EVERYDAY
ELECTRONICS
and computer PROJECTS
OCTOBER 1985 £1·10

UNDERSTAND ELECTRONICS!

TEACH IN '86

Starts this Month

Project One...
Safe Power Supply Unit

NEW SIZE!

Soldering-Buyer's Guide

Australia $1.75 New Zealand $1.95 Malaysia $4.95

£1 BAKERS DOZEN PARCELS

(all £1 each 13 for £12)

All parcels are brand new components price £1 per parcel – if you order 12 then pick another free

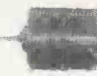
- BD115 – 1 Wall mounting thermostat with thermometer
- BD116 – 3 pairs small and 2 pairs medium insulated croc clips
- BD117 – 4 pairs large croc clips (car battery type)
- BD118 – 1 Teak look 5" extension speaker cabinet with back
- BD119 – 2 fibreglass fire fronts log effect & coal effect
- BD120 – 2 component boards with 2 amp 400v bridge rectifier and 15 other recs
- BD121 – 4 push push switches for table lambs etc
- BD122 – 10 mtrs twin flex, screened and outer pvc covered
- BD123 – 100 staples for thin flex white plastic and hardened nail
- BD124 – 25 clear plastic lenses 1¾" diameter
- BD125 – 4 items: rev per hour mains motor, counter, coin switch and srbp panel
- BD126 – 4 pilot bulb lamp holders bakelite batten type
- BD127 – 4 pilot bulb lamp metal clip on type
- BD128 – 10 very fine drills for pcbs etc
- BD129 – 4 extra thin screw drivers for instruments
- BD130 – 2 centre zero panel meters 100-0-100 uA
- BD131 – 1 100 uA edge wise balance meter
- BD132 – 2 plastic boxes with windows, ideal interrupted beam kits
- BD133 – 1 Microsonic radio case in leather zipper pouch
- BD134 – 10 model aircraft motors – require no on/off switch, just spin
- BD135 – 10 large and 20 small Screwit porcelain connector/insulators
- BD136 – 2 car radio speakers 5" round 4 ohm made for Radiomobile
- BD137 – 1 5" 4 ohm speaker and matching tweeter 5 watt
- BD138 – 1 9" × 4" 8 ohm 5 watt speaker
- BD139 – 4 600 ohm microphone/speaker inserts
- BD140 – 1 waterproof metal cased plug and socket 3 pin
- BD141 – 10 miniature slide switches 2 pole c/o
- BD142 – 10 4 ba spanners 1 end open, other end closed
- BD143 – 5 100k multi turn pots with knob
- BD144 – 10 chassis mounting fuse holders for 5 mm fuses
- BD145 – 2 4 reed relay kits 3v coil can be normally open or c/o
- BD146 – 20 pilot bulbs 6.5v ·3a Philips
- BD147 – 1 Secret switch kit with data
- BD148 – 1 Printed circuit kit with data and 100 circuits
- BD149 – 4 socket covers (protect inquisitive little fingers) for twin 13A
- BD150 – 5 socket covers (protect inquisitive little fingers) for single 13A
- BD151 – 20 4 way terminal blocks 3A 250v bakelite body
- BD152 – 1 Air or gas shut off valve – clockwork operated
- BD153 – 1 Air or gas shut off valve – thermostat operated
- BD154 – 1 12v drip proof relay – ideal for car jobs
- BD155 – 3 Varicap push button tuners with knobs
- BD156 – 2 pairs Ferrite cores Neosid 56 × 18 mm
- BD157 – 6 2 circuit micro switches – Licon ideal for Joystick
- BD158 – 5 12 way connector blocks 2A 250v
- BD159 – 3 12 way connector blocks 25A 250v
- BD160 – 6 pairs 3 way connectors plug in, terminal block type
- BD161 – 1 13A panel socket MK ref 735 WH1
- BD162 – 1 13A fused and switched spur for surface mounting or can be removed from box for flush mounting
- BD163 – 3 13A sockets good British make but brown
- BD164 – 2 13A switched sockets good British make but brown
- BD165 – 1 13A panel switched socket on base for surface mounting
- BD166 – 1 30A panel mounting toggle switch
- BD167 – 1 8 pin flex terminating plug and chassis mounting socket (s.h.)
- BD168 – 2 50 tag component mounting strips
- BD169 – 4 Short wave air spaced trimmers 2 – 10pf
- BD170 – 2 Hivac numicator tubes neon type
- BD171 – 1 Shocking coil kit with data – have fun with this
- BD172 – 10 12v 6w bulbs Philips m.e.s.
- BD173 – 1 6v d.c. solenoid with plunger 1" travel
- BD174 – 2 end of travel c/o switches – very robust mounted on heavy metal plate 10A 250v
- BD175 – 1 200 rpm motor mains operated 2 watt
- BD176 – 4 heavy duty push switches – ideal for foot operation 3A 250v
- BD177 – 5 Lilliput bulbs 12v
- BD178 – 3 Oblong amber indicators with lilliputs 12v
- BD179 – 3 Oblong amber indicators with neons 240v
- BD180 – 6 round amber indicators with neons 249v
- BD181 – 100 p.v.c. grommets ⅝ hole size
- BD182 – 1 short wave tuning condensor 50 pf with ¼" spindle
- BD183 – 1 two gang short wave tuning condenser with ¼" spindle
- BD184 – 1 three gang tuning condenser each section 500 pf with trimmers and good length ¼" spindle
- BD185 – 4 ferrite rod aerials 8" × ⅜" rods with long and medium wave coils
- BD186 – 1 3 wafer switch: 18 pole 2 way, 12 pole 3 way, 9 pole 4 way, 6 pole 6 way, 3 pole 12 way, your choice
- BD187 – 22 wafer switches 12 pole 2 way, 8 pole 3 way, 6 pole 4 way, 4 pole 6 way, 2 pole 12 way, any 2 your choice
- BD188 – 1 plastic box sloping metal front, size 160 × 95mm average depth 45mm

VENNER TIME SWITCH

Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only **£2.95** without case, metal case – £2.95, adaptor kit to convert this into a normal 24hr. time switch but with the added advantage of up to 12 on/offs per 24hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is **£2.30**.

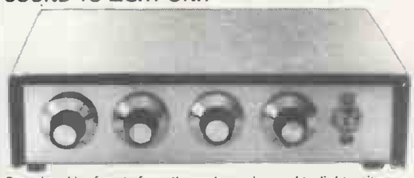
Ex-Electricity Board. Guaranteed 12 months.

12 volt MOTOR BY SMITHS



Made for use in cars, etc. these are very powerful and easily reversible. Size 3½" long by 3" dia. They have a good length of ¼" spindle –
1/10 hp £3.45
1/8 hp £5.75. 1/6 hp £7.50

SOUND TO LIGHT UNIT



Complete kit of parts for a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four pin plug and socket facilitate ease of connecting lamps. Special price is **£14.95** in kit form.

PRESTEL UNITS

These are brand new and we understand tested, came with manufacturer's guarantee now void as the manufacturer no longer trades. These originally sold for over £150. We offer then complete, except for 7 plug in i.c.s and price is only **£14.95** (less than the value of the modem included).

YOUR TELEPHONE

Can be frustration free with the ABS one push dialling unit. You program its index with up to 220 of your important numbers. From then on all you do is flip the index to the person you want, press the call button and the number will be dialled automatically (numbers not worth programming can still be fast push button dialled). Should the number be engaged whether it is in your index or not it will be memorised and at a touch of the button you can try again.
Another big feature – the built in speaker and microphone allow you to have your hands free for other jobs whilst awaiting your call.
The ABS unit is B.T. approved and simply plugs into a B.T. socket and a mains point. We have 50 only of these, so send or phone your order TO-DAY the price **£57.50** but you will save this in a few weeks even if you value your time at only 10p a minute.

CORDLESS TELEPHONES

"IT'S FOR YOU-OU" even if you are in the bath, its an infinite extension any room and even in the garden – have one on approval or come and try one here. BT approved **£120** not yet approved **£69**. plus **£2** post.
SOCKETS PLUGS ETC for BT phones
Master socket (has surge arrestor – ringing condenser etc) and takes B.T. plug £3.95
Extension socket £2.95
Dual adaptors (2 from one socket) £3.95
Cord terminating with B.T. plug 3 metres £2.95
Kit for converting old entry terminal box to new B.T. master socket, complete with 4 core cable, cable clips and 2 BT extension sockets **£11.50**

25A ELECTRICAL PROGRAMMER

Learn in your sleep. Have radio playing and kettle boiling as you wake – switch on lights to ward off intruders – have a warm house to come home to. You can do all these and more. By a famous maker with 25 amp on/off switch. Independent 60 minute memory jogger.
A beautiful unit at **£2.50**

THE AMSTRAD STEREO TUNER

This ready assembled unit is the ideal tuner for a music centre or an amplifier, it can also be quickly made into a personal stereo radio – easy to carry about and which will give you superb reception.
Other uses are a "get you to sleep radio", you could even take it with you to use in the lounge when the rest of the family want to view programmes in which you are not interested. You can listen to some music instead.
Some of the features are: long wave band 115 – 170KHz, medium wave band 525 – 1650KHz. FM band 87 – 108 MHz, mono, stereo & AFC switchable, fully assembled and fully aligned. Full wiring up data showing you how to connect to amplifier or headphones and details of suitable FM aerial (note ferrite rod aerial is included for medium and long wave bands). All made up on very compact board.
Offered at a fraction of its cost — only **£4.95**

COMPUTER DESKS

Few still available
Computer desks – size approx 4' × 2' × 2'6" high formica covered, cost over £100 each. Our price only **£9.50** – you must collect – hundreds supplied to schools.

J. BULL (Electrical) Ltd.

(Dept. EE), 34 - 36 AMERICA LANE, HAYWARDS HEATH, SUSSEX RH16 3QU. Established 30 YEARS

MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £20 add £1 service charge. Monthly account orders accepted from schools and public companies. Access & B/card orders accepted day or night. Haywards Heath (0444) 454563. **Bulk orders:** phone for quote. Shop open 9.00 – 5.30, Mon to Fri, not Saturday.

TWO POUNDERS

Following the popularity of our BAKERS DOZEN £1 PARCELS, we are now introducing some BAKERS DOZEN £2 PARCELS. We feel that you will agree that most are exceptional bargains but you can still get a bit extra, as with the £1 parcel, if you buy 12 you get another free!

- 2P1 – 24 hour time switch with 2 on/offs, an ideal heating programmer
- 2P2 – Wall mounting thermostat, high precision with mercury switch and thermostat
- 2P3 – Variable and reversible 8-12v power supply, ideal for model control
- 2P4 – 24 volt psu with separate channels for stereo made for Mullard UNILEX Amplifiers.
- 2P5 – 12 volt psu 750 ma output – plastic cased and with mains lead
- 2P6 – 100 watt mains to 115 volts auto-transformer with voltage tappings
- 2P7 – Mini key, 16 button membrane keyboard, list price over £12, as used on PRESTEL
- 2P8 – Mains motor with gear box and variable speed selector. Series wound so suitable for further speed control
- 2P9 – Time and set switch. Boxed, glass fronted and with knobs. Controls up to 15 amps. Ideal to program electric heaters or cookers, even battery chargers
- 2P10 – 12 volt 5 amp mains transformer – low volt winding on separate bobbin and easy to remove to convert to lower voltages for higher currents
- 2P11 – Power amp module Mullard Unilex EP9000 (note stereo pre-amp module Unilex 9001 is available £1)
- 2P12 – Disk or Tape precision motor – has balanced rotor and is reversible 230v mains operated 1500 rpm
- 2P13 – Sun Lamp switch stays on for ½ hr or 1 hr depending on setting of grub screw
- 2P14 – Mug Stop kit – when thrown emit piercing squawk
- 2P15 – Interupted Beam kit for burglar alarms, counters, etc
- 2P16 – Lockable metal box with 2 keys, ideal for your tools
- 2P17 – 1 rev per minute mains driven motor with gear box, ideal to operate mirror ball
- 2P18 – Liquid/gas shut off valve mains solenoid operated
- 2P19 – Disco switch-motor drives 6 or more 10 amp change over micro switches supplied ready for mains operation
- 2P20 – 20 metres extension lead, 2 core – ideal most Black and Decker garden tools
- 2P21 – 10 watt amplifier, Mullard module reference 1173
- 2P22 – Motor driven switch 20 secs on or off after push on
- 2P23 – Long and medium wave radio chassis – with slow motion drive ideal music while you work, could be mounted on extension speaker cabinet
- 2P24 – Clockwork operated 14 hour switch 15A 250V with clutch

MORE BAKERS DOZEN £1 PARCELS

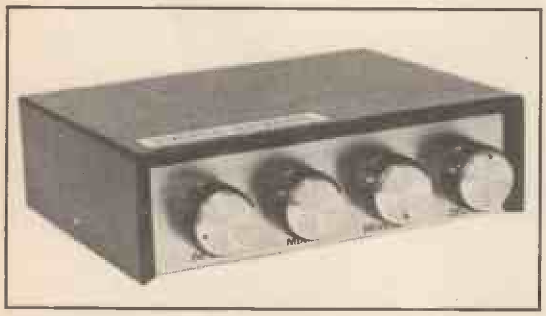
- BD189 – 2 double pole 20 amp 250v flush mounting switches – white
- BD190 – 2 double pole 20 amp 250v surface mounting switches with neon indicators – brown
- BD191 – 6 B.C. lamp holder adaptors white
- BD192 – 3 B.C. to 2 pin lamp holder adaptors with plugs
- BD193 – 6 5 amp 3 pin flush sockets brown
- BD194 – 3 5 amp 3 pin switched sockets surface mounting, brown
- BD195 – 5 B.C. lampholder brown bakelite threaded entry
- BD196 – 1 in flex simmerstat for electric blanket soldering iron etc
- BD197 – 2 thermostats, spindle setting – adjustable range for heaters ovens etc
- BD198 – 1 rod thermostat for water heater etc 11" rod
- BD199 – 1 mains operated solenoid with plunger 1" travel
- BD200 – 1 10 digit switch pad for telephones etc
- BD201 – 8 computer keyboard switches, with knobs, pcb or vero mounting
- BD202 – 1 solenoid mains operated air valve 110v coil
- BD203 – 2 8 push button switch banks 6 interlocking and two independent locking less knobs or one with knobs your choice
- BD204 – 3 push mains voltage switches with integral knobs
- BD205 – 1 ultra small 12v relays 3A gold-plated contacts normally open
- BD206 – 20 metres 80 ohm coax, standard type off white
- BD207 – 20 metres high voltage heavy insulated flex 14.0075
- BD208 – 1 Photo multiplier tube RCA 4555 or equivalent Japanese make
- BD209 – 1 Metal box approx. 8" × 3" × 4" ex equipment but good condition
- BD210 – 4 Transistors type 2N3055
- BD211 – 1 Electric clock mains driven, always right time – not cased
- BD212 – 1 Double 8v ½ amp mains transformer ideal for dimming or strobing fluorescent tubes or psu etc
- BD213 – 2 Curly 5 core leads for mobile telephones, transmitters etc, stretched length approx 2 metres
- BD214 – 3 sub-miniature toggle switches spdt with plastic dolly
- BD215 – 5 miniature slide switches dpdt with chrome dolly
- BD216 – 1 Stereo preamp Mullard EP9001
- BD217 – 100 push on tag connector ¼ straight
- BD218 – 100 push on tag connector ¼ right angled
- BD219 – 100 soldercon terminals make IC sockets any length and width
- BD220 – 3 Heat sinks for flat ICs predrilled size 40 × 40 × 25mm
- BD22 – matt black, four sided

VOL 14 Nº10 OCTOBER'85

EVERYDAY ELECTRONICS and computer PROJECTS

ISSN 0262-3617

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



TEACH IN '86
Don't miss the start of this important new series—See page 531

PROJECTS

SERIES

FEATURES

BUYER'S GUIDE

Our November 1985 issue will be published on Friday, October 18. See page 549 for details.

CT1000K CLOCK/TIMER KIT
24hr Digital clock with presetable ON and OFF time for output. Ideal for use with tape recorders, lighting etc. **£14.90**

VERO

XK113 M.W. RADIO KIT
A sensitive radio with wound aerial & earpiece requires 9V battery **£5.50**

BOOKS
By Babani, TI and Elektor

DIGITAL LOCK KIT
operates from 5 to 18Vdc supply and gives 5040 combinations. 10 way keyboard supplied. 750mA output. Ideal for disabling car ignition or for door lock when used with 701 150 lock mechanism **£11.50**
701 150 **£14.95**

MULTIMETERS
Analogue from **£6.50**
Digital from **£26.95**

Mk1 THERMOSTAT KIT
will control 1kW heater. Ideal for greenhouse. ONLY **£4.60**

TRIACS

REGULATORS
78 Series **50p**
78L Series **30p**

FREE 28 page catalogue. Send 9x6 SAE NOW!
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RING 01-567 8910 (24hrs)

LINEAR ICs
555 **21p**
CMOS 555 **55p**
741 **22p**
LM3914 **£2.65**
LS7225 **£2.60**
+ Lots lots more in our Cat.

ULTRA SENSITIVE DVM/THERMOMETER KIT
3½ Digit LCD design drawing a mere 150µA at 9v. 200 mV full scale or −20 to + 150°C thermometer **£15.50**

ANTEX SOLDERING IRONS
15w **£5.60** ST4 stand **£1.90**

BT Phone connectors starter pack **£9.50**

BOXES
Plastic, diecast aluminium

LEDs from **9p**

BEGINNERS PROJECT PACK
Build 10 fascinating projects including burglar alarm, intercom, thermostat etc on the solderless breadboard enclosed. Full circuit descriptions and layouts included
XK118 **£12.50**

TOOLS **£2.10**
Side cutters
See Cat. for full range.

CMOS
4001 **18p**
4017 **39p**

XK102 3 NOTE DOOR CHIME
complete kit includes box & speaker **£5.50**

PLUS A WIDE RANGE OF PLUGS, SOCKETS, RESISTORS, POTS, CAPS, VERO etc etc

PANTEC KITS

VELLEMAN KITS

ELECTRONICS
13 BOSTON RD
LONDON W7 3SJ
Tel. Orders: 01-567 8910
Enquiries: 01-579 9794
Shop Hours: Mon-Fri. 9am-5pm
Sat. 10am-4pm. Closed Wednesday

ORDERING INFORMATION:
ALL PRICES EXCLUDE VAT
FREE P&P on orders over £20 (UK only), otherwise add 75p + VAT. Overseas P&P: Europe £2.75. Elsewhere £6.50. Send cheque/PO/Barclaycard/Access No. with order. Giro No. 529314002.
LOCAL AUTHORITY AND EXPORT ORDERS WELCOME
GOODS BY RETURN SUBJECT TO AVAILABILITY

MARCO TRADING

NEW 1985/86 CATALOGUE

1985-86 IS NOW AVAILABLE.
Range of components greatly increased – over 125 pages fully illustrated. Price £1.00 per copy. (Free upon request with orders over £15). Includes 50p Credit Note, Special Offer Sheets, Order Form and Pre-Paid Envelopes.

COMPONENT KITS

¼W Pack 10 each value E12 10R-1M
Total: 610 resistors ONLY 5.75
¼W Pack 5 each value E12 10R-1M
Total: 305 resistors ONLY 3.35
½W Pack 10 each value E12 2R2-2M2
Total: 730 resistors ONLY 7.95
½W Pack 5 each value E12 2R2-2M2
Total: 365 resistors ONLY 4.75
50v Ceramic Kit 5 each value
125 Per Kit £4.75

ZENNER PACK

ZENNER PACK – 400MW-50FF each valve 55 zenners £3.50

CHART RECORDERS

Brand new 3 channel pen recorders complete with charts spares kits. full spec upon request. Once only bargain £40 + £10 p&p plus 15% VAT.

C-MOS

4000	0.19	4021	0.58	4036	2.48
4001	0.24	4022	0.68	4038	0.73
4002	0.24	4023	0.30	4039A	2.70
4007	0.24	4024	0.49	4040	0.58
4011	0.23	4025	0.24	4042	0.48
4012	0.24	4027	0.44	4043	0.42
4013	0.35	4028	0.44	4044	0.48
4014	0.58	4029	0.73	4046	0.58
4015	0.58	4030	0.33	4049	0.38
4016	0.38	4031	1.28	4050	0.34
4017	0.54	4033	1.25	4051	0.68

74LS

LS00	24p
LS01	24p
LS02	24p
LS03	24p
LS03	24p
LS08	24p
LS09	24p
LS10	24p
LS11	24p
LS12	24p
LS13	33p
LS14	48p
LS15	24p
LS20	24p
LS21	24p
LS22	24p
LS30	24p
LS32	24p
LS37	24p
LS74	33p
LS122	68p
LS138	44p
LS139	58p
LS151	70p
LS155	550p
LS157	45p
LS158	58p
LS160	62p
LS161	68p
LS162	70p
LS163	68p
LS166	1.56

TRANSISTORS

AC128	0.30	BF338	0.28
AC176	0.30	BFX29	0.28
AF239	0.50	BFX80	6.46
BC107	0.10	BFX85	0.35
BC108	0.10	BFX87	0.26
BC109	0.10	BFY50	0.22
A.B.C.	0.14	BFY52	0.22
BC147	0.18	BFY90	1.34
BC182	0.09	BSX20	0.30
BC182L	0.12	BU208	1.40
BC184	0.10	BU407	1.10
BC184L	0.10	MJ2955	0.90
BC212	0.10	OC45	0.58
BC212L	0.09	OC71	0.50
BCY70	0.15	OC72	0.52
BDI31/2	0.36	TIP31A	0.32
BDI33	0.56	TIP32A	0.42
BDI35	0.26	TIP33A	0.55
BDI36	0.26	TIP34A	0.70
BF115	0.32	TIP2955	0.70
BF184	0.30	TIP3055	0.58
BF185	0.28	TIS43	0.88
BF194	0.15	TIS88	0.50
BF195	0.12	2N3055	0.65
BF196	0.10	2SC1098	0.94
BF197	0.10	2SC1173Y	0.38
BF200	0.30	2SC1306	0.92
BF224	0.18	2SC1307	1.50
BF244	0.20	2SC1957	0.70
BF244A	0.30	2SC2028	0.73
BF244B	0.30	2SC2029	2.70
BF259	0.30	2SC2078	1.05
BF262	0.34	2SC2122A	3.20
BF263	0.38	3SK88	0.80
BF337	0.28	40673	1.80

DIODES

IN916	0.04	AA119	0.12
IN4001	0.05	AA129	0.18
IN4004	0.06	AAY30	0.16
IN4005	0.06	BA100	0.24
IN4007	0.07	BY126	0.12
IN4148	0.05	BY127	0.10
IN4149	0.06	BY133	0.16
IN5400	0.12	BY184	0.40

THIS IS ONLY A SMALL PART OF OUR RANGE. SEE OUR LATEST CATALOGUE 85-86 FOR REDUCED PRICES.

MARCO TRADING (DEPT EE10)
The Maltings
High Street
Wem, Shropshire SY4 5EN
Tel: 0939 32763 Telex: 35565

BARCLAYCARD VISA

ORDERING. All components are brand new and to full specification. Please add 60p postage/packing (unless otherwise specified to all orders then add 15% VAT to the total. Mini order £5.00. Either send cheque/cash/postal order or send/telephone your Access or Visa number. Official orders from schools, universities, colleges, etc, most welcome. (Do not forget to send for our 1985 catalogue – only £1.00 per copy.
Ali orders despatched by return of mail.
NEW RETAIL 1,000 sq. ft. shop now open. Mon-Fri 9.00-5.00, Sat 9.00-12.00.

SOLDERING AIDS

Antex 15W iron	5.25
Antex 18W Iron	5.50
Antex 25W iron	5.75
Antex Elements	2.75
Antex Bits	0.90
Antex stands	2.10
Desolder Tool	4.50
Spare nozzle	0.65
25W Kit-iron with 13A plug & stand	ONLY 10.00
18W Kit	9.90

NI-CAD CHARGER

Universal charger to charge PP3, AA, C, D PRICE 5.99

SPEAKERS

4" Round 1.6W 4 Ohm £1.50 pair
4" Round 1.6W 4 Ohm Plus Mounting Bracket £1.00 each
2¼" Round 0.4W 8 Ohm 85p each

EQUIPMENT WIRE

1/0.6 4	p/m	£2.75/100
7/0.2 5	p/m	£3.50/100
16/0.2 8	p/m	£5.35/100
24/0 2 10	p/m	£7.50/100

SCREENED CURLY LEADS

Black – 3 core (2 metres extended) 75p each. £6.00/10

PLUGS SOCKETS

Metal Co-ax Plug	0.18
Plastic Co-ax Plug	0.14
Metal Line Socket	0.50
Single Junc Socket	0.30
Plastic Phono	0.15
F.M Plugs	0.20
PL259 Plugs	0.30
Reducer	0.15
Low loss splitter 1 in 2 out	1.00

DC MOTOR

6-12V 75p
5 for £3.00

IC SOCKETS

Dil to Dil

8 pin	0.08	0.70/10
14 pin	0.10	0.95/10
16 pin	0.11	1.00/10
22 pin	0.21	1.95/10
28 pin	0.30	2.75/10
40 pin	0.34	3.10/10

SWITCHES

Sub-Miniature Toggle
SPST 60p SPDT 63p DPDT 66p
Miniature Toggle
SPDT 68p SPST 65p DPDT 72p
DPDT Centre off 85p
Standard Toggle
SPST On/Off Plate 48p
DPDT On/Off Plate 58p
Miniature DPDT Slide 15p
Push-To-Make 20p
Push-To-Break 25p
Rotary Switch
1 pole 12 way, 2 pole 6 way, 3 pole 4 way, 4 pole 3 way 50p

BATTERY HOLDERS SNAPS

EH73S/Take 2 AA Cells	17p
A302/Take 4 AA Cells	21p
A304/Take 6 AA Cells	32p
EH80S/Take 8 AA Cells	40p
EH80T/Take 10 AA Cells	48p
CX2/Take 2 C Cells	29p
B203/Take 4 C Cells	31p
DX2/Take 2 D Cells	29p
PP3 Battery Snap	7p, £6/100
PP9 Battery Snap	17p/pr £16/100

NI-CADS

PP3	£4.45,	4/16.00
AA	£0.95,	10/8.00
HPII	£2.30,	4/8.50
C	£1.95,	4/8.75

FLEXIBLE MAINS CABLE

0.5mm 2 core (3A) round 12 p/m £9.75/100
0.75mm 2 core (6A) round 17 p/m £13.50/100
0.5mm 3 core (3A) round 18 p/m £15.00/100

CLOCK RADIO – VHF/LW/MW

Mains, digital display alarm clock/radio. Alarm control/Wake to music. Sleep control – 10 min. Snooze. Hour/Minute Time Setting. Brightness Control. £8.50 each (plus additional postage 75p per set).

PLASTIC BOXES

3 × 2 × 1"	0.35
3 × 2½ × 2"	0.65
4 × 3 × 1½"	0.83
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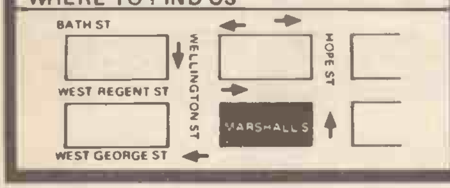

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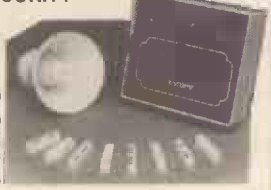

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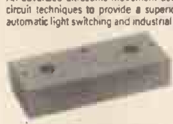

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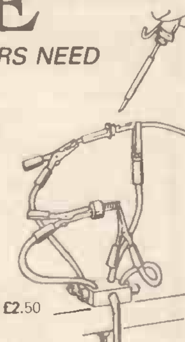

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INCREASE

I HOPE you have noticed your magazine is a larger size than normal; unfortunately I expect you have also noticed it has cost you 10 pence more than normal. Strange as it may seem the two are *not* related. We have been able to increase the size without increasing our printing and paper costs—such are the quirks of modern printing. However, due to generally increasing costs—like me (and the rest of the staff) asking for a pay rise occasionally and sometimes even getting it!—we have been forced to add that 10p to the cover price.

Of course EE has been cheaper than its competitors for some time, and still is in some cases. We believe it has also represented better value for money than the competition and we intend to make sure that continues. The new size is here to stay, and it does add some more words to the page. Now for more news.

TITLE CHANGE

Next month the title of your magazine will change slightly, but don't worry what is inside will still be very much the same—in line of course with our policy of continual improvement and value for money. What we have done is to purchase *Electronics Monthly* magazine and we will be merging it with EE—*Everyday Electronics and Electronics Monthly* will be born. Yes, it is a bit of a mouthful but we want to welcome *Electronics Monthly* readers to our pages so it is necessary. You will find some more information about next month's issue on page 549.

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Because *Electronics Monthly* readers will also now be buying EE & EM there will be a large increase in demand for issues. We will, of course, be printing many more but **you should make sure of your copy by placing an order with your newsagent now.** Alternatively, why not take out a subscription (see page 468), the issues will then be posted to you for no extra charge. In fact at £13 for a UK subscription you save 20p on the actual cover price over the year. You are also saved from any cover price increases in that year (although we hope there will not be any!).

Everyday Electronics moves ahead yet again.

Mike Kenward

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SIMPLE REVERB UNIT

JOHN M.H. BECKER

IN the author's dictionary *echo* and *'reverberation'* are given a similar definition of *to send back sound.* In reality, with effects units the author regards reverb as referring to narrowly spaced repetitions of an original sound, each at a slightly lower level than the preceding one—the sort of sound created when speaking in a bare room with nothing to absorb the reflections. Echo on the other hand is also regarded as successive repetitions but with wider spacing between them, as found when shouting across a steep valley or when surrounded by tall buildings. In the former case the repetitions cannot be distinguished too clearly from each other, but with the latter shortish words can be heard to repeat. It will be apparent that a time delay exists in the repetition rates of both cases, but for reverb the delay time need only be short providing the number of repetitions is sufficiently spread over a reasonable period.

One way of producing a delay for electronic reverb modules is to send an audio signal along a mechanical spring line which itself physically vibrates, and catching it at the other end, the delay depending upon the spring length and the reverb upon its shakability. Unless expensive, these units are notoriously prone to distortion and create 'clangs' if knocked. They are also bulky and the units to drive them are current-hungry and usually need a mains power supply. Over the last few years, a selection of integrated circuit delay chips has become available at a reasonable price and which can be battery powered, take up far less space, and also produce much longer delay times than the spring line units, especially if chained. However, there is a penalty inherent in them in that a high frequency clock signal is required to drive them, and which contributes to background noise levels. The frequency of the clock determines the delay length—for longer delay times the slower the clock that is needed, and this can come down towards the audio range. Low pass filtering is thus required, which inevitably means that some of the upper frequencies of the required signal are lost. In a simple unit it becomes a trade off between long delays with an upper frequency cut, or short delays with little treble cut. The length of delay also depends on the number of stages within the chip. The author is aware of several available chips: the 512, 1024, 1536 and 4096 stages. The latter though is in the £40·00 price bracket.

For the unit described here the chip chosen is a single 1536 stage unit, the TDA1097. At the highest clock frequency permitted of 100kHz, this produces a delay of 7·68ms. The slowest clock can be 5kHz, giving a delay of 153·6ms. The clock frequency though should be outside the normal audible range, and three times greater than the maximum input signal frequency. The compromise slowest clock frequency chosen is 12kHz for 60ms delay. The main filter stage gives a 12dB cut at 4kHz. This may be low for music purists, but for those who do not need perfection this unit should be ideal. For those who do there are more expensive units available elsewhere. The signal-to-noise ratio is not hi-fi but consideration has gone into maximising it, whilst keeping low costs in mind. The highest clock frequency of 36kHz gives a 20ms delay. With careful setting up and at maximum delay, a single input pulse can reverb for three or four seconds before dying away to about 50mV.

HOW IT WORKS

The signal, which should preferably be preamplified, is brought in to the volume control VR1. From here it is split to pass unprocessed to the output stage IC1c, and to the first filter stage IC1a. This serves the dual purpose of removing some of the upper frequencies to minimise distortion through the delay chip at slower clock speeds, and also acts as a secondary filter in the reverb feedback path, further reducing clock residue signals. C2 and C3 are the prime setters of the low pass range. For signals within that range, the output amplitude from IC1a is roughly equal to that put in. The signal strength reaching the delay chip IC2 should not exceed 1·5mV r.m.s. As the feedback signal will be added to the original within IC1a, the amplitude emerging from it could be twice that of the original signal. This restricts the maximum presented from VR1 to 750mV r.m.s. VR1 of course will accept much higher than that, but the control will need to be kept down.

DELAY STAGE AND CLOCK

The input port to IC2 requires an optimum d.c. bias to be added to the signal. The correct bias will keep the signal symmetrical within the chip, and so minimise distortion. This is derived from VR2 inserted in the potential divider chain R6, R7, R9, the latter ensuring a small bias also on pin 7 of IC2. The preset voltage from VR2 is applied via R8. As previously stated, a clock signal is required in order to pass the signal successively along all 1536 stages within IC2. IC1d forms the high frequency oscillator producing a square wave output. An initial bias is set by R20 and R21, and the frequency of oscillation is set by the value of C16 and the total resistance across R23 and VR7/R29. As the resistance of VR7 is reduced, so the rate of charge of C16 increases, resulting in a higher output frequency. The full range available with VR7 on its own was felt to be too great, and R29 has been shunted across to reduce it. The total maximum resistance across VR7/R29 is approximately 80k, as opposed to the nominal 100k of the pot itself. IC2 needs two opposing clock signals simultaneously, one going up while the other goes down. The first is taken direct from IC1d to IC2, the second is produced by inverting the first at TR1. C17 is a buffer capacitor, R24 & R25 set the bias, and R26 is the collector load. The two signals are slightly disparate in shape and amplitude but this is unimportant in this simple unit. The signal passes through IC2 and emerges at two outputs, pins 4 and 6, and summed at R10. Here the composite signal also contains a certain amount of the clock signal superimposed. Although this is outside the average audio range, it still needs to be reduced.

FILTER AND OUTPUT

In more expensive units, several filter stages are often cascaded to achieve this. Here some of it is mopped up by C7 before reaching the main filter IC1b. The action is the same as that in IC1a, with C8 and C9 doing the work at a lower frequency cut off point. There is roughly a 50dB cut at 12kHz so the signal at the output of IC1b is mostly free of the clock noise and for normal amplification uses the remainder will only be apparent in the absence of the main signal to those with exceptional hearing. At this same point the processed signal is now split. It is of course delayed in respect to the original, and with which it can now be mixed at IC1c via VR4. For the original signal the amplitude is kept constant by the ratio of R17 and R18, however, the ratio of R16 to R18 has been arranged to give an increase to the delayed level for greater emphasis. From C15 the multiple signal can be passed to the normal amplifier system.

