shockproof and easily read. A miniature panel meter would be too delicate, an l.c.d digital display would be difficult to read, and both would be too expensive. Bargraph displays in the form of a row of l.e.d.s are rugged and relatively cheap. They have limited resolution (the ability to indicate very small changes) but for a simple probe displaying 10 levels gives sufficient information (much more than the standard two-level logic probe.

CIRCUIT

As Fig. 1 shows the circuit for the Analogic Test Probe is very simple, relying on the LM3914N l.e.d. bargraph driver i.c. This is not the cheapest of i.c.s but its simplicity and low external component count make it good value.

Before settling on this approach several other ways of driving a column of l.e.d.s were tried. Some were cheaper, but needed much more p.c.b. space and were more complicated. Using the LM3914N gives several other benefits. It has a stable internal reference voltage, programmable l.e.d. current, and a high input impedance. It is also very tolerant of overloads.

A simplified internal schematic diagram of the i.c. as it is used in this application is shown in Fig. 2. Pin 9 allows the display to be set to either Bar mode (where a column of l.e.d.s light up) or Dot mode (where only one l.e.d. lights at a time). Dot mode is chosen because of its much lower current demand, and is selected by leaving pin 9 open circuit. There is some small overlap between l.e.d.s so that the display appears to move smoothly up and down as the input voltage varies.

The brightness of the display is determined by the value of the resistor from pin 7 to the negative supply. This is set to 4mA per l.e.d. by a 3k3 resistor, and gives plenty of brightness with good quality standard l.e.d.s, and very good battery life.

The power supply arrangements for the probe are shown in Fig 1. A three-way slide switch S1 allows power to be taken from either an internal 9V battery or via a

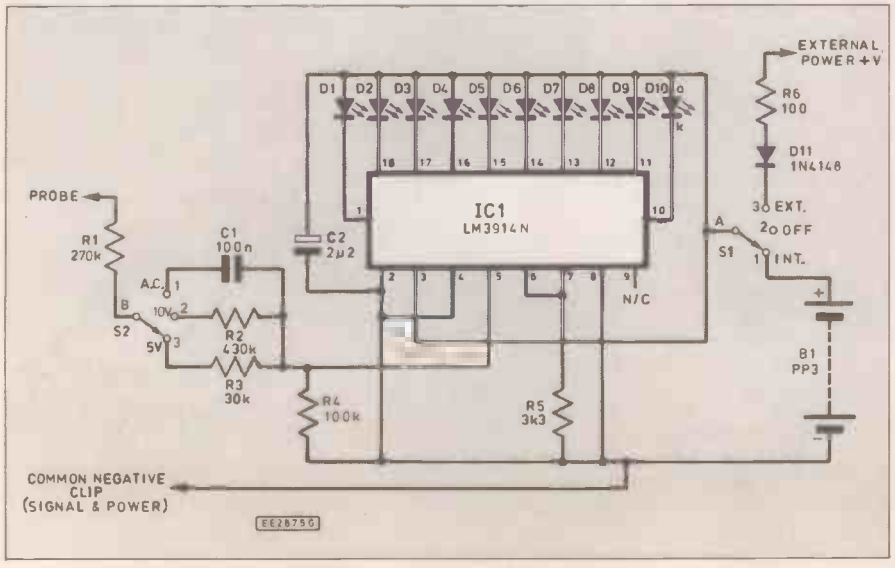


Fig. 1. Complete circuit diagram for the Analogic Test Probe.

COMPONENTS

Resistors

R1	270k	
R2	430k	
R3	30k	
R4	100k	
R5	3k3	¼W carbon ± 5%
R6	100	¼W carbon ± 5%

All ± 1% metal film, except where stated.

See SHOP TALK Page

Capacitors

C1	100n 100V ceramic plate
C2	2µ2 sub.min radial elect. 63V

Semiconductors

D1-D10	3mm red l.e.d.s (10 off)
D11	1N4148 diode
IC1	LM3914N bargraph driver

Miscellaneous

S1,S2	Single-pole 3-way slide switch (2 off)

Printed circuit board available from the *EE PCB Service*, order code EE720; red and black insulated crocodile clips and matching extra flexible leads (approx. 50cm long); PP3 battery clip and battery; M3 fixings for probe; probe case.

Approx cost guidance only **£14**

crocodile clip lead from the circuit under test. Voltages between 7 and 18 volts can be used as external supplies and up to 25V can be applied without damage. Current limiting resistor R6 and a polarity protection diode D11 prevent damage from incorrect power connection.

The input to pin 5 of IC1 needs to be 1.25V to give a full scale reading (top l.e.d. on). This is the input of a non-inverting op-amp and has a very low input leakage current and very high impedance. These characteristics make it easy to add a potential divider circuit so that the probe will read the required voltage range. In the prototype the ranges are 0-5V and 0-10V d.c., and 0-5V r.m.s. a.c.

On the a.c. range a capacitor is added in series with the input path. This blocks all d.c. up to the capacitor voltage rating of 100V, and allows only any a.c. element present to pass. The i.c. displays only positive half cycles and ignores the negative ones, giving a simple form of rectification. The resulting display will indicate the waveform as well as the peak voltage and gives full scale for 5V r.m.s.

As the a.c. wave rises and falls from its peak value the intermediate l.e.d.s will respond and their brightness will indicate the amount of time that the signal spends at each voltage level. A triangular wave will light all l.e.d.s evenly as it passes through each value, whilst a square wave will light only the peak value as it moves so rapidly between the intermediate values. These types of displays will also be observed when using the d.c. ranges if the voltage is varying. A good illustration of this can be obtained by using the probe to observe the capacitor voltage in an astable 555 i.c. oscillator.

the board after the switch has been fitted. To keep the board as small as possible one pin of each switch must be bent under the switch body, this should be done carefully so that the mechanism is not distorted in any way.

The l.e.d.s must be mounted so that they align with the holes in the case. To do this, first fit all of the l.e.d.s into their holes in the p.c.b. leaving them unsoldered and with full length leads.

Fit the board in position, taking care to line up the switches in their slots, and push the l.e.d.s into place in their holes in the case. Ensure that all of the l.e.d.s are the correct way round by checking that the short lead which indicates the cathode (k) is

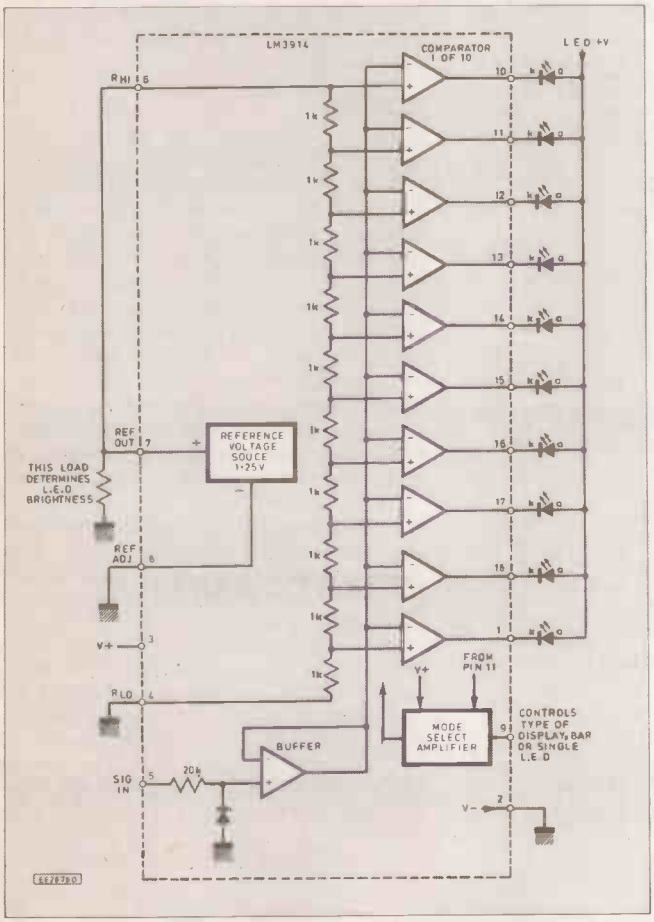


Fig. 2. Internal circuit details for the LM3914N i.c.

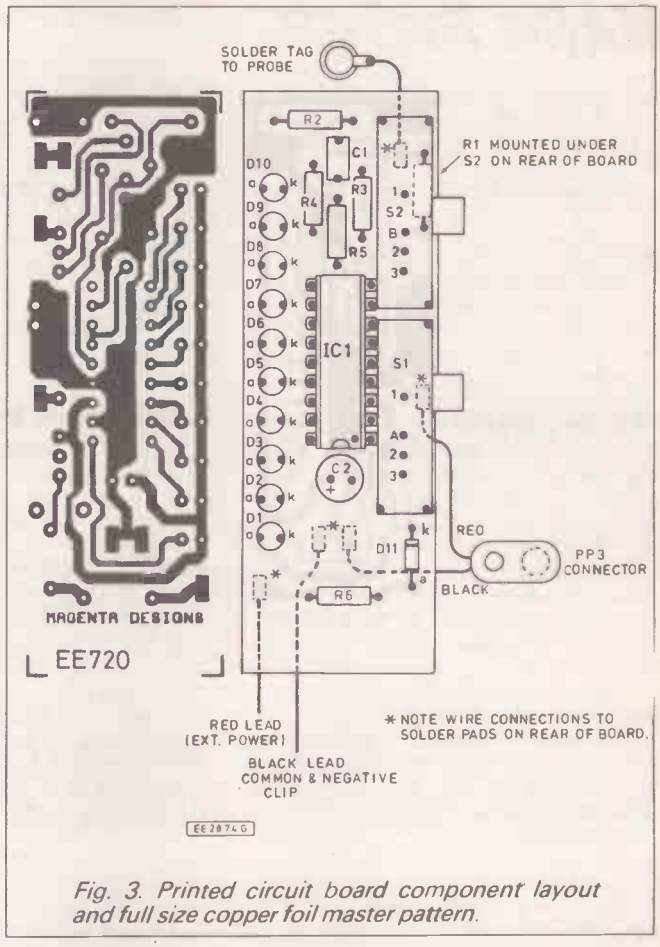


Fig. 3. Printed circuit board component layout and full size copper foil master pattern.

RANGE SWITCHING

The three position slide switch S2 selects the range by introducing the necessary divider components. Resistors R1, R3, and R4 on the 5V range, R1, R2, and R4 on the 10V range, and series d.c. blocking capacitor C1 along with R1 and R4 on the a.c. range.

Changing the values of R1, R2, and R3 will allow different ranges to be covered. For example making R1 from two 10M resistors in series will give 0-250V d.c. High voltages such as these will not be applied directly to the i.c. because of the potential divider and so are quite acceptable.

The resistor values are selected to divide by four for the 5V range and eight for the 10V range as follows:

5V – 1.25V R4/(R1 + R3 + R4)
= 100/270 + 30 + 100)
= 100/400 = 1/4

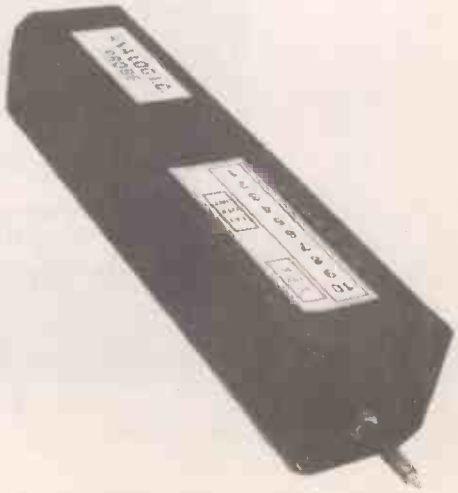
10V – 1.25V R4/(R1 + R2 + R4)
= 100/270 + 430 + 100)
= 100/800 = 1/8

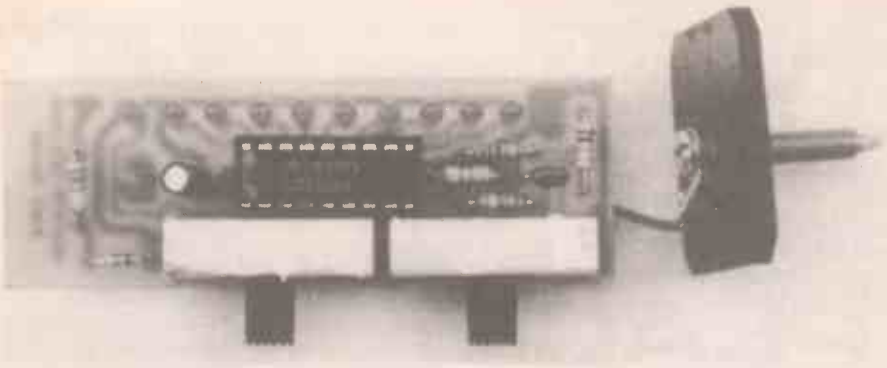
CONSTRUCTION

A special probe case is used to house the circuit. This is available pre-drilled for the l.e.d.s and slide switches. The circuit is built on a printed circuit board. The foil track pattern and the component layout is shown in Fig 3. The resistors and capacitors should be fitted first, followed by D1 and a socket for the i.c. Capacitor C2 and D1 must be fitted the right way round as shown in Fig 3.

Resistor R1 is fitted beneath S2 and so double check that it is the correct value before fitting the switch over it. Alternatively R1 can be fitted to the track side of

The completed Analogic Test Probe showing lettering of the l.e.d.s.





The completed circuit board with the slide switches soldered in position. Resistor R1 is mounted track side – see photo below.

nearer to the i.c., and solder them into position one by one, ensuring that they are pushed evenly down into the case holes. The board can now be removed and the connecting leads added.

The leads from the battery clip, the probe tip, and the external ground and power leads are connected to rectangular track areas on the rear of the board. Use thin extra-flexible test lead wire for the ground and power leads. Do not fit the clips to the other ends of these leads yet, as first they must be threaded through their hole in the case, after the circuit has been tested.

TESTING

For testing it is better to apply power via the external power leads than from the battery clip because the series diode and resistor will prevent excess current if there is a fault. Insert the i.c. being careful to get it the right way round, set the switches to "external power" and 10V d.c., and apply 9V via the external power leads. There should be no smoke and all l.e.d.s should be out.

Next connect the probe input lead to the positive supply and check that l.e.d.s D8, D9, or D10 light. Switch to the 5V d.c. range and only l.e.d. D10 should be lit. On the a.c. range the l.e.d.s should light briefly as the input is connected and then go out.

If all is well, try to find other voltages and see that the readings correspond with the range selected. If nothing works check for dry joints, reversed power leads and components, and p.c.b. track bridges and cracks. Check the voltages around IC1, in particular, the power supply to pin 3 and the reference voltage on pins 6 and 7.

A wrong value resistor for R3 could give very low l.e.d. current, and any wrong values at the probe potential divider will give incorrect ranges. There can be few faults with such a simple circuit and hopefully most units will work from scratch.

FINAL ASSEMBLY

A long M3 screw which is filed to a point and fitted with sleeving over most of its length forms the probe tip. This is fitted to the front panel of the case with one nut and a shakeproof washer. Its connection to the board is via a solder tag and a short length of flexible wire.

The board is held in position by means of the switch bodies which are glued to the case on two sides. Use a flexible glue such as Evo-Stik which will allow the board to be removed in the future if repairs are needed. Apply glue to both surfaces and allow 15 minutes for it to go tacky. The board will then be held firmly immediately it is pressed into position. Alternatively double-sided sticky pads are suitable but do not give quite as rigid a result.

The case specified has interlocking top and bottom sections that take a certain amount of knack to separate. The plastic material used is very tough however and so should resist considerable force. To retain the battery an internal divider can be made and glued in and the battery retained with foam plastic. Alternatively a sticky pad can be used to hold the battery directly to the case.

BATTERY LIFE

The circuit consumes approximately 4mA when the l.e.d.s are out, so battery drain should be very small. Take care though to switch off after use as even this low current will flatten a PP3 in a less than a week. Note that either the Off or External Power positions of the switch will disconnect the battery.

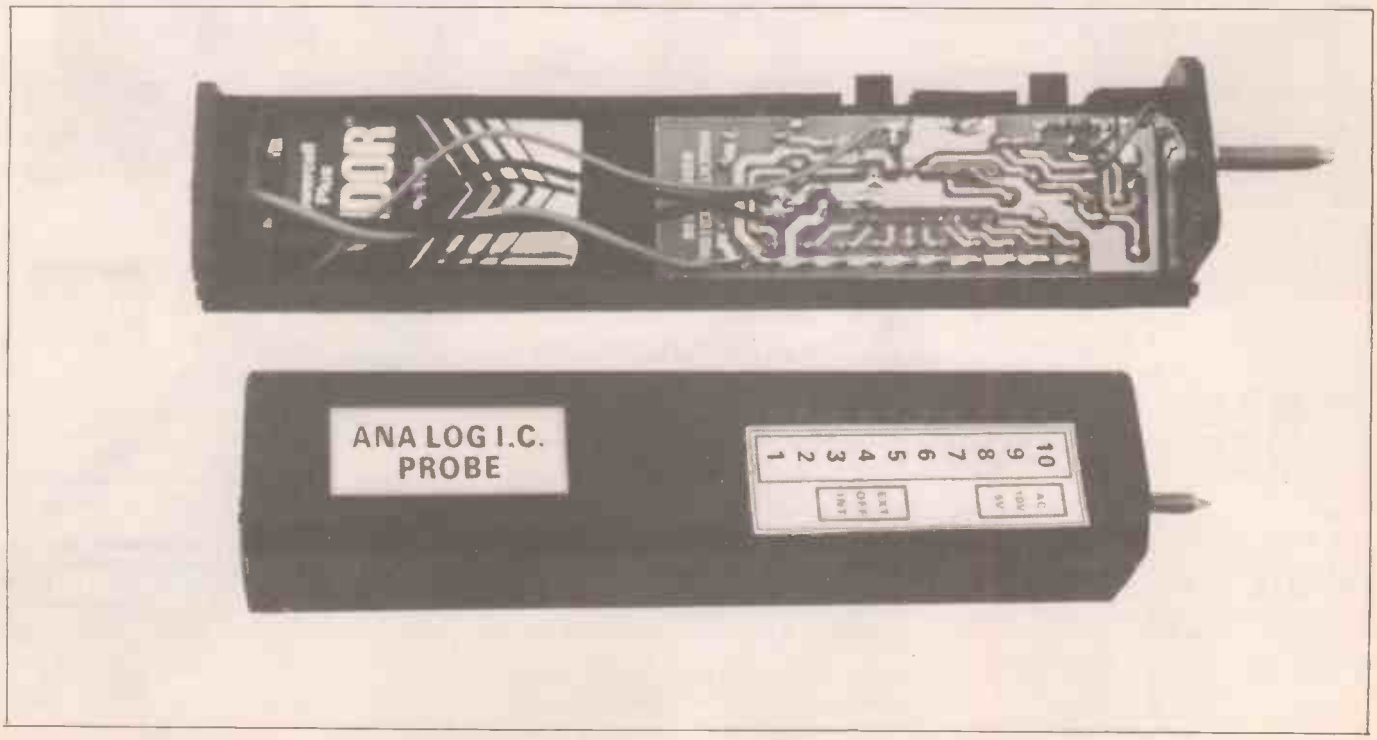
USE

There is little that can be said about such a simple and versatile instrument except that it will become indispensable and get regular use. The probe tip is able to withstand overloads in excess of 250V a.c. on all ranges and the power input is safe up to 25V. Remember that two connections are required to get sensible voltage readings and so the Ground lead must always be connected to the *negative* point in the circuit under test.

The external power lead can be removed if its use is unlikely. When external power is connected always connect the Ground lead first. Accuracy is assured by the use of one per cent potential divider resistors. The i.c. has similar accuracy, and so the readings are as precise as the display allows.

CUSTOMISING

Individual ranges can be tailored for specific uses by altering the voltage divider resistors as discussed earlier, and extra range switching could be incorporated by adding a small toggle switch and additional resistors. In this way the probe can be set up for unskilled users to make simple checks on equipment in the field or in factory test departments. □



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PROJECT DEVELOPMENT FOR GCSE

Get the grade you deserve! A GCSE assessor gives some practical advice.

THIS is the first part of a six-part series concerned with the GCSE Electronics Practical Assignment. By making clear what is expected of you and in helping you to plan your time and pace the work, you are more likely to obtain the best mark for your ability. This month, I shall give some GCSE background information and discuss how the practical project will be assessed.

Although aimed at mainstream **GCSE Electronics**, much of this information would be helpful for students making projects for **GCSE (mature)**, **GCSE Technology** and for certain non-GCSE based examinations.

Background Information

The examining board offering GCSE Electronics are, MEG (Midland Examining Group), LEAG (London East Anglian Group), SEG (Southern Examining Group), NEA (Northern Examining Association) and the Welsh Joint Education Committee. The system north of the border is different but the Scottish Examining Board operates a system of short courses one of which – Electronics Design Project – involves similar processes. Students entering for this would benefit from some of the information given here.

As well as the written examination(s) sat in the summer of the second year of study, GCSE boards require students to construct a practical project or projects. In most cases you have a free choice of topic.

Precise requirements and the percentage of final mark available for the project varies from one board to another. It may also depend on whether or not you are attempting the extension paper. This information is set out in more detail later.

Extension paper

The extension paper is a more difficult written paper aimed at the most able students. Doing this enables you to obtain a grade A or B and normally you cannot obtain these grades without having sat it. Many schools use the results of a mock examination to determine whether or not you will be allowed to attempt the extension paper. You will have to trust the judgement of your teacher or lecturer – the school or college cannot enter candidates for the extension paper who have no chance of obtaining grade A, B or C.

If you are entered for the extension paper and make an unexpectedly poor effort, you will not end up with a grade lower than you would have obtained had you not attempted it. Also, under exceptional circumstances, a candidate not entered for the extension paper may occasionally obtain a grade B with some boards. Note that the syllabus number often depends on whether the extension paper is included or not.

Detailed requirements

Note: the following requirements apply to candidates entering as full-time students at a school or college. Part-time and privately-entered students should consult the board as should students taking GCSE Electronics as a one-year course. This is because there may be differences in detail.

Midlands Examining Group (MEG) Syllabus 1751

Candidates must attempt either one long or up to three short practical assignment(s). Although there is a free choice of topic, the board publishes a list of suggestions. The total time spent on the project should be in the region of 20 hours and will be worth up to 40 per cent of your final mark.

You must complete a specification sheet and have it approved by your teacher before work commences. You will be asked to complete all work and hand in your written report sometime in April.

Southern Examining Group (SEG) Syllabus 1060 or 1061 (with extension paper)

Candidates must undertake one major project. A free choice is allowed but the board requires a project brief to be approved before starting development work. This must be completed during late February.

The project is worth up to 25 per cent of the final mark and will involve, typically, 24 hours of work. You will be asked to hand in all work, including at least one photograph of the completed artefact, sometime in mid-April. The written report should be 1000 to 3000 words in length.

London East Anglian Group (LEAG) 1505 or 1506 (with extension paper)

In January, schools are sent six outline project briefs in booklet form and each candidate will receive a copy. The school offers at least four and from these you choose one. If you are attempting the extension paper, the project is worth 15 per cent but if not, it is worth 20 per cent. You are expected to spend about 12 hours of laboratory time on your project and will be asked to hand in all work towards the end of April.

Northern Examining Association (NEA)

One major project is required and this is expected to occupy approximately 30 hours of laboratory time. Although a free choice is allowed, an outline form must be completed and submitted to the board. You will be asked to hand in all your work, including the written report (a maximum of 2000 words is suggested) and a photograph of the completed device, sometime in May. The project is worth up to 35 per cent of the total marks.

Welsh Joint Education Committee

One major project is required and although a free choice is allowed, approval is needed by the board before work commences. The project is worth up to 30 per cent of the final mark.

Assessment

When students learn that it is their own teacher who does an initial assessment of their practical work they sometimes think that this degrades the status of the exam. Some mistakenly believe that their teacher will give them higher (or lower!) marks than they deserve. Think though – who is better at knowing you as an individual and how much (or how little !) of your own effort has gone into the work you produce?

As regards giving marks which are too high – this is not possible because your teacher follows a standard set of criteria supplied by the board – not his or her own. Also, the work is subject to moderation by the examining board. This means that an assessor, or moderator, appointed by the board, may visit your centre, talk to your teacher and look at candidates' work. The assessor may not visit the centre but instead ask for the work of certain candidates to be sent by post.

The moderator sees the work of several schools and can apply an adjustment where necessary so that the mark you obtain is

fair and reflects the quality of the work not only in your own centre but nationwide. Assessors meet, mark the same pieces of work independently and compare results. The board can then be sure that they are applying uniform standards. You may be assured that assessment is closely controlled and fair.

Get organised!

When you are told that you may begin preliminary work on your project, there are a few things to get clear in your mind. Firstly, find out which examination board is setting your exam. Remember, this will not necessarily be the same as the Physics or Technology one.

Find out the syllabus number and whether you will be entered for the extension paper or not. Find out what approximate grade you would have achieved based on any mock exam mark you have obtained. Ask your teacher – and yourself – what grade you should reasonably aim for and go for it.

Find out the deadlines you will be working to. You teacher will tell you the date on which any outline brief is required as well as that for the finished project and written report. **This really is a deadline and schools will not accept material arriving late.** Your teacher has quite a lot of administration to do before sending the paperwork off to the board.

Enter in your diary your own deadline which will take account of little things going wrong. One or two weeks before the true deadline will be sufficient. Find out what proportion of lesson time will be devoted to pursing the project. Some teachers allow only some of the lessons to be used, others allow all available time. Find out whether you will be able to work in lunchtimes.

Generally, you cannot take your project home to work there because your teacher must certify that it is all your own work and must therefore keep you under supervision. Remember, where a certain number of hours laboratory work are suggested, these are only guidelines. You may spend longer if you wish.

At first the deadline will seem far away and many students only really start to work when the end is in sight and they feel the pressure. *These students are unlikely to obtain a good mark* – I have seen this time and time again. Those who start planning straight away do well. Remember – **best project marks do not necessarily go to candidates who produce the most elaborate device.** It is quite usual for some of the best marks to be awarded for very modest – even non-working – projects. You must treat your own situation in the most advantageous way. All this will be discussed in detail in later articles.

Who pays for the components?

Schools often allow development work to be carried out with their components. This saves you money especially where a few components are destroyed by what may be called "forgivable experimentation". Some schools insist on payment for components which you ruin when you should have known better – operating an l.e.d. without a series resistor to limit the current, for example.

You will be asked to pay for any components taken from school stock and used in building the final version of your circuit. This is especially true if you intend keeping it after it has been assessed (although it may not be released by the examining board until September). Different schools have different policies so find out now what costs you will be responsible for.

You may be able to buy components cheaply through the school as a result of bulk buying. Alternatively, you may be able to form your own purchasing group with a few other students and so save packing and postage costs. Some mail order suppliers give a discount where several of the same item are ordered together.

Being realistic

I cannot stress enough the importance of having a realistic view of your ability in relation to the complexity of the circuit you are wishing to build. At this time of year, the EE editor's office receives a number of letters from students asking for assistance. Some of these pass through my hands. Frankly, *I am dismayed by the complexity of many of the proposed circuits.* It is usually clear that the candidate has only the basic knowledge and average ability. Embarking on such a project would certainly end in disaster.

Some candidates wish to use radio links which, apart from being illegal, would be very difficult to construct even by an expert. **These complicated circuits are not required for GCSE.** I hate to dampen enthusiasm but there would be very little of this left in March or April anyway! Your teacher's advice is, of paramount importance. If you are not sure of the standard required, *ask the examination board* – they will probably oblige with a list of examples.

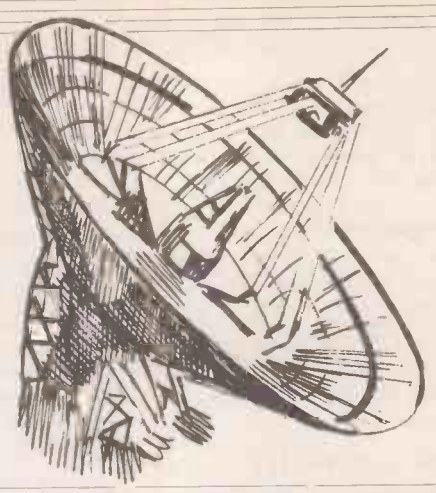
Final point

GCSE examinations are based on positive achievement. This means that you gain marks for what you do well and do not lose them for things which you do badly. In other words, you only stand to win!

That's all for this month. Next time we shall look in detail at the steps you should take in preparing to build your chosen circuit. We shall also look at the development work needed for a fictitious project.

Feature

MILITARY ELECTRONICS



PETE CHOWN

MILITARY electronics suddenly became headline news at the start of the Falklands war when *HMS Sheffield's* Seawolf defence system failed with catastrophic results. The problem was a classic one of technology being placed in an unfamiliar situation. Because the Exocet was made in France, the system decided that it was friendly (it was designed to defend shipping from an Eastern Block attack) and no attempt was made to shoot it down.

In this article, we can only consider a small part of the vast subject of military electronics; we will be emphasising missiles and guidance systems, battlefield simulations, radar and communications. Finally there is a brief look at what the future of warfare may be like.

Missiles and Guidance Systems

Despite the huge variety of different missiles, guidance systems follow only a few basic patterns.

Anti-aircraft or anti-missile missiles generally are either heat seeking or radar guided. Heat seeking missiles carry an infra-red camera, which allows them to detect the exhaust plumes from aircraft or missiles. It is much better to detect infra-red than visible light, because there is a large amount of infra-red coming from the exhaust plumes, whereas for visible light it would be necessary to use reflected light. The missiles would then be ineffective at night and more sophisticated electronics would be needed to analyse the pictures coming in.

Radar guided missiles can be used for any target that can easily be distinguished from its background by reference only to its silhouette. They are thus used for anti-ship missiles as well as for anti-missile or aircraft missiles. There are several different approaches here – most of these missiles only have a radar receiver and not a transmitter because this would mean carrying a large power source. A helicopter or ground-based transmitter is therefore used, commonly from the same equipment that fired the missile.

Certain missiles fired from one aircraft to another need the firing aircraft to remain in position until the missile strikes, to provide a radar beam, this tends to make the attacker vulnerable. Consequently most of these missiles are heat-seeking.

Cruise

There is another type of radar guided missile which is quite different. The cruise missiles (not necessarily nuclear; the term refers to any long range missile that flies fairly close to the ground) are typically guided by a radar system that takes readings from the ground along the path down which it is flying, and compares them with a map of the terrain which it knows it will be flying over. This then tells it which route it is currently on and so how it should change that to stay on course.

Whether an incoming missile is heat or radar guided determines to a large extent what the appropriate defence response should be. Certain methods are obviously effective for both, but the two main responses of aircraft under attack are each only effective against one type. Aircraft fire flares which produce localised intense heat to confuse infra-red guided missiles, and discharge chaff (small aluminium strips) to confuse radar guided missiles.

Sea Skimming

Sea skimming missiles are becoming increasingly important in battles at sea. They represent a radical departure form the conventional anti-ship missile, in that they fly only a couple of metres above the sea. This makes them much harder to shoot down, because they are reflected in the water, in various different distortions, and so any radar tracking them must be able to distinguish the real missile from its images.

Interestingly, the problem of the sea skimmers seems to have been largely solved; despite many naval conflicts since the Falklands the only ship to have been damaged by one is the *USS Stark*, which was hit in the Gulf. Even here the damage was only possible because the ship was not in a situation of all-out war, and so the firing aircraft was allowed to get fairly close before any action was taken.

The Europeans and Americans have defended their ships against these missiles in different ways. The Americans designed a rapid-fire gun, which discharges a large cloud of shells, practically guaranteeing a hit. The Europeans have defend their ships mainly with missiles, such as the Seawolf.

Shells are cheaper and likely to be more reliable, being less complex, however the major disadvantage is that a large amount of ammunition needs to be stored, since a large number of shells need to be fired at each target.

Air-to-Surface

The final kind of missile is the air-to-surface missile, which is used when a very specific target must be destroyed. The large expense associated with this kind of weapon means that bombs tend to be used instead wherever possible. Air-to-surface missiles tend to be laser-sighted – they are aimed by someone on the ground pointing a laser at the target. The missile then homes in on the laser spot.

The reason for adopting this method is that targets on the ground are much more difficult to pick out; a target might be a building, one vehicle among many and so on. Only a human can therefore know what is a valuable target and what is entirely irrelevant.

A variant on these laser-sighted missiles is the laser-sighted bomb. Generally these are not guided in their own right, although a few are, but instead electronics in the aircraft detects the laser spot, and calculates when the pilot must release the bomb in order for it to hit the target.

The reason that guided bombs are sometimes used is that passive bombs are not always reliable, because strong winds can spoil the calculations, and cause the bomb to fall slightly off target. If a bomb only misses a tank slightly, it will of course have no effect, a direct hit is needed to penetrate the armour.

Battlefield Simulations

In one sense, the military have a unique training problem; if you learn by doing, you are quite likely to get shot.

The answer to this has been to create battlefield simulators, which can teach people basic combat skills without the element of make-believe which has traditionally been present. One of the most important roles of simulators is to teach people to use weapons which are too expensive to fire very often outside war.

One weapon which falls into this category is the MILAN

anti-tank rocket. It is a missile which is guided by moving the launcher from side to side once it has been fired. This causes the missile to move similarly, so that it can be guided onto a moving vehicle, or so that poor aim can be compensated for.

Because one shot cost £20,000, those who might have to use it in wartime would only have fired it once or twice (this missile would, of course, be very widely used in war, so many people have to be trained to use it). In this case the simulator has been fitted into the original size of the launcher, it is therefore very realistic to use. The small size also allows it to be "fired" while crouching in a ditch, it can thus be used during exercises.

The simulator works by projecting, onto a piece of glass in the sights, a small light which represents the exhaust plume of the missile, this dies away as it gets further into the distance. Eventually the light "flares up" to symbolise the explosion.

The spot of light can be guided onto any target, for example a car on a nearby road, or alternatively the system can provide a symbol as a target, whose speed and direction can be varied by the instructor.

Tanks and Infantry

Other simulators allow tanks to be simulated – both in being shot at and in firing; or indeed both at the same time in the case of large exercises. Generally these work by looking at the gun's positioning and calculating if it will hit its target. If it will then a smoke canister is set off, otherwise the information is stored and it can be examined later to see what went wrong and why.

Yet another variant is a system which simulates infantry fire. Here individuals' rifles are replaced by simulated weapons which detect whether they have hit their target, if they have a buzzer is set off, this can only be silenced by the victim lying on his back. Meanwhile, the umpires assess what is happening and can also reactivate "dead" people.

This system makes the exercises much more realistic than conventional ones in which blanks are used, since it allows a much more realistic representation of a battlefield.

Radar

Radar has also developed a great deal in the last few years. Gone are the days when someone has to sit watching a screen showing a large amount of clutter (i.e. stationary objects that reflect the radio waves) and estimate the type or attacker from the size of the moving "blip".

Modern radars can to a large extent identify the attacker by computer and so show on a screen the identity of the "blip". They can also scan more quickly, because the single rotating radar dish has been replaced by multi-element radars which can look at a whole range of points at once.

Radar has always been, however, rather a mixed blessing. Passive devices have been developed which can detect intruders by their radar transmissions, and not send out a beam of their own which might be intercepted.

Most combat aircraft now incorporate a system which detects when a radar beam is being used to lock a missile onto them and this sets off an alarm to the pilot. Evasive action can then be taken, very often this will cause the missile launcher to lose track of the plane, even before a missile is fired.

Jamming

Radar jamming is also becoming increasingly effective. It is this technology which it is hoped will make the Stealth bomber invisible to enemy radar – the bombers first approach low down, out of radar view, and then fly up and jam the radar with a high-intensity beam of their own.

One of the problems encountered, however, is that it is also necessary to make the shape of the aeroplane such that it does not produce a large image on the radar; this is not compatible with the other objective of producing a fast plane which can turn reasonably quickly. The speed requirement is further hampered by the fact that the exhausts have to be prevented from showing up too much to avoid heat seeking missiles. Since several of the early bombers crashed, it would seem that they have not been an overwhelming success. Stealth bombers were used in Panama, they were invisible to the radar and did not crash, however they bombed a field behind the targeted barracks. The US military claimed this was deliberate and aimed at stunning the occupants!

Communications

Communications are very much the weak link in modern warfare; it is not so much the ability to achieve the various communications links as the need to make them secure and safe from jamming. An example illustrates the point:

A few years ago it was decided to develop a system which would fly, what was essentially, a radio controlled model plane over a battlefield and use it to aim a laser at enemy tanks. This would enable allied tanks to fire copperhead guided shells which would home in on the laser spot.

This system could obviously be very beneficial on a modern battlefield, however, the system was never produced because the secure microwave link that was to run between the plane and its ground-based controllers proved to be impossible to develop. Apart from this link the project was comparatively simple, and could have been achieved without much trouble.

Communications back to the military headquarters are also very important in any campaign. These links are normally carried by satellite. In this way the signal can be sent up nearly vertically and there is less chance of the enemy being able to jam it.

Enemy interception is not very important because modern codes can normally resist even the most determined assault. The only problem that there might be with interception is if information about the code was passed to the enemy.

The Future

There are two possible ways for warfare – one is increasing sophistication, the other is simply increasing firepower without really increasing accuracy. Both have been seen very recently. The two major examples of increasing firepower are the A10 fighter and a new rocket launcher being used by the British Army in Germany.

The A10 is more in line with what was accepted as the norm during the second world war in terms of electronics, it has very little in the way of sophisticated navigation, radar or missiles, it does, however, carry laser targeted bombs. The A10's main weapon is a large "gatling gun" which fires around 50 shells per

Sea Eagle missiles on a Buccaneer aircraft. Sea Eagle is in service on Royal Air Force Buccaneers and Royal Navy Sea Harriers. It is a sophisticated long-range fire-and-forget missle designed for use against modern warships up to the largest size and equipped with the latest countermeasures and air defences. British Aerospace (Dynamics) Ltd

second. The idea is that the A10 can destroy a large number of tanks using the gun (each one of the shells can destroy a tank!) while being fairly invulnerable itself, due to a heavily armoured area which protects the pilot and important instruments.

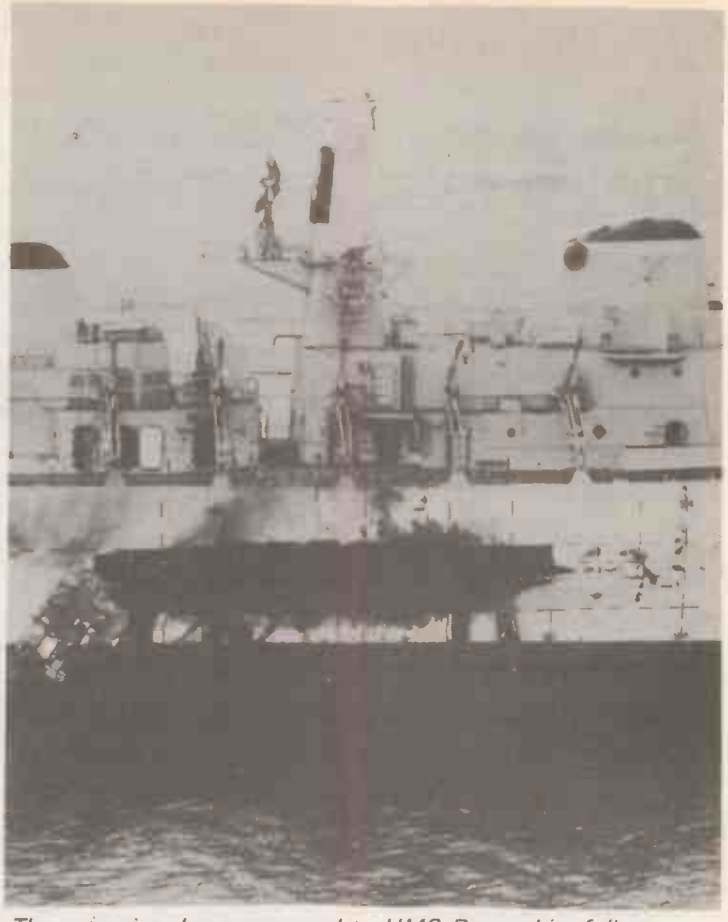
The new rocket launcher is also an anti-tank weapon. It has a firepower equivalent to a regiment of artillery, although individual shots are less accurately targeted, and it cannot keep up the rate of fire for long. What it does is to fire a rocket which cruises to the target area and then breaks up into a cloud of tiny bomblets. This cloud can cover around two acres, destroying most if not all of the equipment there.

Sophistication

The alternative way forward is increasing sophistication, so that although less shots are fired many more of them strike home. The most promising development is also on anti-tank weapon, it will carry out a similar role to the rocket launcher. It comprises a rocket which is fired from some way behind the front line, and given a preprogrammed destination. It then breaks up into a large number of small shots which parachute down. When these shots pass over a tank, they explode, firing a cloud of hot gas and metal vapour downwards with sufficient speed to cut through the armour on the tank.

Another of these sophisticated weapons is a conventionally armed cruise missile. This is given a tactical target such as an airfield in enemy territory, which it flies to and then breaks up into a cloud of smaller bombs which can then completely destroy a relatively small target such as an airfield.

