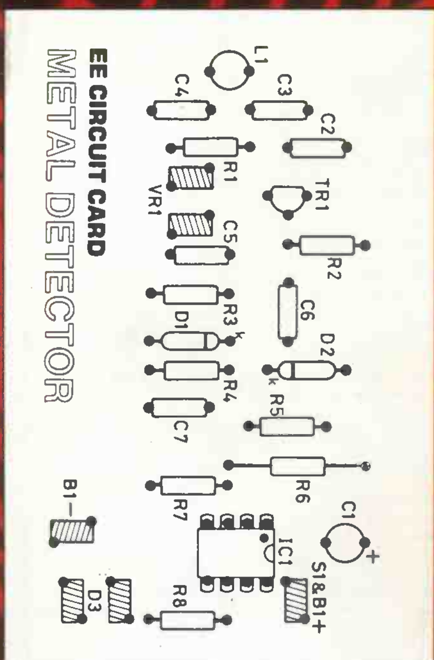
EVERYDAY ELECTRONICS

MAY 1989

INCORPORATING ELECTRONICS MONTHLY 29 [illegible] Place. 5/5 £1.40

FREE!

CIRCUIT CARDS



to build a
RADIO
and a
METAL DETECTOR

HI-FI SPEAKER DESIGN

PET SCARER

The Magazine for Electronic & Computer Projects

No. 1 LIST BAKERS DOZEN PACKS

All packs are £1 each, if you order 12 then you are entitled to another free. Please state which one you want. Note the figure on the extreme left of the pack ref number and the next figure is the quantity of items in the pack, finally a short description.

- BD2 5 13A spurs provide a fused outlet to a ring main where devices such as a clock must not be switched off.
- BD7 4 In flex switches with neon on/off lights, saves leaving things switched on.
- BD9 2 6V 1A mains transformers upright mounting with fixing clamps.
- BD11 1 6½in speaker cabinet ideal for extensions, takes our speaker. Ref BD137.
- BD13 12 30 watt reed switches, it's surprising what you can make with these—burglar alarms, secret switches, relay, etc., etc.
- BD22 2 25 watt loudspeaker two unit crossovers.
- BD29 1 B.O.A.C. stereo unit is wonderful breakdown value.
- BD30 2 Nicad constant current chargers adapt to charge almost any nicad battery.
- BD32 2 Humidity switches, as the air becomes damper the membrane stretches and operates a microswitch.
- BD42 5 13A rocker switch three tags so on/off, or change over with centre off.
- BD45 1 24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day. original cost £40 each.
- BD49 10 Neon valves, with series resistor, these make good night lights.
- BD56 1 Mini uniselector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through one pole.
- BD59 2 Flat solenoids—you could make your multi-tester read AC amps with this.
- BD67 1 Suck or blow operated pressure switch, or it can be operated by any low pressure variation such as water level in water tanks.
- BD91 1 Mains operated motors with gearbox. Final speed 16 rpm, 2 watt rated.
- BD103A 1 6V 750mA power supply, nicely cased with mains input and 6V output leads.
- BD120 2 Stripper boards, each contains a 400V 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers, etc.
- BD122 10m Twin screened flex with white pvc cover.
- BD128 10 Very fine drills for pcb boards etc. Normal cost about 80p each.
- BD132 2 Plastic boxes approx 3in cube with square hole through top so ideal for interrupted beam switch.
- BD134 10 Motors for model aeroplanes, spin to start so needs no switch.
- BD139 6 Microphone inserts—magnetic 400 ohm also act as speakers.
- BD148 4 Reed relay kits, you get 16 reed switches and 4 coil sets with notes on making c/o relays and other gadgets.
- BD149 6 Safety cover for 13A sockets—prevent those inquisitive little fingers getting nasty shocks.
- BD180 6 Neon indicators in panel mounting holders with lens.
- BD193 6 5 amp 3 pin flush mounting sockets make a low cost disco panel.
- BD196 1 in flex simmerstat—keeps your soldering iron etc. always at the ready.
- BD199 1 Mains solenoid, very powerful, has 1in pull or could push if modified.
- BD201 8 Keyboard switches—made for computers but have many other applications.
- BD210 4 Transistors type 2N3055, probably the most useful power transistor.
- BD211 1 Electric clock, mains operated, put this in a box and you need never be late.
- BD221 5 12V alarms, make a noise about as loud as a car horn. Slightly soiled but OK.
- BD242 2 6in x 4in speakers, 4 ohm made from Radiomobile so very good quality.
- BD252 1 Panostat, controls output of boiling ring from simmer up boil.
- BD259 50 Leads with push-on ¼in tags—a must for hook-ups—mains connections etc.
- BD263 2 Oblong push switches for bell or chimes, these can mains up to 5 amps so could be foot switch if fitted into pattress.
- BD268 1 Mini 1 watt amp for record player. Will also change speed of record player motor.
- BD283 3 Mild steel boxes approx 3in x 3in x 1in deep—standard electrical.
- BD293 50 Mixed silicon diodes.
- BD305 1 Tubular dynamic mic with optional table rest.

VERY POWERFUL 12 VOLT MOTORS—⅓rd HORSEPOWER. Made to drive the Sinclair C5 electric car but adaptable to power a go-kart, a mower, a rail car, model railway, etc. Brand new. Price £15.00 plus £2.00 postage. Our ref 15P8.

WHITE CEILING SWITCH 5 amp 2 way surface mounting with cord and tassle. Made by the famous Crabtree Company. Price £1 each. Our ref BD528.

13A SWITCH SOCKETS Top quality made by Crabtree, fitted in metal box with cutouts so ideal for garage, workshop, cellar, etc. Price £2 each. Our ref 2P37.

MAINS TRANSFORMER Upright mounting Normal mains input, gives 28V at 3.5A so should be ideal for big amplifier, etc. Price only £4. Our ref 4P24, please add £1 postage.

POWERFUL IONISER

Generates approx. 10 times more IONS than the ETI and similar circuits. Will refresh your home, office, workroom etc. Makes you feel better and work harder—a complete mains operated kit, case included. £12.50+£2 P&P. Our ref 12P5/1.

POTENTIAL PROFIT MAKERS We can offer shop rejects and customer returns covering a range of clock radios, cassette radios, cassette players, in-car cassette/radios, etc., all of which should be repairable. If you buy four of a type we will give you one extra free of charge. All are by Far East makers, sold under the trade names of: Sony, Matsui, Panasonic, etc. You will buy so cheaply that even if you are unlucky and cannot repair them you will be buying spares at a very low price. CLOCK RADIOS: Digital clock display with snooze, alarm and brightness controller, 2 band radio and built-in speaker. Price £5 each. Our ref 5P131. WALKMAN TYPE PERSONAL CASSETTE PLAYERS: Complete with stereo headphones. Price £5 each. Our ref 5P132. Ditto, but with graphic equaliser. £6 each. Our ref 6P11. PERSONAL RADIOS: AM/FM stereo, built-in speaker and light weight headphones. Price £4 each. Our ref 4P33.

ECHO BOX Intended to make dolls and robots talk. These units record speech and other sounds then play back the sounds a few seconds after hearing it. Basically the unit consists of a FET microphone, a micro-processor and lots of ICs, transistors, etc., on a pcb, coupled to a 2in speaker. All put together in a case size approx 4½in×2¾in×1¾in deep. In addition to talking back undoubtedly these models could, with a few alterations, be made to perform functions in repsonse to sound frequencies. Price £5 each. Our ref 5P130.

ATARI 65XE COMPUTER At 64K this is most powerful and suitable for home and business. Complete with PSU, TV lead, owner's manual and six games. Can be yours for only £45 plus £3 insured delivery.

DATA RECORDERS ACORN for Acorn Electron, etc., reference number ALF03, with TV lead, manual and PSU. Brand new. Price £10 plus £1.50 post. Order ref 10P44.

JOYSTICK FOR ATARI OR COMMODORE for all Atari and Commodore 64 and Vic20. New. Price £5. Order ref 5P126.

EXTRA SPECIAL OFFER. The ATARI Compendium contains computer 65XE data recorder XC12, joystick and ten games for **£62.50 plus £4 insured delivery.**

TIME AND TEMPERATURE LCD MODULE This is a 12 hour clock, a Celcius thermometer, a Fahrenheit thermometer, a too hot alarm and finally a too cold alarm. Nice size, approx 50mm×20mm, with 12.7mm digits which clearly display the time or temperature. Requires only a 1.5V battery and a few switches. Comes complete with circuit diagram and explanation. Price £6. Our ref 6P12.

40 WATT THREE-WAY SPEAKER SYSTEM Woofer, mid-range and tweeter, all assembled in a shelf mounting case, size 180mm long ×100mm high × 140mm deep. Really beautifully made. 4ohm impedence. New and tested. £10 each. Our ref 10P64.

CAMERAS Three cameras, all by famous makers, Kodak, etc. One disc and two differnt instant cameras. All in first class condition, believed to be in perfect working order but sold as untested. You can have the three for £10 including VAT, which must be a bargain—if only for the lenses, flash gear, etc. Our ref 10P58.

1/8th HORSEPOWER 12 VOLT MOTOR. Made by Smiths, the body length of this is approximately 3in, the diameter 3in and the spindle 5/16th of an inch diameter. It has a centre flange for fixing or can be fixed from the ends by means of 2 nuts. A very powerful little motor which revs at 3,000 rpm. We have a large quantity of them so if you have any projects in mind then you could rely on supplies for at least two years. price **£6**. Our ref 6P1, discount for quantities of 10 or more.

PHILIPS LASER

This is helium-neon and has a power rating of 1.6mW. Completely safe so long as you do not look directly into the beam when eye damage could result. Brand new, full spec, £30 plus £3 insured delivery. Mains operated power supply for this tube gives 8kv striking and 1.25kv at 5mA running. Complete kit with case £15. Battery operated P.S.U. now available at £15.

HAND-HELD VIDEO LAMP. Mains operated and will enable you to take professional standard videos. Made by the famous Ferguson Company, this uses a 1000w halogen lamp in a fan cooled, hand-held and hand-switched metal housing. Comes complete with optional barn-door assembly and camera bar. Obviously intended to retail at over £60, we offer these at £30 each plus £3 insured delivery. Our ref 30P3.

HIGH RESOLUTION MONITOR. 9in black and white, used Philips tube M24/306W. Made up in a lacquered frame and has open sides. Made for use with OPD computer but suitable for most others. Brand new. **£16 plus £5** post. Our ref 16P1.

12 VOLT BRUSHLESS FAN. Japanese made. The popular square shape (4½in×4½in×1¾in). The electronically run fans not only consume very little current but also they do not cause interference as the brush type motors do. Ideal for cooling computers, etc., or for a caravan. **£8** each. Our ref 8P26.

ORGAN MASTER is a three octave musical keyboard. It is beautifully made, has gold plated contacts and is complete with ribbon cable and edge connector. Brand new, **only £15 plus £3 postage.** Order ref 15P15

MUSIC FROM YOUR SPECTRUM 128 We offer the Organ Master three octave keyboard, complete with leads and the interface which plugs into your 128. You can then compose, play, record, store, etc., your own music. Price £19 plus £3 special packing and postage. Order ref. 19P1.

FDD BARGAIN

3½in made by Chinon of Japan. Single sided, 80 track, Shugart compatible interface, interchangeable with most other 3½in and 5¼in drives. Completely cased with 4 pin power lead and 34 pin computer lead **£40**. Our ref 40P1.

OUR ALADDIN'S CAVE. You may be a new reader and now know that we have a shop at 12 Boundary Road, Hove, where you can go and have a browse around at our assortment of 'goodies'. Unfortunately, because of staff shortages, we cannot be open on Saturdays yet, so the hours are 9.30am to 5pm, Monday to Friday. We of course still serve callers at 250 but request that you bring a completed order form as 250 is really the mail order depot.

J & N BULL ELECTRICAL
Dept. E.E., 250 PORTLAND ROAD, HOVE, BRIGHTON, SUSSEX BN3 5QT

MAIL ORDER TERMS: Cash, PO or cheque with order. Orders under £20 add £1.50 service charge. Monthly account orders accepted from schools and public companies. Access and B/card orders accepted. —minimum £5. Phone (0273) 734648 or 203500.

POPULAR ITEMS
Some of the many items described in our current list which you will receive if you request it

DOUBLE MICRODRIVES. We are pleased to advise you that the Double Microdrives which we were offering at about this time last year as being suitable for the 'QL', 'OPD' and several other computers are again available, same price as before namely £5. Our ref 5P113.

SOFTWARE FOR REMAKING. Just arrived. Large quantity of mainly games. All are on normal tape spool in cassette holders and should be suitable for wiping out and re-making into games or programmes of your own design. We offer 5 different for £2 or 100 assorted for £20. Important note: We cannot say which titles you will get nor accept orders for specified titles or 'so many, all different', etc., so only order if you can take them as they come. Order ref 5 for £2 is 2P224, 100 assorted is 20P10.

VERY USEFUL MAGNETS. Flat, about 1in long, ½in wide and ¼in thick. These are polarised on their faces which makes them ideal to operate reed switches in doors and windows or to hold papers or labels, etc., to metal cabinets, or even to keep cupboard doors firmly closed. Very powerful. 6 for £1. Our ref BD274(a).

ACORN COMPUTER DATA RECORDER REF ALF03 Made for the Electron or BBC computers but suitable for most others. Complete with mains adaptor, leads and handbook. £10.00. Ref 10P44.

FREE POWER! Can be yours if you use our solar cells—sturdily made modules with new system bubble magnifiers to concentrate the light and so eliminate the need for actual sunshine—they work just as well in bright light. Voltage input is .45—you join in series to get desired voltage—and in parallel for more amps. **Module A** gives 100mA, Price £1, Our ref. BD631. **Module C** gives 400mA, Price £2, Our ref. 2P199. Module D gives 700mA. Price £6. Our ref. 6P3

SOLAR POWERED NI-CAD CHARGER 4 Ni-Cad batteries AA (HP7) charged in eight hours or two in only 4 hours. It is a complete, boxed ready to use unit. Price £6. Our ref. 6P3.

SWITCH AC LOADS WITH YOUR COMPUTER This is easy and reliable if you use our solid state relay. This has no moving parts, has high input resistance and acts as a noise barrier and provides 4kW isolation between logic terminals. The turn-on voltage is not critical, anything between 3 and 30V, internal resistance is about 1K ohm. AC loads up to 10A can be switched. Price is £2 each. Ref. 2P183.

METAL PROJECT BOX Ideal size for battery charger, power supply, etc.; sprayed grey, size 8in x 4¼in x 4in high, ends are louvred for ventilation other sides are flat and undrilled. Price £2. Order ref. 2P191.

4-CORE FLEX CABLE. Cores separately insulated and grey PVC covered overall. Each copper core size 7/0.2mm. Ideal for long telephone runs or similar applications even at mains voltage. 20 metres **£2**. Our ref.2P196 or 100 metres coil **£8**. Order ref. 8P19.

6-CORE FLEX CABLE. Description same as the 4-core above. Price 15 metres for **£2**. Our ref. 2P197 or 100 metres **£9**. Our ref. 9P1.

13A PLUGS Pins sleeved for extra safety, parcel of 5 for £2. Order ref. 2P185.

13A ADAPTERS Takes 2 13A plugs, packet of 3 for £2. Order ref. 2P187.

20V-0-20V Mains transformers 2½ amp (100 watt) loading, tapped primary. 200-245 upright mountings £4. Order ref. 4P24.

BURGLAR ALARM BELL—6" gong OK for outside use if protected from rain. 12V battery operated. Price £8. Ref. 8P2.

VERY RELIABLE CAPACITOR 4.7μ 400v not electrolytic so not polarised, potted in ali can, size 1¾×¾×1½in high. A top grade capacitor made for high class instrument work. Ideal for PCB mounting. 2 for £1. Our ref BD667.

CAPACITOR BARGAIN—axial ended, 4700μF at 25V. Jap made, normally 50p each, you get 4 for £1. Our ref. 613.

SINGLE SCREENED FLEX 7.02 copper conductors, pvc insulated then with copper screen, finally outer insulation. In fact quite normal screened flex. 10m for £1. Our ref BD668.

M.E.S. BULB HOLDERS Circular base batten type fitting. 4 for £1. Our ref BD127a.

SPRING LOADED TEST PRODS—Heavy duty, made by the famous Bulgin company. very good quality. Price 4 for £1. Ref. BD597.

3-CORE FLEX BARGAIN No. 1—Core size 5mm so ideal for long extension leads carrying up to 5 amps or short leads up to 10 amps. 15mm for £2. ref. 2P189.

3-CORE FLEX BARGAIN No. 2—Core size 1.25mm so suitable for long extension leads carrying up to 13 amps, or short leads up to 25A. 10m for £2. Ref. 2P190.

ALPHA-NUMERIC KEYBOARD—This keyboard has 73 keys giving trouble free life and no contact bounce. The keys are arranged in two groups, the main area is a QWERTY array and on the right is a 15 key number pad, board size is approx. 13" x 4"—brand new but offered at only a fraction of its cost, namely £3, plus £1 post. Ref. 3P27.

WIRE BARGAIN—500 metres 0.7mm solid copper tinned and p.v.c. covered. Only £3 plus £1 post. Ref. 3P31—that's well under 1p per metre, and this wire is ideal for push on connections.

1/8th HORSEPOWER 12 VOLT MOTOR Made by Smiths, the body length of this is approximately 3in, the diameter 3in and the spindle 5/16th of an inch diameter. It has a centre flange for fixing or can be fixed from the end by means of 2 nuts. A very powerful little motor which revs at 3,000rpm. We have a large quantity of them so if you have any projects in mind then you could rely on supplies for at least two years. Price £6. Our ref 6P1, discount for quantities of 10 or more.

3 VOLT MOTOR Very low current so should be very suitable for working with solar cells. £1 each. Our ref BD681.

MINI SPEAKERS to use instead of headphones with your personal stereo—simply plug in to earphone socket. Excellent sound quality, only £4 per pair. Our ref 4P34.

SEALED LEAD ACID BATTERIES Japanese made re-chargeable and maintenance-free. Leak-proof construction, so could be used in any position. Long life expectancy—usually four to five years. 12V 2.6Ah, £10 each. Our ref 10P59. 6V 1Ah, £5 each. Our ref 5P135.

INNER EAR STEREO HEADPHONES Ideal for lady listeners as they will not mess up your hair do! Come complete in a neat carrying case. Price £3. Our ref 3P56.

STEREO HEADPHONE AMPLIFIER Very sensitive. A magnetic cartridge or tape head will drive it. Has volume control and socket for stereo headphones. 3V battery operated. £1 each. Our ref BD680.

FET CAPACITOR MICROPHONE EAGLE CI.200 Output equivalent to a high class dynamic microphone while retaining the characteristics of a capacitor microphone. Price £1. Our ref BD646.

SUB-MIN TOGGLE SWITCH Body size 8mm×4mm×7mm SBDT with chrome dolly fixing nuts. 4 for £1. Our ref BD649.

SUB-MIN PUSH SWITCH DPDT. Single hole fixing by hexagonal nut. 3 for £1. Our ref BD650.

DISPLAY 16 CHARACTER 2 LINE As used in telephone answering and similar machines. Screen size 85mm×36mm×9.3mm. Alpha-numeric, dot matrix module with integral CMOS micro processor. LCD display. Made by the EPSON Company, reference 16027AR. Price £10. Our ref 10P50.

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INCORPORATING ELECTRONICS MONTHLY

ABC

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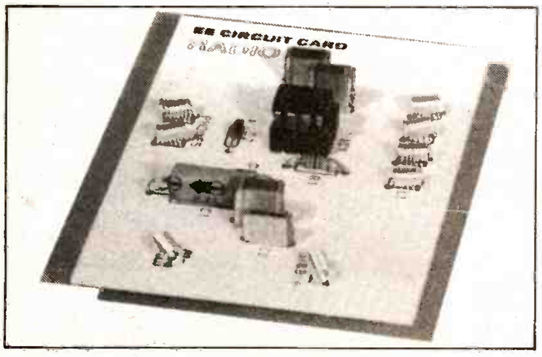
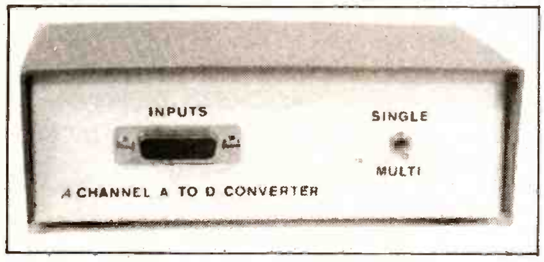
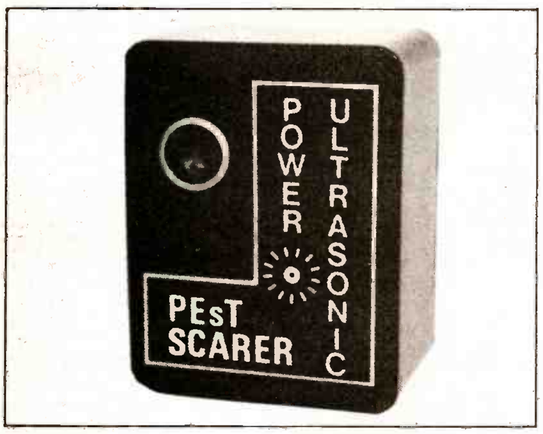
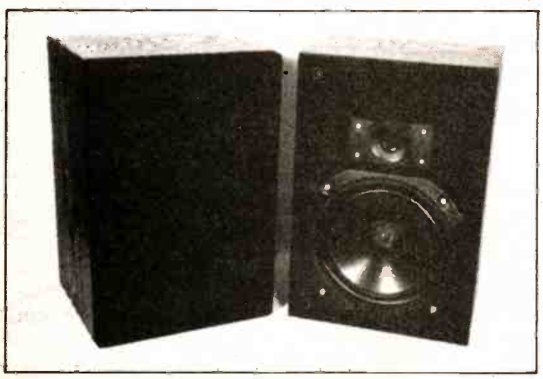
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .









Our June '89 issue will be published on Friday, 5 May 1989. See page 291 for details.

Projects

Series

Features

MAGENTA ELECTRONICS Ltd.

A SELECTION OF OUR BEST PROJECT KITS

As usual these kits come complete with printed circuit boards, cases, all components, nuts, screws, wire etc. All have been tested by our engineers (many of them are our own designs) to ensure that you get excellent results.

INSULATION TESTER

An electronic High Voltage tester for mains appliances and wiring. An inverter circuit produces 500 volts from a PP3 battery and applies it to the circuit under test. Reads insulation up to 100 Megohms. Completely safe in use.

OUR KIT REF 444 £19.58

'EQUALISER' IONISER

KIT REF 707 £15.53

A mains powered Ioniser that produces a breeze of negative ions in the air. A compact, safe, simple unit that uses a negligible amount of electricity.

3 BAND SHORTWAVE RADIO

OUR KIT REF 718 £26.53

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

DIGITAL CAPACITANCE METER

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

£41.55 OUR KIT REF 493

ULTRASONIC PET SCARER

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

KIT REF 812 £13.80
***Mains Adaptor £1.98**

VISUAL GUITAR TUNER

Crystal controlled, with a super rotating LED display. Indicates high, low, and exact degree of mistuning. Use with pick-up or mic. Also has audible output.

KIT REF E711 £21.99

COMPONENTS, KITS, BOOKS, TOOLS, MOTORS, GEARS, PULLEYS, OPTICAL FIBRES, ROBOTICS, AND MUCH MUCH MORE–IN OUR CATALOGUE £1.00

MOSFET VARIABLE BENCH 25V 2.5A POWER SUPPLY

TOP KITS

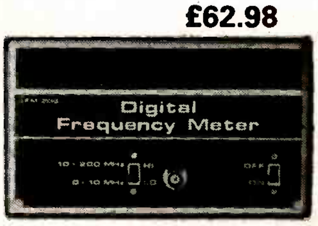
OUR KIT REF. 769 £49.73

A superb design giving 0-25V and 0-2.5A. Twin panel meters indicate Voltage and Current. Voltage is variable from zero to 25V.
Current-Limit control allows Constant Current charging of NICAD batteries, and protects circuits from overload. A Toroidal transformer MOSFET power output device, and Quad op-amp IC design give excellent performance.

DIGITAL FREQUENCY 200 MHz METER

KIT REF 563 £62.98

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



PROJECT KITS FOR E.E. (Just a selection more in our catalogue)

Magenta supply Full Kits: Including PCB's (or Stripboard), Hardware, Components, and Cases (unless stated). Please state Kit Reference Number, Kit Title, and Price, when ordering.
REPRINTS: If you do not have the issue of E.E. which includes the project, you will need to order the instruction reprint as an extra: 80p each. Reprints are also available separately–Send £1 in stamps.

REF NO.	KIT-TITLE	PRICE
812	ULTRASONIC PET SCARER May 89	£13.80
811	MIDI PEDAL Mar 89	£39.98
810	MIDI MERGE Mar 89	£11.59
809	CALL ALERT Mar 89	£13.51
807	MINI PSU Feb 89	£22.71
806	CONTINUITY TESTER Feb 89	£10.28
505	4 CHANNEL LIGHT DIMMER Feb 89	£37.99
803	REACTION TIMER Dec. 88	£29.98
802	PHASOR (Light Controller) Dec 88	£25.61
801	DOWNBEAT METRONOME Dec 88	£17.57
800	SPECTRUM EPROM PROGRAMMER Dec 88	£26.97
796	SEASHELL SYNTHESISER Nov 88	£24.99
795	I.R. OBJECT COUNTER Nov 88	£29.63
790	EPROM ERASER Oct 88	£24.95
786	UNIVERSAL NICAD CHARGER July 88	£6.99
780	CABLE & PIPE LOCATOR April 88	£15.35
775	ENVELOPE SHAPER Mar 88	£14.99
769	VARIABLE 25V-2A BENCH POWER SUPPLY Feb 88	£49.73
	CAR LAMP CHECKING SYST. Feb 88	£7.10
763	AUDIO SIGNAL GENERATOR Dec 87	£13.64
739	ACCENTED BEAT METRONOME Nov 87	£20.95
740	ACOUSTIC PROBE Nov 87 (less bolt & probe)	£16.26
744	VIDEO CONTROLLER Oct 87	£29.14
745	TRANSTEST Oct 87	£9.70
734	AUTOMATIC PORCH LIGHT Oct 87	£17.17
736	STATIC MONITOR Oct 87	£8.66
723	ELECTRONIC MULTIMETER Sept 87	£46.96
728	PERSONAL STEREO AMP Sept 87	£14.31
730	BURST-FIRE MAINS CONTROLLER Sept 87	£13.57
724	SUPER SOUND ADAPTOR Aug 87	£38.39
718	3 BAND 1.6-300MHz RADIO Aug 87	£26.53
719	BUCCANEER I.B. METAL DETECTOR inc. coils and case, less handle and hardware July 87	£26.45
720	DIGITAL COUNTER/FREQ METER (10MHz) inc. case July 87	£67.07
722	FERMOSTAT July 87	£12.14
711	VISUAL GUITAR TUNER Jun 87	£22.99
715	MINI DISCO LIGHT Jun 87	£12.59
707	EQUALIZER (IONISER) May 87	£15.53
700	ACTIVE I/R BURGLAR ALARM Mar 87	£35.65

REF NO.	KIT-TITLE	PRICE
581	VIDEO GUARD Feb 87	£8.39
584	SPECTRUM SPEECH SYNTH. (no case) Feb 87	£20.92
578	SPECTRUM I/O PORT less case Feb 87	£9.44
569	CAR ALARM Dec 86	£12.47
563	200MHz DIG. FREQUENCY METER Nov 86	£62.98
561	LIGHT RIDER LAPEL BADGE Oct 86	£10.20
560	LIGHT RIDER DISCO VERSION	£19.62
559	LIGHT RIDER 16 LED VERSION	£13.64
556	INFRA-RED BEAM ALARM Sept 86	£28.35
544	TILT ALARM July 86	£7.82
542	PERSONAL RADIO June 86	£11.53
528	PA AMPLIFIER May 86	£26.95
523	STEREO REVERB Apr 86	£26.44
513	BBC MIDI INTERFACE Mar 86	£27.94
512	MAINS TESTER & FUSE FINDER Mar 86	£8.82
497	MUSICAL DOOR BELL Jan 86	£18.72
493	DIGITAL CAPACITANCE METER Dec 85	£41.55
481	SOLDERING IRON CONTROLLER Oct 85	£5.47
464	STEPPER MOTOR INTERFACE FOR THE BBC COMPUTER less case Aug 85	£11.68
	1D35STEPPER MOTOR EXTRA	£14.50
	OPTIONAL POWER SUPPLY PARTS	£5.14
461	CONTINUITY TESTER July 85	£6.20
455	ELECTRONIC DOORBELL June 85	£7.56
453	GRAPHIC EQUALISER June 85	£26.94
444	INSULATION TESTER Apr 85	£19.58
430	SPECTRUM AMPLIFIER Jan 85	£6.91
392	BBC MICRO AUDIO STORAGE SCOPE INTERFACE Nov 84	£36.25
387	MAINS CABLE DETECTOR Oct 84	£5.53
386	DRILL SPEED CONTROLLER Oct 84	£8.68
362	VARICAP AM RADIO May 84	£13.15
337	BIOLOGICAL AMPLIFIER Jan 84	£24.14
263	BUZZ OFF Mar 83	£5.68
242	2-WAY INTERCOM no case July 82	£5.69
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205	SUSTAIN UNIT Oct 81	£17.63
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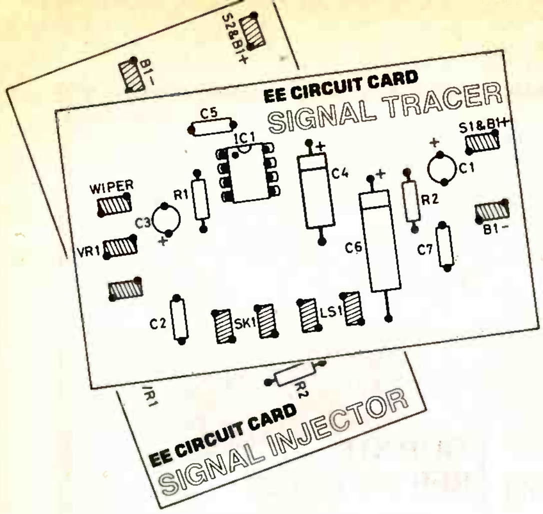

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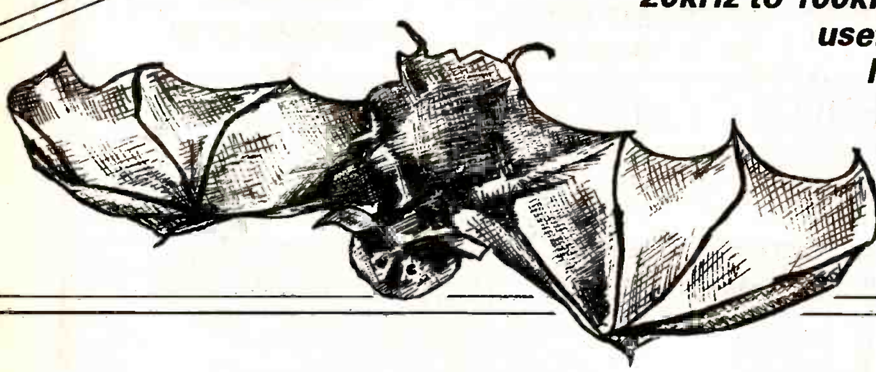

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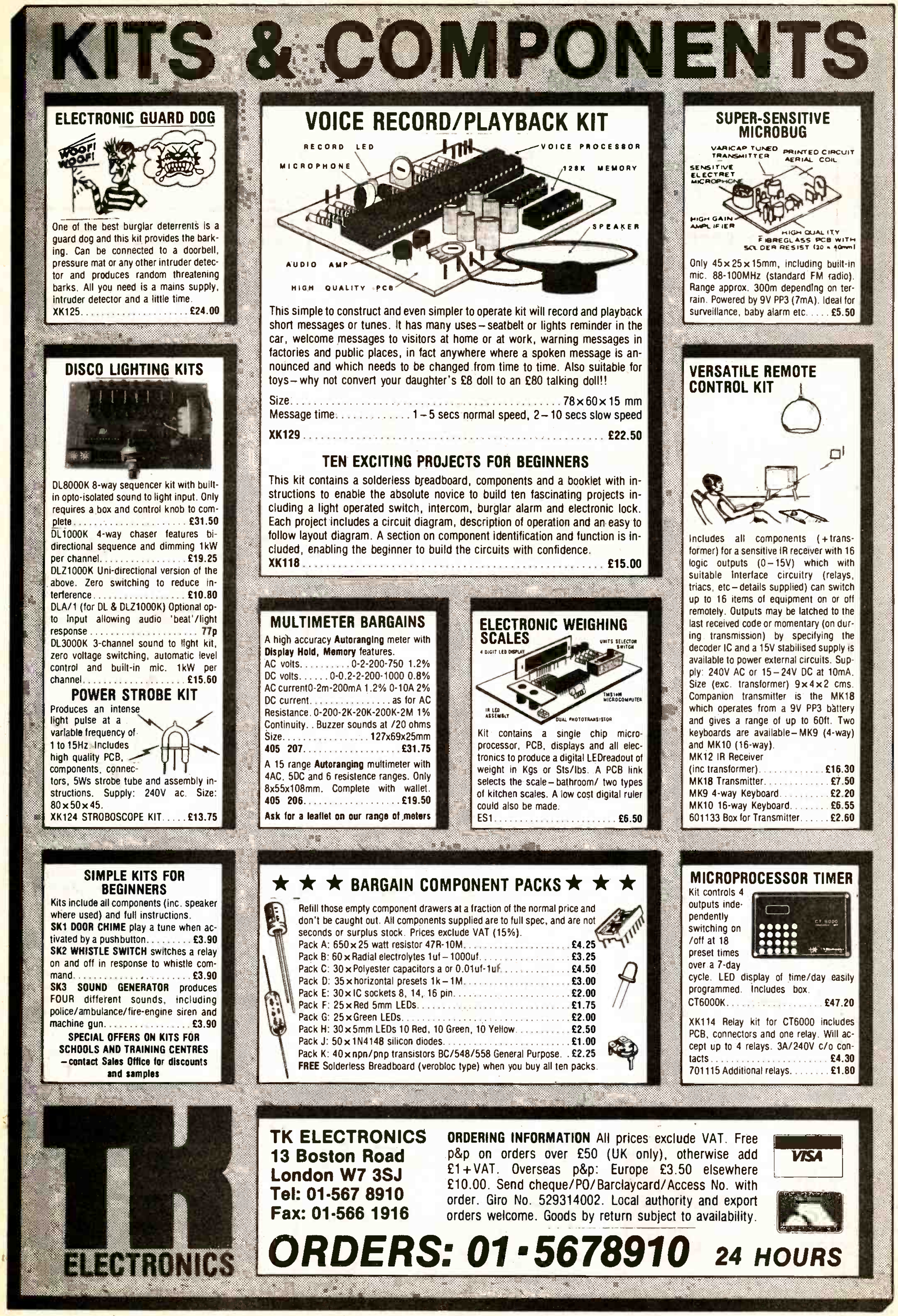
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EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

The Magazine for Electronic & Computer Projects

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BOOKS AND MORE BOOKS

Our *Direct Book Service*—see pages 339 to 341—may look as if it has been cut back from four pages to three pages this month. In fact what we have done is to expand the range of books by adding another twenty titles and split the number of pages —now a total of six—in two. This means that the full range of books we supply is now spread over two months and we will alternate the pages each month.