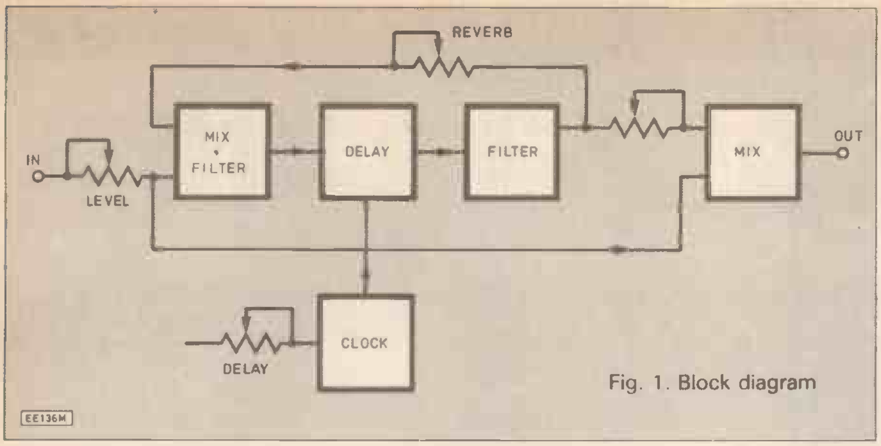
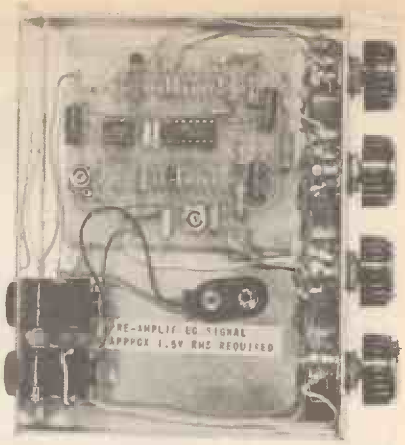


Fig. 1. Block diagram



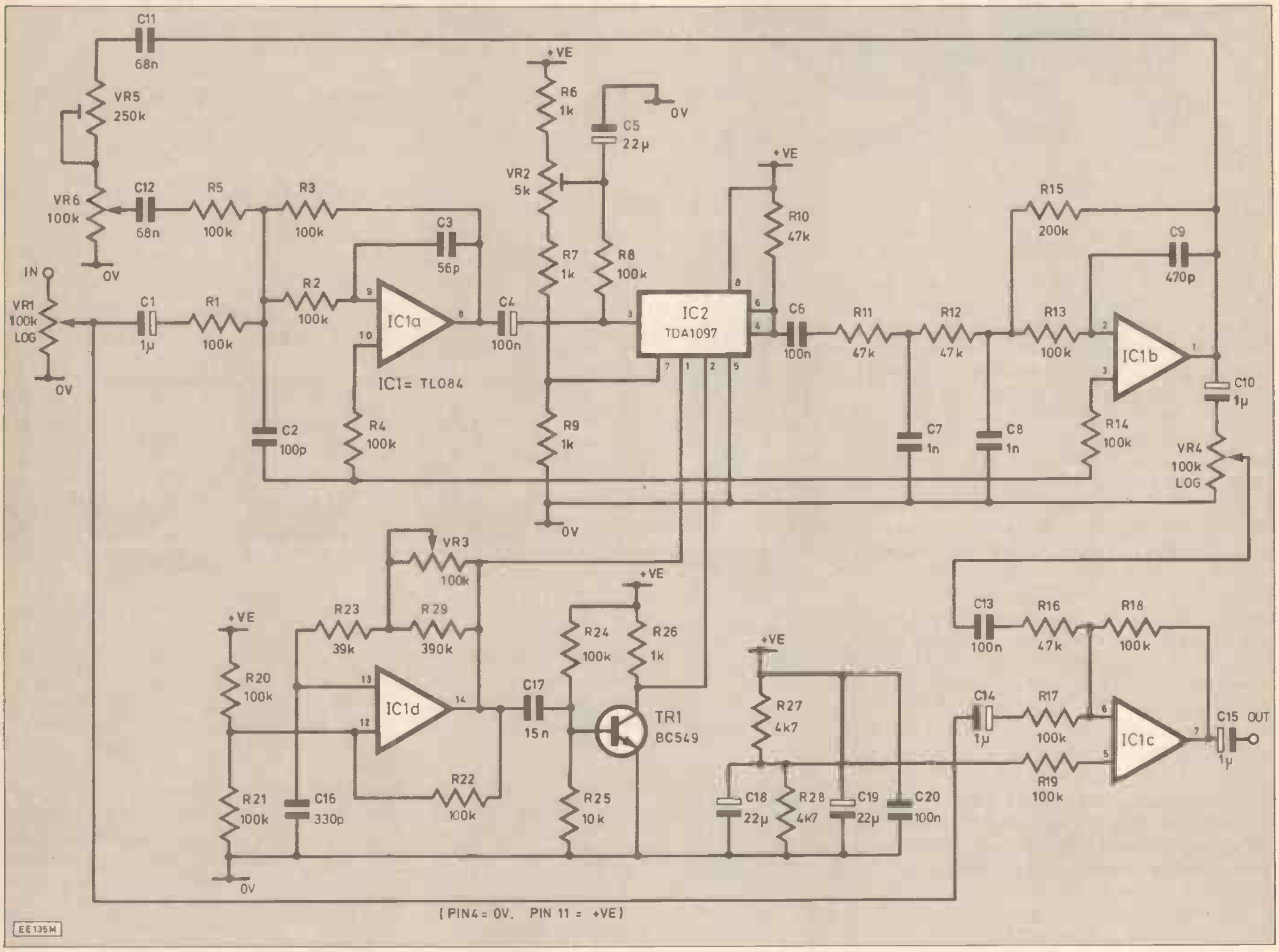


Fig. 2. Circuit diagram for the Simple Reverb Unit

REVERB PATH

The second part of the split signal is the one that determines the reverberation depth. It is passed via C11 to VR5 which presets the maximum that can be fed back, and then to the reverb level control VR6. Thence it is mixed with the original at IC1a and again passed through the delay loop. VR5 and VR6 are set so that the loop signal is slightly lower than the main one, so that on each time round the loop, the total loop level diminishes. This gives the required reverberation decay effect. If VR5 is set too high a perpetual loop can result, which under extreme conditions will provoke 'howl'. This is especially prevalent with lower frequency signals at high amplitude if VR5 is set too low. Careful setting of VR5 and observing the input level restrictions will avoid this. Should it happen, reducing VR6 momentarily will stop it. Simple signal clipping could restrict the 'howl' possibility, but the likelihood of howl was considered less than the greater likelihood of transient peaks being distorted by the clipping.

POWER SUPPLY

The unit is run from a single 9 volt battery at about 12mA. Most of this current is due to the thirstiness of the TL084 high impedance op-amp IC1. In many instances the less thirsty LM324 can be substituted for a TL084. Not in this case as the input impedance is lower and the output swing not so full at higher frequencies. This would not worry the signal stages so much, but the clock generator would definitely suffer and possibly fail to produce the minimum swing needed by IC2. The midway reference point voltage required by the three signal op-amps within IC1, is set by the potential divider R27/R28. C18, C19, C20 provide reference and power line smoothing.

The unit will operate from a power supply up to 16V d.c., but do not exceed this as IC2 could die if supplied with greater than 16V. Two 9V batteries in series are definitely out! The optimum supply actually lies between 12V and 16V, but in the author's expereince only minimal signal degradation results from powering by 9V, a single 9V battery, a PP3 for example, can be used satisfactorily. The input jack socket also serves as the *BAT ON/OFF* switch.

ASSEMBLY

If a unit fails to work first time, the usual most likely reason is bad solder joins. Check the p.c.b. after assembly with a magnifying glass for bad joins, and possible solder

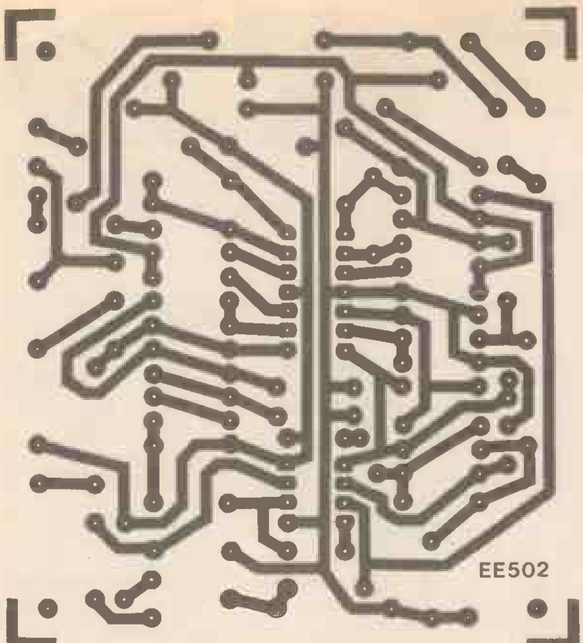


Fig. 3. P.c.b. (actual size)

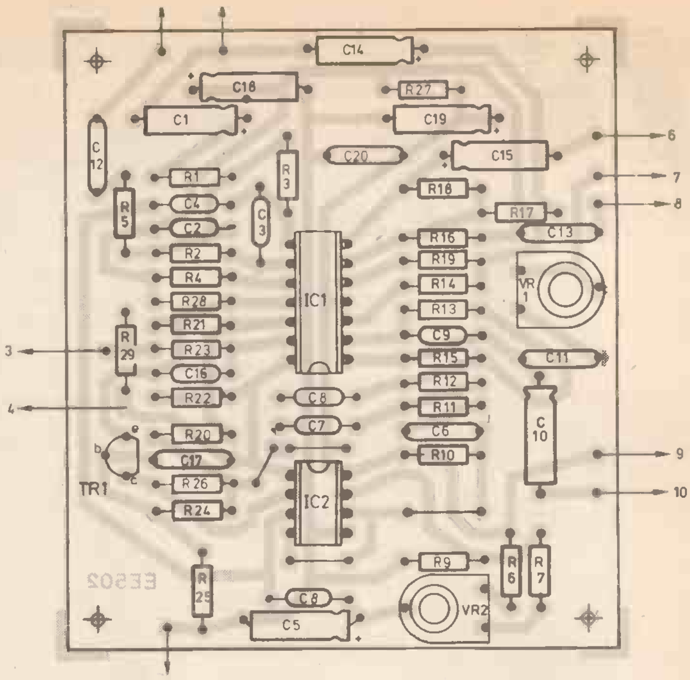


Fig. 4. Component layout

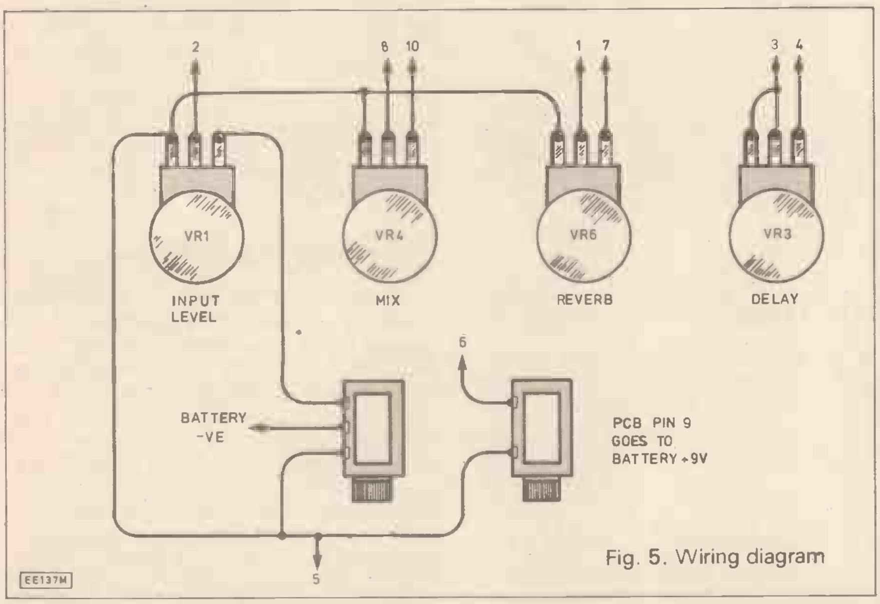


Fig. 5. Wiring diagram

shorts between tracks. Resolder anything doubtful, and cautiously use a pointed tool to scratch away any solder residue between joins, notably between the i.c. legs. Wiring interaction is unlikely and screened leads should not be necessary. Do not screen the leads to VR7 as this could upset the clock response. Just keep wires neat and short, but long enough to examine the other side of the p.c.b. if the need arises. Too much flexing of wires can cause them to break at the soldered ends. IC2 is MOS and should be handled with the usual precautions. Upon completion panel markings can be applied using rub-down lettering.

SETTING UP

VR1, 4, 6 min, VR2 midway, VR5 max resistance, VR7 min (highest clock). Connect unit to signal source and main amplifier. A click track or snare drum recording will show the best effect at this time. Bring up VR1 for a reasonable level less than the maximum stated above, and check that a straight signal passes through to the amplifier via IC1c. If it does not, check your work again! Assuming all is well bring up VR4 fully whereupon a quality change should be apparent. Adjust VR2 around its midway point until the minimum distortion is heard. Too far in either direction will not only result in distortion, but could cause IC2 to not process the signal properly. If necessary this preset can be re-adjusted later following other tests. Reduce VR7 to minimum. The maximum delay signal should be clearly heard mixed with the original. The effect is echo double tracking. Varying VR7 will conform this. Bring up VR6 to max and carefully adjust VR5 from maximum resistance until the reverberation feedback effect is clearly heard. If the resistance is reduced too far howl will occur whereupon VR5 should be backed off markedly and then start again. Aim for the maximum reverb without the unit kicking into perpetual howl on heavier low notes. Taking down VR4 will remove the echo-reverb signal, leaving the unit in bypass mode. With careful setting of VR5 and VR6 a marked tunnel effect should result with VR7 at the slowest clock speed. Experiment with the unit for a while trying various combinations of the panel controls, then if necessary slightly readjust VR2 and VR5.

USE

Reverberation is an extremely useful sound effect which can be used to compensate for flat-sounding live or recorded speech and music, by giving a more spacious sound to the acoustics. For most situations ¾ settings of VR4/6/7 will produce the required enhancement, with VR1 setting the best input level. This should be as close to the maximum as feasible to avoid signal-to-noise degradation. For low level signals it is best to pre-amplify them first, especially for microphone use for which the unit is not suitable without pre-amplification. Remember to turn down VR6 before switching on otherwise the switch-on pulse will kick the unit into full feedback. □

COMPONENTS

See SHOPTALK Page 554

Resistors

R–R5,R8,R13,R14	
R17–R22,R24	100k (15 off)
R6,R7,R9,R26	1k (4 off)
R10–R12,R16	47k (4 off)
R15	200k
R23	39k
R27,R28	4k7 (2 off)
R25	10k
R29	390k

All ¼W 5% carbon film

Capacitors

C1,C10,C14,C15	1µ/63V elec(4 off)
C2	100p polystyrene
C3	56p polystyrene
C4,C6,C13,C20	100n poly (4 off)
C5,C18,C19	22µ/16V elec (3 off)
C7,C8	1n polystyrene (2 off)
C9	470p polystyrene
C11,C12	68n polyester (2 off)
C16	330p polystyrene
C17	15n polyester

Potentiometers

VR1,VR4	100k log mono (2 off)
VR2	5k skeleton
VR5	250k skeleton
VR3,VR6	100k mono (2 off)

Semiconductors

TR1	BC549
IC1	TL084
IC2	TDA1097

Miscellaneous

Clip PP3; P.c.b. clips (4 off); Knobs (4 off); PCB232A; 8-pin i.c. socket; 14-pin i.c. socket; Mono jack socket; Stereo jack socket

TEACH-IN '86

PART 1 · Michael Tooley BA David Whitfield MA M Sc C Eng MIEE

Welcome to *Teach-In* '86. In this, our latest Teach-In series, we intend to provide you, the reader, with a comprehensive background to modern electronics. Our aim has been that of producing a series which is both eminently readable and easy to follow even for those with no previous experience of the subject.

We have therefore placed more emphasis on the practical, rather than the theoretical aspects of electronics. To this end we have kept the mathematical content of our series to an absolute minimum. If you can perform simple addition, subtraction, multiplication and division then you will have no difficulty in following the series!

Although the nine part series has been designed for the complete newcomer, we also expect it to be of value to those with some previous experience. Wherever possible we have related our series to 'real-life' working circuits. We have used practical component values and all the circuits have been well tested.

To complement each published part of the Teach-In series, we have produced an accompanying computer program. This Teach-In software is available for both the BBC Microcomputer (Model B) and the Sinclair Spectrum (48k) or Spectrum-Plus. The programs are designed to reinforce and consolidate important concepts and principles introduced in the series. The software also allows readers to monitor their progress by means of a series of multi-choice tests, with scores at the end.

There will be three cassettes in all, each with three full parts, i.e. parts 1, 2 & 3 will be on Tape 1, parts 4, 5 & 6 will be on Tape 2, and parts 7, 8 & 9 will be on Tape 3. An announcement regarding the cost and availability of the tapes will appear in next month's Teach-In.

Another departure from previous Teach-In's is that, besides the usual selection of experiments designed to complement the teaching text, we shall each month describe a companion constructional project. These have been carefully chosen to illustrate the practical application of the components and devices introduced in the series and, more importantly, each project deals with the construction of an item of test equipment which is useful in its own right.

We hope that you enjoy the series and would welcome any feedback or queries. These should be directed, in the first instance, to the editorial office at Poole, and should be accompanied by a stamped addressed envelope.

PRACTICAL ASSIGNMENTS

No electronics course would be complete without practical assignments. To this end we have included a number of practical exercises designed to complement the theoretical parts of the course.

In order to carry out these exercises readers will have to obtain, or have access to, the following items:—

A multimeter.
A solderless breadboard.
A selection of connecting leads.
Power supply/batteries.
A selection of readily available components (to be specified as required).

For the benefit of the complete newcomer we will briefly explain what each of these items is. Before doing so, however, it is worth mentioning that we have attempted not only to keep the apparatus required for our practical exercises to a bare minimum but also to ensure that it is readily available from both retail component supply shops and mail order suppliers in this magazine. If all items (excluding components) have to be purchased at the outset the cost need be no more than about £25.

MULTIMETER

A simple low-cost analogue multimeter will undoubtedly prove to be a most useful investment which will continue to be a valuable tool long after the 'Teach-In' series has been completed. A typical specification of this instrument would be as follows: **d.c. voltage ranges**: 2·5V, 10V, 50V, and 250V full-scale; **d.c. current ranges**: 5mA, 50mA, and 500mA full-scale; **a.c. voltage ranges**: 10V, 50V, and 250V full-scale: **Resistance ranges**: 10kohm, 100kohm, and 10Mohm full-scale; **Accuracy**: 4% of full-scale deflection on d.c., 5% of full-scale deflection on a.c; **Sensitivity**: 20kohm/V on d.c. and 5kohm/V on a.c., or better.

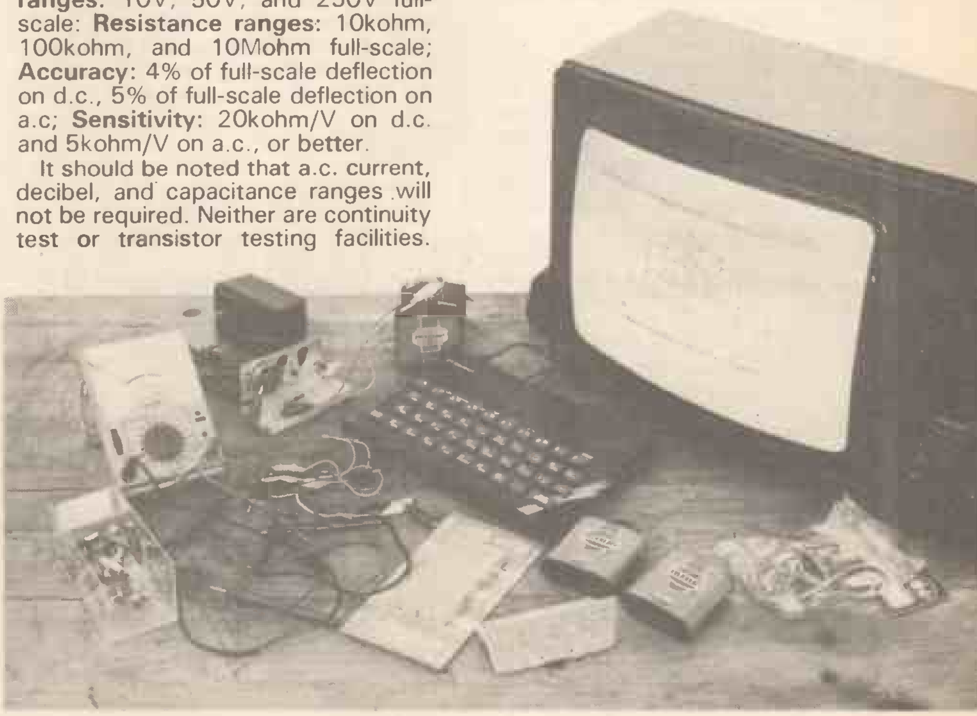
It should be noted that a.c. current, decibel, and capacitance ranges will not be required. Neither are continuity test or transistor testing facilities. A suitable instrument would the the Alt-Ai M–102BZ, around £15.

CONNECTING LEADS

A selection of test leads will be required. Test leads fitted with prods are normally supplied with multimeters (such is the case with the recommended instrument) and hence the requirement will normally be for leads to connect power supplies and test gear to the breadboarded circuit under investigation. For this we would recommend a number (approximately ten) of short leads (350 to 400mm, or so) terminated with insulated crocodile clips. To prevent confusion, these leads should ideally be colour coded so that it is possible to distinguish one from another.

BREADBOARD

In order to provide a solderless method of component interconnection a small 'breadboard' is required. For the benefit of the newcomer, a breadboard is simply a device which allows circuits to be built in such a way that the components can be used over and over again. Component wires are pushed into the boards (rather than being soldered) where they are held firmly by spring contacts. Such circuits can be easily modified by pulling the components out and plugging them in again in the required position.



The breadboard recommended for the Teach-In series is known as a Vero "Plugblock". This provides a total of 360 contacts arranged in two rows of five interconnected sockets on a 0·1 × 0·1 inch matrix. The spacing of the matrix is important and has been designed so that standard integrated circuit devices can be accommodated.

Besides the breadboard itself, readers may find that a small mounting bracket for potentiometers, switches etc, will also be useful. Design sheets are also available from some suppliers which will be useful when the time comes for readers to design their own circuits.

POWER SUPPLY/BATTERIES

Most of our circuits will require a d.c. power source of either 4·5V or 9V, which can be conveniently (and safely!) derived from dry batteries. The most complex circuit arrangement in this series (at least regarding d.c. supplies) will require separate positive and negative d.c. supply rails of +9V and −9V respectively. This can be achieved by means of a series combination of four 4·5V batteries and thus we have chosen to standardise on a commonly available 4·5V torch battery, the Ever Ready 1289. Alternatively a d.c. power supply unit operating from the 240V mains can be employed. Just such a unit is the subject of our first accompanying Teach-In project, see page 560.

COMPONENTS

The components used in the Teach-In practical assignments are available at low cost from component suppliers advertising in this magazine. Some readers will undoubtedly already have many of the necessary components to hand whilst others will have to start from scratch. To assist readers, we shall include a list of all components required for the following month's instalment.

PROBLEMS

At the end of each part of the series we will pose a number of problems for readers to solve. Since these will vary in difficulty we will, for guidance, include a 'difficulty rating'. Readers are encouraged to devote an hour, or two, to produce their own solutions which may be compared with those given in the following month's instalment.

Electronics

Whether we are aware of it, or not, electronics has pervaded almost every facet of our everyday lives. We awake to the sound of a digital alarm clock, catch up with the news by listening to the radio or watching the television, relax in front of the video, and organise our businesses with computers. The list is endless indeed the more cynical amongst us might be excused for wondering how we ever managed without electronics!

For the non-technical, electronic systems appear at first sight to be so complex that a detailed understanding of their operation and behaviour is totally beyond comprehension. Fortunately this is not the case since even the most complex of systems can be broken down into easily understandable component parts.

A radio receiver, for example, usually contains no more than a dozen different types of electronic component. When taken in isolation, the action of each of these component types can be easily explained. As a consequence the collective action of a number of different components can be understood. All this supports a 'bottom-up' approach to electronics; by starting with the nuts and bolts we may eventually hope to build a bridge.

ATOMS, PROTONS, AND ELECTRONS

The smallest part of an element that can exist and yet retain the properties of the element is known as an atom. As you might expect, atoms are very small and are completely invisible to the naked eye. Atoms themselves comprise a central body, the nucleus, around which a number of smaller (and much lighter) particles orbit in spherical layers called shells.

Each of these tiny orbiting particles carries a small negative electric charge (electrons). The nucleus itself contains, amongst other things, a number of positively charged particles (protons). The positive charge on the nucleus exactly balances the total charge on its associated electrons.

Since protons and electrons have dissimilar charges, a force of attraction exists between the nucleus and its associated electrons. Despite this, it is possible for an atom to lose one of its outer shell electrons. The atom is then left with a net positive charge and is called a positive ion. If, on the other hand, the atom gains an electron it will acquire a net negative charge and is then referred to as a negative ion.

CURRENT

By organising electrons into motion we can produce an electric current. To do this, however, we need a source of charge. Happily this need be nothing more than a single cell battery! (The positive and negative electrodes of a battery can be thought of as sources of positive and negative charge respectively).

As electrons arrive at the positive electrode, other electrons will be injected at the negative electrode and the current will continue as long as an imbalance of charge exists across the ends of the conductor (or as long as the battery remains active!).

The outer shell electrons within a metallic conductor are relatively mobile and are continually in random motion even when no external source of charge is connected, as shown in Fig. 1.1. When dissimilar charge sources are connected to the ends of a conductor the free electrons (i.e. those which are relatively mobile) drift towards the positive electrode, as shown in Fig. 1.2.

It is important to note that the passage of electrons from the negatively charged electrode to the positively charged electrode is not instantaneous. Electrons leaving the conductor at the positive electrode are replaced from adjacent atoms and this process is repeated throughout the length of the conductor.

The magnitude of a current is a measure of the number of electrons passing a given point in a fixed interval of time. It is not possible for us to measure individual electrons but we are able to detect this rate. The unit of current is the ampere (A). For the curious, a current of 1A is equivalent to approximately $6{\cdot}2 \times 10^{18}$ electrons passing a point in one second!

CIRCUIT DIAGRAMS

Circuit diagrams are simply 'electronic street maps' which show, in a convenient symbolic form, how individual components are linked together. Direct connections are shown with solid lines and junctions with 'blobs'. We can, within a circuit diagram,

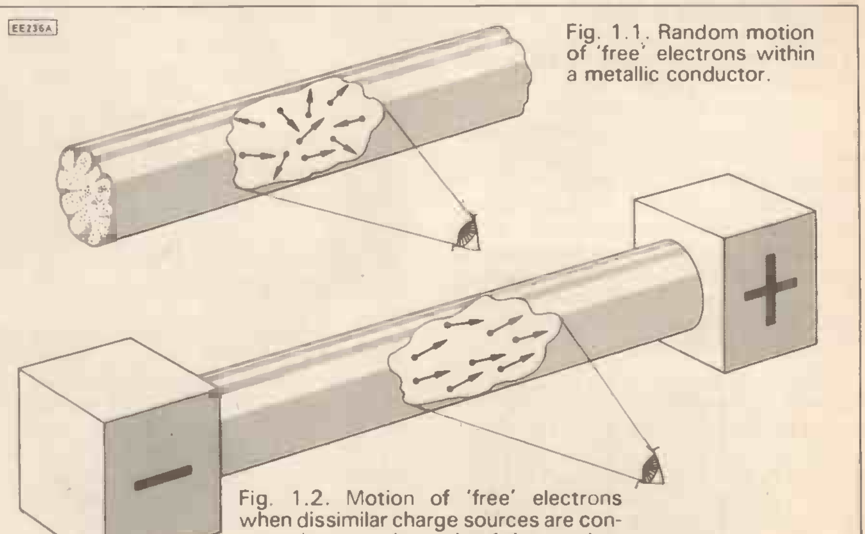


Fig. 1.1. Random motion of 'free' electrons within a metallic conductor.

Fig. 1.2. Motion of 'free' electrons when dissimilar charge sources are connected across the ends of the conductor in Fig. 1.1.

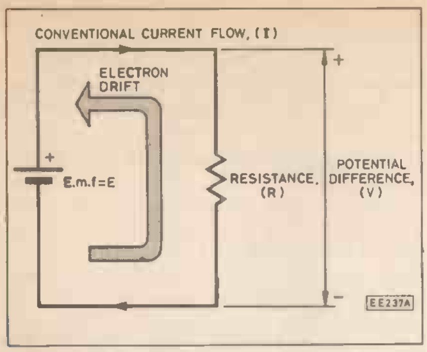


Fig. 1.3. A simple circuit using only two components.

clearly identify the paths along which electric current can pass.

Fig. 1.3 shows a simple circuit diagram using just two components, a battery and a resistor. The connecting wires between the components are assumed to be perfect conductors (i.e. they are assumed to have zero resistance). In practice this would never be the case however, since the resistance of the wires is almost always negligible compared with the resistance of the resistor, we can safely ignore any small value of resistance which they may possess.

Electrons with their accompanying negative charge, will travel around the circuit away from the negative and towards the positive terminal of the battery. Unfortunately, the conventional direction of current flow is assumed to be from positive to negative hence, whilst electrons drift in one direction (anticlockwise in Fig. 1.3) the conventional flow of current (as indicated by the arrows on the wires) is in the opposite direction.

ELECTROMOTIVE FORCE AND POTENTIAL DIFFERENCE

The ability of a battery to produce a movement of electrons within a conductor is a measure of its electomotive force (e.m.f.) measured in volts (V). For a given conductor the strength of current flowing in it (in terms of the number of electrons passing a given point in a fixed time) will depend on the strength of the e.m.f. applied. Doubling the e.m.f. will double the current flowing, halving the e.m.f. will halve the current flowing, and so on.

Whenever an e.m.f. is applied to a circuit a potential difference (p.d.) exists. Thus e.m.f. and p.d. are inseparable; e.m.f. is the cause and p.d. is the effect. Like e.m.f., p.d. is measured in volts (V). In many practical circuits there is only one e.m.f. present (the supply) whereas a p.d. is developed across each component.

RESISTANCE

Clearly for any given conductor, the current flowing will be directly proportional to the e.m.f. applied. This, however, is not the end of the story! The current flowing will also be dependent on the conductor itself; its physical dimensions (length and cross-sectional area) and the material of which it is composed.

The amount of current that will flow in a conductor when a given e.m.f. is applied is inversely proportional to its resistance. Resistance, therefore, may be thought of as an opposition to current flow; the higher the resistance the smaller the current that will flow in it (assuming that the applied e.m.f. remains constant).

Provided that temperature does not vary; the ratio of p.d. across the ends of a conductor to the current flowing in the conductor is a constant. This relationship, known as Ohm's law, leads us to the conclusion that:—

$$\frac{V}{I} = \text{a constant} = R$$

Where V is the p.d. in volts (V), I is the current in amps (A), and R is the resistance in ohms (Ω).

The foregoing formula may be rearranged to make V or I the subject as follows:—

$$V = I \times R \quad \text{and} \quad I = \frac{V}{R}$$

RESISTORS IN SERIES

When two or more resistors are connected so that the same current flows first through one and then the other, the resistors are said to be connected in series. The total p.d. across the series arrangement of resistors will be equal to the sum of the individual voltage drops, as shown in Fig. 1.4.

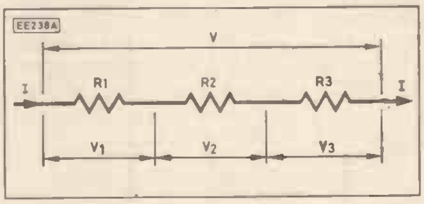


Fig. 1.4. Resistors connected in series.

Applying Ohm's law to each resistor we therefore conclude that:—

$$V = V_1 + V_2 + V_3$$

$$V = IR_1 + IR_2 + IR_3$$

But, $V = IR$

Where R is the equivalent resistance of the series combination.

Hence, $IR = IR_1 + IR_2 + IR_3$

Dividing both sides by I we get:—

$$R = R_1 + R_2 + R_3$$

Hence the equivalent resistance of a series circuit is the sum of the individual resistance values.

RESISTORS IN PARALLEL

When two or more resistors are connected so that the current is divided between them, the resistors are said to be in parallel. In a parallel circuit the same p.d. will appear across each resistor, as shown in Fig. 1.5. The total current must be equal to the sum of the individual currents and thus:—

$$I = I_1 + I_2 + I_3$$

But using Ohm's law we get:—

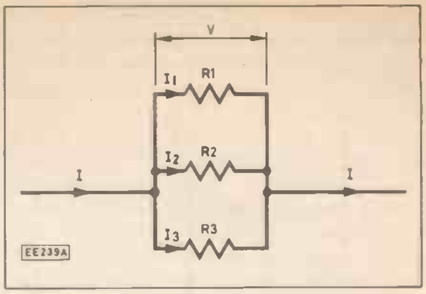


Fig. 1.5. Resistors connected in parallel.

$$I_1 = \frac{V}{R_1},\ I_2 = \frac{V}{R_2} \text{ and } I_3 = \frac{V}{R_3}$$

and also, $I = \frac{V}{R}$

Where R is the equivalent resistance of the parallel combination.

Thus, $\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$

Dividing both sides by V we get:—

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

When only two resistors are involved, rather than three or more, we can use a somewhat simpler expression:—

$$R = \frac{R_1 \times R_2}{R_1 + R_2}$$

(Readers proficient in the art of mathematics are invited to confirm that this expression is valid!)

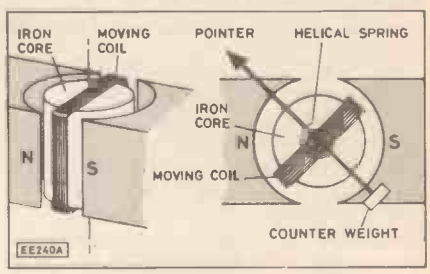
Thus, provided that a parallel circuit comprises only two resistors, its equivalent resistance will be given by the product of the two resistance values divided by the sum of the two resistance values.

AMMETERS AND VOLTMETERS

It is impossible from a mere visual inspection to determine the magnitude of current in a conductor. Indeed, the difficulty many people have understanding electricity arises from the simple fact that an electric current cannot be seen. Instead we have to learn to recognise the presence of an electric current by its effects.

The most obvious effect of an electric current is associated with a rise in temperature within a conductor (or resistor) and, whilst this may be self evident when sitting in front of an electric fire, the magnitude of the current involved with most electronic circuits precludes us from detecting

Fig. 1.6. Internal arrangement of a moving coil meter.



current by means of temperature changes alone. Instead our most familiar instrumentation, the moving coil meter, relies upon the magnetic effect of a current.

The moving coil meter consists of a coil of fine wire suspended in a radial magnetic field, as shown in Fig. 1.6. A pointer is attached to the coil and deflection of the coil and pointer results from an interaction between the constant magnetic field produced by the permanent magnet and the (much weaker) field which encircles a current carrying conductor.

With typical full-scale deflection sensitivities of between 50μA and 1mA, the moving coil instrument is able to detect quite weak currents in a circuit. To measure the current we must break the circuit at some point and re-make the connection with the moving coil instrument. Where currents in the circuit exceed the basic full-scale deflection of our meter we can simply bypass excess current using a parallel connected 'shunt' resistor, as shown in Fig. 1.7.

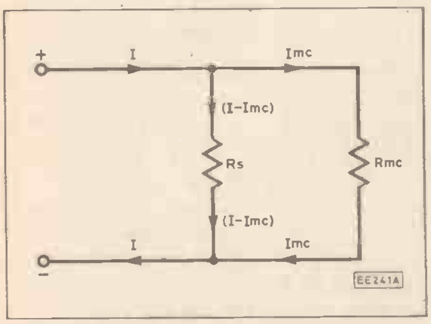


Fig. 1.7. Use of a shunt resistor to measure current.

Since the moving coil meter is basically a current sensing device we will have to modify the circuit before attempting to measure voltage. This can be done by connecting a 'multiplier' resistance in series with the meter, as shown in Fig. 1.8.

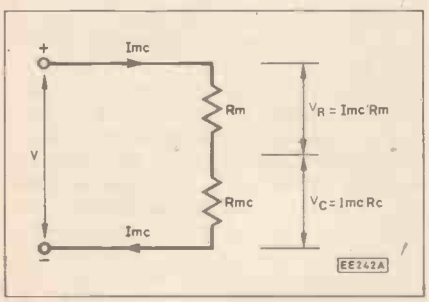


Fig. 1.8. Use of a multiplier resistor to measure voltage.

The required value of shunt or multiplier can be easily calculated using nothing more than Ohm's law. However we do need to take into account the resistance of the moving coil itself, as indicated by the following formulae:—

$$R_S = \frac{I_{MC}\,R_{MC}}{I - I_{MC}} \quad \text{(see figure 1.7)}$$

$$R_M = \frac{V}{I_{MC}} - R_{MC} \quad \text{(see figure 1.8)}$$

Where, R_S = required value of shunt resistor

R_M = required value of multiplier resistor

V = full-scale deflection voltage (voltmeter)

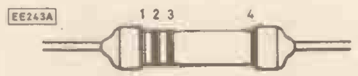
I = full-scale deflection current (ammeter)

I_{MC} = basic full-scale deflection current of the moving coil meter

R_{MC} = resistance of the moving coil meter

RESISTOR COLOUR CODE

A system of colour coding is universally adopted for carbon and metal oxide resistors (wirewound resistors of high power rating normally have their values printed on their ceramic bodies). The resistor body is coded with coloured bands, see Fig. 1.9.



COLOUR	BAND 1 1st FIGURE	BAND 2 2nd FIGURE	BAND 3 MULTIPLIER	BAND 4 TOLERANCE
BLACK	0	0	X1	
BROWN	1	1	X10	1%
RED	2	2	X100	2%
ORANGE	3	3	X1,000	
YELLOW	4	4	X10,000	
GREEN	5	5	X100,000	
BLUE	6	6	X1,000,000	
VIOLET	7	7		
GREY	8	8		
WHITE	9	9		
GOLD			X0.1	5%
SILVER			X0.01	10%

Fig. 1.9. Resistor colour code.

With only a little practice, it is relatively easy to read the value of a resistor. Three examples are shown in the box below.

MULTIPLES AND SUB-MULTIPLES

In electronic circuits resistances are often quite large in value (resistors of several thousands or tens of thousands of ohms are quite common) and thus currents are consequently quite small. Hence, rather than talk in terms of the basic units (A, V and Ω) we adopt standard multiples and submultiples. For the benefit of newcomers these are listed below together with their associated prefixes:—

Thus a resistance of 1200 ohms is usually referred to as 1·2kΩ, a voltage of 0·045 volts as 45mV, and a current of 0·0000067 amps as 6·7μA. All we need do is move the decimal point the appropriate number of places (3, 6, 9, 12 etc) to the right or left and use the corresponding prefix.