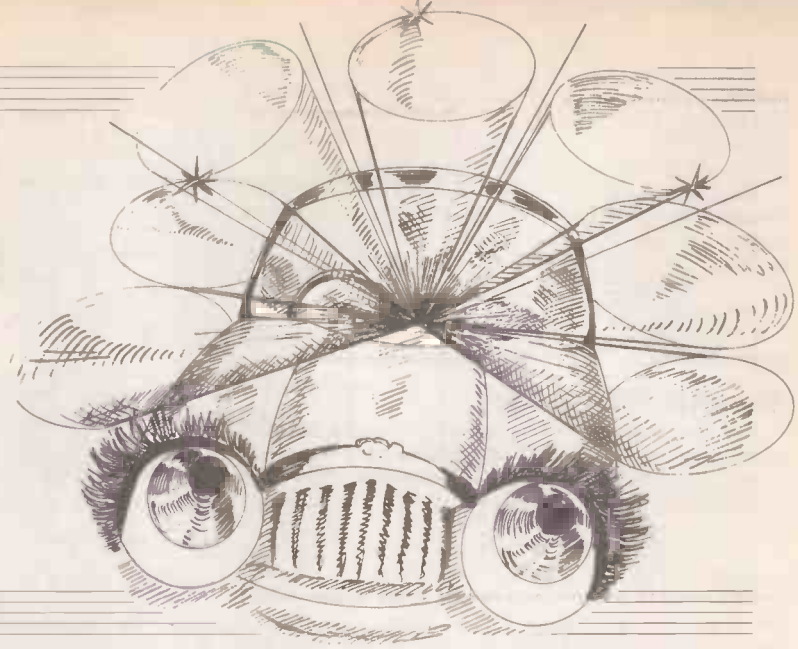
As far as winning a future war goes, it seems that the increased firepower weapons may be the best. The experience of the unproven Seawolf missiles in the Falklands suggests that sophisticated weapons do not necessarily perform correctly the first time they are sent into a combat situation. Unfortunately, increased firepower could mean increased civilian deaths; the sophisticated weapons hold the promise of being able to destroy military targets and nothing else. □



The extensive damage caused to HMS Devonshire following a direct hit by the Sea Eagle missile. In operational circumstances this would have resulted in complete disablement for the ship. (British Aerospace (Dynamics) Ltd

Constructional Project

SPATIAL POWER DISPLAY



GARY CALLAND

A novel and attractive way of monitoring the output from a stereo system. Provides four separate l.e.d. displays.

UNLIKE its name suggests, the Spatial Power Display, or SPoD for short, is an attractive and novel way in which to monitor the power output from a stereo. Although primarily designed for car stereo systems, the SPoD can be used with other stereos, providing a suitable power supply exists.

The SPoD provides four separate visual displays representing the output from each of the four car stereo loudspeakers. Coloured l.e.d.'s are arranged so that their positions represent the probable path of a sound wave; the greater the power, the wider reaching the sound wave is likely to be. In addition, as the power output increases to a maximum, green, yellow and finally red l.e.d's are progressively illuminated to provide additional power output information.

The SPoD can be easily fitted to any stereo system, regardless of power output and loudspeaker impedance; a simple preset control on the circuit board can be adjusted to suit any power indication requirements. Also, since the SPoD is small and compact, it can be discretely mounted virtually anywhere.

Not only can the SPoD be used to help balance loudspeakers, or to give indication of a faulty amplifier output, it provides rather a pleasing visual accompaniment to in-car music, perhaps even helping to ease the frustrations of those all too frequent hold-ups and traffic jams.

HOW IT WORKS

The basic principle of operation is shown in Fig.1. Firstly, to simplify the explanation, only a single loudspeaker system will be considered. The a.c. voltage waveform developed across the loudspeaker is converted by a rectifier stage into a d.c. voltage, the magnitude of which is proportional to the power output of the loudspeaker.

This d.c. voltage is fed to a set of voltage level comparators. These change their output state from a logic low to a logic high when their input signals exceed a preset reference level.

Each comparator has a higher reference level than the one below it, hence an increase in loudspeaker power increases the number of comparators which have a high output. The output from the comparators simply switch on or off their associated l.e.d's.

MULTI-SPEAKER SYSTEM

To increase the system to accommodate four loudspeaker inputs, the single system described above could simply be repeated. However, this is undesirable due to the cost of components and in the large amount of board space required. Instead, Time Divi-

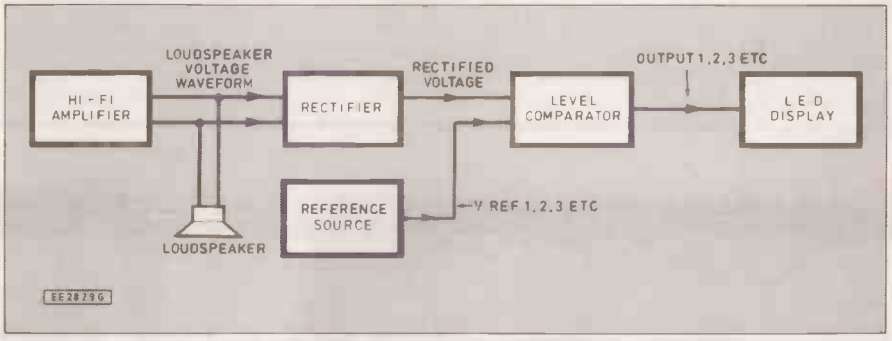
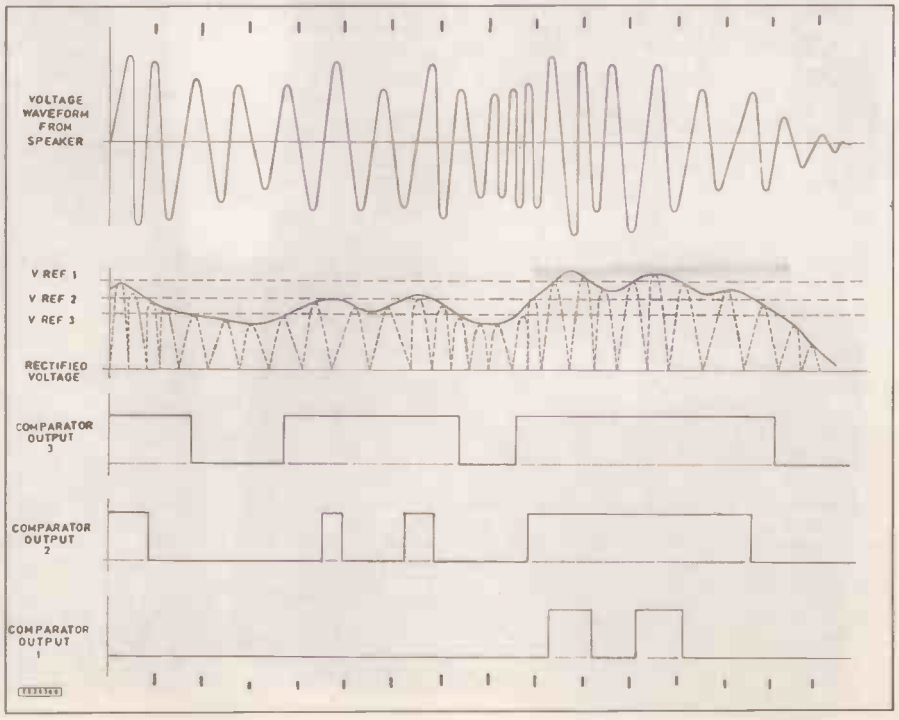


Fig. 1. Spatial Power Display block diagram and waveforms (below) showing the basic principle of operation



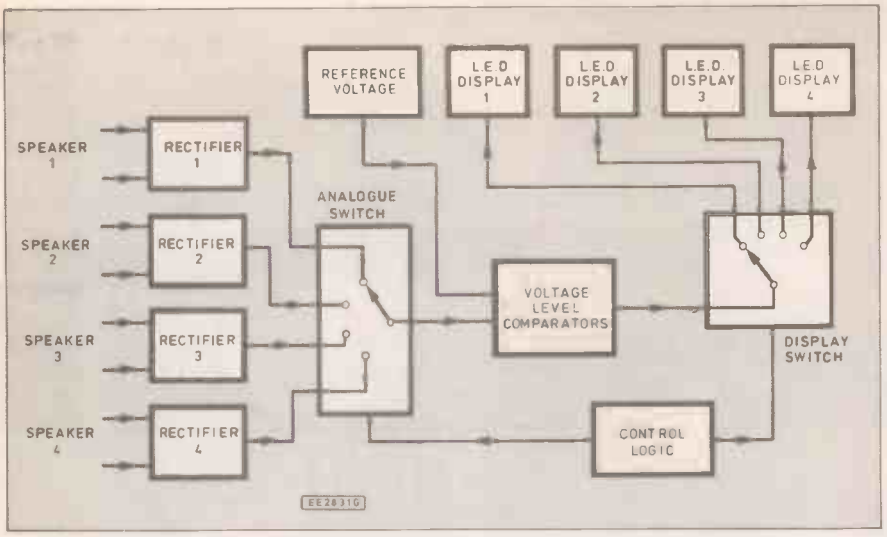


Fig. 2. Block diagram for the "cost saving" time division multiplexing system.

sion Multiplexing, as shown in Fig.2., is used to decrease costs and space.

Again, as before, the a.c. waveform from the loudspeaker is converted into a d.c. level. However, each of the four d.c. voltages is fed to a single set of level comparators, one after another, rather than each being fed to their own set. Likewise, the output from the comparators only activates one of the four l.e.d. display sets, one after another.

Hence in this way, all four inputs are continuously, sequentially sampled to produce a visual output on their associated l.e.d display. This scanning is performed at such a speed that it cannot be detected by the human eye and so the illusion of four permanently activated l.e.d. displays is given.

As an idea of the cost and space saving advantages of this technique, the SPoD only uses six i.c.'s whereas a comparable unit using four identical separate systems would use nearly double that number.

CIRCUIT DESCRIPTION

The complete circuit diagram for the Spatial Power Display is shown in Fig. 3.

The voltage waveform presented to each set of loudspeaker terminals is fed to a diode rectifier bridge via d.c. blocking capacitors C1 to C8. These are necessary since some car stereos use a bridge amplifier output stage, and the nominal voltage applied to each of the two loudspeaker terminals is about 5-6 volts referenced to ground.

Individual diodes as opposed to a packaged diode bridge were used to reduce space and costs. Each rectified waveform is smoothed by capacitors C9 to C12 and resistors R1 to R4 to produce four d.c. voltages.

These are fed into the four inputs of the analogue switches contained in IC3. Only one switch is closed at any one time, depending upon the logic state of the control inputs. Hence, only one of the four d.c. voltages is allowed to pass onto the next stage.

The selected voltage from IC3 is buffered by IC4c and fed into each of the non-inverting inputs of the five comparators formed by IC4b and IC5. Zener diode D18, resistor R6 and preset VR1 produce a constant reference voltage in the range 0 to 10 volts. This is buffered by IC4a and potted down into five voltage levels by the resistor network formed by R8 to R12.

These five voltages are fed into the inverting inputs of the comparators to provide the five different reference levels. Varying VR1, and therefore the reference voltages, allows different stereo amplifier outputs to be catered for.

Each comparator output is buffered by IC6 to produce a common l.e.d. drive to each l.e.d. display, via current limiting resistors R17 to R21. Only one l.e.d. display set is activated at any one time since only one of the transistors TR1-TR4 is switched on at any one time.

The transistor control signals are the same signals that close IC3's analogue switches, and are obtained from four alternative outputs from the eight available outputs of the octal counter IC2. This is clocked by the oscillator formed by IC1a, IC1b, capacitor C13 and resistor R5.

All unused logic gate inputs are tied to ground and diode D1 ensures that incor-

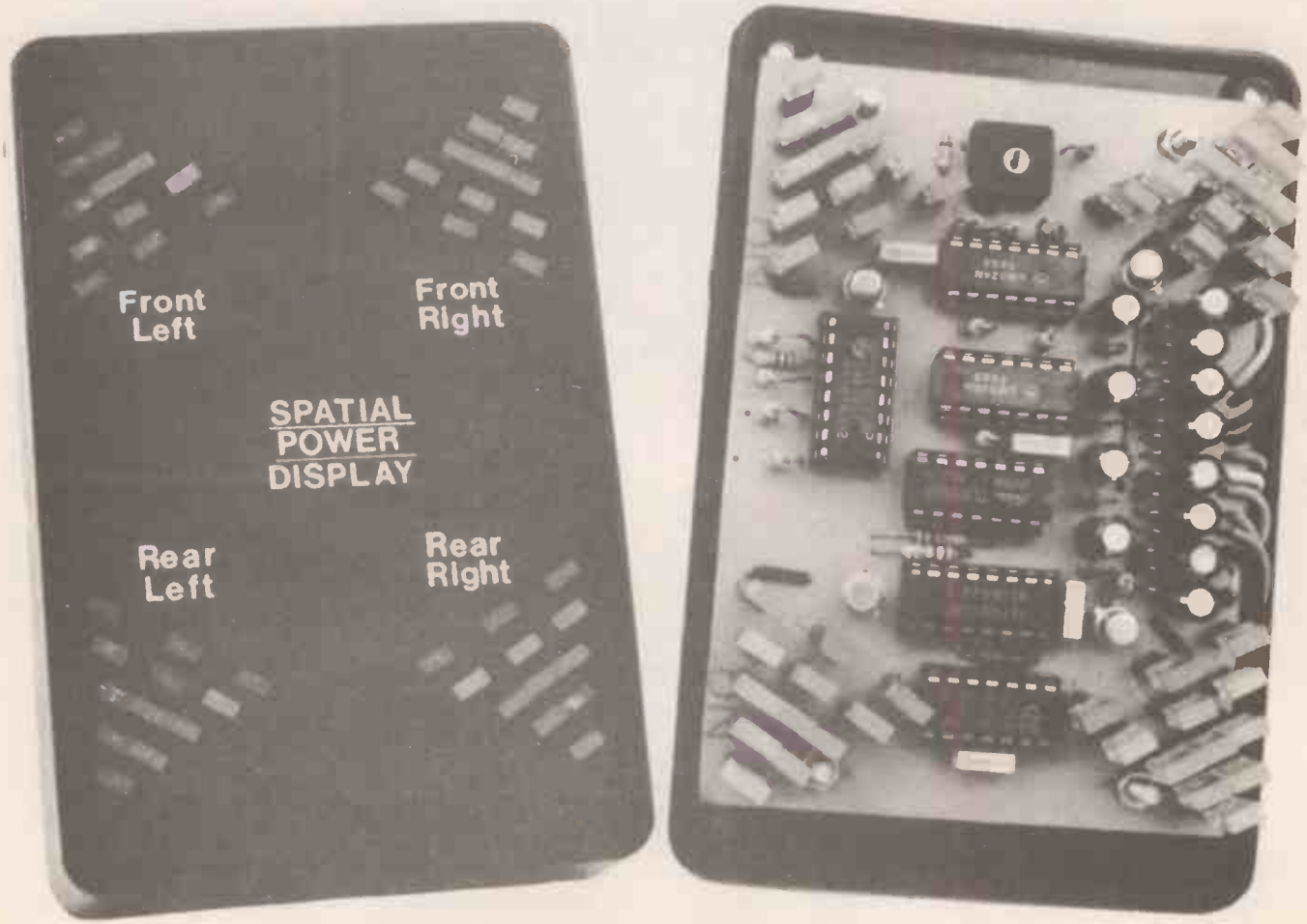
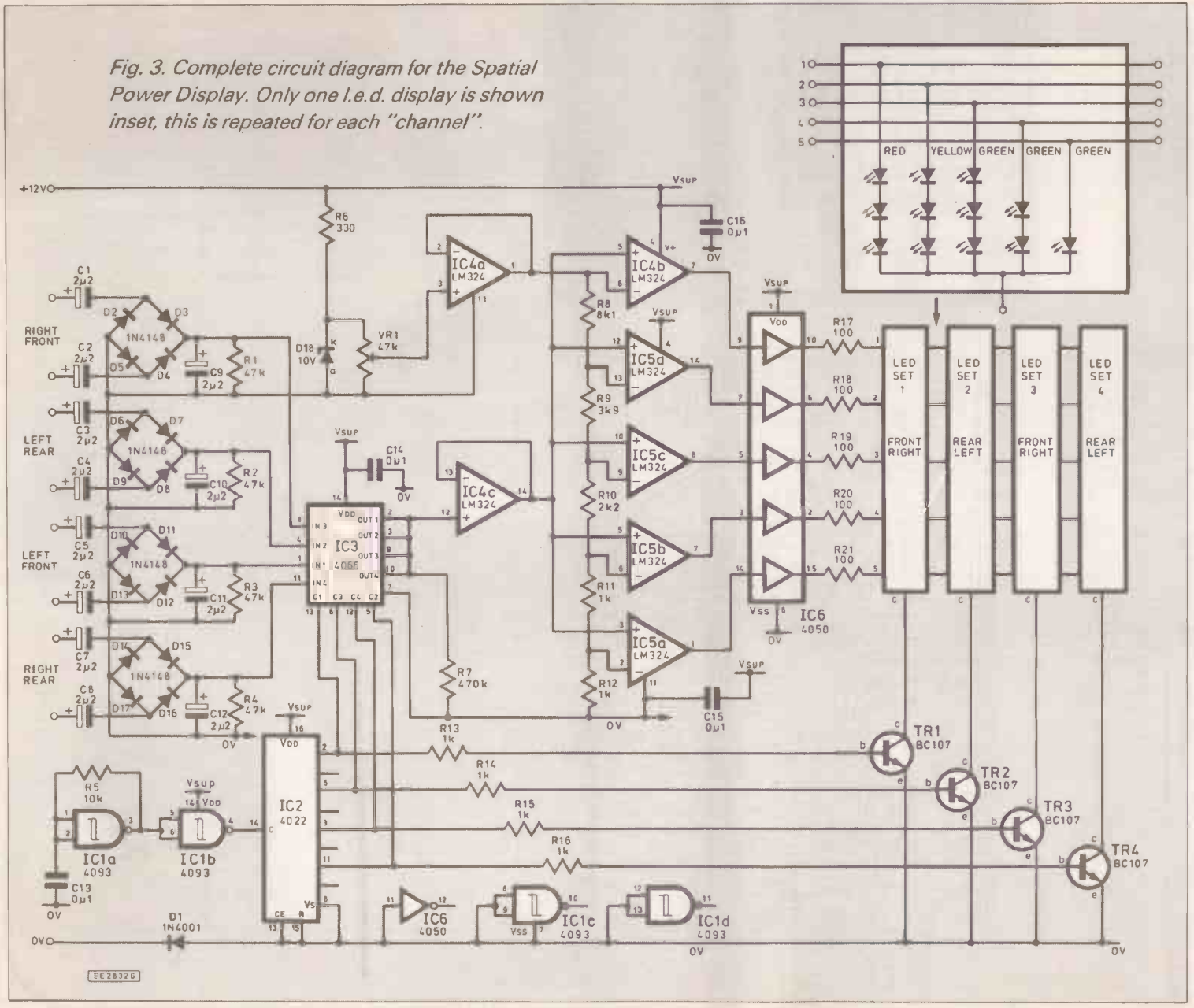


Fig. 3. Complete circuit diagram for the Spatial Power Display. Only one l.e.d. display is shown inset, this is repeated for each "channel".



COMPONENTS

Resistors

R1 to R4	47k (4 off)
R5	10k
R6	330
R7	470k
R8	8.1k
R9	3.9k
R10	2.2k
R11 to R16	1k (6 off)
R17 to R21	100 (5 off)

All 0.25W 5% carbon

See SHOP TALK Page

Potentiometer

VR1	47k lin.horizontal preset

Capacitors

C1 to C12	2µ2 radial elect. 16V (12 off)
C13 to C16	0µ1 50Vd.c. 5mm p.c.b. boxed polyester (4 off)

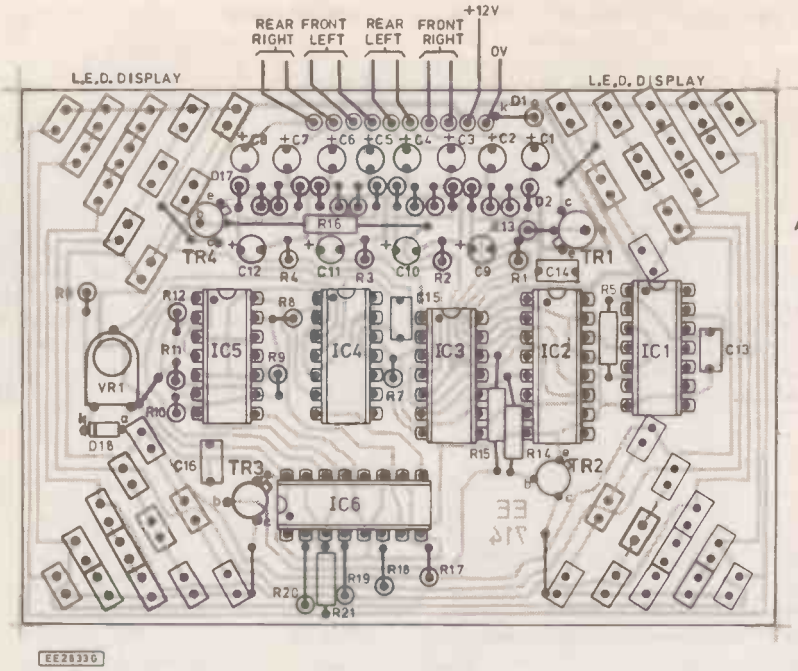
Semiconductors

D1	1N4001
D2 to D17	1N4148 (16 off)
D18	10V Zener
L.E.D.s	2.5mm x 5mm Green (24 off)
L.E.D.s	2.5mm x 5mm Yellow (12 off)
L.E.D.s	2.5mm x 5mm Red (12 off)
TR1 to TR4	BC107 or similar (4 off)
IC1	4093 quad 2-input NAND Schmitt trigger
IC2	4022 divide by 8 counter
IC3	4066 quad switch
IC4, IC5	LM324 quad op.amp (2 off)
IC6	4050 Hex buffer non-inverting

Miscellaneous

Printed circuit board, available from *EE PCB Service*, code EE714; 14 pin i.c. sockets (4 off); 16 pin i.c. sockets (2 off); case 120mm x 80mm x 30mm; 10-way terminal block; mounting bolts; connecting wire, solder etc.

Approx cost guidance only **£28**



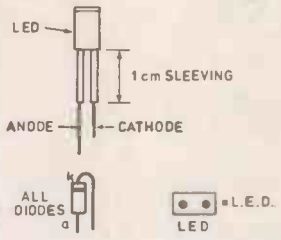
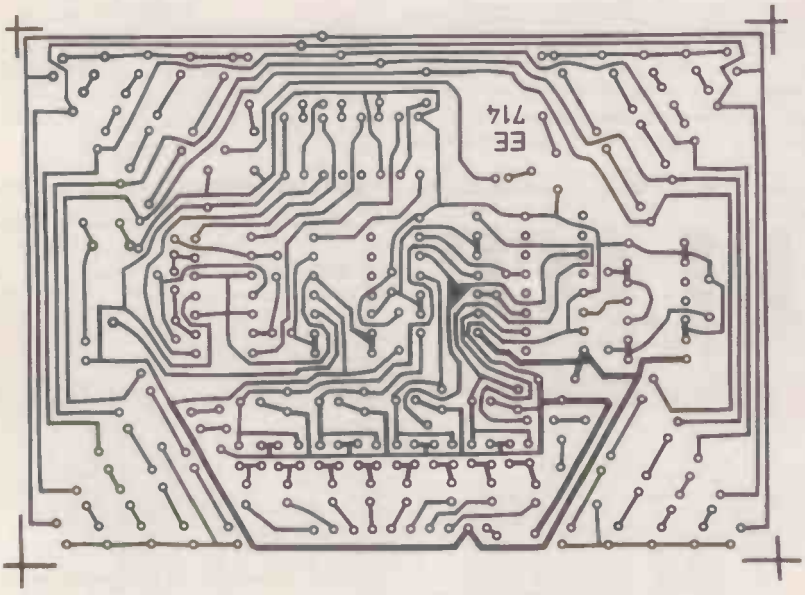
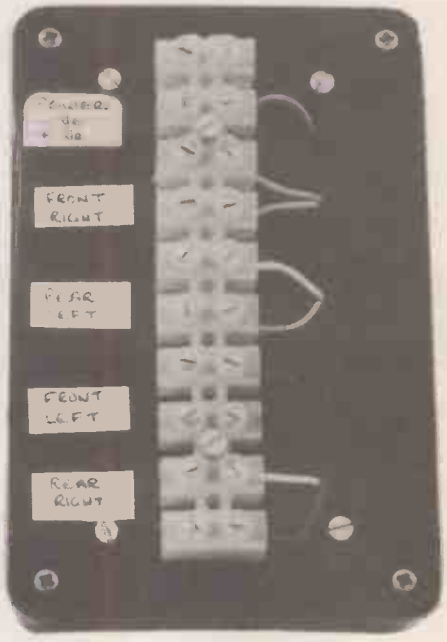


Fig. 4. Printed circuit board component layout and full size copper foil master patern. The method of mounting the diodes and l.e.d.s is shown above.





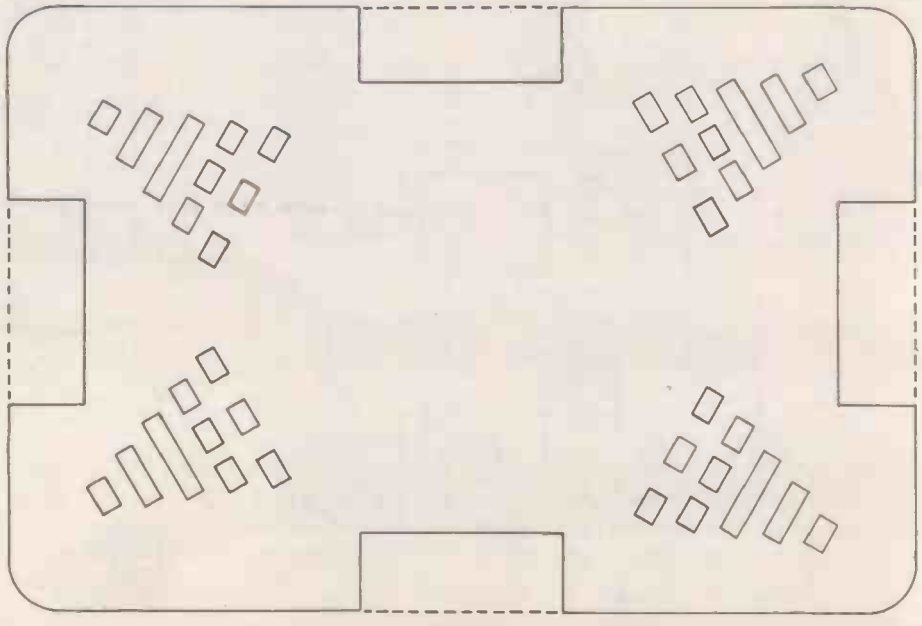


Fig. 5. Full size l.e.d. display drilling template for the specified plastic case.

rect connection of the power leads (the wrong way round) does not result in a useless set of smouldering i.c.'s!

CONSTRUCTION

Construction of the SPoD is straight forward as all the components fit quite tightly on a standard sized p.c.b. The component layout and full size copper foil master pattern is shown in Fig. 4. This board is available from the *EE PCB Service*, code EE714.

It is best to start construction of the p.c.b. with the five wire links and diodes D2 to D17, as these would be difficult to fit if other nearby components were in position. Note the orientation of the diodes.

Next, the resistors and capacitors may be fitted, followed by the diodes D1 and D18. Capacitors C1 to C8 are quite densely packed and so it is best to fit the innermost capacitors first, then work outwards. I.C. sockets are recommended to reduce i.c. damage, and they should be fitted next, together with the four transistors.

Finally, the l.e.d.'s should be mounted, all at the same height above the p.c.b. This is ensured by fitting a 1cm long piece of plastic sleeving over each l.e.d. lead. Also, the orientation of the l.e.d. is important; the long lead (the anode) of the l.e.d. should always be inserted in the inner most of the two l.e.d. holes.

A careful inspection of the copper track side of the p.c.b. to check for solder bridges is a good idea before the i.c.'s are inserted into their sockets: the usual CMOS handling precautions should, of course, be observed. Short lengths (about 10cm) of power supply and loudspeaker cable can then be soldered into their associated p.c.b. pads. The p.c.b. is then ready for mounting in its case.

The p.c.b. is mounted on the inside of the case lid by four 6BA bolts. The cables are then connected to a 10-way strip of terminal block mounted on the other side of the case lid. The use of terminal block allows ease of connection to the power supply and amplifier loudspeaker outputs.

Drilling the holes for the l.e.d.'s, in the case body is quite difficult and is best done using the template, Fig.5. (or a photostat of it). This is stuck onto the case top with sticky tape and a small drill (about 1mm diameter) is used to produce a hole at each corner of the l.e.d. cutout.

Once this is complete, the template can be removed, and the complete l.e.d. cutout can be made using the small corner holes for guidance. This method will ensure a neat, balanced distribution of l.e.d. holes which lie directly above their associated l.e.d.'s. Appropriate lettering will finish the unit off nicely.

POWER INDICATION CALCULATION

The SPoD relies on the formula:

$$\text{Power} = V^2/R$$

to indicate the peak power output of a loudspeaker where V = voltage across the speaker terminals, and R = loudspeaker impedance (4 ohms for most car speakers).

The following table shows at what approximate power levels each l.e.d. will illuminate for various reference voltage settings.

Reference Level	10V	9V	8V	7V	6V	5V
Red	25W	20W	16W	12W	9W	6W
Yellow	6W	5W	4W	3W	2W	1.5W
Green	1.8W	1.5W	1.2W	0.9W	0.6W	0.5W
Green	0.4W	0.3W	0.25W	0.18W	0.14W	0.09W
Green	0.09W	0.07W	0.06W	0.04W	0.03W	0.02W

TESTING AND INSTALLATION

With the unit powered, turning the reference level control preset VR1 to give 0 volts out should result in all the l.e.d.s being illuminated. If this is so, all is well. All that remains is to connect the SPoD to your stereo system, and to adjust the level control to the required power level setting. □

MARKET PLACE

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WANTED Bush Ranger P.T.V. tuner unit. Ex Ranks R3 (price). Details of Sony AC2DL mains adaptor. Mr R. Trayers, 6 Woodfield Road, Bebington, Wirral, Cheshire.

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(Elektor Electronics June 89)

This low cost echo unit is certain to impress music lovers - amateur and professional - everywhere. Excellent specification and top performance make the EU 1000 a winner and despite meeting professional requirements the unit will not make too big a hole in your pocket.
Working on the delta modulation principle on a digital base, delay times up to one second are possible at full bandwidth and large signal to noise ratio.

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Specification

Input sensitivity:
Input 1 : 2 mV
Input 2 : 200 mV
Dealy Time:
variable from 60 ms to 1 s
Bandwidth :
100 Hz to 12 kHz

Additional features:
- inputs mixable
- single and multiple echo
- adjustable delay level
- switchable vibrator
- switch-controlled noise suppression

PC Radio (Elektor Electronics Febuary 1990)

This FM radio consists of an insertion card for IBM PC-XTs, ATs and compatibles and is available as a kit or a ready-built and aligned unit. The radio has an on-board AF power amplifier for driving a loudspeaker or a headphone set, and is powered by the computer. A menu-driven program is supplied to control the radio settings.

Complete kit
44.544BKL ..... £ 82.75

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(Elektor Electronics March 90)

Many inexpensive or older TV sets lack a SCART or other composite video input, and can only be connected to a video recorder or other equipment via an RF modulator. The modulator operates at a UHF TV channel between 30 and 40. Use is made of a single-chip RF modulator that couples low cost to excellent sound and picture quality.

Complete kit
44.546BKL ..... £ 36.90

RFK 7000 RGB-CVBS Converter

(Elektor Electronics October 89)

Nearly all computers supply as an output signal for colour monitors RGB signals. With the help of the RFK 7000 it is possible to record this signals with a videorecorder or to give them onto a colour TV (This is only possible, if the computer delivers a vertical sync. of 50 Hz and a horizontal sync. of 15.625 Hz).
The voltage supply is gained from a 12V/300mA-DC voltage mains adaptor.

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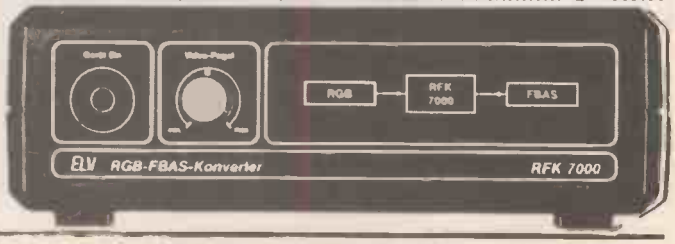

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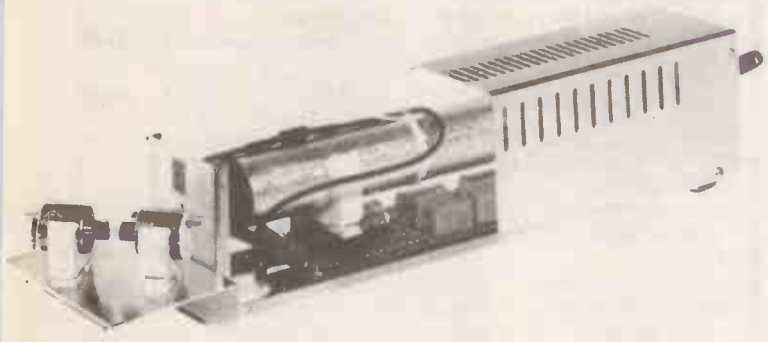
LPS 8000 / LC 7000 Low Cost Show Laser

(Electronics The Maplin Magazine Dec 88 + Feb-Mar 90)



An almost infinite number of circular patterns can be projected onto a wall or ceiling with this super laser show equipment.
The complete project includes a laser tube and accompanying power supply, housed in a metal case, and a laser controller, LC 7000. The laser controller drives the accompanying deflection unit, fixed onto the laser power supply case, which produces the numerous configurations.
Naturally the laser tube, together with the power supply, can produce beams without the laser controller and the controller can be used with other, similar lasers.

LPS 8000 Laser Power Supply, complete kit
Version 240 Volts AC
44.428BKL220 ..... £ 86.90
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Version 12 Volts DC
44.427BKL ..... £ 60.80

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44.428LR ..... £ 60.80

LPS 8000 Laser Power Supply, ready assembled module
Version 240 Volts AC
44.428F240 ..... £ 156.50
Version 220 Volts AC
44.428F220 ..... £ 156.50

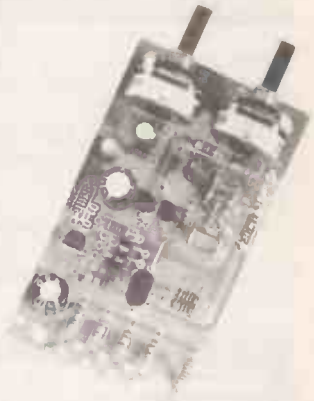
LC 7000 Laser Controller, ready assembled module
Version 12 Volts DC
44.427F ..... £ 104.30

Laser Motor-Mirror Set, complete kit
44.506M ..... £ 22.95

VIDEO RECORDING AMPLIFIER

(Elektor Electronics April 89)

Losses can easily occur when copying video tapes resulting in a distinct reduction in quality. By using this video recording amplifier, with no less than four (!) outputs, the modulation range is enlarged and the contrast range of the copy increases.
Two level controllers for edge definition (contour) and amplification (contrast range) allow individual and precise adaptation.

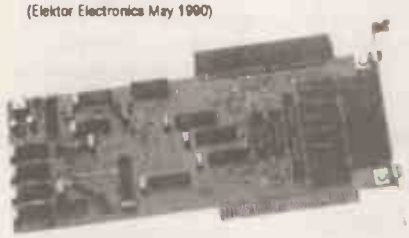


Complete Kit
(including Box, PCB and all parts
44.324BKL ..... £ 14.75

IBM PC Service Card

(Elektor Electronics May 1990)

This card was developed for assistance in the field of service, development and test. The card is used as a bus-extension to reach the measurement points very easy. It is also possible to change cards without having a "hanging computer".



Complete kit
44.517BKL ..... £ 77.95

Ready assembled module
44.517F ..... £ 137.95

TA 1000 Telephone Answering Unit

(Elektor Electronics January 1990)

This automatical telephone answering unit uses a 256-kbit voice recording circuit to store and replay your spoken message of uo to 15 seconds. Noteworthy features are that it is available as a complete kit, providesd a battery back-up facility and does not require alignment. No provision is made, however, to record incoming calls.

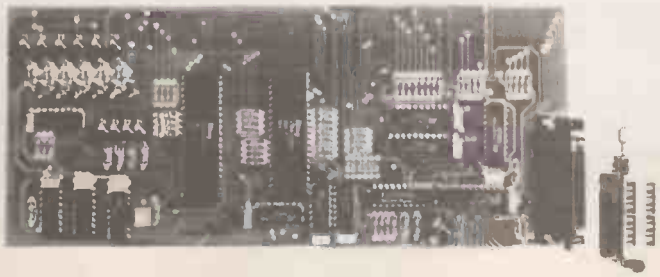
Complete kit
44.433BKL ..... £ 45.65

Ready assembled module
44.433F ..... £ 87.25

IC TESTER for IBM-PC-XT/AT

(Electronics The Maplin Magazine Jun-Jul 89 +
Elektor Electronics December 89)

With the ELV IC tester logic function tests can be carried out on nearly all CMOS and TTL standard components, accommodated in DIL packages up to 20 pin. The tester is designed as an insertion card for IBM-PC-XT/AT and compatibles. A small ZIF test socket PCB is connected via a flat band cable. Over 500 standard components can be tested using the accompanying comprehensive test software.



Complete Kit including Textool socket, connectors, sockets, Flat band cable, PCB, Software
44.474BKL ..... £ 60.85

Ready Assembled Module
4.474F ..... £ 113.00

Software, single
44.474SW ..... £ 17.85

ELV France - B.P. 40 - F-57480 SIERCK-LES-BAINS - France - Tel.: (33) 82.83.72.13 - Fax: (33) 82.83.81.80

FOR YOUR ENTERTAINMENT

by Barry Fox

Highly Desirable

There is a new breed of shop in Britain which sells electronic gadgetry with a difference. The difference is that everything is high tech, high price and high design, irrespective of manufacturer. You will see a Bang and Olufsen hi fi alongside a Sony personal video player, a Tissot quartz watch carved out of granite, the smallest camcorders, personal stereo players that work under water and radios powered by the sun.

The idea for this kind of shop came from America and over there the format has broadened, to a shop or mail order house, which sells anything that has a high tech feel about it. The leader of the pack is *The Sharper Image* with a catalogue which costs $2 and is read by over twenty million people a month.

The secret of the catalogue is that it's glossy, and makes everything seem eminently desirable. The secret of the shop is that it is laid out to let customers get their hands on the gadgets and try them.

I browsed recently, trying a leather bound chair with motor-driven massaging rollers built in and a footstool that vibrates to sooth tired muscles. A car cassette radio is built into the chair for music while you relax.

An ordinary cordless phone is repackaged in transparent plastics so that all the components are visible. Panasonic has a battery powered vacuum cleaner that looks like a computer mouse, and cleans up desk tops. A Swiss clock runs on air, getting its power from changes in room temperature which cause expansion and contraction of a gas chamber, which in turn winds the main spring.

Shockproof

There's shockproof baggage, waterproof camcorders, an outdoor loudspeaker system from Bose, and various gaily coloured p.v.c. personal swimming pools with sun-reflecting surfaces, to tan while you soak. A pocket computer helps you quit smoking by telling you when the next one in a cut down programme is due. Of various ultrasonic gadgets, one is for personal massage and another to scare off pests.

Inevitably, there are air ionizers, and a hand-held electronic dictionary that takes phonetic entries and both displays and speaks the correct spelling. A key ring, designed in Germany, has a range of rings which slide round a precision engineered track.

For the car there are radar speed trap detectors and for the health freak there's a hand-held device that takes your blood pressure from a finger ring. A watch with titanium dial creates bizarre colour patterns and a head for a conventional shower produces a pumped spray for massage. And so it goes on with fancy baggage, sports shoes that float, stylish portable alarms and pocket electronic memos.

The Sharper Image's rival, *B N Genius,* plays the same mouth-watering game with a video projector that looks like a slide projector (from Sharp), a book with built-in safe, a portable copy machine that sends faxes and a wrist-watch for cyclists that computes speed.

In their own right none of these gadgets is really that special. The trick is either to put them all together in a hands-on showroom or offer them in a glossy catalogue with beautiful colour pictures and text which emphasises the technical tricks which they play.

As so often happens with gadgets, the chances are that most people will buy for the sake of a feature or facility that sounds exciting, but in practice is of no long term value. How many people who have bought video recorders with perfect freeze frame reproduction, actually use it?

In Reverse

While browsing in The Sharper Image, I came across one gadget which for years I've been hunting. It's called a reverse converter.

Anyone with equipment, like a portable computer, radio, audio recorder or camcorder, which uses rechargeable batteries, will know the value of a charger which copes with *all* mains voltages. Too many chargers work on one voltage only, 220/240V for most of Europe. So when you are in a country like the US, Japan and parts of Southern France with 100 or 110V mains, you can't charge your batteries – which is no joke if the machine runs only on its own rechargeable cells.

It is easy to buy a plug-in converter that drops 220/240V mains to 100/110V, so that American and Japanese equipment can be used all over Europe. But until recently there were only two ways of coping with the reverse problem.

One was to buy and carry round a bulky and heavy bench transformer that lifts 100/110V to 220/240V. The other way is to buy a 100/110V charger (while abroad) and either carry both chargers or use the foreign one in Europe with a down converter.

The Sharper Image had the perfect solution. A reverse converter looks exactly like one of the small 220/240V-to-100/110V droppers but works in the reverse direction, stepping up from 100/110V to 220/240V.

These reverse converters are made in Hong Kong, but sold in the US by a company called Franzus of Middlebury in Connecticut. The price is around $15 or £10. Doubtless some enterprising firm will soon catch on and import them into the UK.

Goodbye Disaster

After 35 years of controlling commercial TV and radio the Independent Broadcasting Authority shuts down at the end of the year, to be replaced by the Radio Authority and Independent Television Commission. Although the IBA employs some fine engineers at its laboratory in Winchester, the desk bound brass at its headquarters in Brompton Road have never seemed to understand anything of the technology which ultimately pays their salaries.

For many, the IBA has seemed toothless, even when it did understand what was going on. The Authority let TV-AM win a breakfast TV franchise on the promise of a mission to inform, and then make scuds of money from superficially covering trivia. I am one of several who remembers how the original TV-AM researchers kept wanting help on technical items which never appeared and for which the helpers were never paid.

Brompton Road made a complete hash of the launch of Nicam digital stereo sound for TV, which crept onto the market with almost no publicity.

Most recently the Authority let its satellite operator BSB run amok, to create the IBA's biggest ever disaster and almost certainly kill the MAC TV system which had been developed at Winchester. With MAC goes the European high definition TV system that Winchester has also been helping to develop.