In response to demand from readers we have added a number of new books from various publishers. Some of these new books are quite expensive, like Mike Tooley's *Servicing Personal Computers* and *The Illustrated Dictionary of Electronics*, however, they have all been carefully selected and they all represent good value. Other titles are right up to the minute, like John Breeds *Satellite Television Installation Guide*. Even though this is a second (expanded) edition the title has only been around for a few months—the first edition sold out so quickly. Regular readers will have seen a review of this book in Barry Fox's *For Your Entertainment* page last month.

We also have some more titles lined up for later in the year when they are published. It seems your appetite for technical books is insatiable—our expanded service should help to satisfy your requirements.

ANOTHER CATALOGUE

Another company is now making its catalogue available free to all readers via EE. In addition to the Free Circuit Cards, which will be cover mounted again next month, the issue will also carry the new SCS Components catalogue. This is the third catalogue we have been able to give away with EE in the last eight months.

We believe these catalogues are very useful to all readers and expect to present at least two more next Autumn.

POCKET MONEY

Following the popularity of our Circuit Card projects, which are cheap and easy to build, we will be commencing a long series of *Pocket Money Projects* starting in the July issue. These should meet the needs of many of our younger readers who find some projects too expensive.

I urge you not to miss your copy of EE, place an order with your newsagent NOW!, or take out a subscription—see page 314.

Mike Kenward

SUBSCRIPTIONS

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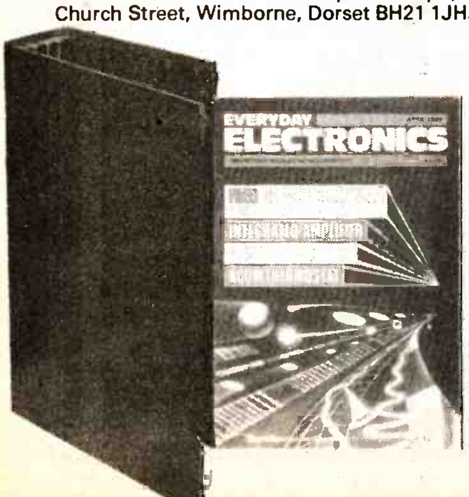

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Certain back issues of EVERYDAY ELECTRONICS are available price £1.50 (£2.00 overseas surface mail—**£ sterling only please)** inclusive of postage and packing per copy. Enquiries with remittance, made payable to Everyday Electronics, should be sent to Post Sales Department, Everyday Electronics, 6 Church Street, Wimborne, Dorset BH21 1JH. In the event of non-availability remittance will be returned. *Please allow 28 days for delivery.* **We have sold out of Sept. Oct. & Dec. 85, April, May, Oct. & Dec. 86, April, May & Nov. 87, Jan., March, April, June & Oct. 88.**

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

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

OLD PROJECTS

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

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

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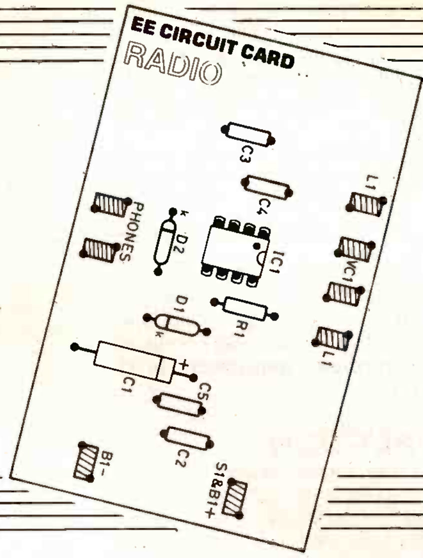
TRANSMITTERS/BUGS

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

The law relating to this subject varies from country to country; overseas readers should check local laws.



SIMPLE RADIO

ROBERT PENFOLD

Use your FREE Circuit Card and the BICC-Vero Easiwire system to make this simple, single i.c., MW radio and tune into your favourite programme.

THE HUMBLE broadcast radio receiver is no longer considered the wonder of science that it was some years ago. Nevertheless, a simple medium wave broadcast band receiver of the type described here still represents an interesting and useful project for the electronics hobbyist. This design is for use with medium impedance headphones (the type sold as replacements for personal stereo units) and should provide good reception of several stations in most areas.

It is a simple t.r.f. (tuned radio frequency) receiver, which does not provide quite the same level of performance as the more usual superheterodyne ("superhet") type circuit. On the other hand, it is much simpler to build, cheaper, and requires no complicated alignment once completed. Above average t.r.f performance is obtained by the use of an integrated circuit specially developed for this application.

RECEIVER BASICS

The block diagram of Fig. 1 shows, in somewhat simplified terms, the basic arrangement used in this receiver.

The ferrite rod aerial serves two functions, with the most obvious of these being to pick up radio waves and to convert them into electrical signals. In order to function properly the receiver must select just one transmission from the plethora of signals received by the aerial. The tuning capacitor and the coil of the aerial together form a parallel tuned circuit, which acts as a tunable filter so that the desired station can be picked out.

A problem with simple filtering of this type is that it does not provide particularly good selectivity, and it can result in the set simultaneously receiving two adjacent transmissions. A buffer amplifier ensures that the aerial feeds into a high input impedance, and this helps to maximise the selectivity.

There also seems to be a certain amount of stray positive feedback that aids selectivity. In any event, performance in this respect is quite adequate.

DETECTOR

An r.f. (radio frequency) amplifier considerably boosts the very weak aerial signal, and it is here that most of the circuit's voltage gain is provided. The next stage is the a.g.c. (automatic gain control) and detector circuit.

Taking the detector first, its purpose is to convert the received radio frequency signal into an audio frequency (a.f.) type that can drive the headphones. The audio signal is amplitude modulated (a.m.) onto the radio frequency carrier wave, which simply means that the strength of the radio signal is varied in sympathy with the volume of the audio input signal.

The average voltage of the radio frequency signal is always zero. This must be so since the positive half cycles are always cancelled out by equal but opposite negative half cycles, regardless of the signal's strength.

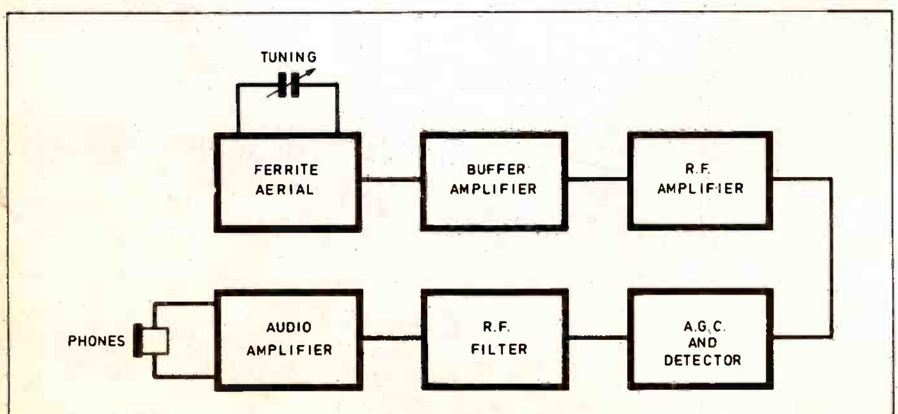
The most simple method of a.m. demodulation is to rectify the signal so that (say) the negative half cycles are removed. Then this cancelling of the two sets of half cycles no longer occurs, and the result is a signal with an average level that does reflect the audio voltage in the modulation signal. Some simple filtering is then all that is needed in order to remove the radio frequency signal and leave the required audio signal.

Applying further filtering to some of the demodulated signal gives a d.c. voltage that is proportional to the strength of the received signal. This is used to reduce the supply voltage to the r.f. amplifier and reduce its gain.

The stronger the received signal, the lower the gain of the circuit. This gives an almost constant volume from signals of widely varying strengths. It can also help to combat fading on stations that are prone to this problem.

The audio output of the detector is subjected to some further filtering before being fed to the audio amplifier. This additional filtering is needed to prevent instability due to stray feedback. The audio amplifier provides little voltage gain, and its main function is to produce the relatively high drive currents required by the headphones.

Fig. 1. Block diagram for the Simple Headphone Radio.



CIRCUIT DESCRIPTION

Most of the circuitry for the Simple Headphone Radio is provided by a ZN415E integrated circuit, as can be seen from the circuit diagram Fig. 2. The ZN415E is a development of the better known ZN414 radio chip. It is in a standard 8-pin d.i.l. plastic package, and is effectively just a ZN414 plus an audio output stage (the ZN414 has no audio stages at all).

A supply voltage of only about 1.3V is needed, and this is derived from a 9V battery (B1) via a simple voltage regulator circuit comprised of resistor R1, and diodes D1, D2. The current consumption of the circuit is only three to four milliamps, and a PP3 size battery should give many hours of operation.

Coil L1 is the ferrite aerial and VC1 is the tuning capacitor. Capacitors C1, C3 and C5 are all filter/decoupling capacitors. Capacitor C4 is an audio coupling capacitor.

The headphones are driven direct from the output of the circuit, and form the load resistance for the output stage of IC1 (pin 5). The output stage is specifically designed for driving medium impedance headphones in this way.

CONSTRUCTION

The complete *Simple Headphone Radio* has been designed to be built on one of the Free Circuit Cards attached to the front cover of this issue – see the next page for "Using Your Circuit Cards" information. It could, of course, be transposed to plain matrix board or p.c.b. if an alternative constructional method is required. Details of the component board and wiring are shown in Fig. 3.

There is little out of the ordinary about the component board, but be careful to fit the electrolytic capacitor C1 and the semiconductors round the right way. On the underside of the board there is no connection to one lead of the right hand headphone "spring" connector, so that a wire can pass between its two leads. It is still advisable to individually wire-wrap the unused lead of the connector so that it is fixed to the board firmly.

AERIAL

The minimum size of case that can be used for this project is determined by the ferrite aerial used. The Denco 5FR/MW type is about 125 millimetres long. This has flying leads which can be fitted with Easiwire plugs, but note that it is only the larger winding that is used. The smaller winding can be carefully removed or just ignored.

The Cirkit MWC2 aerial coil plus FRA (140 millimetres) and FRE (75 millimetres) ferrite rods are also suitable. Again, only the larger winding is needed. This aerial coil has tags, and the connections to it must be made via insulated leads wire-wrapped to the tags, and fitted with Easiwire plugs at the board ends.

Proper mounting clips for ferrite aerials seem to be impossible to obtain these days. However, a couple of large "P" style cable grips will do the job quite well, and can be obtained from some of the larger component suppliers.

TUNING CAPACITOR

The tuning capacitor VC1 can be any variable type which has a maximum value of about 200pF to 350pF. A cheap miniature solid dielectric type is perfectly adequate for this application. Some of these have built-in trimmers, and in some cases are multi-gang types. These are perfectly suitable – simply ignore any sections that are not required.

The retailers catalogue should provide connection details so that you can choose the right two tags, but you can always use trial and error if necessary. Incorrect connection will not damage anything.

Most of these miniature variable capacitors are mounted via two small screws and not by the usual mounting bush and nut. Make sure that you obtain one with a standard 6mm or 6.35mm shaft that will take ordinary control knobs.

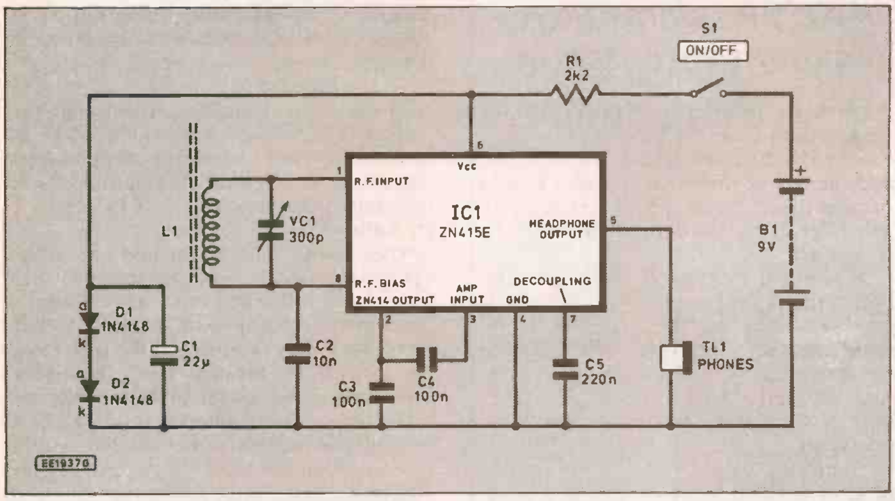


Fig. 2. Complete circuit diagram for the Simple Headphone Radio showing the pin functions of the ZN415E radio chip.

HEADPHONES

The connections to the headphones can be made by way of a 3.5mm stereo jack socket. These can be a bit difficult to obtain though, and it is easier to remove the plug from the headphones and then wire them direct to the board.

If you use the personal stereo type headphones, there is a twin lead coming from each phone and these must be wired in series. In other words, connect together one wire from each phone, and then make no further connection to these wires. This leaves two wires which are connected to the board via Easiwire plugs.

COMPONENTS

Shop Talk see page 314

Resistors
R1 2k2
0.25W 5% carbon

Capacitors

C1	22µ axial elect. 10V
C2	10n polyester 7.5mm pitch
C3, C4	100n polyester 7.5mm pitch (2 off)
C5	220n polyester 7.5mm pitch
VC1	300p variable solid dielectric (see text)

Semiconductors

D1, D2	1N4148 silicon signal diode (2 off)
IC1	ZN415E t.r.f. a.m. radio with amplifier

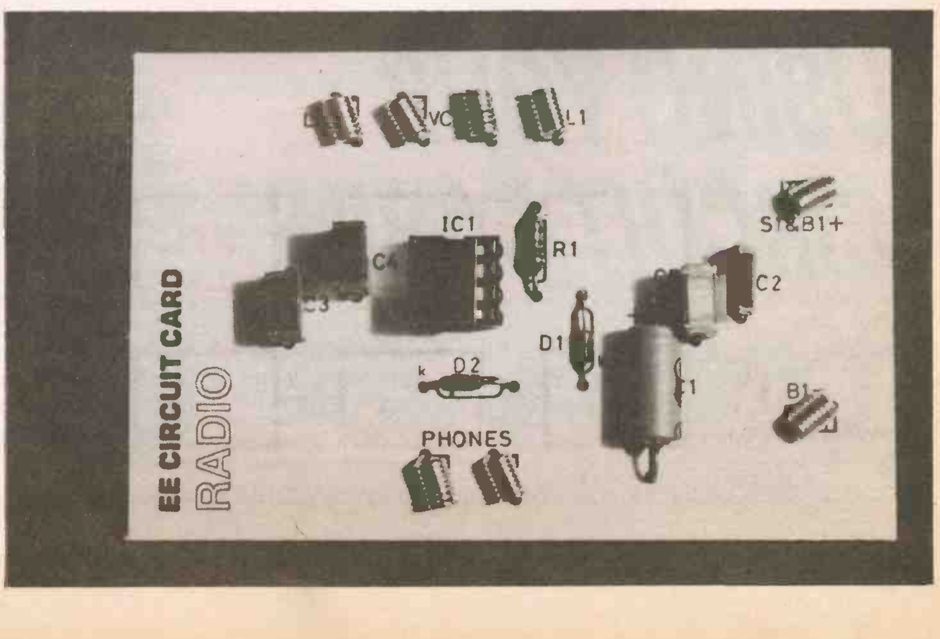
Miscellaneous

B1	9 volt (PP3 size battery)
L1	M.W. ferrite rod aerial (see text)
S1	s.p.s.t. sub-min. toggle switch

Personal stereo type headphones; battery connector; Free EE Circuit Card or Easiwire board; control knob; 8-pin d.i.l. i.c. holder; plastic case; wire, etc.

Approx. cost Guidance Only **£10** excl. 'phones

Components mounted on the FREE Circuit Card.



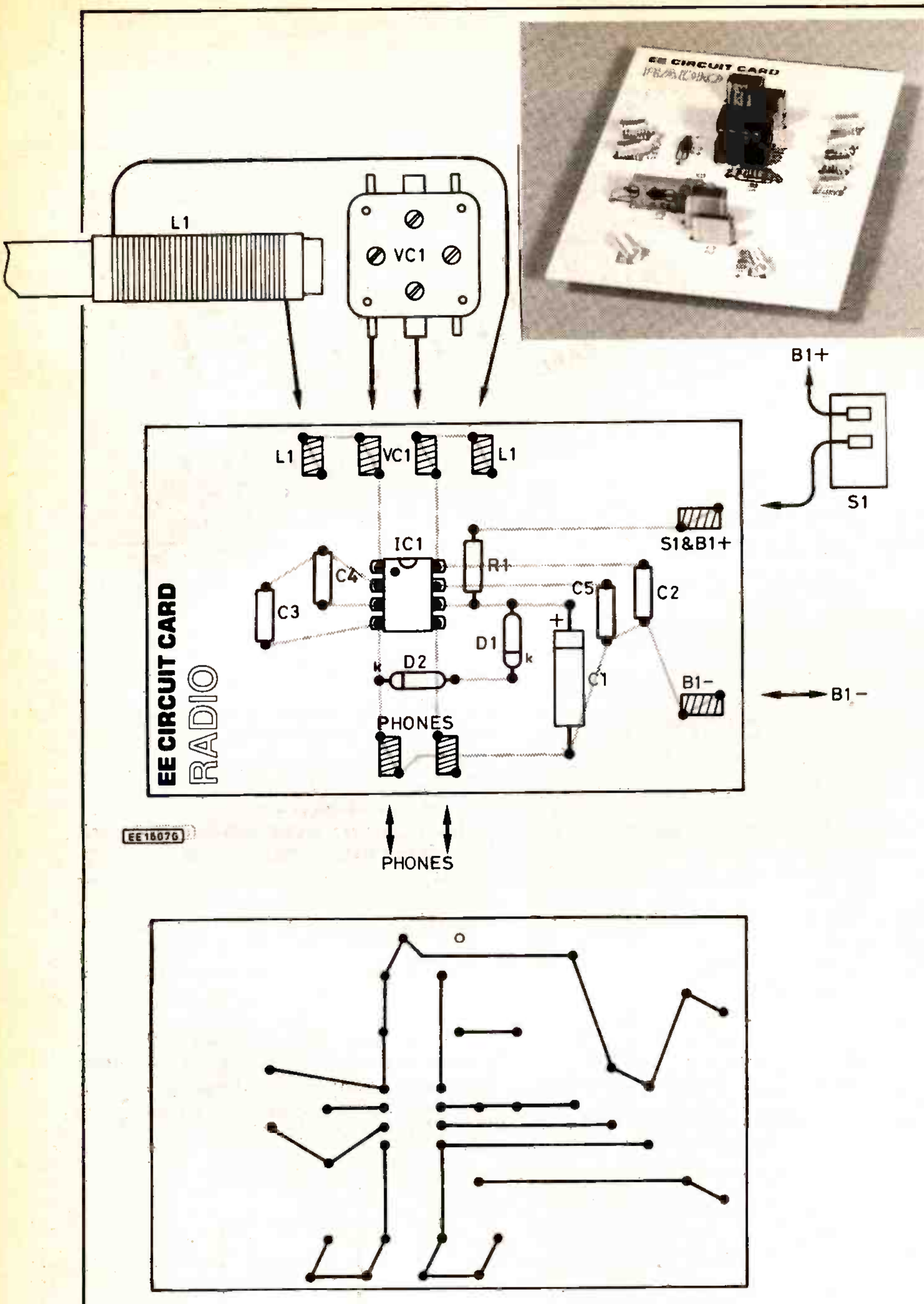


Fig. 3. Component "board" layout and underside wiring details.

An Easiwire plug also represents a simple means of connecting the other two wires together, but cover the plug with insulation tape so that there can be no accidental short circuits to it. Use a cable grip to provide the cable with strain relief.

The final component layout inside the case needs to be carefully thought out. In particular, try to have the aerial coil a reasonable distance from any other components.

There is a slight risk of feedback from some components causing instability, or in the case of the battery it could tend to screen the aerial. It is important to use a non-metallic case, as a metal type would fully screen the aerial and prevent any signal pick up.

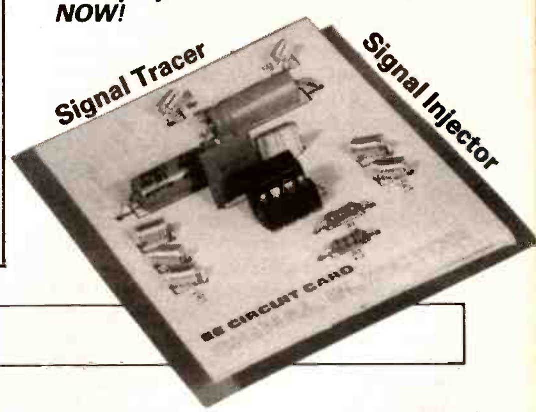
IN USE

No alignment of the finished receiver is required, but the aerial coil must be given a position on the ferrite rod that provides full coverage of the medium waveband. This usually means having the coil almost right at one end of the rod so that full coverage at the *high* frequency end of the band can be obtained. A little experimentation may be required here.

If it is difficult to obtain full coverage at this end of the band, the tuning capacitor might have built-in trimmers that are giving problems. Try adjusting the trimmer screws at the rear of the component to see if this provides a solution.

For a simple t.r.f. receiver the selectivity is quite good. Strong signals can still cause problems though. Remember that a ferrite aerial is directional, and that rotating the set will often enable an interfering signal to be nulled. This also enables the strength of a station to be reduced if it is so strong that the set is being overloaded (which will result in a slight degradation of the audio output quality). □

Next Month: Two more FREE Circuit Card projects.–*ORDER YOUR COPY NOW!*



USING YOUR CIRCUIT CARDS

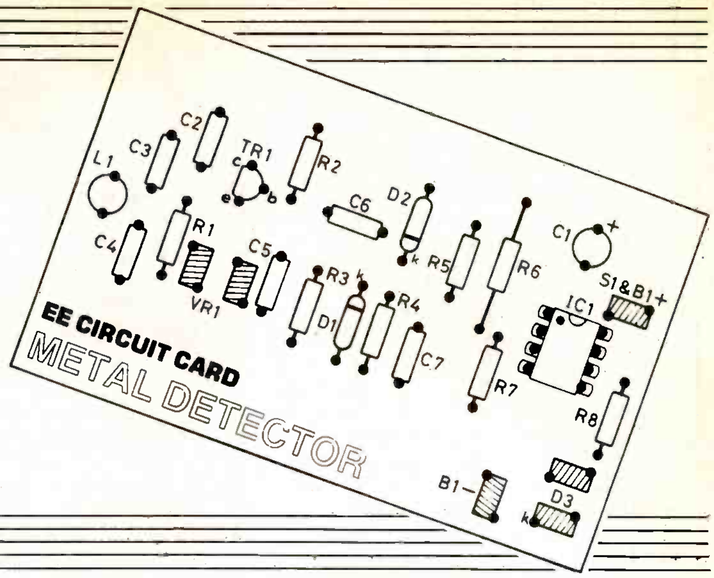
THE CIRCUIT CARDS attached to the front cover of this issue have been specially designed for easy, solderless construction of projects using the BICC-Vero Easiwire system.

HOLE PUNCHING

Carefully remove your Circuit Cards from the cover taking care not to damage them, then cut them in half along the centre line. Next, using the pointed end of the Easiwire unwrap tool, make holes through the board for the component leads. This is best done by placing the Circuit Card, component side up on a piece of thick cardboard or a pad of scrap paper then push the point through the Circuit Card at all the points marked with a "●".

Once all the holes are made you can use the Circuit Card, as described in the special articles in this issue, to build your projects. If you do not have a BICC-Vero Easiwire kit see the special offer on page 303.

Circuit Card Project



METAL DETECTOR

ROBERT PENFOLD

Use your FREE Circuit Card and the BICC-Vero Easiwire system to build this low cost project and locate those hidden pipes and wires.

METAL detectors have a multitude of uses, but for the amateur user they are either "treasure" locators or used for detecting pipes, wires, screws, etc. in walls when doing a spot of do-it-yourself. This metal detector is intended for the second of these applications.

Although it is extremely simple and can be constructed at very low cost, its level of performance is quite good. It can detect quite small screws at a distance of 25 to 50 millimetres. This may not seem to be particularly good, but it requires quite complex circuits to detect small objects at ranges substantially larger than this.

The maximum range of the unit with much larger pieces of metal is not much greater than the range with small target objects. However, as a unit of this type is normally only used for detecting small pieces of metal at relatively small depths, this lack of range on large objects is not of major importance.

The unit uses standard "off-the-shelf" components, including the search coil. Some metal detectors are difficult to use because the presence of metal is indicated by a small change in pitch from an audio tone. This method of indication can be difficult even for someone with a good sense of pitch. In this case the method of indication is very clear, with a panel l.e.d. switching on when metal is detected.

In this circuit a feedback control is used to adjust the oscillator so that there is only just sufficient feedback to sustain oscillation. While it might appear that placing metal near the search coil will have no significant effect on the circuit, it does in fact have a very strong influence on the performance of the oscillator.

One effect is to change the value of the inductance by a small amount, but this often exploited effect is not utilized in this circuit. Instead it is the slight change in the *Q* of the coil that is of importance.

rectifier and smoothing circuit. This provides a d.c. output signal that is roughly proportional to the strength of the a.c. output signal from the oscillator.

The next stage is a voltage comparator. This compares the output from the smoothing circuit with a reference voltage. If the voltage from the smoothing circuit is lower than the reference voltage, the output of the comparator goes high and switches on the l.e.d. If the output from the smoothing circuit is the higher of the two voltages, the output of the comparator goes low and the l.e.d. is switched off.

In practice the feedback control is adjusted so that under standby conditions the output voltage from the smoothing circuit is just high enough to hold the l.e.d. in

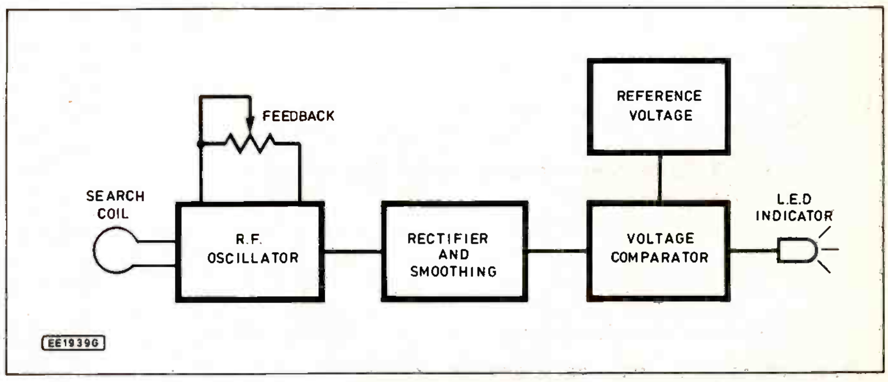


Fig. 1. Block diagram of the basic setup for the Metal Detector.

OPERATING PRINCIPLE

There are probably more than a dozen methods of electronically detecting metal, but nearly all rely on a search coil, and metal near the coil influencing its electrical characteristics in some way. A requirement of this unit was that it should use a handful of components, and should be very easy to construct. This excludes the use of most popular methods of metal location!

The block diagram of Fig. 1 shows the basic setup used in the metal detector. Like most metal locators, it is based on an L–C oscillator which has the search coil as the inductor in the parallel L–C tuned circuit.

Q VALUE

The *Q* value of an inductor is effectively a measure of its efficiency, and the result of metal close to the search coil is to give a reduction of its *Q*. This slightly dampens the oscillator, and the strength of the output signal decreases. In fact the *Q* will be reduced to the point where oscillation ceases altogether if even a small piece of metal is brought very close to the coil.

This reduction in the amplitude of the oscillations must be converted into a switching signal to operate the l.e.d. indicator. This is achieved using two simple signal processing stages, the first of which is a

the off state. Metal close to the search coil then gives a lower output voltage and switches on the l.e.d.

CIRCUIT DESCRIPTION

The full *Metal Detector* circuit diagram appears in Fig. 2. The oscillator is based on transistor TR1 which operates in the emitter follower mode. This provides slightly less than unity voltage gain, but there is a voltage step-up through the tuned circuit which enables oscillation to be sustained.

The tuned circuit is formed by coil L1, capacitors C3 and C4, with the two capacitors providing a capacitive centre tap. Potentiometer VR1 is the feedback level control. With the specified values the circuit oscillates at about 20kHz, which is well within the permitted band for metal detectors.

Capacitor C6 couples the output of the oscillator to the rectifier and smoothing circuit. The voltage comparator is an operational amplifier (IC1) used open loop. Due to their very high d.c. gain operational amplifiers work very well in this role.

REFERENCE VOLTAGE

The reference voltage is provided by resistors R6 and R7. These produce an output voltage of well under 1V, and there seems to be an advantage in a low reference level. This is because a low reference level permits VR1 to be adjusted for a very low level of oscillation without the l.e.d. being activated, and a low level of oscillation seems to offer optimum sensitivity. In fact, making resistor R7 even lower in value might give improved sensitivity. Diode D3 is the l.e.d. indicator and it is driven from the output of IC1 by way of current limiting resistor R8.

The current consumption of the circuit under standby conditions is about 2.5 milliamps, but this increases to approximately 9 milliamps when the l.e.d. switches on. A small (PP3 size) battery is adequate as the power source and should provide many hours of operation.