POWER RATING

Power is the rate at which energy is consumed. In terms of the heat produced by a resistor, the power dissipated is the product of the p.d. developed across the resistor and current flowing in it. Hence:—

$$P = I \times V$$

Power is measured in watts (W) and a power of 1W is dissipated when a p.d. of 1V exists across a resistor carrying a current of 1A.

We can use Ohm's law to replace either I or V in the previous relationship to obtain the following formulae:—

$$P = \left(\frac{V}{R}\right) V = \frac{V^2}{R}$$

and, $P = I(IR) = I^2R$

In a practical circuit it is important that resistors are rated for adequate power dissipation. The result of using a 0·5W resistor to replace an identical value component dissipating 2W would be disastrous—the replacement would very quickly burn out!

It is also important, though to a lesser extent, that we do not use grossly over-rated resistors. There would be little point in using large (and expensive!) 10W resistors in a circuit in which the power dissipation of the resistors never exceeded 1W.

Unfortunately, power rating does not form part of the resistor colour code and, although some of the larger ceramic resistors have a power rating printed on them, we can often only guess the power rating of a resistor (unless, of course, we were aware of the manufacturer's rating when the resistor was originally purchased!). Happily, the power dissipation in most modern electronic circuits is very small and a stock of 0·25W or 0·3W resistors will generally prove adequate for most applications.

PREFERRED VALUES

Normal manufacturing tolerances for resistors lie in the range ±2% to ±10% and hence, rather than attempt to supply every conceivable resistance value, manufacturers provide us with a limited range of 'preferred'

Prefix			
Mega	= one million	$= \times 10^6$	abbreviated M
kilo	= one thousand	$= \times 10^3$	abbreviated k
milli	= one thousandth	$= \times 10^{-3}$	abbreviated m
micro	= one millionth	$= \times 10^{-6}$	abbreviated μ
nano	= one billionth	$= \times 10^{-9}$	abbreviated n
pico	= one trillionth	$= \times 10^{-12}$	abbreviated p

Three typical resistor values (see Fig. 1.9).

Band 1	Band 2	Band 3	Band 4			
Orange	Orange	Black	Silver	=	33 × 1	= 33Ω 10%
Blue	Grey	Brown	Gold	=	68 × 10	= 680Ω 5%
Brown	Black	Red	Gold	=	10 × 100	= 1000Ω 5%

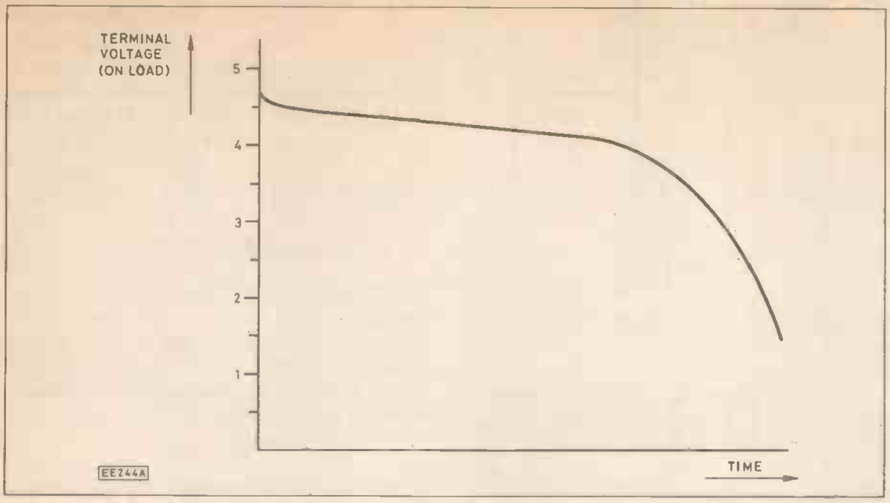


Fig. 1.10. Typical voltage/time graph for a 4·5V battery 'on-load'.

values. This, however, is no serious shortcoming since circuits can usually be designed so that they do not require precise values (indeed this is good practice on the part of the circuit designer!).

With ± 10% tolerance we can cover the entire range of resistance values with minimum overlap using just twelve basic values and their decade multiples. This range is known as the E12 series and is based on the following values:—

1, 1·2, 1·5, 1·8, 2·2, 2·7, 3·3, 3·9, 4·7, 5·6, 6·8, and 8·2.

Hence 10Ω, 150Ω, 1·8kΩ, 22kΩ and 820kΩ are all members of the E12 family and would be used in circuits where, for example, we required values of 9Ω, 160Ω, 1·7kΩ, 24kΩ and 900kΩ respectively. A second series of 24 basic resistance values (known as the E24 series) is available for resistors of ±5% tolerance.

DIRECT AND ALTERNATING CURRENT

Batteries are a common source of what is known as direct current (d.c.). Direct current may be defined as current which flows in one direction only. In dealing with battery powered circuits we also assume that the direct current supplied by the battery remains constant over a period of time. Although this may be the case in the short term, in the long term the terminal voltage of a battery on load (i.e. one which is delivering current to a circuit) will fall as the active constituents of the cell become exhausted.

We can illustrate this relationship using a simple voltage/time graph as shown in Fig. 1.10. As the e.m.f. falls so the current supplied will decrease in proportion and, to restore the performance of our circuit to its original level we will need to replace the battery.

To overcome the obvious limitations of batteries, at least in equipment which is not specifically designed for portable use, we can make use of the mains supply. Unlike a battery, however, this is a supply of alternating current (a.c.) rather than direct current.

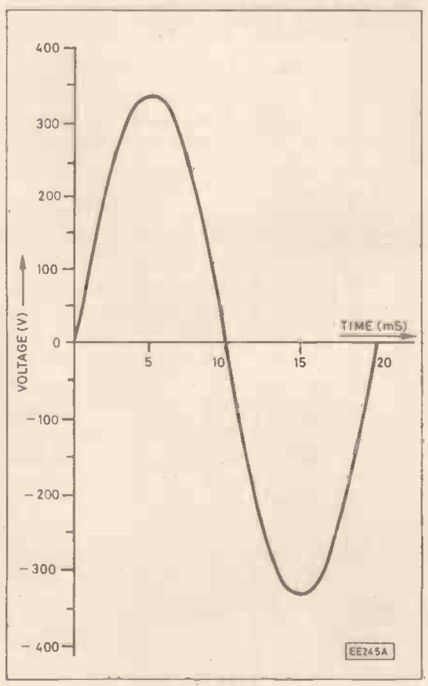
Alternating current, as its name implies, is current flowing alternately in one direction and then in the other. The 240V UK a.c. mains supply, for example, changes its direction 50 times per second and its voltage/time graph has a sinusoidal shape (i.e. its value is proportional to the sine of an angle) as shown in Fig. 1.11.

WAVEFORMS

Time related graphs are extremely useful when dealing with alternating currents and voltages. Such graphs allow us to 'see' the shape of a voltage or current and are called waveforms. It is obviously not possible to display waveforms using a moving coil instrument, instead we must use a rather expensive device known as an oscilloscope.

Although sine waves are often found in electronic circuits, not all waveforms are sinusoidal. Fig. 1.12 shows some common examples.

Fig. 1.11. Graph showing one cycle of the 240V 50Hz a.c. mains supply.



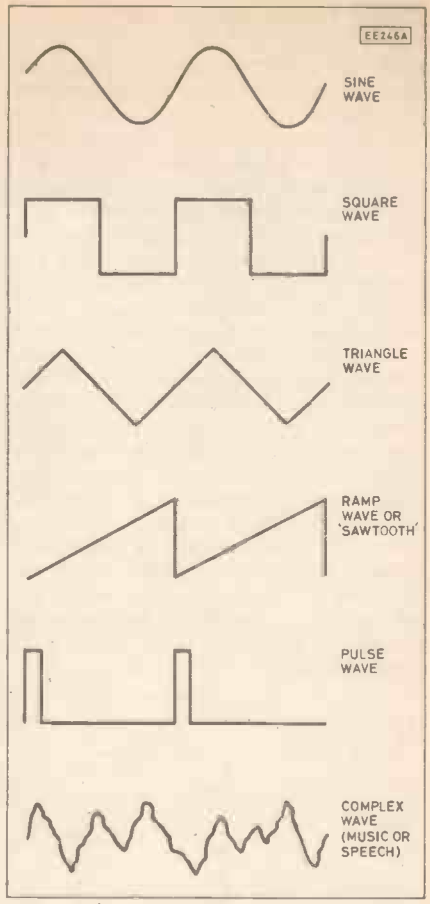


Fig. 1.12. Some common waveforms.

FREQUENCY, AMPLITUDE, AND PERIODIC TIME

At this point it is worth introducing some of the terms employed in conjunction with waveforms. The maximum positive or negative excursion of a waveform is known as its peak value or amplitude. For sinusoidal waveforms this excursion is usually measured from the mean point whereas, for pulse and square waveforms the excursion is often measured from zero (0V).

Often it is more convenient to measure the overall excursion of a waveform between its negative and positive peaks. This is known as the peak to peak value and, for a sinusoidal wave this is twice the peak value. The frequency of a wave is simply the number of cycles (complete reversals) which occur in a time interval of one second. Frequency is measured in Hertz (Hz) and thus the frequency of the UK a.c. mains supply is 50Hz (i.e. 50 cycles per second).

The periodic time of a wave is the time taken for one complete cycle. Again, using the mains supply as an example, if 50 cycles occur in one second the time for one complete cycle must be 1/50 second (20ms). The relationship between periodic time (t) and frequency (f) is thus:—

$$t = \frac{1}{f}$$

As a further example, assume we have tuned a radio receiver to receive a signal at 1MHz. One million cycles of the radio signal occur in one second and it has a periodic time of 1μs.

RMS VALUES

Rather than use peak or peak to peak values, sinusoidal alternating currents and voltages are often specified in terms of the equivalent direct current or voltage which would produce the same power dissipation in a resistor. The 240V a.c. mains supply is a case in point; to achieve the same heat output from an electric fire we would need to connect it to a battery with an e.m.f. of 240V.

To distinguish the effective value of an alternating quantity from its peak and peak to peak values we use the abbreviation r.m.s. (standing for root mean square). The UK mains supply is thus 240V r.m.s. rather than peak or peak to peak. Common usage, however, often disregards the all important r.m.s. units.

For any given repetitive waveform there is a relationship between the r.m.s. and peak (or peak to peak) values. For a sine wave these are as follows:—

$$\text{r.m.s. value} = 0{\cdot}707 \times \text{peak value}$$

$$\text{peak value} = \frac{\text{r.m.s. value}}{0{\cdot}707}$$

$$\text{r.m.s. value} = 0{\cdot}354 \times \text{peak to peak value}$$

$$\text{peak to peak value} = \frac{\text{r.m.s. value}}{0{\cdot}354}$$

POWER SUPPLIES

All electronic circuits, regardless of their complexity, require a source of energy for their operation. We have already discussed the limitations of batteries and have suggested that the solution might involve the use of the domestic a.c. mains supply. There are, however, two problems now confronting us.

Firstly, how can we change a sinusoidal alternating current into a steady direct current and, secondly, how can we convert the relatively high voltage of the a.c. mains to the relatively low voltage required by our circuitry? For reasons which should soon become apparent, we will attend to these problems in reverse order!

The reason for a.c. (rather than d.c.) mains distribution is that energy can be efficiently transmitted over long distances using high voltages and low currents to minimise the power loss in the transmission conductors.

Voltages can be easily stepped-up and stepped-down using transformers. These devices consist of two coils which are wound on a common iron core. Alternating current applied to one coil (the primary) will produce an alternating magnetic field which will induce current in the other coil (the secondary). By selecting an appropriate ratio of primary to secondary turns we can step-up or step-down the voltage by a corresponding amount.

It should be noted that, unlike a resistor, in an 'ideal' transformer there is no power loss and thus the input power to the primary is equal to the output power from the secondary. As an example, consider the arrangement of Fig. 1.13. Here the transformer is assumed to be perfect (in practice its full-load efficiency would be around 95% as some energy would be required to magnetise the core) and a secondary load of 2A at 12V would give rise to a primary input of 100mA at 240V.

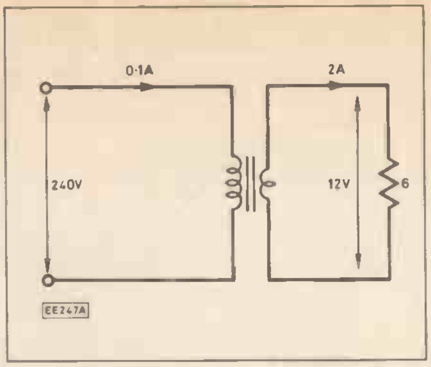


Fig. 1.13. Typical relationship between primary and secondary voltages and currents in a 'perfect' transformer.

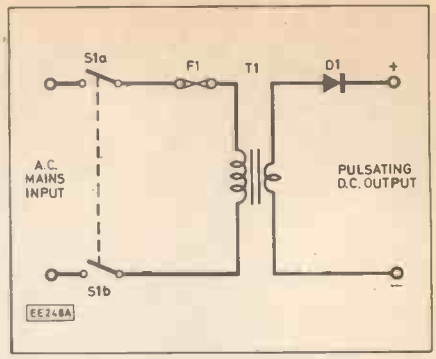


Fig. 1.14. A rudimentary low voltage power supply (we have added an on/off switch and fuse).

Having found a simple (and convenient!) means of stepping-down an a.c. voltage we now require a device which will convert alternating current to direct current. This can be achieved using a one-way device known as a diode. This component allows current to flow in one direction only and we shall be looking at the operation of these devices in detail in Part Three of the Teach-In series.

In the meantime it should suffice to say that a diode acts rather like an automatic on/off switch. The diode conducts (passing an appreciable current) when the applied e.m.f. is in one direction but does not conduct (passing no current at all) when the e.m.f. is applied in the opposite direction. In the context of power supplies, the action of a diode is called rectification.

Unfortunately this is not quite the end of the story. Our rudimentary low voltage power supply (shown in Fig. 1.14) still leaves something to be desired. Indeed, a circuit connected to

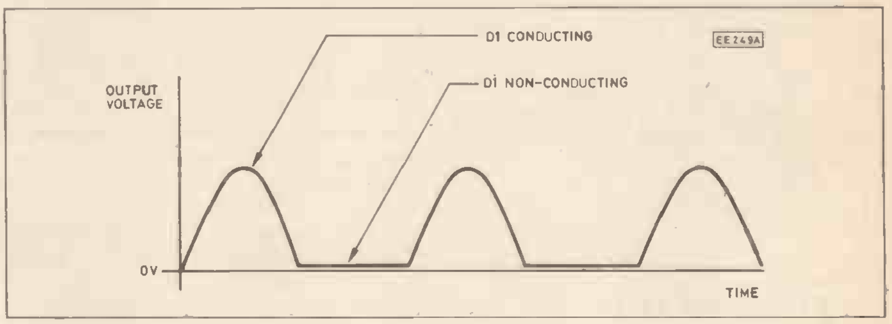


Fig. 1.15. (Above) Pulsating d.c. output waveform, produced by the arrangement in Fig. 1.14. An ideal output waveform (a steady direct voltage) can be seen in the drawing on the right.

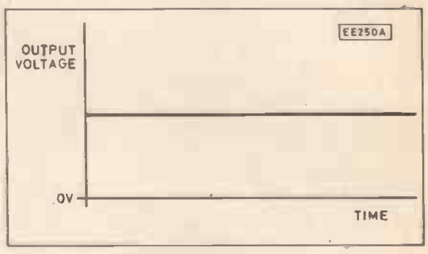


Table 1.1. (Below) The results obtained in Assignment 1.2 should be entered in this table.

R = 2k7	VOLTAGE, V (V)	0	2	4	6	8	10
	CURRENT, I (mA)	0	0·7	1·45	2·2	2·9	3·65
R = 2k2	VOLTAGE, V (V)	0	2	4	6	8	10
	CURRENT, I (mA)						
R = 3k3	VOLTAGE, V (V)	0	2	4	6	8	10
	CURRENT, I (mA)						

EE255A

it would probably not perform too well, if at all!

The reason, if you had not already guessed, lies with the fact that, since the diode conducts for only 50% of the time, the waveform consists of a series of 'half' sine wave pulses, as shown in Fig. 1.15. To overcome this problem we require a component which can store electric charge when the diode is in its conducting (switched 'on') state and then release its charge when the diode is non-conducting (switched 'off').

Next month we shall introduce a component which will meet this need and show the final circuit of our low voltage power supply.

PROBLEMS

Difficulty rating: (e) easy; (m) moderate

1.1 How many series connected 1·5V cells are there in a 9V battery? (e)

1.2 Which of the following resistors are *not* members of the E12 family? 8·2Ω, 11Ω, 150Ω, 2·7Ω, 36kΩ, 470kΩ, 2MΩ (e)

1.3 A 2·7Ω resistor is connected to a 6V battery. What current will flow in the resistor? (e)

1.4 A 4·5V battery supplies a circuit consisting of a 56Ω resistor connected in series with a 47Ω resistor.
(a) What current will be supplied to the circuit?
(b) What p.d. will appear across the 47Ω resistor? (e)

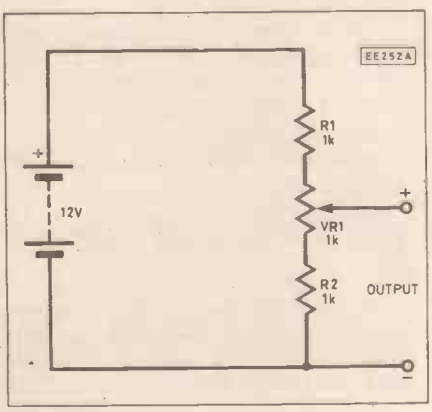
1.5 A certain circuit requires a resistance of exactly 75Ω rated at 1W. Which two 0·5W resistors selected from the E12 series will satisfy this requirement when connected in parallel? (e)

1.6 Resistors of 220Ω, 330Ω and 470Ω are connected in parallel. If the current in the 270Ω resistor is 1mA determine,
(a) The current in the other two resistors.
(b) The total power dissipated in the parallel circuit. (m)

1.7 A variable bias voltage supply uses the circuit shown in Fig. 1.16. Determine the range of output voltages obtainable from this circuit (you may assume that no current is drawn from the circuit). (e)

1.8 A circuit having an equivalent resistance of 2kΩ is connected to the output terminals of Fig. 1.18. Determine the new range of output voltages that would result. (m)

Fig. 1.16. Circuit for Problems 1.7. and 1.8.



1.9 A resistor is marked with four bands reading (from left to right) red, violet, orange, gold. What is its value, and tolerence? (e)

1.10 A resistor is marked with a value of 180Ω and tolerance 5%. Its resistance is accurately measured and found to be 170Ω. Is it within tolerance? (e)

1.11 A 100μA meter movement has a coil resistance of 750Ω. Calculate the value of multiplier resistor to allow the meter to be used as a voltmeter with a full scale deflection of 5V. What nearest preferred resistor from the E12 series should be used and what will its colour code be? (m)

1.12 Determine the peak and peak to peak value of the 240V r.m.s. a.c. mains supply. (e)

1.13 Determine the peak to peak value and frequency of the waveform shown in Fig. 1.17. (e)

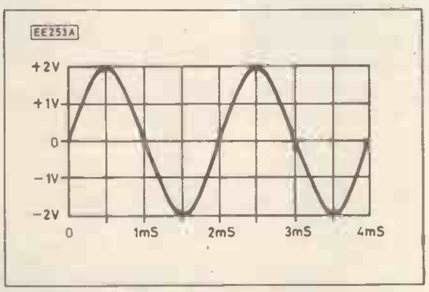


Fig. 1.17. Waveform for Problem 1.13.

THE ANSWERS TO THESE PROBLEMS WILL APPEAR IN TEACH-IN PART 2

Practical Assignments

COMPONENTS

Besides the items mentioned earlier, you will need the following components in order to complete the practical assignments described in this part of Teach-In:—

Resistors (0·25W, 5%), 1k, 2k2 and 2k7 (one of each)
Variable 1k carbon potentiometer (linear) (one)
Control knob (to fit above)

ASSIGNMENT 1.1.

Voltage & Current Measurement

This assignment is designed to introduce readers to the use of a multimeter for measurements of voltage and current. We shall also calculate the resistance of the circuit using the measured values of voltage and current.

PROCEDURE

Carefully read the Instruction Manual provided with your multimeter and, in particular, check that you understand the procedure for selecting the various ranges. Insert the 1k resistor between points B10 and B20 of the Plugblock. Connect a 4·5V battery using two crocodile leads (one red and one black) as follows:—

Red lead from battery positive (+) to B20
Black lead from battery negative (–) to B10

Ensure that the multimeter is placed in its normal position (with the M-102BZ this should be with the stand extended) and check that the meter reads zero. Select the 10V d.c. range and connect the meter leads taking care to observe the correct polarity (i.e. red to 'A-Ω-V' and black to 'COM/+Ω' on the multimeter). Connect the leads to each end of the resistor as shown in the photograph. Observe the reading on the meter and note down the voltage indicated. (This should, of course, be approximately 4·5V!).

Now disconnect the red crocodile lead. Select the 5mA d.c. range and re-connect the meter as shown in the second photograph. Here the red lead of the meter should be taken directly to the battery positive whilst the black lead of the meter should be connected to the resistor at B20. Observe the reading on the meter and *make a note* of the current indicated. Finally, disconnect the battery and meter not forgetting to switch the meter off.

RESULTS (1.1.)

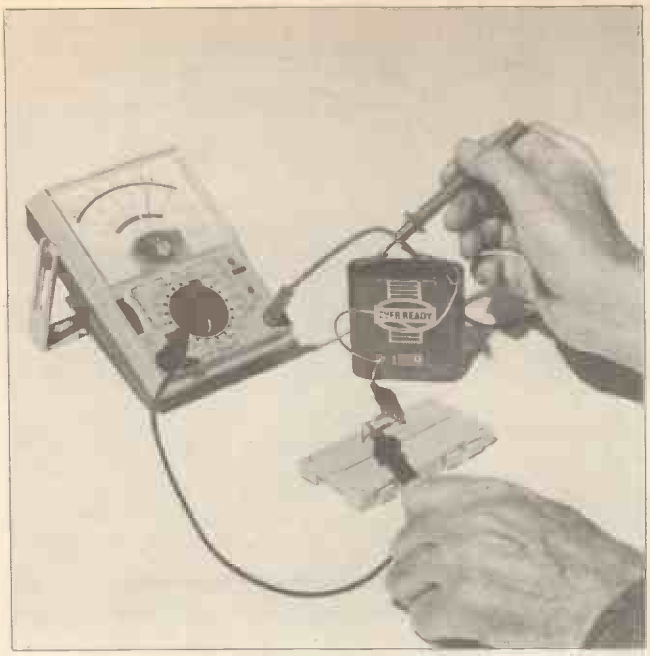
You should have found that the battery voltage is 4·5V. A 'fresh' battery (i.e. one that is unused and has not spent a long time in storage) may read slightly higher whereas one that has been used (or left in store for some time) may read somewhat less. The current should have been approximately 4·5mA though again there may have been some slight variation due to the state of the battery.

If you now apply Ohm's law to the values which you have measured you should be able to confirm that the resistance was indeed 1k. Simply divide the value of voltage by the value of current. If you are confused by having the current in mA (rather than A) don't worry—simply remember that if *volts* are divided by *milliamps* the answer will be in *kohms*. This keeps the arithmetic nice and simple!

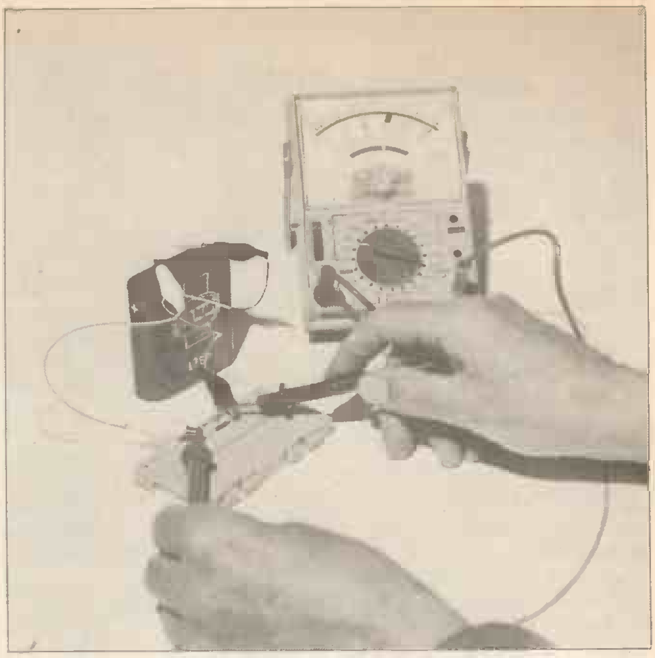
ASSIGNMENT 1.2.

Ohm's Law

Ohm's law is so important that it is worth spending just a little more time on it. Rather than rely on one pair of values (as we did in Assignment 1.1) we shall take a whole set of readings of voltage and current and use them to plot a graph. If the resistance does not change, these values, when plotted, should yield a straight line. Furthermore, if we plot voltage on the horizontal axis and current on the vertical axis, the slope of the line will be inversely proportional to the resistance of the circuit (i.e. a low resistance should produce a steep slope whereas a high resistance should produce a more gradual slope when plotted on the graph).



Measurement of current in Assignment 1.1.



Measurement of voltage in Assignment 1.1.

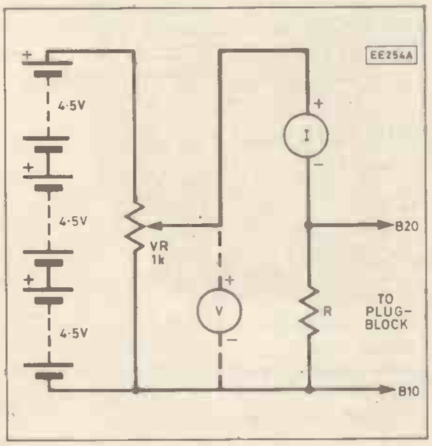
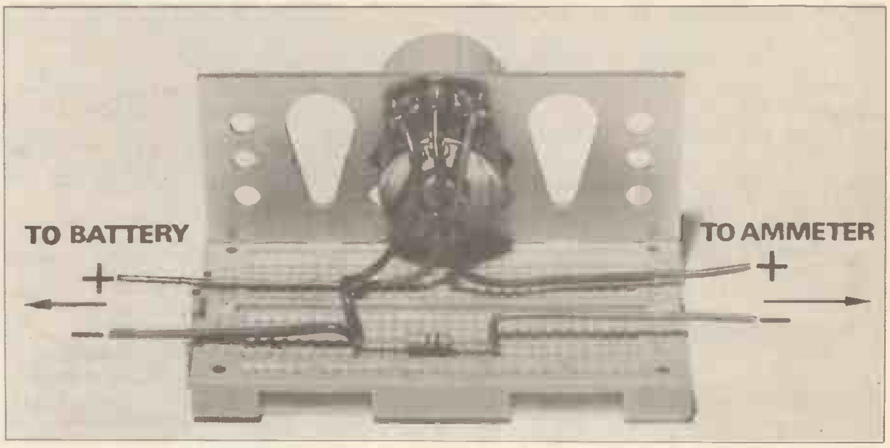


Fig. 1.18. Circuit diagram for Assignment 1.2.



Wiring arrangement for Assignment 1.2.

PROCEDURE

Since we wish to vary the voltage in regular steps, we shall have to devise a means of varying the voltage supplied. To do this we shall use three batteries connected in series and a variable potentiometer (resistor), as shown in Fig. 1.18. This simple arrangement allows us to vary the voltage from 0V to approximately 13V.

It will be necessary to solder the connections to the potentiometer with small lengths of equipment wire. Single core would be preferable, as this will easily plug into the Plugblock. If multicore is used the stripped ends should be tinned to prevent fraying. At the other ends (the battery and meter connections) small crocodile clips should be fitted.

The physical arrangement of the circuit of Fig. 1.18 is depicted in the photograph. The 2k7 resistor should be connected between B10 and B20 and the potentiometer set to its extreme anti-clockwise position. The two ammeter leads should then be touched together (short circuited) and the meter (switched to the 10V d.c. range) should be connected between the positive 'ammeter' lead and battery negative. You should confirm that the meter indicates 0V.

Now disconnect the meter and select the d.c. 5mA range. Re-connect the meter in the 'ammeter' position and measure the current supplied. Since there is no potential difference across the resistor the current reading should, of course, be zero!

Now disconnect the meter and short the ammeter leads again. Select the 10V d.c. range and re-connect in the voltmeter position. Increase the voltage to 2V and repeat the current measurement. Continue by taking four further readings at 4V, 6V, 8V and 10V. Record your results in the table on page 536, and then repeat the procedure for the 2k2 and 3k3 resistors.

RESULTS (1.2.)

Results should be recorded along the lines shown in the table. Note that we have included typical readings for a 2k7 resistor. Now, using a common set of voltage and current axes, plot the results for each resistor and confirm that they take the form of a straight line. Finally, see if you can relate the slope of each line to its resistance.

NEXT MONTH

You will need the following additional components in order to complete the practical assignments in next month's instalment of Teach-In:—

Resistors ($\frac{1}{4}$ Watt, 5% carbon).
100Ω (1 off); 470Ω (4 off); 1kΩ (1 off); 10kΩ (3 off).

Capacitors (16V, electrolytic).
1,000μF (1 off); 2,200μF (1 off).

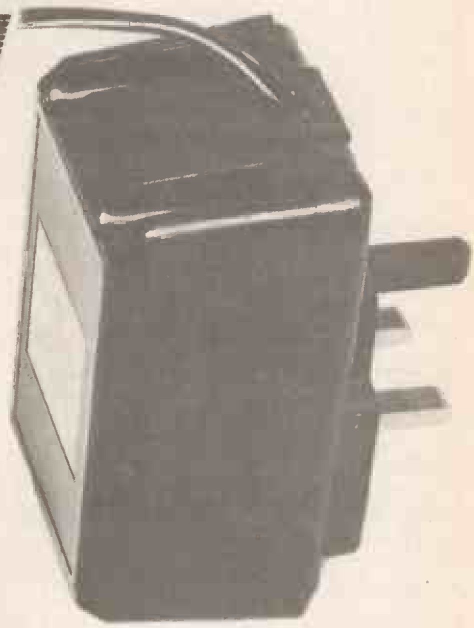
In the meantime, this month's practical project involves the construction of a simple d.c. power unit. See page 560.

SPECIAL OFFER

MAINS ADAPTOR

FOR

TEACH-IN '86



SAFE POWER SUPPLY UNIT

£4·95

INCLUDING VAT AND POSTAGE

EVERYDAY ELECTRONICS has arranged a special offer for readers on this isolated mains adaptor. Use of the adaptor will ensure safety when building the *SAFE POWER SUPPLY* (see page 560) and keep the cost of the project down. To avoid the need for the constructor to become involved in any mains wiring, a special combined sealed mains plug and double-insulated transformer unit has been employed. The unit plugs directly into a 13 amp socket and produces an output of 14V a.c. at 600mA. The sealed construction of the unit also prevents unauthorised handling.

To take advantage of this offer, simply cut out the coupon, fill it in clearly and send it with your remittance (or Access details) to the address given.

DO NOT ENCLOSE ANY OTHER CORRESPONDENCE. *ONLY ONE ADAPTOR WILL BE SUPPLIED FOR EACH COMPLETE CUT-OUT COUPON.*

Make sure your address appears on the coupon twice

TEACH-IN '84 PART 1 (SEE PAGE 531) — **SAFE POWER SUPPLY UNIT (SEE PAGE 560)**

Post to: EE SPECIAL OFFER (PSU), GREENWELD, 443 Millbrook Road, Southampton, SO1 0HX.

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Please send me **ONE MAINS ADAPTOR**

One Adaptor costs £4.95, including VAT & p/p

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SOLDERING IRON POWER CONTROLLER

MARK STUART

GOOD project building relies above all upon good quality soldered connections. One dry joint or stray thread of solder can take hours to find, especially when the constructor is inexperienced. Good soldering is only possible when the soldering iron bit is clean, evenly tinned and free from scale and corrosion. It is also important to have the soldering iron bit at the correct temperature. A bit which is too cool will not allow the solder to run over the joint properly. If the bit is too hot it will evaporate the flux from the solder before the parts to be soldered are properly tinned. Also an overheated bit will rapidly become encrusted with scale and corrosion and will be very difficult to keep clean and properly tinned.

The normal type of soldering iron used by most hobbyists does not have any form of temperature feedback control. A fixed amount of power, usually 15W to 25W is used by the iron. The bit temperature rises until the heat losses from the bit are equal to the power input.

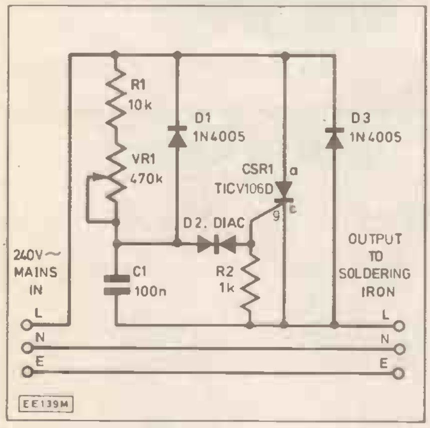


Fig. 1. Complete circuit diagram.

The problem is that the heat losses are dependent upon how the iron is being used. An iron that is used to solder a few joints every five minutes or so will tend to overheat. If the same iron were used continuously for soldering to large solder tags it would loose a lot more heat and so run cooler. In general the manufacturers seem to set the temperature on the high side so that the iron is always hot enough for the heavier jobs. A number of excellent temperature controlled irons are available from a range of manufacturers but the price tends to take them out of the "hobby bracket".

A simple cheap method of bit temperature control is difficult to achieve because it involves sensing the bit temperature with a thermocouple or similar device, and applying this feedback signal to a power controlling circuit. An alternative approach is to control manually the power input to the iron to match the particular job being done. This is simple to do using a variation on the lamp dimmer principle.

The circuit described here produces the desired power control cheaply and simply. It is designed to be connected permanently into the soldering iron lead although it can be fitted into a socket outlet if required. A range of power control from half power up to full power is adequate since the iron is too cool to use at half power.

CIRCUIT

The circuit diagram of the controller is shown in Fig. 1. Negative half cycles of the incoming mains are fed direct to the iron via D3. On positive half cycles D3 does not conduct and current can only be supplied via the thyristor CSR1 after it has been turned on by a gate trigger pulse. Once CSR1 has been turned on it will remain conducting until the end of the positive half cycle. At this point it turns off and stays off until a new gate trigger pulse is received during the next positive half cycle of the mains.

The power applied to the load is determined by how early CSR1 is turned on in the positive half cycle. An early trigger pulse means that nearly all of the positive half cycle is applied to the iron as well as the negative half cycle, i.e. full power. A trigger pulse late in the positive half cycle allows only a small part of the half cycle to be passed to the load along with all of the negative half cycle. In this case the iron receives just slightly more than half power.

The timing of the trigger pulse is determined by R1, VR1, C1 and the diac D2. At the start of the positive half cycle C1 begins to charge via R1 and VR1. Capacitor C1 charges until the threshold voltage of the diac D2 is reached. At this voltage—which is around 30 volts—the diac changes from being an open circuit to being a short circuit. When this happens C1 is discharged into the gate of CSR1 via the diac, and CSR1 is switched on. If VR1 is set to maximum resistance (anti-clockwise) the current charging C1 is small and C1 charges slowly. The threshold voltage of D1 is reached almost at the end of the half cycle and so CSR1 receives a late trigger pulse. If

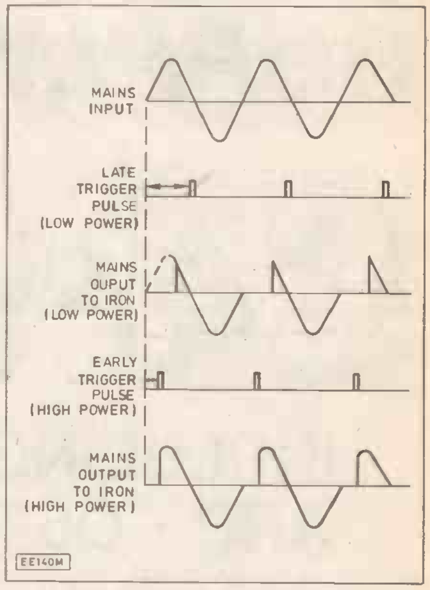
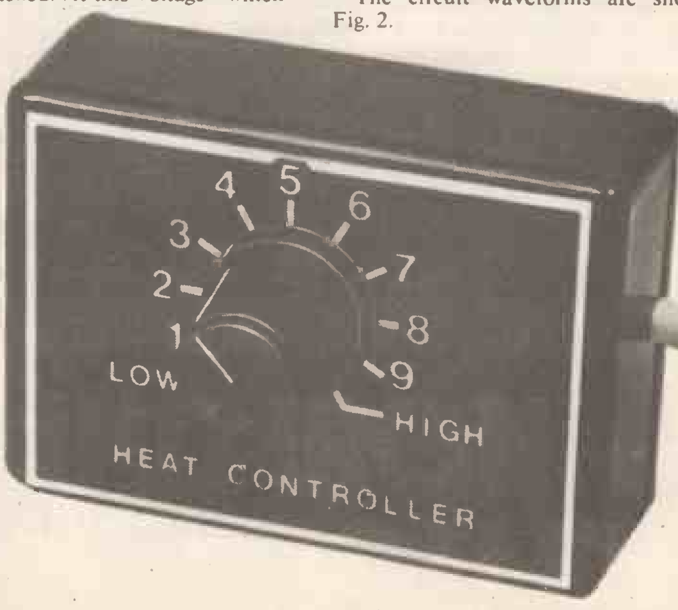


Fig. 2. Waveforms produced.