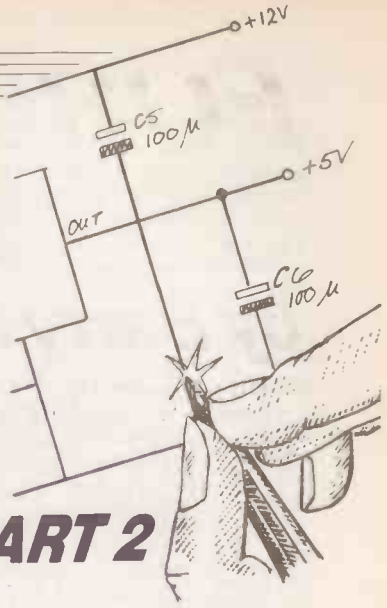
So when IBA Chairman George Russell gave a farewell speech at the Banqueting House in Whitehall recently the room was packed with people hoping for some horse's mouth comment about the BSB debacle.

But they were disappointed. Although Russell talked at length about the IBA's grand achievements he only mentioned BSB in passing, saying he was sure the audience would understand why he was not going to say more.

What he did do, however, was play a long video tape compilation of excerpts from commercial TV programmes. Although the sound system used in the Hall to amplify Russell's speech worked perfectly, the sound from the IBA's video tape was so appalling that no-one could hear the dialogue or commentary.

All things considered this seemed an appropriate way to say goodbye to the IBA.

DESIGN YOUR OWN CIRCUITS



Small Signal Amplifiers

MIKE TOOLEY BA — PART 2

This ten part series aims to dispell some of the mystique associated with the design of electronic circuits. It shows how even the relative newcomer to electronics can, with the right approach, design and realise quite complex circuits.

In this second part we deal with small-signal amplifiers and introduce a number of useful circuits based on transistors and integrated circuit operational amplifiers. Our design problem is based on a microphone pre-amplifier system and our companion project deals with the construction of a simple intercom.

Introduction

Amplifiers are found in some form or another in almost every electronic circuit. Since this topic is extremely broad (covering a.c., d.c. and power amplifiers) we have divided it into two parts. This first part deals with amplifiers which operate with signals of relatively small amplitude. These "small-signal" amplifiers are found in the initial stages of a wide variety of electronic apparatus including audio equipment and test instruments.

In general a small-signal amplifier should:

(a) provide a defined value of voltage gain
(b) maintain the desired value of voltage gain over a defined range of frequencies
(c) exhibit pre-determined constant values of input and output impedance
(d) operate without producing significant distortion or noise (which would otherwise mar the signal)
(e) operate within prescribed limits over a range of supply voltages and ambient temperatures

Specifications

A typical small-signal amplifier specification may run along the following lines:

Voltage gain:	100
Frequency response:	20Hz to 20kHz at -3dB
Hum and noise:	Less than 100µV r.m.s.
Distortion:	Less than 0.01% t.h.d.
Input impedance:	50kilohm
Output impedance:	600ohm
Supply voltage:	+9V to +12V at 10mA (nominal)

This specification should be reasonably self-explanatory. The stated voltage gain (i.e. ratio of output voltage to input voltage) is 100. Hence, an input signal of 1mV should produce a corresponding output signal of 100mV, an input of 2mV should produce an output of 200mV, and so on.

A point will, however, arise when the output voltage no longer increases as the input voltage increases. At this point, the output signal will become "clipped" and severe distortion will result. It is worth noting that, since the maximum amplitude of the output voltage is usually dependent upon the supply voltage, the maximum undistorted output voltage will normally increase if the supply voltage is increased.

The frequency response is a measure of the amplifier's ability to amplify signals over a range of frequencies. Rather than specify the voltage gain at a number of frequencies, we simply state the two frequencies (one lower and one upper) at which "cut-off" is said to occur. The term is, however, a little misleading since it would tend to imply that there is no output signal at all beyond the specified cut-off frequencies.

Since the cut-off frequency is usually taken to mean the frequency at which the voltage gain falls by 3dB from its maximum (mid-band) value, this notion is patently untrue! In fact, a reduction of 3dB corresponds to a decrease of approximately 30 per cent (i.e. the voltage gain at the cut-off frequencies will be approximately 70 per cent of its maximum value). Fig. 2.1 illustrates this point (note how the voltage gain remains substantially constant over the mid-band region but falls off beyond the two cut-off frequencies, f_L and f_H).

All amplifiers, however well designed,

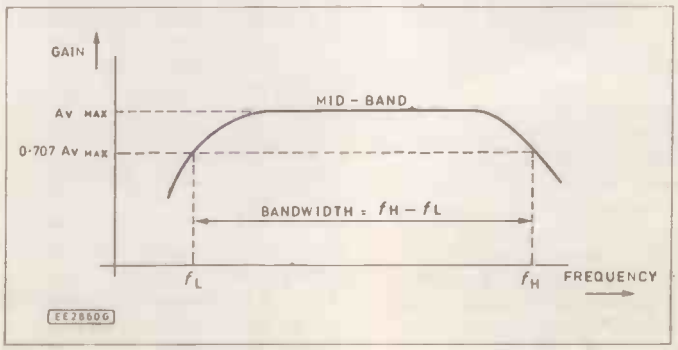


Fig. 2.1. Typical frequency response for a small-signal amplifier

produce some noise and some distortion. Noise may arise from several sources (including that which is produced within transistors and resistors). In mains operated equipment, "hum" (a signal which is induced from the a.c. supply mains) and "ripple" (a residual a.c. component present on the d.c. supply rail) are invariably present.

The sample specification lumps all forms of hum and noise together and simply indicates that the maximum value of unwanted signal component (i.e. hum *and* noise) at the output will amount to 100μV r.m.s. Since the signal level at this point will normally be several hundred or several thousand times greater, the unwanted component will usually be negligible (this point is further developed later).

Distortion arises from the inherent non-linearity of transistor characteristics and results in the generation of unwanted harmonic components. Since a very large number of such components may be present, it is usual to quote a figure for the "total harmonic distortion" (t.h.d.) present. This is usually specified as a percentage of the maximum output. A value of 0.01 per cent is, to all intents and purposes, negligible.

Input and output impedances are specified in order that the amplifier stage can be "matched" to a particular application. Some input devices (such as microphones and pick-up cartridges) require reasonably accurate termination in order to provide their stated characteristics. An amplifier designed for use in such a configuration must, therefore, provide a correct value of input impedance.

Matching of output impedances is equally important although an amplifier with a low output impedance will usually drive another amplifier stage having a high input impedance without any special precautions.

Input signal characteristics

Before we start to delve into the circuitry used in a variety of small-signal amplifiers, it is worth considering some of the essential characteristics of the signals which we might have to deal with.

The most important parameters are input levels (usually expressed in r.m.s. or peak-peak voltages) and frequency response (expressed in terms of the maximum and minimum frequency components which must be present in order to ensure reasonably faithful reproduction of the signal).

These parameters will be of considerable importance in the design of the amplifier. We must, for example, ensure that the input stage (and any subsequent stages) are not over-driven by excessive signal amplitudes. Failure to observe this precaution will result in excessive distortion on signal peaks due to "clipping". Furthermore, the frequency response of the circuit must be tailored to the signal.

If the bandwidth of the amplifier is made excessive (in comparison with the signal) we will unnecessarily worsen the signal-to-noise ratio at the output (this topic is also dealt with in greater depth later). If, on the other hand, the bandwidth is made too narrow, the quality of the signal will suffer and the output signal will no longer be a faithful reproduction of the input. This may all sound too obvious but nevertheless these simple precautions are often overlooked.

The following information is provided as a guide to some of the most common signals and sources that will be encountered:

Signal/source	Typical impedance	Typical amplitude range (r.m.s.)	Typical frequency range
High quality microphone used with speech and music	150ohm	500μV to 5mV	50Hz to 15kHz
Communications quality microphone (speech only)	600ohm	2mV to 10mV	300Hz to 4kHz
Compact disk (line output)	50kilohm	10mV to 1V	20Hz to 20kHz
V.H.F. radio tuner (line output)	50kilohm	100mV to 1V	40Hz to 15kHz
Medium wave radio (headphone output)	150ohm	200mV to 1V	200Hz to 6kHz
High quality cassette tape deck (line output)	50kilohm	50mV to 1V	50Hz to 12kHz
Low quality cassette tape deck (earphone output)	150ohm	200mV to 1V	100Hz to 6kHz
Record pick-up cartridge (dynamic)	50kohm	2mV to 10mV	20Hz to 20kHz
Record pick-up (piezoelectric)	2megohm	10mV to 100mV	20Hz to 20kHz

Transistor amplifiers

The prime mover within most practical amplifier circuits is the humble transistor. A single transistor is capable of providing a current gain (in common-emitter mode) of typically between 150 and 300. This current gain can be easily harnessed to provide voltage amplification.

In order to operate in a linear mode (in which the output signal produced by an amplifier is a faithful replica of its input) it is necessary to bias the transistor into the linear region of its operating characteristic. In practice, a small current must be applied to the base in order to produce a standing (quiescent) current in the collector. The base bias current is then effectively modulated by the input signal (i.e. the value of base current increases and decreases around the mean value of bias current).

The collector current is an amplified version of the base current. This current similarly increases and decreases around its standing value. Since this action is adequately explained in most electronic text books, we shall develop this theme no further other than to state that the value of bias current is crucial to the operation of an amplifier stage in a true linear mode. Failure to set the bias current correctly (either too high or too low) can result in excessive distortion (clipping) of the output signal.

Selecting transistors

Since transistor current gain (h_{fe}) is liable to considerable variation it is wise to design circuits that are tolerant of a wide variation in current gain. In the case of linear circuits (e.g. small-signal amplifiers) negative feedback should be used to determine actual stage gains. Remember, also, that current gain falls at high values of collector current.

Low noise transistors (e.g. BC109) should be used in circuits where signals have a relatively low amplitude (10mV, or less). Such devices should normally be fitted in the first and subsequent stages of an audio pre-amplifier.

The following table relates to the most popular types of bipolar transistor for use in small-signal amplifiers (r.f. transistors will be dealt with separately in Part 7):

Device	Type	I_c max.	V_{ceo} max.	V_{cbo} max.	V_{ebo} max.	P_{tot} max.	h_{fe}	at I_c	f_t typ	Case style	Application
2N2926	NPN	100mA	18V	18V	5V	200mW	200	2mA	200MHz	TO98	General purpose
2N3702	PNP	-200mA	-25V	-40V	-5V	360mW	175	2mA	100MHz	TO92	General purpose
2N3703	PNP	-500mA	-30mV	-50V	-5V	300mW	125	2mA	100MHz	TO92	General purpose
BC107	NPN	100mA	45V	50V	5V	300mW	240	2mA	250MHz	TO18	Driver
BC108	NPN	100mA	20V	30V	5V	300mW	240	2mA	250MHz	TO18	General purpose
BC109	NPN	100mA	20V	30V	5V	360mW	250	2mA	250MHz	TO18	Low noise
BC142	NPN	800mA	60V	80V	5V	800mW	>25	200mA	40MHz	TO5	Driver
BC143	PNP	800mA	-60V	-60V	-5V	800mW	>25	200mA	100MHz	TO5	Driver
BC168	NPN	50mA	20V	30V	5V	300mW	240	2mA	250MHz	TO92	General purpose
BC169	NPN	100mA	20V	30V	5V	300mW	250	2mA	250MHz	TO92	Low noise
BC171	NPN	100mA	45V	50V	5V	300mW	290	2mA	250MHz	TO92a	Plastic BC107
BC177	PNP	100mA	-45V	-50V	-5V	300mW	240	2mA	200MHz	TO18	BC107 complement
BC178	PNP	-100mA	-25V	-30V	-5V	300mW	240	2mA	200MHz	TO18	BC108 complement
BC179	PNP	-100mA	-20V	-25V	-5V	300mW	240	2mA	200MHz	TO18	BC109 complement
BC182L	NPN	200mA	50V	60V	5V	300mW	225	2mA	150MHz	TO92	Driver
BC183L	NPN	200mA	30V	45V	5V	300mW	250	2mA	150MHz	TO92	General purpose
BC184L	NPN	200mA	30V	45V	5V	300mW	250	2mA	150MHz	TO92	Low noise
BC212L	PNP	-200mA	-50V	-60V	-5V	300mW	200	2mA	200MHz	TO92	BC182L complement
BC213L	PNP	-200mA	-30V	-45V	-5V	300mW	200	2mA	200MHz	TO92	BC183L complement
BC214L	PNP	-200mA	-30V	-45V	-5V	300mW	225	2mA	200MHz	TO92	BC184L complement
BC478	PNP	-50mA	-40V	-40V	-5V	360mW	175	2mA	150MHz	TO18	BC108 complement
BC548	NPN	100mA	30V	30V	5V	625mW	250	2mA	300MHz	TO92a	Plastic BC108
BC549	NPN	100mA	30V	30V	5V	625mW	250	2mA	300MHz	TO92a	Plastic BC109
BC558	PNP	-100mA	-45V	-50V	-5V	625mW	250	2mA	360MHz	TO92a	Plastic BC178
BC559	PNP	-100mA	-30V	-30V	-5V	625mW	250	2mA	250MHz	TO92a	Plastic BC179
BCY70	PNP	-200mA	-40V	-50V	-5V	300mW	150	2mA	200MHz	TO18	General purpose
BCY71	PNP	-200mA	-45V	-45V	-5V	300mW	150	2mA	200MHz	TO18	General purpose
ZTX107	NPN	100mA	50V	60V	5V	250mW	240	2mA	300MHz	E-line	Plastic BC107
ZTX108	NPN	100mA	30V	45V	5V	250mW	300	2mA	350MHz	E-line	Plastic BC108
ZTX109	NPN	100mA	30V	45V	5V	250mW	400	2mA	350MHz	E-line	Plastic BC109
ZTX300	NPN	500mA	25V	25V	5V	300mW	150	10mA	350MHz	E-line	General purpose
ZTX500	PNP	-500mA	-25V	-25V	-5V	300mW	150	10mA	150MHz	E-line	ZTX300 complement

The column headings used in the foregoing table deserve a little more explanation. They have the following meanings:

Heading	Meaning
Device	Manufacturer's coding
Type	Transistor type; either *npn* or *pnp*
I_c max.	Maximum value of collector current
V_{ceo} max.	Maximum value of collector-emitter voltage with base left open-circuit
V_{cbo} max.	Maximum value of collector-base voltage with base left open-circuit
V_{ebo} max.	Maximum value of (reverse) emitter-base voltage with base left open circuit
P_t max.	Maximum total power dissipation
h_{fe}	Small-signal current gain (in common-emitter configuration)
at I_c	Value of collector current at which the small-signal current gain is quoted
f_t typ.	Transition frequency (i.e. the frequency at which the common-emitter current gain falls to unity)
Case style	Transistor encapsulation (and pin connections)
Application	Recommended use for the device (or generic type if the device is a plastic encapsulated or complementary version of another transistor)

Question 1: The following transistors are available: BC142, BC107, and BC109. Which of the transistors is most suitable for operating:

(a) in a complementary configuration in conjunction with a BC177
(b) as the first stage of a pre-amplifier in a low-noise amplifier
(c) in a circuit where the collector-emitter voltage is expected to be in the range 20V to 40V with a maximum collector current of 15mA?

Gain groups

Various transistors (such as the BC107, BC108, BC109, BC168, and BC169) are available in one of several "gain groups". The gain group is denoted by means of a suffix letter as follows:

Suffix	Current gain (h_{fe})
A	110-220
B	200-450
C	420-800

Thus a BC108B can be expected to exhibit a current gain in the region 200 to 450 (when operated with a nominal 2mA collector current). If high gain is important, it is thus important to obtain a transistor from the highest available gain group.

Readers should note that at least one supplier only supplies devices from the highest gain groups, thereby ensuring that performance specifications are more than adequately met!

Low noise amplifiers

Special precautions must be taken with the design of amplifiers which are to be operated with very small signals. A meaningful indication of the effect of noise within an amplifier is provided by the "signal-to-noise ratio". Clearly, the effect of noise will be more significant when the relative magnitude of the signal present is reduced (e.g. in the quieter passages of a piece of music).

The signal-to-noise ratio provides a yardstick which allows the effect of noise to be quantified in relation to the signal present. Since the signal cannot readily be separated from the noise at the output, the signal-to-noise ratio is usually specified as:

$$\text{Signal-to-noise ratio} = 10 \log_{10}\left(\frac{P_{SIG+NOISE}}{P_{NOISE}}\right) \text{dB}$$

$$= 20 \log_{10}\left(\frac{V_{SIG+NOISE}}{V_{NOISE}}\right) \text{dB}$$

where $P_{SIG+NOISE}$ is the r.m.s. output power developed with the signal present (i.e. including the residual noise), P_{NOISE} is the r.m.s. output power without the signal present (i.e. residual noise only present), $V_{SIG+NOISE}$ is the r.m.s. output voltage developed with the signal present (i.e. including the residual noise), and V_{NOISE} is the r.m.s. output power without the signal present (i.e. residual noise only present).

The effect of passing a signal through an amplifier is a degradation of the signal-to-noise ratio. This is sometimes specified as the "noise figure" and is defined as:

$$\text{Noise figure} = \frac{\text{signal-to-noise ratio at the input}}{\text{signal-to-noise ratio at the output}}$$

Note that, where the signal-to-noise ratios are expressed in decibels (dB), the noise figure (expressed in dB) is found by simply subtracting the signal-to-noise ratio at the output from the signal-to-noise ratio at the input.

Question 2: An amplifier has matched input and output impedances of 600 ohm. The signal (plus noise) at the input has an r.m.s. voltage of 20mV. In the absence of a signal, the noise at the input has an r.m.s. value of 1mV. The signal (plus noise) at the output of the amplifier has an r.m.s. voltage of 800mV. If, in the absence of the signal the noise at the output has an r.m.s. value of 60mV, determine:

(a) amplifier voltage gain (expressed as a ratio)
(b) amplifier voltage gain (expressed in dB)
(c) signal-to-noise ratio at the input
(d) signal-to-noise ratio at the output
(e) amplifier noise figure

Noise versus gain

It is important to note that most transistors provide optimum low-noise performance when operating with relatively low values of collector current (e.g. 100μA). Maximum current gain, on the other hand, usually corresponds with much larger values of collector current (e.g. 2mA). Hence, there is a trade-off between gain and noise performance.

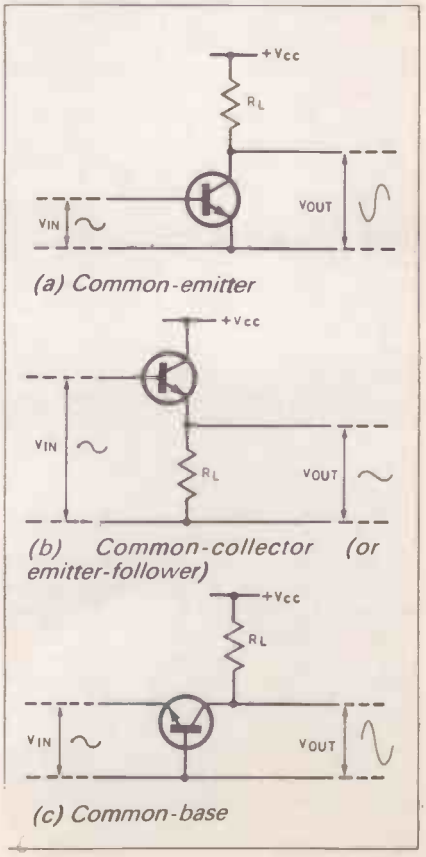
In the first stage of a multi-stage amplifier we would thus usually sacrifice gain in favour of noise performance and operate the transistor with a low value of collector current. Subsequent stages (where noise is not so critical) could benefit from the larger values of current gain which can be obtained by employing larger values of collector current.

Transistor amplifier configurations

Three different circuit configurations are employed for transistor amplifiers depending upon which of the three transistor connections is made "common" to both input and output (see Fig. 2.2). The three basic circuit configurations exhibit the following characteristics (typical values given in brackets):

Parameter	Mode of operation		
	Common emitter	Common collector (emitter follower)	Common base
Voltage gain	medium/high (40)	unity (1)	high (200)
Current gain	high (200)	high (200)	unity (1)
Power gain	very high (8000)	high (200)	high (200)
Input resistance	medium (2.5kilohm)	high (100kilohm)	low (200ohm)
Output resistance	medium high (20kilohm)	low (100ohm)	high (100kilohm)
Phase shift	180 deg.	0 deg.	0 deg.
Fig. reference	2(a)	2(b)	2(c)
Typical applications	General purpose, a.f. and r.f. amplifiers	Impedance matching, input and output stages	R.F. and V.H.F. amplifiers

Fig. 2.2. Transistor amplifier operating configurations



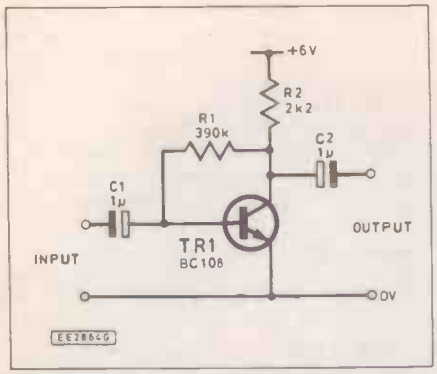


Fig. 2.3. Simple common-emitter amplifier stage

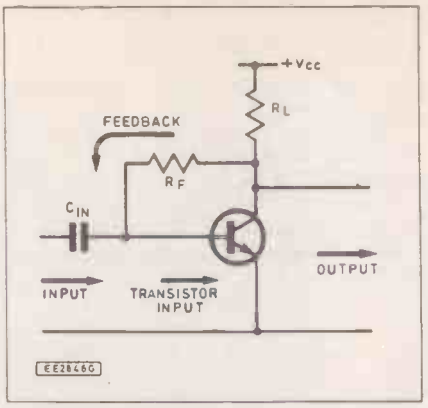


Fig. 2.4. Feedback path in the simple common-emitter stage

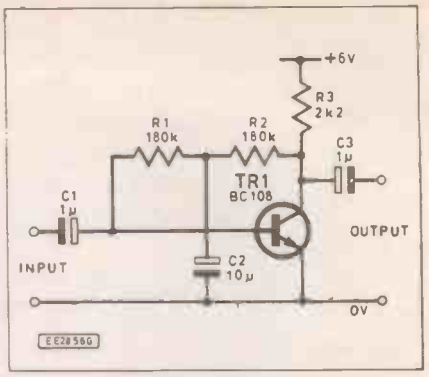


Fig. 2.5. Reducing the amount of a.c. feedback

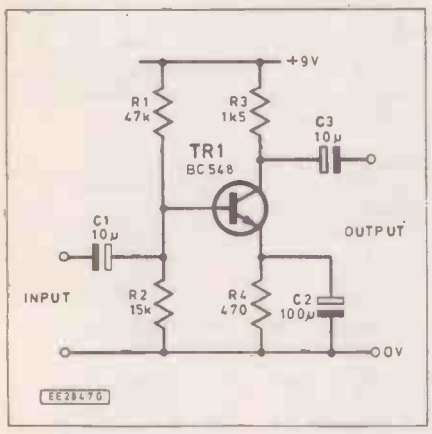


Fig. 2.6. Emitter stabilised common-emitter amplifier stage

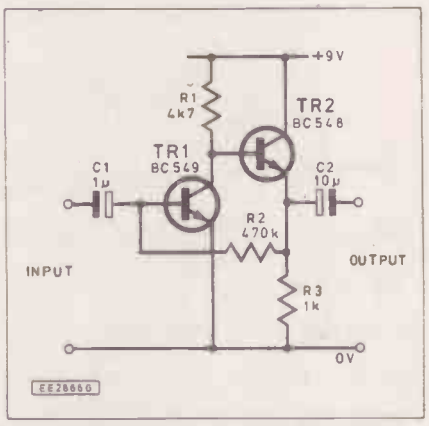


Fig. 2.7. Two-stage amplifier with low-impedance output

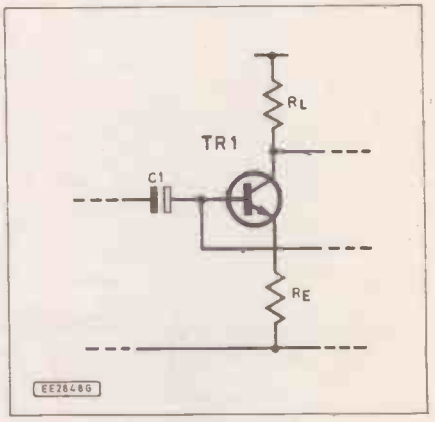


Fig. 2.8. Modification to Fig. 2.7 to permit gain setting by negative feedback

Practical amplifier circuits

The basic circuit of a bipolar transistor operating in common emitter mode is shown in Fig. 2.3. This simple circuit can provide voltage gains of around 100 with a frequency response extending from about 60Hz to several hundred kilohertz. The input impedance is approximately 2.5 kilohm. The maximum input signal amplitude is approximately 10mV r.m.s. (approx. 30mV pk-pk).

The circuit of Fig. 2.3 employs negative feedback stabilised bias (i.e. the base current is derived from the value of collector-emitter voltage). Fig. 2.4 illustrates the feedback process. Both a.c. and d.c. feedback is present, the amount of the former type of feedback (which reduces the overall stage gain) is very much dependent upon the source impedance. Where the gain reduction is significant, the bias resistor can be split and the a.c. negative feedback component removed by means of the arrangement shown in Fig. 2.5.

An emitter-stabilised common-emitter amplifier stage is shown in Fig. 2.6. This stage provides a voltage gain of around 125 coupled with an input impedance of around 2 kilohm. The bandwidth extends from around 10Hz to well over 100kHz.

An improved two-stage amplifier in which TR1 operates as a common-emitter stage whilst TR2 is connected as an emitter-follower is shown in Fig. 2.7. The stage employs negative feedback stabilised bias by means of R2. One significant advantage of this circuit over that shown in Fig. 2.6 is that the output impedance is much reduced (typically approximately 50ohm). The circuit of Fig. 2.7 provides a typical gain of 200 with a bandwidth of 50Hz to 120kHz (or more). The input impedance is approximately 3 kilohm.

Unfortunately, the voltage gain offered by the circuit of Fig. 2.7 (and all previously described amplifier stages) is very much dependent upon the individual value of transistor current gain (h_{fe}). Since h_{fe} can vary (often by as much as 50 per cent) for a given transistor type, the stage gain is not readily predictable unless the transistors are specially selected.

In many applications, it is necessary to determine the actual stage gain by means of the application of a pre-determined amount of negative feedback. Fig. 2.8 shows how this can be achieved within the circuit of Fig. 2.7. The voltage gain of the circuit with this modification in place is given simply by the ratio of R_L to R_E (provided that this ratio is not too large). Hence, if we require a stage gain of 10, we could simply make R_L 4k7 (as in Fig. 2.7) and add an emitter resistor, R_E, of 470Ω. It is, however, important to note that, by incorporating this type of negative feedback, the input impedance will be raised.

Without R_E (i.e. with R_E replaced by a short-circuit) the stage offers an input impedance of approximately 3k. With R_E of 470Ω, however, the input impedance is increased to around 25k. This may, or may not, be desirable!

In order to obtain a high value of input impedance, a field-effect transistor (connected as a source-follower) may be added at the input of the circuit of Fig. 2.7. Fig. 2.9 shows an amplifier based on this arrangement which provides a voltage gain of approximately 200 coupled with an input impedance of approximately 4M5. This circuit makes an ideal input stage for an instrumentation amplifier.

The maximum values of voltage gain which can be achieved by the previously described circuits (which essentially all rely on the gain provided by a single common-emitter stage) is limited to about 200. Clearly this value of gain will be inadequate for a number of applications. Fig. 2.10 shows a two-stage amplifier in which both stages operate in common-emitter mode. The overall stage gain is given (approximately) by:

$$\text{Voltage gain, } A_V = \frac{R3}{R1} \times \frac{R4}{R5}$$

Note that maximum gain is achieved with R1 short-circuit, in which case the

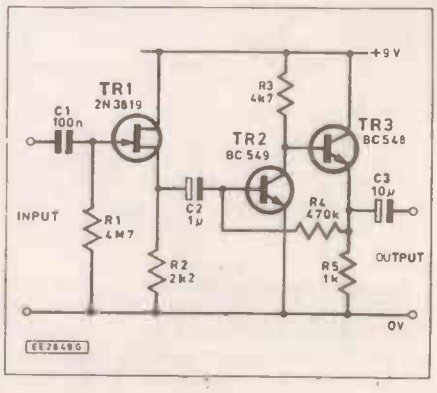


Fig. 2.9. Adding an f.e.t. input stage to obtain a very high input impedance

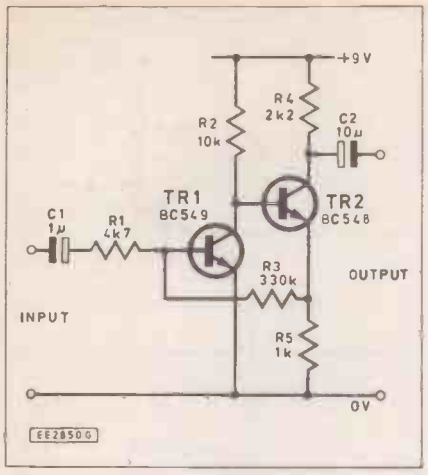


Fig. 2.10. Two-stage high gain amplifier

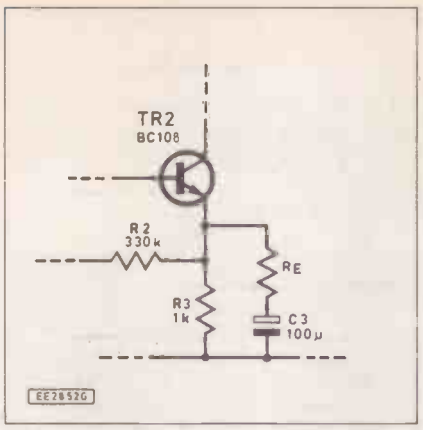


Fig. 2.12. Modification to the general purpose transistor amplifier module in order to permit gain setting

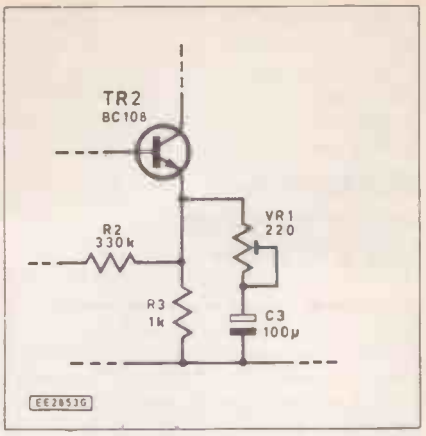


Fig. 2.13. Modification to the general purpose transistor amplifier module in order to permit variable gain adjustment

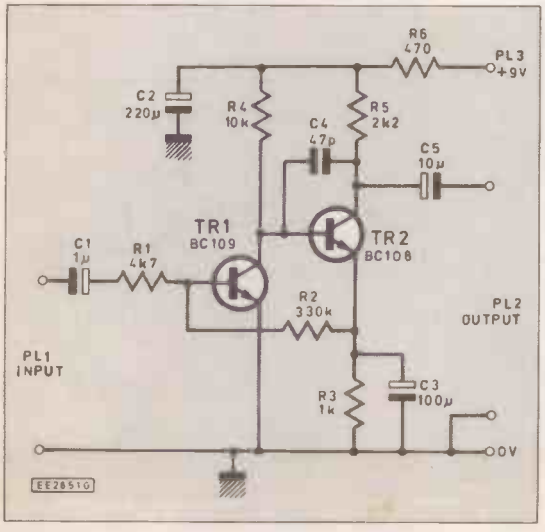


Fig. 2.11. General purpose transistor amplifier module

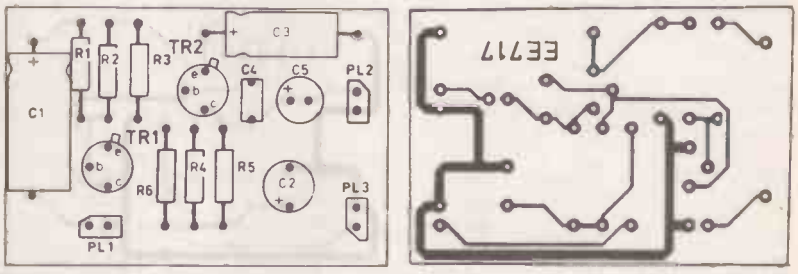


Fig. 2.14. P.C.B. layout for the general purpose transistor amplifier module

overall voltage gain will typically be in the region of 350 to 500 with the values shown.

If even more gain is required, then R5 may be bypassed to a.c. by means of an electrolytic capacitor of appropriate value. Gains of up to 5000 can be achieved by this means.

General purpose transistor amplifier module

The circuit diagram of a general purpose transistor amplifier module is shown in Fig. 2.11. This circuit can be configured in a variety of ways and the frequency response and voltage gain can be readily pre-defined. A BC109 (or BC549) should be used for TR1 whilst a BC108 (or BC548) should be used for TR2. The circuit requires a 9V d.c. supply rail and consumes a mere 2mA, or so.

With C3 connected and values as shown in Fig. 2.11, the voltage gain for the circuit is approximately 5000. The maximum input voltage in this configuration should not be allowed to exceed 1mV pk-pk.

Where reduced values of gain are required, a fixed resistor may be wired in series with C3, as shown in Fig. 2.12. With R_E of 220Ω, the voltage gain is reduced to approximately 700. Alternatively, R_E may be replaced by a miniature preset potentiometer of 220Ω, as shown in Fig. 2.13. The voltage gain may then be adjusted to any required value in the range 700 to 5000 approximately.

The low frequency response of the module can be determined by choice of an appropriate value for C1 whilst the high frequency cut-off is determined by the value of C4. Note that, when operating in the high-gain configuration (with C3 present) it may be essential to have a minimum value of C4 present (e.g. 47p) in order to ensure unconditional high-frequency stability.

The copper foil and p.c.b. component layouts for the general purpose transistor amplifier module are shown in Fig. 2.14.

Low-power output driver

Occasionally, we require a small-signal amplifier to drive a low impedance load. In such cases, we will require a low-power output stage which can source a reasonable amount of current. Fig. 2.15 shows a typical solution to this problem. TR1 and TR2 operate as complementary emitter-followers. Resistors R1, R2 and the forward biased diodes, D1 and D2, provide the necessary bias for TR1 and TR2. R3 and R4 provide a degree of temperature stabilisation for the output transistors which may operate at an appreciable collector current when driving a low-impedance load with a signal of appreciable amplitude. The stage provides unity voltage gain.

Operational amplifiers

In recent years, the advent of the high-performance operational amplifier has provided the electronic circuit designer with another means of faithfully amplifying low-level signals. For the benefit of the newcomer, operational amplifiers are simply analogue integrated circuits which offer near-ideal characteristics (virtually infinite voltage gain and input resistance coupled with low output resistance and wide bandwidth). As such, they can be used effectively as a "block of gain" which can be inserted readily into a circuit without the need for complex bias arrangements.

Operational amplifiers are available packaged singly, in pairs (dual types), or in fours (quad types). The TL081, for example, is a single general purpose b.i.f.e.t. operational amplifier which is also available in dual (TL082) and quad (TL084) forms.

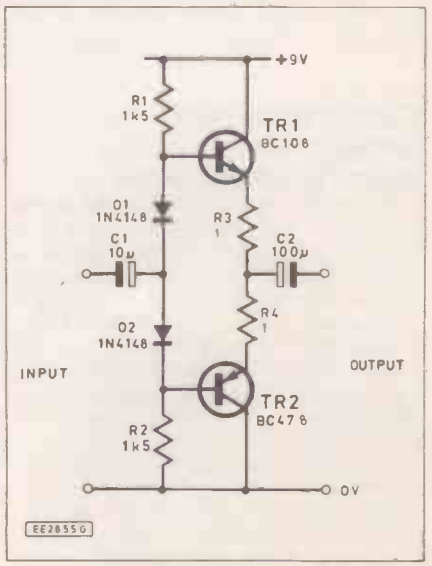


Fig. 2.15. Low-power complementary output dirver for use with low impedance loads.

Where several operational amplifiers are required in a circuit, it usually makes good sense to use dual or quad devices rather than single devices in order to minimise the number of components and reduce the size of the p.c.b. required.

Selecting operational amplifiers

When selecting an operational amplifier for use in a small-signal amplifier, the open-loop voltage gain and input bias current ratings are invariably less important parameters than supply voltage range and slew rate. This last named parameter provides a measure of the response of an operational amplifier to a step function input; the larger the slew rate, the wider the frequency reponse.

The following table relates to the most popular types of operational amplifier for use in small-signal amplifiers (integrated circuit power amplifiers will be dealt with separately in Part 3). Note that the TL071 and TL081 series of f.e.t. input operational amplifiers offer excellent all-round performance in terms of operating voltage range, open-loop voltage gain and slew rate.

Device	Type	Package	Supply voltage range (V)	Open loop voltage gain (dB)	Input bias current (A)	Slew rate (V/us)	Output voltage (V) (note 1)
LF347	FET	Quad	±5 to ±18	110	50p	13	±13.5
LF351	FET	Single	±5 to ±18	110	50p	13	±13.5
LF353	FET	Dual	±5 to ±18	110	50p	13	±13.5
LF355	FET	Single	±4 to ±18	106	30p	5	±13
LM324	Bipolar	Quad	3 to 32 (or ±15)	100	45n	0.6	28 (or ±14) (note 2)
LM348	Bipolar	Quad	±10 to ±18	96	30n	0.6	28 (note 2)
NE531	Bipolar	Single	±5 to ±18	96	400n	35	±15
TL071	FET	Single	±3 to ±22	106	30p	13	±13.5
TL072	FET	Dual	±3 to ±18	106	30p	13	±13.5
TL074	FET	Quad	±3 to ±18	106	30p	13	±13.5
TL081	FET	Single	±3 to ±18	106	30p	13	±13.5
TL082	FET	Dual	±3 to ±18	106	30p	13	±13.5
TL084	FET	Quad	±3 to ±18	106	30p	13	±13.5
741	Bipolar	Single	±5 to ±18	106	80n	0.5	±13
741S	Bipolar	Single	±5 to ±18	100	200n	20	±13
747	Bipolar	Dual	±7 to ±18	106	80n	0.5	±13
748	Bipolar	Single	±7 to ±18	106	80n	0.8	±13
759	Bipolar	Single	7 to 36 (or ±3.5 to ±18)	106	50n	0.5	±12.5

Notes

1. Measured with supplies of 15V (or ±15V).
2. Measured with supplies of 30V.

Operational amplifier configurations

The three basic configurations for an operational amplifier are shown in Fig. 2.16. The circuit of Fig. 2.16(a) shows an inverting amplifier which provides a phase shift of 180 degrees between the input and output signals. The circuit of Fig. 2.16(b) shows a non-inverting amplifier which provides a phase shift of 0 degrees (i.e. input and output signals are in-phase) whilst that of Fig. 2.16(c) shows a differential amplifier (the output voltage is proportional to the difference between the two input voltages).

The voltage gain (A_V) of the circuit in Fig. 2.16(a) is given by:

$$A_V = \frac{V_{OUT}}{V_{IN}} = -\frac{R_F}{R_{IN}}$$

(the minus sign indicates inversion *not* attenuation)

whilst that for Fig. 2.16(b) is given by:

$$A_V = \frac{V_{OUT}}{V_{IN}} = \frac{R_F}{R_{IN}}$$

For optimum performance, R` is equal to the parallel combination of R_{IN} and R_F in order to retain symmetry. Hence (for both circuits):

$$R` = \frac{R_{IN} \times R_F}{R_{IN} + R_F}$$

Practical inverting and non-inverting amplifier stages are shown in Figs. 2.17 and 2.18. With the values shown, these stages provide a nominal voltage gain of 10 (note that the capacitors should be non-electrolytic types). Fig. 2.19 shows an audio frequency amplifier which has cut-off frequencies and bandwidth determined by the component values employed. The following equations relate to this circuit:

Mid-band voltage gain: $A_V = R_2/R_1$

Mid-band input impedance: $Z_{IN} = R_1$ ohm

Lower cut-off frequency:

$$f_L = \frac{1}{2\pi C_1 R_1} = \frac{0.159}{C_1 R_1} \text{ Hz}$$

Upper cut-off frequency:

$$f_H = \frac{1}{2\pi C_2 R_2} = \frac{0.159}{C_2 R_2} \text{ Hz}$$

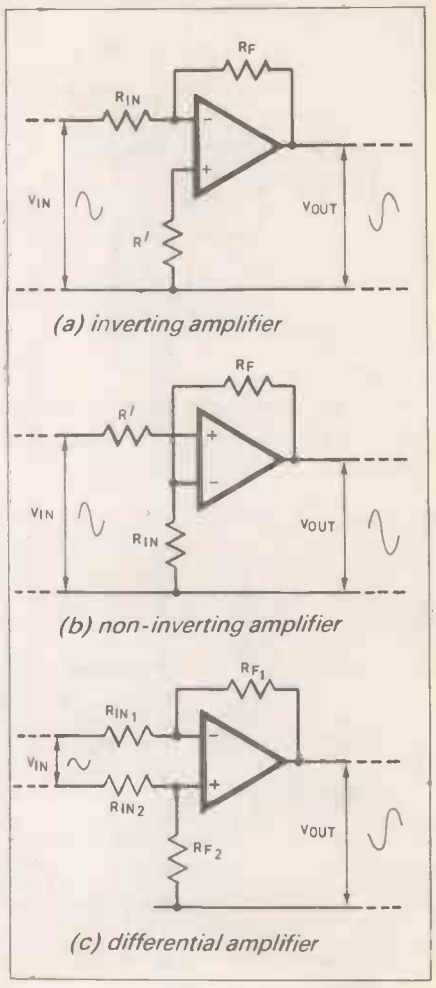
Bandwidth: $f_W = f_H - f_L$ Hz

General purpose operational amplifier module

The circuit diagram of a general purpose operational amplifier module is shown in Fig. 2.20. This circuit can be configured in a variety of ways and the frequency response and voltage gain can be readily pre-defined. The operational amplifier, IC1, should be a TL072 or TL082 dual device.