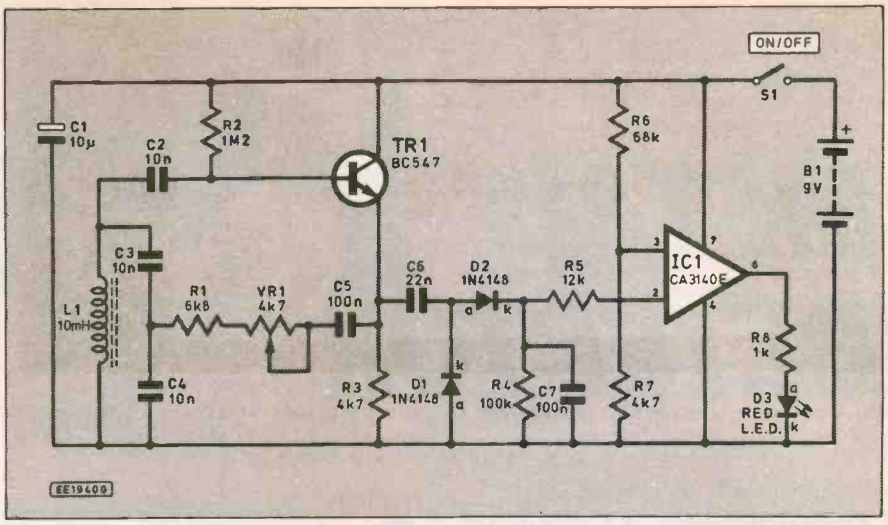


Fig. 2. Full circuit diagram for the Metal Detector.

CONSTRUCTION

The *Metal Detector* has been designed to be constructed with the BICC Vero Easiwire system using the *Free* Circuit Card attached to the front of this issue. It could, of course, be built on plain matrix board.

Details of the component layout and underside wiring of the board are given in Fig. 3. Please read the details on *Using Your Circuit Cards,* on page 300, before you begin construction.

As IC1 is a MOS input device, the use of an i.c. socket is recommended. Leave the i.c. in its anti-static package until the unit is in all other respects finished, and try to handle this component as little as possible when fitting it into its holder.

Make sure you fit IC1 the right way round, and be equally careful with the other semiconductors and capacitor C1. Any 10mH choke should be suitable for L1, but as maximum sensitivity is end-on to

COMPONENTS

Shop Talk see page 314

Resistors
R1 6k8
R2 1M2
R3, R7 4k7 (2 off)
R4 100k
R5 12k
R6 68k
R8 1k
All 0.25W 5% carbon

Potentionmeter
VR1 4k7 rotary carbon lin.

Capacitors
C1 10µ radial elec. 25V
C2, C3
C4 10n polyester 7.5mm pitch (3 off)
C5, C7 100n polyester 7.5mm pitch (2 off)
C6 22n polyester 7.5mm pitch

Semiconductors
D1, D2 1N4148 signal diode (2 off)
D3 Red panel mounting l.e.d.
TR1 BC547 silicon *npn*
IC1 CA3140E MOS op. amp

Miscellaneous
L1 10mH radial choke
S1 s.p.s.t. sub-min. toggle
B1 9 volt (PP3 size) battery
Case; battery connector; Free EE Circuit Card or Easiwire board; control knob; 8-pin d.i.l. i.c. holder; wire, etc.

Approx. cost Guidance only **£6**

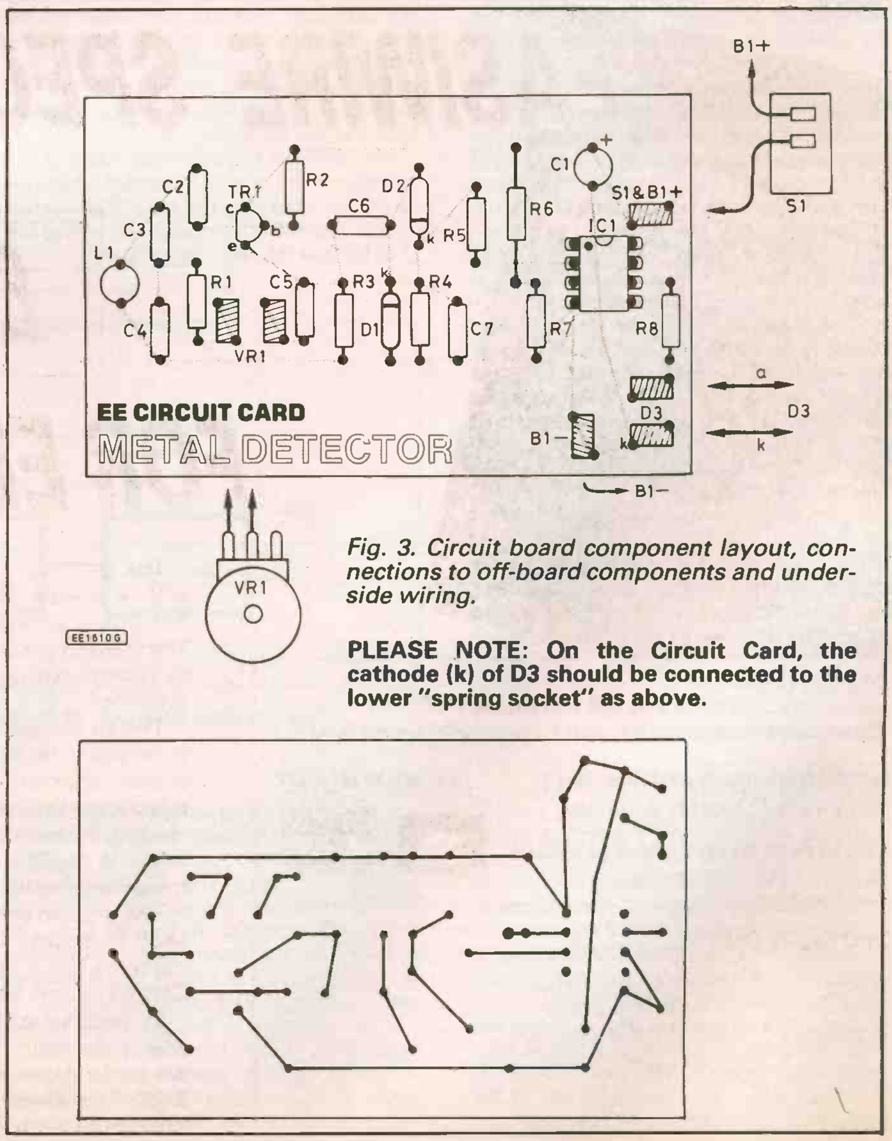
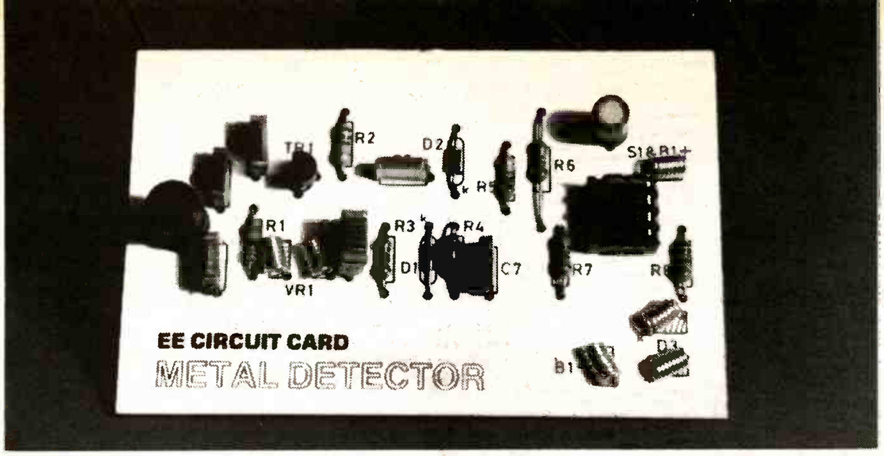


Fig. 3. Circuit board component layout, connections to off-board components and underside wiring.

PLEASE NOTE: On the Circuit Card, the cathode (k) of D3 should be connected to the lower "spring socket" as above.



this component, a radial lead type is most sutiable (e.g. the Cirkit 8RB type).

Once all the components have been fitted, check that there are no errors and then trim off the leadout wires so that only about four millimetres of each one protrudes on the underside of the board. The wiring is then added using the Easiwire "pen". This is largely straightforward, but there is one awkward wire which passes between IC1's two rows of pins and carries the negative supply rail to capacitor C1.

This branch must be added after the main negative supply wire has been fitted, and it is advisable to use some Easiwire backing material or a piece of insulation tape to fix it in position. Carefully route it away from the several connection points it comes close to, but which it must NOT be allowed to touch.

CASE

The case for this project must be plastic (or some other non-metallic substance) as a metal case would screen the search coil and prevent the unit from functioning. The board must be mounted on long mounting bolts with spacers used to bring coil L1 right up against the front panel.

Having L1 well back from the front panel would effectively reduce the range of the unit. You could even drill a hole for it in the front panel so that its top surface could be brought flush with the front panel.

Diode D3 must be mounted on the rear panel so that it is visible with the front panel placed against a wall. The cathode ('k") terminal of a l.e.d. is normally indicated by a shorter leadout wire.

Switch S1 and potentiometer VR1 must not be mounted on the front panel as they would prevent the panel from being placed close against walls. Again, the rear panel is probably the best position for these. There is no need to go to great lengths to keep all metal well away from coil L1 as VR1 can be adjusted to compensate for a certain amount of metal close to L1.

IN USE

After a final check of the wiring, switch on and try adjusting potentiometer VR1. The l.e.d. should switch on with the control fully advanced, but should switch off if it is backed off somewhat.

Optimum sensitivity is obtained with the "feedback" or sensitivity control VR1 backed off just far enough to extinguish the l.e.d., and for really good sensitivity VR1 must be adjusted very carefully. If you try placing a small piece of metal near L1, such as the blade of a screwdriver, it should be readily detected.

The prototype readily detected screws, pipes, and cables in the walls of my house, as well as some unexpected pieces of metal such as reinforcing over some doors. □

FOR YOUR ENTERTAINMENT

BY BARRY FOX

No Thanksgiving

This is not a funny story. The BBC's local radio station in London, *Radio London,* recently changed its name to *GLR,* changed all its presenters and completely changed its style of broadcasting.

There was a lot wrong with Radio London, mainly caused by lack of money. Many people did programmes either free or for a pittance. GLR seems to have far more money to spend, which obviously gives them confidence.

On a recent TV programme, which gave an insight into how the BBC spends its licence revenue, we saw the people at GLR brushing aside criticism. By chance this followed a bizarre incident.

On Christmas morning I was tuned to GLR and could hardly believe my ears. The station broadcast a tape recording of a bogus call made to the Salvation Army, in response to an advert for volunteers.

The GLR presenter mocked the Salvation Army officer mercilessly, prattling on about being good about getting money out of people, being unable to play a musical instrument but wanting to be in the band, liking the idea of wearing a uniform, thinking it was an army of "salivationists", and finally being upset to find that it was a Christian, not a minority body. There was no qualifying follow-up and no mention of all the quiet work the SA do for London's homeless and luckless, while never ramming religion down anyone's throat.

I put a written question to GLR's Managing Editor, Mathew Bannister, hoping he would say it was all a ghastly mistake.

I heard nothing, so phoned. The Ed's secretary told me that, yes he had received my notes, but had been away for two weeks over Christmas and was now busy getting ready for a holiday.

A week later I had still heard nothing, so I put the same question to Broadcasting House. As if by magic GLR suddenly woke up, sending me a letter from the ME which had been back-dated a week. This claimed that the BBC had not intended to make fun of the SA.

But nowhere does the head man at new GLR say he has actually *listened* either to the broadcast or the tape log which all radio stations keep of everything they broadcast in case there are complaints about content.

The neatest irony of all is that on Christmas morning another BBC local radio, *Radio Oxford,* was doing an outside broadcast from the local prison with, guess who, the Salvation Army. The SA band spend their day playing carols for the prisoners.

Guesstimating

Logica made its name as a computer software company, grew, diversified and is now in the business of publishing market analysis reports.

One of their more recent reports, "*Satellite Television Receivers—the European Market*", runs to 350 pages and costs £695. The report contains some interesting predictions. But they are inevitably only guesstimates, and the way in which the guesses were estimated colours their value.

They forecast, for instance, that by the end of 1991, between 1.6 and 2.2 million homes in the UK will be receiving satellite television. But Logica goes on to say that over half these homes will be receiving their satellite programmes on some kind of community cable system with only 45 per cent of the couple of million viewers actually owning their own satellite television receiver.

One year later, the percentage of homes owning their own STRs will peak and then start to decline with cable distribution systems taking over.

As for dish/receivers sales, Logica asks the reader to guesstimate between its own maximum and minimum forecasts. For instance in the first year of satellite broadcasting, the trade can expect to sell only between 80,000 and 170,000 systems, with a cumulative total of between 690,000 and 1.3 million by mid 1991. Meanwhile cable connections (from which the electronics trade earns nothing) will grow from a current 300,000 to three quarters of a million. But so far only around 60,000 of these will be able to get all six *Sky* channels. The rest rely on cables which do not have enough bandwidth for the extra channels.

The trade's only hope is to cash in on a new market for cabling small groups of homes. But for that they will need to run the gauntlet of getting permission and licences for the Cable Authority.

The irony of all this is that the whole point of direct broadcasting by satellite is that spending money on a powerful transmitter in the sky makes it cheaper to receive at home on a small dish. If clusters of homes share large dishes, there is no point in having a powerful transmitter in the sky.

No Hard Facts

Logica admits it did not do any original *consumer* research in preparing the report, arguing that there is no point in asking the public hypothetical questions about new technology they know nothing about. So they took all available facts, looked at the VCR statistics, made some adjustments and plotted graphs.

The underlying problem is that the emerging satellite industry runs on lies. Hard facts are hard to come by. Logica has for instance believed what it was told by BSB about the squarial and the £250 all-in price tag, even though Ferguson has now broken ranks and quoted a more realistic £300.

Experience may prove Logica wrong to compare VCRs with STRs. One comes in a box and needs only to be switched on; the other needs to be fitted on a roof by a skilled engineer.

They do not attempt to predict how BSB will fare against Astra, but concludes that BSB has "two things going for it, an all-in-one kit and the squarial dish". But so far no-one has seen a working squarial.

Pay-Per-View

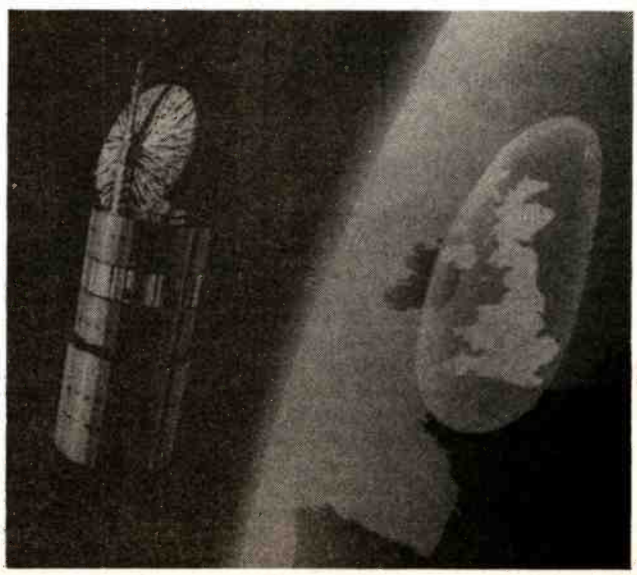
The plans for the BSB film channel have at last been unveiled. Between 1pm and 6pm each day this will be *Free;* old classics will be screened. Between 6pm and 3am, the *Movie Channel* will show more recent films, for subscription of £9.99 a month.

John Gau, Deputy Chief Executive, says the film channel is a "cracking package". BSB shareholders have now provided an extra £130 million to fund programming, mainly films. But the films promised, (*Lethal Weapon, Fatal Attraction, Crocodile Dundee II, Last Emperor, A Fish Called Wanda*) almost all have a guaranteed video hold-back of twelve months.

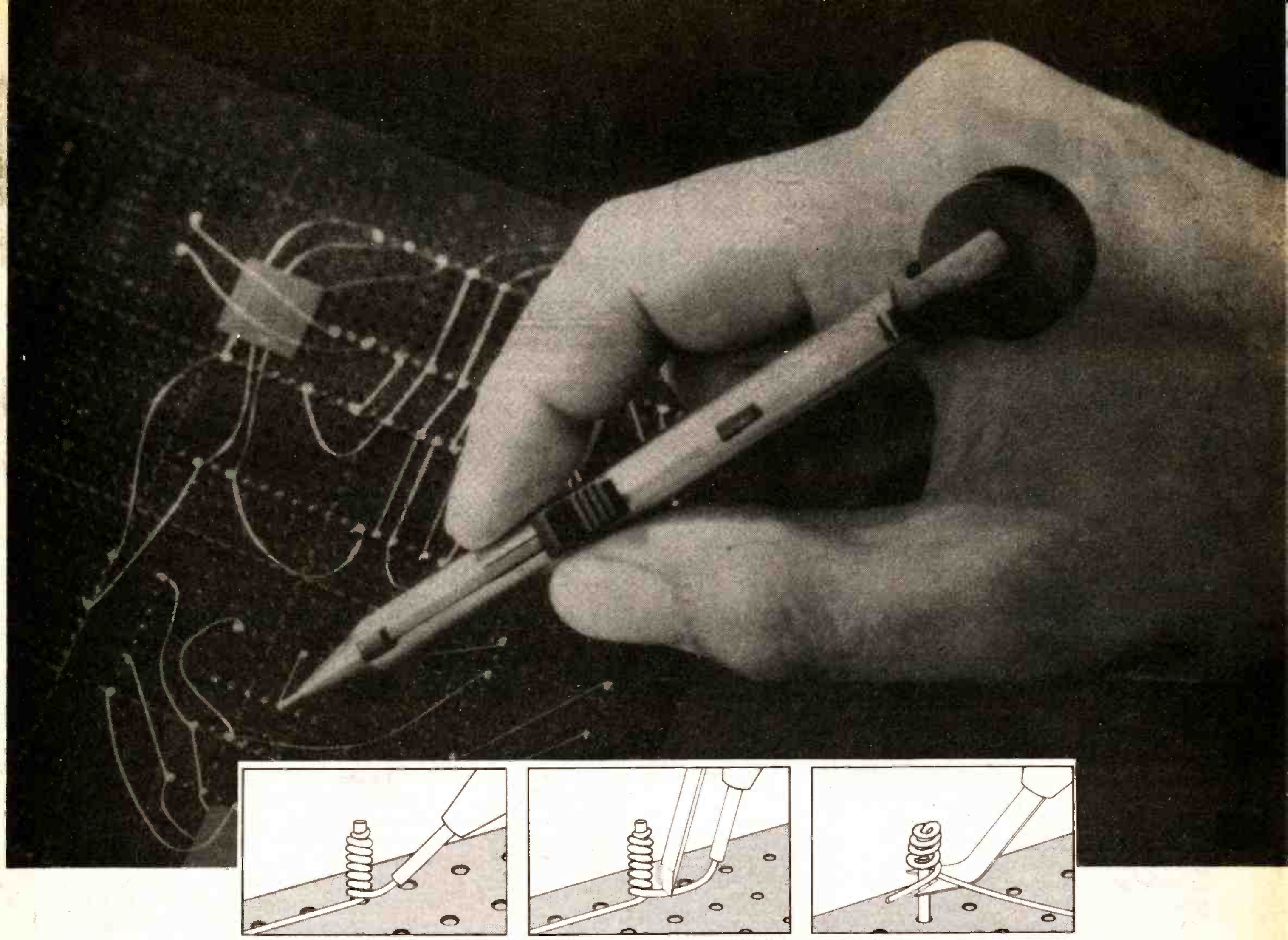
Only when quizzed on this, did BSB come clean. The company is planning to broadcast some programmes on "pay-per-view" basis with a high one-off fee charge for a special event. Initially these special events will be sport and music spectaculars, but BSB does not rule out the possibility of pay-per-view movies.

Says Anthony Simonds-Gooding, BSB's Chief Executive, "You know the scenario. You go out in the rain to rent a video, find they haven't got what you want and come back with something crutty. We are absolutely convinced that the convenience factor of movies by satellite will be very compelling. We believe the hold-back window will shrink to six months".

Sky has now made it clear that it sees movie rental as a competitor and target. It is only a question of time before the Sky and BSB are fighting the video industry as hard as each other.



Artist's impression showing the Hughes HS376 satellite due to be launched by a McDonnell-Douglas Delta rocket in August. This satellite will be operated by British Satellite Broadcasting and will compete directly with Astra for UK viewers.



City and Guilds

Certificate Course

Introducing DIGITAL ELECTRONICS

Part 8 Capacitors and Capacitance

By Michael J. Cockcroft
Training Manager, Peterborough ITeC

THE sheer number of different electronic components can make our subject daunting to the beginner. If we consider the complexity of some of these components while trying to understand the basic circuit principles we are going to get bogged down in confusing detail. This can be avoided by learning here and now that any electronic circuit or component only has one or more of three properties: they have **resistance, inductance, capacitance,** or a combination of these. A thorough understanding of these properties and bearing them in mind when analysing circuit actions will help to keep electronics simple.

Resistance we covered last month, inductance is part of next month's treatment, this month we deal with capacitance and satisfy some more City and Guilds objectives:

4.3 Capacitors

4.3.1 Explain, in very simple qualitative terms, the action of a capacitor.

4.3.2 Identify series and parallel modes of connection.

4.3.3 Describe the two most common applications of capacitors as d.c. blocking and smoothing.

4.3.4 Explain the importance of using capacitors of the correct voltage rating.

Electrostatics

Last month, although we didn't say it, we embarked on a basic law of **electrostatics.** Electrostatics is the science of electric charges at rest (static electricity) and is fundamental to the study of capacitors and capacitance. The first law of electrostatics is:

Like charges repel; unlike charges attract.

A force of attraction exists between two bodies of unequal charges and a force of repulsion exists between two bodies of equal charges, as shown last month in Fig. 7.3. This principle can be demonstrated by a simple experiment which produces static electricity: if a balloon is rubbed on woollen clothing (or your hair—especially after it has recently been washed) and touched to a wall, the balloon will attach itself to the wall. This is an example of creating electricity by applying friction energy.

Electrons are dislodged from one material and attached to the other, giving one body (the balloon or the wool) a positive charge and the other a negative charge. The wall is neutral (like all matter under natural conditions i.e. not under the influence of an external energy) so there is a force of attraction between the two unlike bodies.

This *force* is called an **electric field;** the balloon, for example, acquired a field of force around it (the lines of force will, of course, be concentrated around the area of the balloon that was rubbed) after it had been charged by friction. The greater this charge on the balloon, the greater the electric field around it; also, the electric field will disappear when the body loses its charge (when it is in its normal neutral state).

An electric field exists between any two different voltages. The direction of force in an electric field depends on the polarity of the charged body. The direction is away from negative charges and towards positive charges, as shown in Fig. 8.1a. When two unlike charges are acting upon each other (when they are close enough together, as in Fig. 8.1b) the negative charge moves towards the positive charge.

With this in mind, consider the simple circuit of Fig. 8.2 (the "load" resis-

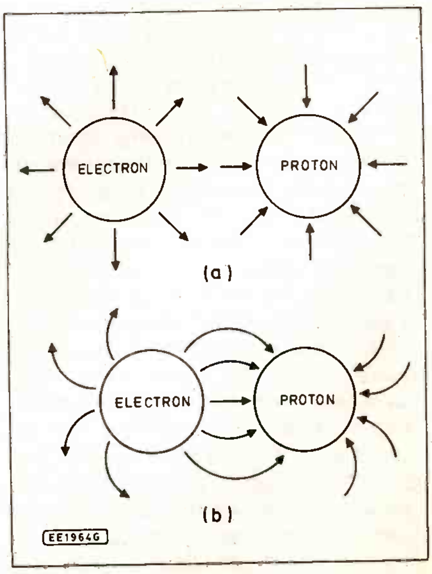


Fig. 8.1. The electric field.

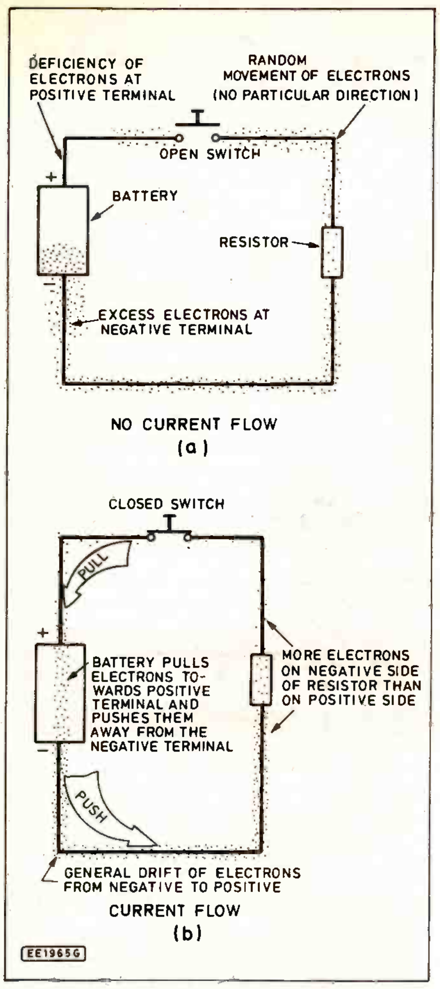


Fig. 8.2. Electrons in a simple circuit.

tor represents any component or components as an equivalent resistance). When the switch is open there is no current flow but the battery is charged (the chemicals inside the battery force an accumulation of electrons at one terminal with respect to the other terminal—we call the force acting to convert chemical energy into electrical energy [voltage] an **electromotive force** or e.m.f.).

When the switch is closed the electric field causes electrons in the wire to move away from the negative terminal (where they are repelled by the excess electrons) of the battery, through the component/s, and back to the positive terminal (where they are forced by a chemical action [electromotive force] back to the negative terminal inside the battery). This movement is repeated again and again around the circuit the whole time that there is enough charge in the battery.

So *current flows from negative to positive;* but be aware that early scientists, from the results of experiments and before a true theory could be formulated, thought that current moved in the opposite direction. We call the early theory, that current flows from positive to negative, **conventional current** and many authors of electronic texts still use it today.

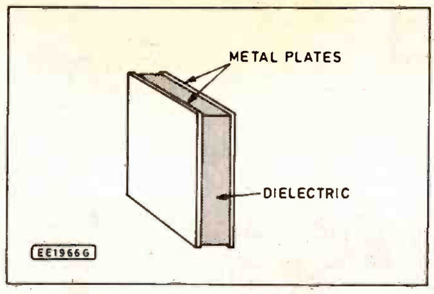


Fig. 8.3. Basic capacitor.

Capacitors and Capacitance

Capacitance exists between any two conductors in close proximity and it is the property of a circuit that causes an electric charge to be stored. Components manufactured to specific values of capacitance are called capacitors.

Capacitors

Capacitors fall into two main groups, the "polarised" capacitor and the "non-polarised" capacitor. Electrolytic and tantalum capacitors are polarised and the correct polarity must be applied to their terminals. If a voltage is applied to the capacitor in the reverse direction the internal insulating layer, which we will talk about in a moment, will break down and short circuit the capacitor. The result will be damage to the capacitor and possibly other components in the circuit.

All polarised capacitors are clearly marked "+" and "−" on the body of the device and care must be taken that these polarities are observed when constructing circuits. Electrolytics, in particular, may explode if connected in reverse polarity to a sufficiently high voltage.

Non-polarised capacitors can be freely placed either way round into a circuit. All capacitors, however, have a maximum voltage rating; they are usually marked with their working voltages and this voltage should never be exceeded, as stated in Part 2.

A capacitor consists of a thin strip of insulating material, known as the **dielectric**, sandwiched between two metal plates, as shown in Fig. 8.3. The dielectric describes the capacitor type and is often paper, air, mica, polyester or ceramic.

All capacitors have (at least) two plates and a dielectric layer. The use of a variety of dielectrics and the employment of different construction processes yield an assortment of capacitor shapes and sizes (see Table 2.5—Part 2).

High values of capacitance, in a compact form, can be achieved by rolling or stacking strips of metal foil and dielectric material, as shown in Fig. 8.4. Sometimes the dielectric is a paste or liquid instead of a solid; electrolyte, in the electrolytic capacitor, for example, is a paste. Table 8.1 gives a small selection of typical capacitors with relevant comments about each (refer to Part 2 for more information including value colour coding).

Variable capacitors are also available. The dielectric in these capacitors is usually air because it is convenient to vary capacitance in variable capacitors by mechanically adjusting the distance between their plates (or the amount of overlap of the plates). The distance between the plates (which is the thickness of the dielectric) is only one of three factors that determine the capacitance of capacitors.

Capacitance of Capacitors

The capacitance value of a capacitor determines the amount of charge it is capable of storing; this

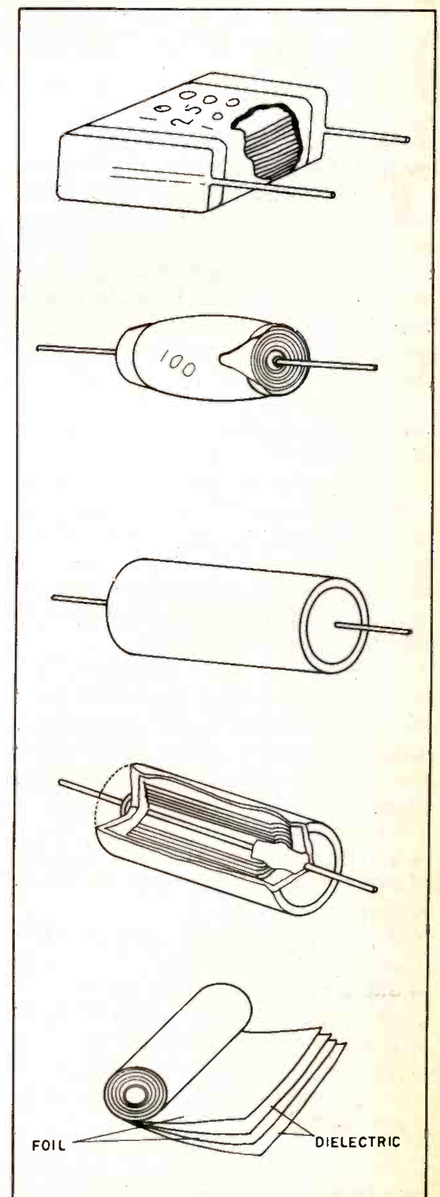


Fig. 8.4. Construction of capacitors.

TABLE 8.1

Type	Identification	Common Range of Values	Common Working Voltage ratings	Polarised?	Comments
Electrolytic		$1\mu F-10,000\mu F$	10–450	Yes	Used where large values of capacitance are needed and losses *are unimportant. Often used for smoothing (see text)
Tantalum		$100nF-100\mu F$	6–35	Yes	General purpose. Often used in timing circuits
Mica (silvered)		2pF–10nF	350	No	Used in precision (low loss) circuits (TV and radio tuners etc)
Polystyrene		10pF–10nF	Up to 500	No	Very low losses (better than mica) but more bulky
Ceramic		10pF–100nF	1000V d.c. 300V a.c.	No	Very suitable for noise suppression in digital circuits

*A proportion of the energy supplied to a capacitor is lost in the dielectric. This is true for all capacitors but the amount of loss varies with the dielectric material.

depends on the following characteristics of the device:

(a) The area of the plates.
(b) The thickness of the dielectric.
(c) The material used for the dielectric.

Plate Area

The value of a capacitor determines the amount of charge it is capable of holding. The amount of charge it will hold is directly proportional to the area of its plates; this stands to reason since a larger plate area holds more electrons. Fig. 8.5a shows that, for two capacitors with the same dielectric material and distance between the plates, the one with the larger plates has the greater capacitance.

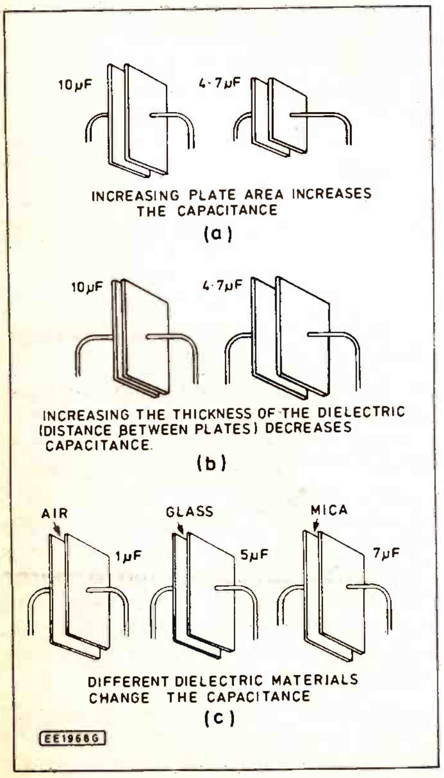


Fig. 8.5. Variation of capacitance with dimensions of a capacitor.