VR1 is set to minimum resistance C1 charges quickly via R1 and an early trigger pulse is produced. Between the two extremes the trigger pulse can be set anywhere in the half cycle by VR1 and so the power to the iron can be varied smoothly.

The circuit waveforms are shown in Fig. 2.



COMPONENTS

Resistors

R1	10k
R2	1k
¼W ±5% carbon film	

Potentiometer

VR1	470k linear with plastic spindle

Capacitor

C1	100n 250V polyester

Semiconductors

D1,D3	1N4005 (2 off)
D2	diac
CSR1	thyristor TICV106D

Miscellaneous

Plastic case approx 70mm × 50mm × 25mm; p.c.b. available from the *EE PCB Service,* order number 504; knob with marker; cable clamps; studding and fixing screws.

Approx. cost Guidance only **£6**

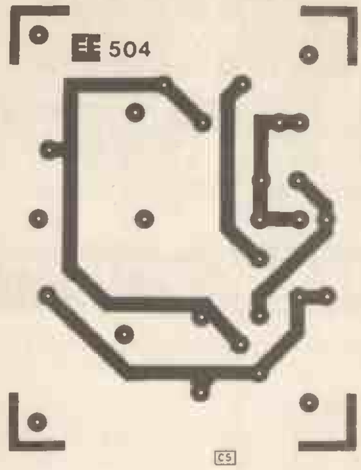


Fig. 4.

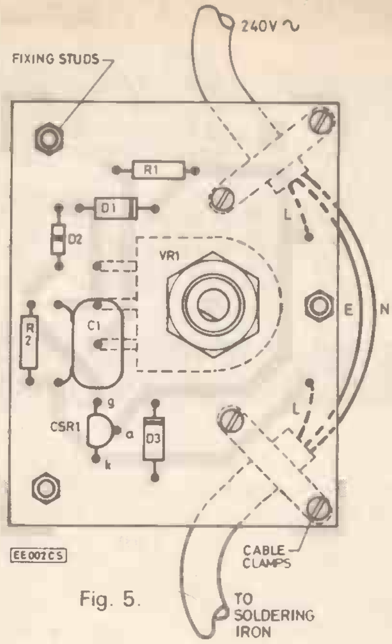
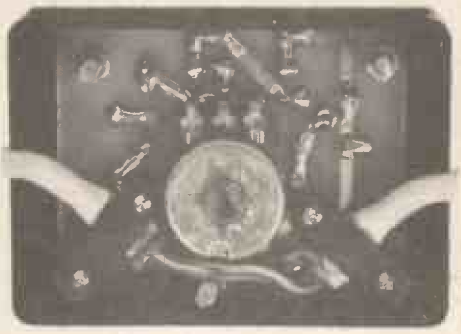


Fig. 5.

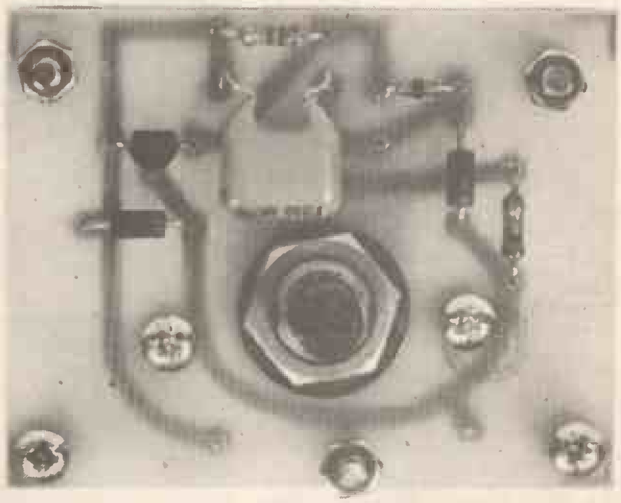
Fig. 4. (above) P.c.b. pattern for the Soldering Iron Power Controller.

Fig. 5. (above) Component layout for the Soldering Iron Power Controller.

Photographs (right and below) illustrating the constructional details of the Soldering Iron Power Controller showing details of the potentiometer mounting and wiring.



See Shop Talk page 554



CONSTRUCTION

The circuit is constructed on a small printed circuit board which fits neatly into the small plastic case used for the prototype. For safety, the circuit board is fixed in the case by means of three screws which are trapped between the case bottom and the inside of the lid. The only holes in the case are for the mains lead (in and out) and the plastic spindle of the potentiometer. Screws or lengths of studding cut to length are suitable; Fig. 3 shows the method of mounting more clearly. The screws should be cut carefully so that they fit snugly without distorting the case.

This method of fixing means that there are no exposed metal parts on the case that could become live in the event of an internal short circuit. Before assembling the board use it as a template to position the ¼ inch diameter hole in the base of the case for the potentiometer spindle.

The printed circuit board and component overlay is shown in Fig. 4 and Fig. 5. The potentiometer VR1 is mounted with its body on the track side of the board. Its three terminals should be bent forward carefully to fit the three connecting pads. A locking washer should be fitted between the body of VR1 and the board. The nut is fitted without a washer onto the component side of the board. Note: a potentiometer with *a plastic spindle must be used for safety.*

The other components should be mounted as shown taking care to get CSR1, D1 and D3 the right way round. The input and output connections to the board are made directly by the two live leads. The neutral and earth leads do not need to be connected to the board and so can be passed straight through the case. The ideal way to make the connection is to carefully strip away the outer from the centre section of a length of the soldering iron lead where the controller is to be fitted. The neutral and earth leads can be left intact and the live lead cut, stripped and tinned to be connected to the board.

Two saddle type cable clamps must be fitted as shown so that the cable is not fractured by movement in use. The cables are brought out of the ends of the case by means of two notches cut in the centre of each end. These notches should be cut to be a tight fit around the lead to keep out foreign bodies, etc.

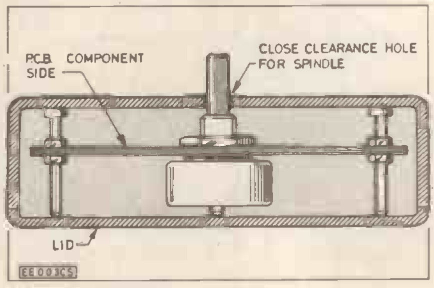


Fig. 3. Mounting details.

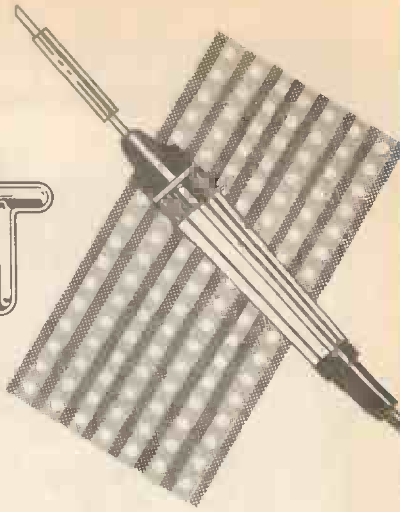
TESTING AND USE

The effect of the controller can be easily observed by trying various settings and allowing the soldering iron time to stabilise at each new setting. The power setting should be fixed for the lowest temperature that gives satisfactory joints.

The reduced scaling and corrosion are the benefits that will be appreciated most. The life of the bit will be considerably extended. □

SOLDERING INSTRUMENT

Buyer's Guide



SOLDERING is one area of electronics where many constructors seem to give little thought to either the equipment they use or the methods they adopt. This often causes damage to components and p.c.b. tracks and can result in many unnecessary hours of fault finding once the project has been assembled. These problems can be easily overcome by using a suitable soldering iron and following the few simple rules set out below.

The basic requirement of a soldered joint is to provide an electrically conductive path with a secondary consideration being the mechanical strength of the joint.

Before soldering it is essential that the surfaces to be soldered are clean and free from any dirt or grease. If solder is to be applied to any heat-sensitive components then a suitably sized heat-shunt should be used. These are normally in the form of specially designed tweezers, although many people prefer to use a small pair of pliers.

The most important part of the soldering iron is the 'tip' or 'bit'. This is the part of the iron which stores the heat ready for passing onto the joint. The size of the bit and the power rating of the iron will determine the amount of heat that is supplied by the iron to the work and also the rate at which the work can be carried out.

If the temperature of the bit is incorrect it can lead to a number of problems. Too low a temperature can result in the insufficient activation of the flux, poor solder flow and therefore dry joints. If a joint is dry it will exhibit a high resistance which can be very difficult to trace. It should be noted that the majority of dry joints will only become dry after a period of time.

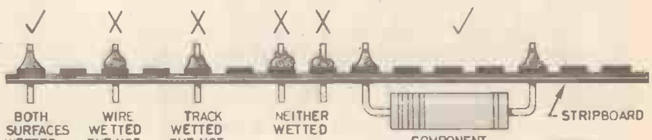
When the temperature setting is too high the flux will be vaporised, causing the solder to oxidise, resulting in poor quality joints, or damage a heat-sensitive component.

Soldering iron bits are usually made from copper to provide the maximum heat transfer at low cost. Because the copper soon becomes eroded many bits are coated with either nickel or chromium on their non-soldering surfaces to prevent oxidising whilst the tip can be coated with iron to increase its operating life.

The surface of the bit should be clean and free from any pits, burrs or indentations. To enable the smooth flow of heat from the surface of the bit to the joint a small amount of solder is placed on the bit prior to soldering each joint, this is called 'tinning'. After each soldering operation the bit should be cleaned with either a damp cloth or sponge and re-tinned if another joint is to be made.

When making a soldered joint the pre-tinned bit of the iron should be held against the joint and the flux-cored solder applied; the solder should flow immediately covering the entire joint. The solder should be removed first and then the iron. After the joint has cooled it should then be checked. Remember, to ensure a good joint, never blow or move a soldered joint before it has set!

A good joint should have a smooth, shiny appearance with no pitting, spikey or dull parts; and should of course be mechanically sound.



It doesn't take long to realise that when you are soldering you always seem to need an extra pair of hands to hold either the work or the component. If you are working on a p.c.b. then it is best to use a p.c.b. holder which will allow you easy access to both sides of the board and hold it steady whilst you are soldering.

Before you start soldering ensure that all the components you require are laid out in the order in which they are to be soldered. An ideal method of storing components prior to soldering is to use a polystyrene block; note though that MOS components should be kept in their packages until you are ready to solder them into place.

You should also ensure you have plenty of light over your workplace and that you have a comfortable sitting position.

Always replace your iron in its holder when you have finished with it. Never leave an iron on your workbench.

When choosing a soldering iron for your particular needs you must take into account all the applications for which it will be used. Soldering irons come in a variety of wattages, bit sizes and operating voltages. Some irons come as part of a soldering station and include a holder, sponge tray and a temperature adjustment to set the temperature of the bit.

In this buyer's guide we have tried to show the wide range of soldering irons currently available and have also included some of the soldering aids that can be used.

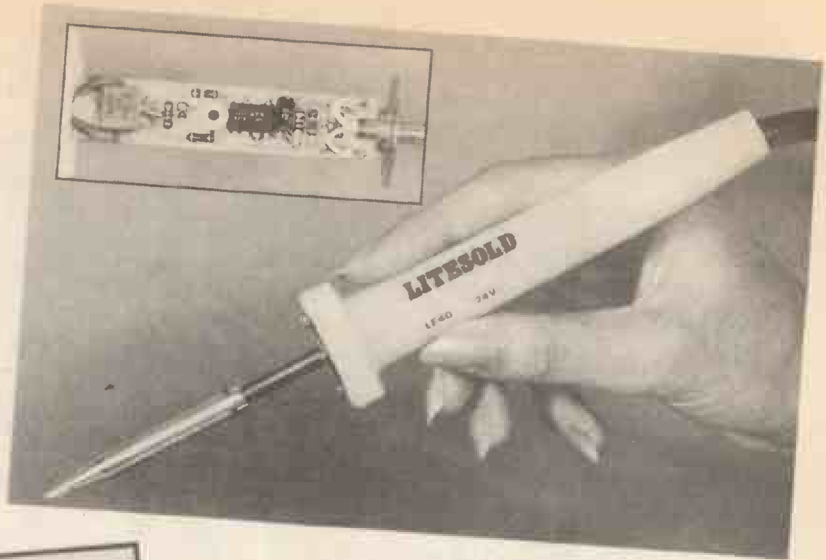
The prices shown include VAT but not post and packing except where stated.

PLEASE NOTE

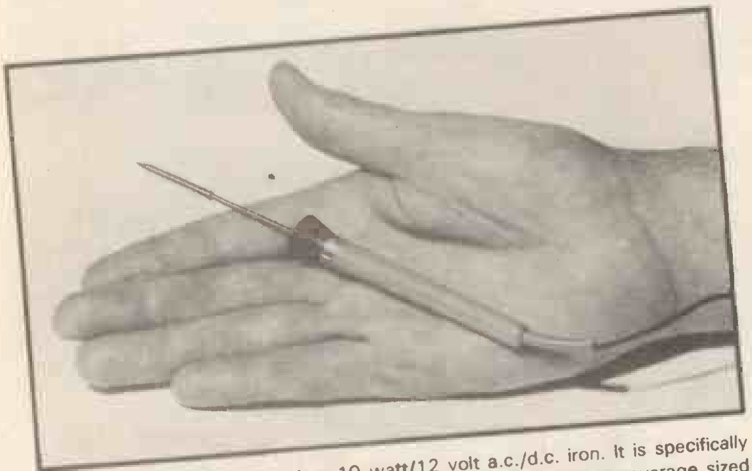
We would like to point out that readers buying from the guide are not protected by the Mail Order Protection Scheme unless the company concerned have advertised the product in a display advertisement in this issue.

The guide is designed as an aid to the purchaser and makes no recommendations.

SOLDERING INSTRUMENT *Buyer's Guide*



The **Litesold LE40** is a low voltage 40 watt iron. It can be operated from any 24 volt a.c. (2A) power supply. It has a proportional-band electronic control built into the handle, providing higher reliability. Temperature is adjustable, via an access hole in the handle, between 280 and 400°C. A range of bits is available. Price £22·18; No. 3 spring stand £5·13 (inc. p & p). Available from **Light Soldering Developments Ltd.,** Spencer Place, 97/99 Gloucester Road, Croydon, CR0 2DN. ☎ 01-689 0574.



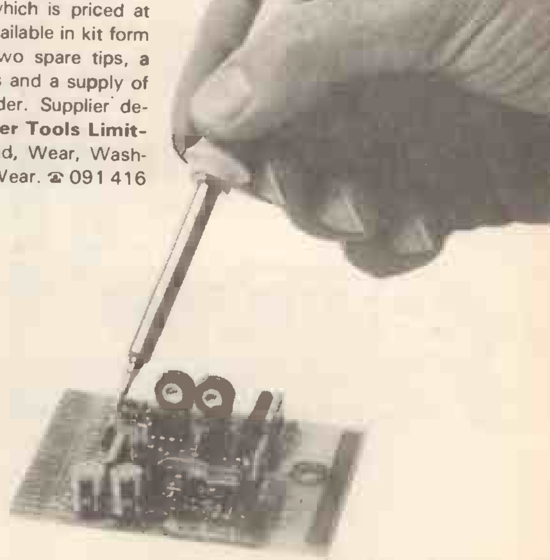
The tiny **Maxicraft 90034** is a 10 watt/12 volt a.c./d.c. iron. It is specifically designed for fine circuit work, and is capable of minimal use on average sized p.c.b.s. The fine bit enables the user to delve into the most delicate of areas. Price £3·75. Replacement bits 70p each. A 12 volt boxed transformer is also available for £2·75 (p & p 80p per order). From **Croydon Discount Electronics,** 38 Lower Addiscombe Road, Croydon, Surrey, CR0 6AA ☎ 01-688 2950.

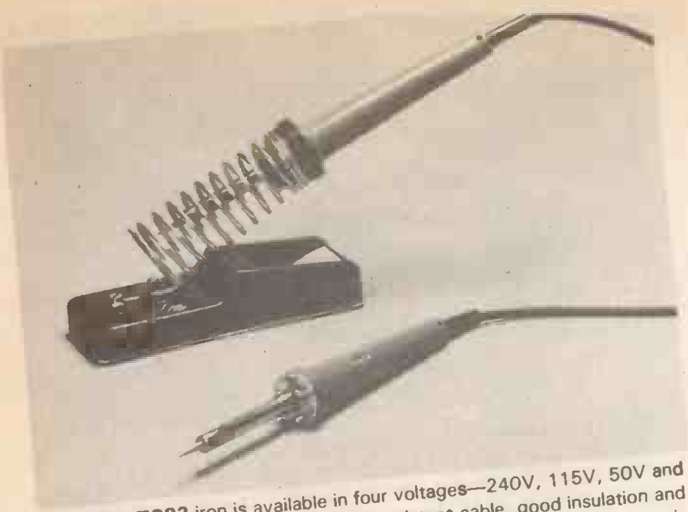
SA-6 desoldering iron is a powerful lightweight tool combining heating and suction. The suction chamber is easily removed for cleaning. Available 115 or 230V. Price £19.19 from **OK Industries UK Ltd.,** Dutton Lane, Eastleigh, Hants SO5 4AA. ☎ 0703 619841.

The **S·R·B Type 1** is a 16/18 watt iron, available in three voltages—12V, 110V and 240V. The element is completely shrouded by the bit providing increased thermal efficiency, enabling the iron to be used for work which might normally be expected of a 25 watt tool. This example from the Brewster range of irons is priced at £6·38. Spare bits 97p, long life bits £2·55 (inc. p & p). From **S & R Brewster Ltd.,** 86-88 Union Street, Plymouth, PL1 3HG. ☎ 0752 665011.

Adcola 101 electronic controlled soldering iron is production orientated. Features r.f.i. free temperature control, zero leakage, open circuit failsafe protection, l.e.d. temp. indicator, and lockable temp. dial (120–420 deg. C) Bifilar wound to prevent magnetic effects. Price £88·19 (p & p £6) from **Adcola Products Ltd.,** Adcola House, Gauden Rd., London SW4 6LH. ☎ 01-622 0291.

The Weller **WM12D** weighs just 7 ounces and is the smallest iron in their range. It is rated at 12 watts and develops a tip temperature of 425 degrees centigrade. There is a choice of three tips which can be easily interchanged. The WM12D which is priced at £6·58 is also available in kit form together with two spare tips, a pair of tweezers and a supply of resin cored solder. Supplier details from **Cooper Tools Limited,** Sedling Road, Wear, Washington, Tyne & Wear. ☎ 091 416 6062.





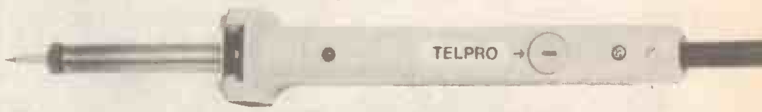
The **Oryx TC82** iron is available in four voltages—240V, 115V, 50V and 24V a.c. The 45 watt iron has a burn-resistant cable, good insulation and supply isolation on removal of the one-piece handle. The tip temperature is adjustable between 260 and 420°C with visual indication of setting. A 100 watt version the **TC82 100** is also available. Prices respectively are £18·75 and £28·46. From **Greenwood Electronics,** Portman Road, Reading, Berks, RG3 1NE. ☎ 0734 595844.

Adamin Model 12 miniature iron is available in 240V or 12V (12 watts). One of the smallest irons in the world and takes a range of bits from 1·2mm to 4·7mm. Price (iron) £6·27, (spring stand) £5·13 (inc. p & p) from **Light Soldering Developments Ltd.,** Spencer Place, 97/99 Gloucester Road, Croydon, Surrey CR0 2DN. ☎ 01-689 0574.

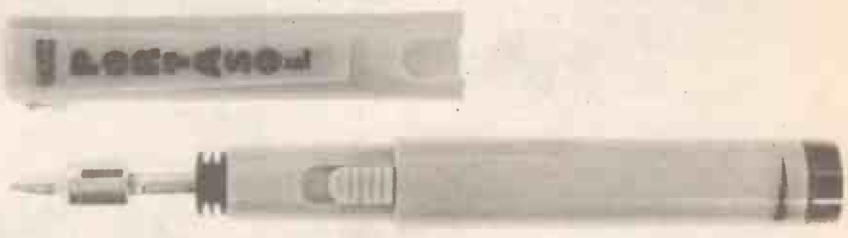
The Thermomatic irons from Tele-Production are available complete with a power supply unit. The power unit will supply 24V and has an iron rack and sponge holder. Priced at £46 (inc. p & p) it is available from **Tele-Production Tools,** Stiron House, Electric Avenue, Westcliff-on-Sea, Essex. ☎ 0702 352719.

Litesold SK18 Soldering Kit includes the LS18 18 watt iron along with a selection of bits, 18 s.w.g. fluxed solder, tweezers, three other aids and desolder braid. All in p.v.c. wallet. Price £12·60 (inc. p & p), from **Light Soldering Developments Ltd.,** Spencer Place, 97/99 Gloucester Road, Croydon, Surrey CR0 2DN. ☎ 01-689 0574.

The **K1000** 12 watt iron is available in a range of operating voltages from 12V to 240V. An Adcola long-life bit is fitted as standard and the tool will operate at 380 degrees centigrade. A safety stand is also available. The iron is priced at £9·14. **Adcola Products Ltd.,** Adcola House, Gauden Road, London. ☎ 01-622 0291.



The 24V Thermomatic iron is rated at 50 watts and is fully adjustable from 200 to 400 degrees centigrade. A range of 14 long-life bits is available and the iron is priced at £20·12 (inc. p. & p.). From **Tele-Production Tools,** Stiron House, Electric Avenue, Westcliff-on-Sea, Essex. ☎ 0702 352719. (See above left for 24V p.s.u.)



The new portable butane powered soldering iron from Oryx is only slightly bigger than a felt-tip pen. There is no flame during use, the chemical energy of the gas is converted into heat by means of a catalytic converter in the bit. The iron delivers the equivalent of 60 watts with the tip temperature being variable between 250 and 450 degrees centigrade. The iron will run for 60 minutes on its gas supply. The Oryx Portasol is priced at £17·25. **Greenwood Electronics,** Portman Road, Reading, Berks RG3 1NE. ☎ 0734 595844.

SOLDERING INSTRUMENT *Buyer's Guide*

P.c.b. Track Repair Kit includes master frames with tracks fingers, pads, elbows and flatpack pads, eyelets and funnelets plus the setting tools. Includes epoxy, flux, cleaner, spatulas, abrasive sticks, tweezers, clamps and knives. An economy version is also available. Price, standard £145·90. Economy £72. **OK Industries UK Ltd.,** Dutton Lane, Eastleigh, Hants SO5 4AA. ☎ 0703 619841.

Oryx ISO-TIP series irons are cordless (rechargeable) for complete mains isolation. The iron automatically recharges itself when placed in its base, and has a built in spotlight. The 50 watt iron can solder 100 joints between charges. Tip temperature is 370°C. Also takes a drill attachment. Price £49.45 from **Greenwood Electronics,** Portman Road, Reading, Berks RG3 1NE. ☎ 0734 595844.

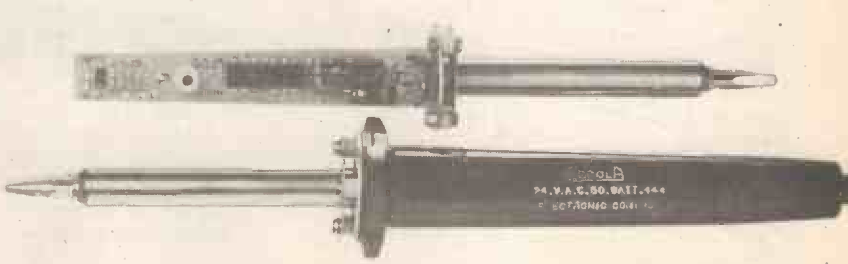
The **Oryx M3** iron is rated at 17 watts and has a normal operating temperature of 380 degrees centigrade. It is supplied complete with a replaceable push-on tip and storage hook. The M3 is available in 12V, 110V and 210/240V versions with the 12V model fitted with a cigar-lighter plug for car repair work. Priced at £7·47 it is available from **Greenwood Electronics,** Portman Road, Reading, Berks, RG3 1NE. ☎ 0734 595844.

SA-8 series industrial grade soldering irons, available in 371 deg. C (SA-8-15) and 427 deg. C (SA-8-20), heat-up in two minutes using ceramic elements. They may be used with static-sensitive components without earthing. Tips are corrosion resistant. Available in 115 and 230V versions. Price £21·50, from **OK Industries UK Ltd.,** Dutton Lane, Eastleigh, Hants SO5 4AA. ☎ 0703 619841.

The **Self-feed** soldering iron from Gardner Precision has been designed for one-handed operation. The solder is housed in the transparent handle and fed through a stainless steel tube to the bit. Solder is applied to the joint by turning a serrated wheel with the index finger. The iron is rated at 18 watts and can hold 4 metres of solder. Priced at £17·25 it is available from **Gardner Precision Engineering,** North Road, Woking, Surrey. ☎ 04862 20722.

The **TCSU-D** is a 50-watt soldering station with an electronic temperature control range of ambient to 450 deg. C. The iron itself works on 24V stepped down from mains to safety and isolation. Price £91·17 (inc p & p), from **Antex (Electronics) Ltd.,** Mayflower House, Plymouth, Devon. ☎ 0752 667377.

The **Adcola 444** has its control circuit housed in the handle. It operates from a 24V supply and the 50 watt element can be controlled from 220 to 420 degrees centigrade. The temperature is factory set at 360 degrees and can be adjusted through the handle. The 444 is priced at £28·73 (compatible power supply £33·86) and is available from **Adcola Products Ltd.,** Adcola House, Gauden Road, London. ☎ 01-622 0291.



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a world of soldering

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ANTEX Soldering Irons exhibit exceptionally low leakage currents & hence are suitable for use on Static Sensitive Devices. Sophisticated temperature controlled soldering units have recently been added to the ANTEX range.

Model C
– 15 Watts. Available for 250, 220, 115, 100, 50 or 24 volts.

Model XS
– 25 Watts. Available for 240, 220, 115, 100, 50, 24 or 12 volts.

Model XS-BP
– 25 Watts. 240 volts, fitted with British Plug.

ST4 Stand
– To suit all irons.

SK5 Soldering Kit. Contains model CS 240v Iron, an ST4 Stand and solder.

SK6 Soldering Kit. Contains model XS240v Iron, an ST4 Stand and solder.

SK5-BP and **SK6-BP** Soldering Kits as above with British Plug.

Model CS
– 17 Watts. Available for 240, 220, 115, 100, 50, 24 or 12 volts.

Model CS-BP
– 17 Watts. 240 volts, fitted with British Plug.

TCSU1
– Very robust temperature controlled Soldering Unit, with a choice of 30 Watt (CSTC) or 40 Watt (XSTC) miniature irons. Range 65°C to 420°C. Accuracy 2%.

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Elegant Temperature Controlled Soldering Unit with 50 W Iron (XSD) and built around FERRANTI custom-made ULA. Range Ambient to 450°C. Accuracy ± 5°C. Zero crossing switching. Detachable sponge tray.

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Address
Telephone

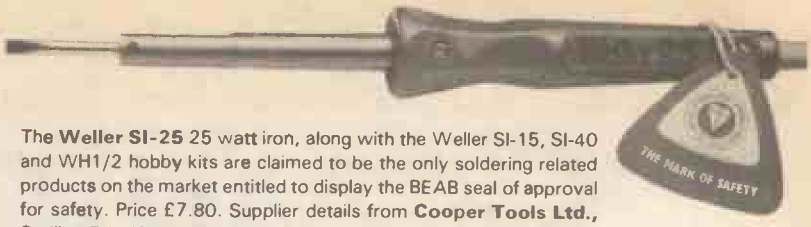
EE/10/85

SOLDERING INSTRUMENT *Buyer's Guide*

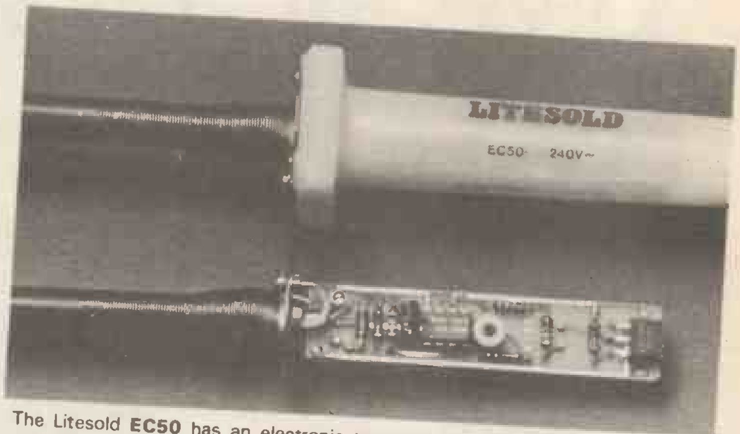
This helpful gadget, mounted on a solid cast base, consists of a support bar fitted with two crocodile clips and a 5 dioptre magnifying glass. The support bar, clips and lens are all mounted on adjustable ball-joints for cleaning, adjusting and soldering etc, giving a clear magnified view of the workpiece. 'Helping Hands' is priced at £6·75 (inc. p & p), it is available from **Electrovalue Ltd.,** St Judes Road, Englefield Green, Egham, Surrey, TW20 0HB. ☎ 0784 33603.

The Antex **TCSU1** soldering station has an anti-static earth connection to protect MOS devices. The temperature can be pre-set anywhere between 65 and 430 degrees centigrade. Three iron-coated bits are also supplied with each station. Priced at £82·17 (inc. p & p). **Antex (Electronics) Ltd.,** Mayflower House, Plymouth, Devon. ☎ 0752 667377.

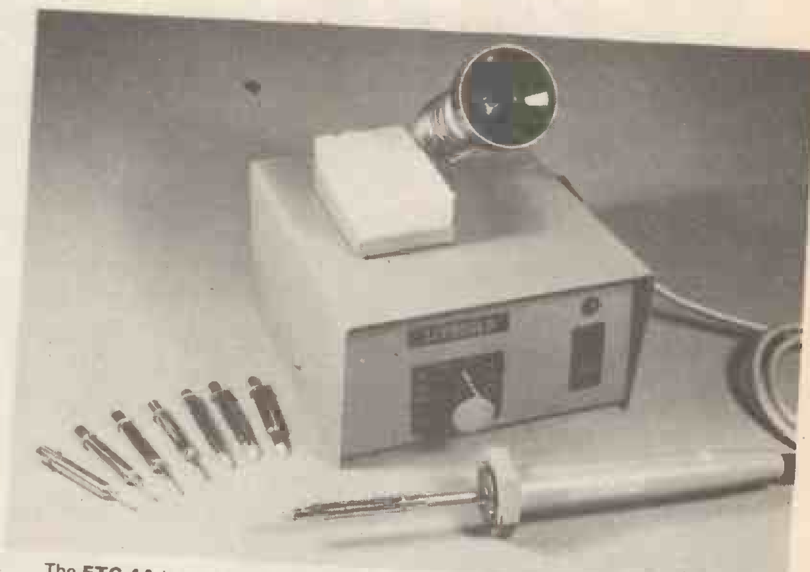
The **LC18** from Litesold is a high effciency iron suitable for general electronic assembly and servicing work. It can be either mains or low voltage powered and takes a wide range of bits. The **LA12** is similar to the LC18 but is rated at 12 watts and is mainly intended for smaller work. The LA12 is priced at £6·26 and the LC18 is priced at £6.30 (inc. p & p). **Light Soldering Developments Ltd.,** Spencer Place, 97/99 Gloucester Road, Croydon, Surrey CR0 2DN. ☎ 01-689 0574.



The **Weller SI-25** 25 watt iron, along with the Weller SI-15, SI-40 and WH1/2 hobby kits are claimed to be the only soldering related products on the market entitled to display the BEAB seal of approval for safety. Price £7.80. Supplier details from **Cooper Tools Ltd.,** Sedling Rd., Wear, Washington, Tyne & Wear NE38 9BZ. ☎ 091 416 6062.



The Litesold **EC50** has an electronic temperature control which can be easily adjusted via an aperture in the handle. The temperature can be adjusted between 280 and 400 degrees centigrade. The bits are iron coated copper for long life and are retained by circlips to prevent sticking. The 50 watt iron is priced at £27·50 (inc. p & p). Available from **Light Soldering Developments Ltd.,** Spencer Place, 97/99 Gloucester Road, Croydon, Surrey CR0 2DN. ☎ 01-689 0574.



The **ETC 4A** is a variable temperature soldering station with a 40 watt iron (180-400°C). The mains supplied station is available in four versions. Potentiometer control (ETC-4A), with digital display (ETC 4C). Tamper-proof setting type (ETC 4B), with digital display (ETC 4D). This unit offers close temperature control and a fast heat-up/recovery time. The ETC-4A illustrated is priced at £66·84 (inc. p & p). From **Light Soldering Developments Ltd.,** Spencer Place, 97/99 Gloucester Road, Croydon, Surrey CR0 2DN. ☎ 01-689 0574.

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NOVEMBER 1985 ISSUE ON SALE FRIDAY, OCTOBER 18

a regular feature for the Spectrum Owner...

by Mike Tooley BA

THE procedure for setting-up the digital-to-analogue converter described in last month's *On Spec* requires nothing more than an accurate multimeter and a little patience. First connect the multimeter (switched to the 10V d.c. range) to the output of the digital-to-analogue converter, taking care to observe the correct polarity. Next make the following keyboard entry:

OUT 255,0

(or OUT 191,0 if you are using the modified address decoder shown in Fig. 4 last month). Carefully adjust VR1 so that the output is exactly 0V. Now make the following keyboard entry:

OUT 255,200

(or OUT 191,200) and adjust VR2 so that the output is exactly 10V.

As a final test, make the following entry:

OUT 255,100

(or OUT 191,100). The output should now be exactly 5V. If this is not the case, carefully check the circuit and component values.

The foregoing procedure ensures that the digital-to-analogue converter provides output steps of 50mV. To ensure linearity, the maximium data value sent to the output port should be restricted to 200 (rather than 255). The output is thus programmable from 0V to 10V in 200 steps of 50mV.

Controlling the Digital-to-Analogue Converter

The digital-to-analogue converter can be easily controlled from BASIC. Not only is it possible to generate fixed voltages (d.c. levels), it is also possible to generate repetitive waveforms of relatively low frequency.

The following BASIC routine prompts the user for a voltage and then outputs this value from the DAC.

```
100 REM Voltage generator
110 LET v=0
120 OUT 255, (v*20)
125 CLS
130 PRINT AT 0,0;"Output voltage =
  ";v;"V"
140 INPUT #0;"Output voltage  ? ";v
150 IF v<0 OR v>10 THEN BEEP
  0·5,0·5: GO TO 140
160 GO TO 120
```

More Output

The maximum current drawn from the digital-to-analogue converter should not be allowed to exceed around 5mA (corresponding to a minimum load resistance of 200Ω). While this will be adequate in many applications, there may be occasions when higher current and/or voltage capability is required. In such cases a simple d.c.-coupled power amplifier can be added along the lines shown in Fig. 1. This arrangement employs a 759 power operational amplifier and is capable of delivering output voltages of up to 20V at load currents of up to 350mA.

In order to realise a 20V ouptut from the 10V supplied by the digital-to-analogue converter, the circuit of Fig. 1 is designed to produce a voltage gain of 2. The output of the composite arrangement is thus programmable in 200 steps of 100mV (rather than 50mV).

A keyboard entry of:

OUT 255,200

will consequently produce 20V whilst:

OUT 255,100

will result in an output of 10V.

Since the operational amplifier uses a single positive supply rail (rather than the more usual dual-rail arrangement), the linearity of the circuit is poor at low output voltages. This is particularly evident with output voltages of less than 1V and hence the minimum data value that should accompany an OUT statement is 10.

It is important to note that the circuit of Fig. 1 derives its nominal 24V d.c. supply rail from an external source and *not* from the Spectrum's own supply. The design of such a power source is uncritical (the positive rail can be anything from 23V to around 30V) and thus we have not included details here. The only noteworthy feature is that the supply *must* be capable of supplying the full load current (i.e. 300mA, or so).

Since IC5 can be expected to dissipate several watts in typical applications an adequate heatsink (5°C/W typical) is essential. Furthermore, it should be noted that, as the metal tab of the 759 forms its negative connection, the heatsink will be at 0V.