With the values shown, each half of the circuit provides a nominal mid-band voltage gain of 22 and the frequency response extends from 160Hz to 7.2kHz approximately. The two stages may be used independently (e.g. as "left" and "right" channel amplifiers in a stereo system) or may be connected in tandem to provide a high gain

Fig. 2.16. Operational amplifier circuit configurations



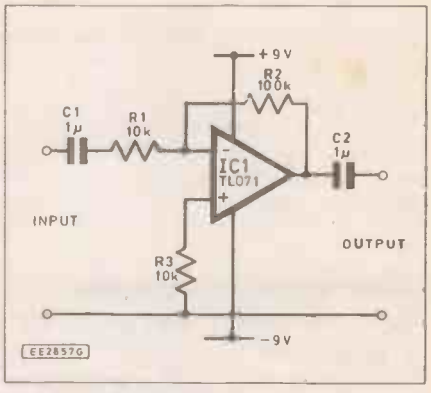


Fig. 2.17. Practical inverting amplifier

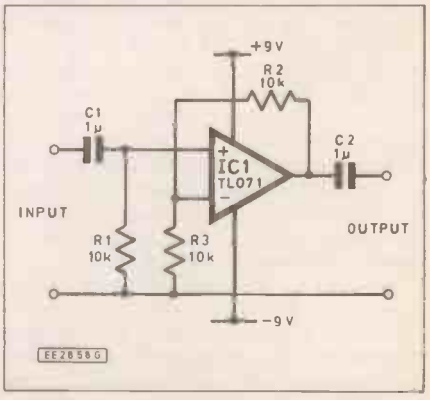


Fig. 2.18. Practical non-inverting amplifier

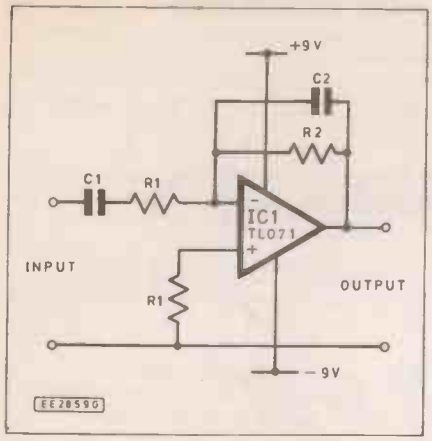
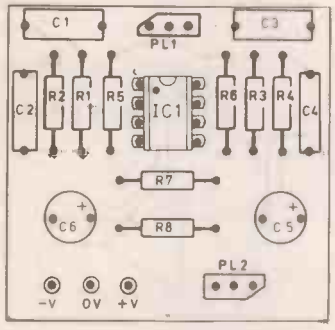


Fig. 2.19. Bandwidth limited inverting operational amplifier



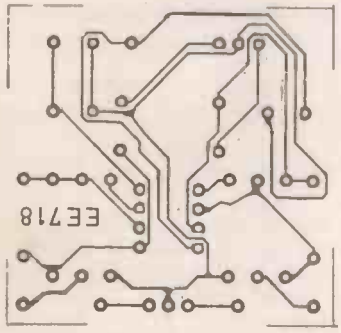


Fig. 2.21. P.C.B. layout for the general purpose operational amplifier module

amplifier stage. The circuit requires a dual rail power supply of ±5V to ±15V. The copper foil and p.c.b. component layouts for the general purpose operational amplifier module are shown in Fig. 2.21.

Question 3: An audio amplifier stage is to operate according to the following specifications:

Mid-band voltage gain = 100
Mid-band input impedance = 600ohm
Lower cut-off frequency = 300Hz
Upper cut-off frequency = 3.4kHz

Devise a suitable circuit arrangement based on an operational amplifier. Specify the value of all components used.

Design Problem

This month's design problem (as with all of the design problems presented in this series) is designed for readers who would welcome the opportunity of tackling a little "homework". The exercise may be tackled purely "on paper" or may be used as the basis of a complete constructional project.

This month's problem arises from the need for a means of amplifying the low-level audio signal from a dynamic microphone:

A public address amplifier provides full

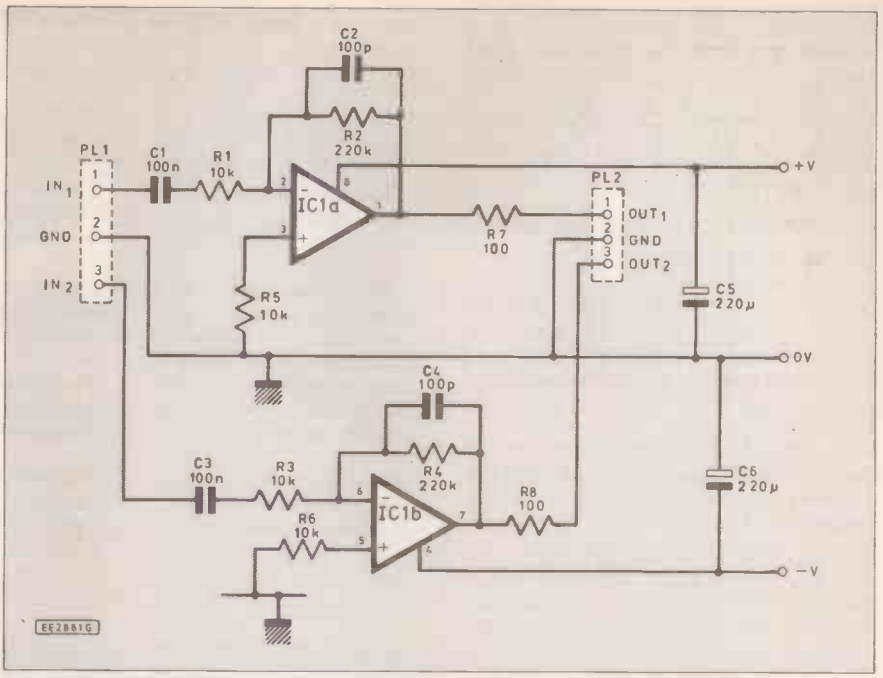


Fig. 2.20. Circuit diagram of the general purpose operational amplifier module

COMPONENTS

General Purpose Transistor Amplifier

Resistors

R1	4k7
R2	330k
R3	1k
R4	10k
R5	2k2
R6	470

All resistors are 0.25W ±5% carbon

See Shop TALK Page

Capacitors

C1	1µ axial elect. 63V
C2	220µ radial elect. 35V
C3	100µ radial elect. 35V
C4	47p miniature plate ceramic
C5	10µ radial elect. 16V

Semiconductors

TR1	BC109
TR2	BC108

Miscellaneous

PL1 to PL3 2-way straight p.c.b. headers (0.1inch pitch), 3 off
SK1 to SK3 2-way socket housing (0.1inch pitch), 3 off
Printed circuit board, available from the *EE PCB Service*, order code EE717.

General Purpose Operational Amplifier

Resistors

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

All resistors are 0.25W ±5%

Capacitors

C1	100n 100V miniature dipped polyester
C2	100p 100V miniature ceramic plate
C3	100n 100V miniature dipped polyester
C4	100p 100V miniature ceramic plate
C5	220µ radial elect. 35V
C6	220µ radial elect. 35V

Semiconductors

IC1 TL072 or TL082

Miscellaneous

PL1, PL2 3-way straight p.c.b. headers (0.1inch pitch), 2 off
SK1, SK2 3-way socket housing (0.1inch pitch), 2 off
Printed circuit board, available from the *EE PCB Service*, order code EE718; terminal pins 1mm (3 off).

Approx cost guidance only **£6** *transistor amp.* **£7.50** *op. amp.*

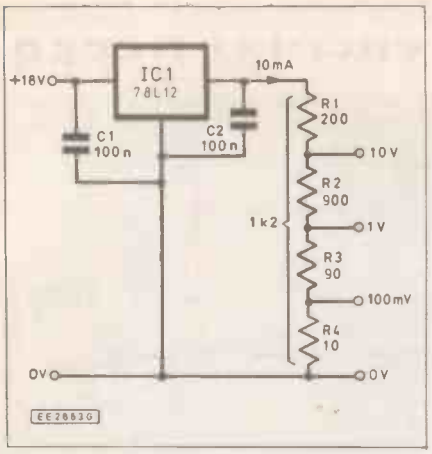


Fig. 2.22. Voltage calibrator circuit (solution to last month's Design Problem)

rated output from a nominal line input of 1V r.m.s. The amplifier is to be fitted with a microphone input facility which will match a 50k impedance dynamic microphone. If the microphone produces a nominal output of 2mV r.m.s., design a simple pre-amplifier based on a dual operational amplifier.

Answer to last month's design problem:

An oscilloscope is to be fitted with an accurate d.c. voltage calibrator. This circuit is to provide fixed d.c. levels of 100mV, 1V and 10V at a front-panel test point. The voltage levels should be accurate to within ± 2 per cent and the voltage level should be maintained within this range when the test point is "loaded" by a standard oscilloscope input (equivalent to 1M). Design a suitable circuit arrangement based on a standard voltage regulator operating from an internal +18V rail. Specify all component values required.

One solution to last month's design problem is shown in Fig. 2.22. A low-power 12V regulator (78L012) is used to provide an accurate (to within ± 2 per cent) supply which is then applied to a voltage divider chain. To keep things fairly simple, we have made the total resistance of the divider chain 1k2 and, since the output of the regulator is 12V, a current of 10mA will flow in the divider chain. The required voltages are simply "tapped off" from resistance of 10Ω (100mV), 100Ω (1V), and 1k (10V). The rather awkward values of resistance needed in the chain can easily be made up from preferred resistors as follows:

R1 (200Ω): 2 x 100Ω in series
R2 (900Ω): 2 x 1k8 in parallel
R3 (90Ω): 2 x 180Ω in parallel

All the resistors should be two per cent (or better) close tolerance types.

Answers to questions in Part Two

Question 1

(a) BC107
(b) BC109
(c) BC142

Question 2

(a) 40
(b) 32dB
(c) 26dB
(d) 22.5dB
(e) 3.5dB

Question 3

Since the mid-band input impedance is to be 600Ω, R1 must be 600Ω (in practice we could use two 1k2 resistors connected in parallel). In order to provide a mid-band voltage gain of 100, R2 must be 100 times 600Ω (or 60k). This value can be achieved by wiring two 120k resistor in parallel.

If, however, we can tolerate a small error in the input impedance (less than 10 per cent) we could make use of resistors of the nearest preferred values. We could thus make R1 and R2 560Ω and 56k, respectively.

The values of C1 and C2 can be calculated from:

$$C1 = \frac{0.159}{R1\ f_L}$$

hence

$$C1 = \frac{0.159}{560 \times 300} = 9.46 \times 10^{-7}\ F$$

thus

C1 = 0.946 (nearest preferred value 1μ)

Similarly,

$$C2 = \frac{0.159}{R2\ f_H}$$

hence

$$C2 = \frac{0.159}{56 \times 10^9 \times 3.4 \times 10^9} = 0.835 \times 10^{-9}\ F$$

thus

C2 = 835p (nearest preferred value 820p)

Hence the final circuit arrangement will be similar to that shown in Fig. 2.19 with:

R1 = 560Ω, R2 = 56k, C1 = 1μ, and C2 = 820p

Next month: In next month's instalment we deal with power amplifiers and consumer audio frequency integrated circuits. Our design problem involves a guitar amplifier and our constructional project features a bench amplifier/signal tracer.

Cumulative index to modules

Title	Part	Function/specification
Dual output power supply module	1	Dual ± 5V, ± 12V or ± 15V regulated power supply rated at 1A max. output.
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General purpose transistor amplifier module	2	Pre-defined voltage gain and frequency response. Low/medium input impedance, low output impedance. Requires a single 9V d.c. supply at 2mA nominal.
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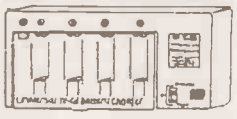

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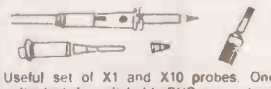

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ECC84	0.65	GY501	1.55	UBC81	2.05
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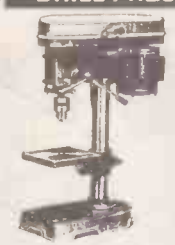

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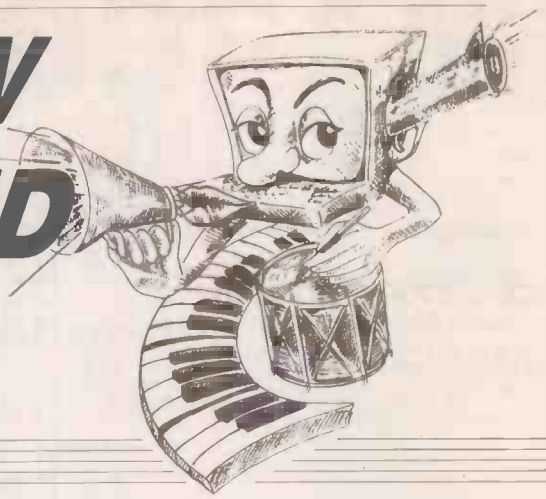
Constructional Project

AMSTRAD PCW STEREO SOUND GENERATOR



JASON SHARPE

Uninspired by your PCW's 'bleeping'? Well now you can have three channel stereo sound effects.

THIS project gives the PCW three channel (left, left and right (centre), right) stereo sound, the frequency and volume of each channel is software programmable, "noise" can also be mixed into any or all channels, there is also an envelope generator.

The circuit was originally designed and built around the AY-3-8913, however this chip is no longer available and the slightly more expensive AY-3-8912 has had to be substituted. The later type is an identical device but has an additional I/O port which is not required in this design.

HOW IT WORKS

The AY-3-8912 programmable sound generator (more about this chip later), is connected to the PCW using a Z80 PIO (IC1 in Fig.1). The PIO has two ports (port A and port B), port B is used to transfer data and addresses to IC4, three of the eight lines on port A are used for control signals and resetting IC4, the other five lines are unused.

Integrated circuit IC2 is a three to eight line decoder, which is used as an address decoder to select the PIO. The PIO is enabled between ports 160 and 163 (inclusive). IC3 divides the Z80's 4MHz clock by two, to supply IC4 with a 2MHz clock.

The three audio outputs (A,B,C) of the AY-3-8912 are available on pins 5, 4 and 1 respectively, these are fed into a simple mixer circuit comprising of resistors R1, R2, R3 and R4. The result is two sound channels, one consisting of channel A and half (volume) of channel B, the other channel C and half of channel B, this gives the

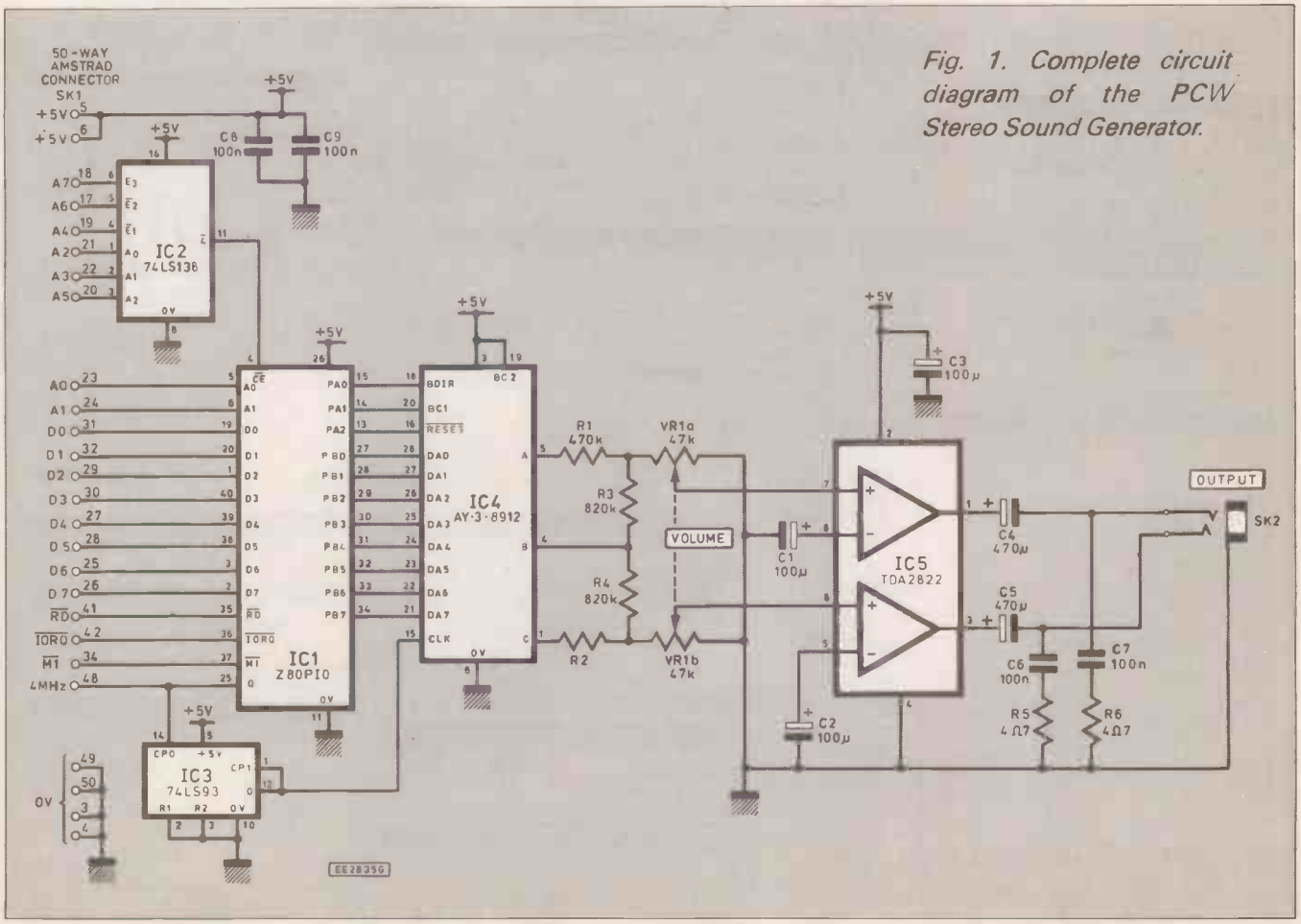


Fig. 1. Complete circuit diagram of the PCW Stereo Sound Generator.

effect of channel B being "between" the two speakers.

The output of the mixer is fed into a stereo amplifier (IC5) through volume control (VR1). IC5 is a TDA2822 low power stereo amplifier, this amplifier i.c. is used because of its low voltage requirement and also because it needs very few external components. The output of this i.c. is sufficient to drive a pair of personal stereo headphones or small speakers, alternatively the output can be amplified again by using an external amplifier.

CONSTRUCTION

The sound generator can be quite easily constructed on the p.c.b. shown in Fig. 2, when soldering in the components be very careful not to short out any tracks with solder as some of them are very close together.

When assembling fit the resistors and link first, then the i.c. sockets, followed by capacitors. The 50 way cable can now be connected to the board, the prototype used a ready made cable terminated with a 50 way edge connector at one end and a 50 way transition header at the other. Next insert the i.c.s and then the stereo output socket and volume control, use screened cable for these to prevent to much digital noise getting into the signal, also if the case of the volume control is metal connect it to 0V.

TESTING

Before plugging the unit into the computer check the board for short circuits caused by solder etc.

Make sure you have the edge connector the right way up, with pin 1 as shown in Fig. 2. (It is best to fit a polarising key between pins 22 and 24 (see Fig. 3.), and plug the unit into the expansion slot on the back of the PCW. Plug the headphones or speakers in, switch on and boot up as nor-

COMPONENTS

Resistors

R1, R2	470k (2 off)
R3, R4	820k (2 off)
R5, R6	4Ω7 (2 off)

All ¼W 5% carbon.

Potentiometers

VR1	47k stereo log.

Capacitors

C1 to C3	100µ elect. 12V (3 off)
C4, C5	470µ elect. 12V (2 off)
C6 to C9	100n (4 off)

Semiconductors

IC1	Z80PIO
IC2	74LS138
IC3	74LS93
IC4	AY-3-8912
IC5	TDA2822

Miscellaneous

SK1	50 way transition header with ribbon cable and Amstrad connector.
SK2	3.5m stereo jack socket

P.C.B., available from the *EE PCB Service*, order code EE715, screened lead for audio connections; suitable case, minimum size, 120 x 95 x 45mm; control knob.

Approx cost guidance only **£25**

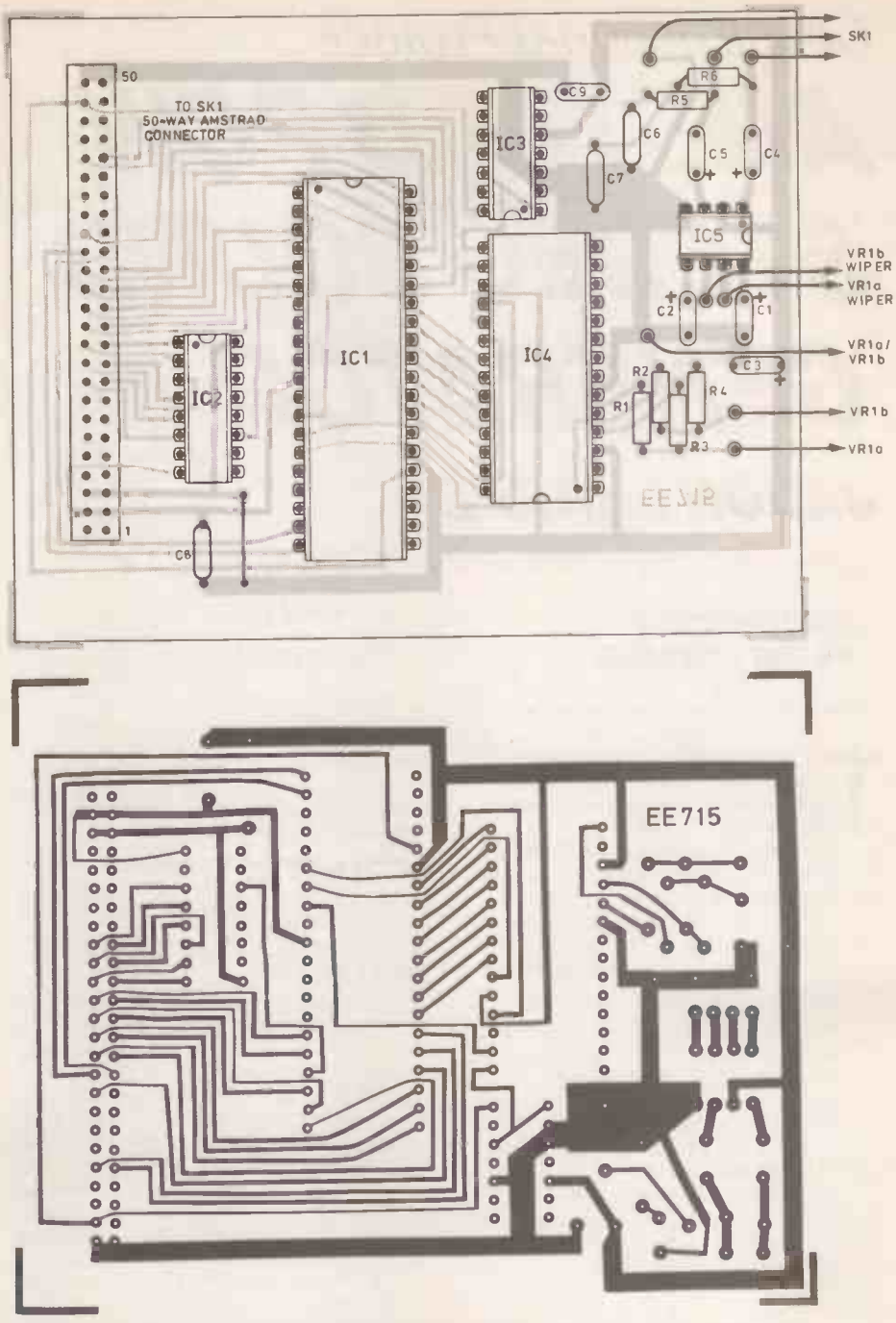
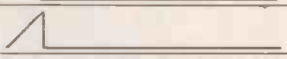
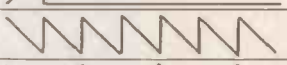


Fig. 2. P.C.B. for the sound generator.

Table 1. Register Functions

Register	Function	Range
0	Channel A frequency, fine tune	0→255
1	Channel A frequency, course tune	0→15
2	Channel B frequency, fine tune	0→255
3	Channel B frequency, course tune	0→15
4	Channel C frequency, fine tune	0→255
5	Channel C frequency, course tune	0→15
6	Noise frequency control	0→31
7	Not mixer enable	0→255
8	Channel A amplitude (15 loud, 16 envelope)	0→16
9	Channel B amplitude (15 loud, 16 envelope)	0→16
10	Channel C amplitude (15 loud, 16 envelope)	0→16
11	Envelope period, fine tune	0→255
12	Envelope period, course tune	0→255
13	Envelope shape cycle	0→15

Table 2

REG. VALUE	ENVELOPE CYCLE SHAPE
0	
4	
8	
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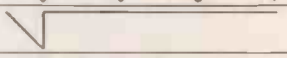
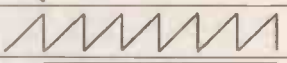
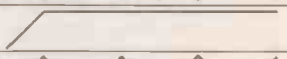
11	
12	
13	
14	

mal. If the computer will not boot up, or does anything abnormal, turn the computer off, unplug the unit and check all wiring, joints etc. For test program see PROGRAMMING.

REGISTER FUNCTIONS

The AY-3-8912 is register based, this means that you need to set the values of the registers (like memory locations) in the 8912 to certain values, depending on what you want it to do, the register functions are shown in Table 1, and explained below.

FREQUENCY CONTROL:

The frequency of each channel is determined by setting registers 0 to 5, the frequency of the output is equal to: $125000 \div (FTV + 256 \times CTV)$ where FTV is the FINE TUNE VALUE and CTV is the COURSE TUNE VALUE

NOISE CONTROL:

Noise can be mixed into any or all of the channels for special effects (drums, guns, waves, etc.)., the base frequency of the noise is given by: 125000 ÷ (VALUE OF NOISE REGISTER)

NOT MIXER ENABLE:

The value of this register controls which frequencies are "switched on" and whether the channels have noise mixed into them.

	NOT NOISE ENABLE			NOT FREQUENCY ENABLE		
CHANNEL	C	B	A	C	B	A
VALUE	32	16	8	4	2	1

The value you need to set this port to enable the required things can be worked out by $255 - (V_1 + V_2 + \ldots + V_n)$ Where V_1 to V_n are the values of the things you wish to enable, e.g. $255 - (16+4+2+1)$. This will enable all of the frequencies and enable noise to be mixed with channel B.

AMPLITUDE CONTROL:

The value of these registers control the amplitude of the channels. 0 is QUIET, 15 is LOUD, setting the register to 16 lets the amplitude of that signal be controlled by the envelope generator.

ENVELOPES:

As mentioned earlier the AY-3-8912 has envelope capability, but what is an envelope? An envelope is a waveform that varies the amplitued of a signal (in this case the channels that have the amplitued control set to 16), another way of explaining this is that it is similar to turning the volume control on a radio up to full and then down again then up to full etc. The speed at which you turn the volume down (or up) is the envelope period, this can be varied from approx. 7812Hz to about 0.12Hz (≅8.4 second period).

ENVELOPE PERIOD:

These registers determine the frequency of the envelope cycle which is given by: $7812 \div (256 \times ECT + EFT)$ Where ECT is the ENVELOPE COURSE TUNE value and EFT is the ENVELOPE FINE TUNE value.

ENVELOPE SHAPE:

This controls the shape of the envelope cycle (see Table 2).

PROGRAMMING

Program 1 selects random registers and then sends random data to the selected register, the effect is a jumble of frequencies, noise, etc. from the headphones, so this is a good program to test the sound generator.

If you wish to write your own programs you must include lines 100 to 140 as these set up the PIO and also reset the sound i.c. Line 220 is a subroutine to select a register, the value of which is in A. Line 240 is similar to 220 but sends data (in A) to the previously selected register.

Program 2 is almost the same as Program 1, but instead of choosing random registers and data they are input by the user.

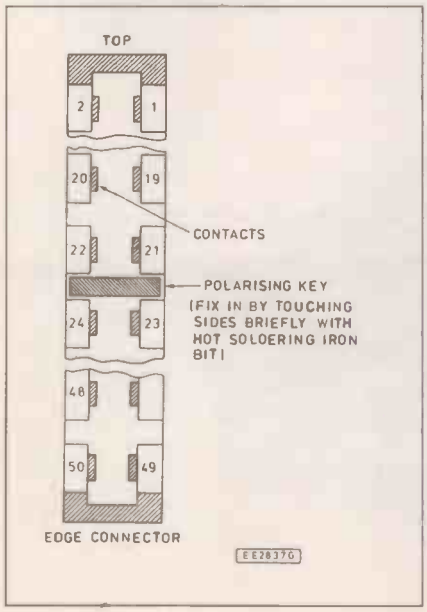
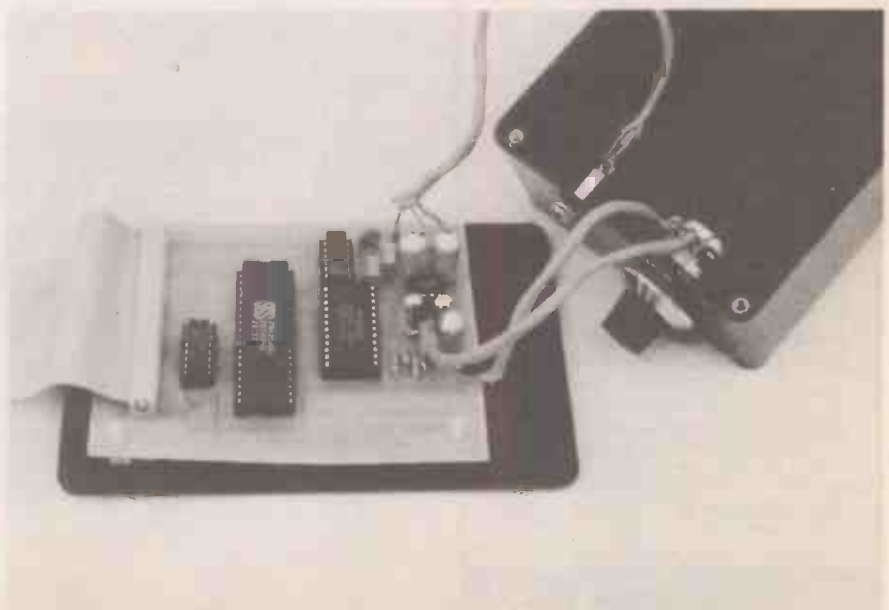


Fig. 3. Polarising key positioning in the Amstrad connector.



Prototype of the sound generator p.c.b.. In this verison the AY-3-8913 was used.

TEST PROGRAMS

PROGRAM ONE

```
100 PAD=160:PAC=161:PBD=162:PBC=162 :REM PAD=PORT A DATA
120 OUT PAC,15:OUT PBC,15:REM SET PIO TO OUTPUT MODE
140 OUT PAD,0 :REM ***RESET SOUND CHIP***
160 A=INT(RND*15) :PRINT "Register:";A;:GOSUB 220
180 A=INT(RND*255):PRINT " Value:";A   :GOSUB 240
200 GOTO 160
210 REM ******SELECT REGISTER (A) ON AY-3-8913******
220 OUT PAD,4:OUT PBD,A:OUT PAD,7:RETURN
230 REM **WRITE DATA (A) TO LAST REGISTER SELECTED**
240 OUT PAD,4:OUT PBD,A:OUT PAD,5:RETURN
```

PROGRAM TWO

```
100 PAD=160:PAC=161:PBD=162:PBC=162 :REM PAD=PORT A DATA
120 OUT PAC,15:OUT PBC,15:REM SET PIO TO OUTPUT MODE
140 OUT PAD,0 :REM ***RESET SOUND CHIP***
160 INPUT "Register:",A:GOSUB 220
180 INPUT " Value:",A  :GOSUB 240
200 GOTO 160
210 REM ******SELECT REGISTER (A) ON AY-3-8913******
220 OUT PAD,4:OUT PBD,A:OUT PAD,7:RETURN
230 REM **WRITE DATA (A) TO LAST REGISTER SELECTED**
240 OUT PAD,4:OUT PBD,A:OUT PAD,5:RETURN
```

Program 3 shows how noise can be used to create a drum effect, channel B is set-up so that the tone is disabled and the noise is enabled, the amplitude register is set to 16 (amplitude controlled by envelope generator). The effect of this is that this channel has plain "noise" on it, this is modulated by envelope cycle shape 8 (amplitude starts at 15 and fades to 0, this repeats until another envelope is defined or the i.c. is reset). This creates a (snare) drum beat.

If the tone on channel B is also enabled, and set to a high frequency, the drum will sound more metallic.

The next part of the program reads the data for notes from lines 280 onwards, until it finds a data statement with 999 in it, at which point the data is read from line 280, and repeats.

The data is in the form:- NOTE A, VOLUME A, NOTE C, VOLUME C, PAUSE

Where NOTE A,C is the frequency of the note (see Table 3).

VOLUME A,C is the volume of the channel (from 0 to 15).

PAUSE is the duration of this note.

The sound i.c. cannot use the frequency information directly, so it is converted at line 200 (and 210).

Frequencies can be converted into time periods for the sound i.c. by:

FTV = (125000/frequency) AND 255

CTV = INT (125000/(256 × frequency))

where FTV is the fine tune value.

CTV is the course tune value.

Frequency is in Hertz.

The minimum frequency possible is 31Hz and the maximum is 125kHz.

Program 4 is a simple piano program, use keys 1 to 7 to play notes. To make the piano sound slightly more realistic the note is modulated by an envelope similar to the drum in Program 3, although this only happens once (not repeatedly like the drum). This sound takes about a second to die away, unless another key is pressed first, in which case the new note will start immediately. Envelope cycle shape 0 is used for this, and must be initalised directly before the note is programmed into the i.c. (line 200).

Program 5 is a sound effect (that sounds quite like a plane diving and then exploding!). This shows the effect of mixing noise with a tone, if the noise is turned off you would just hear a "scale", but with the noise the sound is a lot more realistic.

The explosion at the end is created by turning off the tone, and then fading out the noise by using envelope cycle shape 0.

PROGRAM THREE

```
100 REM ****************SET UP PIO AND SOUND CHIP****************
110 PAD=160:PAC=161:PBD=162:PBC=163:OUT PBC,15:OUT PAC,15
120 OUT PAD,0:REM ***RESET SOUND CHIP***
130 REM ***SET CHANNEL B AS DRUM BEAT(NOISE & ENVELOPE ONLY)***
140 RESTORE:FOR N=1 TO 5:READ R,A:GOSUB 1010:NEXT
150 R=7:A=234:GOSUB 1010
160 RESTORE 280
170 REM ******READ NOTE A,VOLUME A,NOTE C, VOLUME C,PAUSE******
180 READ NA,VA,NB,VB,P:IF NA=999 THEN 160
190 REM **CHANGE FREQUENCY INTO PERIOD,AND SEND TO SOUND CHIP**
200 R=0:A=(125000!/NA) AND 255:GOSUB 1010:R=1:A=INT(125000!/(256*NA)):GOSUB 1010
210 R=4:A=(125000!/NB) AND 255:GOSUB 1010:R=5:A=INT(125000!/(256*NB)):GOSUB 1010
220 REM ************SET VOLUMES OF CHANNEL A&C****************
230 R=8:A=VA:GOSUB 1010:R=10:A=VB:GOSUB 1010
240 FOR N=1 TO P:NEXT:GOTO 180
250 REM ********************DRUM DATA**************************
260 DATA 9,16, 6,5, 11,30, 12,13, 13,8:REM VOL=16,NOISE=5,ENV=13*256+30,ENVSHAPE
270 REM ************MUSIC DATA (NA,VA,NB,VB,PAUSE)************
280 DATA 156,15,156,15,40, 175,15,175,15,30, 165,15,165,15,40 ,156,15,156,15,50
290 DATA 175,15,195,15,60, 185,15,175,15,60, 175,15,185,15,60 ,185,15,175,15,60
300 DATA 175,15,195,15,40, 195,15,175,15,40, 195,15,233,15,40 ,220,15,220,15,40
310 DATA 999,0,0,0,0
320 :
1000 REM ****************SELECT REGISTER (IN R)*****************
1010 OUT PAD,4:OUT PBD,R:OUT PAD,7
1020 REM ******WRITE DATA (IN A) TO LAST REGISTER SELECTED******
1030 OUT PAD,4:OUT PBD,A:OUT PAD,5:RETURN
```

PROGRAM FOUR

```
10 REM ********PIANO PROGRAM, USE KEYS 1(=A) TO 7(=G)**********
20 REM **BASIC NOTE FREQUENCY IS FADED OUT SLOWLY BY ENVELOPE**
30 :
100 REM ************SET UP PIO AND SOUND CHIP*****************
110 PAD=160:PAC=161:PBD=162:PBC=163:OUT PBC,15:OUT PAC,15
120 OUT PAD,0:REM            RESET SOUND CHIP
130 R=9 :A=16:GOSUB 280:REM SET VOLUME OF B TO BE CONTROLED BY ENVELOPE
140 R=11:A=0 :GOSUB 280:REM SET ENVELOPE FINE TUNE PERIOD
150 R=12:A=28:GOSUB 280:REM SET ENVELOPE COURSE TUNE PERIOD
160 R=7:A=253:GOSUB 280:REM ENABLE CHANNEL B ONLY
170 DIM F(7):FOR N=1 TO 7:READ F(N):NEXT:REM *READ NOTE FREQUENCIES*
180 A$=INKEY$:IF A$="" THEN 180 ELSE NA=VAL(A$)
190 IF NA<1 OR NA>7 THEN 180 ELSE NA=F(NA)
200 R=13:A=0:GOSUB 280:REM ****SET ENVELOPE CYCLE TO SHAPE 0***
210 REM **CHANGE FREQUENCY INTO PERIOD,AND SEND TO SOUND CHIP**
220 R=2:A=(125000!/NA) AND 255:GOSUB 280:R=3:A=INT(125000!/(256*NA)):GOSUB 280
230 GOTO 180
240 REM ******************NOTE/FREQUENCY DATA*****************
250 DATA 220,247,262,294,330,349,392
260 :
270 REM ****************SELECT REGISTER (IN R)*****************
280 OUT PAD,4:OUT PBD,R:OUT PAD,7
290 REM ******WRITE DATA (IN A) TO LAST REGISTER SELECTED******
300 OUT PAD,4:OUT PBD,A:OUT PAD,5:RETURN
```

Table 3 Notes and Frequencies

NOTE	FREQUENCY			
A	110	,220	,440	,880
B	123	,247	,494	,988
C	131 (LOW)	,262 (MIDDLE)	,523 (HIGH)	,1047
D	147	,294	,587	,1175
E	165	,330	,659	,1319
F	175	,349	,698	,1397
G	196	,392	,784	,1568

This table gives the approximate frequencies of the notes, though this is not the entire range of frequencies available.

PROGRAM FIVE

```
10 REM ********PLANE FALLING OUT OF SKY AND EXPLODING**********
20 REM ****************ON CONTACT WITH GROUND******************
30 :
100 REM *************SET UP PIO AND SOUND CHIP*****************
110 PAD=160:PAC=161:PBD=162:PBC=163:OUT PBC,15:OUT PAC,15
120 OUT PAD,0:REM              RESET SOUND CHIP
130 R=9 :A=9   :GOSUB 260:REM SET VOLUME OF B TO 9
140 R=11:A=0   :GOSUB 260:REM SET ENVELOPE FINE TUNE PERIOD
150 R=12:A=180:GOSUB 260:REM SET ENVELOPE COURSE TUNE PERIOD
160 R=7 :A=237:GOSUB 260:REM ENABLE CHANNEL B TONE AND NOISE
170 FOR NA=100 TO 450:REM     FREQUENCY OF NOTE INCREASES FROM 100Hz TO 450Hz
180 REM **CHANGE FREQUENCY INTO PERIOD,AND SEND TO SOUND CHIP**
190 R=2:A=(125000!/NA) AND 255:GOSUB 260:R=3:A=INT(125000!/(256*NA)):GOSUB 260
200 FOR N=1 TO 40:NEXT N,NA
210 REM ************************EXPLOSION************************
220 R=9:A=16:GOSUB 260:R=13:A=0:GOSUB 260:R=7:A=239:GOSUB 260
230 END
240 :
250 REM ****************SELECT REGISTER (IN R)*******************
260 OUT PAD,4:OUT PBD,R:OUT PAD,7
270 REM ******WRITE DATA (IN A) TO LAST REGISTER SELECTED******
280 OUT PAD,4:OUT PBD,A:OUT PAD,5:RETURN
```

SOUNDS

The sounds made by musical instruments have quite complex waveforms, which this unit is not capable of generating, but with the use of envelopes the sounds can be made slightly less digital (as with the piano program), and simple tunes can be played. Sound effects for cars, explosions, drums, etc. are a lot more realistic if they have noise mixed in with them rather than just the basic frequency.

When writing your own program follow this list..

1) Make sure the first thing you do is to set-up the PIO and reset the sound chip (lines 110 and 120).
2) Include lines 1010 to 1030 on your program, when you want to change the contents of a register set R = REGISTER N. A = NEW VALUE OF REGISTER. GOSUB 1010. On return register R will be set to value A.
3) Set the volumes of the channels of the channels you wish to use (and any envelope delays, noise, or frequencies that you need).
4) Enable the required channel (register 7).
5) Remember that if you want to use frequencies (the sound i.c. uses tone periods), to use the conversion program (at line 200). The first R is FINE TUNE VALUE Reg. (0 = A, 2 = B, 4 = C). The second R is COURSE TUNE Reg. (1 = A, 3 = B, 5 = C), and NA = frequency of required note (in Hz).

NOTE: All line numbers above refer to PROGRAM 3. □

SHOP TALK

with David Barrington

Kit News

The improvement in the quality, range and professional approach adopted by kit/module advertisers over the years is highlighted by a new audio company this month.

After an extensive search of the overseas manufacturers, **Platinum Audio** ***(0273 685904)*** has been set up to import a range of audio products in kit form. Ranging from simple preamplifiers to a 300W slave amplifier, all kits come complete with any necessary heatsinks/hardware.

Talking of amplifiers, we see that the latest 1990/91 Velleman catalogue from **High-Q Electronics** ***(0707 263 562)*** contains details of a "valve" amplifier that is claimed to give up to 200W *music power* output. The catalogue contains approximately 30 additions to their extensive range of kits.