Dielectric Thickness

The strength of the electric field between the plates depends on the distance between them, the closer the plates are together the greater the intensity of the field. The distance between the plates is, of course, a function of the thickness of the dielectric. Fig. 8.5b shows that, for two capacitors with the same dielectric material and plate area, the one with the plates nearest to each other has the greater capacitance.

The thickness of the dielectric is also important in determining the working voltage of the capacitor; the thicker it is, the greater the voltage needed to destroy it.

Dielectric Material

Dielectrics are of materials that can sustain strong electric fields without breaking down. A measure of this strength is termed the **dielectric constant**. The greater the dielectric constant, the better the dielectric.

Dry air has a dielectric constant of 1, glass about 5, and mica about 7. The higher the dielectric constant for the same plate area, the greater the capacitance; for example, a $1\mu F$ air capacitor would become $7\mu F$ if a mica dielectric was placed between its plates, and $5\mu F$ for a glass dielectric.

Fig. 8.5c shows that, for three capacitors with the same dielectric thickness and plate area, the values vary according to the dielectric constants of the different dielectric materials.

Unit of Capacitance

A capacitor holds (stores) electric charge, rather like a bucket holds water. The amount of charge it stores depends on the capacitance value (in farads) of the capacitor and the size of the voltage used to charge it. Charge (symbol Q) is a quantity of electricity, the elementary particles of which are protons and electrons. Since the charge on an electron (or proton) is

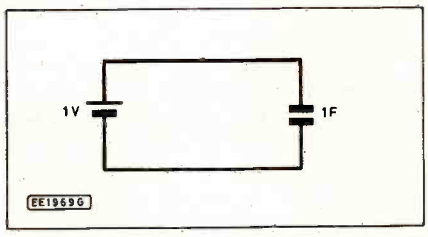


Fig. 8.6. Charging a capacitor.

very small, charge is measured in **coulombs** (symbol C); one coulomb is equal to 6.29×10^{18} electrons.

A capacitor is "charged" by connecting it to a voltage source, as shown in Fig. 8.6. The amount of charge acquired by the capacitor can be defined as follows:

A capacitor has a capacitance of one farad if a charge of one coulomb raises the potential difference by one volt.

This means that for a one farad capacitor connected to a one volt d.c. source, as shown in Fig. 8.6, the capacitor will acquire a charge of one coulomb (i,e, 6,290,000,000,000,000,000 more electrons on one plate than on the other plate). So, for any given capacitor:

$$\text{Capacitance}=\frac{\text{Charge}}{\text{Voltage}} \quad \text{i.e. } C=\frac{Q}{V}$$

Illustrative Example

What is the charge on a 100μ capacitor connected across a supply of 10V d.c.?

$$C=\frac{Q}{V} \quad CV=\frac{QV}{V}$$

$$Q=CV=10\times100\times10^{-6}$$
$$=1000\times10^{-6}=1\times10^{-3}$$

Therefore Charge (Q)=1mC (one milli-coulomb)
(Refer to Part 2 for scientific notation)

Capacitors in Parallel

Total capacitance in a circuit containing capacitors in parallel is the

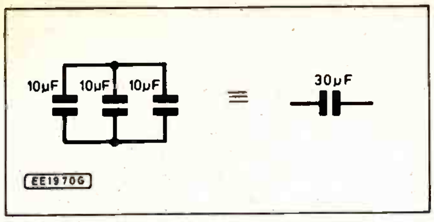


Fig. 8.7. Capacitors in parallel.

sum of all the individual capacitors:

$$C_t=C_1+C_2+C_3 \ldots +C_n$$

This is easy to understand because adding capacitors is the same as increasing the plate area and, as we have just seen, an increase in plate area increases the value of the capacitor. Fig. 8.7 demonstrates that adding three 10μ capacitors connected in parallel produces an equivalent 30μ capacitance.

Care should be taken, when increasing a particular value of capacitance by connecting capacitors in parallel, not to reduce the working voltage of the combination below the required value. The working voltage of the combination will be the rating of the capacitor having the lowest working voltage; for example, a 47μ capacitor with a working voltage of 6.3 volts and a 10μ capacitor with a working voltage of 100 volts connected in parallel have a maximum working voltage of 6.3 volts for the combination.

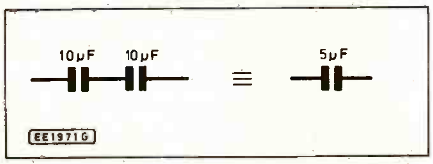


Fig. 8.8. Capacitors in series.

Capacitors in Series

Connecting capacitors in *series* reduces the total capacitance in the same way that connecting resistors in *parallel* reduces the total resistance (Fig. 8.8). So the formula for calculating the equivalent capacitance of series capacitors is similar to the formula for finding the equivalent resistance of parallel resistors:

$$C_t=\frac{1}{1/C_1+1/C_2+1/C_3 \ldots +1/C_n}$$

The expression can be simplified by using the "product over the sum" process when there are only two capacitors:

$$C_t=\frac{C_1 \times C_2}{C_1+C_2}$$

The maximum working voltage for a combination of series connected capacitors will be greater than any one of the voltage ratings of the individual capacitors; for example, for a couple of 10μ capacitors each with a 10 volt working voltage rating (connected in series to make an equivalent 5μ capacitor), the equivalent safe working voltage for the combination will be 20 volts.

Capacitors and D.C.

When a capacitor is first connected to a d.c. power supply, current flows in the circuit until the capacitor is fully charged (it is fully charged when the voltage across the plates is equal to the supply voltage) and then current stops. The fact that current flows at all may be a bit of a surprise; after all, the capacitor sits in the circuit rather like an open switch, particularly if the dielectric of the capacitor is air.

Actually, open switch contacts do act like a capacitor but the distance between the contacts is so great (remember?–the closer the capacitor plates are to each other, the greater the capacitance) the capacitance is negligable.

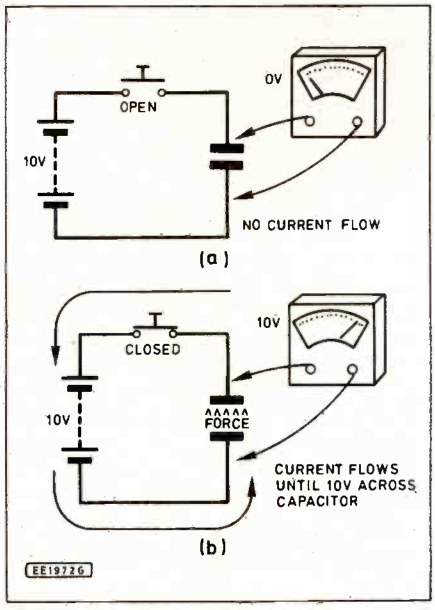


Fig. 8.9. Voltage across a capacitor.

Consider the diagram of Fig. 8.9a. While the switch is open there is no voltage across the plates of the capacitor. When the switch is closed current flows, rapidly at first, in the direction of the arrows shown in Fig. 8.9b; current continues to flow, but diminishing all the time, until the capacitor is charged to the same level as the battery when current stops. How long it takes for the capacitor to charge is a period of time which is determined by the value of the capacitor and the resistance in the circuit (in this case, the resistance of the battery, connecting wires and component leads); we will come to this a little later.

Current flows because electrons from the top capacitor plate are attracted to the positive terminal of the battery (unlike charges attract), pushed towards the negative terminal inside the battery (by electromotive force), and repelled from the negative terminal to the bottom plate of the capacitor (like charges repel). An excess of electrons then exists on the bottom plate and a deficiency on the top plate, giving a potential difference equal to the supply voltage across the two plates as the current ceases to flow.

The electrons belonging to the top capacitor plate are now on the bottom plate and they cannot return whence they came because of the insulating properties of the dielectric. An electrostatic field with a force equal to the supply voltage is now acting inside the capacitor; Fig. 8.10 shows how the unlike charges of the protons and electrons from the two plates line up in the electrostatic field, attempting to move together to equalise the charges. This force field remains even when the switch is opened or the capacitor is removed from the circuit; hence the capacitor is referred to as a storage device.

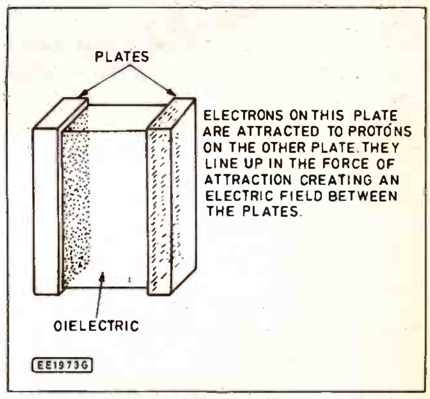


Fig. 8.10. Electrons in a charged capacitor.

The capacitor can be discharged by providing a conductive path between the two plates, as shown in Fig. 8.11, allowing the excess electrons to bypass the dielectric and return to the plate from which they originally came. Fig. 8.12 shows a s.p.d.t. switch configured to charge the capacitor, through a resistor, in one position and discharge it, again through the resistor, in the other position.

In this circuit the capacitor charges or discharges, depending on the switch position, through the same resistance–the value of R–(the resistance in the battery and the wires is so small it can be

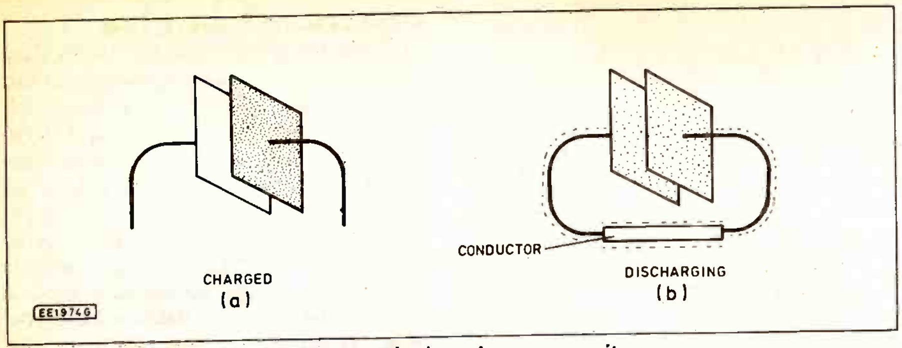


Fig. 8.11. Discharging a capacitor.

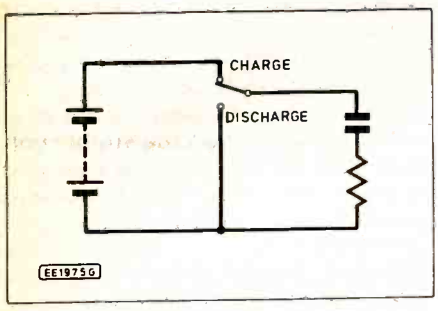


Fig. 8.12. Circuit to charge and discharge a capacitor.

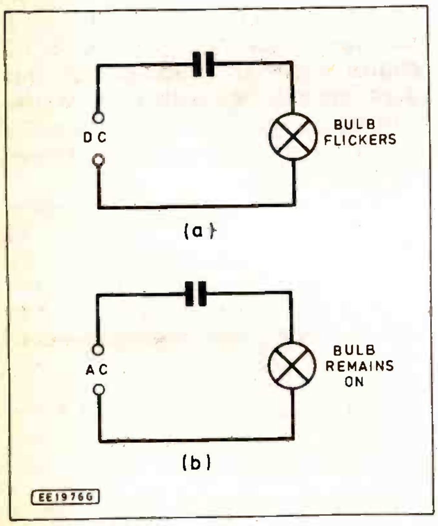


Fig. 8.13. Capacitors in d.c. and a.c. circuits.

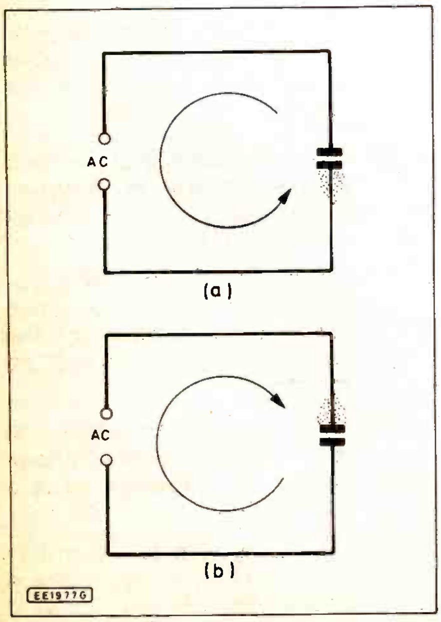


Fig. 8.14. Electrons in an a.c. circuit.

ignored) so the time taken for both charge and discharge is the same.

Capacitors and A.C.

When a d.c. voltage is applied to the circuit of Fig. 8.13a, the bulb just flickers as a result of the transient current. When an a.c. voltage is applied to the same circuit (Fig. 8.13b), however, the bulb will remain illuminated. Alternating current flows continuously in an a.c. circuit. It is important to realise, though, that current does *not* flow *through* the capacitor–it cannot because of the dielectric between the plates.

In fact, as illustrated in Fig. 8.14, current flows into the capacitor (to charge it–electrons accumulate on one plate) during one half cycle and out of the capacitor (to discharge it) then into the capacitor to charge it in the opposite direction, (electrons accumulate on the other plate) during the other half cycle. It does this repeatedly for as long as the a.c. supply is present.

The capacitor is first charged positively and then discharged to zero volts, then it is charged negatively followed by being discharged back to zero again. So, as Fig. 8.14 shows, electrons repeatedly flow back and forth in a continuous cycle of the capacitor trying to first charge in one direction and then in the other.

Phase

But the current flow does not change in step with the voltage (we say current and voltage are out of phase in a capacitor circuit), as illustrated in the graph of Fig. 8.15. At the instant a.c. is applied, the voltage starts to rise in the positive direction. As the supply voltage increases, the capacitor charges, the voltage across it gets closer to the supply voltage and current decreases accordingly. At time t_1 the capacitor is charged to the maximum value and current is zero.

As the supply voltage decreases the capacitor discharges and, at time t_2, the power supply voltage is zero and current has taken a maximum negative value. The current continues to flow but diminishes as the voltage builds up in the negative direction. When the supply voltage has reached its maximum in the negative direction (at t_3) the capacitor has again become fully charged and current has dropped to zero. It can be seen from the graph that current is a quarter of a cycle (90°) ahead of the supply voltage.

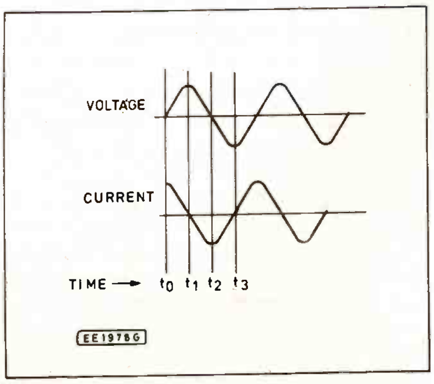


Fig. 8.15. Voltage and current in Fig. 8.14 circuit.

CR Time Constant

The time taken for capacitors to either charge or discharge through a resistance is measured in terms of *capacitance-resistance time constants* (usually abbreviated to CR time constants). The CR time constant is the time taken to charge any value capacitor to a voltage equal to 63.2 per cent of the final fully charged voltage or discharge a capacitor to 36.8 per cent of the original fully charged voltage. The time constant (T) of a CR circuit is calculated as follows:

$$T = C \times R$$

A capacitor charges to 63.2 per cent of its final value in one CR time constant so, for example, a 10μ capacitor charged through a 10k resistor from a 10 volt source would have 6.32 volts $((63.2 \times 10)/100 = 6.32)$ across its plates 100 milli-seconds $(10^{-5} \times 10^{4} = 10^{-1} = 0.1$ sec$=100$ms$)$ after power was applied to the circuit. For the same CR circuit, the same time constant (100ms) applies for discharging the capacitor to 3.68 volts. Capacitor charge and discharge times are shown graphically, in terms of CR time constants and voltage, in Fig. 8.16.

It can be seen from these graphs that it takes about five CR time constants to completely charge or discharge a capacitor; we have to decide on a voltage very close to the supply because theoretically, as shown by the graphs, the capacitor never quite completes the charging or discharging process. We say, as a rule of thumb, that it takes five CR time constants to complete the process.

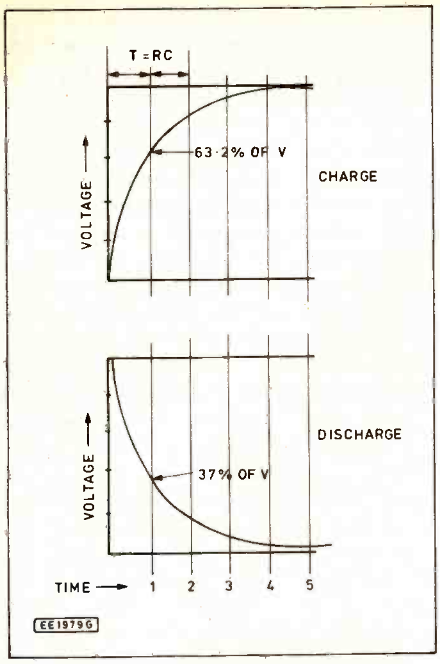


Fig. 8.16. CR charge and discharge graphs.

The subject of the time constant equation can be changed to determine the value of either the resistor or capacitor for the required time constant:

$$R=\frac{T}{C} \text{ and } C=\frac{T}{R}$$

Illustrative example

What capacitor must be used with a 500 ohm resistor for a 50ms time constant?

$$C=\frac{T}{R}=\frac{50\times10^{-3}}{500}=0.1\times10^{-3} \text{ or } 100\mu$$

What resistor must be used with a 10n capacitor for 100μs time constant?

$$R=\frac{T}{C}=\frac{100\times10^{-6}}{10\times10^{-9}}=10\times10^{3} \text{ or } 10\text{k}$$

We have looked, above, at how the capacitor works with respect to current flow in the process of storing a charge, and at the charge and discharge of capacitors in time constants. Now let us look a little closer at what happens with respect to current and voltage in a CR circuit. Fig. 8.17 shows a capacitor and resistor connected in series across a battery supply via a s.p.s.t. switch.

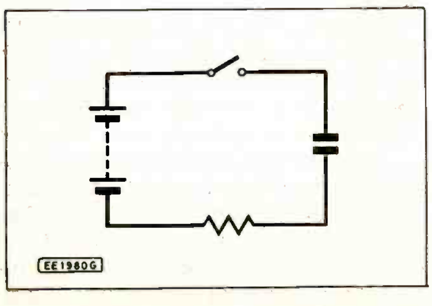


Fig. 8.17. Simple test circuit.

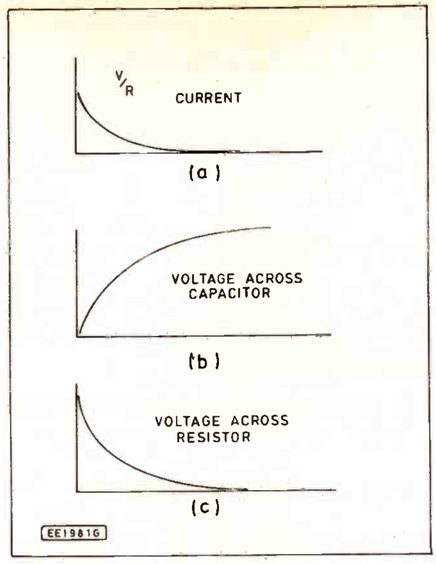


Fig. 8.18. Graphs obtained from circuit of Fig. 8.17.

The capacitor is initially uncharged with zero volts across its plates.

If we measured the voltage across the resistor and the current through it, and the voltage across the capacitor at regular intervals throughout the time that the transient current flows (i.e. the time it takes for the capacitor to charge up), the whole picture may be represented by the three graphs of Fig. 8.18. Current would vary throughout the transient period as shown in Fig. 8.18a: at the instant the switch is closed the current will be at its maximum value (V/R) and then fall quickly over the period to zero as the capacitor becomes charged.

The voltage across the capacitor starts at zero (at the instant the switch is closed), as Fig. 8.18b shows, and quickly increases as the current in the circuit diminishes. Now, you will recall from last month, *all* the applied voltage in a circuit is divided proportionally between the component parts of the circuit; hence, as the voltage across the capacitor increases, the voltage across the resistor falls, as shown in Fig. 8.18c.

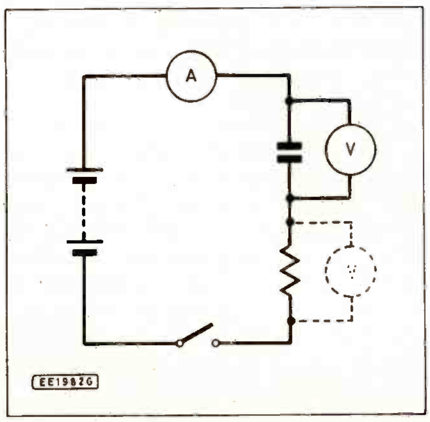


Fig. 8.19. Circuit for the practical exercise.

Practical Exercise

These findings may be verified by means of a practical exercise using two meters, a clock or wrist-watch with a second counter/hand, and the circuit of Fig. 8.19. Use any combination of resistor and capacitor that gives a CR time constant equal to or greater than 10 seconds (you will need either a very large resistor or a very large capacitor) and a power supply that does not exceed the capacitor voltage rating or the resistor power rating ($P=V^2/R$—at one point, although only for a short time as shown in the graph of Fig. 8.18c, the voltage across the resistor is the entire source voltage).

Adjust the voltmeter range to a setting greater than the supply voltage and the ammeter to a setting greater than the supply voltage divided by the resistor in your circuit (I=V/R). Place the two meters in the circuit as shown in the diagram.

Create a table in which to chart the voltage across the capacitor, the voltage across the resistor, and the current in the circuit at every CR time constant interval for five time constants; for example, Table 8.2 charts a set of readings for this practical exercise with a circuit containing a one megohm resistor and a ten microfarad capacitor driven by thirty volts.

When you have charted the values for various circuits, plot graphs from the readings and compare the shapes between the different circuits and to those of Fig. 8.18. Then ask yourself these questions about the CR circuits:

(a) How does the value of resistor affect the rate at which a particular capacitor charges.

(b) How does varying the value of the capacitor affect the rate at which it charges when the resistor value is constant.

(c) What percentage of the total supply voltage is dropped across the capacitor in the first CR time constant.

(d) What percentage of the total supply voltage is dropped across the resistor in the first CR time constant.

(e) What is the relationship between the voltage dropped across the capacitor and the voltage dropped across the resistor.

(f) What happens to current in the circuit when the voltage across the capacitor is at a maximum.

(g) What happens to current in the circuit when the voltage across the resistor is at a maximum.

TABLE 8.2

		CR TIME CONSTANTS 1st	2nd	3rd	4th	5th
Time (seconds)	0	10	20	30	40	50
Current (microamps)	30	11	6	2	1	Almost zero
Voltage across capacitor	0	19	26	28	29	Almost 30
Voltage across resistor	30	11	6	2	1	Almost zero

V=30V: C=10μF: R=1MΩ: CR=10 sec:

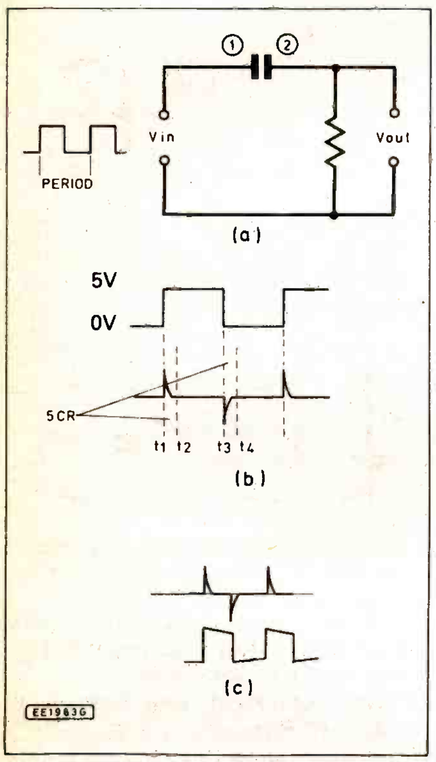


Fig. 8.20. Response of the circuit to a square wave.

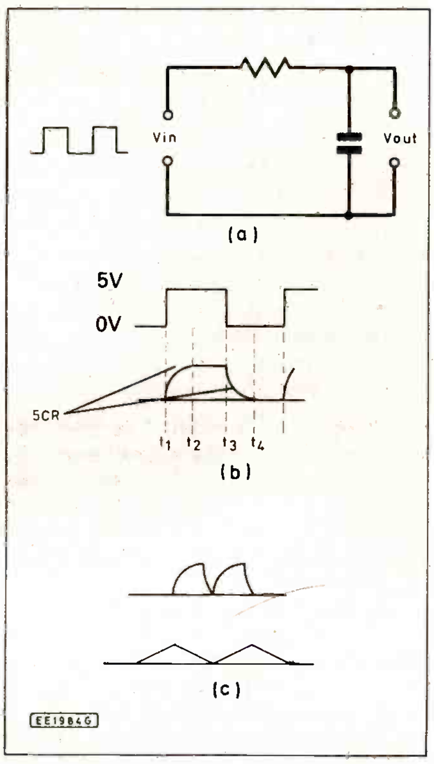


Fig. 8.21. Response of the circuit to a square wave.

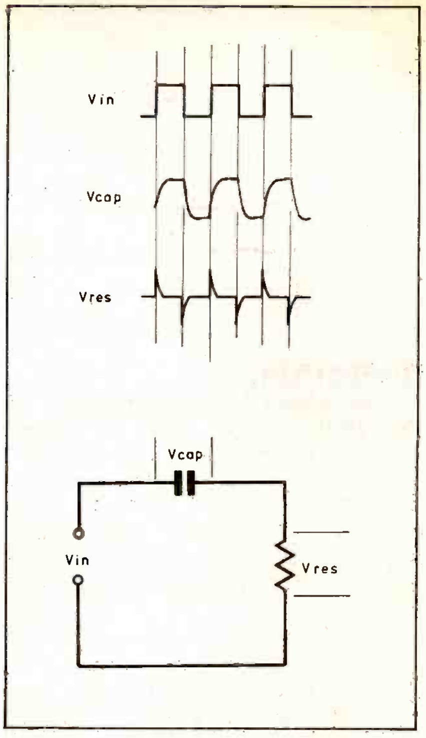


Fig. 8.22. Voltage graphs in a simple circuit.

CR Response to Digital Signals

Now that we have the concept of the CR time constant under our belts, we can look at the transient response of CR circuits to signals which are more likely to appear in digital circuits. We will analyse the response of the circuits in Figs. 8.20 and 8.21 to the input of a square wave.

Applying a square wave to the input of the circuit (a) in Fig. 8.20 produces an output looking like the graph in (b). When the input goes to +5 volts at time t_1, plate 2 of the capacitor also goes to +5 volts (current is at its maximum so all the source voltage must be across the resistor): it takes 5×C×R to charge up—in the charged state plate 1 of the capacitor would be at +5 volts and plate 2 at 0 volts.

By the time five time constants have passed (at t_2) the capacitor is charged and plate 2 becomes zero volts; it remains at zero volts until the square wave changes to zero volts at t_3 when the voltage at plate 2 goes negative (to −5 volts!, why? Because at the time immediately before t_3 the capacitor was fully charged, it takes time for it to discharge so 5 volts worth of negative charge piles onto plate 2 at the instant t_3). It discharges five time constants later (t_4). And so on at each transition from 0 volts to 5 volts and back again.

The waveforms in Fig. 8.20c show how the value of the CR time constant compared to the period of the input waveform change the shape of the output. The shorter the CR time is, compared to the period of the input, the more spikey will be the output. For CR times much greater than the period of the input, the shape of the output closely resembles the shape of the input.

Applying the same square wave to the input of the circuit in Fig. 8.21 (where, compared to Fig. 8.20 the positions of the resistor and capacitor have been reversed) produces an output looking like that in (b) of the same figure. At time t_1 the capacitor starts to charge through the resistor, taking five time constants to reach 5 volts (at t_2). The capacitor remains charged until t_3 when the input changes from 5 volts to 0 volts; from this time it takes five time constants to discharge back to zero at t_4. And so on at each transition from 0 volts to 5 volts and back again.

The wave shapes for time constants greater than and shorter than the period of the input waveform are shown in Fig. 8.21c. When CR is shorter than the period of the input waveform, the output is a rounded triangle waveform. When CR is very great compared to the period of the input signal, the output quite closely resembles a d.c. level.

We separated the circuits, Fig. 8.20a and Fig. 8.21a, to illustrate the way in which CR arrangements appear in circuit diagrams, but it is important for you to see that the two circuits are more alike than different. The difference between the two arrangements is from where in the circuit the output is taken, from across the resistor or from across the capacitor. Fig. 8.22 clarifies this by showing both arrangements from the same circuit.

It can be seen from the foregoing examination that the ability of such circuits to change the shape of the signal can be used to great advantage in some applications. An application of particular interest to us, in this course, is that of "smoothing".

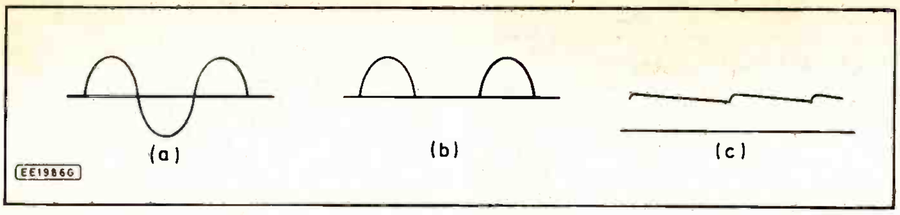


Fig. 8.23. Smoothing action.

Smoothing

Smoothing is an application of the above ideas used in mains derived d.c. power supply circuits. The smoothing capacitor is used in the process of converting a.c. into d.c. We do not go into detail here but the stages involved in a simple a.c. to d.c. conversion are outlined in Fig. 8.23.

First the negative half cycle of the a.c. signal (a) has to be removed to produce a signal like that in (b). This is a pulsating d.c. and not *smooth* enough for most applications. The easiest way of smoothing out the pulses is by feeding the signal into a capacitor (as shown in Fig. 8.24) to produce a d.c. output something like that in Fig. 8.23c. This d.c. voltage still fluctuates but it is acceptable for many applications.

The smoothing capacitor works by holding the charge (or only discharging a little) between one input pulse and the next, as illustrated in Fig. 8.25. The larger the capacitor, the longer it holds the charge and the smoother the d.c. signal becomes.

Blocking

Another application relevant to our immediate City and Guilds objectives is "blocking". Blocking is used in applications where a.c. and d.c. voltages are both present in the same circuit. An amplifier, for example, has both types of voltage and often requires just the a.c. signal to be amplified; the d.c. voltage must be *blocked.*

The circuit of Fig. 8.26 shows how d.c. blocking is done. With the switch open, and after the transient current period (5CR), there is no voltage across the resistor. Applying an a.c. signal, by closing the switch, puts an a.c. signal across the resistor. Exchanging the resistor in this circuit for an amplifier would allow the a.c. to be amplified without being affected by the 10 volts d.c.

Reactance

Before we leave the subject of capacitors and capacitance we should mention a property called *reactance.* Reactance is a sort of resistance that only affects capacitive (and inductive) a.c. circuits; for example, replacing the capacitor in the circuit of Fig. 8.13b by a wire link would cause the bulb to get brighter—this means that more current would flow so the capacitor must have a resistance to a.c.

Reactance, unlike resistance, is not a constant—it changes with the frequency of the a.c. Reactance is lower for high frequency signals than it is for low frequency signals; doubling the frequency halves the reactance. The equation for capacitive reactance (Xc measured in ohms) is as follows:

$$Xc = \frac{1}{2 \times \pi \times f \times C}$$

In which π is 3.1416, f is the frequency (in Hz) of the signal and C is the capacitance (in Farads) in the circuit.

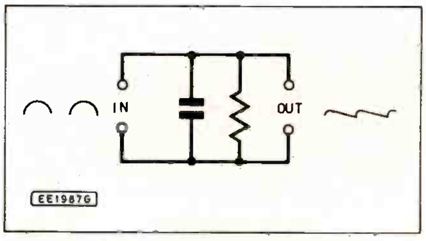


Fig. 8.24. Smoothing circuit.