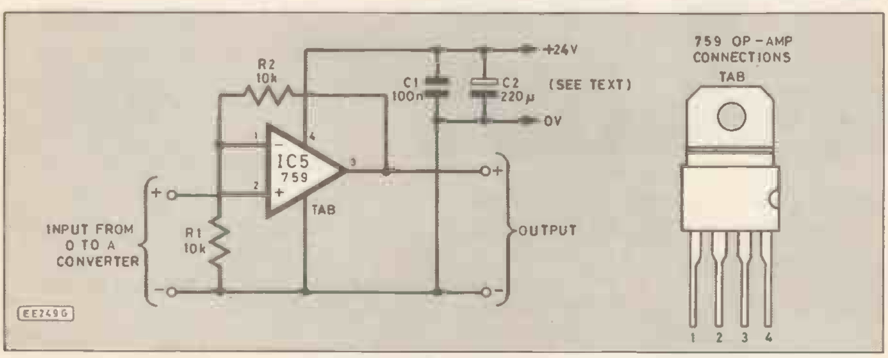

Fig. 1. Simple power amplifier option for the digital-to-analogue converter.

Waveform Synthesis

Besides the obvious application of generating accurate fixed direct voltages, the digital-to-analogue converter can be used to generate a variety of different waveforms. The following routines should form a basis for your own experiments.

```
Example 1:
100 REM Square wave
110 OUT 255,200
120 PAUSE 10
130 OUT 255,0
140 PAUSE 10
150 GO TO 110
```

This routine generates a square wave of 10V p-p with a frequency of approximately 120Hz. To alter the frequency simply change the values in lines 120 and 140. Note also that the mark to space ratio can be varied by placing different values in lines 120 and 140.

```
Example 2:
200 REM Ramp waveform
210 FOR v=0 to 200
220 OUT 255,v
230 NEXT v
240 GO TO 210
```

This produces a voltage which ramps from 0V to 10V in approximately 1·5 seconds. The amplitude of the ramp is governed by the limit of the FOR statement in line 210. Line 210 can also be modified to include a STEP value. This will allow you to change the frequency of the ramp. Note, however, that a large STEP value will produce a waveform which looks more like a flight of stairs than a smooth ramp.

```
Example 3:
300 REM Sine wave
310 FOR x=0 TO 360 STEP 10
320 LET r=x*(6·28/360)
330 LET v=100+(100*SIN r)
340 OUT 255,v
350 NEXT x
360 GO TO 310
```

This routine generates a wave with a period of approximately 4 seconds. The period of the waveform is dependent upon the STEP value in line 310. Unfortunately this also governs the quality of the waveform produced. As with example 2, the smaller the STEP value the more accurate the waveform produced.

```
*HISOFT GENS3 ASSEMBLER*
48K ZX SPECTRUM / SPDOS

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Pass 1 errors: 00

                   100 ; Square Wave Generator
                   110 ;
                   120 ; Everyday Electronics
                   130 ;      October 1985
                   140 ;
A000               150           ORG  £0A000
0064               160 PERIOD    EQU  100
A000 F3            170           DI
A001 3E7F          180 START     LD   A,£7F
A003 DBFE          190           IN   A,(£FE)
A005 1F            200           RRA
A006 D0            210           RET  NC
A007 3EC8          220 HIGH      LD   A,200
A009 D3BF          230           OUT  (191),A
A00B CD17A0        240           CALL DELAY
A00E 3E00          250 LOW       LD   A,0
A010 D3BF          260           OUT  (191),A
A012 CD17A0        270           CALL DELAY
A015 18EA          280           JR   START
A017 013200        290 DELAY     LD   BC,PERIOD/2
A01A 0B            300 LOOP      DEC  BC
A01B 78            310           LD   A,B
A01C B1            320           OR   C
A01D 20FB          330           JR   NZ,LOOP
A01F C9            340           RET
A000               350           ENT  £0A000

Pass 2 errors: 00

DELAY  A017    HIGH   A007
LOOP   A01A    LOW    A00E
PERIOD 0064    START  A001


Table used:     82  from    144
Executes: 40960
```

Listing 1, left, shows the complete assembled code for a high-frequency square-wave generator program. At the extreme left, the (hexadecimal) addresses appear in sequence; next, the actual machine-code. The line numbers in the centre are those used by the assembler Editor, and have no relation to actual program addresses.

Labels such as DELAY, and LOOP help to show what the program is doing. Finally, there are the assembly language instructions themselves—such as LD A,200: this instruction loads the accumulator register (A) with the decimal value 200. For further details see the text.

The alternative BASIC loader is shown below (Listing 2). The DATA statements are simply the machine code instructions and data of Listing 1, but in decimal, rather than hex.

```
600 REM Square wave generator
610 REM Everyday Electronics
620 REM October 1985
630 REM
640 CLEAR 40959: LET c=0
650 FOR x=40960 TO 40991
660 READ y: POKE x,y: LET c=c+y
670 NEXT x
680 IF c<>4149 THEN  PRINT "Checksum
error - check data!": STOP
690 PRINT "Routine installed"
700 PAUSE 100: NEW
710 REM
720 REM Data Statements
730 REM
740 DATA 243,62,127,219,254,31,208,62
750 DATA 200,211,191,205,23,160,62,0
760 DATA 211,191,205,23,160,24,234,1
770 DATA 50,0,11,120,177,32,251,201
```

```
Example 4:
400 REM Triangle wave
410 FOR v=0 TO 200 STEP 10
420 OUT 255,v
430 NEXT v
440 FOR v=200 TO 0 STEP -10
450 OUT 255,v
460 NEXT v
470 GO TO 410
```

This generates a triangle wave. The same comments and restrictions on the STEP value apply as in the previous examples.

Machine Code Routines

Due to the speed limitations inherent in BASIC, we are often forced to revert to machine code when generating signals of several kHz or more. A sample assembly language routine for producing a high frequency square wave is shown in Listing 1. This routine occupies 32 bytes and starts at location A000 (40960 decimal). The following comments are provided for the benefit of the newcomer to machine code programming:

The routine starts by examining the state of the BREAK key. This provides us with a means of exiting from the routine when the BREAK key is depressed and returning control to the main program.

To generate a "high" output state we simply load the accumulator register of the Z80 with a value which corresponds to the amplitude of the wave and then output this value to the digital-to-analogue converter port.

The OUT instruction is then follwed by a delay loop of appropriate length. The delay may be easily changed by simply POKEing different data values into addresses A018 and A019 (40984 and 40985 decimal). It should be noted that the most significant byte is stored in A019 (40985) whilst the least significant byte is held in A018 (40984).

Having completed the delay loop, we load the accumulator with zero and then output this value. The delay loop is then executed for a second time before returning to the start of the program. The state of the BREAK key is then examined again and, provided no depression is detected, the program is repeated.

If you are lucky enough to have an assembler to hand, Listing 1 can be entered and the object code generated saved to tape/microdrive for incorporation in programs. As an alternative, a BASIC loader is shown in Listing 2. This modifies RAMTOP to protect the routine and then POKEs it into memory. When the installation process is complete, the BASIC loader clears itself from memory leaving the machine code intact. Thereafter, the code may be subsequently called by incorporating a statement of the form:

```
200 RANDOMIZE 40960
```

in your program.

Spectrum Shutter Speed Tester

In the June issue of *EE*, R. A. Penfold described a "Computerised Shutter Timer" for the BBC and VIC-20 machines. Not to be outdone, Graham Curtis from Derby has sent in details of a simple and effective shutter timer which he has developed for the Spectrum. Graham writes:

"The Spectrum has an onboard clock running at 3·5MHz and can communicate with the 'outside' world through the joystick port of Interface Two. The lefthand connector (looking from the keyboard) provides a duplication of the top lefthand row of the keyboard (keys '1' to '5'). By connecting a suitable light activated switch across certain pins on the joystick connector a shutter timer can be constructed."

Clock Speed

"Although the clock runs at a very high speed, Sinclair BASIC is not sufficiently speedy to time the operation of a camera shutter so a machine language program is required.

"The following notes outline a system for testing both focal plane and iris type shutters from 100 sec down to 1/1000 sec."

Software

"The program (Listing 3) simply waits for key '5' or its joystick equivalent to make contact, then measures the time elapsed until it is released. A very fast machine-code routine at line 4000 is used for counting and stores the 'count' away in memory where it can be retrieved by the BASIC part of the program. Once retrieved the data is scaled and printed out to give results in milliseconds and in nearest fraction form.

"When running, the program can be checked against a good stopwatch for accuracy as it will run up to 150 seconds. If the calibration is in error it can be altered at line 140 in the program."

The Sensor

"Once the timing program is functioning, a sensor is needed. Fig. 2 shows the circuit diagram for the sensor. This is very simple to construct from the parts specified.

"When the light falls on TR1, current flows through R1 which causes TR2 to 'close the circuit' between pins 6 and 8 on the interface, and the counter begins. When light is removed from TR1 the process is reversed, stopping the count.

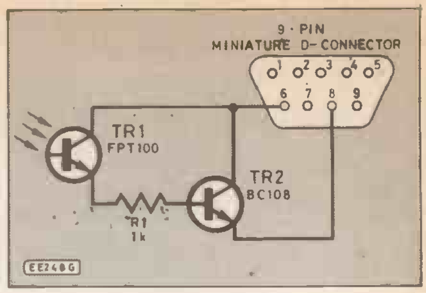


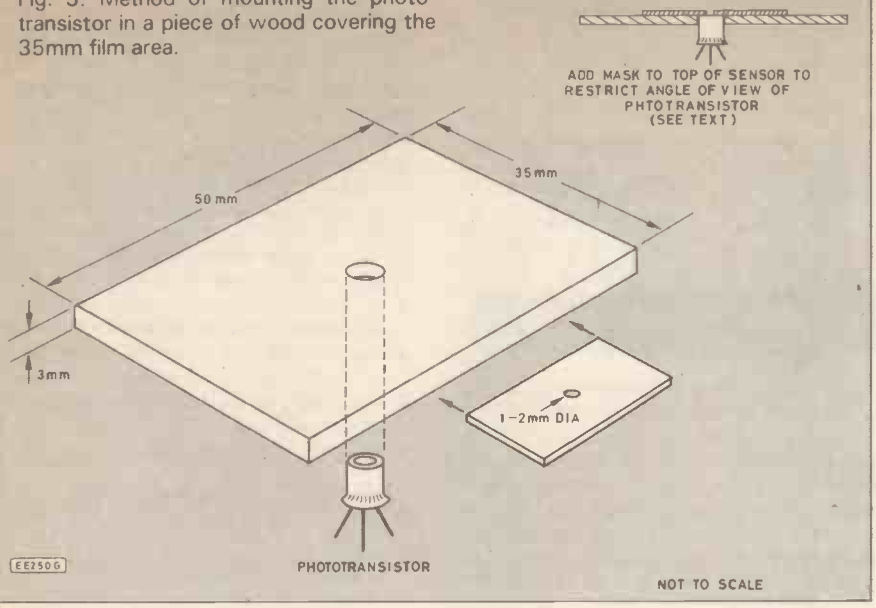
Fig. 2. Sensor circuit.

"The sensor can be mounted in a small piece of wood or other material, as in Fig. 3.

Listing 3: the program listing for the Shutter Timer project. The main body of the program is written in BASIC, but—as explained in the text—the speed of machine code is necessary to accurately time shutter openings. The code at line 4000 provides this.

```
  70 REM ************************
  80 REM *    SHUTTER TIMER     *
  85 REM *     48K Version      *
  90 REM *    G.E.CURTIS 1985   *
 100 REM ************************
 105 REM
 110 CLEAR 63999
 130 REM
 140 LET cal=65.5
 145 REM
 150 FOR a=64000 TO 64047
 160 READ n: POKE a,n
 170 NEXT a
 180 GO SUB 6000
 190 REM
 200 REM **  SET UP  SCREEN  **
 210 REM
 220 PRINT AT 4,7;"PRESS '5'  TO TEST"
 230 PRINT AT 5,7;"PRESS '1'  TO RESET "
 240 PLOT 10,10: DRAW 235,0: DRAW 0,155: DRAW -235,0: DRAW 0,-155
 250 PLOT 13,13: DRAW 229,0: DRAW 0,149: DRAW -229,0: DRAW 0,-149
 260 PLOT 16,16: DRAW 223,0: DRAW 0,90: DRAW -223,0: DRAW 0,-90
 270 REM
 280 REM ***  START TIMER  ***
 290 REM
 300 RANDOMIZE USR 64000
 310 REM
 320 REM *** GET  COUNT DATA ***
 330 LET l=PEEK 64050
 340 LET h=PEEK 64051
 350 LET hh=PEEK 64052
 360 LET c=l+256*h+32768*hh
 370 REM
 380 REM ***  PRINT RESULTS  ***
 390 REM
 400 IF c=1 THEN  PRINT AT 14,11;"FAILED": GO TO 460
 410 PRINT AT 10,7;INT (100*c/cal)/100;" Milliseconds"
 420 PRINT AT 14,10;" (OR) "
 430 LET f=INT ((1000/(c/cal))+0.5)
 440 IF f>1 THEN  PRINT AT 18,9;"1/";f;" Second"
 450 IF f<=1 THEN  PRINT AT 18,9;INT ((100*c/cal/1000)+.5)/100;" Seconds"
 460 PRINT AT 7,7;"PRESS 'Q'  TO QUIT "
 470 IF INKEY$<>"Q" AND INKEY$<>"q" AND INKEY$<>"1" THEN  GO TO 470
 480 IF INKEY$="Q" OR INKEY$="q" THEN  GO TO 9999
 500 CLS : GO TO 200
 510 REM
 520 REM *** M/CODE DATA  ***
 530 REM
4000 DATA 22,0,33,0,0,1,254,247,237,120,230,16,194,0,250,35,62,128,164,194,40,2
50,237,120,230,16,202,15,250,34,50,250
5000 DATA 122,50,52,250,201,0,0,0,20,33,0,0,195,22,250,201
5500 REM
5510 REM *** INTRODUCTION ***
5520 REM
6000 BEEP 0.5,5
6030 PRINT
6040 PRINT AT 6,0;"  This program measures camera   shutter   speeds    using
 a  phototransistor sensor  coupled to the computer through the joy stick port."
6050 PRINT AT 20,7;"Press 'C' to continue."
6100 IF INKEY$<>"C" AND INKEY$<>"c" THEN  GO TO 6100
6110 CLS
6120 RETURN
```

Fig. 3. Method of mounting the phototransistor in a piece of wood covering the 35mm film area.



(I use a piece which covers a 35mm film area.)

"If the device is to be used on focal plane shutters, the area of the sensor will need reducing by placing it behind a mask of around 1mm diameter. If this is not done, the width of the sensor will be greater than the slit width at high speeds and will affect the accuracy of the timer.

"For the same reason the light level used should be kept to the minimum which will give reliable results. If the light level is too high the measured times seem to be extended. Leaf shuttered cameras do not suffer the former problem but are equally susceptible to the latter."

Setting Up and Using the Timer

"Before testing a shutter the sensor needs checking to see that it triggers under reasonable light levels. This can be done by simply plugging the sensor into the interface. If the sensor sees light it will send a stream of '5's across the screen until the light is blocked out. If the level at which it switches on or off is incorrect, this can be adjusted by altering R1 in the circuit.

"When everything is working satisfactorily, the timer can be tested by placing the sensor centrally in the film gate. With the lens removed, the camera should be pointed at a light source (daylight works best).

"The timer should be reset by pressing key '1' and the required speed on the camera should be selected (try 1 sec first).

"Now fire the shutter. If the 'failed' message appears, the light source is not bright enough and should be moved closer. (The sensor may not have seen enough light and will simply be 'waiting'.)

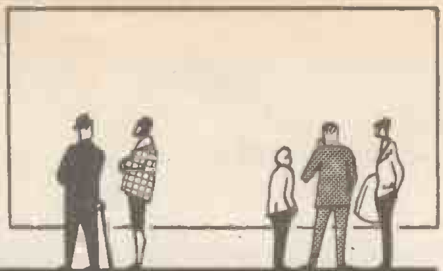
"After a few attempts the optimum set-up will be found and you will be able to operate the system with confidence."

If you have any comments or suggestions for inclusion in *On Spec* please drop me a line at:

The Department of Technology,
Brooklands Technical College,
Heath Road,
WEYBRIDGE,
Surrey KT13 8TT

NEXT MONTH: A number of simple add-on's to improve the Spectrum's sound and video capabilities (including sound from your own TV).

SHOP TALK



BY RICHARD BARRON

As part of our general editorial policy, we at *Everyday Electronics* endeavour to provide a wide range of services to our readers, especially in the hobbyist and education field. At the same time we try to keep up with the ever changing trends in the general electronics and computer market.

Shoptalk Extended

One particular service offered to our readers, is this, the *Shoptalk* page. To boost this service, over the next few months, we will be expanding *Shoptalk* to give a more general guide to the products and services available through retailers and suppliers. We will be taking a close look at various companies, their catalogues, special offers and the services which they provide.

This guide will not only help those of you who have experienced component buying problems but should be useful to all our readers. For those of you who are designing new projects, it is always useful to know what is available and from where. We will be looking at all areas of our hobby including: electronic components, equipment housing, wire, cable, soldering aids and test gear.

Catalogues Received

Over the last few weeks, we have received quite a number of catalogues and stock lists from a variety of companies. We have also had news of many new products which may be of interest. Some of these items will be mentioned this month and some will be held over until later months. This will not reflect their importance but will merely give us a chance to devote the time and space to which they all deserve.

Micro Catalogue

For some time now **Watford Electronics** have not produced a complete catalogue containing their full range of stock, however, they do have a "Micro Catalogue" available which contains a fairly comprehensive guide to their computer related products. This in not really surprising as Watford Electronics have become one of Britain's leading suppliers of home micro allied products. Indeed, the Watford disc filing system is said to be the ultimate DFS for the BBC Micro.

Shopping at Watford

Recently, I visited their retail outlet and warehouse in Watford. It was quite an eye-opener; not only do they have a massive amount of computer stock, but their analogue component range is very impressive. This includes a wide variety of linear i.c.s, transistors, capacitors, regulators, opto devices and other miscellaneous items.

As well as basic components, Watford's stock a range of other items including: seven-segment displays, equipment housing, p.c.b. materials, connectors and switches. In fact, whatever your electronic needs, they can probably supply them.

Computers

Back to computers, as I said, Watford's main interest seems to be in the micro market. They deal in all sorts of peripherals such as: printers, monitors, disc drives and general accessories. On top of this, Watford's also produce a great deal of their own software and firmware which is fast gaining an excellent reputation in the home micro field. And, for those of you who want to know more about such things as disc drives and printers, before you make any great investment, Watford's even produce their own books on the subject.

The general marketing strategy of Watford's has proved to be very successful with last year's turnover exceeding £5M. They now deal with 70 percent of their trade over the counter from their spacious, new retail shop built in 1984, and to give some idea of the scale of the operation, they sold over $\frac{1}{4}$million 2764 i.c.s in one year, and now boast over £1M turnover on disc drives alone.

If you are in the Watford area, then it could be well worth your while to pay them a visit. They would be only to pleased to demonstrate one of their systems.

If you want to know more about their products and services, then you will be pleased to know that they are in the process of producing a comprehensive catalogue which will be available sometime around Christmas. For information or mail order service ☎ (0923) 40588 and for 24-hour service, you can order by Access, ☎ (0923) 50234.

For more information or copies of the Watford's Micro Catalogue, contact: **Watford Electronics, 250 High St., Watford WD1 2AN.**

Broad Range

Cricklewood Electronics Ltd. pride themselves in supplying a broad range of electronic components to the hobbyist at very competitive prices. In their new catalogue, which is free on request, they advertise: "speedy delivery, new and old technology and 'super service' ".

Over the last four years, since they were established, Cricklewood have built up a good reputation amongst hobbyists. Their shop on Cricklewood Broadway in London is well stocked and new stock is ordered every day. This ensures customers are not disappointed, but should any part be unavailable, they will order it immediately. Cricklewood also offer another very useful service; they will source equivalents for most **RS** parts which, of course, are not available to hobbyists directly.

"New and old technology, speedy delivery and super service"

Their stock covers thousands of components from valves (old technology) to 256K memory i.c.s (new technology) and includes a comprehensive range of audio and power transistors.

Specialist in Non-Specialisation

Cricklewood have no plans to specialise, except in their policy of "non-specialisation." They intend to continue with their general range of electronic components and will be avoiding the home micro market. Presumably this allows them to continue to supply a vast range of "smaller" components at competitive prices without having to risk massive investment.

For mail order you can pay by cheque or credit card, or for personal service why not call in at their London shop. A catalogue or further information can be obtained from: **Cricklewood Electronics Ltd., 40 Cricklewood Broadway, London NW2 3ET. ☎ 01-450 0995.**

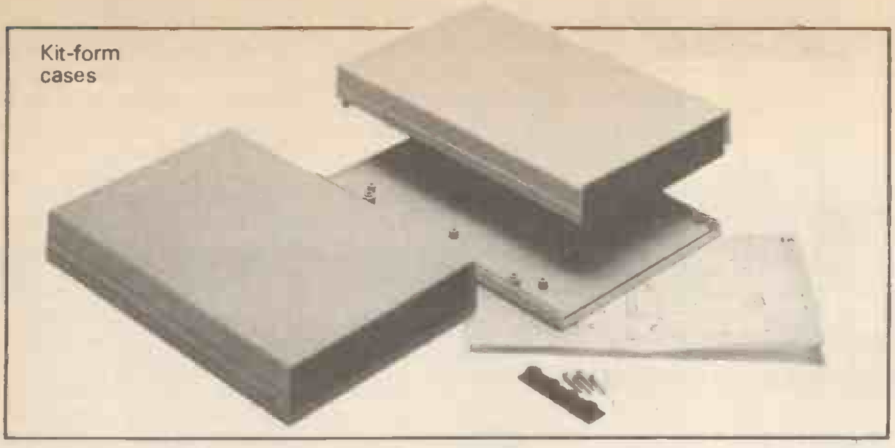
The Tool Book

Now published by **STC Electronic Services** is the 1985 edition of *The Tool Book*, a catalogue containing a wide range of tools and associated products stocked by this distributor who now has what is probably the largest range of tools, assembly aids, storage equipment, service aids, cells and batteries currently available from any one UK source.

Over 400 Products

Covering over 80 pages and in excess of 400 products, each of which is fully described and illustrated together with the latest pricing information, The Tool Book introduces a number of new products ranging from the Fortex guillotine to the Mitutoyo electronic calipers with liquid crystal display. Batteries include the latest lithium types whilst standard screwdrivers vie with component forming machines and complete soldering/desoldering stations for the attention of the reader.

The Tool Book is available, free-of-charge, from: **STC Electronic Services, Edinburgh Way, Harlow, Essex CM20 2DE. ☎ 0279 26777.**



Modular Kit-Form Enclosures

A new colour brochure is now available which describes **OK Industries'** range of PacTec moulded ABS enclosures. Available in kit form and with the option of customised panels, the enclosure range includes small units to house hand-held electronics such as calculators and control boxes, bench-top cases for all types of instrumentation and video terminal and keyboard housings for computer and allied equipment.

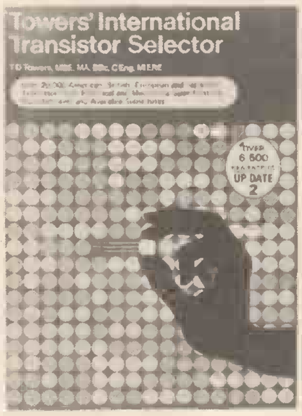
Copies of the brochure are available from: **OK Industries, UK Ltd., Dutton Lane, Eastleigh, Hants SO5 4SL.**

Transistor Selection

Despite the enormous use of i.c.s, many projects still demand the use of discrete transistors. It can sometimes be difficult to find the specified transistor so a desperate search for an alternative is often necessary.

One publication which is designed specifically for this purpose is the *Towers International Transistor Selector*.

This book contains a fully cross referenced list of over 20,000 transistors with their basic specifications, terminal identification and manufacturer's equivalents.



Useful Guide

Since its introduction this book has been up-dated three times, the third edition being priced at £12.95. However, the second update is still a very useful reference aid which covers transistor ranges manufactured up to 1980. This issue is available for only £6.75 inc. VAT and p & p from **Croydon Discount Electronics**.

Also available from Croydon is a $3\frac{1}{2}$ digit l.c.d. digital multimeter for only £29.95 inc. VAT to EE readers.

For information about this and their other products, contact: **Croydon Discount Electronics, 38 Lower Addiscombe Rd., Croydon, Surrey CR0 6AA. ☎ 01-688 2950.**

Cassettes Ejected

Many home micro owners have been considering taking the big step into serious computing which usually involves the purchase of at least one disc system. Maybe this news will help to make up their minds.

RSC Computer Services are now offering what must be one of the lowest priced fully packaged disc drives available for the BBC Micro. At just £66 inc. VAT, users who have suffered with unreliable cassette data recorders can now afford to upgrade their system.

The unit is based on the well proven Olivetti $5\frac{1}{4}$ inch drive, giving 100k capacity on a 40-track format. It comes complete with utility disc, manual and all cables ready for operation with any BBC Microcomputer fitted with Acorn DFS or compatible disc interface. For users without a disc interface fitted into their micros, RCS is offering a special package price of £165 including VAT to upgrade a model B microcomputer and supply a disc drive (plus £7.00 postage and packaging for return of the micro).

RSC Computer Services is the central repair agent for Acorn and will give six months warranty on parts and labour with this product. Telephone orders can be accepted with a credit card number and further information can be obtained from: **Leeway Data Products Ltd, Enterprise House, Central Way, North Feltham Trading Estate, Feltham, Middlesex TW14 0RX. ☎ 01-844 2044.**

CONSTRUCTIONAL PROJECTS

Iron Power Controller

It is very important to ensure that the correct type of components and housing are used for the *Iron Power Controller*. There will be mains electricity on the p.c.b. when the unit is operating, so safety must take priority. The unit must be housed in a plastic case and the potentiometer should have a plastic spindle.

A full kit of parts, including p.c.b., is available for £4.72 plus 60p P&P per order from: **Magenta Electronics Ltd., 135 Hunter St., Burton-on-Trent, Staffs., DE14 2ST. ☎ (0283 65435).**

**Please mention
EVERYDAY ELECTRONICS
when replying to
products mentioned
on this page
and to Classified Ads**

Safe Power Supply (Teach In '86)

The popular *Teach In'* series is back with more practical circuits which demonstrate the techniques of electronics. Each month, a complete project will be built to back up the theory learnt, the first of these being a *Safe Power Supply* which is capable of powering a wide range of circuits including all the *Teach In* projects.

As usual, we expect a number of advertisers to make complete kits available for the series, but to get you started, we have arranged an ***EE Special Offer*** for the transformer used in Part 1. For more details, see page 539 in this issue.

Also, readers will notice that the prototypes for all the Teach In '86 projects will use the same type of case and each month a front panel layout will be printed which will fit exactly.

The case used in the prototypes is the 'TEK A22' and is available in black, grey or lobster red. It is supplied from **West Hyde Developments Ltd.,** for £6.18 inc. VAT and P&P. For orders and details, contact: **West Hyde Developments Ltd., Unit 9, Park St. Ind. Estate, Aylesbury, Bucks. HP20 1ET.**

Signal Generator (Building Blocks)

No component buying problems are envisaged for this month's Building Blocks, as the Simple Audio Generator consists of only a handful of components which are readily available. Remember that the "bargain" p.c.b. (four projects) is available from the ***EE PCB Service***, see page 573 for details.

Simple Reverb

A full kit of parts for the *Simple Reverb* is available from **Becker Phonosonics**, price £32.95 inc. VAT, P&P. For more details of this and other products, contact: **Becker Phonosonics, Dept EE, 8 Finucane Drive, Orpington, Kent, BR5 4ED. ☎ (0689) 37821.**

Strain Gauge (Transducers-2)

Most of the components for the *Strain Gauge* are commonly available but the actual strain gauge transducer may be a problem to find. The one used in the prototype (**RS** 308-102 or 308-118) is available for around £2.50.

TRANSDUCERS

PART 2 STRAIN GAUGES - THEORY OF OPERATION AND A PRACTICAL PROJECT... MIKE FEATHER BSc

THE DETECTION and measurement of strain in a material subjected to mechanical stress is an area of importance paramount to the engineer and designer of mechanical structures of all types.

Several measurement methods exist, but perhaps the commonest and most straightforward of these entails the use of resistive strain gauges which rely upon the stretching or compression of a conductor and the consequent change in its length, cross-sectional area and hence electrical resistance. Some contribution to the change in resistance is also brought about by an alteration in the conductivity of the material as a result of a change in its structure, but this effect is usually small.

Early resistive strain gauges employed a grid of fine wire mounted on a semi-rigid backing which was glued firmly to the specimen or structure under stress.

More recent gauges use copper-nickel alloy elements, which can be produced so as to possess very low temperature coefficients thus rendering the resistance of the gauge relatively insensitive to changes in temperature. The grid itself is usually formed by photo-etching techniques and encapsulated in a polyester film in order to protect it from damage.

GAUGE FACTOR, K

This is a constant for a particular gauge and is defined as the change in resistance expressed as a fraction of the total resistance produced by the application of a unit strain. Expressing this in the form of an equation:

$$K = \frac{\triangle R}{R.E}$$

Where $\triangle R$ is the change in resistance produced by the strain E and R is the unstrained resistance of the gauge.

If the equation is rearranged slightly, we can obtain an expression for the change in resistance and see how it depends upon gauge factor and other considerations. This gives us:

Change in resistance = $\triangle R = E \times K \times R$

So, for a certain value of strain, a large (and hence easily measurable) change in resistance will be produced by a gauge having a large gauge factor K and a large unstrained resistance R. Both of these factors are characteristics of a particular strain gauge and are usually to be found in data supplied by the manufacturer.

TEMPERATURE COMPENSATION

As already mentioned, strain gauge elements are usually made from specially formulated alloys which show little change in resistance with temperature.

A difficulty can arise in precise work however, when the specimen itself expands or contracts due to changes in its temperature: this will clearly give rise to changes in the gauge resistance which do not originate from mechanical strains on the specimen. Fortunately, most manufacturers produce gauges which will self-compensate for thermal changes when employed with particular metals, commonly mild steel and aluminium.

MOUNTING OF STRAIN GAUGES

In order to obtain accurate and consistent results from strain gauges, it is important that the gauge itself and the surface to which it is to be affixed are both carefully prepared.

The specimen surface should be clear of paint or any other surface covering and all traces of rust removed. Any traces of grease etc. should be removed with an appropriate solvent and the surface then allowed to dry thoroughly.

The gauge surface should be identified and a thin layer of epoxy resin adhesive (e.g. "Araldite") carefully applied to it; the gauge should then be carefully positioned on the prepared area of the specimen and gently pushed down so as to exclude any air bubbles from underneath it. Allow twenty four hours for the adhesive to set.

Lead wires are usually rather fragile and should be handled with care; it is conventional to take them to rigidly mounted solder pads adjacent to the gauge from which the main leads may be taken.

STRAIN GAUGE CIRCUITRY

Strain gauges are almost invariably wired into some form of bridge circuit and, if a single gauge is used, it forms one arm of the bridge, appropriate fixed resistors being used for the others. A typical circuit arrangement is shown in Fig. 2.1.

The output voltage from the bridge is dependent upon the strain, the gauge factor and the bridge supply voltage Vs. As the change in resistance due to strain of the gauge itself is likely to be very small, any changes in the values of the other bridge resistors are likely to produce considerable errors. For this reason, precision strain gauge measurements require the use of high stability, high precision resistors in the bridge.

These are rather expensive components and, if only fairly elementary investigations are envisaged, then it is possible to use 1 or 2 per cent metal oxide film types for the bridge resistors and achieve reasonable stability.

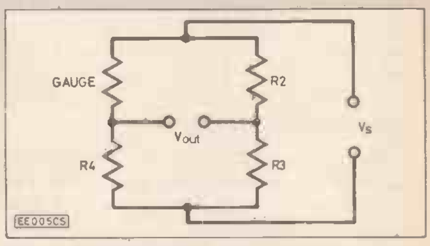


Fig. 2.1. Principle of quarter-bridge strain gauge circuit.

The output from the bridge will normally be very small and require appropriate amplification. Fig. 2.2 shows a suitable bridge amplifier circuit which will develop outputs of up to 100mV for a range of gauge deformations. The circuit was originally designed for use with the data acquisition system described in the December, 1983, issue of this magazine, but a digital or analogue voltmeter can be used to indicate the output.

CIRCUIT DESCRIPTION

The circuit employs a 725CN instrumentation amplifier which offers a superior performance to more conventional operational amplifiers such as the 741, CA3140. In particular, drift characteristics are much improved—a significant factor in this application.

The bridge circuitry comprises R1 (the strain gauge), R2, R3 and R4. These three resistors must be equal in value to the unstrained gauge resistance and must be at least 1% tolerance metal oxide film types.

The bridge supply voltage Vs is derived from the regulated +5V and −5V supply lines via resistors R6 and R7 which should also be high stability types.

The prototype strain gauge amplifier, fixed in the case adopted as standard for all the projects in this series. Full details, see the components list overleaf.

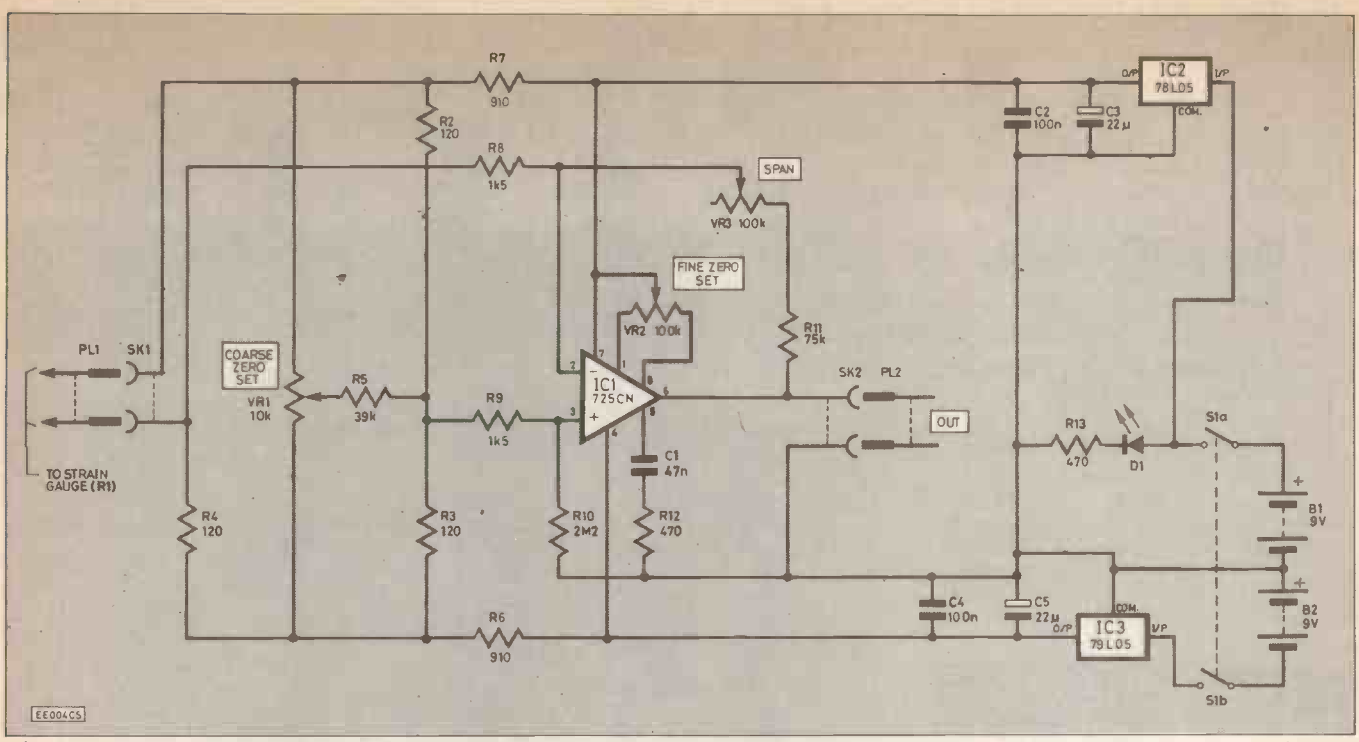


Fig. 2.2. Strain gauge bridge amplifier circuit, giving an output up to 100mV.

A variable offset voltage is applied to one arm of the bridge; this is summed with the bridge output and applied to the non-inverting input of the operational amplifier. This arrangement provides a coarse zero set facility for the circuit; VR1 must be a multi-turn device of at least 10 turns. Fine zero set is catered for by VR2, which is the normal offset-null control for the 725CN. A 100k multi-turn potentiometer is used and the two controls can compensate for inequalities in the bridge circuit components.

The other arm of the bridge is taken, via R8, to the inverting input of the op-amp.

Variable negative feedback is applied to the op-amp circuitry by the resistors R11/VR3. Adjustment of VR3 thus allows the overall gain to be varied, hence providing a facility for varying the range of strain gauge deformations that are required to produce full scale output. This arrangement is often known as a span control.

C1 and R12 determine the band width of the operational amplifier and, since strain gauge deformations are likely to be slow, only low frequency signals need be catered for. This is particularly important if the circuit is to be used with the data acquisition system previously referred to.