CONSTRUCTIONAL PROJECTS

Simple Intercom

On checking out the prototype model for the *Simple Intercom,* this month's back-up project for the *Teach-In '91* series on *"Design Your Own Circuits,"* we have found that the loudspeaker used is a 3½in. diameter type. This speaker has a 35 ohm speech coil and was purchased from RS Components through **Electromail** ***(☎ 0536 204555)***, their mail order operation.

Although the speaker is stamped with the reference 9L957, looking through the catalogue it can only be from their general purpose range and be the one coded 248-274 (£4.78). Provided the speaker has a coil rated at 35 ohm, and it will fit inside the chosen case, practically any reasonable size speaker will be suitable for this simple circuit.

The printed circuit board for the intercom is available from the *EE PCB Service,* code 719. For those wishing to build up the two demonstration amplifiers contained in this month's Design Your Own Circuits teach-in, the General Purpose Transistor Amplifier (EE717) and the Operational Amplifier (EE718) boards are also available from the EE PCB Service, see page 68.

Analogic Test Probe

The interlocking plastic case for the *Analogic Test Probe* is only available from **Magenta Electronics.** The rest of the components seem to be standard lines and should not cause any local sourcing problems.

A full kit of parts including the printed circuit board, drilled case, but excluding battery, is available from **Magenta Electronics, Dept EE, 135 Hunter Street, Burton on Trent, Staffs, DE14 2ST** ***(☎ 0283 65435)*** for the sum of £12.95. Add a further £2 for posting and packing.

The small printed circuit board for the probe is available through the *EE PCB Service,* code EE720 (see page 68).

Amstrad PCW Sound Generator

There should be no purchasing problems when shopping for the components required to build the *Amstrad PCW Sound Generator.* However, the programmable sound generator chip AY-3-8912 may prove to be in short supply in some local areas. If you do have difficulty locating this device, it is currently listed by **Maplin** code RA90X (AY-3-8912). They also stock the 1W stereo amp i.c.

Most components suppliers stock a fairly good supply of computer parts and should be able to offer the 50-way header, with ribbon cable and Amstrad connector.

The single-sided printed circuit board is available from the *EE PCB Service,* code EE715, See page 68 for details.

Sound Operated Switch

We do not expect any component buying problems to be encountered when building the *Sound Operated Switch* project. Some component stockists may not carry the 4.7 megohm preset potentiometer and the designer suggests that a 2.2 megohm preset is more readily available and can be used in this circuit.

The crystal microphone inserts are generally available and come in two types of casing, metal or plastic. Because of the high sensitivity of the circuit, and to avoid "stray" pick up, it is best to use a metal case type and "earth" the casing as outlined in the article.

Spatial Power Display

Once again this month, there should be no nightmares about obtaining components for the *Spatial Power Display,* they are all standard "of-the-shelf" stock items.

When pricing up this project we found the bulk of the cost was taken up by the l.e.d.s. As we priced them on the high side at 26p each, quite a considerable saving could be made if you purchased one of the "l.e.d. component packs" on offer from **Greenweld** ***(☎ 0703 236363)***. In fact, it might be a good idea to approach your supplier about a "quantity" discount price.

The printed circuit board for the l.e.d. display project is available from the *EE PCB Service,* code EE714 (see page 68).

Help

We are trying to locate a source for the ML927 decoder i.c.

RTVC HAVE DONE IT AGAIN!

We have secured all stocks of nearly new factory refurbished units with manufacturer approval, at unrepeatable prices. We also offer a 6 month guarantee with all units (this only applies to products marked ★ on this page.)

Alba digital auto reverse push button AM/FM / LW car stereo with separate bass/treble control APPSS on tape. 25 watts per channel output, with line output for car components use.

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Sparkomatic Auto reverse AM/FM car stereo with tone, volume and balance control

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150W output 75 x 2 inputs as above

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8" 60W Nom. 90W Max, 4-5 ohm Richard Allen woofer **£33.80 + £3.50 pp**

10" 100W Nom. 150W Max 4-5, ohm Richard Allen woofer **£41.50 + £3.50 pp**

10" 150W nom, 300W max 4-5 ohm Eminence sub woofer **£43.50 + £3.50 pp**

12" 100W Nom. 250W Max, 4-5 ohm Richard Allen woofer **£43.50 + £4 pp**

12" 150W nom 300W max 4-5 ohm Eminence sub woofer **£45.00** + £4 pp

15" 200W Nom. 400W Max, 4-5 ohm Richard Allen woofer **£60.00 + £5 pp**

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4½" 100W 4-5 ohm sealed back mid-range. Goodman **£5.50 + £1.50 pp**

2¼" 65W 4-5 ohm Ferro fluid cooled dome tweeter with housing. Audax **£5.00 + £1.20 pp**

3½" 100W 8 ohm Ferro fluid cooled dome tweeter for 4-8 ohm use **£6.90 + £0.80 pp**

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£24.20 + £1.80 pp

As illustrated above with 7 slider controls

£19.90 + £1.80 pp

ACOUSTIC REAR PARCEL SHELF

To get the best sound from your car woofers, replace your rear hatchback parcel shelf with one of these 14mm thick fibreboard units, tailor made for your car, supplied with grille cloth and fixings. When ordering please state make, model, and year of Reg. **£39.80 + £6 pp**

AUSTIN ROVER SHELF SPEAKERS

15 watt speaker. Moulded in black plastic housing for vertical or horizontal use, contains 4½" Goodmans drive unit with a good size magnet **£6.95 pair + £2 pp**

HIFI WOOFERS

10" round 100 watt Goodmans Hifi woofer 2" coil, paper cone, foam rubber surround 4½" magnet, frame size 10⅞" imp 8Ω **£17.50 + £2.80 pp**

8" round 100 watt Audax Hifi woofer, 1" coil with fitted phaseplug. Hiteck TPX polimar core with rubber surround 4¾" magnet, die cast chassis, size 9¼" 8Ω imp **£34.90 + £4 pp**

8" square 80 watt Audax Hifi woofer, 1¼" coil, polypropylene cone, rubber surround, 3¼" magnet, chassis size 8⅜" square 8Ω imp **£19.70 + £2.50 pp**

8" round 70 watt Peerless Hifi woofer 1" coil, treated paper cone, foam rubber surround, 3¼" magnet, 8Ω imp **£12.50 + £2.50 pp**

5¼" 45 watt Audax Hifi woofer 1" coil, Bextrene treated cone, rubber surround, 4" magnet, 8Ω imp **£9.80 + £3 pp**

5¼" 35 watt Goodmans Hifi woofer, 1" coil, treated paper cone, rubber surround, 3½" magnet, 8Ω imp **£7.20 + £2.50 pp**

4½" square 35 watt Audax Hifi woofer, 1in coil, paper cone, rolled surround, 2¾" magnet, 8Ωimp **£7.50 + £2.50 pp**

HIFI TWEETER AND MID RANGE

4⅜" square 100 watt Goodmans sealed back mid range, 1" coil, treated paper cone, 2⅞" magnet, 8Ω imp **£5.50 + £2.50 pp**

4" square 75 watt Audax sealed back mid range ¾" coil treated paper cone, Ferrofluid cooled coil, chassis size 3⅞" 8Ω imp **£7.95 + £1 pp**

4" round 130 watt Peerless 1" metal dome Hifi tweeter, 1" coil, 2¾" magnet, rec. crossover freq 3KHz **£15.90 + £1.60 pp**

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With this handy unit you can transmit the output of your home video, video camera or satellite 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 dc power supply extra **£3.75** size 122 x 70 x 21mm **£18.95** + 1.55 pp

VHF RADIO TRANSMITTERS

100mW mini bug. Built on a neat little fibre glass pcb with condenser mic. Fully tunable over the FM band. 9V DC **£5.75** + £0.90 pp

2 Watt transmitter kit, supplied with fibre glass pcb, all components, diagrams, ready for you to build. 12-24V DC. **£7.50** + £0.70 pp

25 Watt Transmitter kit. Fully tuneable over the FM band. Kit comprises double sided pcb diagrams and all components, including heat sink. Supply voltage 12-18V DC. **£67** + £1 pp

Transmitters listed on this page are not licensable in the UK.

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Kit enclosed: case. PCB, all components, scale and knobs **£36.80** + £3.50 pp.
(Featured project in *Everyday Electronics*, April 1989 issue). Reprint Free with kit.

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INTERFACE

Robert Penfold

THIS MONTH we will continue with the topic of interfacing to the IBM PCs and compatible microcomputers. Last month we briefly considered the 8-bit expansion bus. This month the input/output map and address/control bus decoding will be discussed. Note that the 8088 series of microprocessors used in the PCs have separate input/output and memory maps.

As user add-ons will not normally have memory circuits to place in the memory map, they will only fit into the input/output map. Consequently, here we will only be concerned with this method of interfacing, and will not consider units that fit into the memory map.

Map Reading

As pointed out last month, the 8088 series of microprocessors use the sixteen least significant address lines for mapping input/output devices, but in the PCs only the ten least significant address lines are actually utilized. This gives 1024 usable addresses (from 0 to 1023), rather than the 65536 that the microprocessors are capable of using.

Addresses from 1024 to 65535 are simply echoes of the 1024 base addresses. Obviously this reduced number still leaves plenty of address space for standard peripherals such as printer ports and display cards, with sufficient left over for more specialised add-ons.

Table. 1 shows the input/output map for the PCs, and it will be apparent from this that the entire memory map has been allocated to specific functions. This does not mean that there is nowhere in the map that can accommodate user add-ons.

The lower half of the map is reserved for the motherboard, and addresses from 000 to 1FF are definitely out of bounds (and are not included in Table. 1). The addresses in Table. 1 are all in hexadecimal incidentally, and from here onwards, all addresses will be given in hexadecimal form.

If you look at the map you will note that addresses from 300 to 31F are for prototype cards. Possibly this address space is really intended for testing prototype cards which will actually be located elsewhere in the map in their final form.

However, it represents an obvious and pretty safe area of the map for your own circuits. This section of the map provides some thirty-two input and output addresses, which obviously permits a substantial amount of expansion. Half-a-dozen 8-bit input/output ports plus a couple of analogue ports would use up only one quarter of the available addresses!

If further addresses are required, there are other parts in the map which could probably be exploited. In fact any block of addresses which is reserved for hardware which your computer does not actually have fitted is a legitimate section of the map for your own circuits.

Bear in mind though, that this is a slightly unsafe method if you are designing circuits which will be used in computers other than your own PCs. The fact that your computers do not have fixed disks and matching controller cards installed, does not mean that other PCs will lack this equipment.

If you decide to use a section of the input/output map other than the one set aside for prototype cards, then it is obviously better to select one that is reserved for an unusual piece of hardware that will be installed in very few PCs. Something like the address block reserved for SDLC communications represents a safer choice than a section of the map such as the one reserved for the second serial port.

There would appear to be small sections of the map which are not allocated to any purpose, or reserved for future expansion, and these might offer suitable niches for your own add-ons. Where possible, it is probably best to only use the addresses set aside for prototype cards though. Here we will only consider address decoding for this particular section of the input output map, but the general principles described in this article apply to interfacing using any section of the input/output map.

Table. 1: Input/Output Map

Address Range	*Function*
200 - 20F	Game Port
210 - 217	Expansion Unit
220 - 24F	Reserved
278 - 27F	Printer Port 2
2F0 - 2F7	Reserved
2F8 - 2FF	Serial Port 2
300 - 31F	Prototype Card
320 - 32F	Hard Disc Controller
378 - 37F	Printer Port 1
380 - 38C	SDLC Communications, or
380 - 389	Synchronous Port 2
3A0 - 3A9	Synchronous Port 1
3B0 - 3BF	Mono display/Printer Port
3C0 - 3CF	Reserved
3D0 - 3DF	Colour Graphics Adaptor
3E0 - 3F7	Reserved
3F0 - 3F7	Floppy Disk Controller
3F8 - 3FF	Serial Port 1

Echoes

It is perhaps worth mentioning a technique that effectively enables the 300 to 31F address range to be used several times over, permitting more expansion that anyone is ever likely to need. Suppose that several circuits are all mapped to address 300, but some or all of address lines A10 to A15 are decoded so that each device is only activated if these lines are at a certain set of logic levels, with a different set being used for each device.

Normally a device at address 300 would be activated if the base address was used, or if one of the echoes at 700, B00, F00, etc. was accessed. By decoding A10 to A15 it is possible to map devices to the base address or specific echoes of the base address.

Although the computer's normal hardware does not make use of these address lines, they can still be utilized by your own add-ons. It is only echoes of addresses in the range 300 to 31F that are made available, and most of the addresses in the upper 63K of the map remain unusable. However, with each of thirty-two base addresses having up to sixty three available echo addresses, these inaccessible parts of the input/output map are not really needed.

PC Languages

If you are going to experiment with user add-ons, then you will need a programming language that provides access to the registers of the hardware in the input/output map. This may seem an obvious point, but less obviously, not all PC programming languages actually give direct access to the hardware. There is obviously no difficulty with assembly language or machine code, where the microprocessor's full range of input and output instructions are available.

Most BASICs provide access to the hardware via the INP function and the OUT instruction, or an equivalent to these. Most PCs are supplied complete with Microsoft's GW BASIC, which has suitable commands available. Many other BASICs for the PC also provide easy access to the hardware.

There are exceptions though. In particular, the BASIC 2 that was supplied with my Amstrad PC1512 seems to offer no easy means of directly accessing the hardware. I could be overlooking something, but it would seem that Amstrad PC users will need to invest in an alternative programming language if they wish to dabble with home constructed add-ons.

The situation with non-BASIC high level languages for the PC seems to vary from one language to another, or even from one dialect to another. Often access to the hardware registers is possible, but you might need to delve deep into the manuals in order to discover precisely how it is achieved. In some cases it might only be possible via specially written machine code routines which the main programming language can call up and run, as and when necessary.

Although GW BASIC is not exactly a state of the art PC programming language, it is quite a good one when experimenting with home constructed add-ons. It provides very easy access to the add-ons, and for most purposes it is fast enough. A compatible compiled BASIC is a good alternative where higher operating speed is required.

Address Decoding

On the face of it there are a substantial number of lines that must be decoded by any user add-on. For a start, there are the ten least significant address lines (A0 to A9). There are also numerous control lines on the expansion port.

In practice, matters are not quite as difficult as it might at first appear. It is only necessary to decode all ten of these address lines if a device is to be placed at a single address. Often this will not be the case, and some simplification will be possible.

In an extreme example you might only wish to add one input or output port, and this could then occupy the base address plus echoes at the other addresses up to 31F. This would avoid the need to decode the lower five address lines (A0 to A4).

The five upper address lines (A5 to A9) must always be fully decoded though. Table. 2 shows the states of these lines when a device in the address range 300 to 31F is activated.

Table. 2: Address Line Condition

Address Line	*Logic State*
A5	LOW
A6	LOW
A7	LOW
A8	HIGH
A9	HIGH

Although there are quite a number of control bus lines available on the expansion port, for most purposes the vast majority of these can simply be ignored. There are some which must be decoded though. The input/out read and write lines (IOW and IOR) certainly fall in this category.

Input devices must only be activated if IOR is low, and output circuits must only be activated if IOW is low. Therefore, at least one of these lines must always be decoded, and for an input/output device they must both be decoded.

In most cases the only other control line that must be decoded is AEN, which goes low when a processor bus cycle (rather than a DMA type) is in progress. Any user add-on, whether it is an input or an output type, must therefore only be activated when AEN is low.

The most fundamental decoding that will provide usable results therefore consists of having the add-on activated when A8 and A9 are high, and AEN plus A5 to A7 are low. Additionally, input devices should only be activated when IOR is low, and output devices should only be activated when IOW is low.

This means that a practical add-on might need to decode as few as seven or eight lines. Of course, if the add-on occupies several addresses, then further address lines will need to be decoded, possibly taking the number of lines to be decoded as high as twelve.

Address Decoder

Although the PCs operate at relatively high clock frequencies, ordinary 74LS or 74HCT logic gates etc. are quite fast enough to provide address decoding, latch output data, and provide the other usual interfacing tasks. Using gates, inverters, 3 to 8 line decoders, etc., there are numerous ways of providing any desired address/control bus decoding. Fig.1 shows a simple method using a 8-input NAND gate and a hex inverter.

The output of IC2 will go low if all eight of its inputs are taken high. Obviously in this case we require a decoded output that assumes the active state when certain inputs are high and others are low, not when they are all high.

However, simply adding an inverter ahead of an input effectively makes an active low type instead of an active high type. In this case only A8 and A9 will be high when the add- on is accessed, and so all the other lines drive IC2 via inverters.

IC2 provides a negative output pulse if any address in the range 300 to 30F is read. Slightly less than the minimum of address decoding is used here, since A4 is decoded. If the inverter on this line is omitted, then the circuit will be activated when any address from 310 to 31F is read.

In practise it is a good idea to at most only use half the address space for your first PC add-on, so that you have some address space left for any subsequent DIY cards you may wish to add. Note that by decoding IOW instead of IOR the circuit will be activated by write operations instead of read types.

Separate Outputs

Separate decoded read and write outputs will often be needed. Using entirely separate circuits to provide these outputs is definitely doing things the hard way. Also, ideally any add-on should not load the bus by more than one LS TTL input per line.

A better way of providing separate read and write outputs is to first decode AEN and the appropriate address lines, and to then process the decoded output with the IOR and IOW signals using a couple of OR gates. Fig.2 shows how the two OR gates are used.

The output of an OR gate is only low if both inputs are low. The output of IC1a therefore goes low if there is a read operation to the decoded address range, while IC2b's output goes low if there is a write operation to this address range.

The circuit of Fig.1 can still be used to provide the main decoding, but pin 12 of IC2 is tied to the +5 volt rail. Alternatively, it could be used to decode A3, and this would permit up to four cards occupying eight addresses each to be used.

If a standard 80** bus interface chip is used (such as the 8255), this will have inputs for IOR and IOW, making it unnecessary for the address decoder to process them. Most of these chips have several registers, with the desired one being selected via register select inputs. These would normally be driven from the least significant address lines of the processor.

NEXT MONTH: A Simple Input/Output Port will be described, and we will look at the potentially awkward mechanical side of PC interfacing.

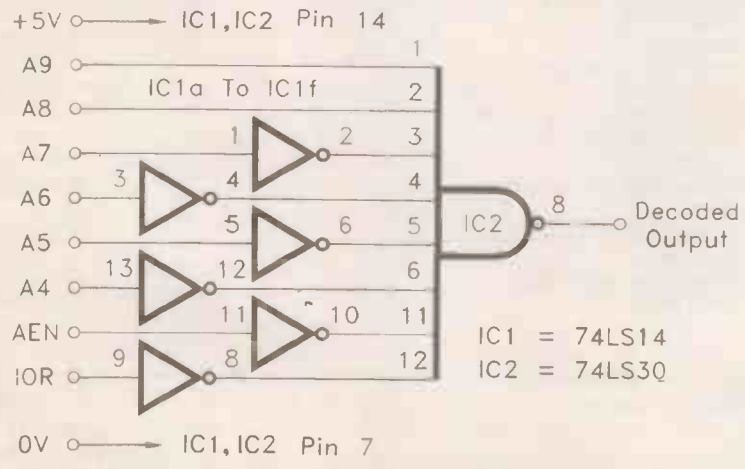


Fig. 1. A simple PC address decoder circuit. It is activated by read operations in the address range 300 to 30F.

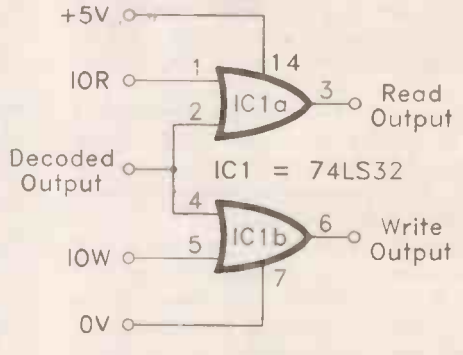
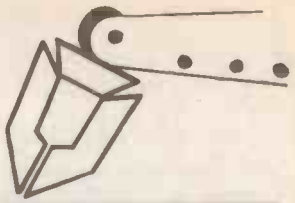


Fig. 2. A couple of OR gates provide a simple means of obtaining separate decoded read and write outputs.

ROBOT ROUNDUP



Nigel Clark

SUCCESSFUL CHAOS

Assemble a group of robot enthusiasts from all over the world, asking them to bring along their latest developments, and you have a major ingredient for chaos. Add a large amount of flexibility to allow for the expected breakdowns and the fact that a similar event has never been held before and any hopes that you will achieve any sort of smoothly running organisation can be thrown out. In a nut shell you have the first *Robot Olympics* held at the Turing Institute, Glasgow in September.

However with 60 robots from 12 countries and a large amount of interest from spectators and the Press it could be considered a success.

"It has taken me three weeks to recover," said Dr Peter Mowforth, who organised the event. "It was much bigger than I had expected and considering that there could not be a lot of advance planning it went very well. We were carried along by the enthusiasm and the motivation of the people involved."

He added that on one of the days 1,500 school children visited the Olympics and showed a great deal of interest. "If just a few of them decided to become electronics engineers rather than accountants or lawyers then it will have all been worthwhile."

The organisers are now setting out rules and regulations as a basis for future Olympics, the next of which will be held in two year's time and every two years after that. It is intended to hold the event in Glasgow every four years. Bids from organisations interested in holding the next competition are being sought and there has already been an enquiry from Nagoya in Japan.

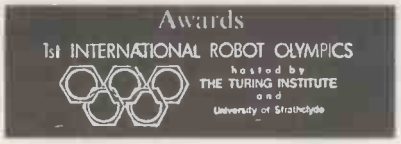
CONTESTS

Mowforth said that the first event had had to be flexible because they did not know what or who to expect. However with the experience gained they would be better prepared in the future. The flexibility had continued throughout the Olympics. The different contests were not set up until the organisers knew which robots were available. On registration entrants filled in the capabilities of their machines and wherever there were capabilities in common a contest was created.

This resulted in eleven sections in all, wall climbing, two-legged races, races for more than two-legged, javelin, talking, obstacle avoidance, phototrophic, pole balancing, manipulation, behaviour and wall following. There were also a number of special awards, see below.

Mowforth said that another reason for this approach had been that he thought existing international robotic competitions did not help the general advancement of robotics as they had too narrow a specification which kept robot builders in a very narrow niche. He mentioned as specific examples Dr John Billingsley's Micro-Mouse and Robot Ping Pong competitions.

However Dave Buckley of the Shadow Group thought that the approach had resulted in a series of competitions which were not challenging enough to encourage the development of robot technology. He cited the success of a number of simple devices or ones which had been around for a few years. The most obvious example was the 19th century Japanese archer, brought along by the Museum of Automata in York, which won the javelin event.



Obstacle Avoidance
1. *ASTERIX* Toronto University, Canada. Anthony Green, Pavel Rozalski
2. *OSCAR* Artificial Intelligence Department, Edinburgh University, Scotland
3. *YAMABICO* Tsukuba University, Japan. Shouji Suzuki

Pole Balancing
1. *SALFORD PENDULUM* Salford University, England. F Nagy, G A Medrano-Derda
2. *LANKY* Lancaster University, England

Phototrophic
1. *ALPHA PHOTON* Kent University, England. David Bisset
2. *ICARUS* The Shadow Group, London, England. D Buckley

Manipulators
1. *BELGRADE / USC HAND* University of Belgrade, Yugoslavia
2. *BCI* St Patricks High School, Coatbridge, Scotland

Biped Race
1. *CARDIFF BIPED* University of Wales, Cardiff. Paul Channon, Simon Hopkins, Prof Pham
2. *ROBBIE* Paisley College of Technology, Scotland. Ken MacFarlane, Gordon Allan

Javelin
1. *YORK ARCHER* Museum of Automata, York, England
2. *WILBERFORCE* East London Polytechnic, England. Martin Smith
3. *ELEPHANTS TRUNK* Heriot-Watt University, Edinburgh, Scotland. J B C Davies, J Morrison

Multi Legged Race
1. *PENELOPE* Edinburgh University, Scotland, D J Todd
2. *GENGHIS* Massachusetts Institute of Technology, AI Lab, USA. Olaf Beck, Prof Rodney Brookes, Colin Angle

Wall following
1. *YAMABICO* Tsukuba University, Japan. Shouji Suzuki
2. *SAM* Kent University, England. David Bisset, Jason Garforth, Jeremy Laycock

Talking
1. *RICHARD 1st* The Turing Institute, Glasgow, Scotland. Ketil Undbekken, Peter Mowforth
2. *SHADOW WALKER* The Shadow Group, London, England. D Buckley

Wall Climbing
1. *ZIG ZAG* Portsmouth Polytechnic, England. A A Collie, Prof J Billingsley, R. P Smith
2. *RVP II* Soviet Academy of Sciences, Moscow, USSR. Prof Chernousko, Prof Gradestsky
3. *RVP I* Soviet Academy of Sciences, Moscow, USSR. Prof Chernousko, Prof Gradetsky

Behaviour
1. *GHENGHIS* Massachusetts Institute of Technology, AI Lab, USA. Olaf Beck, Prof Rodney Brookes, Colin Angle
2. *SHEEP AND SHEEP DOG* Computer Science Department, Strathcylde University, Scotland. Peter Barrie, Gerry Haran
3. *SIAS* City Montessori School, India. Mr Ashish Panwar

IEEE ROBOTICS & AUTOMATION SOCIETY YOUNG ROBOTICIST AWARD

BC1 Brian Carr (School pupil), St Patricks High School, Coatbridge, Scotland.

Awarded with a £25 Book token

NATWEST BANK PRIZE FOR TECHNOLOGY TRANSFER

ATTILA Massachusetts Institute of Technology, AI Lab, USA. Olaf Beck, Prof Rodney Brookes, Colin Angle.

Awarded with a Caithness Crystal Bowl and £200 from NatWest

BEST SCHOOL AWARD

XYBOT Inverkeithing School, Class 7S.

Presented with a Cup from the Turing Institute and £100 special prize from NatWest

OLYMPIC CHAMPION

YAMABICO Tsukuba University, Japan. Shouji Suzuki.

Awarded with a Caithness Glass Trophy

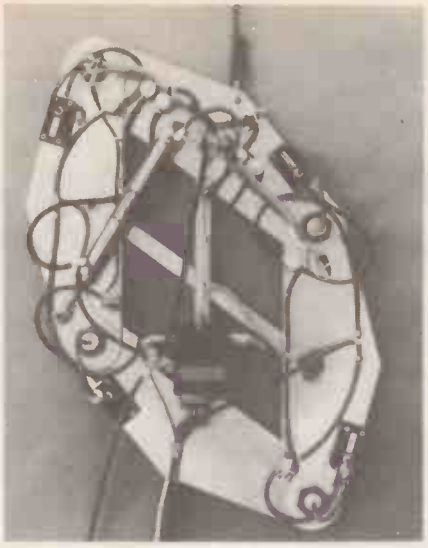
While accepting that not all the entries were at the forefront of technology Mowforth pointed out there was much to be admired particularly in Yamabico. from Tsukuba University in Japan, which was named Olympic Champion. The basis for making this choice was the quality of the electronic and mechanical building, the sophistication of the resulting behaviour and its novelty.

Earlier in the contests the Japanese machine had won the wall following and came third in the obstacle avoidance. Problems with pronunciation meant it was not placed in the talking contest but that did not prevent it making a small speech in Japanese thanking the humans for inviting it to Scotland.

ZIG ZAG DISQUALIFIED

Mowforth was also impressed by Zig Zag from Portsmouth Polytechnic. The machine is the latest development of the work of Arthur Collie which began with his cockroach-inspired six-legged walking robot Robug. Zig Zag won the wall climbing contest easily against less sophisticated machines from the Soviet Academy of Sciences in Moscow. The contest might have been closer if Collie's more complex Robug II had not been disqualified for stepping on one of the Russian robots. However there was no international incident the transgressor being dealt with quickly and firmly, making it the first machine to be disciplined in a Robot Olympics.

Collie was not too unhappy because this unexpected event allowed him to show the robustness of the technology



Zig-Zag from Portsmouth Polytechnic won the wall climbing event.

used in his series of mobiles. In disentangling Robug II the pneumatic suckers were switched off and, due to a misunderstanding, the person holding the safety rope also let go, resulting in Robug falling three metres to the floor. However it was able to get up and work without any ill affects.

"The construction is so compliant that its operation does not depend on it being mechanically perfect," said Collie. "It could work even if one of its limbs was broken or bent."

He could also claim to be the only person at the event who had a commercial product and had sold his first robot. Called NERO, nuclear environment robot operative – anything for a good acronym – it will be used for working on walls inside nuclear installations. Collie is so confident of the technology that he is sure that a wall-climbing robot could be adapted to any customer's requirements as it was possible to build something which could sense objects in its path or an uneven surface and check that each of its suckers had got a proper hold.

OVERDOSE

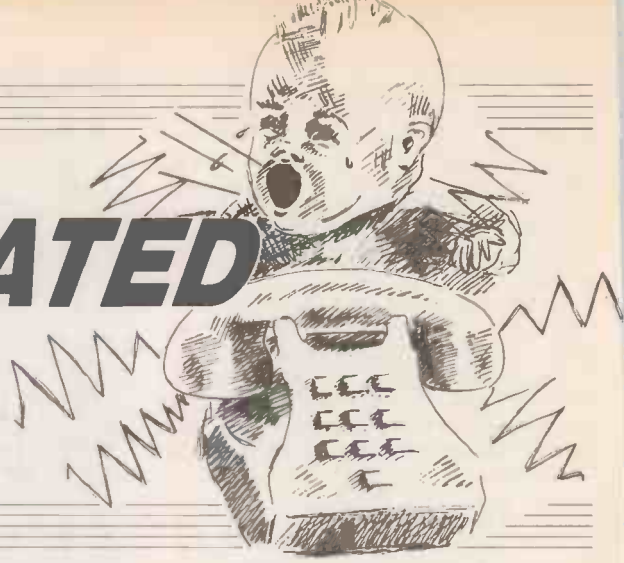
All the expected names were at the Robot Olympics, MIT and various university and polytechnic departments as well as schools and enthusiastic amateurs. TAG of Northumberland took some machines but they were not working and the Shadow Group took its walker but it overdosed on voltage and lost the use of its chips. Replacements were sought but the correct ones could not be found.

It is good news that the concept is to be continued. While accepting that all the technology was not the most up-to-date state-of-the-art, there was plenty that was. It is also worthwhile being reminded that new does not always mean better.

The only concern must be that there will be fall-off in interest by the media and thus a shortage of sponsors. Newspapers and television quickly lose interest if they do not see their expectations of a robot servant being realised.

Constructional Project

SOUND OPERATED SWITCH



OWEN BISHOP

A versatile sound switch with multiple uses. It will also update the Phoney Phone (Aug '90) to a phone-bell repeater or baby alarm.

THIS CIRCUIT was developed for use with the *Phoney Phone*, published in our August 1990 issue. Although the Phoney Phone was originally intended as a device for amusement, it has several serious applications. Among these are its use as a phone-bell repeater and as a baby alarm or alarm for an invalid or an elderly person.

A phone-bell repeater is located in a room such as a workshop, or perhaps in the summer house, where the normal telephone bell cannot be heard. The repeater sounds whenever the phone-bell rings.

To set up such a system we need the Sound Trigger, which is placed close to the telephone and connected to the Phoney Phone which is placed in the workshop or other remote area. When the normal telephone bell rings, its sound activates the Sound Trigger which in turn sets the Phoney Phone ringing.

As a baby alarm, the Sound Trigger is in the bedroom, beside baby's cot, and the Phoney Phone is located in the living room. The trigger is extremely sensitive, so even the faintest whimper will activate it. In turn, the trigger sets the Phoney Phone ringing. Its use as an alert for an invalid or elderly person is similar.

The sensitivity of this device can be set so high that it could also be used as an intruder detector – provided that the ambient noise level is normally low. The device also has other applications as a sound-operated trigger with logic output.

HOW IT WORKS

The system block diagram Fig. 1 shows that the design is quite straightforward. A cheap crystal microphone insert has its output amplified in two stages by two operational amplifiers. The second of these has provision for adjusting the sensitivity.

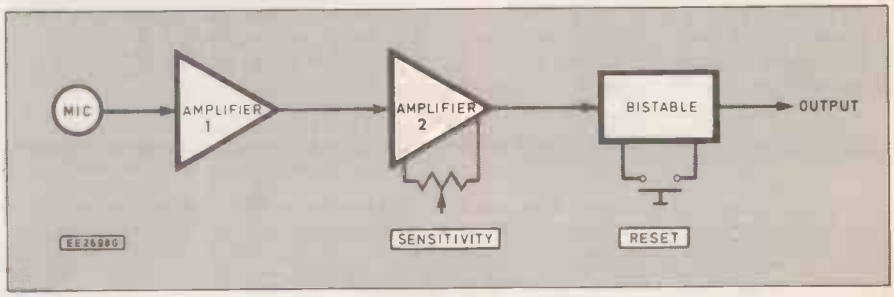


Fig. 1. Block diagram for the Sound Trigger.

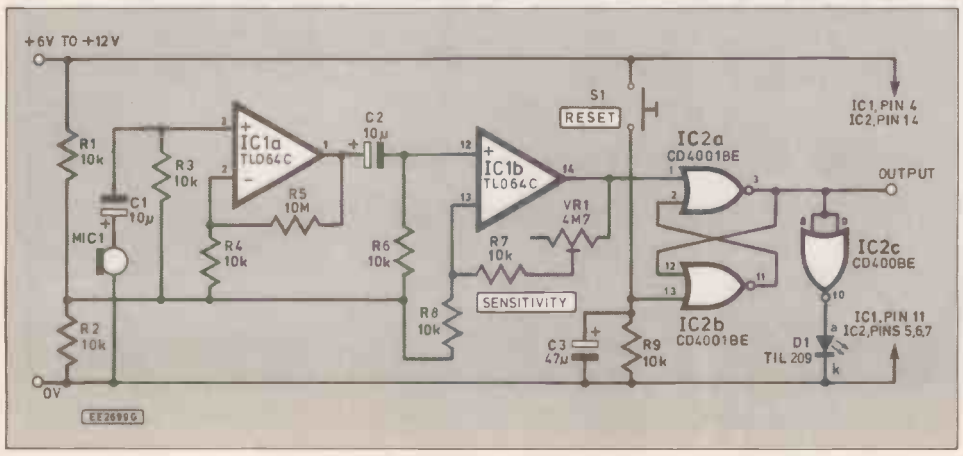
In the absence of sound, the output of the second amplifier is only about 1V, which counts as logical "low" to the logic circuit that follows it. When a sound is detected, the amplifier output rises to logical "high".

The logic circuit is a bistable. It requires a normally low input from the amplifier, and is triggered when the input goes high. The output of the bistable is normally high, but goes low when the bistable is triggered. This mode of operation is compatible with the Phoney Phone circuit.

Once the bistable has been triggered (set) it remains in that condition until it is reset by pressing the Reset button. This means that the Phoney Phone continues to ring until you go to the real phone and press the button on the Sound Trigger. Of course, you could just switch off the Phoney Phone, but that would be cheating!

Also, when used as a baby/invalid/ intruder alarm, a single sound of even very short duration (such as a cough or a click of a door-latch) makes the Phoney Phone ring until the trigger is reset. This is a that needs to be considered when installing the device and adjusting sensitivity, as will be explained later.

Fig. 2. Complete circuit diagram for the Sound Trigger.



DESCRIPTION

The complete circuit diagram for the Sound Trigger is shown in Fig. 2. The circuit is intended to be driven from the power supply of the Phoney Phone, which operates at 12V. At this voltage the Sound Trigger requires only 2mA when quiescent. However, it can also be operated at 5V, 6V and 9V.

Its output is compatible with CMOS at any of these voltages. It can also drive one LS gate if used with TTL at 5V. The split supply for the operational amplifiers is obtained by the potential-dividing resistors R1 and R2.

The TL064C, IC1, contains four operational amplifiers, of which we use two connected in the non-inverting mode. The gain for the first amplifier is about 1000. The signal is further amplified by the second amplifier which becomes saturated when even a small sound is detected.

Its output swings rapidly between the voltages of the positive and negative supply rails. When it swings to the positive rail voltage, this gives the equivalent of a logical high.

The bistable is constructed of two NOR gates, IC2a and IC2b. Both inputs to the bistable are normally low. The output from

the second amplifier is normally about 1V, so satisfies this requirement. The other input of the bistable is connected to the 0V rail through resistor R9.

Under these conditions the output of the bistable is high. The output is fed to a third NOR gate IC2c, with the inputs connected so that it acts as an INVERT gate. Its output is low and the l.e.d. D1 is off.

When sound is detected, the output of amplifier IC1b goes high, setting the bistable. The bistable output goes low and the l.e.d. comes on. The bistable is reset by pressing switch S1.

The difficulty with resetting is that the sound made by the button as it is pressed and released is enough to trigger the circuit. This problem is overcome by the capacitor C3.

When S1 is pressed, the voltage at IC2b pin 13 rises to high, resetting the bistable and charging the capacitor. When the button is released, the capacitor takes a second or two to discharge through resistor R9. Until it is half discharged, the input to pin 13 remains high and the bistable cannot be permanently triggered. This gives time for the button to be fully released and the vibrations produced to die away.

CONSTRUCTION

The circuit is assembled on a piece of 0.1in matrix stripboard, size 16 holes × 24 strips. Details of the component layout and breaks required in the underside copper tracks is shown in Fig. 3.

The prototype was designed to fit into a small "microphone-sized" plastic box. As a result, the circuit layout is slightly cramped. If you are unused to working neatly in a confined area, use a larger box and expand the layout sideways by a few holes on either side of the i.c. sockets.

There should be no problem with assembling the circuit and getting it to work first time. The only point to consider is the possibility of electrical interference from the mains or other sources being picked up by the microphone leads.

If your microphone insert MIC.1 is cased in metal (usually aluminium), you will probably find that one of its two terminals is connected to the case. If so, this is the terminal to be wired to the solder pin at *A*10. The "earthed" case shields the microphone element from interference.

In the prototype the leads between the board and microphone are only 2cm long and interference is negligible. But when using temporary leads 16cm long during testing, interference (mains hum) made the amplifier output oscillate at 50Hz. If you are planning to connect the microphone with leads more than a few centimetres long, use screened cable with the screen connected to the solder pin at *A*10.

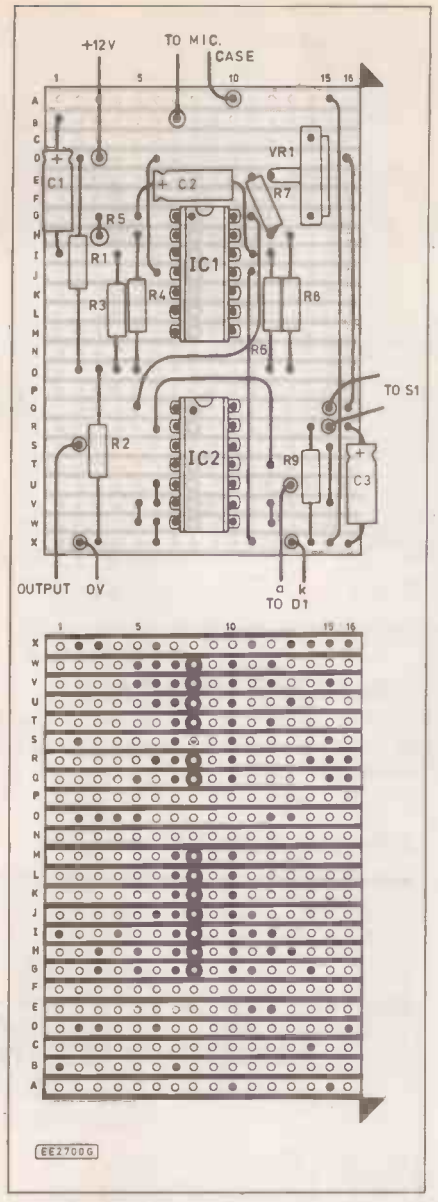
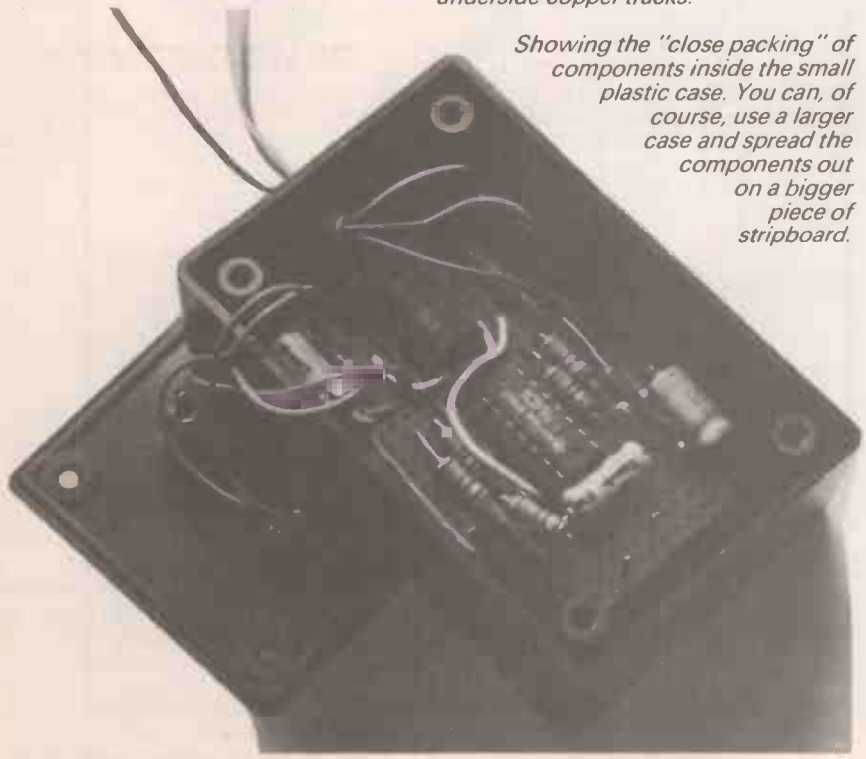


Fig. 3. Stripboard component layout and details of breaks required in the underside copper tracks.



Showing the "close packing" of components inside the small plastic case. You can, of course, use a larger case and spread the components out on a bigger piece of stripboard.