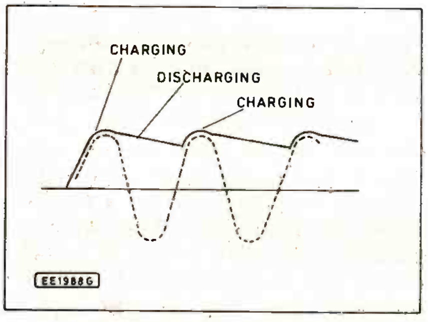


Fig. 8.25. Illustration of smoothing.

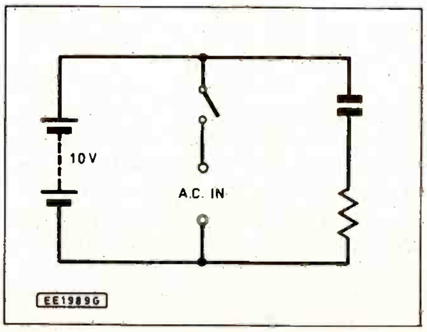


Fig. 8.26. Illustration for blocking.

Illustrative Example

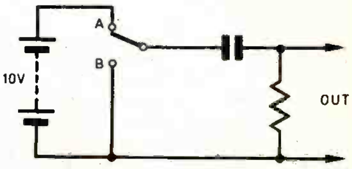
What is the capacitive reactance in a 6kHz a.c. circuit with a total capacitance of 200μ?

$$Xc = \frac{1}{2\pi fC} = \frac{1}{2 \times 3.14 \times 6{,}000 \times 200 \times 10^{-6}}$$

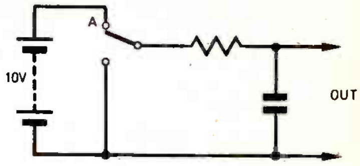
$$= \frac{1}{7.53} = 0.133 \text{ ohms}$$

Questions

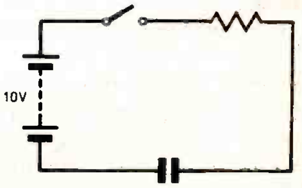
1. Draw an output waveform for the circuit below in response to the switch being in position A for 10 seconds.



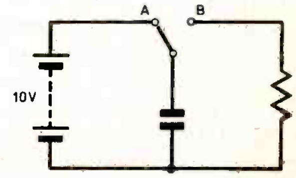
2. Draw an output waveform for the circuit below in response to the switch being in position A for 10 seconds.



3. Three 2μ capacitors are connected in parallel, what is the total capacitance?
4. The same three capacitors are now connected in series, what is the total capacitance?
5. Two capacitors, one having a value of 100μ and the other 50μ are connected in series find the total capacitance?
6. The capacitor in the circuit below is uncharged. Explain what happens to the current in the circuit at the instant the switch is closed.



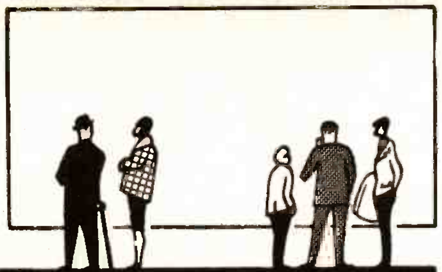
7. Observe the initial position of the switch in the circuit below. What will be the voltage across the resistor at the instant the switch is moved to position B?



Next month: Transformers.

For answers to last months questions see page 347.

SHOP TALK



BY DAVID BARRINGTON

Power Slaves

With the increasing popularity of their OMP amplifier modules, **B.K. Electronics** have finally succumbed to popular demand and cased their MOSFET modules in a rugged, black anodised, aluminium case. The first models contain the MF100 and the MF200 modules.

The new amplifiers will be known as the CA110 and CA210 Slave Amplifiers and retain all the features of their "chassis" counterparts, including the toroidal transformer power supply. Also included is an l.e.d. Vu Meter and an input level control circuit.

Both amplifiers have an input sensitivity of 500mV for full power output. The CA110 provides 115W r.m.s. into 4 ohms and 105W r.m.s. into 8 ohms, whilst its larger brother, the CA210, boasts 215W r.m.s. into 4 ohms at 150W r.m.s. into 8 ohms.

The CA110 is priced at £79 (plus £4 p&p) and the CA210 £99 (plus £5 p&p), inclusive of VAT. For further details or orders contact **B.K. Electronics, Dept EE, Unit 5, Comet Way, Southend on Sea, Essex SS2 6TR (☎ 0702 527572).**

Keyboard Kits

Be it construction or just reading about the latest development, musical effects and complete instruments have always been very popular with readers. The latest, German made, "keyboard" kits from **Brian Price Bohm Organ Studios** of Nottingham should prove most interesting.

Claimed to be the Worlds leaders in the design of electronic musical instruments in kit form, Bohm are based in Minden, West Germany and have been supplying kits and ready-made instruments for the professional and amateur user for over 32 years. They hold a number of World patents, including the latest keyboard controller i.c., designated E510, for "Touch Sensitivity".

The latest organs to incorporate the E510 are the Musica Futura 520 and Double Key 520. The Futura is a spinett organ for the home, the 520 Double Key is the portable version.

The keyboard 16-bit sampled voices are programmed in stereo which, it is claimed, provides a much enhanced sound. The rhythm unit also has 16-bit sampled sounds with different "breaks", "fills", "intros" and "endings" for each rhythm.

For the programming enthusiast the organ has built-in facilities for reprogramming and storing new voices, rhythms and accompaniments. There are also special plug-in RAM Soundcards available and these also make it possible to select many changes in voices and rhythms, e.g. drawbar (flute) type sounds, theatre and classical plus many solo instruments.

Bohm Musica Futura 520

All Bohm organs have full MIDI In/Out/Thru facilities. The Touch-Sensitive 49 note keyboards are 36 note polyphonic. Built-in stereo amplifiers on both versions provide 80W per channel. Prices range from £2069 to £2330, speaker systems are extra, and further details and brochure are available from **Brian Price Bohm Organ Studios, Dept EE, 389 Aspley Lane, Nottingham, NG8 5RR (☎ 0602 296311).**

CONSTRUCTIONAL PROJECTS

HiFi Speaker Design

A special package has been put together for the *HiFi Speaker Design* by **Radio & TV Components (Acton) Ltd.**, and should eliminate any component purchasing problems.

The speaker kit for the RTC2 design contains the four drive units (for the two loudspeakers), all the crossover components, two pre-cut front panels, speaker cloth for the two front grilles, 8 screw terminals, wire and Blu-Tack all for the sum of £60 including VAT, plus £3.50 p&p.

You will need to buy the specified wood panels for the sides, top and bottom and back panels of both cabinets. Also hardboard for the two crossover units, materials to make the grille frame, the Bonded Polyester Fibre or Superwrap for the internal wadding plus fixing pins, glue and any finishing materials, i.e. veneer etc.

Radio & TV Components (Acton) Ltd., Dept EE, 21 High Street, Acton, London W3 6N9 (☎ 01 723 8432).

Pet Scarer

The 40kHz crystal used in the *Pet Scarer* should not cause any buying problems. However, the ultrasonic transducer is usually sold as part of a pair but we understand that Magenta are prepared to sell this item separately.

A complete kit of parts (£13.80) may be purchased from **Magenta Electronics, Dept EE, 135 Hunter Street, Burton-on-Trent, Staffs DE14 2ST.** Add £1 for p&p per order. They are also able to supply a suitable mains adaptor for the sum of £1.98.

Simple Radio

The tuning capacitor VC1 used in the *Simple Radio* can be any variable type with a maximum value of 200pF to 350pF. Most advertisers stock the cheap solid dielectric types and these should work in this circuit.

The ferrite aerial used in the prototype model was a Denco 5FR/MW type. This aerial may be difficult to locate in some areas and an alternative is the MCW2 coil plus the FRA or FRE ferrite rods from Cirkit, code 8RB.

Electron A/D Interface

Some readers may experience some difficulty in purchasing the ZN449E A/D converter i.c. for the *Electron A/D Interface*. The more expensive ZN447E and ZN448E may be used in this circuit and differ only in the degree of accuracy offered.

The rest of the components are standard items and should be readily available. The printed circuit board is available through the *EE PCB Service*, code EE654 (see page 344).

SPECIAL MULTIMETER OFFER

£15

including VAT and postage

A multimeter is the first item of test gear that most enthusiasts buy and the one they are likely to use the most. We are therefore pleased to offer readers the chance to buy this excellent analogue meter at a very good price.

If you are buying your first meter or replacing a worn out or damaged one this Altai KRT5001 instrument should fit the bill. It is a 50kΩ/V unit with range doubler and d.c. current to 10A. The meter is supplied with batteries, test leads and instruction booklet.

OFFER CLOSES FRIDAY JUNE 30, 1989

SPECIFICATION

* Over-load protected by two silicon diodes.
* Uses double-jewelled ±2% meter with mirror and ±1% temperature stabilized resistors.
* 43 Ranges.

Measurement	Ranges	Accuracy	Remarks
DC-Volts	0-125-250mV 0-1.25-2.5-5-10-25-50-125-250-500-1000V	±3% Except as noted ±4% 125mV to 2.5V 500 to 1000V	Sensitivity 50kΩ/V (V-A/2) 25kΩ/V(V-Ω-A)
AC-Volts	0-5-10-25-50-125-250-500-1000V	±4% of full scale	Sensitivity 10kΩ/V (V-A/2), 5kΩ/V (V-Ω-A)
DC-Current	0-25-50μA 0-2.5-5-25-50-250-500mA 0-5-10A	Same as DC-Volts	
Resistance	0-2k-20k-200kΩ 0-2M-20MΩ (Center Scale 10)	±3% of scale length	Battery: one 1.5V penlight; one rectangular 9V
Decibels	−20 to +62dB		8-Ranges
Size	H170×W124×D50		
Weight	590g (battery and test lead included)		

ALL PRICES INCLUDE VAT, POST & PACKING
Post to: EE Multimeter Offer, Greenweld Electronics Ltd., 443 Millbrook Rd., Southampton SO1 0HX.
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Signature ....

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Tel 0703 772501

PET SCARER

MARK STUART

Keep pets/pests away from newly sown areas, fruit etc. Designed to operate over long periods, this easy to build unit gives a pulsed output.

THIS project was designed to deter a variety of animals from their irritating irrigation pastimes in newly-sown areas of the garden. It also should offer some degree of protection later in the year to young shoots and fruit. Exactly which animals are most susceptible to the high power ultrasound has not been established, but favourable reports were received when a lower power project was published some years ago.

The circuit described here uses a 40kHz ultrasonic transducer which is pulsed at two second intervals with 100V. A very efficient circuit is used so that the total average current consumption is only 15mA at 9V. This makes battery power a possibility, especially if C or D re-chargeable cells are used.

Alternatively, an old car battery will give weeks of operation from a single charge (ideal for allotments) and (at 12V) give a higher output. For continuous use in the garden a plug-in double-insulated 9V a.c. power supply is available which is capable of operating over 50 metres of low cost twin cable.

CIRCUIT DESCRIPTION

The full circuit diagram for the *Pet Scarer* is shown in Fig. 1. A quad 2-input OR gate IC1 does all the complicated work, whilst transistor TR1 provides the output power.

A 40kHz crystal oscillator, producing a square wave output, is formed by IC1c and associated components. This is a standard circuit with resistor R4 providing d.c. bias and setting the gate in a "linear" mode so that it works as an amplifier.

Feedback takes place via resistor R5 and crystal X1 at the resonant frequency of the crystal so that the circuit oscillates. Capacitors C2 and C3 ensure that the feedback is in the correct phase for oscillation and also eliminate the tendency of some i.c.s to ignore the crystal and cheerfully oscillate at 10MHz or more.

From the oscillator the square wave passes via R6, C4 and R7. The effect of this network is to produce a series of short negative-going pulses at 40kHz which are fed to one input of IC1d.

A low frequency oscillator is formed by IC1a, IC1b, and associated components. This oscillator works as follows: Assume that the input to IC1a is low. As it is an inverter, its output will be high, and so the output of IC1b will be low.

Capacitor C1 will charge via resistor R2 and R3/D1 so that the voltage at the junction of resistors R1 and R2 begins to rise. Resistor R1 couples this rise to IC1a input.

After a time the voltage at IC1a input rises to the point where it is taken as a logic 1 instead of a logic 0 and so the output of IC1a goes low. This drives the output of IC1b high (1). This change is coupled back to the input of IC1a via capacitor C1 and resistor R1 forcing the input of IC1a even higher.

This regenerative effect makes the circuit switch over rapidly to a state which is the opposite of the starting condition.

COMPONENTS

Shop Talk see page 314

Resistors

R1	2M2
R2	3M3
R3	1M
R4	10M
R5, R7	10k (2 off)
R6, R8	470 (2 off)

All ¼W carbon film.

Capacitors

C1	1µ 0.6in. pitch 100V
C2	22p ceramic plate 50V
C3	1n ceramic plate 50V
C4, C5	1n mylar 50V (2 off)
C6	22n 100V C344 5%
C7	100µ radial elec. 16V

Semiconductors

D1, D4	1N4148 (2 off)
D2	BY407A
D3	1N4001
D5	3mm standard red l.e.d.
TR1	ZTX451 *npn* silicon
IC1	4001B CMOS quad 2-input NOR gate

Miscellaneous:

X1	40kHz sub miniature crystal
X2	40kHz Ceramic Ultrasonic Transmitter
L1	45 turns of 28s.w.g. enamelled wire on N22 ferrite core assembly

Printed circuit board available from *EE PCB Service,* code EE644; case, Magenta B1; 14-pin i.c. socket; grommet for X2; M3 nylon screw with metal nut; flexible connecting wire 7/0.2, 0.5 metres; 1.5mm sleeving, 100mm.

Approx. cost Guidance only **£14**

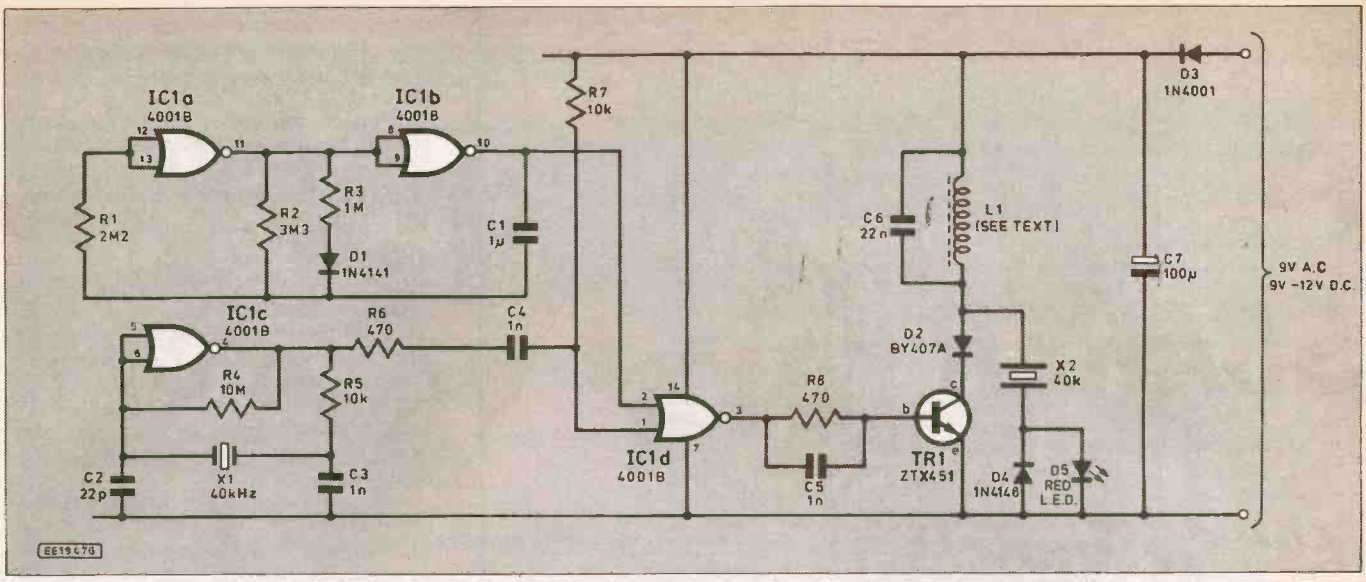


Fig. 1. Complete circuit diagram of the Pet Scarer.

Capacitor C1 now discharges via resistor R2 (diode D1 is reverse biased, blocking the path via resistor R3) and the voltage at the junction of resistors R1 and R2 falls until it reaches the point where IC1a input is taken as a logic 0. The circuit then switches over to the original state and the cycle repeats.

The output of IC1b is a square wave of unequal mark/space ratio due to C1 charging via R2 and R3 and discharging more slowly through resistor R2 only. The periods when the output is high are longer than when it is low. With the component values given these times are two seconds and one second respectively.

Two signals are applied to the inputs of IC1d. A truth table for this two-input NOR gate is shown in Table 1.

Table 1.
Truth Table for 2-input NOR

Input 1	Input 2	Output
0	0	1
0	1	0
1	0	0
1	1	0

With either input held high the output of the gate is forced low. For the two seconds that IC1b output is held high, therefore, the output of IC1d stays low regardless of the other input's state.

During the one second that IC1b output is low, the output of IC1d is an inverted form of the 40kHz signal on its other input. As this is a train of negative going pulses, the output is a train of 40kHz positive pulses. The final result is one second bursts of 40kHz pulses repeated at two second intervals.

OUTPUT DRIVE

The pulse waveform from IC1d drives the output transistor TR1 via resistor R8 and capacitor C5. Resistor R8 limits the maximum base current to a level that does not overload IC1d, capacitor C5 speeds up the pulse edges to give clean sharp switching of TR1.

The collector load of TR1 is a tuned circuit consisting of capacitor C6 and coil L1 in parallel which resonates at 40kHz. The effect of this circuit when driven from the pulsed output of transistor TR1 is to provide a greatly magnified voltage swing of over 100V peak-to-peak which is connected directly to the ultrasonic transducer X2.

The operation of this tuned circuit is analogous to a pendulum which executes large swings when given short pushes. The important thing is that the pushes must be timed to match exactly the pendulum swing. In the case of this circuit the "pushes" take the form of precisely timed pulses of current from TR1, and the "pendulum" which consists of L1 and C1 is tuned to match the pulse rate.

The capacitance of the ultrasonic transducer X2 also influences the tuned circuit and this can vary substantially from unit to unit. To prevent this from causing problems, the value of capacitor C6 is chosen to be much larger than that of the transducer so that it dominates and reduces the effect of X2 to insignificant proportions.

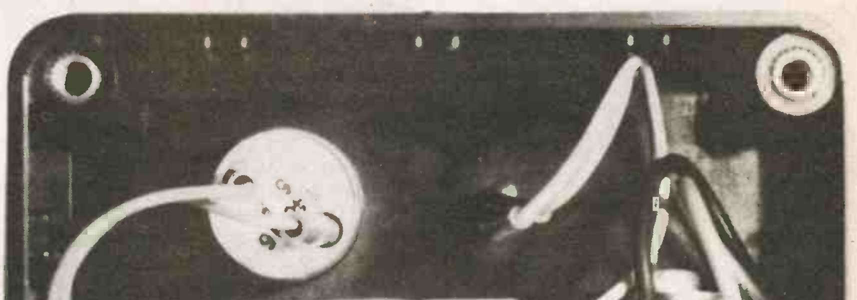
To give an accurate indication of correct operation, an l.e.d. (D5) is connected in series with the transducer and is lit only by the 40kHz current passing through it. A failure in any part of the circuit will put out the light, unlike a simple "power on" l.e.d. which would merely indicate battery condition. The brightness of the l.e.d. also gives some indication of the output power level. Diode D4 is necessary to by-pass the l.e.d. in the reverse direction.

Diode D2 is a very important part of the circuit. It allows the voltage at the lower end of L1 to swing freely below the negative supply rail. Without the diode, TR1 collector/base junction would become forward biased and effectively clamp the negative voltage swing.

Finally, the two power supply components capacitor C7 and diode D3 provide decoupling and polarity protection when d.c. supplies are used, and rectification and smoothing when used with a.c.

CONSTRUCTION

A single printed circuit board holds all of



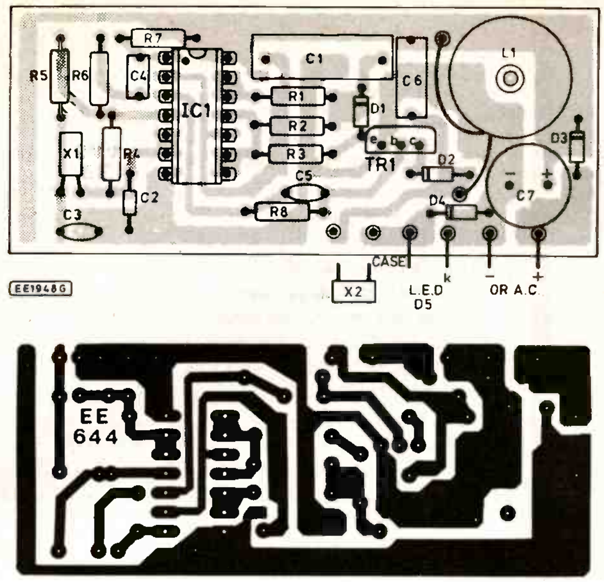


Fig. 2. P.C.B. layout and wiring for the Pet Scarer.

the components, except the ultrasonic transducer and l.e.d. This board is available from the *EE PCB Service*, code EE644 (see page 344).

The size of the board fits exactly into guide slots in the specified case, or can be mounted in an alternative case using screws, nuts and spacers. The leads to the transducer can be extended up to 10 metres without causing any problems, allowing the "electronics" to be kept indoors or in a shed if required. This should not be necessary though if the case is well sealed, and sheltered.

The inductor coil L1 should be wound first with 45 turns of 28s.w.g. enamelled wire. Either a single or multi-section bobbin can be used as there is plenty of winding space available. If a three section bobbin is used, wind 15 turns in each section before moving on to the next. A single section bobbin can be "scramble wound" as there is nothing to be gained by neat layer winding. In either case it is important to bring both ends of the winding out at the same side of the bobbin so that 45 FULL turns are completed.

A layer of p.v.c. tape should be put over the finished winding to protect it and hold the turns in place. Leave 50mm wire ends and "tin" solder 10mm of each wire. If solderable (or self-fluxing) enamelled wire is used this should be easy, although the soldering iron must be held on the wire for some time to start the enamel melting. Other types of enamel will need scraping away to expose the bare copper before soldering. This is best done by folding a piece of emery paper over the wire.

The two core halves should be fitted over the coil with their gaps aligned and fixed together and to the p.c.b. by means of a nylon M3 screw and a metal nut which must **NOT** be over tightened. A metal screw passing through the cores must not be used as it would introduce enormous losses. The core types specified **MUST** be used as the inductance of the final assembly is critical.

CIRCUIT BOARD

The printed circuit board (p.c.b.) component layout is shown in Fig. 2 together with a full size copper foil master pattern. Assembly is straightforward with only crystal X1 requiring special care as it has delicate leads and a glass seal. It is best to leave the leads full length and to fix the crystal to the board with a dab of flexible "impact" adhesive.

A socket should be used for IC1 as it can be a great aid in fault finding to be able to remove the i.c. and make resistance checks. The diodes are marked with a band to indicate the cathode (k) end, and transistor TR1 is shaped so that its polarity can be easily identified. Capacitor C7 has its negative lead indicated by markings on its case.

The l.e.d. D5 should be mounted into a tight fitting hole in the case and its leads left full length. Two 100mm lengths of flexible wire should be attached to the ends of the l.e.d. leads, and fitted with 1,5mm sleeving to cover the full uninsulated length.

Mounting of the ultrasonic transducer X2 to the case is made easy by means of a tight fitting grommet. Varnish, rubber bath sealant or flexible adhesive can be used to make perfect seals around the l.e.d. transducer, and grommet on the inside of the case. Be careful though as some compounds have solvents which will damage the case, and "melt" the l.e.d.

Wires to the power source should be brought out through a small hole in the end of the case which will be the bottom when the unit is working, and sealed as before.

TESTING

If all is well the l.e.d. should flash and the circuit current consumption should be 50mA during the flashes, and practically zero in between. Giving an average of 15mA assuming a 9V supply. On 12V the current consumption will be higher and the l.e.d. brighter. As the circuit is very efficient, transistor TR1 should stay completely cold.

The circuit can be checked in stages if found to be faulty. The output of IC1b can be read with a multimeter as it pulses slowly at three second intervals. The output of IC1c is a 40kHz square wave and will read as half supply voltage on a multimeter d.c. voltage range. The output of IC1d is a series of 40kHz pulses which will read as half supply voltage pulses on and off at three second intervals.

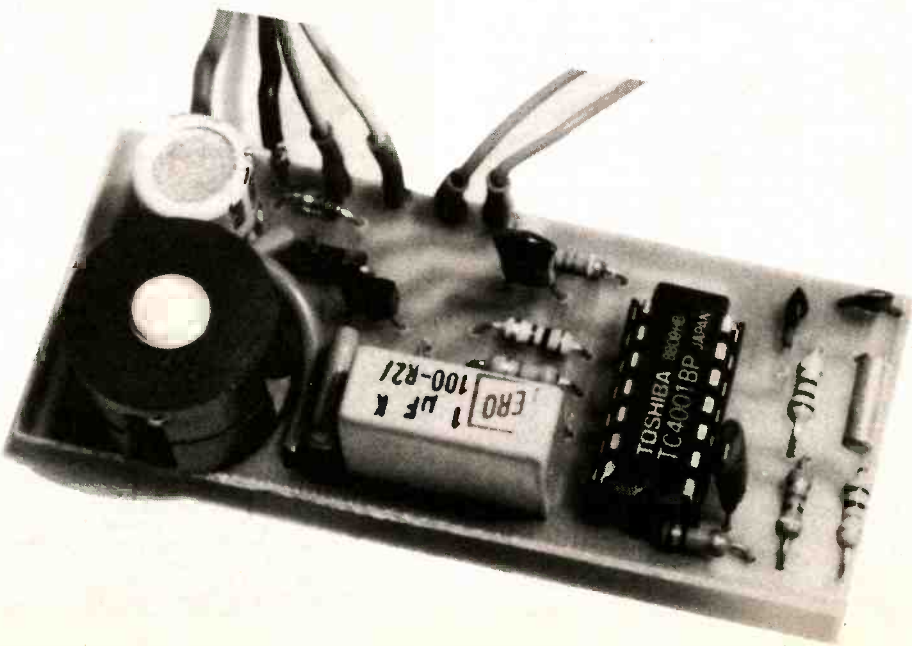
The base of transistor TR1 should read slightly positive during pulses and zero in between. TR1 collector will read approximately 20V and the anode of diode D2 will be at the supply voltage.

For those with an oscilloscope the circuit waveform can be read easily, making fault finding a simple task.

IN USE

Once the circuit is operating normally, the case should be closed and weatherproofed by the use of insulating tape around the lid and over the lid screws. It is recommended that the unit is fitted to a stake in the garden and sheltered from direct rainfall by a flat piece of wood nailed to the top of the stake. Other methods may of course be tried, with such hardware as plastic drink bottles and p.v.c. rainwater pipes offering interesting possibilities.

If a mains transformer is used as the power source, it is essential to use a good quality type with double insulation. Plug-in adaptors are particularly good as they are manufactured to high safety standards. The 9V d.c. adaptor specified is ideal □



SIGNAL GENERATORS

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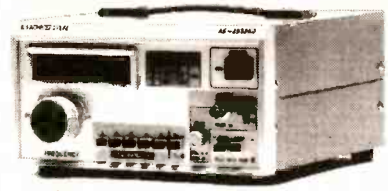

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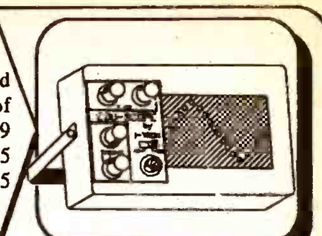

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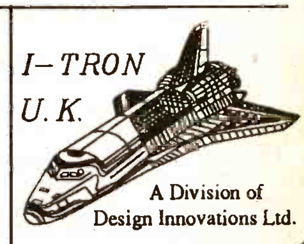

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BP038	20	5 pin din, 180° chassis socket
BP039	6	Double phono sockets, Paxolin mounted
BP040	6	Single phono to phono screen leads 1.2m long *JAPAN made*
BP041	3	2.8m lengths of 3 core 5 amp mains cable
BP042	2	Large VU meters *JAPAN made*
BP043	30	4V miniature bulbs, wire ended, new untested
BP044	2	Sonotone stereo crystal cartridge with 78 and LP styli *JAPAN made*
BP045	2	Stereo cassette record and play heads *JAPAN made*
BP046	4	6-0-6 4VA mains transformers, P.C. mount *UK made*
BP047	1	24V 750mA mains power supply. Brand new boxed *UK made by MULLARD*
BP048	1	Car rear window heater/demister. Self adhesive panel, size 24"×9", complete with switch and cable *UK made* *(Ideal for your old "Moggy 1000" etc)*
BP049	10	OC44 transistors. Remove paint from top and it becomes a photo-electric cell *UK made by MULLARD*
BP050	30	Low signal transistors n.p.n., p.n.p. types
BP051	6	14 watt output transistors. 3 complimentary pairs in T066 case *(Ideal replacement for AD161 and 162s)*
BP052	8	3 watt audio output ICs. No TA7205P *JAPAN made by TOSHIBA*
BP053	5	5 watt audio ICs. No TBA800 *(ATEZ)*
BP054	10	Motor speed control ICs, as used with most cassette and record player motors
BP055	1	Digital DVM meter I.C. *made by PLESSEY* as used by *THANDAR* with diagram
BP056	4	7 segment 0.3 LED display (R.E.D.)
BP057	8	Bridge rectifiers, 1 amp, 24V
BP058	200	Assorted carbon resistors

Hi-Fi stereo cassette deck transport mechanism, complete with 3 digit rev counter and tape heads, 12V d.c. operation. Unused manufacturers surplus *JAPAN made*
£6.20 +£1.50 P&P **2 at £10 +£2.50 P&P**

Garrard stereo record player deck, manual/auto operation, 3 speed (78, 45, 33⅓). 240V operation. Unused but store soiled
£6.50+£2.00 P&P **2 at £10+£3.75 P&P**

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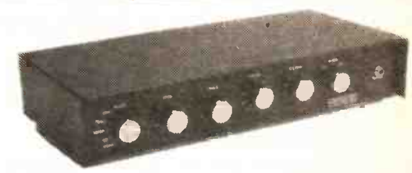


EE STEREO INTEGRATED AMPLIFIER KIT
■ 30W×2 (Din 4 ohms) ■ CD/AUX input
■ Separate Bass and Treble ■ LED power indicator
■ Headphone jack. Size HWD 75×400×195.
PROJECT INC. Pre-drilled case, back printed P.C.B. with ALL components.
ALL YOU NEED IS solder, wire and £36.80 plus £3.50 for postage
(Full instructions in EVERDAY ELECTRONICS APRIL 1989 issue)

THE RTC MONITOR II
100 WATT SPEAKER KIT £60.00 +£3.50 P&P

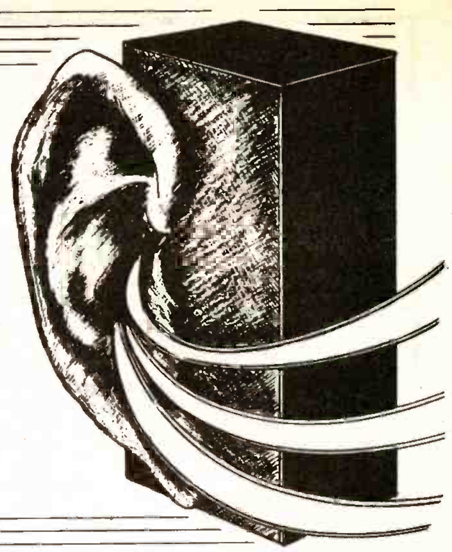
RESPONSE: 55Hz–20kHz
BASS POLYMER CONE D: 22cm
DOME TWEETER: 14mm
OVERALL SIZE (HWD): 382,252,204mm
RECOMMENDED AMP POWER: 10-100 watts

The performance standard achieved in this compact design is distinctively superior to anything else available at the price. The drive units used are of sophisticated design and have been carefully integrated with a Complex Crossover. Stereo performance is exceptionally good with a well focussed sound stage and sharp resolution of detail. Distortion throughout the frequency range is low even at quite high power input and this gives a great sense of dynamic range and openness especially when used in bi-wired mode.
Supplied with:— 2 READY CUT BAFFLES, ALL CROSSOVER COMPONENTS, 2 BASS MID-RANGE, 2 DOME TWEETERS, HOOK UP WIRE, GRILLE CLOTH, SCREW TERMINALS AND SCREWS. *(Featured in Everyday Electronics–May 89 issue)*

Velleman kits in stock. Send for catalogue
Repair your own Hi-Fi speakers. Send s.a.e. for catalogue.