In this case, the analogue signal at the output is sampled quite rapidly and any a.c. signal (e.g. 50Hz hum) will be detected and seriously affect the data value. Positive and negative 5V regulators IC2 and IC3 provide stable supply lines to the circuit whilst C2–C5 give decoupling of supply line signals.

CONSTRUCTION OF THE STRAIN GAUGE AMPLIFIER

The circuit can be built on Veroboard, but the printed circuit board approach is to be preferred. Fig. 2.3 shows full size copper side and component side layouts. An eight pin d.i.l. socket should be used for IC1, which should not be inserted until construction is completed.

Care should be exercised with polarised components such as electrolytic capacitors and regulators IC2 and IC3. Note particularly that the lead out configurations of

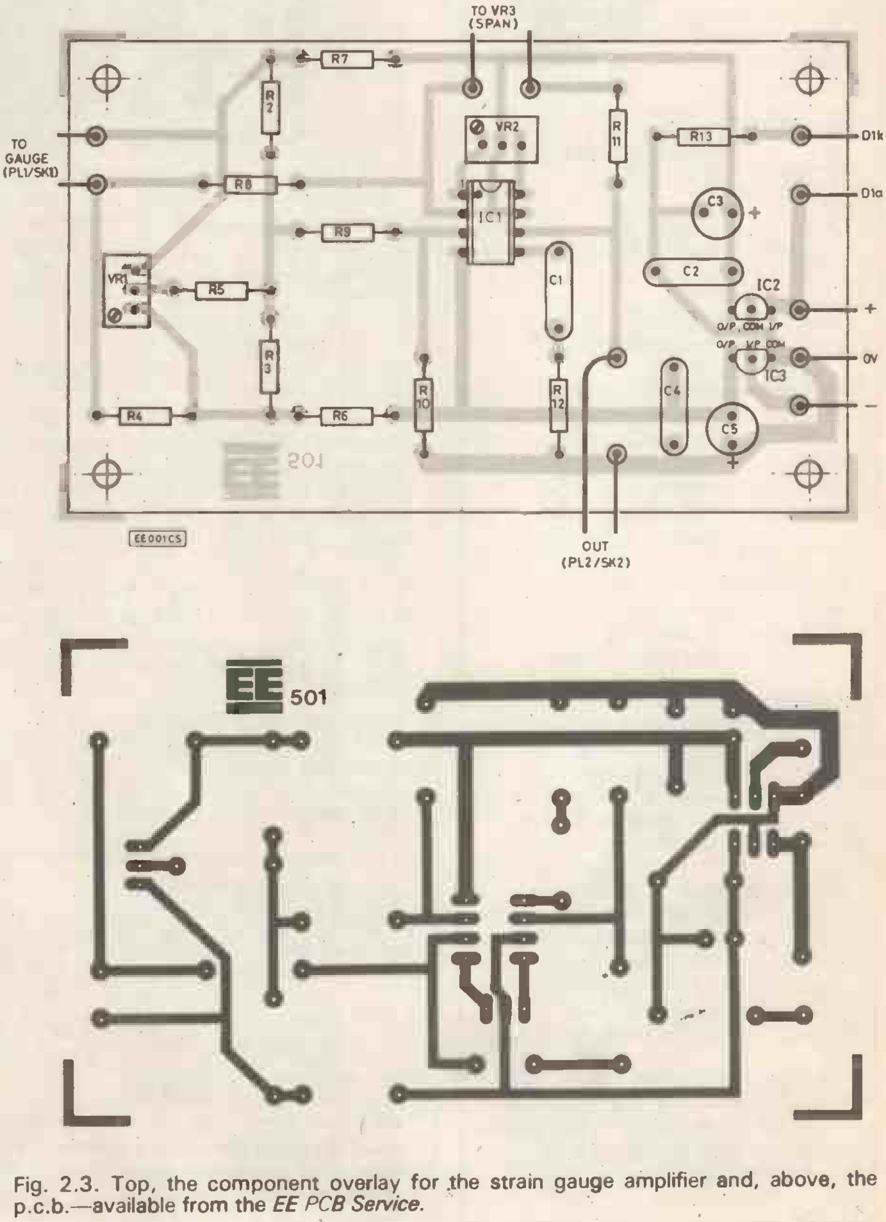


Fig. 2.3. Top, the component overlay for the strain gauge amplifier and, above, the p.c.b.—available from the *EE PCB Service*.

these two otherwise similar devices differ; refer to the diagrams in Fig. 2.4 for clarification of this.

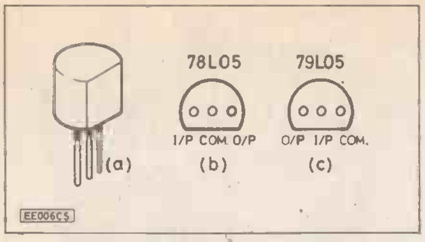


Fig. 2.4. Pinout details for the 78LO5 and 79LO5 voltage regulators.

Connections to off-board components such as VR4, input and output sockets etc. are made by short lengths of twisted insulated 7/0·2 wire, veropins providing the terminations at the p.c.b. (or Veroboard) end. It is essential that the circuit be housed in a metal box in order to provide electrostatic screening.

COMPONENTS

See Shop Talk page 554

Resistors

R1	Strain gauge (see text)
R2–R4	120 (3 off)
R5	39k
R6, R7	910 (2 off)
R8, R9	1k5 (2 off)
R10	2M2
R11	75k
R12, 13	470 (2 off)

All ½W 1% metal film (except R1)

Potentiometers

VR1	10k, 25-turn cermet trimmer
VR2	100k, 25-turn cermet trimmer
VR3	100k, rotary, linear track

Capacitors

C1	47n
C2, C4	100n (2 off)
C3, C5	22µ (2 off) radial

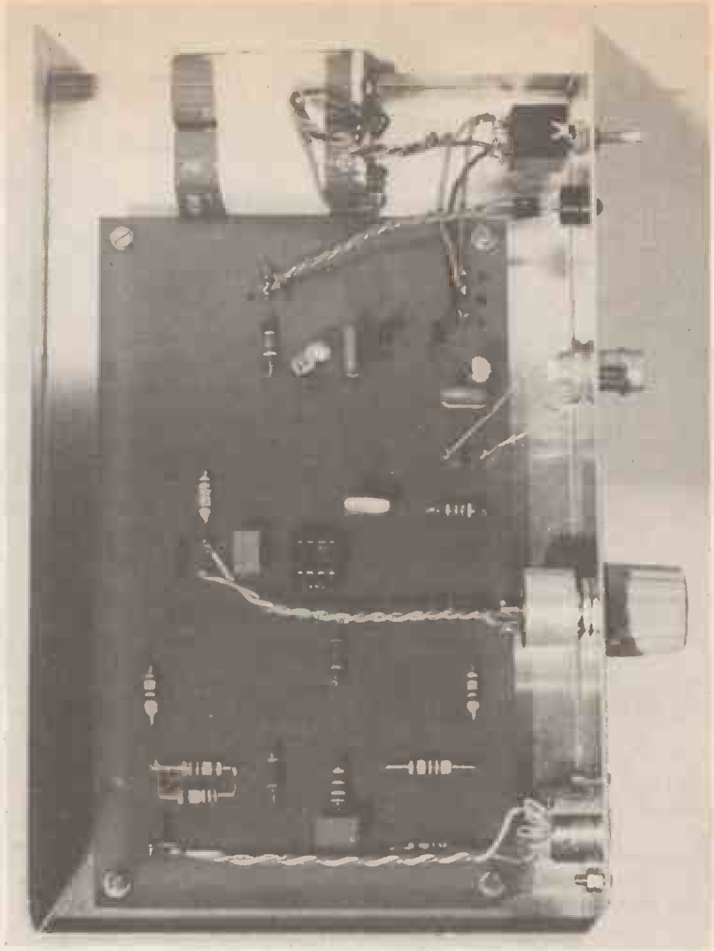
Semiconductors

D1	green l.e.d.
IC1	725CN op-amp
IC2	78L05 voltage regulator
IC3	79L05 voltage regulator

Miscellaneous

B1, B2	9V PP3 batteries
PL1	5 pin DIN plug
PL2	BNC plug
S1	d.p.d.t. toggle switch
SK1	5 pin DIN socket
SK2	BNC socket

Case—203 × 127 × 51mm; printed circuit board, available from the *EE PCB Service*, order code EE-501 knob for VR3; 8-pin i.c. holder; adhesive feet for case.



Internal details of the prototype strain gauge amplifier.

The strain gauge itself was (in this application) mounted on a strip of 16 SWG mild steel of dimensions approx 30 cm × 3 cm. Connections to it must be carefully screened and the arrangement shown in Fig. 2.5 is recommended. A 5-pin DIN plug provides the termination at the amplifier end.

If, as shown in Fig. 2.5, the screen is connected to one of the DIN plug pins, then the same point on the DIN socket should be connected to the 0V line on the circuit. The 0V point is at the junction of the two batteries—that is, the line connected to IC2 and IC3 "common" in Fig. 2.2. This arrangement is probably the best for most purposes, as it gives increased stability.

SETTING UP THE GAUGE AMPLIFIER

With the gauge connected and in an unstressed condition, the amplifier should be switched on. It is as well, at this point, to check the ±5V supply rails; they should not differ appreciably from these values.

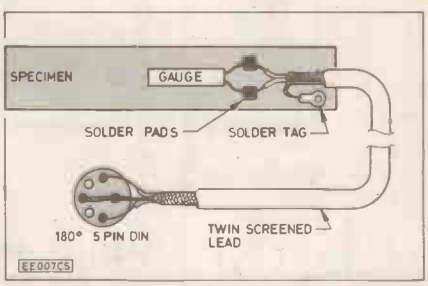


Fig. 2.5. Fixing the strain gauge onto a piece of specimen metal, showing the method of mounting, and the solder connections.

COMPONENTS approximate cost £25.00

Analogue multimeters are unlikely to possess a 100mV f.s.d. range but if a 100µA f.s.d. 1000Ω (or 1mA, 100Ω) meter is available, then this can be used to provide an analogue indication of output. A digital multimeter set to the 200mV range provides a superior alternative.

Whichever is used, it should be connected to the output socket and the span control set at maximum resistance. The coarse zero set control VR1 should now be adjusted to give zero output, final adjustment being made with VR2.

Deflection of the gauge should now produce an output as indicated by the voltmeter. If a simple cantiliver specimen is used (as in the diagram), then calibration can be achieved by suspending known masses from its free end and noting the output voltages for a range of these masses.

Both tensile and compressive stresses may be applied to the specimen and these will give outputs of opposite polarity; the gauge behaviour is, however, different under these two conditions and equal outputs for equal strains are unlikely.

The current consumption of the circuit is fairly small but, if PP3 batteries are employed and prolonged periods of usage are envisaged, it is as well to check the ±5V supply lines from time to time. PP9 batteries will give hours of continuous usage.

NEXT MONTH: A flux density transducer

CMOS	
4000	16p
4001	16p
4002	16p
4006	50p
4007	18p
4008	44p
4009	30p
4010	32p
4011	16p
4012	16p
4013	20p
4014	40p
4015	40p
4016	27p
4017	39p
4018	40p
4019	33p
4020	50p
4021	45p
4022	43p
4023	16p
4024	30p
4025	16p
4026	68p
4027	30p
4028	38p
4029	53p
4030	28p
4031	100p
4032	54p
4033	60p
4034	95p
4035	50p
4036	220p
4037	80p
4038	50p
4039	220p
4040	42p
4041	38p
4042	43p
4043	40p
4044	40p
4045	72p
4046	49p
4047	49p
4048	32p
4049	26p
4050	26p
4051	42p
4052	40p
4053	40p
4054	58p
4055	58p
4056	58p
4060	53p
4063	57p
4066	30p
4067	160p
4068	16p
4069	16p
4071	16p
4072	16p
4073	16p
4075	16p
4076	50p
4077	16p
4078	16p
4081	16p
4082	16p
4085	42p
4086	34p
4089	90p
4093	26p
4095	58p
4098	56p
4099	58p
4501	30p
4502	40p
4503	32p
4504	60p
4505	260p
4506	60p
4507	33p
4508	85p
4510	42p
4511	43p
4512	46p
4513	90p
4514	90p
4515	85p
4516	51p
4517	130p
4518	40p
4519	30p
4520	44p
4521	90p
4522	50p
4526	48p
4527	48p
4528	44p
4529	78p
4532	55p
4551	85p
4553	190p
4555	29p
4556	41p
4557	190p
4583	65p
4584	36p
4585	46p

74LS SERIES	
74LS00	17p
74LS01	17p
74LS02	17p
74LS03	17p
74LS04	17p
74LS05	17p
74LS08	17p
74LS09	17p
74LS10	17p
74LS11	17p
74LS12	17p
74LS13	26p
74LS14	30p
74LS15	17p
74LS20	17p
74LS21	17p
74LS22	17p
74LS24	38p
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74LS27	17p
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74LS30	17p
74LS32	17p
74LS33	17p
74LS37	17p
74LS38	17p
74LS40	17p
74LS42	39p
74LS47	70p
74LS48	60p
74LS51	17p
74LS54	17p
74LS55	17p
74LS73	28p
74LS74	26p
74LS75	32p
74LS76	28p
74LS78	34p
74LS83	46p
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74LS90	39p
74LS91	75p
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74LS196	67p
74LS197	52p
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74LS240	62p
74LS241	60p
74LS242	70p
74LS243	64p
74LS244	64p
74LS245	78p
74LS247	50p
74LS248	50p
74LS249	92p
74LS251	30p
74LS253	50p
74LS256	65p
74LS257	48p
74LS258	45p
74LS259	62p
74LS260	42p
74LS266	28p
74LS273	72p
74LS279	46p
74LS280	140p
74LS290	30p
74LS293	30p
74LS365	42p
74LS366	44p
74LS367	43p
74LS368	41p
74LS373	68p
74LS374	68p
74LS375	58p
74LS399	80p
74LS670	80p

VALVES	
DAF96	60p
DF96	50p
DL92	47p
DY87	50p
DY802	45p
EABC80	50p
EB91	44p
EBF80	45p
EBF89	50p
ECC82	40p
ECC83	43p
ECC84	40p
ECC85	40p
ECH81	49p
ECH84	52p
ECL80	57p
ECL82	59p
ECL84	57p
ECL85	57p
ECL86	49p
EF80	31p
EF85	34p
EF89	43p
EF183	45p
EF184	53p
EL34	190p
EL36	60p
EL84	50p
EL95	50p
EL500	80p
EL504	100p
EY86	31p
EY87	31p
EY88	32p
EZ35	45p
EZ80	50p
EZ81	55p
GZ34	180p
PC97	100p
PCC85	42p
PCF80	58p
PCF200	135p
PCF801	110p
PCF802	57p
PCF806	115p
PCH200	100p
PCL81	54p
PCL82	63p
PCL84	50p
PCL85	55p
PCL86	55p
PCL805	55p
PFL200	85p
PL36	80p
PL82	45p
PL83	32p
PL84	50p
PL95	140p
PL500	110p
PL504	95p
PL508	170p
PL519	450p
PY81	70p
PY88	48p
PY500A	160p

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

VOLTAGE REGULATORS	
7805	35p
7812	35p
7815	35p
7818	35p
7824	35p
7905	35p
7912	40p
7915	40p
7918	40p
7924	40p
78L05	28p
78L12	28p
78L15	28p
78L18	28p
78L24	28p
79L05	40p
79L12	45p
79L15	48p
LM309K	100p
LM317K	220p
LM317T	180p
LM323K	420p
LM723	32p
78HGKC	570p
78H05KC	520p
78GU1C	190p
79GU1C	215p
79HGKC	670p

LINEAR IC'S	
AN-214P	200p
AN-240P	150p
AN-360	120p
AN-7110	140p
AN-7114	160p
AN-7115	160p
AN-7120	140p
AY3-1270	680p
AY3-1350	300p
AY3-8910	360p
AY3-8912	400p
AY5-3600	570p
CA270	40p
CA3046	60p
CA3048	190p
CA3060	280p
CA3080E	70p
CA3086	55p
CA3089E	150p
CA3090AQ	300p
CA3130E	80p
CA3130S	100p
CA3140E	38p
CA3189E	250p
HA-1156W	110p
HA-1197	150p
HA-1306W	170p
HA-1319	250p
HA-1339	170p
HA-1342	170p
HA-1366WR	160p
HA-1368	160p
HA-1377	220p
HA-1389	140p
HA-1392	230p
HA-1397	250p
HA-1398	240p
HA-1201	85p
LA-1352	120p
LA-1365	140p
LA-3301	120p
LA-3350	120p
LA-3361	115p
LA-4030	200p
LA-4031	140p
LA-4032	140p
LA-4050	130p
LA-4051	160p
LA-4100	120p
LA-4101	100p
LA-4102SK	140p
LA-4112	250p
LA-4125	210p
LA-4140	70p
LA-4201	120p
LA-4220	120p
LA-4400	190p
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LA-4422	130p
LA-4430	130p
LA-4460	170p
LA-4461	180p
LA-5112	120p
LM301	26p
LM311	35p
LM324	35p
LM325	45p
LM339	40p
LM348	60p
LM380	100p
LM381	150p
LM382	130p
LM387	100p
LM709 DIL	30p
LM723	40p
LM741 DIL	18p
LM741 MET	45p
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TEACH-IN '86

SAFE POWER SUPPLY

PROJECT 1

Michael Tooley **BA** ***David Whitfield*** **MA MSc CEng MIEE**

THIS is a new constructional series which starts this month, and which will run until next summer. The aims of the series are two-fold. In the first instance it describes a set of useful test instruments which are simple to build, yet offer a useful range of facilities. Secondly, the projects have been organised to complement the material presented in *Teach-In '86* by providing practical illustrations of the techniques introduced.

SELF-CONTAINED

Each project is designed to be self-contained (although not self-powered), and should make a worthwhile addition to any workshop or electronics lab. All of the projects can be used with the power supply being described this month, or with any other suitable d.c. supply. Although the projects have been arranged to fit in with the *Teach-In* material, it must be emphasised that they are all complete in their own right. Each project uses a circuit board which is based on a common size of Veroboard. Full constructional details will be given each month, and these will include printed front panel overlays to give each unit a finished appearance, and simplify calibration.

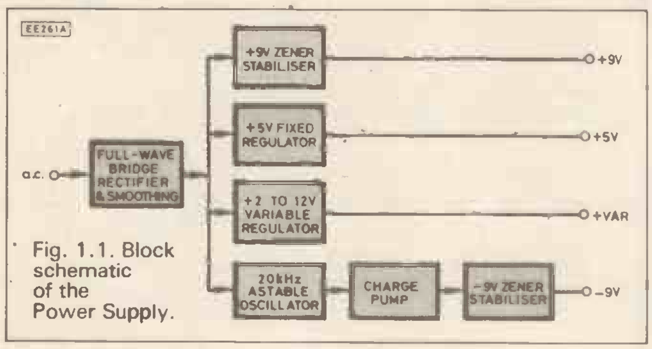


Fig. 1.1. Block schematic of the Power Supply.

POWER SUPPLY

The first project is a basic general purpose d.c. power supply which is suitable for a wide range of applications requiring a d.c. supply. Amongst these, it is capable of providing power for all of the practical assignments in *Teach-In '86*. It is also capable of powering any of the remaining constructional projects in this series. The specification for the unit is given in Table 1.

Table 1.1. Power supply specifications.

Input	
Voltage:	12V to 15V a.c. 15V to 20V d.c.
Current:	1A maximum
Outputs	
Op-Amp:	±9V nominal 20 mA each output
Logic:	+5V ±0·2% 1A maximum output* 750mA short circuit current
Variable:	+2V to +12V 1A maximum*

*Combined current not to exceed 1A (600mA with *EE* adaptor).

This is the only project in the series which involves mains voltages in any way, and hence safety has been one of the overriding concerns in producing the design. To this end, the power supply is divided into two parts: the mains transformer unit, and the rectifier/regulator unit. The output from the transformer and the input to the regulator unit is a maximum of 14V a.c., and within the unit the highest d.c. voltage is less than 20V. This therefore localises the area requiring more than usual care to the transformer and its input wiring.

To avoid the need for the constructor to become involved in any mains wiring, a special combined sealed mains plug and double-insulated transformer unit has been used. This plugs directly into a 13 amp socket and produces 14V a.c. on the output lead. The sealed construction of the unit also prevents any unauthorised tampering. The mains unit is available as an ***EE Special Offer*** at a remarkably low price (see the advert in this issue, but hurry while stocks last! Page 539.)

For those requiring slightly more current than the adaptor unit is capable of delivering (600mA), or for those too late to take advantage of the *EE Special Offer*, the construction of an alternative mains unit using a domestic bell transformer is also described.

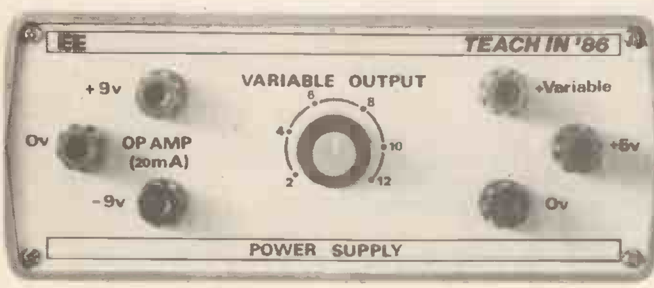
CIRCUIT DESCRIPTION

The block schematic for the power supply is shown in Fig. 1.1, and the complete circuit diagram is shown in Fig. 1.2. The a.c. output from the mains unit is connected to SK1 and SK2. This is then full-wave rectified by the bridge rectifier, REC1, and then smoothed by the reservoir capacitor, C1, to produce an unregulated d.c. supply. With the encapsulated mains unit, this supply will be at approximately 19V, whereas with the bell transformer, it will be approximately 16V.

If a d.c. supply of 15V to 19V (such as a car battery charger) is available, this can be used instead of the mains adaptor unit. It should be connected (either way round) to the a.c. input sockets (SK1 and SK2) and the bridge rectifier will automatically 'steer' the inputs to the correct bridge outputs.

The unregulated d.c. supply is then connected to the four regulators as shown in Fig. 1.1, and is used to produce the four different output voltages. As indicated by Table 1.1, the ±9V outputs can provide up to 20mA each. The +5V and the variable output can each provide up to 1A, provided that the mains transformer and regulator heatsinks are suitable. However, only a *total* of 960mA may be drawn from the combination two outputs when using a 1A transformer (allowing 40mA for the other outputs). Thus, for example, if 300mA is drawn from the +5V supply, this leaves 660mA available for the variable output.

Looking first at the +9V rail, this is produced by a zener shunt stabiliser arrangement. The diode, D1, draws current through the series resistor, R3. The amount drawn is that required to hold the voltage across the diode down to its nominal value of 9·1 volts. When there is a load across the output, some of this current is passed by the load instead of the diode. The diode thus passes less current when a load is connected than when there is none. The value of R3 is chosen so that at 20mA output, there is still around 5mA to 10mA flowing through D1, whereas when there is no load, the full 25mA to 30mA is passed by the diode.



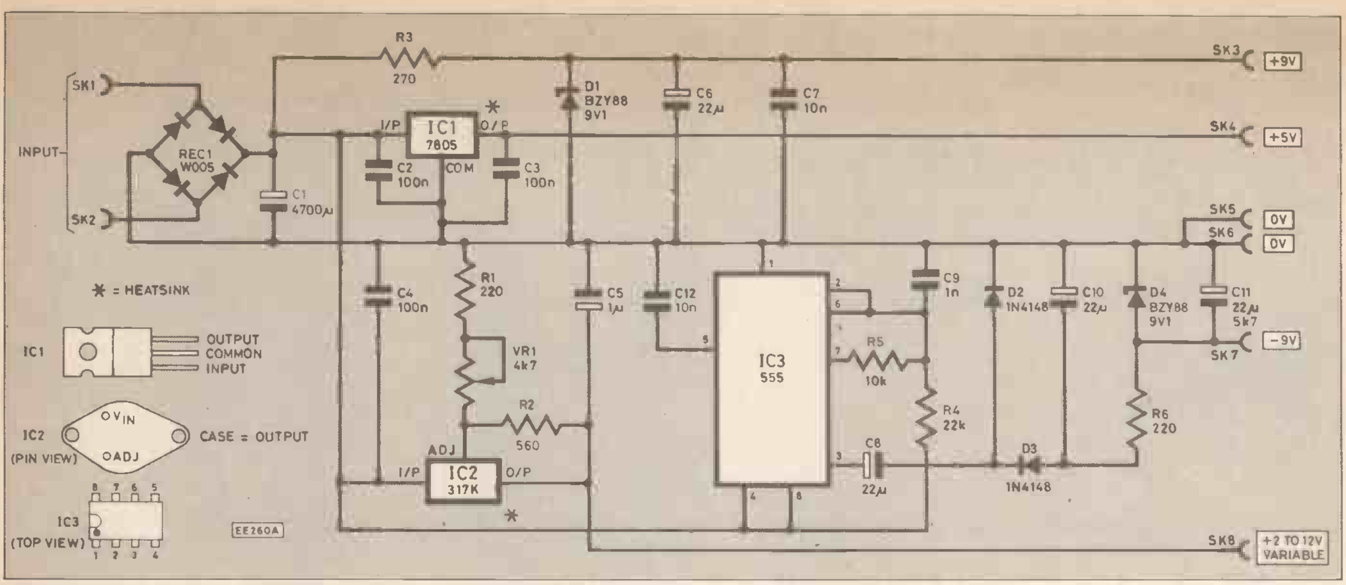


Fig. 1.2. Circuit diagram of the Safe Power Supply.

The –9V output is a little more difficult to produce than the +9V output due to the absence of a negative voltage rail. Initially, therefore, a 20kHz square wave is produced using IC3 configured as an oscillator. The output from the oscillator is then connected to a diode charge pump formed by C8, D2, D3 and C10. Using a fairly high oscillator frequency allows the circuit to operate with low values of capacitor, but without introducing any significant ripple on the output. The output from the pump circuit is then connected to a zener shunt stabiliser circuit similar to that used for the +9V rail.

The simplest part of the supply is the +5V rail, which is produced by a high performance 3-terminal fixed voltage regulator, IC1. This device features internal overload, thermal and short-circuit protection, all contained in a low-cost plastic package. The two capacitors, C2 and C3, provide essential decoupling for the regulator.

The final section in the power supply is the variable voltage regulator. This is a little more elaborate than the fixed regulator used above, and incorporates a 3-terminal variable regulator, IC2. The minimum possible output voltage from the regulator is 1·25V, but in this circuit it is set to approximately 2V by the combination of R1 and R2. The maximum voltage is set by the combination of (R1 + VR1) and R2 to approximately +12V. In order to ensure proper regulation, the maximum regulator output needs to be at least 2V less than the input voltage. The regulator features internal current limiting, in addition to thermal protection.

The construction of the power supply is in two stages: the mains transformer, and the regulator unit.

TRANSFORMER UNIT

There are two choices for the mains transformer unit. The preferred choice, particularly if you have *any* doubts about mains wiring, is to use the *EE Special Offer* adaptor unit. This also works out much cheaper than the bell transformer option.

With the *EE* adaptor (which is similar to some calculator adaptors), it is a simple matter to prepare it for use with the regulator unit. First cut off the small moulded plug which is at the end of the output lead. Next separate the two wires in the lead for a distance of about 20cm back from the free end. Cut one of the wires at this point (it doesn't matter which one), but keep the cut length. Then connect an in-line (car-type) fuseholder to the shorter lead, reattaching the loose length (shortened by the length of the fuseholder). Fit a 1A fuse to the fuseholder, and fit a 2mm plug to each of the free ends of the lead. The 2mm plugs are used to avoid possible confusion with the output terminals, which take 4mm plugs.

Fig. 1.3. Mains adaptor construction.

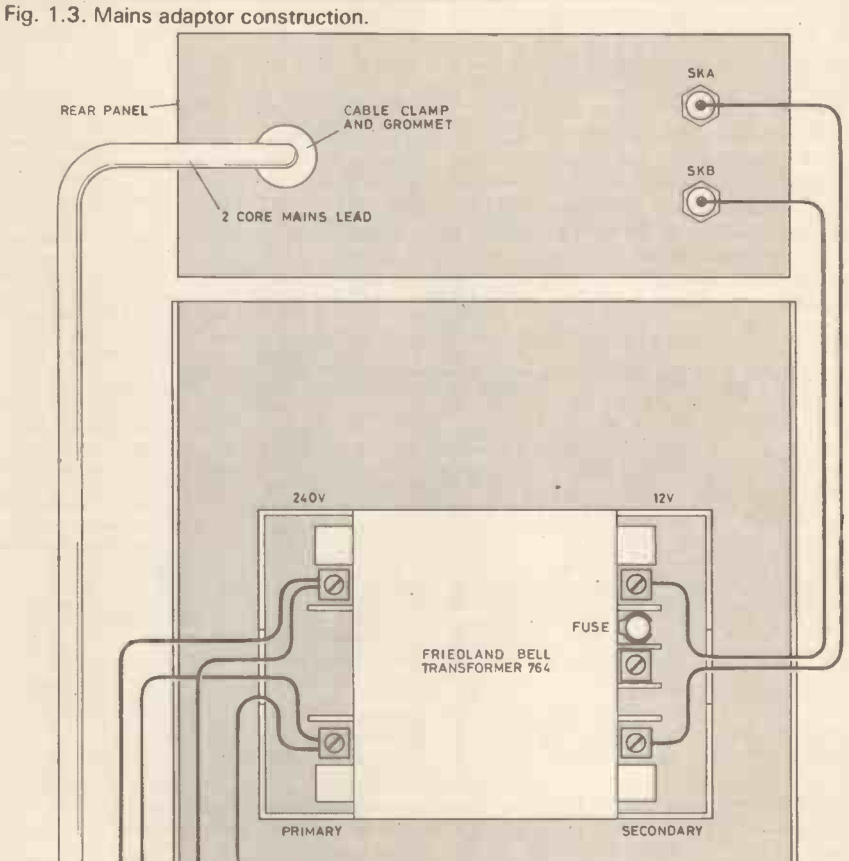
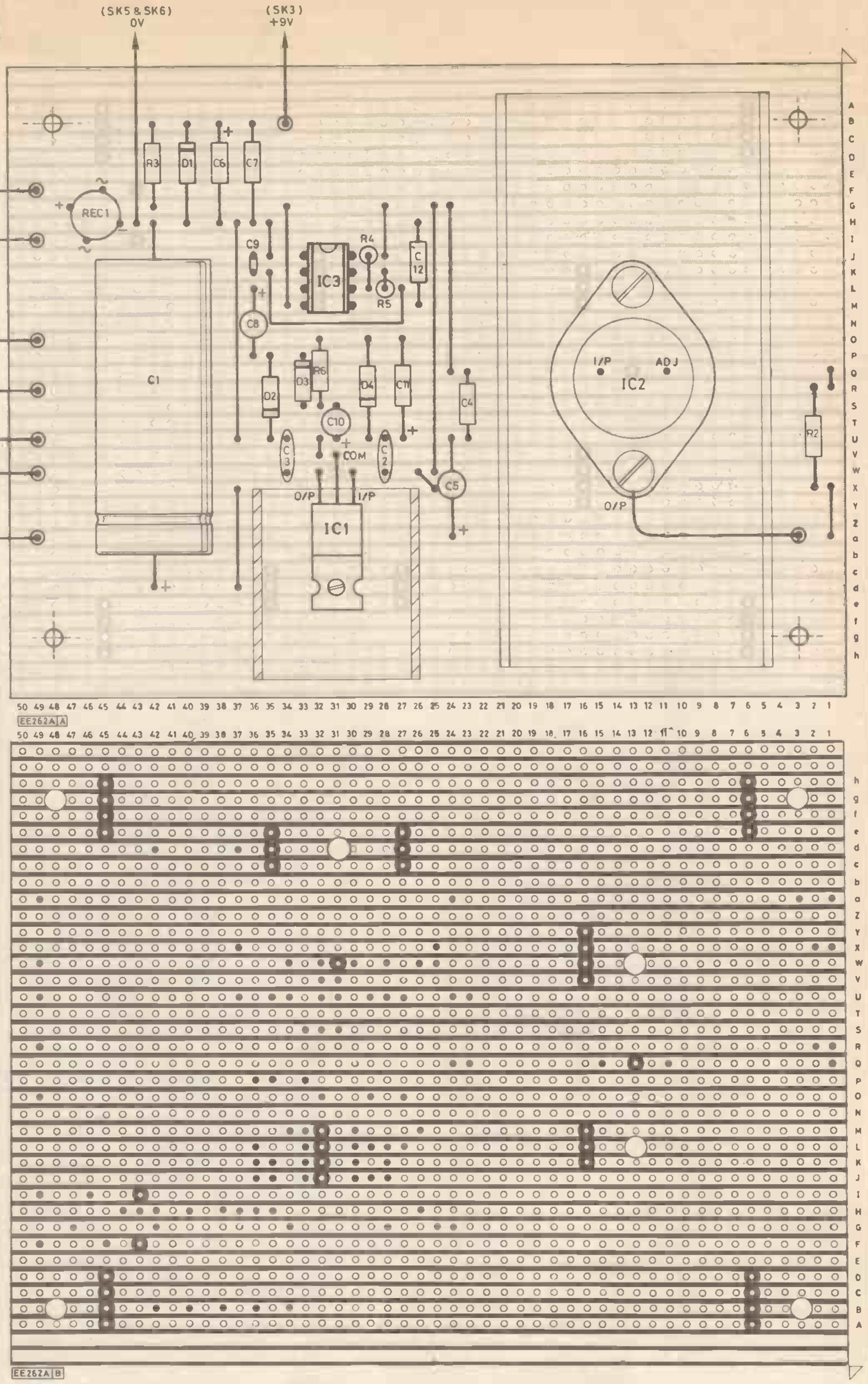


Fig. 1.4. The Veroboard and component details of the Safe Power Supply.



See Shop Talk page 554

See *EE Special Offer* Page 539

If instead, you are using the bell transformer, it is recommended that it is installed in a case of the same type as used for the projects. If you are in *any* doubt about your ability to complete the mains wiring, you *must* get it checked by a suitably qualified expert *before* connecting it to the mains.

Fig. 1.3 shows how the standard domestic bell transformer is fitted into a case, secured to the base by 4 bolts. Included in the unit are a double-pole rotary mains switch (although a toggle type is equally suitable) and a neon indicator to indicate when the unit is switched on.

The hole diameters for the front panel will depend on the components used. The mains lead should be a two-core fitted with a plug and a 3A fuse at one end, and secured to the rear panel by a suitable grommet and clamp arrangement to avoid rubbing on the edges of the panel hole. The transformer output is already protected by an integral 1A fuse shown in the drawing. Fig. 1.3 shows the end covers removed from the transformer, but these should be replaced after the wiring is complete. The output from the transformer is connected to a pair of 2mm sockets on the rear panel.

The front panel overlay is given in Fig. 1.6, which should be cut out (or photocopied) and fixed to the front panel. A covering of self adhesive transparent library film is suggested for protection. Before fixing the top back on the case by means of the upper panel screws at the front and rear, make one final careful check to verify that the wiring is secure, correct and safe, and that there are no inadvertent connections caused by solder splashes or stray wire strands.

Finally, a two-core lead is required, with a 2mm plug at the ends of each core, to link the transformer unit to the regulator unit. It is useful to include an in-line fuse in this lead in a similar manner to that described for the encapsulated transformer unit.

REGULATOR UNIT

The main circuit board for the regulator unit is shown in Fig. 1.4. This is arranged so that IC2 may be mounted either on the board or on a separate heatsink (as used in the prototype unit). If it is expected that a significant current will be drawn from the unit for prolonged periods at low output voltages, the use of a substantial separate heatsink is to be recommended. Otherwise, a piece of 14 gauge aluminium bent to form a 'U' channel, and drilled for the TO-3 outline should be adequate. The piece of metal should be as large as possible, consistent with still fitting into the available space and case. Care should be taken to ensure that the input and adjust terminals do not come into contact with the metal on the heatsink. IC1 mounts on a standard p.c.b. mounting heatsink suitable for plastic packages.

Construction starts by drilling 5 or 7 mounting holes (depending on where IC2 is to be mounted) in a piece of 0·1″ pitch Veroboard measuring 127mm × 95mm. Once this has been done, there are 36 track cuts required, as shown in Fig. 1.4. These should be made using either a track cutter or a large diameter sharp drill, turned slowly by hand. The components can then be mounted, and the recommended sequence is to start by fitting terminal pins in the positions shown. There will be 10 of these if IC2 is mounted on the board, or 12 if it is mounted on a separate heatsink; the extra two go in the positions where the terminals of IC2 are shown. Next, the i.c.s should be mounted, followed by the 12 wire links. The remainder of the components may then be fitted.

After assembly is complete, a careful check should be made of the underside of the board to make sure that there are no accidental splashes of solder, or other unwanted solder bridges. A double check should then be made to ensure that all of the polarised components (e.g. capacitors and diodes) are correctly orientated. Time spent now may well save a lot of time later!