COMPONENTS

Resistors
R1-R4, R6-R9 10k (8 off)
R5 10M
All 0.25W 5% carbon

See SHOP TALK Page

Potentiometer
VR1 4M7 skeleton preset, vert.

Capacitors
C1, C2 10µ axial elec. 16V (2 off)
C3 47µ axial elec. 16V

Semiconductors
D1 TIL209 or similar l.e.d.
IC1 TL064C quad low-power op.amp
IC2 CD4001BE quad 2-input NOR gate

Miscellaneous
MIC. 1 Crystal mic. insert
S1 Push-to-make push-button switch
Stripboard, 0.1in matrix, size 24 strips × 16 holes; plastic case (ABS), approx. 82mm × 53mm × 30mm; 14-pin i.c. socket (2 off); 1mm solder pins (9 off); Blutack; connecting wire, solder etc.

Approx cost guidance only **£7.50**

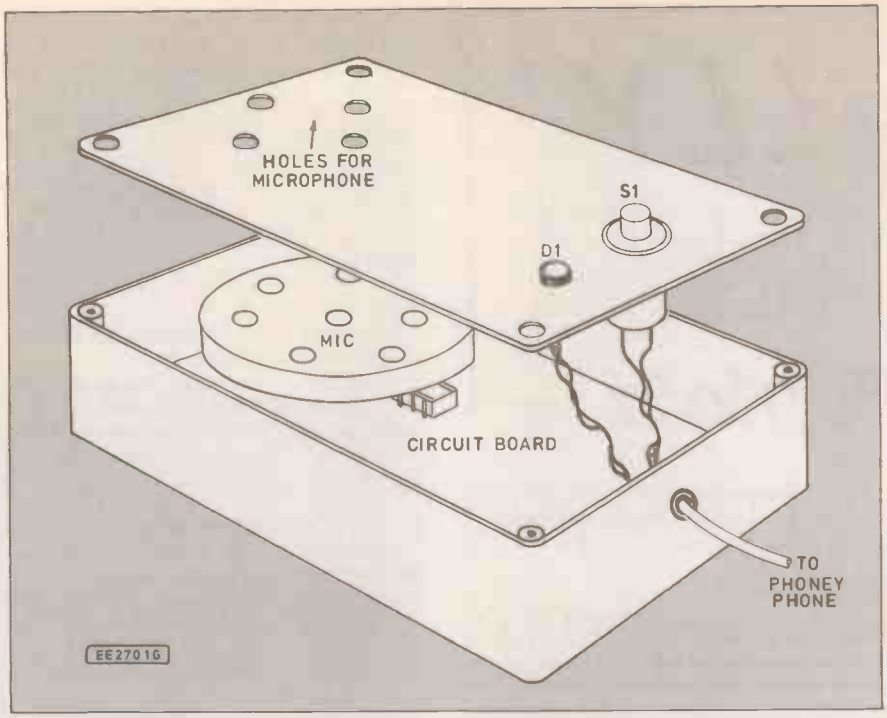


Fig. 4. Guide to the layout of components inside the small plastic case. The microphone insert sits above IC1 and is held in place with a piece of Blutack.

TESTING

Commence testing the unit by turning the wiper of VR1 to a mid-way position. Switch on the power. The l.e.d. D1 usually comes on. Press switch S1 and the l.e.d. goes out – but not if you make a noise at the same time.

The circuit responds to any noise – taps, bangs, whilstles, and speech – made within a radius of a few metres. As soon as the noise is detected the l.e.d. comes on and stays on until S1 is again pressed.

You may decide that the device is too sensitive for your purposes. Other noises made in the vicinity of the Sound Trigger may result in false alarms. The solution is to reduce the sensitivity of the circuit and place it as near as possible to the source of sound (telephone bell, baby, etc).

To reduce sensitivity, turn the wiper of VR1 towards the end of its track nearest resistor R7. If it is still too sensitive, try fastening adhesive tape over the apertures in the microphone case. Alternatively substitute a resistor of lower value for R5.

ASSEMBLY

When the circuit board has been tested successfully, prepare the case by drilling holes in the lid of the box, as shown in Fig. 4. The circuit board is a snug fit in the bottom of the plastic box, and is held there with a piece of Blutack.

The microphone MIC:1 is located immediately on top of IC1. If the microphone case is made of metal, stick insulating tape on its rear surface to prevent possible contact with the circuit. A piece of Blutack on IC1 helps to hold the microphone in place.

You may find that the microphone comes into contact with the lid when this is screwed in place. Three small blobs of Blutack spaced around the circumference of the microphone help to keep it acoustically insulated from the lid of the box and thus less subject to the noise from the push-button.

LINKING TO THE PHONEY PHONE

The Sound Trigger is connected to the Phoney Phone (Aug. '90) by a 3-core lead. The positive and negative supply leads are connected to the 0V and 12V lines of the Phoney Phone circuit. The third line connects the output pin of the trigger to the *control input point* (CP) of the Phoney Phone.

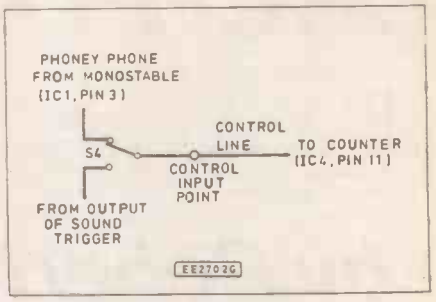


Fig. 5. Fitting a mode select switch to the Phoney Phone (Aug '90).

The control input point of the Phoney Phone is shown in the circuit diagram Fig. 4 (Aug. '90), and corresponds to the pin at *J5* in the stripboard layout (Fig. 9).

If you are using the Phoney Phone solely as a repeater or alarm, you may omit the monostable multivibrator section of the circuit (IC1, C1-C3, R3-R7, VR1-VR4, S2 and S3). The output from the Sound Trigger then goes to the terminal pin at *J5*.

An alternative is to have a mode select switch which allows you to use the Phoney Phone as a timer/joke-phone or as a repeater/alarm. Cut the long wire that runs from IC1 Pin 3 to IC4 pin 11 and connect the cut ends to a SPDT switch, as in Fig. 5. The output from the Sound Trigger goes to the other terminal of the switch. □

ACTUALLY DOING IT!

by Robert Penfold

SEMICONDUCTORS must rank as one of the most confusing aspects of modern electronics. There seems to be endless different types of semiconductor, with countless examples of each of these types. The electronic component catalogues only list a fraction of the semiconductors that are actually produced, but in some cases they still list what I would guesstimate to be well in excess of a thousand different semiconductor devices. Some aspects of these components can give a few headaches even to those who have many years of experience of electronics, but most of what you need to know is not difficult to grasp.

In this month's *Actually Doing It* we will consider some fundamentals of this important topic. We will not consider transistors and integrated circuits on this occasion, as these are worthy of their own articles.

ONE WAY

The most simple of the semiconductor components is the diode, which is a sort of electronic valve. It will allow an electric current to flow in one direction, but it will block a current flow in the opposite direction. Obviously diodes must be connected into circuit the right way round. Otherwise they block the required current flow but permit one in the wrong direction. Fig.1 shows the circuit symbol for a diode, together with some typical physical representations.

The two terminals of a diode are called the "anode" and "cathode", and these are often shown in the abreviated forms "a" and "k" respectively. In the circuit diagrams that appear in *Everyday Electronics* the "a" and "k" markings are included on diodes, but in other publications you may well find that they are omitted, with a "+" sign perhaps being included in place of the "k" marking. I suppose that either type of legend is unnecessary since the diode symbol itself clearly indicates the polarity of the component. However, these markings are useful reminders for those who are not too familiar with circuit diagrams and the circuit symbols.

MARKINGS

Physically, ordinary diodes are virtually all in the form of small glass bodied components having rounded ends. Rectifiers, which are merely diodes designed to handle high currents, are slightly different in that they usually have black plastic cases and are not rounded at the ends. In both cases the polarity is usually indicated by bands marked around the body of the component towards the cathode ("+" or "k") end of the component.

The three main exceptions to this method of polarity marking are diodes which have multiple bands, some high power rectifiers, and bridge rectifiers. The latter are actually four rectifiers ready connected in the bridge configuration, and contained in a single plastic encapsulation. They have four terminals: two which take the a.c. input signal and two which supply the d.c. output signal. The a.c. input can be coupled to the input terminals either way round, and they are normally marked with an a.c. waveform ("~"). The positive and negative terminals are usually just marked with "+" and " – " signs.

Some rectifiers have no band around the body, but instead have one end of the component tapered slightly. This thinner end is the cathode one (i.e. the one that would otherwise carry the white band).

MULTI BANDS

Diodes having multiple bands are not particularly common, but do seem to crop up from time to time. You are only likely to encounter these in the form of the popular 1N4148 silicon diode which sometimes has four coloured bands. Apparently this is a form of colour coding which has similarities to the standard resistor colour code system. It is more simple though, in that the four colours simply represent the four digits of the type number that follow the "1N" prefix. In the case of a 1N4148, the colours are therefore yellow, brown, yellow, and grey.

So how is the polarity of the component indicated? This is achieved by merely having the bands offset towards one end of the component. They are offset towards the cathode ("+" or "k") end of the device. In my experience the offset is quite small, which is to some extent dictated by the small body size of these components.

The band nearest the cathode leadout should be a bit wider than the others, but the difference might be quite marginal. You therefore need to look carefully at these components before deciding on their correct orientation and connecting them into circuit.

HEAT OF THE MOMENT

It is perhaps worth pointing out that although germanium transistors are now largely obsolete, germanium diodes are still used to a significant extent. They have a lower forward voltage drop than silicon types – a factor that enables them to operate in some applications where silicon types give mediocre results or even fail completely.

A point to keep in mind when dealing with germanium diodes such as the popular OA90 and OA91, or germanium transistors, is that they are more vulnerable to heat damage than the more familiar silicon devices.

The safest way to deal with these, or any other heat sensitive components, is to use a heat-shunt when soldering them into circuit. Most heat-shunts look rather like a pair of tweezers, but they do not require you to manually hold them in place. Instead, they have some form of spring mechanism that enables them to be clipped in place, leaving both of your hands free to solder the component in place.

In use the heat-shunt is simply clipped in place over the leadout wire that is about to be soldered, somewhere between the body of the component and the soldered connection. As the heat from the iron travels up the leadout wire towards the body of the component, most of the heat is diverted into the heat-shunt. This keeps the component substantially cooler, and avoids damage unless the iron is kept in place on the joint for several seconds (which is totally unnecessary and likely to produce a poor joint).

You can improvise a heat-shunt from something like a pair of tweezers plus a small rubber band, or a crocodile clip can be used. These methods are unlikely to be as efficient as a proper heat-shunt though, and could lull you into a false sense of security.

To be honest, I do not use a heat-shunt at all, and find that no damage results to germanium components provided the soldered joints are completed fairly swiftly. However, if you are not very experienced at soldering, and are at all hesitant about this task, then it would probably be best to play safe and invest in a proper heat-shunt. These cost a matter of pence rather than pounds.

LED ASTRAY

There are several specialised types of diode, such as variable capacitance (varicap) and Zener types. Many of these

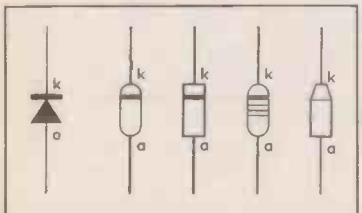


Fig. 1. Common methods of polarity indication for diodes and rectifiers.

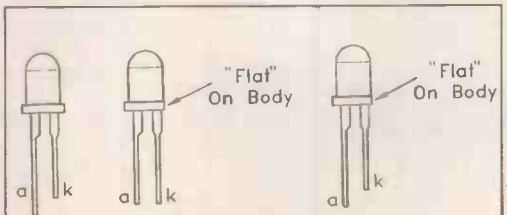


Fig. 2. Polarity indication for l.e.d.s.

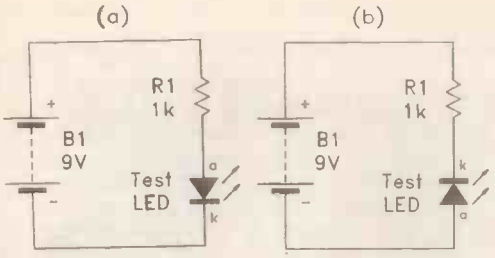


Fig. 3. Simple l.e.d. polarity test circuit. If the l.e.d. lights it has the polarity shown in (a), if not he polarity is as shown in (b).

use one of the methods mentioned above to identify the anode and cathode leadouts. However, some types, such as many infra-red photo-diodes and multiple varicap types, have unusual encapsulations. In order to sort out the correct method of connection with these components it may well be necessary to consult the manufacturers or retailers data.

The humble light emitting diode (l.e.d.) is a specialised form of diode that is worthy of special mention. This is a component that often leads to difficulties. These are true diodes, and unlike ordinary filament bulbs, they will only light up if they are connected the right way round. There is no standard method of indicating the polarities of these components, but Fig.2 shows two common methods. Unfortunately, there are a few l.e.d.s where the shorter lead is the anode, but these are few and far between these days. I have come across many l.e.d.s that seem to be symmetrical, with no obvious means of differentiating between the two leadout wires.

If in any doubt about the polarity of a l.e.d., remember that it is perfectly all right to use trial and error to find the right method of connection. If a l.e.d. is connected with the wrong polarity, it will not light up, but it will not be harmed either. This method is not very practical if you are fitting dozens of l.e.d.s onto a printed circuit board to produce a complex display.

The polarity of a l.e.d. can be checked using a multimeter, and the instructions supplied with the meter should give details of this simple process. If you do not have a suitable meter, then a 9 volt battery and a 1k resistor used in the manner shown in Fig.3 will do the job just as well.

Some of the retailers catalogues give connection details for l.e.d.s. If you are in doubt about the polarity of one of these components, consulting the appropriate catalogue might solve the problem. However, in my experience the components supplied do not always physically match the ones illustrated in catalogues (especially with l.e.d.s). This is presumably due to changes in sources of supply in order to obtain a better buy-in price, and to changes in components introduced by manufacturers. Anyway, as I have pointed out several times before, a few component catalogues should be regarded as absolutely essential for anyone pursuing electronics as a hobby, and they are a valuable source of useful data.

Having experienced difficulties with l.e.d.s on numerous occasions since they first became available, I now always check their polarity with a meter before connecting them. This saves a lot of desoldering and rewiring.

S.C.R.s

Three types of silicon controlled rectifier (s.c.r.) are commonly used in electronic projects. The thyristor is the most basic type, and is used for switching d.c. loads. This is a three lead device, and its terminals are called the anode (a), cathod (k), and gate (g). A triac can switch a.c. loads, and is another three terminal device. Its terminals are called mains terminal 1 (mt1), mains terminal 2 (mt2), and the gate (g).

Both of these components are normally contained in transistor type encapsulations. A few of these devices are intended for low power applications and have small signal transistor type encapsulations. Most though, are power devices, and physically look much like power transistors.

Like transistors, each encapsulation can have several leadout configurations. It is not safe to assume that the device you are using, although of a different type number to the specified device, has the same leadout configuration as the correct device because it also has the same type of encapsulation. If you use a substitute type, check the leadout diagrams for the two components to ensure that they are the same. Triacs are bidirectional, but note that they will still only operate properly if the mt1 and mt2 terminals are connected around the right way.

Although, on the face of it, if you use a thyristor or a triac having suitably high current and voltage ratings it should work correctly, matters are not always as simple as this. Some s.c.r.s need a trigger current of only about 200 microamps, while others need a trigger current around one hundred times higher than this. Some of the other parameters are prone to very large variations. Unless the book or article concerned states that any thyristor or triac having certain minimum current and voltage ratings will suffice, it is best to use the specified type.

DIACS

Diacs are two terminal components, and are mainly used as trigger devices for thyristors and triacs. They are most commonly used in a.c. power control circuits of the lamp dimmer type. Although some of these devices have encapsulations or markings which suggest that they are polarised, they are actually bidirectional. In other words, it does not matter which way round you connect them.

Some triacs have built-in diacs. It is important to use a type that has an integral diac where appropriate, and to use an ordinary type where the design does not call for a built-in diac. Using the wrong type will at best give erratic operation, and at worst will result in the circuit failing to work at all. With triacs it is definitely advisable to use the specified type, rather than dabbling with substitutes which may well turn out to be totally unsuitable.

HIGHGRADE *Christmas* COMPETITION

We've gone completely loopy this year: we're giving away up to £1000! Yes, the winner of our Christmas Competition will receive a voucher for *ten times* the value of the order that accompanies the entry, up to a maximum of £1000! The voucher can be exchanged for any components offered by Highgrade in 1991—you choose what to buy with it. If that's not enough for you, every single competition entry entitles you to a gift, whether you get the answers right or not! Are you ready? Here we go.

Win up to £1,000 worth of components!

In the Highgrade lab we've been experimenting with a special recognition circuit. To test it out, the system is connected to a printer: we speak into the microphone and it prints what it thinks we said. Sad to say, there are still a few bugs in the system. For instance, when I said into the microphone 'Can you recognise speech?' the printer came back with—Can you wreck a nice beach?! Here are some of the mistakes it made when read it a list of television programs. What should it have printed?

1) Colliders Cope should have been _____
2) Casual Tea should have been _____
3) Cora Nation's Treat should have been _____
4) Stale Ucky should have been _____
5) Start Wreck should have been _____
6) Woe Gun should have been _____

Right now we're working on a nudie vice for hoe moaners—sorry, I must remember to turn off the speech circuit. A new device for home owners is what I meant to say, of course. Anyway, now you've filled in your answers you can choose any one of the gifts below!

EVERY ENTRY WINS A PRIZE!

1) Special blade for cutting grooves and notches
2) Mini biofeedback monitor kit
3) Secret circuits file—things the authorities would rather you didn't know!

The competition winner will be chosen by draw from all completely correct entries received by the closing date: December 20th 1990. I'd like to say that some famous celebrity will make the draw, but in reality fair play will be supervised by our not very famous solicitor. The winner will be notified early in January 1991. If you have any queries about the competition, please tel: 0600 3715.

SUPER *Christmas* COMPONENT BARGAINS

As soon as you've decided which offers you can't resist, phone in your order on 0600 3715

BF167 Transistors: pack of 100 for £2.80! ☐
0.68µF Polyester capacitors: bag of 200 for £3.80! ☐
DIL switches, 4-pole, pack of 10 for £1.40! ☐
Horizontal cermet trimmers, 250K, pack of 25 for £1.60! ☐
10-way Molex straight plug, pack of 100 for £2.80! ☐
J201 FETs: pack of 100 for £3.80! ☐
DIN speaker sockets: bargain pack of 10 for 80p! ☐
3A Rectifiers: you'll never see an offer like this again: 25 for £1.80! ☐
Green rectangular LEDs: not perfect, but all working: goofy offer 200 for £2.80! ☐
4n7 Polyester capacitors: wicked! 200 pack for £2.60! ☐
BF394 transistors: extra special Christmas offer: 100 for £2.60! ☐
Push switches: you won't believe this: 100 for £3.80 (less than 4p ea!) ☐
Canned coils: mean looking components: 25 for £2.20! ☐
22n (0.022µF) Polyester capacitors: bag of 200 for just £3.20! ☐
DIL resistor networks: 15 commoned 10K resistors each IC: 25 for £1.60! ☐
Full feature clock module: extra special offers: £2.80! ☐
TEA5570 AM and FM radio IC, with data and circuits: £2.20! ☐
47n (0.047µF) Polyester caps: another monster bargain: 200 for £3.20! ☐
3-way Molex plugs, pack of 100 for £2.20! ☐
Ceramic filter 455kHz (use with radio IC) 2 for £1.00! ☐
Ceramic filter 10.7MHz (use with radio IC) 2 for £1.00! ☐
BC307 Transistors: pack of 100 for £3.20! ☐
Horizontal cermet trimmers, 100R, pack of 25 for £1.60! ☐
Believe this: 39p 2.5% tolerance top grade polystyrene caps: 100 for £1.20! ☐
Trimmer capacitors: delightful components: silly price of 25 for £1.80! ☐
D-sockets: 25-way R/A: pack of 5 for £1.80! ☐
D-plugs: 25-way R/A: pack of 5 for £1.80! ☐
Intelligent 2-digit numeric display, with data: suicidal offer: £1.80! ☐
68n (0.068µF) Film capacitors: the baddests caps around: 100 for £1.60! ☐
BCY56 Transistors: you'll love these: pack of 100 for £2.40! ☐
Presets: miniature carbon, enclosed, 22k, a super bargain: 100 for £2.80! ☐
COP321 Microcomputer ICs: how do they do it?: 2 for 80p! ☐
COP321 circuit and programming data £2.20! ☐
BF410 FETs: super FETs at an amazing price: 100 for £3.60! ☐
Standard red LEDs: light up your Christmas tree! New and perfect. 100 for £2.80! ☐

Thermal fuses: open at 70°C: a pack of 5 is yours for £1.00! ☐
Scarab switching regulator: 5V @ 6A: a £60 regulator for £2.20! ☐
7-way Molex plugs, pack of 100 for £2.60! ☐
Multi-contact lever switch: 2 sets of 4pc/o contacts: loopy price of 2 for £1.00! ☐
Ceramic caps, 120pF, pack of 100 for only £1.20! ☐
Motorola NPN transistors: pack of 100 for...wait for it...£1.80! ☐
Vertical cermet trimmers, 250k, pack of 25 for £1.60! ☐
SAB0600 three tone chime IC, with data and circuits, yours for £1.00! ☐
6A 200V Rectifiers: what a bargain! 25 for £2.80! ☐
78L08 Voltage regulators, 8V @ 100mA: 10 for £1.60! ☐
ST72A FETs: another splendid bargain: pack of 100 for £3.80! ☐
Miniature carbon trimmers, 47k, with finger adjust: pack of 100 for £2.60! ☐
SIL resistor networks: 8 commoned 3k3 Rs per IC: pack of 25 for only £1.60! ☐
Ceramic resonator (use as crystal), 4MHz, pack of 3 for £1.00! ☐
BT137 mains (600V) triac, will switch up to 8A. Yummy offer: 3 for £1.20! ☐
Extra special offer: 6 quad comparator ICs, with data, £1.20! ☐
Miniature STC 12V relays, 2pc/o, pack of 2 for £1! ☐
Ceramics, 5p6 sub-miniature, pack of 100 for £1.40! ☐
1µF Polyester caps: bag of 100 for £3.20! ☐
CMOS25 Power transistors: pack of 10 for £1.20! ☐
BF173 transistors: treat yourself to a pack of 100 for £2.80! ☐
Seven segment LED displays: 0.5" 1½ digit CC: pack of 10 for £2.80! ☐
Multi-turn cermets: ¾" 20-turn 2k2: pack of 25 for £2.80! ☐
Cable clips: tidy up those wires! Pack of 200 for 80p! ☐
Hi-Fi signal switches: 2pc/o contacts: pack of 10 for £1.80! ☐
Push-switch buttons: black with silver trim: 50 for £1.00! ☐
LM342 voltage regulators: 18V @ 250mA: 10 for £1.80! ☐
47n Disc ceramic caps, for decoupling: pack of 50 for £1.00! ☐
Microprocessor IC, 8085, yours at the ridiculous price of £1.20! ☐
Circuit and programming data for 8085: £2.00! ☐
Amp connectors, 4-way, pack of 100 for £1.20! ☐

Please tick the boxes for any components you would like, and send the entire page (with your competition entry!) to: **Highgrade Components Ltd., 8 Woburn Road, Eastville, Bristol, BS5 6TT.**

Name.....

Address.....

.....

.....

.....

☐ I enclose cheque/postal order for.....£.....

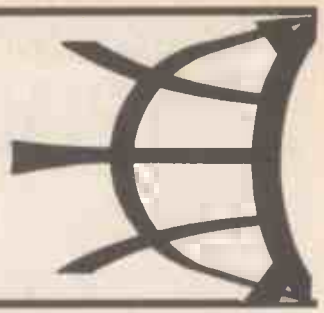
☐ Please charge my Access/Visa card no._____/_____/_____/_____

Expiry date_____/_____

Components total £.....
Postage (£2.80 UK) £.....
Sub total £.....
VAT (UK only)* £.....
TOTAL £.....

Signed.....

REPORTING AMATEUR RADIO



Tony Smith G4FAI

YOUNG AMATEUR OF THE YEAR

Seventeen year old David Martin from Glasgow has received the *Young Amateur of the Year* Award 1990, sponsored by the DTI's Radiocommunications Agency. Chosen from a short-list of six, David, whose callsign is GM0NVE, is a co-founder of YAGIS (Young Amateur's Group in Scotland), has converted PMR (private mobile radio) equipment for use on the amateur bands, is active in radio clubs, has run a special event station in the Scouts Jamboree-on-the-Air, and is a member of RAYNET the Radio Amateur Emergency Network. He received a £250 prize and Certificate, plus a number of other prizes, including a 2m transceiver from Navico, a packet radio controller from Siskin Electronics, and a digital multimeter from Cirkit. Together with the runner-up he will also be invited to a guided tour of the RA's Monitoring Centre at Baldock in Hertfordshire.

Runner-up was Simon Glanville, G7DCY, a student committee member of the Coventry Amateur Society, who regularly assists a local elderly radio amateur who has problems using his hands. He founded his school's Remote Imaging Group which obtains data and weather pictures from satellites, encourages an interest in amateur radio by demonstrating the hobby to pupils, parents and teachers, and illustrates operating procedures to students at his local Radio Amateurs' Examination class.

The Young Amateur of the Year Award is organised by the Radio Society of Great Britain as part of its project YEAR (Youth into Electronics via Amateur Radio) initiative which aims to interest more young people in the hobby.

REPEATER ABUSE IN U.S.A.

British amateurs are not alone in suffering repeater abuse as illustrated by a recent story in the *W5YI Report* concerning Richard Burton, ex-WB6JAC, who lost his licence in 1981 for malicious interference, failure to use his callsign, use of profane and obscene language, jamming a repeater, and illegal broadcasting. He refused to go off the air and in 1982 was sentenced by a Los Angeles court to eight years imprisonment, suspended for all but six months, followed by five years probation, including 1500 hours community work. It was the first time an American radio amateur had been imprisoned for illegal activity on the amateur bands.

Early in 1990 there were complaints that Burton was back on the 2 metre band, even though he had not been re-licenced, behaving in much the same manner as before. He was re-arrested on May 16 on three charges of unlicensed radio operation, having allegedly made on-the-air threats against the judge and the local FCC engineer-in-charge. He apparently felt that the government had no prerogative to restrain his First Amendment right to say what he thought.

He refused to enter a plea and the court appointed a public defender on his behalf. Bail was set at $10,000 and in the absence of surety he was jailed pending a trial but later, after psychiatric evaluation, was released from custody. On July 20, a jury found him guilty of transmitting without an amateur licence on one only of the three charges, and on October 1st he was sentenced to one year's probation, a $2,000 fine and continuing psychiatric care.

This interesting insight into the behaviour of one "repeater vandal" raises several debatable points. Firstly, as many of those who interfere with UK repeaters behave in much the same way as Burton, should they be dealt with much more severely, as offenders evidently are in the USA?

Or has he got a point. Should he be free to behave as he wishes on the air? Apparently a Los Angeles amateur "Free Radio" community felt that this was a Freedom of Speech issue, and early on some of his supporters appealed for funds, on the 2 metre band, in an attempt to raise his bail.

Another issue concerns the current trend to make entry into amateur radio much easier, to attract more recruits. Will this open the door to more subversive elements, bent on interfering with the activities of the responsible majority? Some have already got in even though they have had to pass the existing examinations to do so. How many more will follow, the easier entry gets, and what will their impact on the hobby be?

AMATEUR RADIO IN THE THIRD WORLD

The Pacific nation of Vanuatu, formerly the New Hebrides, celebrated its 10th anniversary last July. According to a report in *Amateur Radio*, journal of the Wireless Institute of Australia, amateur radio is slowly establishing itself in the infant nation. There are about 20 licensees, all expatriates except for 24 year old Touasi Taiwia, YJ8NTT, a YL (young lady) who recently qualified for her novice licence.

Vanuatu is, however, better known in the amateur world than its present status would suggest. Up to 30 amateurs visit the country each year to operate from this unspoiled Dx paradise, with some setting up high scoring stations during well-known international events such as the CQ World-Wide contest.

On behalf of the authorities the Vanuatu Amateur Radio Society (VARS) appoints an examiner for Morse examinations and invigilates the main examinations which are based on Australian licensing standards. It is not easy, however, for the indigenous population to master the requirements of the examination. Without electricity in their homes, for example, study after sunset at 6.p.m. is difficult.

Language presents another problem when trying to grasp such concepts as inductance, capacitance, etc, from student material written in English. One possible means of overcoming this difficulty would be videotapes of basic electronic concepts obtained from Australia or elsewhere which VARS could use for instructional purposes, but there are obviously many difficulties to be overcome before amateur radio becomes a "people's hobby".

COMPONENTS NOT AVAILABLE

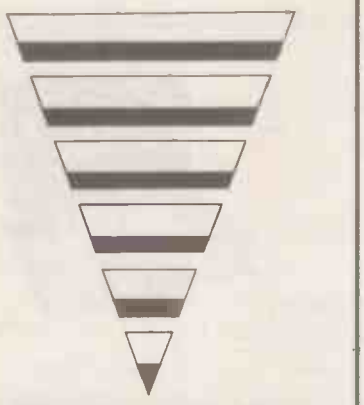
There is, for instance, a great need for suitable and inexpensive equipment, but even simple components, things that we take very much for granted, are not readily available. Some years ago I corresponded with an amateur in Sri Lanka after I wrote an article about QRP (low power) operating in the American *CQ* magazine. I recommended making one's own equipment since a handful of components could equate to a surprising degree of achievement and satisfaction. He was converted by my enthusiasm but, where, he asked, could he get the components?

In his country it was just not possible to get resistors, capacitors, transistors and so on. His immediate problem was solved by a simple QRP transceiver loaned to him through an American aid programme intended to help third world countries beginning to develop amateur radio as a national resource. Eventually he had to pass the set on to another aspiring amateur, but by that time he had become "hooked" and somehow managed to get a second-hand commercially made set from Germany.

One thing strikes me about all this. There are moves afoot in the more developed nations to make amateur radio more hi-tech, to "bring it into the space-age." There was, for instance, a proposal (which was in fact rejected) at a recent IARU conference that the amateur Morse test should be replaced by a test of computer operating skills because an increasing number of operators today use their computers in conjunction with amateur radio for data transmissions and other purposes.

If such a proposal ever comes to fruition where would this leave the amateur radio communities slowly building up in Vanuatu and elsewhere? Most beginners will of necessity be using simple equipment for Morse or speech transmission. Will they find that the goal posts have been moved, and that international contacts will not be possible unless they also have computers and master the intricacies of data communications?

DOWN TO EARTH



George Hylton

BACK in the 18th Century, Benjamin Franklin flew a kite in a thunderstorm. The idea was to find out whether lightening was electrical. By observing detectors attached to the kite string he concluded that it was. Shortly afterwards someone tried to repeat the experiment. He was electrocuted.

Electric shock remains by far the greatest hazard to the experimenter, which is why magazines like this emphasize the need for safety when working with high voltages. In mains powered equipment the danger is obvious. But even equipment powered by dry batteries can deliver nasty shocks. A common case is the electronic photographic flash unit, where a large capacitance is charged to perhaps several hundred volts and may hold its charge for some time after switch-off.

HIGH FREQUENCIES

It is not sufficiently known that the body's ability to detect current flowing through it diminishes as the frequency is raised. At mains frequency the average human can feel 1mA, but at 100kHz even 100mA may be imperceptible. This suggests that there is a special need for care in working with high-power, high-frequency equipment such as radio transmitters.

As the frequency is raised, there is a risk even when there is no contact with the equipment. This is because the body acts as a lossy aerial and absorbs energy when immersed in a radio-frequency field. According to the National Radiological Protection Board (N.R.P.B.) which keeps an eye on these matters, the human aerial is most efficient in the range 40-100MHz (3-7 metres wavelength).

If you walk barefoot in a radio frequency electric field the current in your body can reach $(0.11 \times h^2 \times f \times E)/1000$ milliamps. (Here h is your height in metres, f is the frequency in kilohertz and E is the field strength in volts per metre). The permitted powers of amateur radio transmitters are low enough to make the risk small, and when high-power broadcast transmitters are built their boundary fences are normally sited so that passers-by are in no danger.

Apart from shock, damage can be done by the heating effect of currents in the body. In the "standing near a radio mast" situation the ankles get the most concentrated current.

However, at microwave frequencies the eyes are vulnerable. The very short wavelengths can cause local heating. In most parts of the body blood-flow acts as a coolant but the eyes are poorly equipped with blood vessels and can suffer.

RADAR

This is one reason why microwave cookers are carefully screened and are automatically shut off when their doors are opened. However, these sort of frequencies are also used in radar, which may be very high-powered. Radar technicians must be protected and of course be aware of hazards such as looking into a waveguide carrying microwave power.

The question arises, does long-term exposure to *small* doses carry a risk? Attempts have been made to show that there is a higher than normal incidence of cataracts among radar technicians, but with no very clear-cut results. If there is a risk it is a small one, provided proper precautions are taken.

MOSCOW MYSTERY

Back in the 1950s, the Americans discovered that their Moscow embassy was being irradiated from outside by microwaves. The energy level was fairly low (up to 0.15 watts per square metre, corresponding to an electric field strength of 7.5 volts per metre). Nevertheless the embassy staff complained of all sorts of health problems.

Very careful investigation failed to demonstrate any connection between staff health and the microwave radiation.

PLACEBO EFFECT

The embassy affair demonstrates how difficult it can be to establish a real connection between cause and apparent effect. If the staff knew they were being irradiated by an unfriendly power and then had headaches they were very likely to attribute the headaches to the irradiation. That's only human.

The reverse situation can also occur. If you start with a human problem and then treat it in any way the patient is likely to feel better. This is the "placebo effect", so called because doctors who suspect a patient's illness may be imaginary may prescribe a placebo, that is, a pill which is merely sugar or starch but looks genuine. Quite often, it works – for a while.

After World War Two there was an interest in something called "radio-aesthesia". People were offered electronic "black boxes" said to create healthful emanations.

Convinced that this was mere quackery, somebody brought a court case against the black box providers, and lost. The judge said that, in a spirit of impartial enquiry, he had had a black box installed in his house, and felt benefit from it.

OTHER HAZARDS

Recently there have been several attempts to show that people involved in electrical and electronic work, or merely living near overhead power lines, are exposed to special health risks. In particular, certain rare forms of cancer seem to be less rare among these people.

In the power-line case, the initial idea, that long-term exposure to electrical and magnetic fields might be responsible, suffered a setback when it was established that fields from domestic appliances are much stronger than those from the power lines. However, the anomaly is real and requires explanation.

In the case of radio and TV service engineers one suggestion is that their work involves exposure not only to fields but also to chemicals such as the fumes from solvents and solder. Because it is suspected from animal experiments that solder fumes might cause cancer it is now normal in British factories to fit hand soldering irons with a suction device to remove them. Once again, the risk, if real, is small, and is presumably smaller still in the case of the electronics hobbyist who is not exposed for long periods.

One must never discount small risks. Nor must one be unduly worried by them. Life is full of risks. You are certainly more likely to be killed in a road accident than by solder fumes, but I don't think this need keep you off the streets.

My feeling is that until somebody shows otherwise, one should worry about electric shock and not worry unduly about other theoretical hazards. After all, there are millions of semiconductor devices in use, containing arsenic compounds. Have you ever heard of anyone being poisoned by them?

USEFUL REFERENCES

1) Advice on Protection of Workers and Members of the Public from the Possible Hazards of Electric and Magnetic Fields with Frequencies Below 300GHz (1986).

2) Health Issues in the Siting of a Low Frequency Transmission Mast (1988).

Both published by N.R.P.B., Chilton, Didcot, Oxon. OX11 0RQ.

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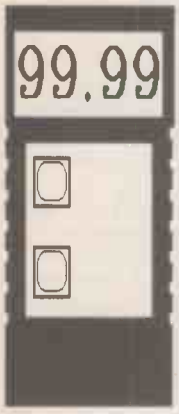

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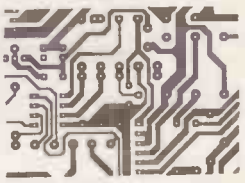

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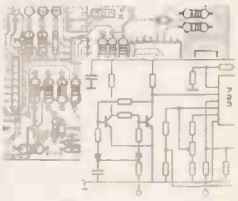

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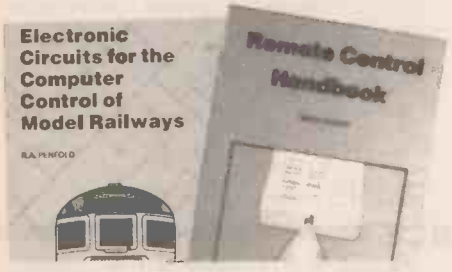

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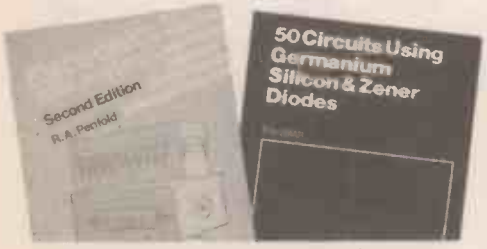

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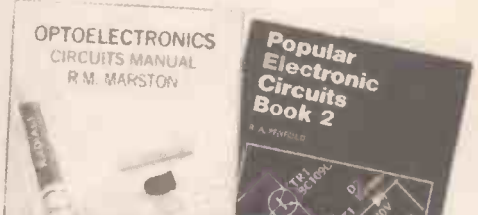

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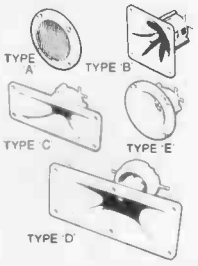

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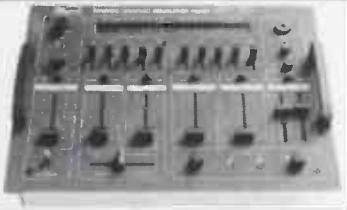

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50 simple LED projects book 2.	1	£1.95	BP87
A concise introduction to MS-DOS.	1	£2.95	BP264
A concise introduction to D-BASE.	1	£3.95	BP263
A concise introduction to GEM.	1	£2.95	BP230
A concise introduction to MS-DOS.	1	£2.95	BP232
A concise introduction to OS-2.	1	£2.95	BP260
A concise introduction to SYMPHONY.	1	£3.95	BP270
A concise introduction to BBC BASIC.	1	£1.95	BP149
A concise introduction to WORD PERFECT.	1	£2.95	BP262
A concise introduction to SUPERCALC.	1	£3.95	BP274
A concise introduction to LOTUS 1-2-3.	1	£2.95	BP261
Word processing on the 8256 & 8512.	1	£5.95	BP187
TV DXers handbook.	1	£5.95	BP176
A Z80 workshop manual.	1	£3.95	BP112
Advanced shortwave receiver construction.	1	£3.95	BP276
Alternating current theory.	1	£3.50	BP63
An introduction to BASIC on a PC.	1	£5.95	BP199
An introduction to amateur radio.	1	£3.50	BP257
An introduction to computer graphics.	1	£4.95	BP268
An introduction to desktop publishing.	1	£5.95	BP269
An introduction to loudspeaker enclosure design.	1	£2.95	BP256
An introduction to satellite television.	1	£5.95	BP195

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
An Introduction to Amstrad PC's.	1	£5.95	BP197
An Introduction to Z80 machine code.	1	£2.75	BP152
Audio amplifier construction.	1	£2.95	BP122
Audio projects.	1	£2.50	BP90
Coil design and construction manual.	1	£2.50	BP160
Computer hobbyists hand book.	1	£5.95	BP251
Computer music projects.	1	£2.95	BP173
Digital audio projects.	1	£2.95	BP245
Digital IC equivalents and pin connections.	1	£5.95	BP140
Electronic circuits for model railways.	1	£2.95	BP180
Electronic circuits for robots.	1	£2.95	BP179
Electronic hobbyists handbook.	1	£4.95	BP233
Electronic projects for cars and boats.	1	£1.95	BP94
Electronic science projects.	1	£2.95	BP104
Electronic security projects.	1	£2.50	BP56
Crystal set construction.	1	£1.75	BP92
Electronic calculations and formulae.	1	£4.95	BP144
HI FI loud speaker enclosures.	1	£2.95	BP205
High power amplifier construction.	1	£3.95	BP277
How to design and make your own PCB's.	1	£2.50	BP121
How to design electronic projects.	1	£2.25	BP127
How to get your electronic projects working.	1	£2.50	BP110
How to identify unmarked IC's.	1	£0.95	BP101
555 timer project book.	1	£2.95	BP44
Interfacing PC's and compatables.	1	£0.95	BP272
International diode equivalents book.	1	£2.95	BP108
International radio stations guide.	1	£4.95	BP255
International transistor equivalents.	1	£3.50	BP85
An introduction to UNIX.	1	£2.95	BP259
Linear IC's equivalents and pin connections.	1	£5.95	BP141
Midi projects.	1	£2.95	BP184
Model railway projects.	1	£2.95	BP95
Modern op-amp projects.	1	£1.95	BP106
Modern opto device projects.	1	£2.95	BP194
Advanced electronic security projects.	1	£2.95	BP190
Advanced midi projects.	1	£2.95	BP247
Advanced power supply projects.	1	£2.95	BP192
Popular electronic circuits book1.	1	£2.95	BP80
Popular electronic circuits book2.	1	£2.95	BP98
Power transistor selctor guide.	1	£4.95	BP235
Power supply projects.	1	£2.50	BP76
Projects in opto electronics.	1	£1.95	BP45
Upgrading and repairing PC's and compatables.	1	£3.95	BP272
Remote control handbook.	1	£3.95	BP240