Constructional Project

HiFi SPEAKER DESIGN



This RTC2 hi-fi speaker has been designed to achieve exceptional performance for price and to be easily constructed by the amateur.

SPECIFICATION RTC2

Bass unit	026 8Ω 70W bass/mid range driver (210mm)
Tweeter	004M 8Ω 60W dome tweeter (60×110mm) with modified phase plug, ferrofluid cooling and polymer cone.
Crossover	Third order two way at 3kHz with damping resistors for close impedance control.
Impedance	8 ohms.
Minimum Impedance	6.3 ohms.
Frequency Response	55Hz-20kHz +/− 2.5dB.
Recommended amplifier power	10 watts to 100 watts.
Cabinet size	382×252×220mm approx.

THE performance standard achieved in this compact design is distinctly superior to anything else available at the price. The drive units used are of sophisticated design and they have been very carefully integrated with a fairly complex crossover. Stereo performance is exceptionally good with a well focussed soundstage and sharp resolution of detail.

When placed well clear of room boundaries the image is notably deep. Against a wall the image becomes somewhat shallower but still convincing. Bass performance is augmented by presence of the rear boundary but with no trace of the boom or overhang of lesser designs. In fact a position 150 to 200mm from the rear wall seems about right for bass balance. Distortion throughout the frequency range is low even at quite high power input and this gives a great sense of dynamic range and openness.

The response graphs shown (Figs. 1 to 4) are for one of the prototype loudspeakers—both cabinets were tested and the results were virtually identical for both. The far left hand display scale (0, −2, −4, −6, −8 db) is used in all cases.

BUILDING THE LOUDSPEAKERS

The instructions contained in this article were written for the audio enthusiast who does not have a full cabinet maker's workshop at his disposal. For this reason the cabinet described is simplified to ensure that the correct acoustic results are obtained. Those lucky enough to have woodworking skills and equipment available are free to use more advanced construction techniques and more costly materials provided that the requirements for strength and air tightness are met.

MATERIALS

In its simplest form the cabinet should be constructed from 18mm high density chipboard, of the type normally called "flooring grade", or from medium density fibreboard (MDF) of the same thickness. Of the two materials MDF is marginally superior but is sometimes difficult to obtain. It also is very hard on cutting tools. This is a small cabinet so do not be too worried if you have to use chipboard. The

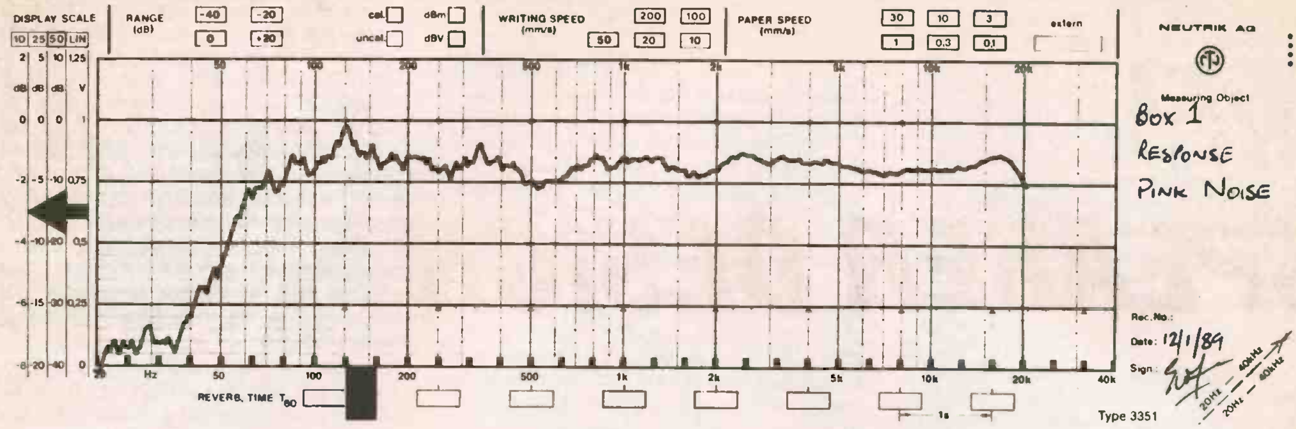


Fig. 1. Response of the RTC2 to pink noise.

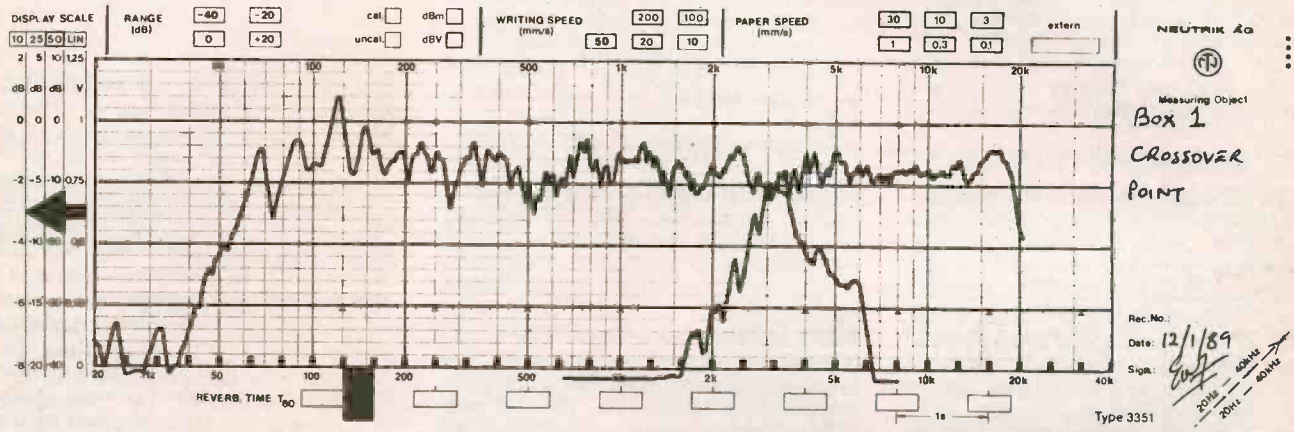


Fig. 2. Response showing crossover point.

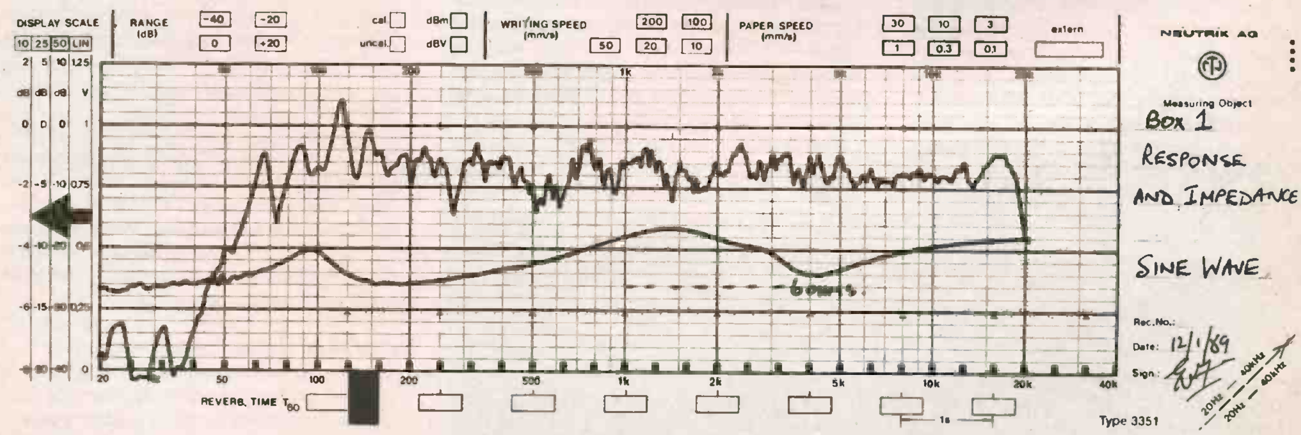


Fig. 3. Response and impedance.

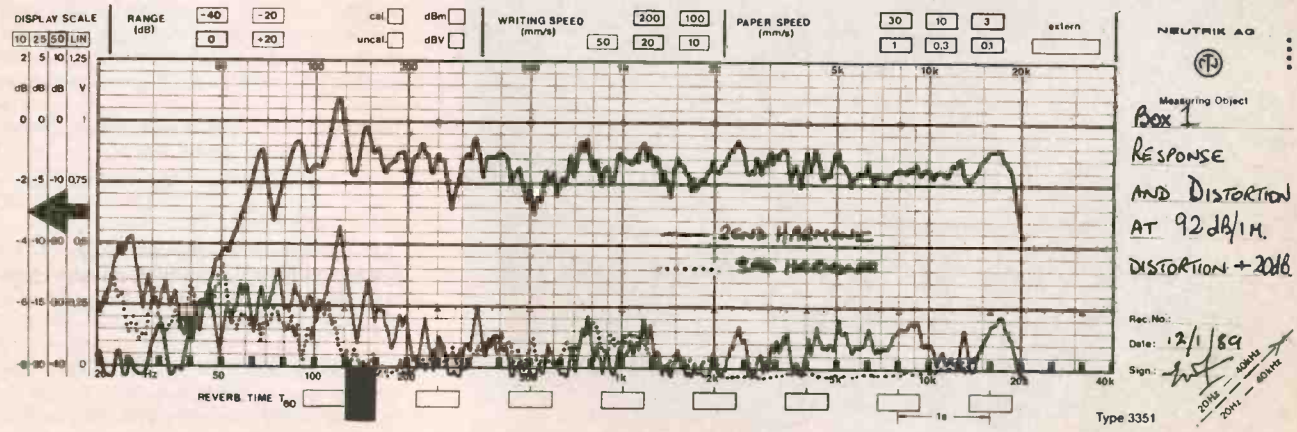
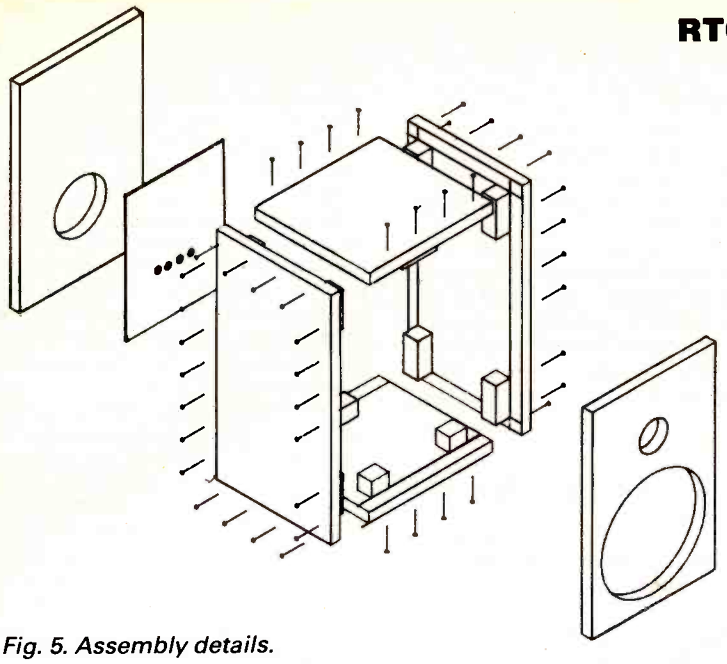


Fig. 4. Response plus 2nd and 3rd harmonic distortion.

RTC2 SPEAKER ASSEMBLY



Cabinet overall dimensions 382 high × 252 wide × 204 deep. All cabinet panels 18mm high density chipboard or medium density fibreboard. Terminal panel 3mm hardboard. All joints sealed internally with a bead of wood glue and reinforced with glue-blocks. pin all joints with 40mm panel pins every 50mm.

Fig. 5. Assembly details.

results will still be superior to commercially manufactured loudspeakers where, for reasons of cost, the walls are often as thin as 12mm.

If you choose a pre-veneered board then the cut edges will have to be veneered with "iron-on" strip veneer which is sold separately. It will also be necessary to fasten the glue-blocks along the inside of each joint by pinning through from the inside to avoid marring the veneer. With limited woodworking experience and equipment the best results will be obtained by building the boxes from plain board and veneering afterwards using sheet veneer and contact adhesive as described below.

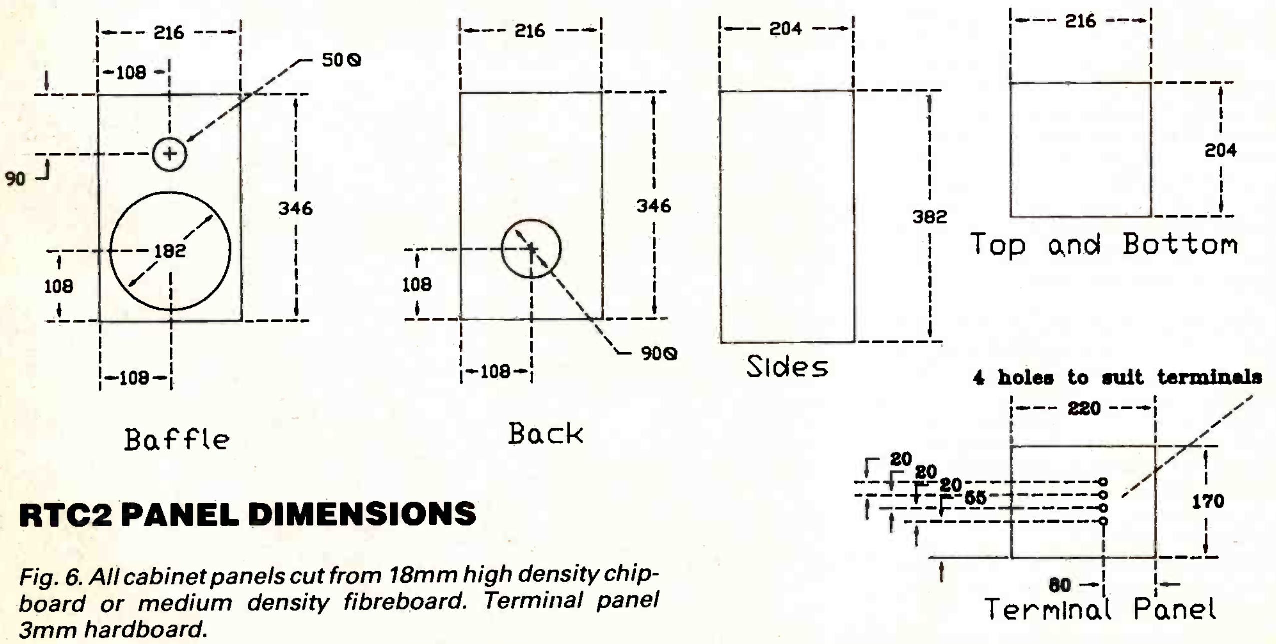
Skilled woodworkers who wish to use more advanced construction methods should make sure that they choose a board with properties similar to MDF or heavy grade chipboard. Even quite costly pre-veneered boards may be of "block board" internal construction which is distinctly inferior to chipboard or MDF in acoustic properties.

CUTTING

The cabinet is constructed from plain, sawn, panels butt jointed with white PVA woodworking adhesive and fastened with plenty of 40mm panel pins to hold it square until the adhesive sets, see Fig. 5. For this reason **it is important that the panels are the correct size and are cut square and smooth edged.** In most cases the best way to achieve this is to have your wood supplier do the cutting on his panel saw. At least have him cut the board into strips of the correct widths, leaving you only the cross cutting to do. If you cut the boards at home make sure that all saw cuts are made on the waste side of the dimension lines and finish each cut with a smoothing plane or Surform type rasp to exact size. Fig 6 shows the panel cutting details.

CONSTRUCTION

It is best to assemble the carcase before cutting the bass speaker mounting holes in the baffle. (The baffle is precut with the kit supplied by Radio and TV Components). By looking at the plans you will see that the bass unit cutout occupies a substantial proportion of the width of the baffle and if it is cut before assembly the baffles will be very weak. After assembly when the glue has thoroughly dried the holes are easily cut with a padsaw or electric jigsaw without fear of breaking the baffle at the weak points. The aperture in the rear panel for the terminal plate, and the tweeter holes may be cut before assembly.



RTC2 PANEL DIMENSIONS

Fig. 6. All cabinet panels cut from 18mm high density chipboard or medium density fibreboard. Terminal panel 3mm hardboard.

The next step is to mark each side panel with the thickness of the baffle, back, top and bottom which will be joined to it. This is best done using the actual panel as a ruler as boards are not always exactly the advertised thickness. Then mark the top and bottom with the width of the baffle and back. Now glue and pin several short lengths of 25mm square softwood along your marked lines to act as supports during assembly. Make sure that these glue-blocks are accurately placed to the marked lines.

Use one piece 60mm long front and back on the top panel, one piece at the back of the bottom panel and two 30mm pieces at the front, one at each end. This ensures that you do not have to saw through a glue block when cutting the bass unit hole. Use two 60mm pieces front and rear of each side panel and again be sure to avoid placing a block where it will interfere with cutting the bass aperture. Make sure at this stage also that no glue block interferes with the location of a block on an adjacent panel.

ASSEMBLY

When the glue-blocks are thoroughly dried it should be possible to assemble the cabinet dry to check that everything fits together. It is much better to discover the silly mistake at this stage than when you are juggling with six pieces of wood running with wood glue. If there are no problems glue up and pin together all of the panels. Begin with the baffle and top, then the bottom followed by the back and finally, after gently tapping the sub-assembly square, pin on the sides.

There are two rules to be followed during these operations.

1. Use wastefully large amounts of good quality white PVA wood glue, for example Evostick Resin W. The glue should ooze out of each joint as the panels are brought together ensuring a strong and airtight cabinet.
2. Use one 38mm panel pin every 50mm or so along each joint, just like in the assembly diagram. Be very careful not to place pins where they will hit the saw blade as you cut the bass unit aperture. Draw the hole on the outside of the baffle as a guide.

Now wipe excess wood glue away with a damp cloth and leave the assembled cabinet to set.

Cut the apertures for the bass units with any suitable tool. A padsaw or an electric jigsaw are best. As with all cutting keep to the waste side, of the lines and clean up afterwards to the correct size. Then vacuum out the cabinet **very thoroughly** to remove all of the wood dust. Using the drive units as their own templates mark the position of the screw holes and drill pilot holes right through the baffle using a 2mm drill.

It will probably be necessary at this stage to sand or file the edges of some of the panels to bring them flush with their neighbours. First punch all of the panel pins slightly below the surface and then fill over the heads and any other gaps or chips with a decent wood filler. If you have used chipboard also fill the cut edges of the panels by scraping a thin layer of filler firmly into the chip matrix.

The easiest filler to use is car body filler such as Isopon which adheres very firmly and does not shrink. Finally thoroughly sand the whole carcase till all of the joints lie flush and smooth. Be careful not to round off the corners. You should now have a very strong box which can be finished in various ways.

FINISHING

If you have filled the surfaces properly and sanded really smooth then it is possible to prime and paint the surfaces, even to a piano finish. Talk to your local paint specialists about the techniques to use.

A number of specialist companies sell sheet veneer in various woods. Some of the larger d.i.y. stores have a pre-glued "iron-on" veneer which is particularly easy to apply. For absolutely the best results buy good quality veneer leaves from a specialist supplier and glue it to the cabinet using Dunlop Thixofix contact adhesive. For a small cabinet like this it is possible to buy veneer wide enough to cover the panels in one piece, avoiding the tricky job of edge butting and grain matching.

To make a really splendid job of the veneering first unroll your veneer and cut pieces for top, bottom and both sides of each cabinet. Cut each piece only a few millimetres longer than the panel and cut in order round the cabinet, top first, then right-hand side, then bottom and finally the left-hand side. This will allow the grain to be matched over each corner. Finally cut pieces for front and back.

Now, following the manufacturers instructions, coat the top of the cabinet and the inside surface of the top piece of veneer with contact adhesive and allow them to dry till tack free. Chipboard is fairly absorbent and it may be necessary to apply a second coat of adhesive to the cabinet for good adhesion. Lay the veneer onto the cabinet, lining up the grain parallel to the front edge and smooth it into place. Work carefully from one side to the other to avoid trapped air. Then rub down the veneer firmly with the edge of a length of glue block to ensure good adhesion.

Lay the cabinet top down on a flat surface and use a sharp trimming knife to cut off the excess veneer flush with the edges. Be especially careful when cutting along the grain as the blade will tend to follow the pattern and pull veneer off the surface. Take it easy and use a very sharp blade.

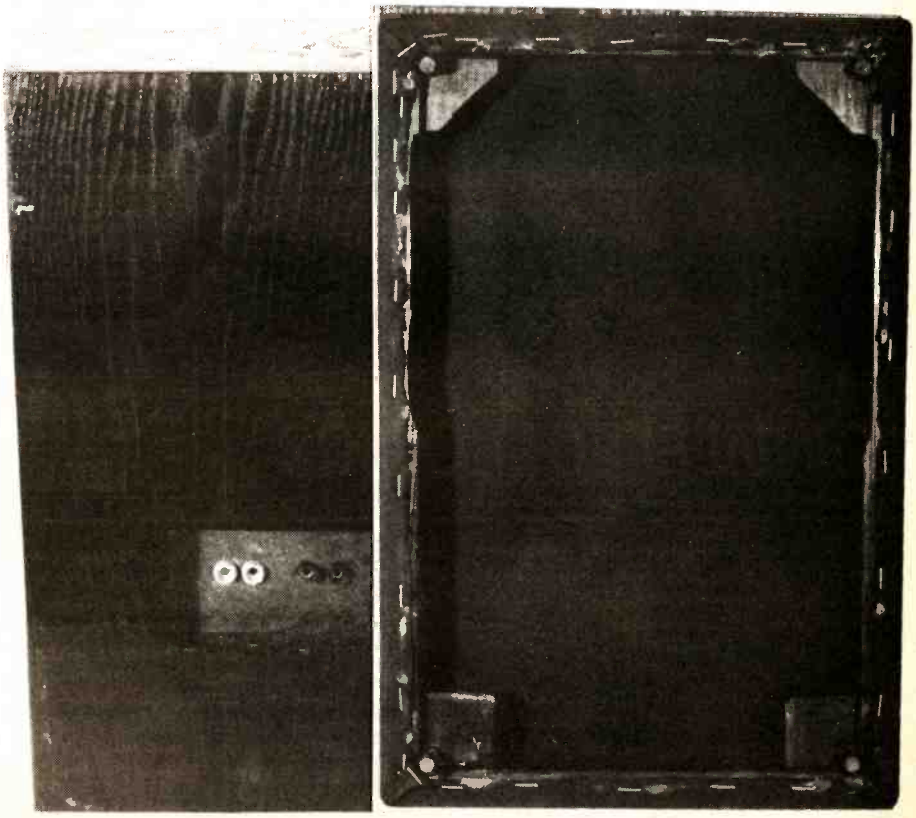
Repeat the process for the right-hand side, the bottom and the left hand side sliding the grain into register with the adjacent panel at each corner. Now veneer the back panel and baffle in the same way with the grain vertical. Take great care when cutting the veneer away from the apertures to avoid tearing the grain.

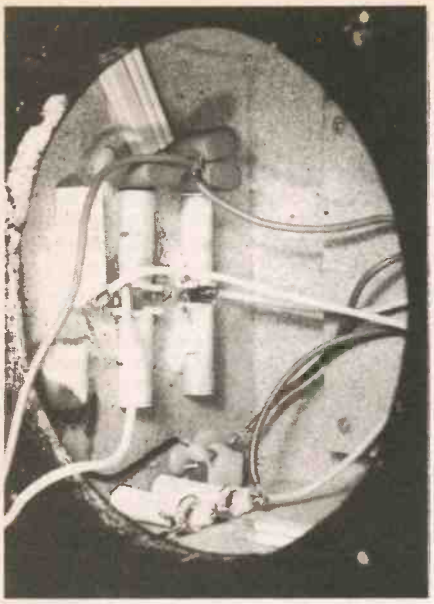
Your cabinet now looks almost like a solid block of your chosen wood. Finish it with a suitable stain and polyurethane varnish following the maker's instructions. For the modern satin finish simply rub down the varnished surface with Scotch-brite cabinet finishing pads or fine wire wool liberally lubricated with furniture wax. This process must be done slowly, evenly and carefully to avoid cutting through the varnish.

MAKING THE GRILLES

For best results the grilles must be acoustically transparent and the frame should be as slim as possible. One very good technique for making a suitable grille is to use picture frame moulding, neatly mitred, and reinforced at each corner with a small triangular piece of hardboard glued inside the frame. To hold the grille in place on the cabinet use short lengths of wooden dowel glued into the hardboard triangles and matching holes in the cabinet baffles. Make sure the holes are only about 8mm deep—**they must not penetrate the panel.** Round

Photographs of the back of the prototype speaker and the back of the grille showing the construction of the frame.





Prototype crossover construction.

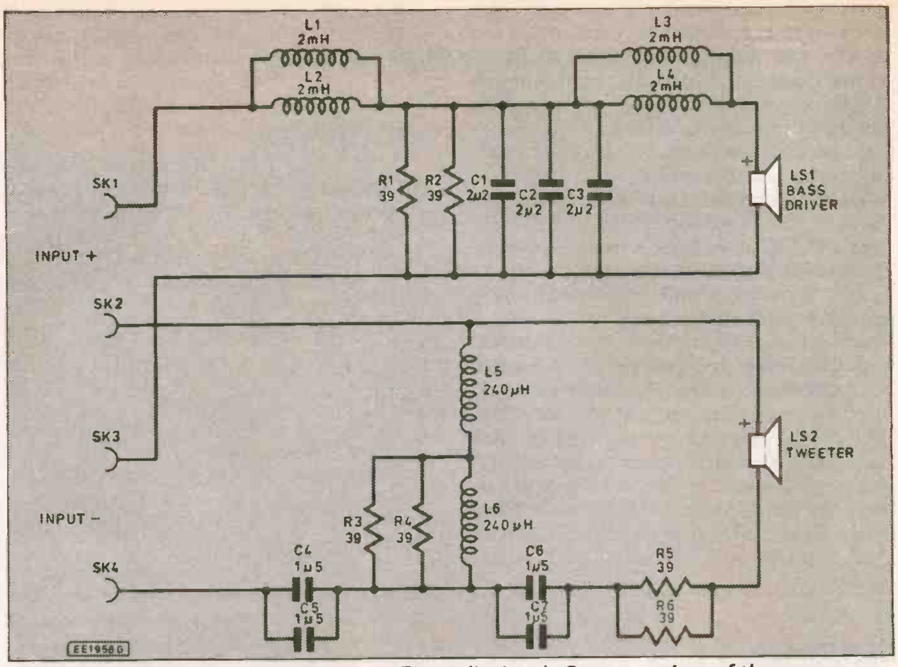
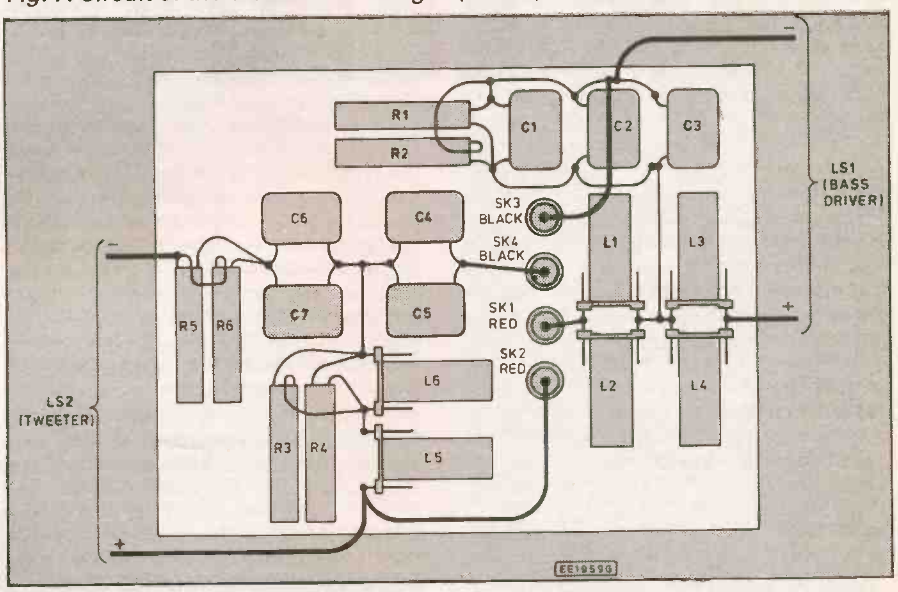


Fig. 7. Circuit of the crossover.

Fig. 8 (below). Construction of the crossover.



off the corners of the frame and cover it with a light weight cloth.

There are special loudspeaker grille cloths available (again the kit comes with speaker cloth) but the best fabric is thin polyester jersey which most sewing shops stock. Make sure that the fabric is open enough to see through against the light and avoid anything "fluffy". Staple the cloth to the rear surface of the frame stretching it fairly tight and trim off the excess.

CROSSOVER NETWORKS

This is a fairly complex crossover design (Fig. 7) so take great care to follow the wiring diagram (Fig. 8) and check the layout after completion to make sure it is correct. **An accidental short circuit here could cause amplifier damage.** Place the components on the *rough* surface of the hardboard terminal panel as shown in the layout drawing and tack each one in place using a hot-melt glue gun, or epoxy resin (Araldite). Fit terminal posts into the drilled holes in the terminal panel with a dab of epoxy or hot melt to prevent loosening.

To interconnect the components, strip a short length of 15 amp ring main cable and use the red and black cores (brown and blue). They are stiff and have low resistance. Bend each piece neatly to fit. Use heavy insulated wire for connections from the crossover to the drivers and the four sockets on the terminal panel. Use black for negative leads, red for bass unit positive and yellow for tweeter positive. Wire up the components exactly as in the layout diagram, Fig. 8.

When the crossovers are complete glue the hardboard panel inside the back of the cabinet with wood glue making sure that the glue joint seals all the way round. Then screw four small woodscrews (0.75×6) through the terminal panel into the rear panel around the terminal opening to prevent buzzing.

FINAL ASSEMBLY

The drive units in the kit do not have sealing gaskets so use Blu Tack or draught excluder foam. (Choose the 6mm wide, white, soft, self adhesive foam tape sold by most d.i.y stores.) The tweeter flange is rather narrow at the top and bottom so, using a sharp knife slit a 200mm length of

COMPONENTS

Approx. cost guidance only **£75** per pair

COMPONENTS AND MATERIALS SHOWN ARE FOR ONE SPEAKER ONLY

Resistors
R1 to R6 — 39 11W (6 off)

Capacitors
C1 to C3 — 2µ2 (3 off)
C4 to C7 — 1µ5 (4 off)

Inductors
L1 to L4 — 2mH (4 off)
L5, L6 — 240µH (2 off)

Miscellaneous
LS1 — bass driver 026 8Ω 70W
LS2 — tweeter 004M 8Ω 60W
SK1, SK2 — Screw terminals—red (2 off)
SK3, SK4 — Screw terminals—black (2 off)

NOTE: A kit of the above parts is available—See *Shop Talk*, page 314.

Miscellaneous
Wire, screws, panel pins, glue, speaker cloth, Blu-Tack, etc.—see text.

Materials
MDF or high density chipboard 18mm thick
2 off 216×236mm (front and back)
2 off 382×204mm (sides)
2 off 216×204mm (top and bottom)

3mm Hardboard
1 off 130×110mm (terminal panel)
4 off 50×50mm (grille frame)

25×25mm batten × 720mm (glue blocks—11 off 60mm, plus 2 off 30mm long)

Picture frame moulding 1300mm (grille frame)

Dowel 6mm×60mm (grille frame)

Bonded Polyester Fibre (or two pieces of Superwrap loft insulation material) 50mm × 660mm × 660mm.

the tape in half along the length and carefuly glue each half to the rear of the tweeter plate around the central barrel to form a gasket. Cut the gasket to the correct length and tightly butt the ends together but do not overlap. Glue a complete turn of tape on the rear of each bass unit chassis overlapping slightly.