The circuit board is next mounted in the front part of the case using four pillars, taking care to leave adequate clearance for mounting the front panel components. If IC2 is mounted on a separate heatsink, this should be fixed over the cooling vents at the rear of the case. The front and rear panels should next be drilled to accommodate the various connectors and VR1. The layout for the front panel is given in Fig. 1.7. The panel mounting components and front panel overlay should then be fitted, with the overlay protected as for the mains adaptor unit. Finally, the interconnecting wiring (which includes R1) should be installed as shown in Fig. 1.5. After a final check, the lid may be put back on the case.

SETTING-UP CHECKS

Once construction is complete, the next step is to set the power supply to work. First of all, the mains adaptor should be tested. If the *EE* type has been used, make sure that the output fuse has been fitted, and that the output plugs are not shorting. Plug in the adaptor, and measure the output using a multimeter set to an a.c. voltage range capable of reading up to 20V. The meter should read around 14V–15V. If this is not the case, switch off and check the fuse, and the wiring to the fuseholder.

If the alternative mains adaptor design has been used, first of all check that the switch is in the off position. Check that the fuse in the plug has a 3A rating, and plug in the unit. The neon should remain off. Connect the multimeter, set up as above, to the 2mm output sockets on the rear of the unit, and switch on. The neon should become illuminated and the meter should indicate approximately 12V–13V. If this is not the case, ***switch off before investigating further***. Areas to check are the wiring to the switch and transformer, and the fuse in the transformer. When all is satisfactory, connect the two-core lead to the outlet sockets, and verify that the same voltage is measured at the far end of the lead.

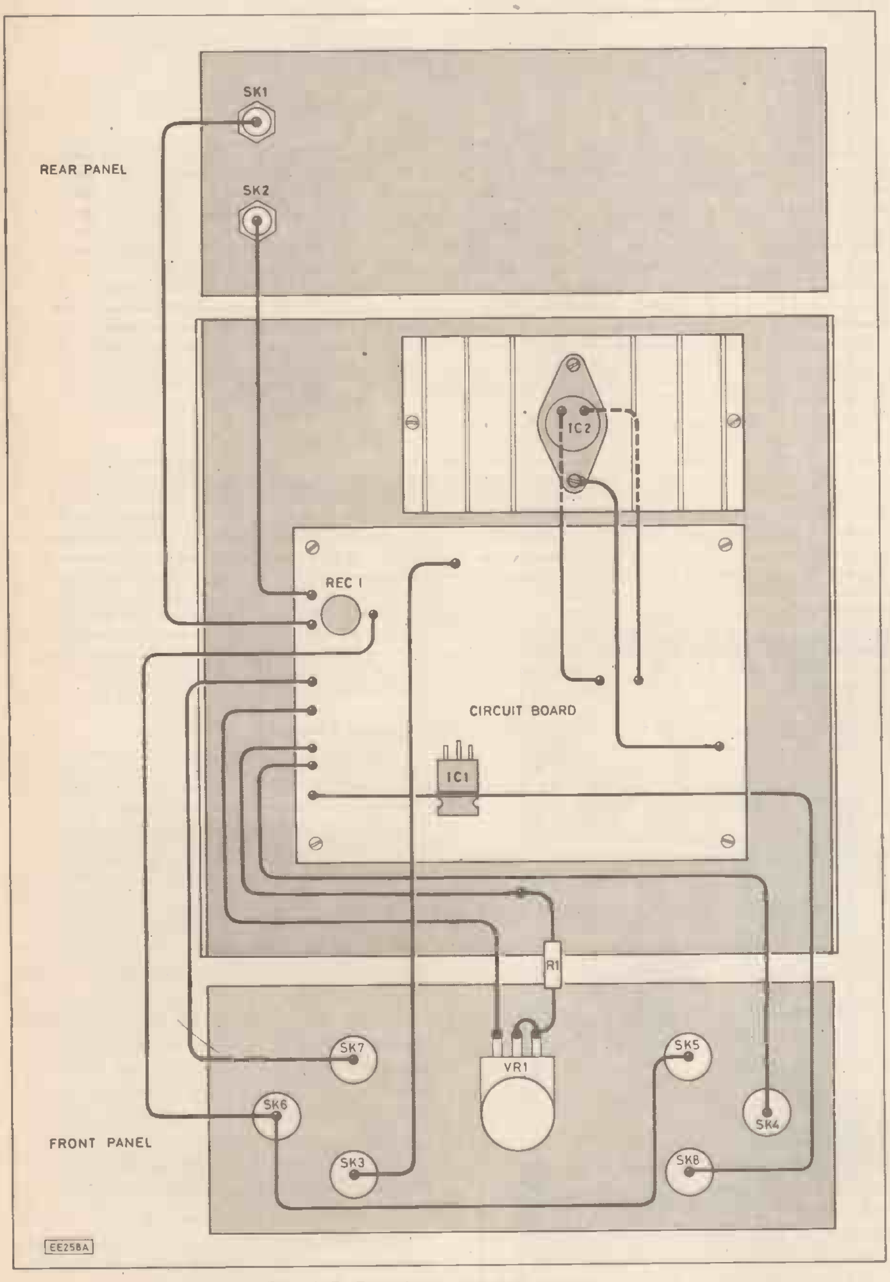


Fig. 1.5. Regulator unit construction.

COMPONENTS

EE Mains Adaptor

EE Special Offer mains adaptor, In-line fuseholder with 1A fuse, 2mm plugs (2 off)

or

Friedland 12V-1A bell transformer with integral fuse (type 764); 2-core mains lead with plug and 3A fuse; panel cable clamp and grommet; 2-pole rotary mains switch; knob with pointer; panel mounting mains neon; 2mm sockets (2 off); case (see text); stick-on plastic feet (4 off); 2-core lead with two 2mm plugs at each end and an in-line fuseholder fitted with 1A fuse.

Regulator Unit

Resistors

R1,R6	220 (2 off)
R2	560
R3	270
R4	22k
R5	10k
VR1	4k7 linear pot.
All resistors $\frac{1}{4}$W	±5%

Capacitors

C1	4700µ 25V electrolytic
C2,C3,C4	100n polyester or polycarbonate (3 off)
C5	1µ 16V electrolytic
C6,C8,C10,C11	22µ 16V electrolytic (4 off)
C7	10n polyester or ceramic
C9	1n polyester or ceramic

Semiconductors

REC 1	W005 50V 1A bridge
D1,D4	BZY88 9V1 400mW zener (2 off)
D2,D3	1N4148 (2 off)
IC1	7805 5V regulator
IC2	317K T03 regulator
IC3	555 timer

Miscellaneous

Veroboard 0·1" pitch 50 × 34 holes; terminal pins; knob with pointer (to suit VR1); mounting pillars (4 off) and hardware; SK1, SK2 2mm sockets (2 off); SK3, SK8 insulated terminals (red) (2 off); SK4 insulated terminals (blue); SK5, SK7 insulated terminals (black) (2 off); SK6 insulated terminals (green); heatsinks for IC1 (p.c.b. type) and IC2; stick-on plastic feet (4 off).

Approx. cost Guidance only **£24.50**

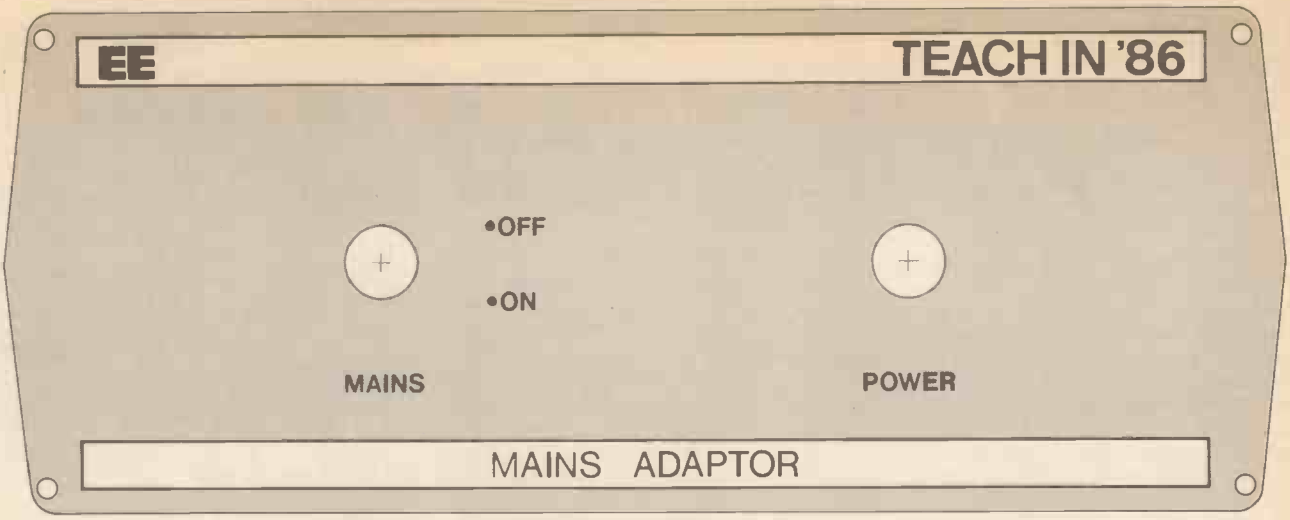


Fig. 1.6. Mains adaptor front panel.

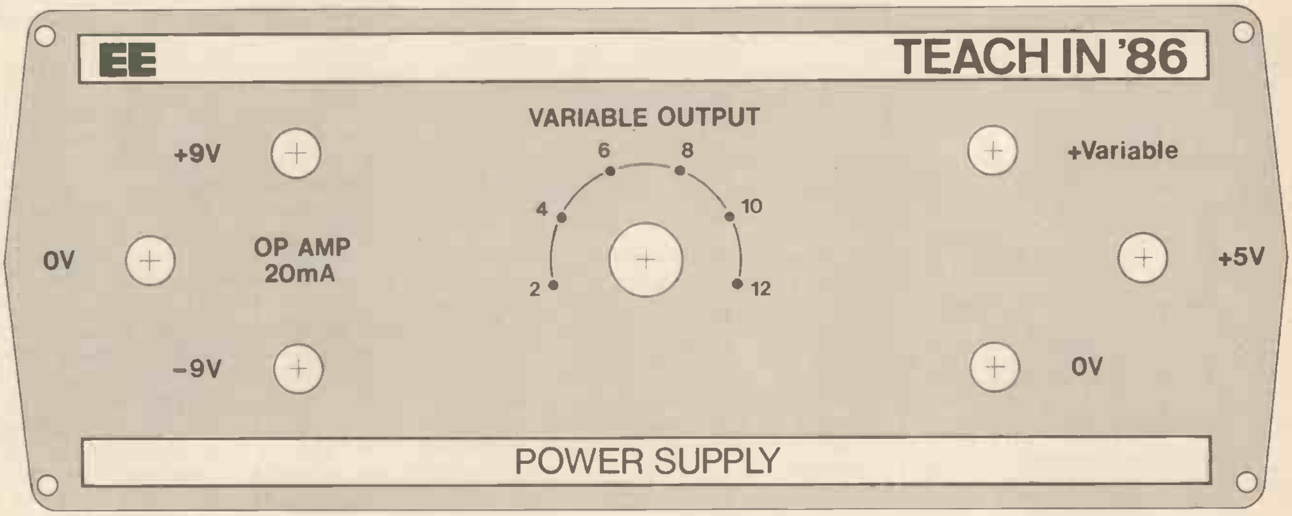
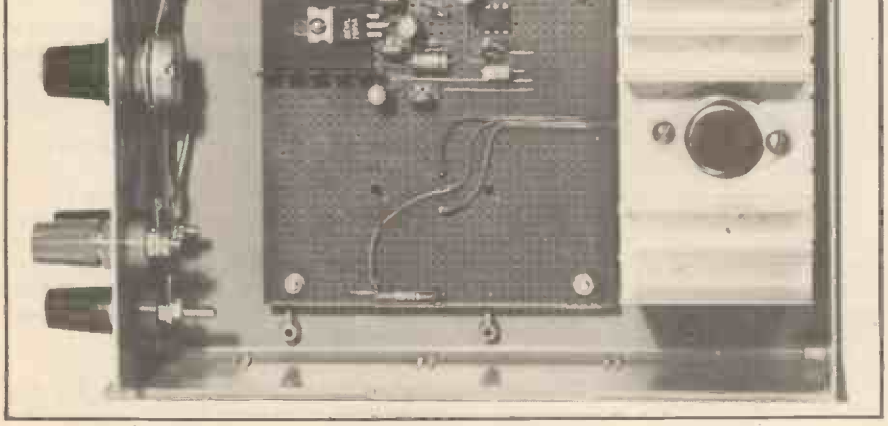


Fig. 1.7. Regulator unit front panel.

Once the mains adaptor has been tested, the next step is to check the regulator unit. Switch off, unplug the adaptor, and connect the output lead to the two sockets on the rear of the regulator unit. Now, with the meter set on a d.c. voltage range, check that the outputs on the front panel terminals are correct. In particular, check that the variable output approximately follows the calibration marks. If the variation is opposite to the calibration, re-check the wiring to VR1. If no output is measured on any terminal, the problem lies either in the input wiring or the rectifier stage; check that there is a voltage above 15V across C1. If only one output is not correct, the problem is probably in the regulator circuit associated with this output, and the main circuit board should be re-checked in this area.



CONCLUSION

The power supply will prove invaluable in a wide rage of applications, and its outputs are all protected against serious abuse. If problems do arise, disconnect the load to identify whether the problem is inside or outside the unit. If the overload protection built into the two regulators operates, switch off, identify the reason for the overload, and allow the unit to cool down. The trips are automatically reset when the overload disappears.

In use, the calibration of the variable output will follow the calibration marks approximately. Where a precise voltage is required, however, it is worth setting the output with the aid of a voltmeter. Finally, it is good practise to leave VR1 set to the minimum output level when not in use to prevent accidentally connecting a high voltage to a delicate load! □

Next Month: Project 2 will be a Universal Bridge for component testing.

Actually Doing it!!

STRIPBOARD (also sold under the proprietary name of and better known as "Veroboard"). This is really a form of printed circuit, but one that can be adapted to suit practically any circuit under the sun, rather than just one particular circuit. Most (probably all) the printed circuit construction techniques described in a previous *Actually Doing It* apply equally to stripboard, but there are some additional points which need to be borne in mind when using this method of construction.

For those who are unfamiliar with stripboard it should perhaps be explained first that it differs from an ordinary printed circuit board in that it has rows of copper strips on a 0·1 inch pitch running down the full length of the board. Holes in a 0·1 inch matrix are drilled over the entire surface of the board (see Fig. 1). At one time 0·15 inch matrix board was quite popular, but as this is not compatible with d.i.l. integrated circuits it has fallen from use.

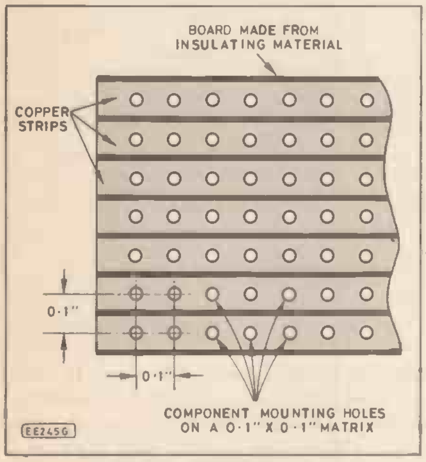
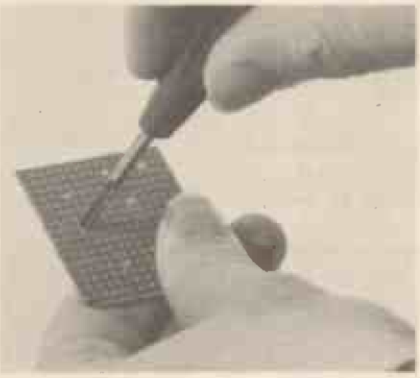


Fig. 1. Stripboard

Components are mounted on the board in just the same way as for an ordinary printed circuit board, and the copper strips carry the interconnections. An important difference between the two types of board is that there are normally no unused holes in a printed circuit board, whereas the majority of holes in a stripboard are usually left vacant. This may seem to be of no practical relevance, but it is important to realise that this factor greatly increases the possibility of making mistakes when fitting the components into place. When using stripboard always take great care to fit the components precisely in the right positions, and thoroughly check the completed board. The construction diagrams in magazines often include identification numbers and letters for the strips and rows of holes, and many constructors find it helpful to mark these onto the board using a fibre-tipped pen or self-adhesive labels.

Although a standard size board may sometimes be needed, it is more usual to have to cut out a board of the required size from a larger piece. Modern stripboard seems to be rather thinner and more brittle than the original product, and it needs to be carefully cut using a hacksaw, applying no more pressure to the saw than is absolutely necessary. Cut along rows of holes rather than trying to cut between them. This will produce rather rough sawn edges, but they can easily be smoothed off using a small flat file.



Using a spot-face cutter

With the majority of stripboard projects it is necessary to use most copper strips to carry more than one group of connections, and consequently breaks must be made in the strips to isolate groups from one another. A special tool known as a "spot face cutter" is available for this purpose, and is the most convenient way of making the cuts. However, a small twist drill bit of around 4mm in diameter can also be used, but use it hand-held as you might otherwise find that you tend to drill right through the board. Even when using the special tool it is necessary to make the cuts with a degree of restraint. The breaks in the copper strips are often scattered in an apparently random fashion over the board, rather than being grouped in lines where possible. This is because long lines of cuts can seriously weaken the board and are best avoided, so do not try to tidy the cuts into neat rows. It is best to make the cuts in the strips prior to fiting the components, since excess solder can make things difficult once the components have been fitted. However, be very careful indeed to make the breaks in the right places. Unwanted breaks can be bridged with link-wires, but this would give a rather scrappy and possibly unreliable finished product.

It has been assumed here that the breaks occur at holes in the board, which is generally the case, but occasionally a design might call for breaks between holes. These cuts can be made (while exercising due care to only cut the appropriate strips and not other strips or yourself) using a sharp modelling knife.

Printed circuit mounting capacitors with very short leadouts may not have long enough leads to stretch between the appropriate two points on the board, and the only options then are to obtain a different type with longer leads or to carefully solder on extension wires.

Stripboard construction diagrams are quite easy to follow, and Fig. 2 shows how the system of diagramatic representation for the underside view operates.

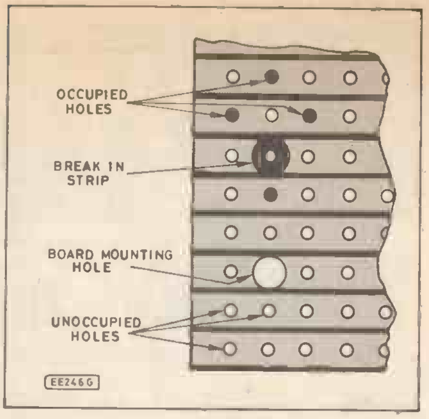


Fig. 2. Diagrammatic symbols

MOS HANDLING

The problems of handling c.m.o.s. integrated circuits were mentioned in an earlier article, and here we will deal with this subject in a little more detail. In fact, it is not just c.m.o.s. devices that are vulnerable to damage by high static voltages (which are quite common in normal domestic environments), but any devices in the general m.o.s. (metal oxide silicon) category. This includes some linear integrated circuits, a great many computer chips, and a few special types of transistor (m.o.s.f.e.t.s).

In a few cases m.o.s. devices require no special handling precautions whatever, but the majority have protection circuits that are less than 100% effective. With inexpensive devices it is probably not worthwhile taking extensive anti-static precautions, but with expensive m.o.s. types it would be foolhardy not to do so. Probably the most important point is to leave m.o.s. components in their anti-static packaging until they are to be fitted in place, and not to handle them unnecessarily. There are several types of protective packaging, but conductive foam and plastic tubes are the most common forms. Always fit m.o.s. devices into a holder and do not solder them to the board directly. The last job when building a board which has m.o.s. devices is to fit them into the holders. All connections to the board must be completed prior to fitting the m.o.s. devices into their holders. Obviously it is necessary to handle the pins of integrated circuits to some extent when plugging them into their holders, especially the larger types which can be a bit reluctant to fit into place, but try to avoid touching the pins any more than is absolutely necessary.

There are further steps that can be taken, and when dealing with expensive m.o.s. devices you may well consider it worth implementing some of these. The obvious extra step is to ensure that the work area is free from likely sources of static, which basically boils down to anything made of plastic. This includes your clothing. Working on a sheet of aluminium or other metal can help, but ideally this would have to be earthed to prevent the metal itself from taking up a strong charge. Use of the mains earth is definitely not a good idea, and an earth connection must be made by connecting a wire to a metal plate or pipe which is buried in the ground. Wrist straps to earth yourself (via a 1M resistor) can be purchased or improvised, but represent a rather extreme measure for the hobbyist.

Robert Penfold

EVERYDAY news ...from the world of electronics

THE WORD IS - AMSTRAD PCW8256

AMSTRAD REVOLUTIONISES COMPUTER INDUSTRY WITH £399 COMPUTER/WORD PROCESSOR COMPLETE WITH PRINTER

Claims that Alan Sugar's Amstrad Consumer Electronics have "set the computer industry on its head" would seem to be well founded with the launch this month of the PCW8256 Personal Computer/Word Processor.

The PCW8256 is a 256K RAM computer complete with monitor, disc drive, new letter quality printer and custom designed word processing software all for the inclusive price of £458.85 (£399 + VAT).

Additionally, it is supplied with, it is claimed, the world's most widely used 8-bit computer operating system, CP/M+ with GSX graphics enhancement. Locomotive Software's Mallard extended BASIC interpreter is provided to operate under CP/M+, along with Digital Research's educational and training language, Dr LOGO.

For the technically minded a breakdown of the specification is as follows:

Screen and Disc

High Resolution Green Monitor, featuring 90 columns, and 32 lines of text, providing over 40 per cent more information area than available on standard 80 × 24 screen displays.

An integral "flip over" 3" disc including AMSTRAD established CP/M standards, offering 180K of formatted storage space per side. A second drive may be fitted optionally.

Keyboard and Software

An 82 key keyboard is provided with several function keys dedicated to the word processing software provided with the system. The keyboard is controlled by its own custom microprocessor enabling a simple cord connection to the main computer/display unit.

The wordprocessing software supplied has been specifically written to provide procedures that will be readily understood by even novice computer users.

It allows for creation of documents up to the maximum available disc capacity, and will permit simultaneous printing and editing. Features such as pagination, automatic paragraph alignment and re-alignment are provided, together with a powerful collection of editing features for cut/paste, etc. The large area screen includes a series of pull-down menus accessed by simple function key selection.

The Digital Research GSX graphic system is supplied with the PCW8256 to provide a standard software interface for graphical programs. Dr LOGO is also supplied, and is compatible with Dr LOGO supplied for the CPC6128, and upwards compatible with Dr LOGO supplied with AMSTRAD CP/M 2.2 stystems.

CPU and RAM

A Z80A microprocessor with 256K bytes of RAM is provided as standard. Approximately 112K of this memory is organised for use as RAM-disc to enhance the speed of operation of the many CP/M programs using overlay techniques. Instead of accessing the disc drive to locate program information not stored in the main memory, this technique uses much faster semiconductor RAM Disc and thus maintains complete compatibility with the vast range of existing CP/M software.

Printer

The integral printer mechanism provides correspondence quality operation at approximately 20 cps, or draft quality text at 90 cps (Elite pitch typestyle). Features such as pitch, italics, boldface, underline, super and sub script are provided by the built-in software.

A tractor feed is supplied for continuous stationary, although single sheet operation is available with an automatic paper alignment system.

The new Amstrad PCW8256 word processor/personal computer.

"We have brought computing and word processing within the reach of every small business, one man band, home worker and two finger typist in the country—not to mention the company chairman who wants one for himself, his secretary and all his managers. The PCW8256 costs less than the average electric typewriter and yet it has features that will make the big trans-Atlantic names wince. We even throw in LocoScript word processing software. With some systems, the software alone would have a £200.00 plus price tag."—Alan Sugar, Amstrad Consumer Electronics plc.

The design brief was to produce a fully integrated package of screen, keyboard and printer that anyone could use. The only problem is convincing prospective purchasers that it is really a full-function word processing system for only £399 plus VAT.

First retailers to be approached with the project were Dixons. *"We were so impressed with the product and market positioning,"* said Eddie Styring, Dixon's Managing Director, *"that we demanded exclusivity in the High Street multiple sector. We will have supplies on shelf throughout our chain by the last week in September."*

MICRO DEBUG

THE engineer's dream of a microprocessor debugging facility at each workbench is claimed to be brought a step nearer to reality as a result of the recent introduction by Thorn EMI Instruments of a lightweight PROM Emulator with an advanced in-circuit monitoring capability.

Designated DTE-1, it features a built-in keyboard and display to "explore" the microprocessor system's registers, memory and input/output.

If any bugs are located in the microprocessor software, the code can be modified, run in the target system and "blown" into a new PROM via the instrument's front panel.

FOR YOUR ENTERTAINMENT

BY BARRY FOX

Forgotten Technology

It seems only yesterday that the world's first Information Technology Minister, Kenneth Baker, was telling us all about how IT held the key to Britain's future. The Prime Minister and John Butcher were equally enthusiastic.

Now, with the collapse of Britain's plans for wiring the nation and putting direct broadcasting satellites in orbit, the IT revolution has been forgotten. But quietly, some people are getting on with the job of using IT.

I have said it before, and I am sure I will say it again, because there's no better way of putting the point: it is cheaper to send information as data down a line, than it is to send people with information from place to place. You don't need an entertainment-led cable TV service, to provide a data-carrying network. We already have one. It's called the telephone system.

The first wires were telegraph lines, intended to carry pulses of Morse code. Then came telephone speech lines. These can be used to carry data, for instance electronic mail. For high speed transmission, special dedicated lines are necessary. There is an underlying principle to all this.

The amount of data which can be sent down a line—or radio link—was predicted by Claude Shannon, of Bell Labs in New Jersey in 1984. Shannon's theory covers the transmission of any information, irrespective of whether it is text, speech or pictures. It ties together two controlling factors, bandwidth and noise.

Clearly, the ablility of a transmission channel to carry pulses or signal changes, will depend on its analogue bandwidth measured in Hertz. If the bandwidth is narrow, then any attempt at sending a very rapid stream of signal changes will fail, because the individual message pulses will merge into mush.

Shannon showed that the capacity of a channel depends also on the level of unwanted noise which pollutes the wanted signal. Error correction, which in its simplest form involves sending the same information twice, increases the chance of error-free transmission. But it also increases the number of bits of information which can be sent.

He tied these contradictory requirements together as a simple equation:

$$C = B \log_2 (1 + S/N),$$

where C is the channel capacity in bits per second, B is the bandwidth in Hz and S/N is the signal-to-noise ratio.

Shannon's theory, and practice, put the maximum data rate for an analogue telephone line at 1200 bits/second. This is why British Telecom has to provide a network of dedicated data lines for businesses which need to transmit data at faster than 1200 bits/sec. The names, Kilostream, Megastream and PSS are banded around without simple explanation.

Data Systems

Kilostream circuits are private, all-digital, links. So no modems are needed to convert the digital data pulses into analogue tones. The data is carried as digital pulses at 2·4, 4·8, 9·6, 48 or 64 kilobits/second down coaxial lines. Think of Kilostream as a super long extension of your RS232 lead.

Packet Switch Stream or PSS is an all-digital public service. When it reaches abroad, it becomes the International PSS or IPSS. Analogue data lines connect your equipment with PSS.

Local modems are used to convert data into tones which travel along the analogue lines and into BT modems. These convert the tones back to data for injection into the PSS system. This runs at 48 kilobits/second, with data from different subscribers divided up into labelled packets and slotted into a common serial stream.

It is routine for electronic mail subscribers to us PSS as a way of calling up the host computer, such as Telecom Gold in London, without having to make a long distance phone call. A local call from most places in the world hooks you into PSS and from there to the London number.

The modem at the subscriber's premises handles data for PSS at 300 or 1200 bits/second for asynchronous working, and 2·4, 4·8, 9·6 or 48 kilobits/second for synchronous working. What is the difference? Obviously some kind of synchronism is necessary between both ends of the line. Asynchronous links lock the data, word by word; synchronous links lock the data in long blocks containing many words.

The other private BT data-carrying service is Megastream, which runs at 2 megabits/second and will eventually rise to 140 Mbit/s. Coax or optical fibre or microwave links are used. Obviously it is all-digital. Think of it again as a super RS232 lead. In practice some subscribers in remote areas may need to get into the service by analogue links.

Electronic mail relies on sending data down a telephone speech line, using modems at each end. Later this year we'll be looking, in a separate feature, at electronic mail: what it is, how it works and what it does. The subject is important because the big question in many minds, is will electronic mail take over from telex?

Telex

A telex link costs two or three thousand pounds a year, for hardware rental and dedicated line to carry the plus/minus 80V pulses which run in groups of five per character at 50 bits a second. An electronic mail link, using ordinary telephone line, micro and modem, costs a fraction the price.

The only reason why electronic mail has not yet taken over from telex is that there is ridiculous confusion of standards in E-mail, with different systems—like Telecom Gold, One to One, Comet, Easylink, and Prestel Mailbox—unable to communicate with each other. Often they have to interface by means of the telex network. There are 1·6 million telex terminals round the world and although they are expensive and use antique technology, they do all have one thing in common, *compatibility*.

One of the most difficult jobs in journalism, is to find out hard fact information on old technology. Once it's widely used, few people remember how it works. Telex is a classic example. Recently, British Telecom celebrated its 100,000th telex subscriber. There are now 2 million in 200 countries. BT talked about telex data rates and also the new teletex or "Super telex" service. I took the opportunity to nail a few elusive points with engineers who were present.

Telex dates back to 1932. Until last year, the transmission standard was rock solid. D.C. pulses at + and − 80V, down a dedicated line, carried the data at 50 baud. Now new lines (although still dedicated to telex use only) are using a new transmission technique. It's called single channel voice frequency (SCVF) and is much the same as that used to transmit electronic mail data down ordinary telephone speech lines. For SCVF telex, modulated audio tones are carried at 12V. But the data rate is still the same, 50 baud.

Data Rate

Some modern telex machines store the incoming data and then print out at 300 baud. This sometimes makes people believe telex messages are running faster than they actually do. But the next step will be an increase in transmission rate to 300 baud.

New computer exchanges, to replace the old electro-mechanical switch centres, will tailor the signals sent down subscribers' lines to the hardware they are using. Already these exchanges automatically decide between 60V d.c. or 12V SCVF. The crux is that as far as the user is concerned, there is no loss of compatibility from the split standard. Everyone can still communicate with everyone else.

The new teletex service, pioneered in Germany and launched in Britain in April, transmits data at 2400 bits per second. All electronic computers are used, instead of elctro mechanical hardware (or electronic hardware which emulates electromechanics as in more modern telex terminals).

Although fine in theory, in practice there is far less chance of finding a high tech teletex terminal than an old-fashioned telex. Also some telephone lines may crack up under the 2400 bit data rate.

How come, I asked that teletex can even hope to put 2400 bits a second down a line when Shannon theory—and electronic mail practice—shows that 1200 or 1300 is the maximum data rate?

This is a neat way of explaining the basic difference between baud rate and bits per second. They are NOT the same. Baud rate is the number of single signal transitions per second, whereas bit rate is the number of bits of information.

At telex rate (50 baud), and low speed modem transmission rates (up to 1200), baud and bit rate are the same. This is because one signal transition carries one bit of information. At above 1200 baud, the modem has to play clever tricks to transmit more than one bit of information for each signal transition. For instance, the modulation may be switchable through several levels.

This is how the higher data rates, for instance for teletex, are achieved. But the two computers at each end of the line have to be locked together in full synchronism. Lower speed systems can work asynchrously, locked together word by word of the data transmitted.

Armed Guard

Using telex can be a real trial. Every travelling business person, and journalist, has a horror story to tell about trying to find a telex terminal in a foreign land. In Japan recently I was with some Fleet Street reporters who were continually struggling to get their stories written before the hotel operator went off duty.

Even when there is a working telex machine, with an operator who speaks English and can be persuaded to send a message, there can be no real security or confidentiality. The direct input of electronic mail into a keyboard, whether an office manager's desk top or by a hotel bedside hooked to the room telephone, is an obvious advantage.

At most North American press conferences facilities are now laid on for the journalists to plug in their portable computers and send text down the line instead of dictating speech. Where direct plug-in is impossible, the journalist can use an acoustic coupler.

These will even work with antique forties style phones. I know; I once sent messages by E-mail from one of these old beauties from a little hotel in the backwoods of Minnesota. But couplers are bulky, so the more enterprising news hounds have learned how to take a telephone apart, and attach a couple of crocodile clips to the wires which carry the signal.

Fleet Street sports reporters now discovering the joys of E-mail remember with misery the problems which they encountered when world champion heavyweight boxer Mohammad Ali fought George Foreman, in Kinshasa, capital of Zaire, in October 1974. Five hundred journalists packed into the local hotels. They were surprised and thrilled to find 14 telex machines on which they could send their stories out of the country. But they were less thrilled to find that there was only one telex line. That was routed via Brussels and usually did not work.

To make matters worse, the telex operators were local French-speaking Africans who understood no English. They did however have a list of words (like "Congo" and "bizarre") which they were forbidden to transmit. A censor stood by to check the text as it was typed.

On one occasion several press men attracted the attention of the censor by admiring his shirt and asking about a cactus plant outside. While he was out of the room another journalist jumped on an unattended telex machine and sent his story. He was caught trying to destroy the paper copy. After that there was an armed guard on the machines.

Food for Thought

An interesting snippet of information from Incpen, the Industry Committee for Packaging and the Environment.

The average man needs about 13 megajoules (equivalent to around 3,000 calories) of food daily. Of this 10 megajoules are converted into heat and three available for doing work. The average household now has so much electric and electronic equipment that it uses 40 megajoules of electrical energy every day.

So if man—or woman—power were used to produce the electricity which we use every day, it would need 14 slaves on a treadmill driving a generator. If each slave were paid at the same rate as we pay for electricity, she (or he) would get 4p per day. That wouldn't pay for their 3000 calories of food.

Think of that next time you switch something on.

ELECTRONIC BUILDING BLOCKS

PART THREE

RICHARD BARRON

LAST month, we completed our design of simple d.c. supplies with a low-cost regulator unit. The regulator unit was capable of supplying a variety of positive and negative d.c. voltages. This month, we shall take a look at some other electrical signals which differ from the smooth signals of the p.s.u.

ELECTRICAL SIGNALS

Electrical signals may come in four basic forms; alternating current (a.c.), direct current (d.c.), unidirectional current or bi-directional current. In fact a.c and d.c. are special cases of bi-directional and unidirectional current respectively. These various signals can be represented by waveform diagrams as shown in Fig. 1.

As can be seen, both d.c. and unidirectional current flow in one direction only, whilst a.c. and bi-directional current alternate between positive and negative directions with respect to a fixed reference (0V). However, the a.c. waveform has characteristics which make it very important to design engineers; it is periodic in nature and its average magnitude is zero.

Varying electrical signals such as sinusoidal a.c., square waves and triangle waveforms are used extensively in electronic circuits to perform many different functions. A very high frequency sine wave might be used to carry audio signals in a radio transmitter or an audio frequency sine wave might be used in an electronic musical instrument. Square waves are frequently used as timing (clock) signals in digital circuits and ramp waves are used in television (CRT) control circuits. There are many different methods by which these signals may be produced but we shall, at the moment, only look at a few simple building blocks which are commonly used.

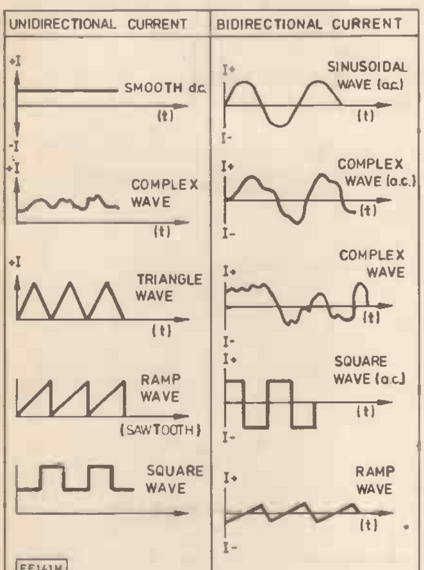


Fig. 1. Waveform diagrams.

CAPACITORS

We have already seen how a capacitor may be used to store electrical energy in the form of an electrical field. It is basically topped up as current flows into it and discharged as current flows out of it. Strictly speaking this description is not quite accurate, but is sufficient for our needs. What is important, however, is the way in which current behaves as it flows in and out of a capacitor.

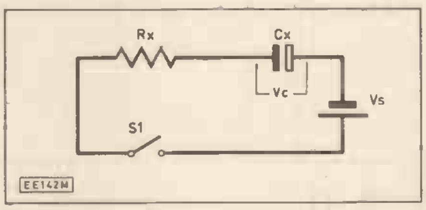


Fig. 2. Series CR circuit.

Since all circuits must contain some resistance, a capacitor cannot be fully charged or discharged instantaneously. This can be seen by considering the action of the circuit of Fig. 2. When the supply is first switched on via S1, the potential across the capacitor, Cx, is 0V and therefore the potential across the resisitor, Rx, is equal to the supply voltage, Vs. This will cause a current flow of Vs/Rx.