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
Simple shortwave receiver construction.	1	£3.95	BP275
TOWERS INTERNATIONAL TRANSISTOR SELECTOR GUIDE.	1	£20.00	20P32
BOXES AND CASES			
Self adhesive brushed aluminium panel. Can be cut with scissors. Very flexible. 16" x 3".	1	£2.00	2P283
Amplifier junction box. Metal sloping front.	1	£2.00	2P256
Black ABS project box 165mm x 119mm x 75mm.	1	£3.00	3P49
Metal box 8" x41/2" x4" louvred ends, ideal psu.	1	£3.00	3P75
Plastic box with window, ideal for beam switch etc.	2	£1.00	BD132
Metal box 8" x4" x1", slightly sloping.	1	£1.00	BD209
PLastic box with screw on lid 216mm x 130mm x 85mm	1	£4.00	4P7
Plastic box with screw on lid 220mm x 159mm x 64mm	1	£4.00	4P8
Signal box. 3 lamps on face plate of metal box.	1	£3.00	3P16
Waterproof case will take 100W transformer.	1	£3.00	3P15
4"x2"x2" project boxes with slot in top.	2	£1.00	BD780
ABS project box 90x50x25mm black.	1	£1.00	CD25
ABS project box 110x56x20mm black.	1	£1.00	CD26
ABS project box 100x75x40mm black.	1	£1.00	CD27
ABS project box 150x100x55mm black.	1	£2.00	2P341
BURGLAR ALARMS			
Ultrasonic intruder detector or alarm 12v op.	1	£18.00	18P3
As above but with external siren and mains adaptor.	1	£30.00	30P5
CABLE TIES			
75mm x 2.4mm nylon white cable ties.	100	£1.00	BD868
75mm x 2.4mm nylon white cable ties (1,000 pack).	1	£5.00	5P181
142mm x 3.2mm nylon white cable ties.	100	£3.00	3P104
142mm x 3.2mm nylon white cable ties (1,000 pack).	1	£14.00	14P6
385mm x 5mm nylon white cable ties.	100	£10.00	10P97
Cable tie bases 21 x 21mm self adhesive.	100	£5.00	5P182
Cable tie bases 28 x 28mm self adhesive.	100	£5.00	7P25
Cable tie gun. Tensions then cuts tie.	1	£6.00	6P38
Spiral cable wrap for 6 -50mm bundles (10 m length).	1	£2.00	2P329
Spiral cable wrap for 12-70mm bundles (10 m length).	1	£4.00	4P74
CAPACITOR BARGAIN PACKS			
Mixed pack of non electrolytic capacitors.	100	£2.00	2P286
Mixed pack of electrolytic capacitors.	40	£2.00	2P287
CAPACITORS AC WORKING			
Capacitor 8uf 440v AC 97 x 45mm.	1	£1.00	BD632
Capacitor 1uf 440v AC 48 x 38mm.	2	£1.00	BD633
Capacitor 15uf 440v AC 120 x 75 x50mm.	1	£2.00	2P201
Capacitor 20uf 440v AC 150 x 75 x 50mm.	1	£2.00	2P200
Capacitor 2uf 440v AC 70 x 35mm.	1	£2.00	2P164
Capacitor 12uf 660v AC 150 x 90 x 45mm.	1	£2.00	2P163

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
Capacitor 1.5uf 440v AC 60 x 40 x 25mm.	1	£1.00	BD279
Capacitor 2.5uf 440v AC 73 x 30mm.	1	£2.00	2P176
CAPACITORS ELECTROLYTIC			
Capacitor 15,500uf 10v can type 110 x 50mm.	1	£1.00	BD18
Capacitor 4,700uf 25v axial.	4	£1.00	BD613
Capacitor 3,150uf 40v can type 110 x 38mm.	2	£1.00	BD237
Capacitor 8uf 275v plastic case 35 x 15mm.	2	£1.00	BD573
Capacitor 32uf + 32uf 350v.			
Capacitor 32uf 500v 75 x 25mm.	2	£1.00	BD609
Capacitor 10uf 25v radial.	20	£1.00	CD26
Capacitor 22uf 25v radial.	20	£1.00	CD27
Capacitor 47uf 25v radial.	15	£1.00	CD28
Capacitor 100uf 25v radial.	12	£1.00	CD29
Capacitor 220uf 25v radial.	10	£1.00	CD30
Capacitor 470uf 25v radial.	6	£1.00	CD31
Capacitor 1000uf 25v radial.	5	£1.00	CD32
Capacitor 2200uf 25v radial.	4	£1.00	BD856
Capacitor 4700uf 16v radial.	4	£1.00	BD857
Capacitor 4,700 16v	4	£1.00	BD858
Capacitor 4.7uf 63v.	10	£1.00	BD859
Capacitor 1uf 63v.	12	£1.00	BD860
Capacitor 2200uf 6.3v 5.8A can type.	1	£1.00	BD644
Capacitor 4700uf 100v 10A 105 x 50mm.	1	£2.00	2P178
CAPACITORS EHT			
Capacitor 1000pf 12kv ceramic.	2	£1.00	BD439
Capacitor 220pf 8kv ceramic.	4	£1.00	BD440
Capacitor 150pf 8kv ceramic.	5	£1.00	BD441
Capacitor 100pf 8kv ceramic.	5	£1.00	BD442
Capacitor 68pf 8kv ceramic.	10	£1.00	BD443
Capacitor 2.5nf 10kv 35 x 15mm.	2	£1.00	BD522
Capacitor .265uf 1.5kv metal case. 110 x55 65mm	1	£1.00	BD362
Capacitor .001uf 28kv plastic 120 x 60 x 80mm.	1	£2.00	2P124
CAPACITORS VARIABLE			
Air spaced 2 gang 1/4" spindle 365pf.	2	£1.00	BD36
Solid di-electric AM & FM sections. Two gang.	2	£1.00	BD37
Solid di-electric compression trimmers.	10	£1.00	BD38
Minature twin tuning condensor 150pf 1/4" sindle.	1	£2.00	2P237
Twin gang 350pf Jackson 1/4" spindle.	1	£2.00	2P170
Transmitter tuning condensor 160pf (ex-equip).	1	£1.00	BD424
Trimmer capacitor 3-40pf Mullard.	1	£1.00	BD656
CIRCUIT BREAKERS			
10A trip with additional signalling contacts (Belling lee). thermal magnetic type. 2 button 55x20x30mm.	1	£3.00	3P103
COMPUTER DATA SWITCHES			

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
2 way RS232 DATA swich (3 female D25). Cased.	1	£14.00	14P7
2 way Centronics data switch (3 Centronics fem) cased.	1	£18.00	18P9
CONTACTORS			
Heavy duty 24v DC operation 4 pole 25A 95x60x70mm.	1	£1.00	BD68
Heavy duty mains operation 4 pole 25A 90x75x90mm.	1	£5.00	5P64
COUNTERS			
Tape deck counter 3 digit. resettable. flywheel/belt op.	2	£1.00	BD26
7 digit 24v counter panel mount.	1	£2.00	2P267
7 digit even numbercounter. mains voltage 47x70x32mm.	1	£1.00	BD890
Resettable 3 digit. mains operated 45x70x60mm.	1	£2.00	2P26
6 digit counter 12v DC operation.	1	£2.00	2P342
CRYSTALS			
1000 KHZ crystal	1	£1.00	BD866
5242.880 HZ	1	£1.00	BD867
2 mhz 10 x 12mm.	1	£1.00	BD658
6 mhz 10 x 12mm.	1	£1.00	BD659
8 mhz 12 x 5mm.	1	£1.00	BD937
12 mhz 12 x 5mm.	1	£1.00	BD938
16 mhz 12 x 5mm.	1	£1.00	BD939
18 mhz 12 x 5mm.	1	£1.00	BD940
CONNECTORS			
9 way D type male solder. Gold plated.	3	£1.00	BD941
9 way D type female solder. Gold plated.	3	£1.00	BD942
Plastic hood for 9 way connector.	3	£1.00	BD943
15 way D type male solder. Gold plated.	2	£1.00	BD944
15 way D type female solder. Gold plated.	2	£1.00	BD945
Plastic hood for 15 way connector	2	£1.00	BD947
25 way D type male solder. Gold plated.	3	£2.00	2P306
25 way D type female solder. Gold plated.	3	£2.00	2P307
Plastic hood for 25 way connector.	3	£2.00	2P308
Centronics 36 way cable plug (inc cover).	1	£1.00	BD948
1 mm banana plug. red.	4	£1.00	BD949
1 mm banana plug black.	4	£1.00	BD950
1 mm banana socket. red.	4	£1.00	BD951
1 mm banana socket. black.	4	£1.00	BD952
4 mm banana plug. red.	4	£1.00	BD953
4 mm banana plug. black.	4	£1.00	BD954
4 mm banana socket red	4	£1.00	BD955
4 mm banana socket. black.	4	£1.00	BD956
Crocodile clips (pack of 10 red and 10 black).	1	£2.00	2P309
BNC 50 ohm plug.	3	£2.00	2P310
BNC 75 ohm plug.	3	£2.00	2P311
SCART plug.	1	£1.00	BD957
CO-AX plug (TV type).	5	£1.00	BD958

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
CO-AX socket (TV type).	2	£1.00	BD959
2.5 mm jack plug. (Mono).	5	£1.00	BD960
3.5 mm jack plug. (Stereo).	3	£1.00	BD961
CONNECTOR AND TERMINAL STRIPS			
12 way 3A connector strip. One side screw terminals the other side is solder terminals.	5	£1.00	BD451
12 pole 25A poly connector strip. Screw type.	2	£1.00	BD159
12 way 5A connector strip.	4	£1.00	BD158
3 way connectors plug in type.	4	£1.00	BD160
CLOCKS			
Flip over digital clock with DIY case.	1	£3.00	3P139
Electric clock mains operated, no case.	1	£1.00	BD211
COILS AND FORMERS			
Subminature I/F transformers (all the same type).	100	£1.00	BD360
465KC I/F transformers 1/2" x 11/2" high.	4	£1.00	BD40
COMPONENT MOUNTINGS			
50 tag component mounting strip.	2	£1.00	BD168
COMPUTER BITS			
16K ram pack for ZX81 computer.	1	£8.00	8P22
8" ex equipment disc drives.	1	£8.00	8P37
Spectrum sound box with amplifier etc.	1	£4.00	4P53
BBC joystick with 2 fire buttons.	1	£5.00	5P159
Quickshot joycard VII for Atari and Commodore.	1	£3.00	3P85
Quickshot joyball IX for Atari and Commodore.	1	£5.00	5P164
Trackball for Dragon computers.	1	£3.00	3P86
Oric/Atmos interface for 2 joysticks with s/ware.	1	£1.00	BD757
Chinnon cased disc drive with leads 3 1/2" 360K	1	£40.00	40P1
Acorn data recorder ALF503 with psu and leads.	1	£15.00	15P43
Coverter to change bbc joystick port to Atari type.	1	£2.00	2P261
Computer terminals s/hand. mixed makes.	1	£15.00	15P33
Roll of paper for plotter.	1	£3.00	3P102
Keyboard made for OPD Computer.	1	£3.00	3P27
Commodore 64 games pack (5 different).	1	£3.00	3P97
Spectrum 48K games pack (5 different).	1	£3.00	3P96
PC power supply 150W switch on back. Cased.	1	£25.00	25P18
DELAY SWITCHES			
0.25 hour delay switch.	1	£1.00	BD101
Mains motor driven switch 20 secs on or off after push of button.	1	£3.00	3P138
DIODES			
OA91 germanium signal diode.	10	£1.00	BD976
IN4148 signal diode.	30	£1.00	BD977
IN4001 50v 1A	25	£1.00	BD971
IN4002 100v 1A	25	£1.00	BD972

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
IN4006 800v 1A	20	£1.00	BD973
IN5401 100v 3A	10	£1.00	BD974
IN5408 1000v 3A	8	£1.00	BD975
DISPLAYS			
16 character 2 line display. Epsom with data.	1	£10.00	10P50
Vaccuum flourescent displays. 4 letters or digits.	2	£1.00	BD614
7 segment displays common cathode .5".	4	£1.00	BD466
.3" 7 segment LED display. Common cathode.	4	£3.00	3P117
.3" 7 segment LED display. Common anode.	4	£3.00	3P118
.5" 7 segment LED display. Common cathode.	4	£3.00	3P119
.5" 7 segment LED display. Common anode.	4	£3.00	3P120
.56" 7 segment LED display. Common cathode.	4	£3.00	3P121
.56" 7 segment LED display. Common anode.	4	£3.00	3P122
Clock display 1/2" figures.	1	£1.00	BD329
16 character 1 line display no data.	1	£6.00	6P32
LCD display 4 digit with connection data.	1	£3.00	3P77
ELECTRICAL ACCESSORIES			
13A switched double socket. White. New.	1	£4.00	4P75
13A switched single socket. White. New.	1	£2.00	2P343
Single gang light switch. White. New.	1	£1.00	CD27
Two gang light switch. White. New.	1	£2.00	2P344
Ceiling rose. White. New	1	£1.00	CD28
Pendant lampholder. White. New.	2	£1.00	CD29
Pendant lampholder with switch. White. New.	1	£1.00	CD30
Batten lampholder. White. New.	1	£1.00	CD31
Battened lampholder angled. White. New.	1	£1.00	CD32
Junction box 15A. White. New.	1	£1.00	CD33
Junction box 30A. White. New.	2	£3.00	3P115
Dimmer switch 630 watt. White. New.	1	£4.00	4P77
Dimmer switch 630 watt brushed aluminium. New.	1	£5.00	5P185
White flush light switches. Standard fixing.	2	£1.00	BD5
Double pole 20A switch on standard plate with neon.	1	£1.00	BD531
Double pole 20A white mains switch that fit a standard pattress.	1	£1.00	BD189
20A double pole switch with neon. Surface mount.	1	£2.00	2P58
Double pole 20A mains brown surface mount switch.	2	£1.00	BD190
White shallow pattress for switches etc.	10	£1.00	BD338
White blanking plates for standard pattress.	5	£1.00	BD358
Mild steel boxes with knockouts 6" x 3".	2	£2.00	2P56
13A panel socket MK ref 735WHI.	1	£1.00	BD161
5A 3 pin rubber/nylon plug tops.	3	£1.00	BD465
25A rotary switch surface mounting, cover engraved high, medium, low and off.	1	£2.00	2P123
30A rotary switch surface mounting with pointer knob.	1	£2.00	2P122

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
MK splitter 45A switch 3 x 15A fuses.	1	£5.00	5P100
Switched spur in meta box.	1	£1.00	BD589
Inflex push switch for table lamp etc.	3	£1.00	BD562
Pull switch celling mount with cord and tassle. white.	1	£1.00	BD528
13A swiched socket and spur on double plate. Brown.	1	£1.00	BD249
13A fused spur and socket on double plate. White.	1	£1.00	BD302
13A ring main spur boxes.	5	£1.00	BD2
Cable clips 2.5mm flat with hardened nails.	50	£1.00	BD577
Brown ceiling roses. (old style)	5	£1.00	BD292
5A lighting switches brown	6	£1.00	BD452
ES lampholders, bakelite through panel fixing.	4	£1.00	BD476
5A 3 pin switched surface mount sockets.	3	£1.00	BD194
5A 3 pin flush sockets. Brown.	6	£1.00	BD193
BC lampholder adaptors, white.	6	£1.00	BD191
Shaver adaptors for 13A sockets.	2	£1.00	BD617
13A adaptors to take 2 13A plugs.	3	£2.00	2P187
13A plugs with sleeved pins. white.	3	£2.00	2P186
13A adaptor, takes 3 13A plugs.	2	£3.00	3P37
Surface mount oblong 5A switches. brown.	5	£1.00	BD4
EMERGENCY LIGHTING (3 HRS)			
3 watt 6" flourescent. cased.	1	£30.00	30P3
8 watt 12" flourescent. cased.	1	£40.00	40P2
2.5 watt Xenon bulb. cased.	1	£20.00	20P10
FANS AND BLOWERS			
4 1/2" x 41/2" Muffin type fan 115v (ex-computer).	1	£3.00	3P36
Snail type. 6"x4" 240v 270mA. silent and powerful.	1	£5.00	5P166
41/2" x 41/2" Muffin type fan 230v (ex-computer).	1	£5.00	5P40
3 3/4" square Papst fan 110v.	1	£5.00	5P53
3 1/4" square 12v brushless fan. 120mA PAPST.	1	£12.00	12P12
85mm square 240v fans.	1	£9.00	9P10
Brushless Muffin fan 18-28v DC.	1	£5.00	5P60
5" Woods extractor fan (ex-equipment) 230v.	1	£5.00	5P41
5" alumimium fan blades to fit 1/4" shaft.	2	£1.00	BD86
Mains motor to suit above blades.	1	£1.00	BD88
18" long tangential blower with motor at 1 end. 230v.	1	£10.00	10P89
14" blower with motor in the middle. 230v.	1	£10.00	10P90
12v DC fan made by Papst 3 1/2" square.	1	£10.00	10P33
Mains operated centrifugal blower 5" x 1 1/2" output.	1	£5.00	5P99
4 1/2" x 4 1/2" Axial fan. Papst 230v.	1	£6.00	6P6
Plastic fan blades approx 3" across.	2	£1.00	BD638
4 1/2" x 4 1/2" brushless fan 12v.	1	£8.00	8P26
6 1/2" powerful fan 240v 210 cu ft min	1	£10.00	10P67
FEET			
38mm square self adhesive feet.	8	£1.00	BD726

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
20mm square self adhesive feet.	8	£1.00	BD891
12.5mm square self adhesive feet.	12	£1.00	BD892
FERRITE POTS ETC			
1" diameter for chokes etc.	20	£1.00	BD363
Assorted ferrite shapes.	5	£1.00	BD99
Ferrite core 56mm x 18mm E shaped.	4	£1.00	BD156
FLUORESCENT LIGHTING			
12" 8 watt fluorescent tube.	1	£1.00	BD314
Phllips W tube 30 watt.	1	£1.00	BD336
Starter for 40-80 watt tube.	4	£1.00	BD92
Starter holders. Standard type.	4	£1.00	BD407
Terry clip for 1 1/2" tube.	5	£1.00	BD406
12v cased flourescent light with on/off switch. 8w.	1	£8.00	8P48
DISC DRIVES AND DISCS			
3 1/2" 720K drive by NEC.	1	£60.00	60P2
Case for 3" or 3 1/2" disc drive. ABS type.	1	£4.00	4P8
3" disc for Amstrad etc.	1	£3.00	3P24
3 1/2" disc.	2	£2.00	2P185
8" ex equipment disc drives.	1	£8.00	8P37
5 1/4" disc drives 360K brand new.	1	£35.00	35P5
5 1/4" ex equipment 360K drive .(condition unknown).	1	£18.00	18P5
5 1/4" discs unbranded but good quality.	10	£5.00	5P168
3 1/2" discs unbranded but good quality.	15	£10.00	10P88
Disc box holds 100 5 1/4" discs. Lockable.	1	£11.00	11P5
Disc box holds 40 3 1/2" discs or CDs. lockable.	1	£9.00	9P4
FUSES AND FUSEHOLDERS			
20mm quick blow 250mA.	12	£1.00	BD983
20mm quick blow 500mA	12	£1.00	BD984
20mm quick blow 1A.	12	£1.00	BD985
20mm quick blow 2A.	12	£1.00	BD986
20mm quick blow 4A.	12	£1.00	BD987
32mm quick blow 250mA.	12	£1.00	BD988
32mm quick blow 500mA.	12	£1.00	BD989
32mm quick blow 1A.	12	£1.00	BD990
32mm quick blow 2A.	12	£1.00	BD991
32mm quick blow 4A.	12	£1.00	BD992
1" plug top fuse 2A.	10	£1.00	BD993
1" plug top fuse 3A.	10	£1.00	BD994
1" plug top fuse 5A.	10	£1.00	BD995
1" plug top fuse 13A.	10	£1.00	BD996
20mm chassis mount fuseholders.	20	£1.00	BD543
Porcelain fuseholders and fuses.	4	£1.00	BD82
20mm chassis mount fuseholders.	10	£1.00	BD144
.5A 20mm fast blow fuses.	20	£1.00	BD542

PRIORITY ORDER FORM

TO BULL ELECTRICAL
250 PORTLAND ROAD
HOVE SUSSEX
BN3 5QT

USE THIS FORM FOR
ANY ORDER WITH CASH
CHEQUE OR CREDIT CARD

QUANTITY	DESCRIPTION	ORDER NO	COST
		POSTAGE	£2.50
		TOTAL	

FROM ______________________________

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CREDIT CARD NO ______________________________ EXP DATE __________

ULTRA SONIC WIRELESS ALARM SYSTEM

This system consists of a small, cased ultrasonic movement sensor with a range of 5 metres. This is plugged into a standard 13A socket. The alarm unit is similar in design and is plugged into a 13A socket where you want the alarm to sound. Any movement in the room with the sensor sounds the alarm, or, if required the sensor. Transmmision is via the mains supply so the units will work anywhere in the building. A basic system comes complete with one sensor and one alarm unit but it is possible to have up to five detector units working to the same alarm unit.

Price for the basic system £20.00 ref 20P34

Additional sensors are £11.00 ref 11P6

RADIO..CONTROLLED..CARS.

We have secured a large parcel of cars which make ideal Christmas prescents.

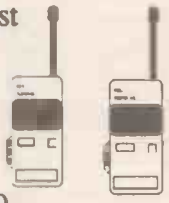
1. A single channel R/C buggy with forward and turn controls, off road tyres,suspension. Fully guaranteed.

£12.00.... ref 12P40.....

2. A Full function **FERRARI TESTAROSSA** A true 2 channel radio controlled car with forward, reverse, steering, 2 gears plus turbo boost and working headlights!.

£22.00....ref 22P6.....

A pair of very low cost walkie talkies with about 100' range Yours for



£8.00 ref 8P50

METAL DETECTOR

Fun lightweight device for buried treasure! 33" long Tune and fine tune controls. **£10.00** ref 10P101

VERY FAST NICAD CHARGER

This very smart plug in unit carries 4 AA cells and plugs into a 13A socket. **Charges 4 cells in 1.8 hrs!** Supplied with 4 AA nicads.

£16.00 ref 16P8

NICAD BATTERIES

AA SIZE 4 FOR £4.00 REF 4P44
D SIZE 4 FOR £9.00 REF 9P12
C SIZE 2 FOR £4.00 REF 4P73
PP3 9V 1 FOR £6.00 REF 6P35
CHARGER....£6.00 REF 6P36

BULL ELECTRICAL 0273-203500

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
Woods metal 15A thermal cutout.	5	£1.00	BD307
Fuse holder 1 1/4" surface mount. Bulgin.	10	£1.00	BD526
Panel mount fuseholder 20mm..	4	£1.00	BD618
1 1/4" fuse holder. Panel mount.	5	£1.00	BD752
GEARS			
Gearbox kit contains 18 gears, 4 axles and 12v motor.	1	£3.00	3P93
GOOSENECKS			
Chrome finshed 8" long with standard fittings.	1	£2.00	2P345
Chrome finished 12" long with standard fittings.	1	£3.00	3P116
Chrome finished 21" long standard fittings.	1	£4.00	4P76
Goose neck base plate. 3 hole fixing.	1	£2.00	2P346
HEATSHRINK SLEEVING			
1.6mm dia shrinking to .8mm. 1.2 metre length.	1	£1.00	BD997
2.4mm dia shrinking to 1.2mm. 1.2 metre length.	1	£1.00	BD998
3.2mm dia shrinking to 1.6mm 1.2 metre length.	1	£1.00	BD999
4.8mm dia shrinking to 2.4mm. 1.2 metre length.	1	£2.00	2P331
6.4mm dia shrinking to 3.2mm. 1.2 metre length.	1	£2.00	2P332
9.5mm dia shrinking to 4.7mm 1.2 metre length.	1	£2.00	2P333
12.7mm dia shrinking to 6.4mm 1.2 metre length.	1	£2.00	2P334
HEATSINKS			
TO220 bolt on heatsink 21 deg C/W.	5	£1.00	CD1
TO3 bolt on heatsink. 6.9 deg C/W.	2	£1.00	CD2
TO5 push on heatsink 50 deg C/W.	4	£1.00	CD3
14" long extruded heatsink.	1	£8.00	8P3
HEATING			
1.2kw min tangential blow heater 70X45mm element.	1	£6.00	6P54
600 watt coil heaters air or liquid. 4"x3" 10 year life.	1	£3.00	3P78
Temperature switches 13A. Contacts open at 120 deg C	3	£1.00	BD745
Time and temp module. Displays either in C or F. 1.5v	1	£9.00	9P5
Additional sensor for above unit on long lead.	1	£3.00	3P60
2.5kw tangential blow heater 195x45mm element.	1	£5.00	5P62
Triple interlocked rocker switch for heaters.	2	£1.00	BD270
3kw tangential blow heater 300x40mm element.	1	£8.00	8P24
4 gang rocker switch for 3kw heater.	1	£1.00	BD666
750 watt standard pencil element 220mm long.	2	£1.00	BD377
1000 watt standard pencil element 232mm long.	2	£1.00	BD376
Heating pad approx 8" x 5" 200 watt mains voltage.	1	£1.00	BD112
80 watt brass encased elements for fridges etc.	2	£1.00	BD8
Pull cord swich as fitted to radiant heaters.	1	£1.00	BD299
15m heating wire, waterproof. Ideal for pipes etc. Mains.	1	£5.00	5P109
2kw tangential heater. 190x65mm element.	1	£5.00	5P127
Quick cuppa 12v immersion heater. Cigar lighter plug.	1	£3.00	3P92
HEADPHONES AND INSERTS			

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
Stereo headphones 8 ohm 1/4" plug.	1	£2.00	2P254
600 ohm inserts. Useable as speaker or microphone.	6	£1.00	BD139
Stereo walkman type headphones.	1	£3.00	3P51
Inner ear stereo headphones.	1	£3.00	3P56
Stereo headphone lead (curly) 1m long with 1/4" plug.	2	£1.00	BD230
Ex GPO earpieces for intercoms etc. 55 ohm.	4	£1.00	BD484
Crystal earpieces for crystal radios etc.	2	£1.00	BD529
Dynamic fullsize stereo h/phones 20-20KHZ 32R imp.	1	£8.00	8P33
PROFESSIONAL LOUDSPEAKERS			
270mm bass/mid range 8R 400w 65-6khz.	1	£75.00	75P3
318mm dia bass/mid range 8R 600w	1	£130	130P1
390mm dia bass unit 8R 600w 35-6khz	1	£110	110P1
Inline headphone volume control with 5m lead.	1	£1.00	BD717
IC SOCKETS			
8 way IC socket.	10	£1.00	BD773
14 way IC socket.	7	£1.00	BD774
16 way ICsocket.	7	£1.00	BD775
18 way IC socket.	5	£1.00	BD776
20 way IC socket.	5	£1.00	BD777
24 way IC socket.	4	£1.00	BD778
28 way IC socket.	4	£1.00	BD779
40 way IC socket.	4	£1.00	BD780
INDICATORS AND BULBS			
12v lilliput bulbs.	5	£1.00	BD177
1.5v 300mA MES bulb.	8	£1.00	CD10
2.5v 200mA MES bulb.	8	£1.00	CD11
3.5v 300mA MES bulb.	8	£1.00	CD12
6.0v 60mA MES bulb.	8	£1.00	CD13
12.0v 200mA MES bulb.	8	£1.00	CD14
24v MES bulbs 80mA 2 watt.	10	£1.00	BD694
Amber indicators with neons 240v. Oblong.	3	£1.00	BD179
Amber neon idicators round 240v.	6	£1.00	BD180
LED holders 3mm	4	£1.00	CD33
LED holders 5mm.	4	£1.00	BD518
LED 5mm red.	15	£1.00	BD893
LED 5mm red. (1,000 pack).	1	£44.00	44P1
LED 5mm green.	12	£1.00	BD894
LED 5mm green. (1,000 pack).	1	£54.00	54P1
LED 5mm yellow.	10	£1.00	CD5
LED 5mm yellow. (1,000 pack).	1	£64.00	64P1
LED 3mm red.	15	£1.00	CD4
LED 3mm red. (1,000 pack).	1	£44.00	44P2
LED 3mm green.	10	£1.00	CD6
LED 3mm green. (1,000 pack).	1	£54.00	54P2

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
LED 3mm yellow.	10	£1.00	CD7
LED 3mm yellow (1,000 pack).	1	£64.00	64P2
FLASHING LED 5mm red 9-12v DC 3HZ.	4	£2.00	2P335
FLASHING LED 5mm green 9-12v DC 3HZ.	4	£2.00	2P336
FLASHING LED 8mm red 9-12v DC 3HZ.	2	£2.00	2P337
FLASHING LED 8mm green 9-12v DC 3HZ.	2	£2.00	2P338
High power INFRA-RED source 12mW 1.7v 5mm.	3	£1.00	CD8
High power INFRA-RED sensor 5mm.	1	£1.00	CD9
3 lamps on a face plate of a metal box. 140x75x45mm.	1	£3.00	3P16
MES bulb holders. Batten type	4	£1.00	BD895
Minature bulb holders for single contact bulbs.	4	£1.00	BD896
3 colour LED.	2	£1.00	BD611
INFRA RED SENSORS ETC			
IR 5 metre beam 22-26v DC 250mA switching.	1	£25.00	25P15
INDUCTIVE PROXIMITY SWITCHES			
98mm barrel type 10-36v 10mm range with LED.	1	£12.00	12P19
INSULATORS AND CABLE GRIPS			
PVC grommets for 3/8" cable.	100	£1.00	BD181
Cable grips for up to 3/8" cable.	10	£1.00	BD431
Cable grips for 3/8" cable.	20	£1.00	BD432
KETTLE ELEMENTS			
Old type with 2 round pins and empty ejector.	1	£1.00	BD395
KEY BOARDS			
84 key keyboards uncased with control PCB.	1	£3.00	3P89
HI FI SPEAKER UNITS			
131 mm dia full range 8R 60W 63-20khz.	1	£12.00	12P33
242mm dia woofer 8R 60w 45-5.5khz.	1	£40.00	40P9
154mm dia dome mid range 8R 100w 300-10khz.	1	£25.00	25P22
106mm dia titanium tweeter 8r 100w 2-22khz.	1	£14.00	14P5
3 way crossover for above 3 units (700 & 5khz 100watt)	1	£12.00	12P34
Set of 2x40P9, 2x25P22, 2x14P5, & 2x12P34	1	£150	150P1
LOUDSPEAKERS AND GRILLS			
Set of 3 speaker grills 140mm, 70mm and28mm. Black.	1	£1.00	BD737
Pair of white plastic speaker grills 6" diameter.	1	£1.00	BD904
Flush mounting speaker grill for 8" speaker.	1	£2.00	2P281
Tweeter on chrome mounting plate.	1	£3.00	3P68
7" x 5" 8 ohm speaker with built in tweeter. 5 watt.	2	£3.00	3P69
8" round 8 ohm 60 watt full range speaker. Ali coil.	1	£12.00	12P14
5" diameter full range speaker 30 watt+HF cone 8R.	1	£8.00	8P49
3" diameter full range speaker 20 watt+HF cone. 8R.	1	£5.00	5P183
Pair of 70w per channel 3 way car speakers.	1	£28.00	28P1
Pair of 100w per channel 3 way car speakers.	1	£30.00	30P7
6" x 9" 8 ohm 15 watt speaker.	1	£3.00	3P76

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
6" x 4" 16 ohm 5 watt rating.	2	£1.00	BD243
6 1/2" 4 ohm speaker 10 watt rating.	1	£1.00	BD137
2 1/4" 60 ohm speaker.	2	£1.00	BD453
2 1/4" 8 ohm speaker.	2	£1.00	BD454
6" x 4" 15 ohm speaker 10 watt rating.	1	£2.00	2P167
3" 4 ohm tweeter.	1	£1.00	BD433
40 watt 3 way crossover.	1	£1.00	BD23
25 watt cross over for woofer and tweeter.	2	£1.00	BD22
Extension speaker cabinet with back and front (5").	1	£1.00	BD118
4 1/2" round mid range speker 4 ohm 10 watt.	1	£2.00	2P195
110 db horn/speaker.	1	£4.00	4P60
Personal mini speaker. Plugs straight into cassette.	1	£4.00	4P50
TV speakers 3 watt 8 ohm 70 x 55m.	2	£3.00	3P108
TV speakers 5 watt 4 ohm 55 x 125mm.	2	£3.00	3P109
Loud speaker wall mounting brackets. (pair).	1	£5.00	5P152
5"x 3" 16 ohm speaker 5 watt.	1	£1.00	BD725
Mylar waterproof cone speaker 3 1/4" sq 35R 2 watt.	1	£1.00	BD903
KNOBS ETC			
Pointer knob for flatted spindle.	4	£1.00	BD295
1" collet knobs, black.	4	£1.00	BD525
Solid aluminium 1 1/8" dia. Grub screw fixing on 1/4" sft.	2	£1.00	BD720
LASERS			
Philips 2mw Helium Neon laser. 260x37mm.	1	£40.00	40P10
Mains ABS cased power supply kit for laser.	1	£20.00	20P33
12v universal supply kit (uncased).	1	£25.00	25P13
Plastic case with PSU kit big enough to hold tube as well.	1	£22.00	22P3
Boxed and built laser.	1	£75.00	75P4
MAGNETS			
Flat magnet 1" x 1/2" x 1/8".	6	£1.00	BD897
Very powerful magnet. 25x13x6mm u shape.	2	£1.00	BD642
MEMORY JOGGER			
Clockwork ringer, setable 0-60 mins then rings bell.	1	£1.00	BD77
MICROPHONES AND STANDS			
600 ohm microphone/speaker inserts. 35mm dia x10mm.	4	£1.00	BD139
Dynamic mic inserts. Mylar cone 200 ohm imp.	2	£1.00	BD762
Unidirectional electret condenser mic. top quality 600r.	1	£15.00	15P28
Dynamic handheld mic with stand. Cassette type.	1	£1.00	BD305
Hand held dynamic mic with on/off switch.	1	£1.00	BD711
Microphone stand. Chrome plated magnetic base.	1	£5.00	5P154
FET electret capacitor mic capsule 1.5v 500 ohm.	1	£1.00	BD646
Crystal microphone 25mm dia high gain.	2	£1.00	BD729
MICROSWITCHES			
V3 size 15A 250v c/o button operated. Push on tags.	3	£1.00	BD341

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
V3 size 10A 250v c/o button operated. Push on tags.	4	£1.00	BD340
V3 size 10A 250 c/o lever operated. Push on tags.	3	£1.00	BD342
Extra thin 1 1/4" x 7/8" x 1/4" 10A contacts.	4	£1.00	BD403
Large micro switch with 2 1/2" lever.	1	£1.00	BD591
Subminature microswitches. Assorted.	5	£1.00	BD313
MISCELLANEOUS			
Musical sounder for cards.	1	£1.00	BD328
Cabinet locking mechanism with 2 keys.	1	£1.00	BD55
Personal stereo innards. Tape mech and head.	1	£1.00	BD763
Mullard thyristor trigger module.	1	£1.00	BD63
Magnetic brake assembly. Instant stop.	1	£1.00	BD66
Clear plastic lense 1 1/4" diameter. (phone type).	25	£1.00	BD124
Safety cover for twin 13A outlet.	6	£1.00	BD149
Safety covers for single 13A socket.	5	£1.00	BD150
Hoseclips, coilspring type. 3 different sizes.	20	£1.00	BD222
Motor start/stop switch, skeleton type with trip.	2	£1.00	BD254
CB coverter converts car radio into AM CB radio.	1	£4.00	4P48
Push on 1/4" tags with leads.	50	£1.00	BD259
Round pin kettle plug with moulded lead.	1	£1.00	BD316
Through panel cable grips. Adjustable size.	10	£1.00	BD431
Personal stereos with headphones. (customer returns).	1	£3.00	3P83
Therocouple for measuring internal heat.	1	£2.00	2P137
Chrome disc 2 1/2" diameter, curved with centre hole.	10	£1.00	BD521
Hoover programmer 3224.	1	£1.00	BD479
Clear lacquer in an aerosol can.	1	£1.00	BD660
Inspection lamp. Mains.	1	£4.00	4P31
2764 eprom BBC compatable.	1	£3.00	3P48
Ceramic insulating beads. Fit 20 swg wire.	100	£1.00	BD690
Insulating tubing made of Paxolin 6" x 1/4".	6	£1.00	BD691
MONITORS			
9" monitor, black and white. Uncased.	1	£20.00	20P26
12" amber high res monitor requires 12v 1.5A, sep syncs. TTL input.	1	£22.00	22P2
Metal case for 9" monitor.	1	£12.00	12P3
Kit to convert comp video into separate H sync, Vsync.	1	£8.00	8P39
AC MOTORS			
1 1/2" stack double ended very powerful motor.	1	£2.00	2P55
3" square shaded pole motor 24v AC.	1	£2.00	2P266
240v AC 25 watt 3000 rpm motor 6"x4"x3".	1	£4.00	4P54
3" square shaded pole motor. 240v AC.	1	£2.00	2P265
Mains shaded pole motor 7/8" stack.	1	£1.00	BD85
Papst motor open type cap start.	1	£2.00	2P71
EMI tape motor, 2 speed reversible. 93mm dia 6mm shaft	1	£2.00	2P70
Precision motor for disc or tape.	1	£2.00	2P12

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
MOTORS WITH GEARBOXES			
200 rpm 2w mains motor. 46mm dia x 18mm worm drive.	2	£1.00	BD175
4 rpm mains motor 2w (suitable mirror ball etc).	1	£2.00	2P17
1 rev per hour 2 watt extra small mains motor. With cog.	2	£1.00	BD500
500 watt mains motor and 3 speed control.	1	£5.00	5P193
5 rpm 60 watt motor with gearbox. Powerful. 125x60x45.	1	£5.00	5P54
16 rpm mains 2 watt motor with gearbox. 50mm dia x30.	1	£1.00	BD91
200 rpm mains 60 watt motor with gearbox. 60x80x90mm	1	£2.00	2P38
6 rpm 60 watt mains motor and gearbox.	1	£5.00	5P74
5 rpm Crouzet type motor 240v.	1	£4.00	4P63
Micro wave turntable motors.Built in weight sensor. 240v.	1	£5.00	5P169
60 rpm 60 watt mains motor.	1	£5.00	5P173
MOTORS DC			
1/6th HP 12v motor. 75x80mm spindle 36x8mm.	1	£8.00	8P14
1/10th HP 12v motor 1/4" spindle. 75x65mm.	1	£4.00	4P22
1/8th HP 12v motor 75x75mm spindle 25x8mm.	1	£6.00	6P1
1/3rd HP 12v motor (Sinclair C5). 180x100mm 3300 rpm	1	£20.00	20P22
C5 motor complete with 4 : 1 reduction box.	1	£40.00	40P8
Electronic speed controller kit for C5 motor or equiv.	1	£17.00	17P3
Model motor 1.5v-9v (speed is voltage dependent).	1	£1.00	BD540
3v cassette motor. Very low current.	1	£1.00	BD681
MOTORS STEPPER			
Stepper motor 7.5 deg step 10-14v 27 ohm 70x40mm	1	£5.00	5P81
MOTORS 1-12V			
Model aircraft motors. Spin to start. 12x20mm.	10	£1.00	BD134
Low current motor for working with solar cells.	1	£1.00	BD681
NOISE FILTERS			
Chassis mounting noise filter. 45x30x16mm.	1	£2.00	2P225
IEC filtered chassis socket.	1	£3.00	3P50
OPTO			
Sub-min light dependent resistor.	2	£1.00	BD19
Camera flash units. Contains Xenon tube etc 3v op.	1	£2.00	2P38
Slotted opto photo transistor.	2	£1.00	BD14
Slotted opto interupted switch	1	£1.00	BD545
Light dependent resistor ORP12.	1	£1.00	BD619
PANEL METERS			
270 deg movement panel meter. 3 1/2" diameter.	1	£3.00	3P87
100uA panel meter 1 1/4" x 1/2" with scale illumination.	1	£1.00	BD700
0-40v panel meter 80 x 70mm.	1	£6.00	6P24
0-50v panel meter 80 x 70mm.	1	£6.00	6P25
0-80v panel meter 80 x 70mm.	1	£6.00	6P26
0-160v panel meter 80 x 70mm.	1	£6.00	6P27
0-200v panel meter 80 x 70mm.	1	£6.00	6P28
0-10A panel meter 80 x 70mm.	1	£6.00	6P29

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
0-5A panel meter 80 x 70mm.	1	£6.00	6P30
45-55 HZ frequency Indicator.	1	£15.00	15P19
55-65 vibrating reed frequency indicator.	1	£15.00	15P18
200uA panel meter 4 3/4" x 2 1/2".	1	£10.00	10P24
1mA panel meter 6" x 3 1/2".	1	£10.00	10P41
0-100uA panel meter. Scale separate.	1	£4.00	4P32
100-0-100uA panel meter. Scale separate.	1	£4.00	4P67
1mA panel meter. Scale separate.	1	£4.00	4P68
VU meter 1 1/2" square.	2	£1.00	BD366
High quality 50uA panel meter. Moveable scales!	1	£3.00	3P81
PANEL METERS 60 X 45MM			
0-50A 2K3 internal resistance.	1	£6.00	6P39
0-100A 1K2 Internal resistance.	1	£6.00	6P40
0-500A 360R internal resistance.	1	£6.00	6P41
0-1mA 100R internal resistance.	1	£6.00	6P42
0-10mA 60R Internal resistance.	1	£6.00	6P43
0-100mA 0.6R internal resistance.	1	£6.00	6P44
0-1A	1	£6.00	6P45
0-25v DC 25K internal resistance.	1	£6.00	6P46
0-30v DC 30K internal resistance	1	£6.00	6P47
PCB PRODUCTION EQUIPMENT			
PHOTO ETCH PCB (UV sensitive)			
100 x 160mm single sided.	1	£3.00	3P133
203 x 144mm single sided.	1	£4.00	4P78
100x 160mm double sided.	1	£4.00	4P79
203 x 144mm double sided.	1	£5.00	5P189
Ferric chloride etchant (makes 1 litre).	1	£3.00	3P134
Developer crystals (makes 1 litre).	1	£2.00	2P348
Polypropylene trays. 325 x 225 x 50mm.	1	£2.00	2P349
Brass wire brush.	1	£1.00	BD837
Transfer starter pack 12 different sheets.	1	£10.00	10P100
Light box kit for PCB layout etc.	1	£16.00	16P7
PLUGS AND SOCKETS			
3.5mm mono jack sockets. Chassis or PCB mount.	8	£1.00	BD697
Chassis mount BNC socket. (4 hole fixing).	2	£1.00	BD851
Bulgin 3 pin plug and socket 1 1/2" diameter.	2	£1.00	BD715
Earphone distribution panel (3 x 3.5mm sockets+led).	1	£1.00	BD727
POTS-VARIABLE RESISTORS			
Standard size 500K with DP switch 1/4" shaft.	4	£1.00	BD245
Mini volume controls. 1/4" shaft. Assorted valus.	10	£1.00	BD109
Slider pots. Various values.	10	£1.00	BD110
10 turn 100 ohm 3w 1/4" shaft.	1	£1.00	BD291
100k multiturn knobs with Integeral knob.	5	£1.00	BD143
Wirewound pots (4 different values with knobs)	4	£1.00	BD71