Bring the correct leads out through the tweeter mounting hole and solder to the terminals of the tweeter making sure that the polarity is correct and that the joints are good. Screw the unit home with 6×1 panhead chipboard screws.

Cut one piece of 50mm thick Bonded Polyester Fibre (or two pieces of Superwrap) 660mm square. Fold it in half and then loosely roll it into a tube. Insert the roll through the base unit aperture and arrange it so that it stands upright in the cabinet. Now solder the bass unit wires to the tags on the driver, fit the driver in place and screw home using 1.25×8 panhead chipboard screws.

For both the bass unit and the tweeter the screws are longer than the thickness of the baffle. This ensures that the screw thread is locked into the skin on both faces of the chipboard for maximum strength. The threads cut into the panel are good enough to be reused at least 20 times.

CONNECTING FOR LISTENING

The system has been designed to allow Bi-Wiring with completely separate bass and tweeter filters brought out to two pairs of terminals on the rear panel. If you do not wish to try this intriguing wiring method then simply short the two negative sockets together and short the two positive sockets together on each speaker. This gives a perfectly normal loudspeaker. It would even be OK to fit only two input sockets and short the wiring inside the cabinet.

To Bi-Wire the cabinets take two positive and two negative leads all the way back to the amplifier terminals. Connect both negatives of each channel to the corresponding negative amplifier terminal and connect both positives to the positive terminal. The effect is to eliminate common signal paths and thus reduce intermodulation. Given good quality equipment the results can be clearly heard as an increase in clarity.

Make sure the units are correctly wired to the amplifier—it is easy to simply connect one pair of terminals which will result in no connection to one or other of the drive units.

For best results these units should be mounted on rigid stands about 450 to 500mm tall. This places the tweeters nicely at seated ear level. Connecting the cabinets to the stands with four small pieces of "Blu Tack" and using spikes on the base of the stands to penetrate the carpet and firmly rest on the floor beneath will give worthwhile increases in solidity of the image and of midrange detail. Now enjoy your high quality speakers. □

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AVAILABLE: Copy of manual and info, including diagrams for Solartron CT436 dual beam oscilloscope. Contact D. M. Shields, 27 Bentinck Road, Newark, Notts.

TELEQUIPMENT D51 double beam oscilloscope, needs attention, £20. Cossor 1039M oscilloscope, working and with manual, £15. Telephone 0254 771769 daytime (Lancashire).

NEW THOUSAND keyless code locks £36 or over each to fund raise for Stafford Deaf Club—need new mini-bus. P. S. Boult, Room 3, 11 St. Vincents Road, Doncaster, S. Yorks DN1 2LR.

WANTED service repair manual for Hammond J222 Organ. Substitute would be acceptable. James Coyne, 9 Coningsby Place, Alloa, Scotland. (Tel. 0259 216909).

WANTED BBC Model B+ for electronics student. Pay £50. Pay extra for disc drive, printer, etc. A. Dean, Oak Tree Cottage, Chilcote, Nr. Burton on Trent DE12 8DQ.

BAX13 Diodes. Accidental purchase. £1 for 100. £8 for 1000. 50V. 150μ/A similar 1N4148. Inc. postage. C. A. Jackson, Thornbury, Sutton-on-Forest, York YO6 1EQ. Tel. 0347 810354.

WANTED IC TDA3650. I need four. A. Rijkebusch, Foulston Avenue, St. Budeaux, Plymouth PL5 1HF.

WANTED circuit HMV 28.18. Tel. 0254 40545. Thomas E. Kenlock, 33 Moorfield Avenue, Blackburn, Lancs. BB1 9BX.

WANTED ITT studio recorder 720 stereo in good condition and working order. N. F. Mullis, 14 Ramsden Road, Orpington, Kent BR5 4LT.

WANTED 4 octave minimum electronic music keyboard, preferably sprung, complete with either box or frame. S. Clark. Tel. 0865 863700 (Oxford).

WANTED Moog Rouge synth manual also Rotel RZ8 preamp play mixer working or non-working. Tel. 0705 253595. P. Redpath, 47 Corbett Road, Waterlooville, Portsmouth, Hampshire PO7 5TA.

VALVES for sale PL509/519, PY500A, PCF802, PCL805/85 £5 or swap for other secondhand components. Jonathan Tilley. Tel. Workley (042879) 2668.

FOR SALE Basic Electronics Learnakit course from B.N.R.E.S. Fully operational 'scope plus literature £75. G. S. Eves, 67 Winifred Road, Dagenham, Essex RM8 1PP. Tel. 592 3201.

BOOKS: Radio and Television Servicing 1952, 1971-1977 £5 per year. Valves, circuits. Ring or write. E. Godley, 18a Bawtry Road, Bessacarr, Doncaster DN4 5NR. Tel. 0302 536246.

FOR SALE ultra-violet light exposure box, see Maplin catalogue, as new, £20. Tel (0946) 61290, Whitehaven.

ATX 987 TRANSMITTER allows cordless performance of guitar/keyboard with any f.m. radio, £24 s.a.e. for details. R. Anderson, 10 Newbiggin Cresc., Tullibody, Clacks, Scotland FK10 2RT.

TELEQUIPMENT OSCILLOSCOPE service manuals. D-31/R, D-43, D-52, S-51, £8.50 each. S. J. Austin, 8 Greenwood Avenue, Chinnor, Oxfordshire.

DIGITAL STORAGE OSCILLOSCIPE OS4040. Gould pulse generator PG58A. Feedback sweep function generator SFG606. Any reasonable offers. J. Pearson, 34 Paddock Mead, Harlow, Essex CM18 7RR. Tel. (0279) 414784.

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EE MARKET PLACE MAY '89

ON SPEC

a regular feature for the Spectrum Owner...

by Mike Tooley BA

THIS month we attempt to throw some light on the problem of suspected RAM faults in early versions of the Spectrum. We shall also be reviewing a package which allows Spectrum users to design and produce their own printed circuit boards. We begin with an item of good news for all Spectrum fans.

SAM

By the time that you read this, **Miles Gordon Technology** should be starting to ship out the first batch of SAM computers. SAM promises to revolutionise the world of Spectrum computing; at last we have a machine which offers a performance to rival the Amiga and ST.

Readers can be assured that, in the months to come, SAM will become just as much a part of this column as the Spectrum-Plus and 128k machines have become. I, for one, am eagerly awaiting the delivery of my own SAM machine!

RAM Problems

David Wiley writes from Essex with a plea for help. He is using an issue 3B Spectrum and upgraded keyboard (available from Video Vault) but is having problems using the system at work as it appears to crash intermittently. David Writes:

"Instead of the usual black screen that appears when the Spectrum is reset, the program simply appears to lock up. On occasions, the screen may also be corrupted. I am fairly sure that this is a RAM fault (the computer was repaired some time ago). Can you tell me how to locate the faulty chip without desoldering it from the PCB?"

Well David, I must confess that I am not convinced that this problem really is caused by a faulty RAM device. The symptom is typical of spikes and other irregularities in the mains supply and it would be well worth checking this out first.

Any large item of electrical apparatus switching on and off is likely to produce transient spikes which can be carried some distance along the mains. These spikes comprise pulses having very fast rise and fall times which pass easily through most conventional power supplies of the transformer, rectifier, series-regulator variety. Having arrived within the computer enclosure, spikes can cause a good deal of havoc by corrupting data and even crashing programs.

In the first instance, it would be a good idea to switch any nearby electrical apparatus on and off to see if you can induce the fault. Alternatively, try moving the system to another room or operating it from a different mains outlet in the same room and see if the problem is cured or worse. The problem might even arise from switching your TV receiver or printer on and off, particularly if they are all connected to the same adaptor or extension cable.

If the mains supply does appear to be at fault, a mains power filter will almost certainly provide an immediate cure. A simple filter adaptor will provide both surge and spike protection and should cost no more than about £20.

If, on the other hand, the supply can be absolved from blame then it is, as David has suggested, worth checking out the RAM. It is possible to locate the faulty address and relate this to a faulty RAM device by the following procedure:

1. In direct mode, enter the BASIC command:

PRINT PEEK 23732+
PEEK 23733 * 256

The value printed on the screen will be the last valid memory location, n (where n will be 65535 and 32767 for 48k and 16k machines respectively). If a different value is printed, this indicates a RAM fault at the next address (i.e. if 43200 is printed, a fault is present at address 43201).

2 In order to determine which i.c. device is faulty, it is necessary to enter the following command:

POKE n+1,85 : PRINT PEEK n+1

3 If the result from step 2 is NOT 85 then refer to the following table in order to locate the faulty device otherwise proceed to step 4.

Value Returned	Error Bit	Faulty RAM Device
84	0	IC6
87	1	IC7
81	2	IC8
93	3	IC9
69	4	IC10
117	5	IC11
21	6	IC12
213	7	IC13

4 If the result from step 2 is 85, enter the following BASIC command:

POKE n+1,170 : PRINT PEEK n+1

Now refer to the table below in order to locate the faulty device:

Value Returned	Error Bit	Faulty RAM Device
171	0	IC15
168	1	IC16
174	2	IC17
162	3	IC18
186	4	IC19
138	5	IC20
234	6	IC21
42	7	IC22

Finally, if more than one RAM location is at fault, it will be necessary to proceed in order of ascending faulty address.

PCB Designer is the title of a remarkable software package from **Kemsoft.** If, like me, you may have been under the misapprehension that computer aided p.c.b. design demands the power of a full-blown PC, a plotter, and expensive software then you are about to be disillusioned. The **PCB Designer** is a quality software package that runs on any 48k or 128k Spectrum that will out perform many of its "professional" counterparts!

Two main versions are available; tape-based and disk (or microdrive) based. In addition, other versions are available which are configured for use with the following systems:

- Opus Discovery system
- MGT Plus-D/Disciple systems
- Tasman Centronics interface
- Kempston-E Centronics interface
- Kempston (early version) Centronics interface
- Datel Inter-printer interface
- ZX-LPRINT III interface
- Spectrum Hardware Manual (Melbourne House) printer interface
- Everyday Electronics Centronics interface (*January 1989*)

It should be noted that Kemsoft state the *minimum* system requirement (to produce UV (Ultra Violet)

Next month: We shall be devoting the whole of *On Spec* to the subject of interrupts. For the practically minded, we shall be including details of a practical Interrupt Controller designed by William Buick, a regular reader of this column.

In the meantime, if you would like a copy of our *'On Spec Update'*, please drop me a line enclosing a ***large*** (250mm×300mm) ***adequately*** (i.e. 42p for UK postage) stamped addressed envelope. *(Please also note that I can no longer provide individual replies to queries as my in-tray is currently overloaded with On Spec post!).*

Mike Tooley, Department of Technology, Brooklands Technical College, Heath Road, Weybridge, Surrey, KT13 8TT.

exposure-ready artwork) is a "Spectrum 48k computer and Epson FX, RX, or LX-80 printer or compatible plus a suitable interface". However, whilst a disc-based system is not essential, this method of storage does make movement from one part of the package to another much simpler and, of course, VERY much faster!

Program Modules

The Kemsoft package consists of a suite of program modules which are linked together by an overall "shell" program. The individual programs deal with p.c.b. track layout, p.c.b. component layout, and circuit diagrams.

The p.c.b. layout module allows users to produce an accurate track design using an Epson (or near-compatible) dot matrix printer. The program can cope with 1:1 artwork (for positive photo-resist coated copper laminated board) or double-size artwork for photo-reduction.

A large library of p.c.b. artwork is supplied (including single isolated pads, integrated circuit pads, edge connectors, and bus lines). In addition, the drawing pen (used to produce the tracks which link the pads) can be set to give a variety of track widths (between 0.3 and 5.1mm).

The program also incorporates a number of sophisticated features including block move / copy / rotate / x-mirror / y-mirror, erase, fill, undo, and preview layout. A dimensionally accurate printer routine is provided as is a means of custom pad design.

The component layout module is designed to allow users to construct component layout diagrams from track layouts produced by the p.c.b. module. Again, a comprehensive library of component outlines has been provided in order to make this task exceedingly simple. This module also incorporates the sophisticated block handling commands and print facilities that are available from within the p.c.b. layout module.

Finally, the circuit diagram module has facilities similar to that of its two companion programs but is intended to provide a means of generating electronic circuit diagrams rather than layout diagrams. Again, a comprehensive library of symbols has been provided.

In Use

Four screens (called pages) are used by the PCB Designer to display the full working area which is equivalent to a standard single-Eurocard sized board. Movement between pages is very straightforward and cursor control (using the Spectrum's number keys, 1 to 8) provides eight directions of motion. Commands are entered from the keyboard and the majority require only a single keypress (either shifted or unshifted).

I put the package through its paces using an MGT Plus-D disc interface, a Chinon 3.5in. disc drive (see *April EE*), a Citizen 120-D printer, and my workshop Spectrum Plus. PCB Designer is supplied on tape, and installation takes some time to perform. The process is, however, automated to a large extent as various BASIC and machine code files are easily transferred, one at a time, to disc.

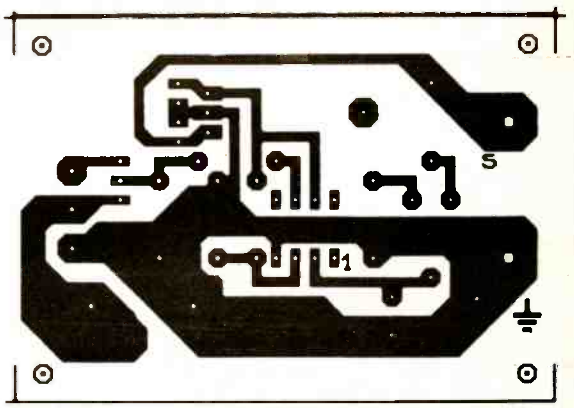
After working through the tutorial section of the PCB Designer manual, I started work on a small p.c.b. for a simple pulse generator based on two 555 timers and a handful of other components. The prototype board layout was completed in about 45 minutes and then I set about printing the 1:1 track layout using my Citizen 120-D printer.

I chose to use the quad density print facility which requires several minutes to generate the final master artwork. The result, however, was well worth waiting for—an exceptionally dense track pattern of astounding dimensional accuracy. The Kemsoft package (used in conjunction with one of the cheapest dot-matrix printers) really was capable of producing a layout which is almost indistinguishable from that produced by equipment and software costing more than ten times the price!

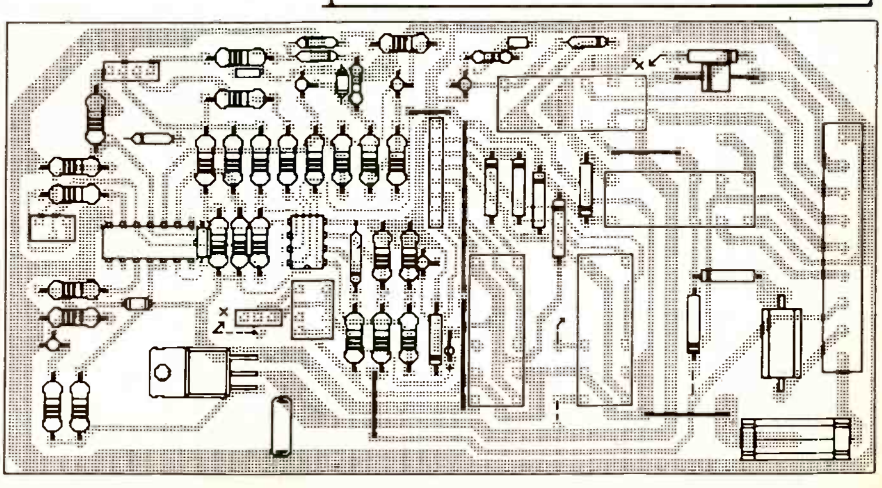
Manual

The A5 format manual supplied with Designer comprises approximately 50 pages of text and diagrams. The manual has a generous tutorial section (organised as a series of "lessons") where the user is introduced to the package.

This progressive approach is very effective and is instrumental in developing a high degree of familiarity with the package in a relatively short time. Further sections of the manual deal with printer compatibility, symbol libraries, and sample artwork.



(right) A p.c.b. layout produced by PCB Designer.



(below) Component layout diagram produced by PCB Designer.

Limitations

There are two principal limitations of the Kemsoft package which must be mentioned. The first relates to the maximum permissible board size (4.4in.×6.4in.) and the second relates to the lack of a multi-plane capability.

In fairness, neither of these shortcomings need concern the hobbyist who is principally concerned with producing single-sided boards of limited size. Indeed, provided that the single-Eurocard board size is not exceeded, the package is perfectly adequate for most "professional" requirements. Furthermore, the manual describes a method which can be applied in order to overcome the limitation of only handling single-sided boards.

In Conclusion

The **PCB Designer** is an exceptional package which can be very highly recommended. It should appeal to any electronics enthusiast involved with circuit layout and design. The package is amazingly sophisticated and offers many of the features which would be expected of packages which cost ten times the price. This must surely be the most useful piece of software that I have seen for a long, long time—well done Kemsoft!

The PCB Designer costs £30 and is available from Kemsoft, Dept EE, The Woodlands, Kempsey, Worcester, WR5 3NB. *(Note that, when ordering, it is important to state the version required and tape/microdrive users should specify the type of Centronics interface in use).*

Robot Roundup

NIGEL CLARK

BIG TRACK

THE NAME of Big Trak lives on. The toy vehicle may have been withdrawn from sale a number of years ago but it is not forgotten. And now two companies have stepped in to fill the gap.

Big Trak was a simple, inexpensive electronically-controlled vehicle which could remember a set of instructions entered by a keypad on the top. Although aimed at the toy market it was taken up enthusiastically by many in education who saw it was a cheap—about £25 at the time—way of introducing young children to the principles of programming and control theory. It used a few Logo-like commands, such as FORWARD and BACK so many steps, and turn through a number of degrees.

Valiant Technology's Roamer is a more complex version using the same basic ideas. ProCom's SEQ is a controller which allows simple instructions to be given to various kinds of robotic devices. Both companies mentioned Big Trak as being the inspiration for their new products, both of which were, coincidentally, on show for the first time at the British Education and Training Technology exhibition at the Barbican in London earlier this year.

The interest however has not prompted Milton Bradley, the US company which made Big Trak to reintroduce it or consider an update. In fact the company has decided to withdraw from the electronic toy market in Britain and is no longer selling its Robotix kits. Fans of the weird and wonderful motorised models will have to go to France where they are said to be selling well.

ROAMER

User friendliness has been the major concern in the development of Roamer. It is not only easy to use but can be customised to create different "characters".

The basic machine is shaped like a large Smartie and it has been described as an upturned wok. It is driven by two d.c. motors, the relative movements of the wheels providing the steering. Optosensors on the wheels provide feedback. It is powered by batteries.

Its memory can hold up to 60 instructions, but the number of movements which can be carried out can be expanded by the use of the Repeat and Procedure functions. Procedures can be created by entering instructions which will be carried out when the procedure is called.

There is also a scaling function enabling the user to set units of movement in multiples of one centimeter. Turns can be set in multiples of one degree.

It is possible to include sounds in a program. There are more than five octaves of sound which can be played at one of eight durations and five tempos.

Roamer is a stand-alone device but it can be linked to a computer for storage and on-screen editing of programs. At present there is an interface kit for the IBM PC and there are plans for others for the BBC range and the RML Nimbus.

Gillian Manvell of Valiant said the BBC interface would be a priority as a large number of schools had requested them. "We were surprised as we thought that schools would want to use Roamer by itself before trying the computer link."

CUSTOMISE

One of the most interesting features is the ability to customise Roamer. At present it comes with face shapes but it is intended to offer covers of different colours to which users can then add their own decorations.

Other functions planned include pen holders and a control box. A pen can be placed in a hole in the centre of the mobile and another three peripheral holders are to be sold so that pens can be placed at different points on the body.

The control box can be attached to Roamer to provide four sockets for operating d.c. and stepper motors and sensors, which Valiant is developing to increase Roamer's possibilities.

At present the basic Roamer pack includes one mobile, user guide, activity book and face shapes for about £90 plus VAT, but with educational discounts.

Two PJ 996 batteries are needed or rechargeable batteries can be supplied for about £80 plus VAT. Valiant says the batteries will last for several weeks of constant use. To help preserve power if Roamer has been left on and is not being used it will sound a warning at five minute intervals. After six warnings it will switch off.

Manvell said Roamer had been developed following a survey of LEA advisors asking what sort of equipment was needed for introducing children to the ideas of programming. She added that requests for a Big Trak replacement had increased as Big Traks grew older and less reliable.

The results showed that what was needed was a non-sexist, non-racist robust but flexible device which would appeal to girls as much as to boys. The result, after much deliberation and the advice of a design consultant was the Smartie shape.

In the meantime Valiant's turtle is selling well but the Microworlds being developed to expand their uses are taking even longer to come through. The first, Geometry I, has been available for some time but the next two, Geometry II and Arithmetic I, have not been completed. Geometry II is promised about now after much revision.

Other support material is being created under the auspices of the DTI's Microelectronics Education Support Unit. These also are not yet available.

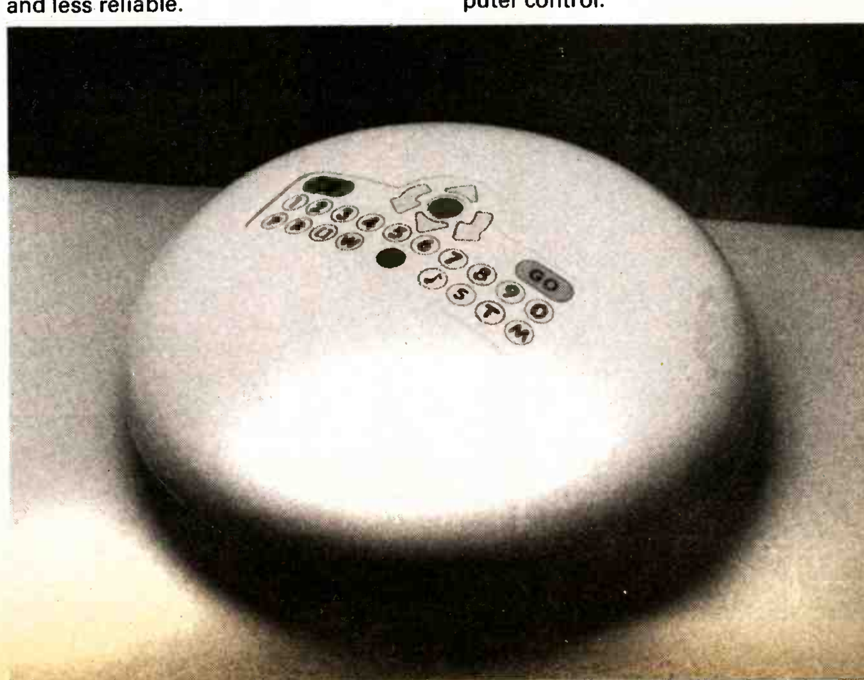
SEQ

ProCom's SEQ, pronounced "seek", is in effect a small computer designed specifically to control models by way of a simple LOGO-like language. It has the usual instructions and all the usual models can be used. The sockets however only accept Lego plugs.

Powered by batteries, the size depending on the equipment to be driven, SEQ has four inputs and four outputs. Each key has a click switch so that users know when a key has been pressed properly and each valid instruction receives a bleep. Up to 40 instructions can be stored.

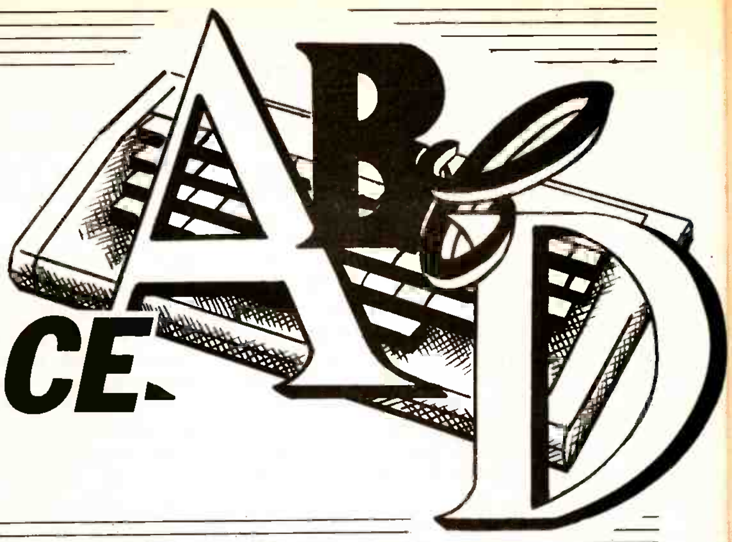
The basic package, costing about £85 plus VAT, includes the controller, instruction booklet, teacher guide, rechargeable batteries and leads with Lego plugs attached. The teacher guide is available separately at about £10.

Paul Spurgeon of ProCom, said he developed SEQ because he was tired of telling teachers at seminars about the benefits of Big Trak and then having to say that it was no longer available. He also thought that it was important that there should be a link between mechanically controlled models and full computer control.



Constructional Project

ELECTRON A/D INTERFACE



ROBERT PENFOLD

Upgrade your micro with this versatile, low cost, 8-bit interface. Ideal for use with the Electron User Port described last month.

THIS analogue to digital converter was primarily designed as an add-on for port A of the *Electron User Port* interface described last month. It provides the Electron with four analogue inputs having a full scale sensitivity of 1.8 volts, which is comparable to the analogue port of the BBC computer.

If preferred, the full scale voltage can be made somewhat higher at 2.55V, but with much better accuracy and stability. When not required, the unit can be unplugged from the user port interface so that port A can be used for other purposes.

The unit will permit the Electron to be used with many projects designed to fit onto the BBC computer's analogue port. However, there are a few points that need to be kept in mind, and the unit does not have total compatibility with the BBC computers.

This converter is only an 8-bit type, as opposed to the 12-bit chip used in the BBC machines. This is only a minor drawback in that the analogue port of the BBC computer suffers from noise problems that reduce it to 10-bit accuracy, and many users find even this level of resolution unattainable without resorting to multi-reading and averaging techniques. Few BBC add-ons rely on more than 8-bit resolution, and any device which use 10-bit resolution would presumably work with this interface, but with slightly reduced performance.

This unit is NOT software compatible with the BBC machines and it is not read via the BASIC ADVAL(x) function. However, it is easily read from BASIC or using assembly language routines, and converting BBC software to operate using this unit should not be difficult.

The analogue port of the BBC computer has two digital inputs that are intended to read the fire-buttons when this port is used with joysticks. This unit only has one digital input, and this is an edge-sensitive type (i.e. it detects a high to low or low to high transition) and is not comparable to the standard digital inputs of the BBC machine's analogue port.

This could result in the unit having too few inputs, but bear in mind that it only occupies one port (port A) of the user port interface. This leaves ten input/output lines available on port B, plus one line of port A, giving a total of eleven digital input output lines available. This should be sufficient for most purposes.

The unit is not really suitable as a joystick port for the Electron, but it was not designed as such. It is only intended for user add-ons.

On the plus side, this converter can provide around one hundred thousand conversions per second, which is about one thousand times as many as the chip used in the BBC machines. This enables it to accommodate high speed applications such as audio digitising, which are well beyond the reach of the BBC computer using its built-in converter.

It is also worth noting that it should work with any user port that can provide eight digital input lines plus one output. This makes it suitable for use with a wide range of computers, including the ***VIC-20, Commodore 64*** series, and ***Memotech MTX*** series. It could even be used with the user port of the BBC computer in order to provide a caster converter than the built-in type.

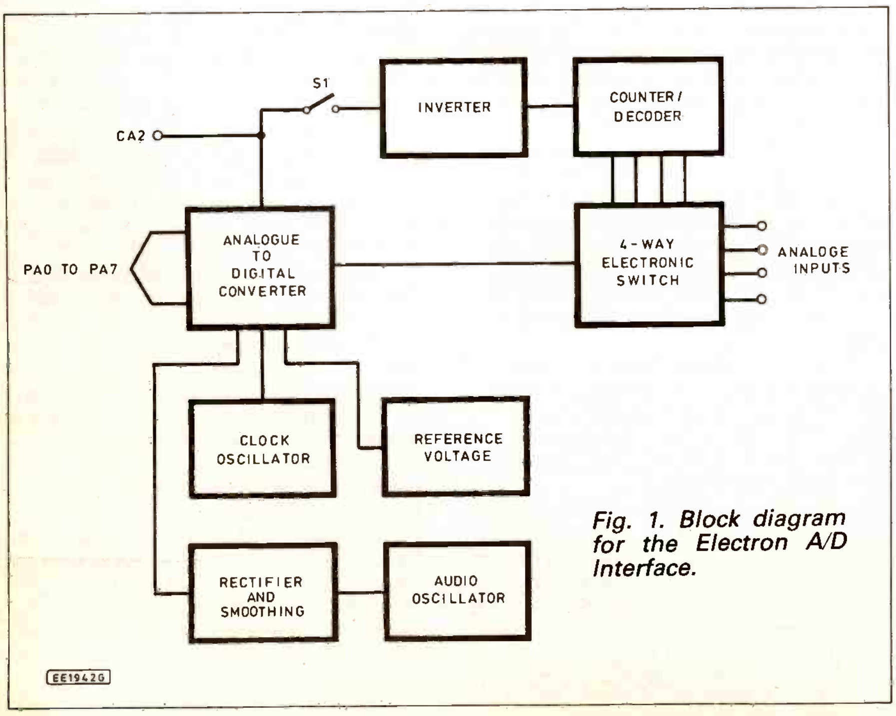


Fig. 1. Block diagram for the Electron A/D Interface.

SYSTEM OPERATION

The general arrangement adopted for this interface is as shown in the block diagram of Fig. 1. The analogue to digital converter is of the successive approximation type, and this is a technique which gives a good compromise between conversion speed and cost. It works by comparing the output from a digital to analogue converter with the input voltage.

Initially bit 7 of the D/A converter is set at 1 ("high") and all the other bits are set to zero ("low"). If the output potential from the D/A converter is lower than the input voltage, then bit 7 is left at 1. If not, it is set to zero.

This same process is then repeated for bit 6, then bit 5, and so on, until all eight bits have been set, and the digital value fed to the D/A converter is a true reflection of the input voltage. This 8-bit signal is fed to the outputs and is read by PA0 to PA7 of the user port interface.

This sequence is under the control of a clock oscillator, and takes nine clock cycles. The clock frequency is approximately 1MHz, and this represents an absolute maximum of about 110,000 conversions per second.

The converter is not guaranteed to operate at higher clock frequencies, but will usually function with a significantly higher clock rate. In practice it might be difficult to take readings at more than about 50,000 per second due to the limitations of the computer, and the time taken to store/process each reading. However, the system as a whole can operate sufficiently fast for most purposes.

The full scale sensitivity of the unit is controlled by the reference voltage generator circuit of the D/A converter, and split across four channels this gives what is only about 27,500 per second for each channel. This is more practical than having one converter per channel, which would be quite expensive.

Also, it is highly unlikely that the computer could keep up with four converters running flat-out (giving about 440,000 readings per second)! Incidentally, the converter in the BBC computer works in much the same way, giving only about 25 readings per channel with all four channels in use.

The computer must have some way of controlling the multiplexer so that it always knows which of the analogue inputs is being read. The system adopted here is a very simple one, and is really rather crude, but this is necessitated by the availability of only a single digital output on port A to control the unit. Remember that only CA1 and CA2 are left spare, and that CA1 can only operate as an edge sensitive input.

CA2 is used in its pulse output mode, and this means that it provides a negative high, in sequence, on successive input pulses.

These outputs drive a 4-way electronic switch, and result in each analogue input, in turn, being coupled through to the converter. Thus, the first reading is of channel 1, the next is of channel 2, then channel 3, and finally channel 4 is read. The unit then cycles back to channel 1 again, and continues in this manner indefinitely.

An important point to remember here is that the channels must be read in sequence, and it is not possibe to randomly access any desired channel. This is only a minor inconvenience, and it simply means that in order to read one or two channels a set of four readings must be taken, with the two or three unwanted readings simply being ignored.