As the capacitor charges up, the voltage across it will increase which will cause the voltage across the resistor to decrease, subsequently the current through Rx will decrease. Eventually the voltage across the capacitor will be (almost) equal to the supply voltage and no current will flow. The way in which the voltage or current behaves in a circuit such as this is called transient response, and follows a natural curve as shown in Fig. 3. A similar action also occurs in a circuit in which a capacitor is discharged through a resistance. The waveforms which describe the rise and fall of currents and voltages in these types of circuits (series RC circuits) are called 'Growth' and 'Decay' curves respectively.

TIME CONSTANTS

In mathematical terms, the instantaneous value of the voltage across a capacitor in a simple RC series circuit is given by:

$V_c=V(1-e^{t/\tau})$ during the growth cycle, and $V_c=Ve^{-t/\tau}$ during the decay cycle, where τ is the 'time constant' given by $\tau =$ CR, and R is the resistance in ohms, C is the capacitance in Farads and e is a constant (2·72 approx.). τ is defined as:

"The time after the quantity would reach its limit if it maintained its initial rate of variation"

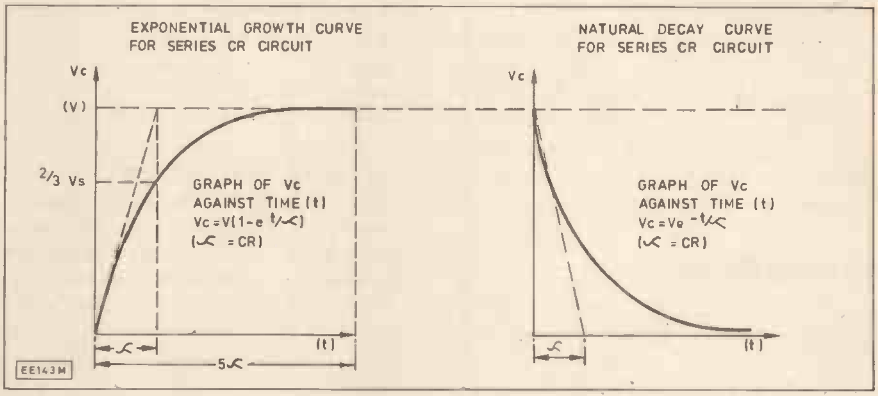


Fig. 3. Transient response.

BASIC RULES

The above formulae is quite complicated. However, for our needs, we can ignore any complicated definitions or maths and use some basic rules which are both useful and practical. Referring again to the circuit of Fig. 2, it can be shown that if the capacitor is fully discharged and S1 is closed, the voltage across the capacitor will reach 2/3 of the supply voltage after a time equal to the time constant of CR. Also, it will be almost fully charged after a time equal to 5τ. This is clearly illustrated in Fig. 3 which shows the general, natural growth and decay curves for series CR circuits.

Once we have understood the basic principles of series RC circuits, we can easily design circuits which incorporate time delays. Then expanding on these designs, we can go on to construct simple oscillators using a handful of components.

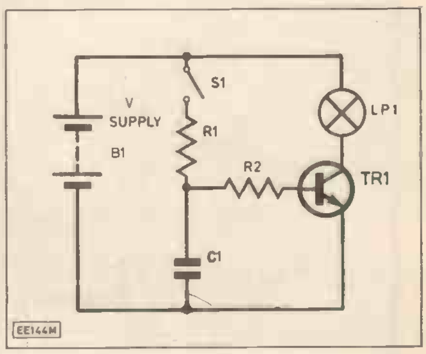


Fig. 4. Time delay circuit.

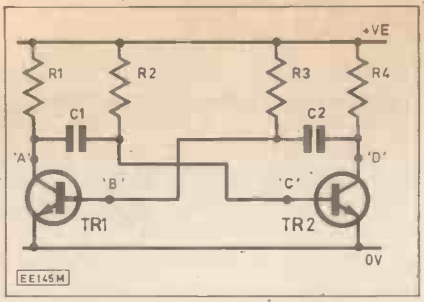


Fig. 5. Transistor oscillator.

TRANSISTOR (RC) OSCILLATORS

The circuit of Fig. 4 shows a lamp connected to the collector circuit of an *npn* transistor. It will not operate until the base-emitter junction of TR1 is forward biassed. When S1 is closed, the capacitor, C1, will charge up very quickly and TR1 will conduct causing the lamp to light, providing R1 is a low resistance, C1 will charge to the full supply potential and the lamp will remain lit even when S1 is opened. This is because the capacitor will have to discharge through the base-emitter junction of TR1 and R2. TR2 will not stop conducting until the base-emitter junction is no longer forward biassed.

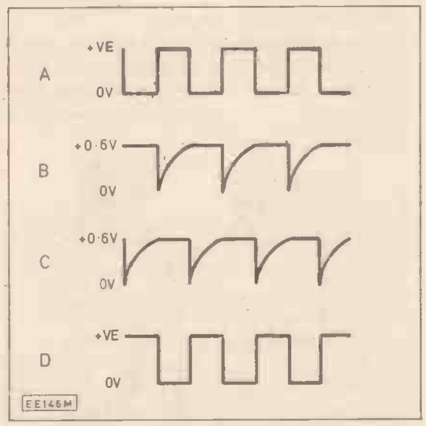


Fig. 6. Oscillator waveforms.

The circuit diagram of Fig. 5 shows a simple transistor oscillator which is capable of producing a square wave output whose frequency and mark–space ratio is dependant on two RC time constants. If we assume that initially, TR1 is conducting, then its collector-emitter current will cause a volt drop across R1. This will mean that point A is at a lower voltage than the positive supply and consequently C1 will begin to charge through R2. When it reaches approximately 0·6V, the base-emitter junction of TR2 will be forward biassed and TR2 will conduct causing a volt drop across R4.

At this time the voltage at point B will be zero as the capacitor, C2, charging through R3, cannot charge instantaneously. This means that the base of TR1 is at a low voltage and is therefore cut off. When C2 charges sufficiently to turn on TR1, TR2 will become cut off and the cycle starts again. The waveforms produced by this type of circuit are shown in Fig. 6. The switching time (T) for the simple transistor oscillator is dependent on the charge times for C1 and C2 through R2 and R3 respectively and the duration of one cycle is given by:

$T = 0{\cdot}7(C1R2 + C2R3)$ and the frequency, $F = 1/T$

Therefore if R2 and R3 are both 10k and C1 and C2 are both 5μ, then the frequency of the output would be:

$1/0{\cdot}7(5 \times 10^{-6} \times 10^{3} \times 2) = 1/70 \times 10^{3}$Hz.

Also using these values, the mark–space ratio of the output would be unity, ie, the mark time would equal the space time. If the time constants of the two RC networks were changed then the waveform would be modified to produce outputs similar to those shown in Fig. 7.

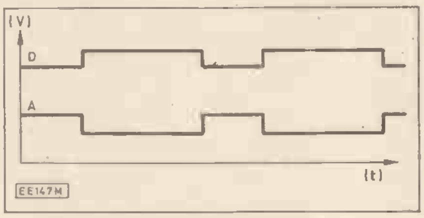


Fig. 7. Unequal mark–space ratio.

INTEGRATED CIRCUITS

As is often the case, there are various i.c.s available, which make the use of discrete component building blocks rarely necessary. However, similar methods are used to determine the frequency and output characteristics of these devices. One of the most common of these i.c.s is the 555 timer.

In the configuration of Fig. 8, the output of the 555 timer is a square wave whose frequency and mark–space ratio is dependent on the values of R1, R2 and C1. This i.c. may also be used in a variety of other applications to produce different waveforms and provide different functions.

Also available are a number of other i.c.s which can be used to provide accurate sine, square, ramp and triangle wave outputs at a wide range of frequencies. Some of these are shown in Fig. 9, together with their basic application and connection details. Before using the i.c.s, it is advisable to consult manufacturers' specifications and data sheets to ensure their correct use.

Next month, we will be taking a look at amplifier design and its associated building blocks.

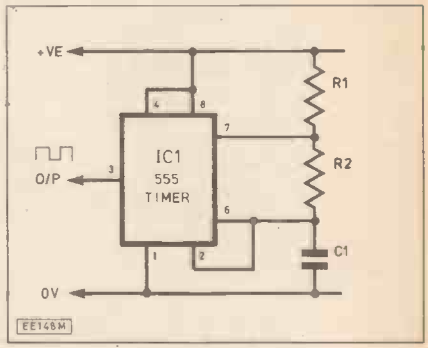


Fig. 8. 555 timer oscillator.

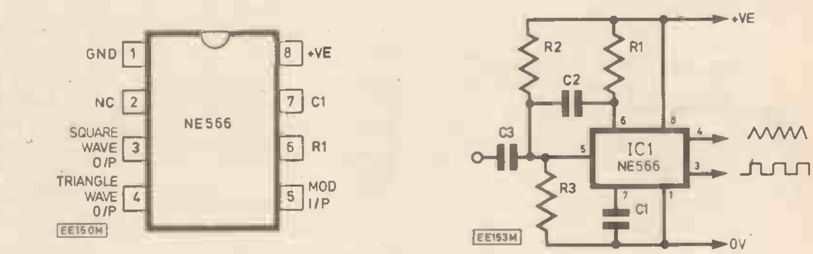


Fig. 9a. The NE566 Timer.

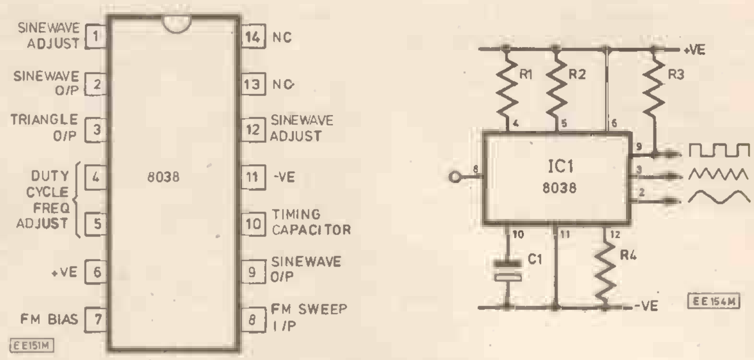


Fig. 9b. The 8038 Waveform Generator.

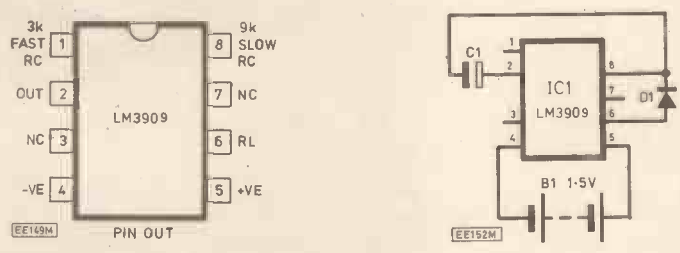


Fig. 9c. The LM3909 "Flasher".

Fig. 9. Some examples of timing and oscillator i.c.s.

SIMPLE AUDIO GENERATOR

This month's constructional project is a simple Audio Signal Generator/Injector, built around the famous 555 timer i.c. Although the project is both simple and inexpensive, it is useful for a variety of applications. It may be used as a basic test instrument for testing amplifiers etc, or with a little modification, may be used as part of a simple electronic musical instrument.

THE CIRCUIT

The complete circuit diagram of the Simple Audio Generator is shown in Fig. 10. As can be seen it consists of a handful of components which are readily available from most suppliers. The heart of the circuit, the 555 timer, IC1 is a very stable device designed to generate accurate time delays. Its internal working is quite simple, consisting of a pair of comparators working at 1/3 and 2/3 of the supply voltage. These comparators set and reset flip-flops which in turn drive an output stage.

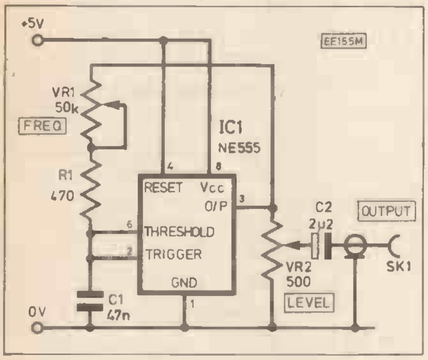


Fig. 10. Circuit diagram of the Simple Audio Generator.

Also other facilities such as control voltage and discharge connections are provided but these are not used in this circuit. Incidentally, comparators and flip-flops will be explained in a forthcoming article in this series.

In the configuration of Fig. 10, the timing circuit consists of only one CR network, rather than two. This ensures unity mark-space ratio of the output by using the same charge and discharge path. The CR network consisting of (R1+VR1)C1, can be adjusted by VR1 to produce a frequency range of between 300Hz and 15kHz.

The output which is available at pin 3 of IC1 is connected to VR2 which allows simple level control. C2 is included in this part of the circuit as a d.c. block, ie, for a.c. coupling.

DEVICE CONSIDERATION

It is always difficult to choose components for oscillator circuits as there are invariably many factors to consider which are all inter-related. For example, resistors and capacitors are given nominal values which are subject to tollerance. Capacitors can cause particular problems, especially electrolytic types, as they do not function correctly unless operated at at least 10 percent of their working voltage. Also stray capacitance in this type of circuit can cause major errors particularly if low value timing capacitors are used.

Since this is only a very simple circuit and accuracy is not critical, we could use almost any components and it would still work in a fashion. However, hopefully, using the components specified, we should achieve an output within the audio frequency range between about 300Hz and 15kHz.

The frequency (F) of the output of the configuration shown in Fig. 10 is given by:

$$F = 1/1{\cdot}4 \times C1(R1+VR1)$$

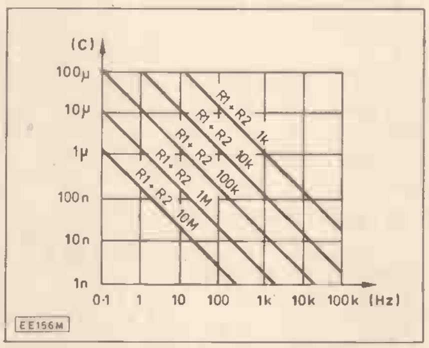


Fig. 11. 555 timing graph.

Since we have two variables it is easiest to select the value of one component in order to work out the other. In this case we have decided to make C1 = 47n, therefore:

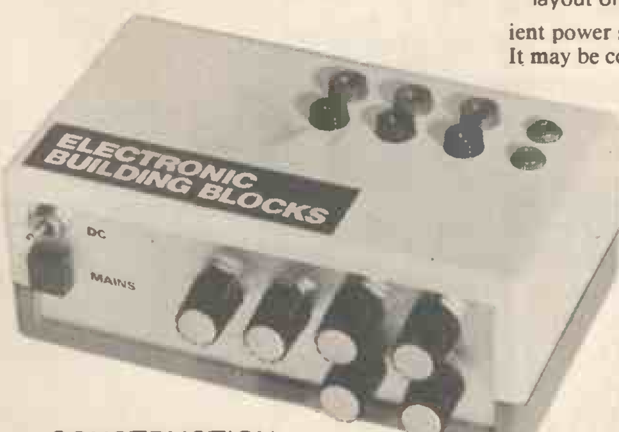
$$F = 1/1{\cdot}4 \times 47n \times (R1+VR1)$$

Using the limits of our specification (300Hz and 15kHz) gives us:

$$300 \leqslant 1/1{\cdot}4 \times 47n \times (R1+VR1) \geqslant 15\times10^3$$

By rearranging the above formula it can be found that the combination of R1 and VR1 should be between approx. 50·5k and 1k. Using these figures, it was decided that convenient values would be R1 = 470 and VR1 = 50k.

This mathematical method of working out the values of components can be both complicated and tiresome. A much easier method is illustrated in Fig. 11. The graph simplifies the formula into an easily readable value, you simply choose your frequency limits, the resistor value and then read off the capacitance value. Graphs of this type are usually available in manufacturers' data sheets.



CONSTRUCTION

Construction should be very straightforward, all the components being mounted on a small p.c.b. (Fig. 12.) The pots, resistor, capacitors and i.c. socket should be mounted first and then the input/output connections made. The i.c. should be mounted last.

The supply for the circuit may be taken from a 9V battery or a p.s.u. but be careful to connect the supply the correct way round, similarly care should be taken when mounting the electrolytic capacitor, C2.

If desired, there is room in the case, used for the power supply and regulator unit of Part 1 and Part 2, to mount the signal generator. If this is done there is a convenient power source available inside the unit. It may be connected to the unregulated d.c. or the +5V terminal block.

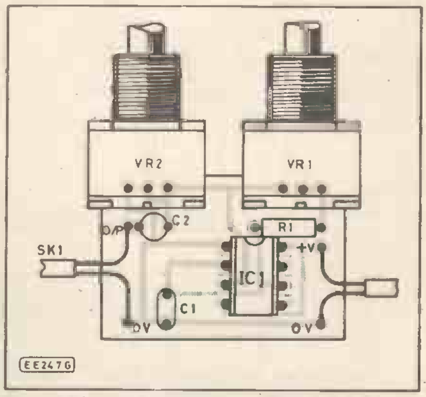
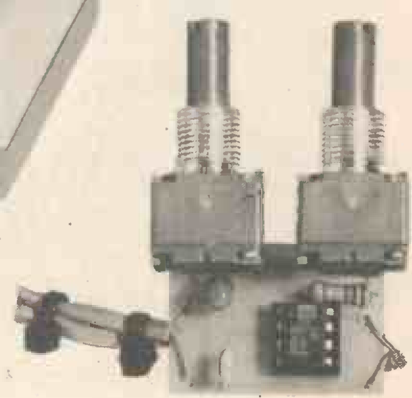


Fig. 12. P.c.b. design and component layout of the Simple Audio Generator.



Next month: The constructional project will be a Simple Audio Amplifier.

COMPONENTS

See Shop Talk page 554

Resistors
R1 470 ¼W 5%

Potentiometers
VR1 50k p.c.b. mounted
VR2 500 p.c.b. mounted

Capacitors
C1 47n Silvered mica
C2 2μ2 tant. bead electrolytic

Semiconductors
IC1 555 timer i.c.

Miscellaneous
SK1 miniature phono socket; p.c.b. EE 8508-03; wire; solder, d.i.l. socket, etc.

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EXPANSION BOARDS

WITH the growing demand from micro users to expand the capabilities of their machines, Velleman have designed an interface system consisting of a specific motherboard for a range of home computers, and interface cards that can be plugged onto the motherboards.

This will enable the user to expand his system to include the following features: Output Board (K2609), eight open collector outputs; A/D Conversion (K2610), 8-bit precision; Input Board (K2611), eight optocoupler inputs; Centronics Parallel Printer Interface, plus support software (K2614); D/A Conversion (K2618), 8-bit precision; CMOS Real-Time Clock and RAM (K2629); Relay Card (K2633), four outputs; Four Triac Output Card (K2634); 8 to 1 Analogue Multiplexer Board (K2635).

There are already motherboards for ZX81, Spectrum and Commodore 64. They are provided with a 23-pole edge connector to allow for connection of a printer or more motherboards. Power is branched off from the computer's 9V d.c. supply or from an external unregulated 9 to 12V d.c. p.s.u., depending on the consumption and number of cards used.

Both motherboards and interface cards are available in kit form or as ready-built and tested units. Prices and further information is available from:

Velleman (UK) Ltd.,
Dept EE, P.O. Box 30,
St Leonards on Sea,
East Sussex, TN37 7NL.

PRESTEL LINK FROM AMSTRAD

WITH the Amstrad computers capturing the news headlines this month, it seems excellent timing for Cirkit to announce the release of a complete Prestel Link for the Amstrad home computers. Coinciding with the publication of their latest components catalogue, the complete package consists of modem, interface, software and connection lead.

The modem is a British designed acoustic coupled type that fits all standard and Herald telephones. The 1200/75 baud operation allows the user to work Prestel, Micronet, BT Gold, etc.

The 1200 baud half duplex operation allows the operator to swap programs and data over the telephone network with other users.

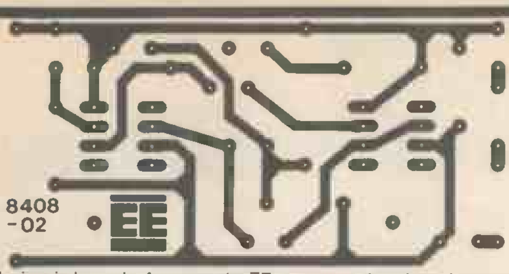
Designed to complement the Amstrad computer, the interface is built in a small plastics enclosure which plugs into the Disc drive port, a through bus connection system allows the Disc drive to be plugged onto the back of the interface. Baud rates supported are: 75 baud transmit—1200 baud receive; 300 baud transmit—300 baud receive; 1200 baud transmit—1200 baud receive.

The interface supports one RS232 type input handshake, for example data terminal ready, carrier detect, and one RS232 output; originate/answer, clear to send. The interface inputs work with TTL or RS232 signals, the outputs generate positive only signals which are compatible with all TTL inputs and most RS232 inputs. It is not directly supported by Amstrad CPM, but full RSX drivers are supplied with the package.

Fully compatible with the CPC464, CPC664 and CPC6128, Cirkit are running a special introductory offer for the Cirkit Prestel Link and making the complete package of Modem, Interface and Software available for the sum of £29.99 inclusive.

Cirkit,
Dept EE, Park Lane,
Broxbourne, Herts,
EN10 7NQ.

P C B SERVICE



Printed circuit boards for certain EE constructional projects are now available from the EE PCB Service, see list. These are fabricated in glass-fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for overseas airmail. Remittances should be sent to: EE PCB Service, Everyday Electronics Editorial Offices, Westover House, West Quay Road, Poole, Dorset BH15 1JG. Cheques should be crossed and made payable to IPC Magazines Ltd.

Please note that when ordering it is important to give project title as well as order code. Please print name and address in Block Caps. Do not send any other correspondence with your order.

Readers are advised to check with prices appearing in the current issue before ordering.

NOTE: Please allow 28 days for delivery. We can only supply boards listed in the latest issue.

PROJECT TITLE	Order Code	Cost
— JULY '83 —		
User Port Input/Output *M.I.T. Part 1*	8307-01	£4.82
User Port Control *M.I.T. Part 1*	8307-02	£5.17
— AUGUST '83 —		
Storage 'Scope Interface, BBC Micro	8308-01	£3.20
Car Intruder Alarm	8308-02	£5.15
High Power Interface *M.I.T. Part 2*	8308-03	£5.08
Pedestrian Crossing Simulation *M.I.T. Pt 2*	8308-04	£3.56
— SEPTEMBER '83 —		
High Speed A-to-D Converter *M.I.T. Pt 3*	8309-01	£4.53
Signal Conditioning Amplifier *M.I.T. Pt 3*	8309-02	£4.48
Stylus Organ	8309-03	£6.84
— OCTOBER '83 —		
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Speech Synthesiser for BBC Micro	8311-04	£3.93
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4-Channel High Speed ADC (Digital) *M.I.T. Part 6*	8312-02	£5.29
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CBM 64 Extension Port Con. *M.I.T. Part 9*	8403-04	£4.71
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Data Acquisition "Output" *M.I.T. Part 10*	8404-03	£5.20
Data Acquisition "PSU" *M.I.T. Part 10*	8404-04	£3.09
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Quasi Stereo Adaptor	8404-07	£3.56
— MAY '84—		
Simple Loop Burglar Alarm	8405-01	£3.07
Computer Controlled Buggy *M.I.T. Part 11*		
Interface/Motor Drive	8405-02	£5.17
Collision Sensing	8405-03	£3.20
Power Supply	8405-04	£4.93
— JUNE '84 —		
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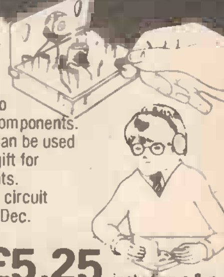

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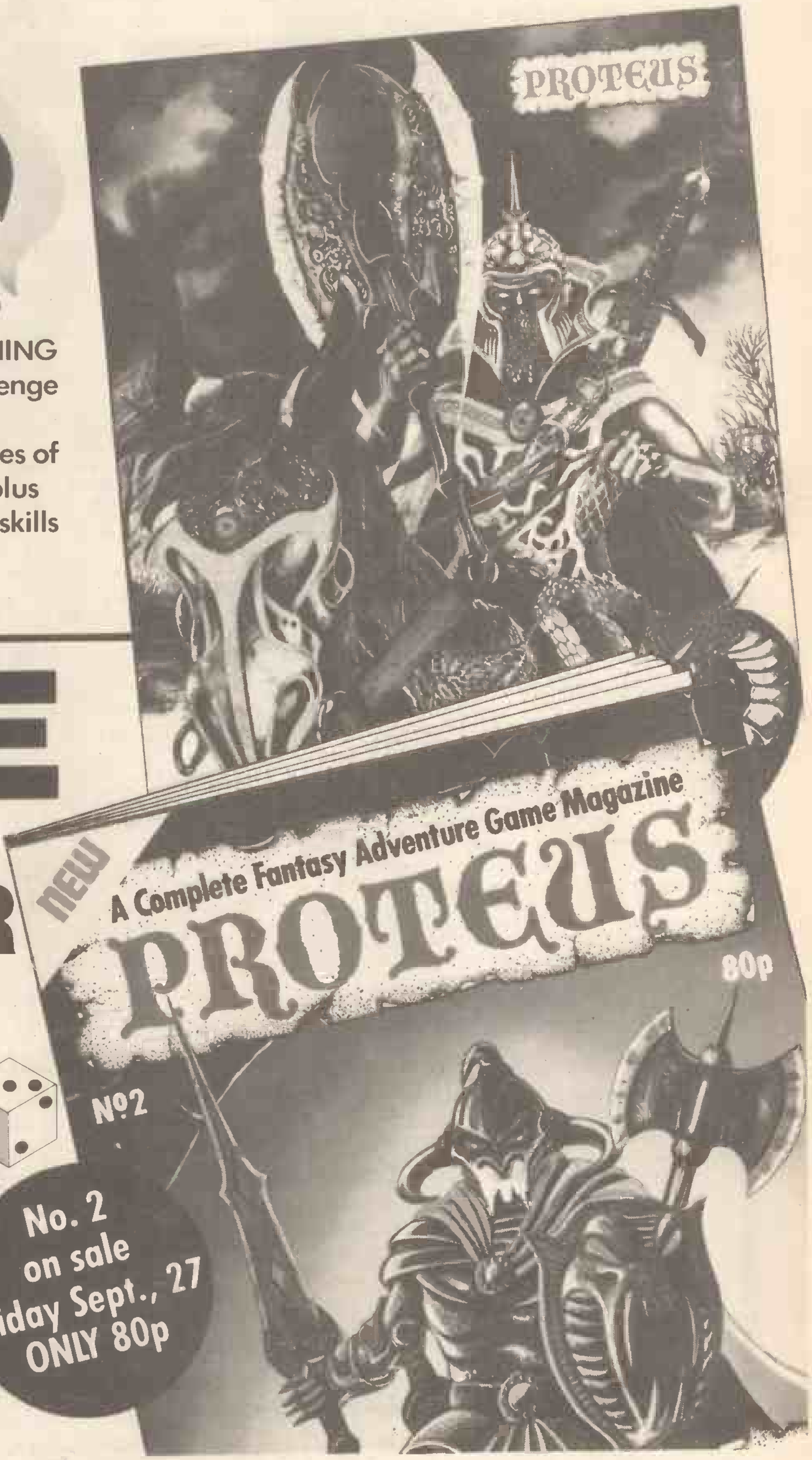

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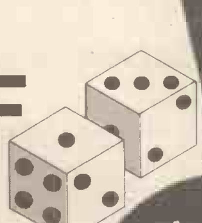

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ditto, but DPDT	195

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Electrolytic, radial or axial leads: 0.47/63V, 1/63V, 2.2/63V, 4.7/63V, 10/25V - 7p; 22/25V, 47/25V - 8p; 100/25V - 9p; 220/25V - 14p; 470/25V - 22p; 1000/25V - 30p; 2200/25V - 50p.
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Polyester, miniature Siemens PCB: 1n, 2n2, 3n3, 4n7, 6n8, 10n, 15n, 7p; 22n, 33n, 47n, 68n, 8p; 100n, 9p; 150n, 11p; 220n, 13p; 330n, 20p; 470n 26p; 680n, 29p; 1u 33p.

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20 way	90	90	95	130
26 way	105	110	115	155
34 way	115	130	130	180
40 wey	140	140	145	210
50 way	165	165	170	240
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709	35	ICL8211A	220	LM382	130	MC3302	75	NE5534	105	TL071	38
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CA3136	100	LM3342	85	LM2917N8	195	NE555	20	TBA950	220	ZN424P	130
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AC126	30	BC158	10	BCY70	16	BFX84	30	2N2222A	20	2N4061	10	TIP36A	115
AC127	30	BC159	10	BCY71	16	BFX85	30	2N2368	25	2N4062	10	TIP36C	130
AC128	30	BC160	40	BCY72	16	BFX86	30	2N2369	18	40360	40	TIP41A	45
AC176	25	BC168C	10	BD115	55	BFX87	30	2N2484	27	40361	50	TIP42A	45
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AF139	40	BC182	10	BD139	35	BRY39	50	2N2907	24	2N697	20	TIP3055	60
AF186	70	BC182L	10	BD140	35	BSX20	22	2N2907A	24	2N698	40	TIS43	40
AF239	55	BC183	10	BD204	110	BSX29	35	2N2926	10	2N706A	20	TIS43	40
BC107	10	BC183L	10	BD206	110	BSY95A	30	2N3053	28	2N708	25	TIS44	45
BC107B	12	BC184	10	BD222	85	BU205	160	2N3054	55	2N918	35	TIS45	45
BC108	10	BC184L	10	BF180	35	BU206	200	2N3055	50	TIP29	35	TIS90	30
BC108B	12	BC212	10	BF182	35	BU208	170	2N3442	120	TIP29A	35	TIS91	30
BC108C	12	BC212L	10	BF184	35	MJ2955	99	2N3702	9	TIP29B	35	VN10KM	65
BC109	10	BC213	10	BF185	25	MJE340	50	2N3703	10	TIP29C	35	VN46AF	94
BC109C	12	BC213L	10	BF194	12	MJE520	50	2N3704	9	TIP30	35	VN66AF	110
BC114	22	BC214	10	BF195	12	MJE521	90	2N3705	10	TIP30A	35	VN88AF	120
BC115	22	BC214L	10	BF196	12	MJE3055	70	2N3706	10	TIP30B	35	ZTX107	11
BC117	22	BC237	7	BF197	12	MPF102	40	2N3707	10	TIP30C	40	ZTX108	11
BC119	35	BC238	7	BF198	15	MPF104	40	2N3708	10	TIP31A	35	ZTX109	11
BC137	40	BC308	10	BF199	18	MPSA05	25	2N3709	10	TIP31B	35	ZTX300	14
BC139	38	BC327	8	BF200	35	MPSA06	25	2N3772	170	TIP31C	40	ZTX301	16
BC140	29	BC328	8	BF244B	35	MPSA12	29	2N3773	195	TIP32A	35	ZTX302	16
BC141	30	BC337	8	BF245	35	MPSA55	30	2N3819	32	TIP32B	38	ZTX304	20
BC142	28	BC338	12	BF256B	45	MPSA56	30	2N3820	50	TIP32C	40	ZTX341	20
BC143	30	BC477	22	BF257	32	MPSU05	55	2N3823	65	TIP33A	65	ZTX500	13
BC147	10	BC478	22	BF258	30	MPSU06	55	2N3866	90	TIP33C	75	ZTX501	18
BC148	10	BC479	22	BF259	30	MPSU55	55	2N3903	10	TIP34A	70	ZTX502	18
BC149	10	BC517	30	BF337	35	MPSU56	55	2N3904	10	TIP34C	80	ZTX503	18
BC157	11	BC547	5	BFR40	35	2N118L	22	2N3905	10	TIP35A	105	ZTX504	25

RESISTORS

Carbon film	1+	25+
¼W 5% 4.7ohm - 10M	2p	1p
½W 5% 4.7ohm - 4M7	3p	2p
Metal film		
¼W 1% 10ohm - 1M	4p	3p

25+ price applies to 25+ per value not mixed.

CRYSTALS

		4.194MHz	150
		4.43MHz	100
100KHz	235	5.008MHz	240
1MHz	275	6.0MHz	140
1.8432M	200	6.144MHz	150
2.0MHz	225	7.0MHz	150
2.4576M	200	8.0MHz	140
3.276M	150	10.0MHz	170
3.579M	95	12.0MHz	170
4.0MHz	140	16.0MHz	200

BOXES

		Aluminium	
		3 x 2 x 1"	65
Plastic with lid & screws		4 x 2¾ x 1½"	95
		4 x 2¾ x 2"	95
71x46x22mm	50	6 x 4 x 2"	120
95x71x35mm	86	7 x 5 x 2½"	165
140x90x55mm	140	8 x 6 x 3"	205

TTL

		7412	25	7440	25	7476	40	74107	40	74157	80	74180	85
		7413	36	7442	74	7480	50	74109	60	74160	90	74181	230
		7414	60	7444	105	7483	65	74121	50	74161	90	74182	85
7400	25	7416	43	7446	130	7485	110	74122	50	74162	90	74190	120
7401	25	7417	43	7447	98	7486	38	74123	92	74163	90	74191	120
7402	25	7420	25	7448	98	7489	170	74125	50	74164	115	74192	120
7403	25	7421	30	7450	25	7490	55	74126	55	74165	90	74193	110
7404	25	7422	30	7451	25	7491	80	74132	60	74167	200	74194	80
7405	25	7427	30	7453	25	7492	55	74141	80	74170	170	74195	63
7406	45	7428	30	7454	25	7493	55	74145	85	74173	100	74196	120
7407	45	7430	25	7460	25	7494	90	74147	130	74174	100	74197	85
7408	25	7432	35	7472	35	7495	80	74148	105	74175	80	74198	195
7409	25	7433	35	7473	40	7496	80	74150	130	74176	80	74199	195
7410	25	7437	43	7474	36	7497	170	74153	70	74177	80		
7411	25	7438	45	7475	55	74100	125	74154	135	74179	90		

CMOS

		4016	26	4034	145	4054	70	4081	18	4502	50	4529	80
		4017	43	4036	270	4055	70	4082	20	4503	45	4532	65
		4018	55	4039	270	4059	400	4085	60	4507	45	4534	390
4000	18	4019	35	4040	46	4060	70	4086	60	4508	115	4538	70
4001	18	4020	48	4041	55	4063	80	4089	120	4510	48	4543	65
4002	18	4021	55	4042	45	4066	24	4093	26	4511	48	4549	390
4006	65	4022	60	4043	45	4067	230	4094	70	4512	50	4553	215
4007	18	4023	18	4044	50	4068	18	4095	70	4514	115	4555	50
4008	50	4024	35	4046	60	4069	18	4097	260	4515	116	4556	50
4009	40	4025	18	4047	52	4070	22	4098	70	4516	48	4559	390
4010	40	4026	120	4048	50	4071	18	40106	38	4518	48	4560	110
4011	18	4027	28	4049	26	4072	18	40109	100	4520	48	4584	38
4012	18	4028	40	4050	26	4073	18	40163	75	4521	110	4585	65
4013	26	4029	45	4051	48	4075	24	40173	100	4526	70	4724	140
4014	50	4030	18	4052	48	4076	60	40175	75	4527	60		
4015	42	4031	125	4053	60	4077	24	40193	90	4528	45		

LS TTL

		LS20	22	LS75	38	LS123	70	LS161	60	LS221	78	LS365	42
		LS21	22	LS76	28	LS125	37	LS162	60	LS240	105	LS366	42
		LS22	22	LS78	28	LS126	37	LS163	60	LS241	80	LS367	42
LS00	22	LS26	22	LS83	68	LS132	53	LS164	70	LS242	80	LS368	42
LS01	22	LS27	22	LS85	82	LS136	35	LS165	95	LS243	80	LS373	80
LS02	22	LS30	22	LS86	35	LS138	35	LS166	88	LS244	80	LS374	80
LS03	22	LS32	22	LS90	40	LS139	48	LS170	120	LS245	88	LS375	55
LS04	22	LS37	22	LS92	50	LS145	92	LS173	80	LS247	77	LS377	100
LS05	22	LS38	22	LS93	45	LS147	130	LS174	60	LS251	55	LS378	88
LS08	22	LS40	22	LS95	58	LS148	115	LS175	60	LS257	55	LS390	82
LS09	22	LS42	60	LS96	120	LS151	55	LS190	75	LS258	55	LS393	82
LS10	22	LS47	78	LS107	42	LS153	80	LS191	55	LS259	90	LS399	115
LS11	22	LS48	78	LS109	42	LS154	220	LS192	75	LS266	28	LS541	115
LS12	22	LS51	22	LS112	42	LS155	55	LS193	75	LS273	80	LS670	170
LS13	35	LS55	22	LS113	32	LS157	48	LS195	60	LS279	55		
LS14	45	LS73	28	LS114	32	LS158	48	LS196	75	LS283	70		
LS15	22	LS74	28	LS122	56	LS160	60	LS197	75	LS353	85		

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