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
50ohm 3w wirewound.	4	£1.00	BD73
8 ohm 25 w 1/4" shaft.	2	£1.00	BD69
1000 ohm 25w 1/4" shaft.	2	£1.00	BD70
Minature pot 1/4" shaft 50K.	4	£1.00	BD781
Minature pot 1/4" shaft 200K.	4	£1.00	BD782
Minature pot 1/4" shaft 3M.	4	£1.00	BD783
Stereo gang pot 1/4" shaft 50K.	3	£1.00	BD784
Stereo gang pot 1/4" shaft 200K.	3	£1.00	BD785
Quad pot 1/4" shaft 50K.	4	£1.00	BD447
POWER SUPPLIES			
AZTEC SWITCHED MODE			
+5v at 3.75A, +12v at 1.5A and -12v at 0.4A			
PCB size is 80mm x 165mm. Brand new.	1	£12.00	12P39
Case for above PSU with IEC filtered inlet &switch.	1	£5.00	5P190
Customer returned switched mode PSU's for repair.	1	£2.00	2P292
Switched mode PSUs ex-equipment +5, +12 & -12v.	1	£8.00	8P36
In car PSU 12v in 3,4.5,6,7.5,9,12v 800mA out, Cig plug	1	£5.00	5P167
24v with sep channels for stereo use. Max 20 watt.	1	£2.00	2P4
Switched mode PSU +12v, -12v, +5v, -5v. 100v input.	1	£9.00	9P2
4.5 100mA PSU in case with lead.	1	£1.00	BD104
6v 200mA PSU in case with lead.	1	£1.00	BD103
6v 700mA PSU in case.	1	£1.00	BD899
8-12v variable PSU.	1	£2.00	2P3
12v 200mA PSU in case for 13A socket.	1	£2.00	2P114
9v 500mA PSU in case for 13A socket.	1	£2.00	2P134
9v 350mA AC PSU in case for 13A socket.	1	£1.00	BD566
24v PSU chassis with all components.	1	£2.00	2P150
9v AC 100mA in case with lead.	1	£1.00	BD733
9v AC 100mA in case for 13A socket.	1	£1.00	BD900
15v 500ma DC power supply.	1	£2.00	2P289
9v AC 300mA in case for shaver socket.	1	£1.00	BD901
PRESSURE SWITCHES			
Brass pressure switch set for 8psi but adjustable to 15psi.	1	£2.00	2P92
Switch with 3 different operating pressures. Can be mouth operated. 85x30mm.	1	£1.00	BD67
PROJECTS AND KITS			
Electronic spaceship kit responds to sound complete with wheels and body.	1	£10.00	10P81
Surface mount kit. Makes mini micro amp.	1	£7.00	7P15
Surface mount solder.	1	£12.00	12P18
FM bug kit with PCB embedded coil and sub min mic.	1	£5.00	5P158
Stabilized PSU kit 3-30v 2A . Excluding case.	1	£20.00	20P25
Solar powered helicopter kit.	1	£9.00	9P6
Solar powered aeroplane kit.	1	£9.00	9P7

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
Solar powered gramophone kit.	1	£9.00	9P8
12-220v inverter kit 15 watt.	1	£12.00	12P17
12-220v inverter kit 100 watt.	1	£20.00	20P27
Microwave tester 9v.	1	£6.00	6P19
Mini radio module. Superhet with aerial 2" square. 9v.	1	£1.00	BD716
Airband receiver with 250 page aircraft guide.	1	£14.00	14P1
Claudivs speech box (64 phrases or words)	1	£30.00	30P10
Telephone autodialler (state no reqd)BT approved.	1	£12.00	12P23
25 watt stereo amplifier IC plus diagram. STK043.	1	£4.00	4P69
Geiger counter kit 9v operation.	1	£39.00	39P1
Educational kits, Ohms law and chemical balance kits.	2	£1.00	BD902
Powerful ionizer mains operated kit with case.	1	£18.00	18P2
3 channel sound to light kit 750w /channel with case.	1	£15.00	15P6
Drill speed controller kit. Max 750 watt.	1	£4.00	4P40
PUMPS			
Drill operated pump. Fits any drill.	1	£3.00	3P140
Washing machine pump. mains.	1	£5.00	5P18
350 psi oil pump. Heavy duty.	1	£10.00	10P2
RECTIFIERS AND DIODES			
5A stud rectifiers 250v.	5	£1.00	BD78
1A 1000v diodes.	10	£1.00	BD471
Minature glass diode for low voltage use. (IN4148).	15	£1.00	BD576
Bridge rectifier 600v 3A.	1	£1.00	BD546
Rectifier 35A 60v.	1	£2.00	2P179
RELAYS			
PCB mount relay 5v coil 2 C/O 2A contacts. 26x18x17.	1	£1.00	BD665
Mains operated relay. Single 8A C/O .45x30x32mm	1	£1.00	BD486
Mains operated relay. 4 8A C/O contacts.60x50x30mm	1	£2.00	2P144
48v low profile relay. Twin C/O contacts.27x22x10mm	2	£1.00	BD225
24v relay in transistor package 2 x C/O contacts.	1	£1.00	BD748
3v reed relay kit. 4 coils and 4 reeds.	1	£1.00	BD145
6v reed switch relays. Normally open contacts.	2	£1.00	BD48
Ultra small 12v relay. 3A contacts. 10x17mm.	1	£1.00	BD205
12v water resistant relay.	1	£1.00	BD154
12v sealed relay 2 C/O contacts. 20x10x22m.	1	£1.00	BD311
12v minature relay 700 ohm coil. 2 C/O contacts.	1	£1.00	BD51
12v minature relay. 4 C/O contacts. 160ohm.	1	£1.00	BD52
12v DC or 24v AC plug in relay. 3 C/O contacts.	2	£1.00	BD50
24v minature relay . 4 C/O 5A contacts. 28x20x32mm.	2	£1.00	BD580
24v minature relay. 2 C/O 5A contacts 28x25x10mm.	2	£1.00	BD850
1.5v relay 16 ohm 2 C/O contacts. 23x18x30mm.	1	£1.00	BD512
2v reed relay. Normally closed contacts.30x12x9mm	2	£1.00	BD549
3.5v mini PCB mount relay. 2 C/O 3A contacts.	1	£1.00	BD548
Assorted motor start relays.	4	£1.00	BD535

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
50v AC ex-equip relay. Plug in. 3 C/O 8A contacts.	4	£1.00	BD578
50v latching relay. 2 C/O 5A contacts.	1	£1.00	BD501
Mains relay 4 pole C/O 8A. Complete with base.	1	£2.00	2P241
RESISTORS 1/4 WATT 2% METAL FILM			
10 x 50 values (500 resistors in all).	1	£5.00	5P170
RESISTORS 2.5 WATT WIRE WOUND			
2.5 watt .068 ohm	15	£1.00	BD830
2.5 watt .075 ohm	15	£1.00	BD831
2.5 watt .33 ohm	15	£1.00	BD832
2.5 watt .44 ohm	15	£1.00	BD833
2.5 watt 1 ohm	15	£1.00	BD834
2.5 watt 1.8 ohm	15	£1.00	BD835
2.5 watt 2 ohm	15	£1.00	BD836
2.5 watt 6.9 ohm	15	£1.00	BD838
2.5 watt 16 ohm	15	£1.00	BD839
2.5 watt 51 ohm	15	£1.00	BD840
2.5 watt 150 ohm	15	£1.00	BD842
2.5 watt 620 ohm	15	£1.00	BD844
2.5 watt 820 ohm	15	£1.00	BD845
2.5 watt 4K7 ohm	15	£1.00	BD847
2.5 watt 6K8 ohm	15	£1.00	BD848
2.5 watt 8K2 ohm	15	£1.00	BD849
RESISTORS 5 WATT WIRE WOUND			
5 watt 1 ohm	13	£1.00	BD883
5 watt 6.8 ohm	13	£1.00	BD884
RESISTORS 6 WATT WIRE WOUND			
6 watt .09 ohm.	12	£1.00	BD786
6 watt .15 ohm	12	£1.00	BD787
6 watt .24 ohm	12	£1.00	BD788
6 watt .27 ohm	12	£1.00	BD789
6 watt .33 ohm	12	£1.00	BD790
6 watt .5 ohm	12	£1.00	BD791
6 watt .68 ohm	12	£1.00	BD792
6 watt 1 ohm	12	£1.00	BD793
6 watt 1.2 ohm	12	£1.00	BD794
6 watt 1.8 ohm	12	£1.00	BD795
6 watt 2 ohm	12	£1.00	BD796
6 watt 2.7 ohm	12	£1.00	BD797
6 watt 3.3 ohm	12	£1.00	BD798
6 watt 3.9 ohm	12	£1.00	BD799
6 watt 12 ohm	12	£1.00	BD800
6 watt 18 ohm	12	£1.00	BD801
6 watt 75 ohm	12	£1.00	BD803
6 watt 100 ohm	12	£1.00	BD804

PRIORITY ORDER FORM

TO BULL ELECTRICAL
250 PORTLAND ROAD
HOVE SUSSEX
BN3 5QT

USE THIS FORM FOR
ANY ORDER WITH CASH
CHEQUE OR CREDIT CARD

QUANTITY	DESCRIPTION	ORDER NO	COST
		POSTAGE	£2.50
		TOTAL	

FROM _____

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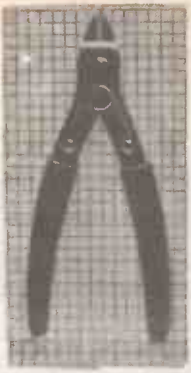
CREDIT CARD NO _____ EXP DATE _____

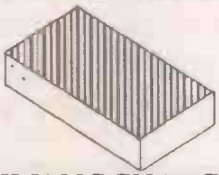
PERSONAL SAFETY ALARM WITH BUILT IN TORCH.
A useful device for home, office or travel! Requires 3 AA batteries.
Price is £3.00 ref 3P135



5" SIDE CUTTERS
Top quality cutters capable of cutting wires as fine as a hair. Pressed steel construction, hardened and tempered with sprung jaws.
Price is £2.00 a pair. ref 2P350

HELPING HANDS
A useful device for any workshop. complete with 2 'hands' and a magnifier. **£4.00 ref 4P80**

0.5KG RESIN CORED 22SWG SOLDER
£4.00 A REEL ref 4P72



WEIR SMM300S SWITCHED MODE POWER SUPPLY.
+5 @ 40A, +12 to +24v (adj) 6A
+12 to +15v(adj) 12A
+5 to15v(adj)3A. £30.00 ref 30P14

12 VOLT SOLDERING IRON COMPLETE WITH CIGAR LIGHTER PLUG AND LEAD.
15 WATT. £3.00 REF 3P136

BULL ELECTRICAL 0273-203500

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
6 watt 400 ohm	12	£1.00	BD810
6 watt 560 ohm	12	£1.00	BD811
6 watt 1K ohm	12	£1.00	BD812
6 watt 1K15 ohm	12	£1.00	BD813
6 watt 1K5 ohm	12	£1.00	BD814
6 watt 3K9 ohm	12	£1.00	BD815
6 watt 15K ohm	12	£1.00	BD816
6 watt 19K ohm	12	£1.00	BD817
6 watt 20K ohm	12	£1.00	BD818
RESISTORS WIRE WOUND 7 WATT			
7 watt 6.8 ohm	10	£1.00	BD880
7 watt 8 ohm	10	£1.00	BD881
7 watt 12 ohm	10	£1.00	BD882
RESISTORS WIRE WOUND 9 WATT			
9 watt 12 ohm	8	£1.00	BD819
9 watt 820 ohm	8	£1.00	BD821
9 watt 1K ohm	8	£1.00	BD822
9 watt 68k ohm	8	£1.00	BD823
RESISTORS WIRE WOUND 11 WATT			
11 watt 6.0 ohm	6	£1.00	BD877
11 watt 6.8 ohm	6	£1.00	BD876
11 watt 11 ohm	6	£1.00	BD878
RESISTORS WIRE WOUND 12 WATT			
12 watt 2.2 ohm	5	£1.00	BD824
12 watt 10 ohm	5	£1.00	BD825
12 watt 12 ohm	5	£1.00	BD826
RIBBON CABLE			
10 way 100' reel grey 7/.127mm	1	£7.00	7P24
16 way 100' reel	1	£12.00	12P32
20 way 100' reel	1	£14.00	14P4
26 way 100' reel	1	£18.00	18P8
34 way 100' reel	1	£24.00	24P6
40 way 100' reel	1	£28.00	28P2
SEMI CONDUCTORS			
LM317T Variable voltage reg 1.5A.	2	£1.00	BD905
Bargain pack of 20 different ICs.	1	£1.00	BD906
TIP3055 power transistor.	1	£1.00	BD655
100 watt mosfet pair 2SJ99 and 2SK343.	1	£4.00	4P51
Power mosfet 2SJ77.	1	£2.00	2P285
J111 JFET.	10	£1.00	BD864
Large power transistors. (unknown spec).	4	£1.00	BD210
3A SCR 50v stud mounting.	4	£1.00	BD575
SERVICE AIDS			

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
Switch cleaner 226g aerosol with applicator.	1	£2.00	2P321
Aero clene precision cleaner. Aerosol.	1	£2.00	2P322
Circuit freezer for fault finding. 226g aerosol.	1	£2.00	2P323
Foam cleanser (powerful). 370g aerosol.	1	£2.00	2P324
Silicone grease for waterproofing. 226g aerosol.	1	£2.00	2P325
Anti static spray mist. 150g aerosol	1	£2.00	2P326
Plastic seal. 145g aerosol.	1	£2.00	2P327
Aero duster. 200g aerosol.	1	£2.00	2P328
Quick fix mains connector.	1	£7.00	7P18
Stylus cleaning brush.	2	£1.00	BD730
Carbon fibre record cleaning brush 1,000,000 fibres.	1	£1.00	BD707
500 ml of precision gear oil with applicator tube.	1	£2.00	2P269
Disc drive head cleaner for 51/4" double sided.	1	£2.00	2P250
Soldering iron stand complete with sponge.	1	£3.00	3P66
Etch resist pen for making PCBs.	1	£1.00	BD699
30 watt mains soldering iron. Wooden handle.	1	£3.00	3P65
Antex 15 watt iron with 1mm bit. 250v.	1	£10.00	10P86
1/2kg solder 60/40 multicore resin solder 18swg.	1	£6.00	6P9
Instrument case with handle 5"x4"x2".	1	£1.00	BD742
Portasol gas soldering iron (uses lighter gas) 10-60w.	1	£18.00	18P4
Loctite metal adhesive.	1	£2.00	2P215
10kv extension for Multi tester.	1	£2.00	2P211
Mini pocket screw driver.	4	£1.00	BD436
1x4.2mm drill bit, 3 allen keys and 1 5mm tap cutter.	1	£1.00	BD863
SOLAR CELLS			
Solar battery charger. Takes 4 AA cells.	1	£6.00	6P3
700mA .45v solar cell. 95x65x7.5mm.	1	£3.00	3P42
400mA .45v solar cell. 75x45x7.5mm.	1	£2.00	2P199
100mA .45 solar cell. 45x26x7.5mm.	1	£1.00	BD631
SOLENOIDS			
Mains solenoid, spring loaded 1 1/2" square 1/4" travel.	1	£1.00	BD701
Mains solenoid. 38x25x32mm 25mm travel.	1	£1.00	BD300
115v solenoid. 50x35x38mm 20mm travel	1	£1.00	BD199
Mains solenoid (push or pull).35x25x32mm 10mm trave	1	£1.00	BD387
Flat solenoids.	2	£1.00	BD59
12v solenoid with plunger. 30x12x12mm 20mm travel.	1	£1.00	BD232
70v DC solenoid 2 1/2" x 1". Powerful.	1	£2.00	2P271
12v DC solenoid 1 3/4" square. Powerful.	1	£2.00	2P272
SPECIAL LIGHTING EFFECTS			
Motor driven switch 6 or more 10A c/o contacts.	1	£2.00	2P19
Sound to light kit. 750 watts per channel(3). Cased.	1	£20.00	20P35
Mains motor driver flasher 1000 watt.	1	£2.00	2P25
Strobe light, cased, 240v AC adjustable speed.	1	£25.00	25P23
STRIP BOARD			

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
5"x 4" .1 spacing copper clad strip board.	1	£1.00	BD736
17" x 4" .1 spacing copper clad strip board.	1	£4.00	4P62
STRIPPERS			
Component board full of diodes etc.	1	£1.00	BD120
Component board full of ICs transistors etc.	1	£2.00	2P282
Magnetic read write unit.	1	£1.00	BD381
Ex GPO boards containing many assorted components.	4	£1.00	BD620
SUPPRESSORS			
Mains filter (inductance and capacitance) with leads 13A.	1	£1.00	BD248
Auto noise eliminator inline for car use.	2	£1.00	BD751
Noise suppressor 2A inline mains. Chassis mount.	1	£1.00	BD570
Noise suppressor 3A 1" x 3/8". Chassis mount.	1	£1.00	BD698
SURVEILLANCE PRODUCTS			
FM bug built inside a 13A mains adapter. The adapter still functions but transmits even the slightest wisper.	1	£26.00	26P2
FM bug kit with embedded coil.	1	£5.00	5P158
Built and tested superior minature FM bug.	1	£14.00	14P3
Built and tested phone bug fits inside phone and is powered by the phone.	1	£20.00	20P28
As above but built into a secondary BT socket.	1	£23.00	23P10
As above but built into a master socket.	1	£24.00	24P5
Handheld built and tested bug detector.	1	£50.00	50P4
Airband receiver.	1	£25.00	25P17
FM bug built into a pen	1	£75.00	75P1
FM bug built into a calculator.	1	£75.00	75P2
SWITCHES ROTARY			
4 pole 3 way.	3	£1.00	BD870
3 pole 4 way.	3	£1.00	BD871
2 pole 6 way.	3	£1.00	BD872
1 pole 12 way.	3	£1.00	BD873
Rotary mains on/off switch.	2	£1.00	BD456
12 pole 2 way.	2	£1.00	BD874
Minature edgewise 4 pole 1 way with knob.	1	£1.00	BD496
Ceramic wave change switch 12 pole 3 way. 1/4" shaft.	1	£1.00	BD303
SWITCHES PUSH			
Normally on heavy duty metal switches.	4	£1.00	BD176
Oblong push switches 5A 220v AC.	2	£1.00	BD263
Key board style push switch with knob.	8	£1.00	BD201
Sub minature push switch DPDT.	1	£1.00	BD650
Panel mount push switch. 5A 250v.	4	£1.00	BD670
12 banks of switches (100 switches).	1	£1.00	BD481
Push mains switches.	4	£1.00	BD494
Pushon push off mains table lamp switch.	4	£1.00	BD121

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
Heavy duty illuminated switch 2 pole C/O at 16A.	1	£1.00	BD722
SWITCHES SLIDE			
Minature slide switch with chrome dolly. DPDT.	4	£1.00	BD215
Sub minature slide switch 2 pole c/o.	5	£1.00	BD553
Slide switch single pole C/O chassis mount.	5	£1.00	BD756
Mini slide switch DPDT 5A.	5	£1.00	BD869
SWITCHES TOGGLE			
2 pole C/O. Toggle springs back to c/off position. 15x15x45mm non latching.	1	£1.00	BD865
Standard size toggle switch.	3	£1.00	BD605
4 pole cetre off c/o toggle switch. 10A 250v.	1	£1.00	BD343
Sub minature toggle switch 8 x 4 x7mm SPST.	3	£1.00	BD649
SWICHES ROCKER			
Rocker switch DPST.	4	£1.00	BD44
Rocker switch panel mount single pole 10A. White.	8	£1.00	BD41
Double pole rocker with built in 3A trip. 240v.	1	£2.00	2P268
Rocker switch 2 pole C/O 10A.	1	£1.00	BD732
Rocker switch SPST centre off. 10A 250v.	5	£1.00	BD43
Rocker switch SPST. 13A.	8	£1.00	BD41
Spring loaded 10A rocker switch. (car window etc).	2	£1.00	BD728
SWITCHES VARIOUS			
30A panel mount toggle switch 250v.	1	£1.00	BD166
PCB mount 16 way BCD output 6mm square rotary.	2	£1.00	BD743
Push swich with protective shoulder. For motor start etc.	4	£1.00	BD257
Motorized stud switch (ex equipment).	1	£1.00	BD98
Key operated switch.	1	£1.00	BD31
Key operated switch good quality Yale.	1	£2.00	2P288
Glass reed switch.	12	£1.00	BD13
Mercury switch. Mains rated.	1	£1.00	BD269
Humidity swich.	2	£1.00	BD32
Low voltage dolls house type switch.	5	£1.00	BD57
Thumb wheel switch minature BCD.	1	£1.00	BD601
Thumb wheel switch standard size normal contacts.	1	£1.00	BD590
Double pole on off leaf switch.	40	£1.00	BD350
TAGS AND CONNECTORS			
Push on 1/4" tag connectors.	100	£1.00	BD217
Push on 1/4" tag connectors (right angled).	100	£1.00	BD218
Soldercon terminals (make your own IC sockets).	100	£1.00	BD219
Push on tags for 1/8" spindle.	100	£100	BD271
Tags with hole to fit 6BA bolt.	100	£1.00	BD547
TAPE BITS			
Double micro cassette deck. Complete with motors.	1	£10.00	10P49
Assorted tape heads.	4	£1.00	BD16
Stereo tape heads (cassette type).	2	£1.00	BD541

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
Tape splicing block with cutter 45 and 90 deg 2 tape size	1	£1.00	BD723
TELEPHONE BITS			
20 metres of 4 core white phone cable.	1	£2.00	2P98
100 metre reel of white 4 core cable.	1	£8.00	8P15
500 pack of cable clips for above cable.	1	£2.00	2P99
10 digit switch pad for telephone etc.	1	£1.00	BD200
Pushbutton 10 memory phones (customer returns).	1	£6.00	6P16
Frequency changer unit. Reduces250v 50hz to 50v 25hz.	1	£10.00	10P37
3 metre phone leads new style plug. Black.	2	£1.00	BD639
3 mtre phone leads new style plug. White.	1	£1.00	BD705
Device to enable any phone to be converted to new plug	1	£2.00	2P249
Twin telephone bells AC.	1	£1.00	BD600
5 pole GPO plug and wall mount socket.	1	£1.00	BD534
5 metre new style telephone extension lead.	1	£3.00	3P70
TERMINALS			
Screw down terminal posts. Also take 4mm banana plug.	6	£1.00	BD264
Minature panel mount terminals. Screw tops.	4	£1.00	BD755
THERMOSTATS			
Danfloss cased wall mount heating thermostat.	1	£4.00	4P4
Wall mounting low voltage thermostat.	1	£1.00	BD115
Capillary type fridge thermostat.	1	£1.00	BD96
Panoset. Keeps saucepans at pre set temperature.	1	£1.00	BD252
Oven thermostat with tep calibrated knob.	1	£2.00	2P158
Appliance thermostat. Spindle type adjustment.	2	£1.00	BD582
Washing machine thermostat.	1	£1.00	BD458
3 level water thermostats.	4	£1.00	BD537
THERMISTORS			
5mm dia NTC 40R @ 100 deg, 300 @ 25R.	4	£1.00	BD978
5mm dia NTC 80R @ 100 deg, 1K @ 25R.	4	£1.00	BD979
5mm dia NTC 380R @ 100 deg, 5K @ 25R.	4	£1.00	BD980
5mm dia NTC 1K8R @ 100 deg, 30K @ 25R.	4	£1.00	BD981
5mm dia NTC 5K1 @ 100 deg, 100K @ 25R.	4	£1.00	BD982
TIMERS AND TIME SWITCHES			
25A electrical programmer (ex equipment).	1	£3.00	3P106
Microwave control panel with digital clock and relay o/p.	1	£6.00	6P18
Plug in 24 hour time switch.	1	£10.00	10P54
Mains motor driven. Switches on or off for 20 secs.	1	£2.00	2P22
10 min clockwork time switch 15A 230v.	1	£1.00	BD579
90 min time switch engraved in mins 15A 230v.	1	£2.00	2P90
2 hour time switch. Clockwork 15A.	1	£2.00	2P89
12 hour time switch. Clockwork 15A 240v.	1	£2.00	2P24
Smiths time and set switch for heating etc. 15A.	1	£2.00	2P9
Omron Industrial timer.	1	£5.00	5P55
100A time switch. 1 on 1 off per 24 hours.	1	£10.00	10P14

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
Plug in Venner solar dial including case with window.	1	£7.00	7P17
Adaptor kit for above to give 12 on/offs.	1	£3.00	3P105
24 hour time switch. (ex equipment).	1	£1.00	BD45
12 hour timer.	1	£1.00	BD478
Mains driven electric clock. (uncased).	1	£1.00	BD211
TOOLS ETC			
Extra thin screw driver.	4	£1.00	BD129
5" electricians pliers.	1	£2.00	2P253
Multimeter 16 ranges .2K OPV with leads.	1	£7.00	7P10
Multimeter 20K OPV 10A AC ample ranges.	1	£15.00	15P30
4BA spanner.	10	£1.00	BD142
Screw drivers.	10	£1.00	BD322
Top pocket screw drivers.	2	£1.00	BD436
7" electricians pliers.	1	£3.00	3P25
6" diagonal side cutters.	1	£2.00	2P161
Set of 10 minature flat blade screwdrivers in case.	1	£2.00	2P311
Set of 10 minature crosspoint screwdrivers in case.	1	£2.00	2P312
Set of 5 minature nut spinners in case (metric).	1	£2.00	2P313
7" Mole grip style wrench.	1	£3.00	3P114
Minature electronics vice, table mounting. Metal.	1	£5.00	5P180
Minature PCB drill 9-16v DC 1.5A. With case.	1	£15.00	15P41
CHROME VANADIUM SCREWDRIVERS			
75 x 3mm flat blade.	1	£1.00	CD15
100 x 3mm flat blade.	1	£1.00	CD16
150 x 5mm flat blade.	1	£1.00	CD17
200 x 5mm flat blade.	1	£1.00	CD18
75mm 0 size pozidrive.	1	£1.00	CD19
75mm 1 size pozidrive.	1	£1.00	CD20
100mm 2 size pozidrive.	1	£1.00	CD21
150mm 3 size pozidrive.	1	£2.00	2P339
TRANSFORMERS COUPLING			
Minature driver transformer 20K to 1K (centre tapped).	1	£1.00	BD653
TRANSFORMERS TOROIDAL			
24v 5A plastic encapsulated 4" diameter.	1	£5.00	5P34
TRANSFORMERS MAINS			
6v 1A upright mounting.	2	£1.00	BD9
8v 1/2A double upright mounting.	1	£1.00	BD212
9v 1/2A upright mounting.	1	£1.00	BD266
12v 1/2A upright mounting.	1	£1.00	BD10
15v 2A upright mounting.	1	£3.00	3P88
15v 4A upright mounting.	1	£4.00	4P56
30v 1A upright mounting.	1	£2.00	2P270
18v 500VA transformer.	1	£20.00	20P9
24v 5A transformer in waterproof box for outside use.	1	£8.00	8P17

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
9-0-9v .4A PCB mounting.	1	£1.00	BD661
12-0-12v 1/2 A PCB mounting.	1	£1.00	BD636
20-0-20v 2.5A upright mounting.	1	£4.00	4P24
24-0-24v plus 12-0-12v 150 watt.	1	£8.00	8P11
50v 2A plus 6.3v upright mounting.	1	£3.00	3P10
90v plus 90v 220mA (large transformer).	1	£5.00	5P128
100v plus100v 1A upright mounting.	1	£5.00	5P86
250-0-250v 60mA plus 6.3v at 5A.	1	£4.00	4P41
20v 1.5A upright mounting.	1	£2.00	2P214
440v to 240v stepdowm transformer.	1	£5.00	5P67
EHT transformer 8kv 3mA.	1	£10.00	10P56
10v plus 17v 1A transformer.	1	£1.00	BD492
CHASSIS MOUNT TRANSFORMERS			
6-0-6 2A 59x50x54mm 24VA.	1	£5.00	5P184
9-0-9 2A 59x59x50mm 36 VA.	1	£6.00	6P48
12-0-12 2A 68x57x55mm 48VA.	1	£7.00	7P27
20-0-20 2A 78x65x66mm 80VA.	1	£10.00	10P98
30-0-30v 2A 78x65x66mm 120VA.	1	£12.00	12P36
6-0-6v 4A 68x57x54mm 48VA.	1	£7.00	7P28
6-0-6v 8A 78x65x72mm 96VA.	1	£12.00	12P37
9-0-9v 4A 68x57x66mm 72VA.	1	£10.00	10P99
12-0-12v 4A 78x65x70mm 96VA.	1	£12.00	12P38
12-0-12v 8A 96x83x82mm 192VA.	1	£22.00	22P4
0-15 3A 68x58x62mm 45VA.	1	£6.00	6P49
AUTO TRANSFORMERS			
Electronic auto transformer 1KW resistive loads only.	1	£5.00	5P157
100 watt auto transformer.	1	£2.00	2P6
TRANSISTORS			
AC128	3	£1.00	BD909
AC127	3	£1.00	BD910
BC108	6	£1.00	BD911
BC109	6	£1.00	BD912
BC140	4	£1.00	BD913
BC141	4	£1.00	BD914
BC142	3	£1.00	BD915
BC143	3	£1.00	BD916
BC149	6	£1.00	BD917
BC158	6	£1.00	BD918
BC160	3	£1.00	BD920
BC182L	12	£1.00	BD921
BC183L	10	£1.00	BD922
BC184L	10	£1.00	BD923
BC212L	10	£1.00	BD924
BC213L	10	£1.00	BD925

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
BC237B	10	£1.00	BD926
BC238B	10	£1.00	BD927
BC337	10	£1.00	BD928
BC338	10	£1.00	BD929
BCY70	4	£1.00	BD930
BCY71	4	£1.00	BD931
BFY50	3	£1.00	BD932
BFY51	3	£1.00	BD933
BU208	1	£2.00	2P298
MJ2955	2	£2.00	2P299
MJE3055	2	£2.00	2P300
TIP29A	6	£2.00	2P301
TIP30A	6	£2.00	2P302
TIP31C	5	£2.00	2P303
TIP32C	5	£2.00	2P304
ZTX300	5	£1.00	BD934
ZTX500	5	£1.00	BD935
2N2905	4	£1.00	BD936
2N3055	3	£2.00	2P305
TRIACS AND THYRISTORS			
TIC206D 3A 400v triac.	4	£2.00	2P314
TIC226D 8A 400v triac.	3	£2.00	2P315
TIC246D 16A 400v triac.	2	£2.00	2P316
TIC106D 4A 400v thyristor.	5	£2.00	2P317
TIC116D 8A 400v thyristor.	3	£2.00	2P318
TIC126D 12A 400v thyristor.	2	£2.00	2P319
TV BITS			
Flyback EHT unit ITT ref 17ACC79.	1	£2.00	2P111
Varicap push button tuner.	2	£1.00	BD155
8kv GEC line output transformers.	1	£2.00	2P262
Yoke assemblies for TV tubes (contain a lot of wire).	1	£1.00	BD747
Linearity coils ref BKM10-7.	2	£1.00	BD462
TV sound receiver box 240v 7 channel.	1	£12.00	12P22
75 ohm low loss co-ax cable.(10 metres).	1	£2.00	2P236
75 ohm low loss co-ax cable (100 metres).	1	£15.00	15P31
ULTRASONICS			
Ultrasonic intruder detector.	1	£20.00	20P11
UNISELECTORS			
Minature 50v unselector with circuit ideas.	1	£1.00	BD56
VALVES AIR AND FLUID			
24v DC air or water valve. Threaded couplings.	1	£10.00	10P73
Air or gas shut off valve. Clock operated.	1	£1.00	BD152
Air or gas shut off valve. Temp operated.	1	£1.00	BD153
110v mains operated air valve.	1	£1.00	BD202

DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
230v mains operated air valve.	1	£2.00	2P34
230v mains water valve.	1	£1.00	BD370
High pressure mains gas or water valve 1/2" thread.	1	£5.00	5P171
High pressure mains gas or water valve 1" thread.	1	£5.00	5P172
VIDEO TAPES			
Blank 3 hour top quality video tape. (VHS).	1	£3.00	3P63
Blank 3 hour top quality video tapes. (VHS).	5	£11.00	11P3
VOLTAGE REGULATORS			
5v 1A TO220 voltage regulator. 7805	3	£1.00	BD962
12v 1A TO220 voltage regulator. 7812	3	£1.00	BD963
-5v 1A TO220 voltage regulator. 7905	3	£1.00	BD964
-12v 1A TO220 voltage regulator. 7912	3	£1.00	BD965
5v 2A TO220 voltage regulator. 78S05	2	£1.00	BD966
-12v 2A TO220 voltage regulator 78S12	2	£1.00	BD967
WHEELS			
13" C5 spoked wheel with tyre & tube. Cycle bearing	1	£6.00	6P10
16" C5 spoked wheelwith tyre & tube. 1" centre hole.	1	£6,00	6P11
WIRE AND CABLE			
2 core pvc covered cable 5A . (18 metres).	1	£2.00	2P218
2 core pvc covered cable 8A. (15 metres).	1	£2.00	2P219
3 core pvc covered cable 5A. (15 metres).	1	£2.00	2P189
3 core pvc covered cable 8A. (14 metres).	1	£2.00	2P220
3 core pvc covered cable 10A. (12 metres).	1	£2.00	2P221
3 core pvc covered cable 13A. (10 metres).	1	£2.00	2P190
IBM printer lead (D25 to Centronics plug). Parallel 2m.	1	£5.00	5P186
IBM printer lead (d25 to Centronics plug). Parallel 3m.	1	£6.00	6P50
RS232 data cable D25 male to D25 male 2Metres long.	1	£5.00	5P187
RS232 data cable D25 female to D25 male. 2M long.	1	£5.00	5P188
Centronics cable. Plug to plug 2 metres long.	1	£6.00	6P51
RS232 D25 gender changers. Male to male.	1	£3.00	3P124
RS232 D25 gender changers. Female to female.	1	£3.00	3P125
D9 gender changer male to male.	1	£3.00	3P126
D9 gender changer female to female.	1	£3.00	3P127
Centronics gender changer male to male.	1	£6.00	6P52
Centronics gender changer female to female.	1	£6.00	6P53
D9 male to D25 female adaptor. (IBM compatable).	1	£3.00	3P128
D9 female to D25 male adaptor. (IBM compatable).	1	£3.00	3P129
IEC lead fitted with IEC socket. 2 metres.	1	£2.00	2P347
IEC lead fitted with IEC socket and 13A plug. 2M.	1	£3.00	3P130
Equipment wire PTFE coated and silver plated. (5m).	1	£1.00	BD564
Single core screened cable 7 x .02 conductors. (10m).	1	£1.00	BD668
4 core cable 7 x .2mm grey. (100 metres).	1	£8.00	8P19
Garden tool extension cable 2 core. (20m).	1	£2.00	2P20
2 core screened cable. (10 metres).	1	£1.00	BD122

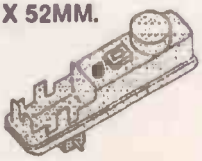
DESCRIPTION	PACK QUANTITY	PACK PRICE	ORDER NUMBER
High voltage flex 14 x .007 heavily insulated. (10m).	1	£1.00	BD207
Curly 5 core phone type lead.	2	£1.00	BD213
Curly 3 core 10A mains cable.	1	£2.00	2P57
2.5mm red and black twisted cable 15A 230v. (10m).	1	£2.00	2P168
2m lenghts of very flexible 4 core flex.	5	£1.00	BD621
Extra flexible cable (ideal test leads) 25m reel. Red.	1	£3.00	3P131
Extra flexible cable (ideal test leads) 25m reel. Black.	1	£3.00	3P132
Curly 3 core 13A cable goes from 1' to 9'.	1	£2.00	2P243
RF cable type RG58C/U 50 ohm black 100m reel.	1	£22.00	22P5
RF cable type RG59B/U 75 ohm black 100m reel.	1	£26.00	26P1
RF cable type RG62A/U 93 ohm black 100m reel.	1	£32.00	32P2
3 metres of speaker cable and 2 2 pin din plugs.	1	£1.00	BD724
10 metres of 24 way cable terminating in 2 D25 plugs.	1	£10.00	10P74
50 metres of white four core cable (D shaped).	1	£5.00	5P153
4 core screened cable 80 metre reel in black.	1	£6.00	6P17
12 core 7/.2 mm individual screens 10mm OD. 3metres.	1	£4.00	4P64
3 metres of iron wire and 3 metres of constantine wire.	1	£2.00	2P284
100m reel of 6 core white phone cable	1	£9.00	9P1
100 mtres of white bell/speaker wire fig 8 shape 7/.2mm.	1	£3.00	3P107

EX BRITISH TELECOM MULTI METERS
VERY GOOD QUALITY COMPLETE WITH

CASE AND LEADS (No battery).

£15.00 **each** **REF 15P36**

FRESNEL MAGNIFYING LENS 83 X 52MM.	**1**	**£1.00**	**BD827**



SONIC 'TRAIN'
Battery operated motorized unit with built in sound activated switch. Supplied complete with 'CLICKER'
Click 1 = motor on, click 2 = reverse direction click 3 = motor off
Price is £3.00 ref 3P137

SAB9 RADIO RECEIVER

First class radio that receives MW/LW/FM/AIR/MARINE bands (108-176)mhz. Fine tuning control on the FM band. Complete with earphone. **£25.00 ref 25P17**

RADIO RECEIVER MBR 7

A fully featured multiband that receives MW 535-1630khz,LW 150-300kh FM 87.5-108,AIR 108-136, MARINE 136-176 SW1 7-23MHZ, SW2 3-7.2MHZ AFC, direction finder, fine tuning mains or battery.

£64.00 ref 64P3

LOW COST RECEIVER 8342

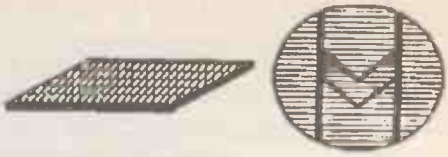
Covers AIR 108-145MHZ, PB 145-176MHZ, WB 162.5MHZ, TV 54-87MHZ, FM 88-108MHZ, CB CHANNELS 1-80.

Receiver measures 100 x 200 x 50mm. Supplied complete with squelch, control and strap. Battery operated.

£19.00 ref 19P14

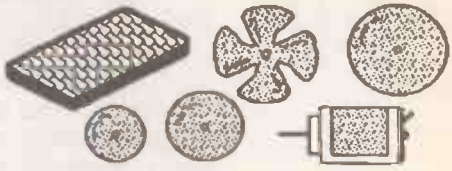
Mains adaptor £5.00 ref 5P191

12v Solar cell 200mA output ideal for trickle charging etc. £15.00 each ref 15P42



SOLAR CELLS

600Ma .45V £3.00 REF 3P42
400Ma .45V £2.00 REF 2P199
100Ma .45V £1.00 REF BD631
new 1 AMP .45 circular solder type only £5.00 ref 5P192



SOLAR KIT

Comprises of solar cell, Special DC motor, plastic fan and turntables, various cutout shapes and a 20 page book about solar energy.

Price is £8.00 ref 8P51

FIBRE OPTIC CABLE

Stranded optical fibres sheathed in black PVC

1 metre length **£2.00 ref 2P351**
5 metre length **£7.00 ref 7P29**

BULL ELECTRICAL 0273-203500

INDEX

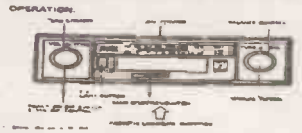
FM CORDLESS MICROPHONE

This device is a small handheld microphone that transmits to an ordinary FM radio. It is battery operated (PP3) and has two transmit power levels. Tuneable from 90-105MHZ max imum range is 500' **£15.00 ref 15P42**

MINATURE RADIO TRANSCEIVERS

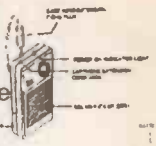
A pair of walkie talkies with a range of up to 2 Kilometres. Units measure 22x52x155mm and come complete with cases, aerials and earpieces. Price for the pair is **£30.00 ref 30P12.**

CAR STEREO AND FM RADIO



Low cost car stereo system giving 5 watts per channel. Signal to noise ratio < 45db wow and flutter less than .35%. neg earth. Retail price £49.95, ours..**£25.00** ref 25P21

WHISPER 2000 LISTENING AID

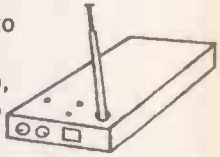


You may have seen these aids advertised in the national press at £8.95. If you haven't its a device that enables you to hear sounds that would otherwise be inaudible.
Our Price is £5.00 ref 5P179

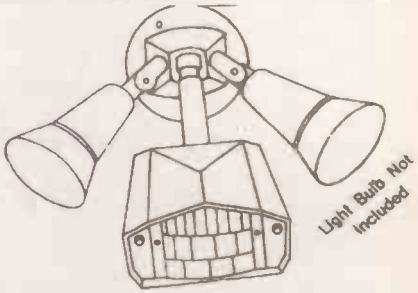
10 BAND COMMUNICATIONS RECEIVER

Cmprehensive receiver covering 7 shortwave bands FM, AM and LW. Tuning eye DX/local switch mains or battery. Complete with shoulder strap & mains lead. **£34.00 ref 34P1**

VIDEO SENDER UNIT



These units are designed to transmit audioand video signals from either a Video, a camera or a computer to a standard TV set. Max range is 100 ft. 12v operation, **Price £15.00 ref 15P39** 12v psu £5.00 ref 5P178.



PASSIVE INFRA RED MOTION SENSOR

Built in day light sensor.
Adjustable lights on time (8 sec-15mins)
50' range with a 90 degree coverage.
Manual over ride facility.
Complete with wall brackets bulb holders etc
Brand new and guaranteed
OUR PRICE £25.00 ref 25P24

BULL ELECTRICAL 0273-203500