CIRCUIT OPERATION

The full circuit diagram for the Electron A/D Interface appears in Fig. 2. IC1 is the analogue to digital converter chip, and is a

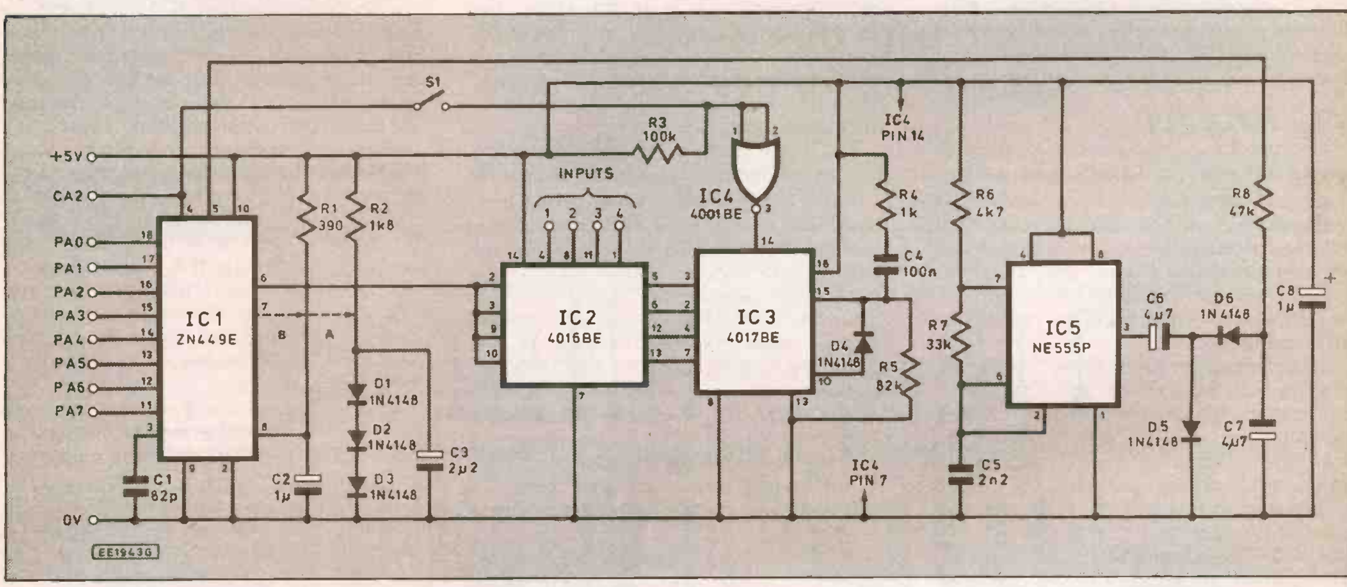


*Fig. 2. Complete circuit diagram for the Electron A/D Interface. The dotted line from pin 7 of IC1 refers to the voltage reference link wires A and B on the circuit board. Only **one** link is required, see text.*

is equal to this voltage. The converter chip has a very high quality built-in 2.55V reference source, but the option of a simple external 1.8V type is provided.

This is to give better compatibility with the BBC computer, which has a nominal input sensitivity of 1.8V full scale. The external reference is considerably inferior to the built-in circuit though, and use of the latter is strongly recommended if compatibility with the BBC computer is of no importance.

A negative supply is required for the "tail" resistor in the converter's high speed voltage comparator. This is derived from the main +5V supply using a simple oscillator, rectifier, and smoothing circuit.

ANALOGUE MULTIPLEXER

Although the converter is only a single channel type, it is easily changed to four channel operation using a simple analogue multiplexer circuit at its input. The idea is to feed each of the four inputs through to the converter in turn, with each input voltage being converted and read by the computer while it is connected through to the converter.

The total number of conversions per second is a maximum of about 110,000, but pulse for one (computer) clock cycle after each reading of PA0 to PA7. This pulse is fed direct to the "start conversion" input of the analogue to digital converter, and taking one reading therefore initiates the next conversion.

This makes the unit very easy to use, since reading the interface is just a matter of first setting CA2 to the right output mode and then repeatedly reading port A at ?&FC01. The only points to bear in mind are that the first reading is erroneous and should be discarded, as it will not have been preceded by a "start conversion" pulse.

If there is a long gap between taking one reading and the next, this second reading will be old data and might not be a valid one. This is not a major problem as the reading can be discarded and a new one then immediately taken.

In its most simple form, the interface is used with the multiplexer effectively disabled by having switch S1 open. The unit then functions as a single channel converter capable of 110,000 conversions per second on that one channel.

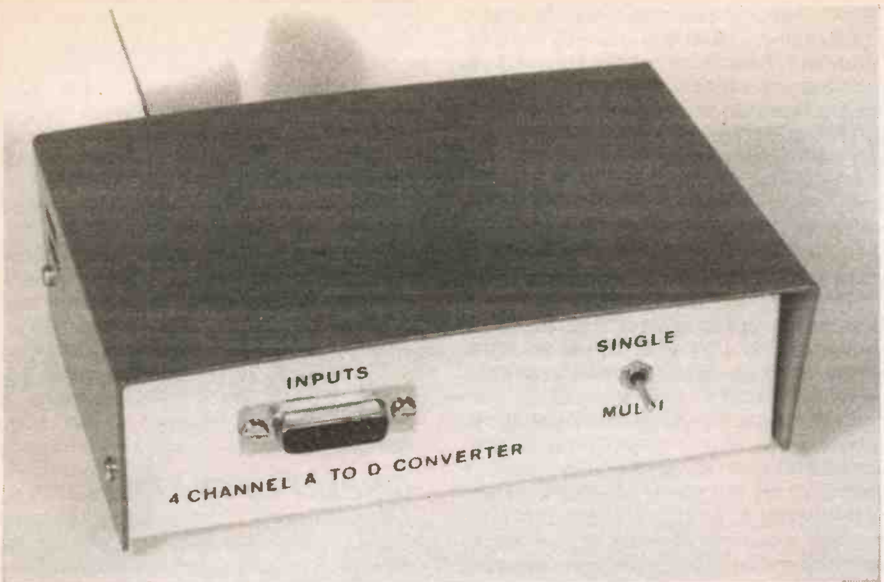
With S1 closed, the pulses from CA2 are fed via an inverter to a counter/decoder circuit. This circuit has four outputs which go Ferranti ZN449E. The ZN447E and ZN448E are also suitable, and these differ only in the degree of accuracy they offer.

The linearity is 0.25 l.s.b. for the ZN447E, 0.5 l.s.b. for the ZN448E, and 1 l.s.b. for the ZN449E. As the higher accuracy of the ZN447E and ZN448E is reflected in their prices, there is no point in using one of these devices unless your applications genuinely demand the higher level of accuracy they provide.

IC1 has an integral clock generator circuit, but this needs a discrete timing capacitor (C1). This has a value that sets the clock frequency at about 1MHz. You may like to try lower values here in an attempt to obtain a higher conversion rate. Some devices seem well able to operate at about 2MHz using just their self capacitance for C1!

The built-in 2.55V reference source of IC1 only requires a discrete load resistor R1 and capacitor C2. The alternative voltage regulator uses three series connected forward biased diodes (D1 to D3) to give an output voltage of about 1.8V.

This circuit has far lower stability than the built-in reference source, and in particular, it has substantially inferior temperature stability. However, as explained pre-



viously, it gives better compatibility with the BBC computers which have a very similar stabilised circuit in their analogue interface.

MULTIPLEXER

The analogue multiplexer is formed around the 4016BE CMOS quad s.p.s.t. analogue switch, IC2. In this circuit the outputs of the switches are connected together so that a four-way single-pole action is provided. Each switch is "on" when its control input is high, and "off" when its control input is low.

The four control signals are provided by IC3, which is a CMOS divide by ten circuit and one of ten decoder. The one of ten decoder section provides what is basically the required action, with outputs "0" to "9" going high, in sequence, for one clock cycle each.

The obvious problem here is that there are six too many outputs. This is overcome by coupling output "4" to the reset input by way of diode D4. Thus, instead of output "4" going high for one clock cycle, IC3 resets itself so that output "4" almost instantly returns to the low state, and output "0" goes high for almost one clock cycle. This effectively eliminates outputs "4" to "9", and gives the required one of four decoder action.

Resistor R4 and capacitor C4 reset IC3 at switch-on so that it starts with analogue input 1 selected. It is, of course, essential that the unit starts out from a known state.

The clock pulses from CA2 are inverted by IC4 prior to them being fed to IC3, and this is necessary to ensure that one conversion is read before the next one is initiated. Switch S1 is the 1/4 channel selector switch.

The 555 timer device IC5 operates in the standard astable configuration. This acts as the oscillator in the negative supply generator circuit. The output from the smoothing and rectifier circuit is only about 3V to 4V, and can supply only a very modest current without substantial loading occurring. However, this is quite adequate

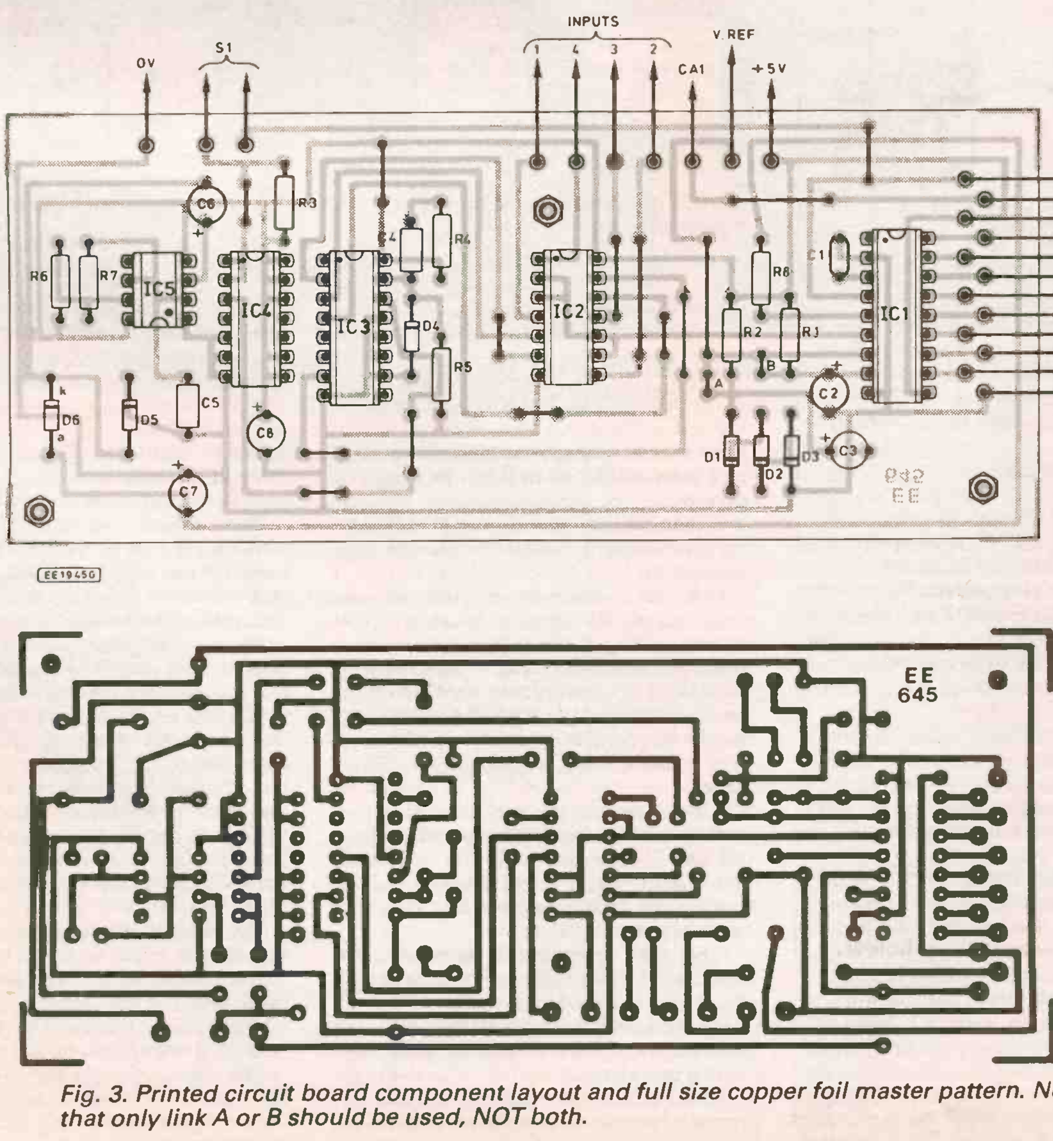


Fig. 3. Printed circuit board component layout and full size copper foil master pattern. Note that only link A or B should be used, NOT both.

for "tail" resistor R8 which only requires about 3V at 65 microamps.

The main circuit is powered by the +5V output of the Electron which is available at port A of the user port board. If the unit is used with a different computer this will almost certainly have a suitable +5V supply output. The typical supply current is a little over 30 milliamps, and under worse case conditions is still under 50 milliamps.

CONSTRUCTION

Construction should be straightforward enough for most constructors. The component layout and full size copper foil master pattern is shown in Fig. 3. This board is available from the *EE PCB Service*, code EE 645.

IC2 to IC4 are CMOS integrated circuits, and the usual anti-static handling precautions should be observed when dealing with these, including the use of integrated circuit holders. As IC1 is not a particularly cheap component, an 18-pin i.c. holder should be used for this device as well. Be careful when fitting IC5 as this has the *opposite* orientation to the other integrated circuits.

A number of link wires are needed, and these can be made from 22s.w.g. tinned copper wire, or resistor leadout trimmings should suffice. Note that you only need to fit the link marked "A" or the link marked "B", and should not fit both of them. Use "A" if you require the external (1.8V) reference, or "B" if you wish to use the internal (2.55V) reference source.

If you require only the internal voltage source, omit components R2, D1, D2, D3, and C3. If you only require the external reference source, omit resistor R1 and capacitor C2. If desired, all the components can be included on the board, and both links can be omitted. A changeover switch can then be used to permit front panel selection of the desired reference voltage output.

At this stage only fit pins to the board at the points where the connections from the output cable and input socket will eventually be made.

The finished interface can be left just as an uncased board, but it will be easier to use if it is fitted in a case. A metal instrument case having approximate dimensions of 150 by 100 by 50 millimetres is a good choice.

The printed circuit board is mounted on the base panel of the case on stand-offs, far enough back to leave sufficient room for switch S1 and an input socket to be mounted on the front panel. Any socket having a large enough number of ways could be used as the input socket, but a 15-way D-type connected to match the analogue port of the BBC computer is the most logical choice.

Suggested connections for the D-type socket are provided in Fig. 4. This shows the socket as viewed from the rear (i.e. as seen when making the connections to the socket). The "V.Ref." and "0V" terminals connect to two pins, and a couple of insulated leads must be used to link these two pairs of pins.

The BBC computer's analogue port actually has two types of earth terminal, the digital and analogue earths. The use of separate earths is supposed to combat the port's noise problems, but in most cases seems to be largely ineffective at doing so.

There is no equivalent in this circuit, and the two "0V" terminals shown in Fig. 4 are the ones used as analogue earth terminals in the BBC computers. Pins 2, 3, and 6 are used as the digital earths, and you may wish to wire these pins to the "0V" pins.

The analogue inputs of the BBC computer are sometimes referred to as channels 0 to 3, and at other times as channels 1 to 4. It is the second method of numbering that is used in this article.

Connection to the user port board is via a 20-way ribbon cable fitted with a 20-way IDC header socket. It is only necessary to connect one +5V lead and a single earth lead, leaving eight leads unused. The easiest way to handle these connections is to use a ready-made 20-way IDC header socket lead (available as BBC user port leads) and to trim back the unwanted leads.

The bare ends of the other leads should be generously tinned with solder, as should the pins on the board. There should then be no difficulty in producing strong soldered connections between the two.

The order of the connections on the board more or less matches the order in which the connections appear on the cable. Take great care to get all the connections right, and if necessary use a continuity checker to make sure that each pin of the socket connects through to the lead that you think it does.

With the case used in the prototype model it was possible to take the ribbon cable out between the top and base sections of the case. However, with most cases it will probably be necessary to file an exit slot in the rear of the case.

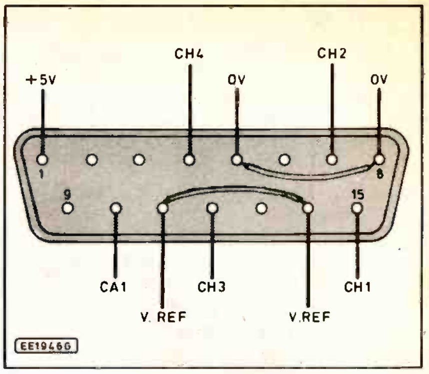
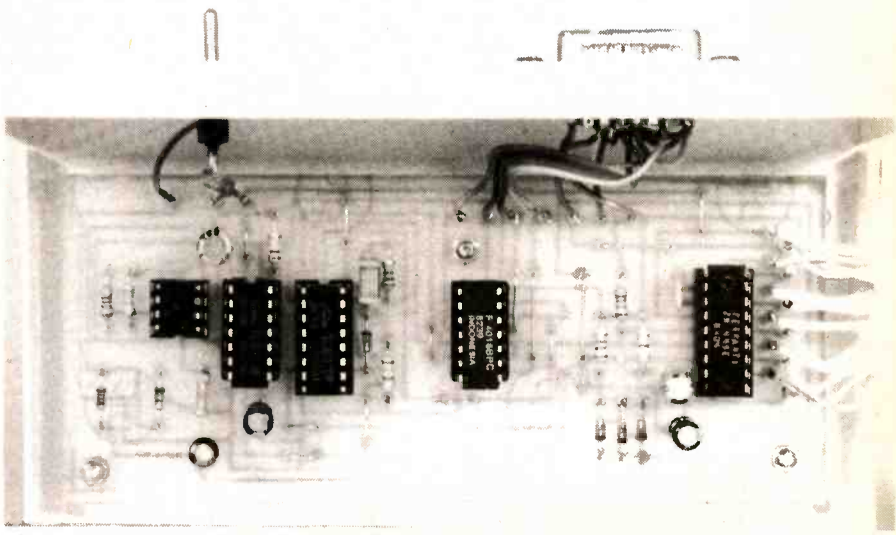


Fig. 4. Connections and wiring to the input socket.



Layout of components on the completed circuit board. Note the use of d.i.l. i.c. holder sockets.

COMPONENTS

Resistors

R1	390
R2	1k8
R3	100k
R4	1k
R5	82k
R6	4k7
R7	33k
R8	47k

All 0.25W 5% carbon

Shop Talk see page 314

Capacitors

C1	82p ceramic plate
C2, C8	1µ radial elec. 50V (2 off)
C3	2µ2 radial elec. 50V
C4	100n polyester
C5	2n2 polyester
C6, C7	4µ7 radial elec. 50V (2 off)

Semiconductors

D1 to D6	1N4148 signal diode (6 off)
IC1	ZN449E A/D converter
IC2	4016BE CMOS quad analogue switch
IC3	4017BE CMOS 1 of 10 decoder
IC4	4001BE CMOS quad 2-input NOR
IC5	NE555P timer

Miscellaneous

S1 s.p.s.t. sub-miniature toggle

Printed circuit board available from *EE PCB Service*, code EE645; case, about 150mm – 100mm × 50mm; 15-way D-socket; 20-way IDC header socket and cable; 8-way d.i.l. i.c. holder; 14-way d.i.l. i.c. holder (2 off); 16-way d.i.l. i.c. holder; 18-way d.i.l. i.c. holder; solder pins; wire; solder, etc.

Approx. cost Guidance only **£24**

TESTING

With the User Port connected to the computer, and the Analogue Interface connected to port A of the user port board, the computer should function normally when it is switched on. If there is any sign of abnormal behaviour, switch off at once and recheck the analogue interface wiring.

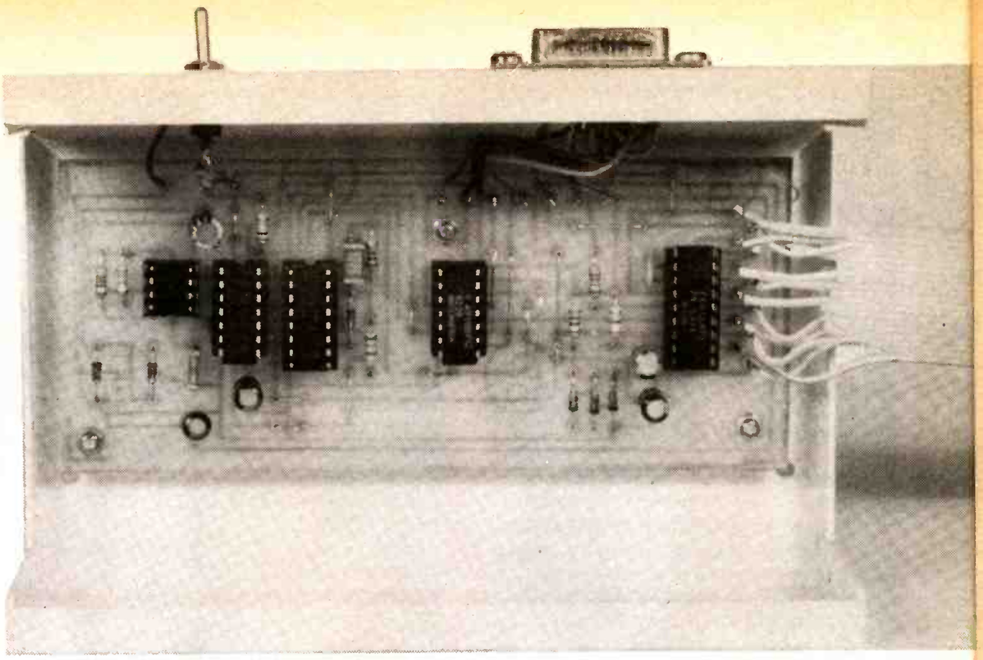
If all is well, try out this simple test programme.

```
10 Analogue Interface Test Prog
20 &FC0C=10
30 FOR L=1 TO 4
40 PRINT ?&FC01
50 NEXT L
60 PRINT " "
70 FOR D=1 TO 2500:NEXT
80 GOTO 30
```

There is no need to set up the port A data lines as inputs, as they are set to this mode at switch-on by the reset pulse supplied to the 6522 VIA. On the other hand, CA2 is an input in its default state, and it must be set to the correct output mode. This is the purpose of line 20 of the program.

Note that if the unit is used with other ports there may be no mode of operation that provides an automatic strobe pulse on an output line each time a read operation is performed. It might be that a strobe pulse can be produced by a write operation, and each reading of the analogue interface must then be followed by a dummy write operation to produce a start conversion pulse. In some cases it might be necessary to use two programme lines to set the strobe output low and then high again.

Lines 30 to 50 form a FOR . . . NEXT loop which reads the port four times. Assuming S1 is closed, this results in a reading for each channel being displayed on the screen (but remember that the initial reading from channel 1 is not a valid reading). The rest of the programme results in these sets of readings being repeated at about three second intervals, with a blank line being inserted between each set.



As a simple test procedure, try connecting the track of a 100k linear potentiometer from "V.Ref" to "0V", and connecting the wiper of each of the analogue inputs in turn. If the unit is functioning properly it should be possible to vary readings on the relevant channel smoothly from 0 to 255.

The A/D Interface is very easy to use when reading in a continuous stream of data, but it can give misleading results in applications where it is only read intermittently. This is due to the conversions on channel 1 being initiated when channel 4 is read, with a long gap then resulting between the conversion being completed and channel 1 being read. To avoid problems with stale data being obtained from channel 1, when the port is used intermittently, discard the first set of readings and then take a new set (which will all be fresh data).

Using the unit from BASIC there is no risk of reading the port faster than it can take readings. This is not the case with assembly language though, and if necessary a timing loop or some dummy instructions must be used to ensure that about 10μs or more is allowed to elapse between one reading and the next. □

b...Beeb...Beeb...Beeb...Bee

...Add Ons...Interfacing Facts and Figures...User Ports...

WHEN producing add-on projects for the BBC computers I seem to spend an inordinate amount of time tracking down the same old piece of information. Connections details for the user port, addresses of the VIA registers, etc.

Presumably many other BBC computer users have the same problem. This month's BEEB Micro article is not so much an article as a collection of the most used BBC interfacing facts and figures, put together to provide a useful source for reference purposes.

This information is primarily aimed at the experienced BBC user, and is not intended to be a complete introductory course on interfacing to the BBC computer. Further details of each of the topics covered can be found in previous *Beeb Micro* articles.

User Port

Probably most user add-ons for the BBC computers utilize the all-important user port. Connection details for this port are provided in Fig. 1. At the computer end there is a 20 way IDC plug–you need a 20 way IDC header socket and ribbon cable in order to make connections to it. There are several ground terminals plus two +5 volt supply lines. PB0 to PB7 are the main user port input/output lines while CB1 and CB2 are the handshake lines. The user port is provided by port B of one of the computer's 6522 VIAs (versatile interface adaptors). This has some sixteen registers, as detailed below:–

ADDRESS	REGISTER
&FE60	Port B
&FE61	Port A
&FE62	Data Direction B
&FE63	Data Direction A
&FE64	Timer 1 Low Byte (latch)
&FE65	Timer 1 High Byte (latch)
&FE66	Timer 1 Low Byte (counter)
&FE67	Timer 1 High Byte (counter)
&FE68	Timer 2 Low Byte (latch)
&FE69	Timer 2 High Byte (latch)
&FE6A	Shift Register
&FE6B	Auxiliary Control
&FE6C	Peripheral Control
&FE6D	Interrupt Flags
&FE6E	Interrupt Control
&FE6F	Port A (no handshaking)

It is easy to confuse the peripheral control and auxiliary control registers. The former controls the operating mode of the handshake lines while the latter is concerned with such things as the timers and shift register.

Port A of the VIA is used to provide the printer port. It is, of course, possible to use the printer port for user add-ons, but the hardware imposes certain restrictions. The main lines are buffered, and can only operate as outputs. CA1 is directly accessible but had been provided with a 4k7 pull-up resistor, while CA2 seems to be obtained via some sort of open collector buffer stage (see page 503 of the BBC manual).

Connection details for the printer port are shown in Fig. 2. It uses a 26 way IDC plug (incidentally use a 26 way IDC header socket to make connections to this port).

Handshaking

Handshake lines CB1 and CB2 are controlled by bits 4 to 7 of the peripheral control register (bit 4 for CB1, and bits 5 to 7 for CB2). Details of the available modes and the values used to select them are provided below:–

BINARY	DECIMAL	MODE
0	0	CB1 high-low handshake input
1	16	CB1 low-high handshake input
000	0	CB2 high-low handshake input
001	32	CB2 high-low independent input
010	64	CB2 low-high handshake input
011	96	CB2 low-high independent input
100	128	CB2 high-low handshake output
101	160	CB2 high-low pulse output
110	192	CB2 low output
111	224	CB2 high output

The lower nibble of the peripheral control register operates in the same way, but sets the operating modes of CA1 and CA2.

Timers

The modes of the two 16 bit timer counters are controlled by bits 5 to 7 of the auxiliary control register (bit 5 controlling timer 1, while bits 6 and 7 control timer 2). The values used to select the timer operating models are shown below:—

BINARY	DECIMAL	MODE
0	0	Timer 2 timed interrupt
1	32	Timer 2 countdown (input on PB6)
00	0	Timer 1 single shot timed interrupt
01	64	Timer 1 continuous interrupts
10	128	Timer 1 single-shot interrupt (output pulse on PB7)
11	192	Timer 1 continuous interrupts (square-wave output on PB7)

Analogue Port

The analogue port is probably second in popularity to the user port as far as do-it-yourself and add-ons are concerned. Unlike most of the other ports utilized for user add-ons, it is situated on the rear panel of the machine and not underneath it. It has a different type of connector as well; a 15 way D type socket. Connection details for this port are shown in Fig. 3.

Although the analogue port is a twelve bit type, noise problems mean that 10 bit accuracy and resolution are the best that are likely to be achieved. Multiple readings and averaging techniques might be needed in order to obtain even this level of accuracy. Separate analogue and digital ground terminals are supposed to permit the noise problem to be minimised, but seem to make little difference in my experience. The full scale value is approximately 1.8 volts for all four inputs, and the input resistance is extremely high.

Fig. 1. Connection details for the User Port.

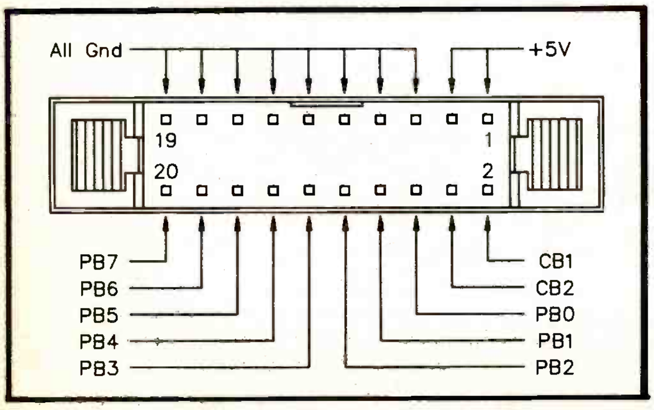
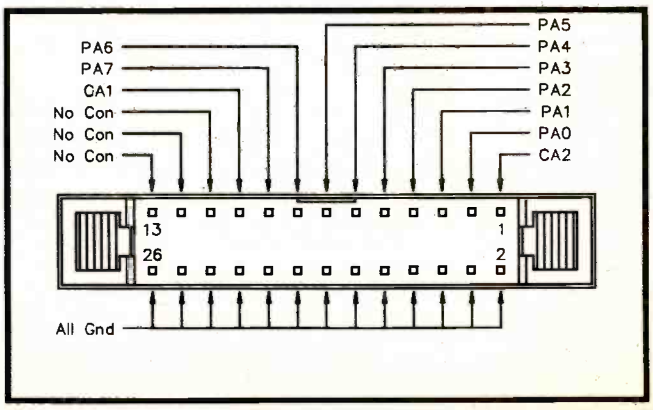


Fig. 2. Connections for the Printer Port when used for DIY add-ons.



Although the inputs are often referred to as channel 0 to 3 in the manual, they are read from BBC BASIC using ADVAL 1 to 4 respectively. Unhelpfully, the manual does sometimes refer to the channels as 1 to 4 (they are always numbered from 0 to 3 in this article). The maximum conversion rate is one hundred per second, which means twenty five conversions per second per channel (there is a single converter preceded by a four way anlogue multiplexer).

If less than four channels are needed it can often be helpful to disable the unused channels so that the conversion rate is as high as possible on the channels that are used. This is achieved using the ***FX16** operating system command, as detailed below:–

- ***FX16,0** disables all ADC channels
- ***FC16,1** enables only ADC channel 0
- ***FX16,2** enables channels 0 and 1
- ***FX16,3** enables channels 0, 1, and 2
- ***FX16,4** enables all four channels (the default setting)

Do not overlook the ***FX17** operating system command. This will force a conversion on the specified channel (using numbers from 1 to 4 to select channels 0 to 3 respectively).

1MHz Bus

The 1MHz Bus probably offers the greatest scope for expansion of the BBC computers. It provides access to the buses of the computer, by way of buffers or bi-directional buffers in most cases. Pages **&FC** and **&FD** are available for devices connected to this port. Address lines above A7 are not available at this port, but decoded page address outputs (**NPGFC** and **NPGFD**) are provided, which greatly simplifies adding circuits onto this port. The 1MHz Bus has a 34 way IDC header socket to make connections to it. Details of this port are provided in Fig. 4.

A problem with this interface is that of spurious pulses on the two page select lines. These tend to cause malfunctions when this port is used with virtually any add-ons unless a suitable de-glitching circuit is used to clean up these two outputs. In most cases the standard circuit of Fig. 5 will suffice. It should certainly be adequate for use with standard 65** and 68** peripheral chips, and I have never found the need for a more elaborate clean-up circuit with any 1MHz Bus add-ons.

The control bus is available at this port in the form of the two interrupt inputs (NIRQ and NNMI), the reset input (NRST), and the read/write line (R/W). The 1MHz clock is also available, and is needed by a lot of the 65** and 68** peripheral chips. This port runs at half the system clock speed so that it can be used with the standard versions of 65** and 68** peripheral chips.

Audio In/Out

The only other terminal of note on the 1MHz Bus is the audio input (AFIN) which can be used to feed the output of an add-on (such as a speech synthesiser) to the computer's internal audio amplifier and loudspeaker. The circuit diagram on page 503 of the user manual shows an audio output (PL16), but there is no proper audio output connector on the model B.

If you look at the front left hand corner of the printed circuit board you will find two pads labelled "PL16", and it would presumably be possible to take an audio output signal from these. Master 128 owners have the luxury of a real audio output socket on the rear panel of the machine.

Power Port

Five volt (+ve) outputs are available at both the user and analogue ports, but are absent from the printer port and 1MHz Bus. There is a power port on the BBC machines which provides a +5 volt output, together with +12 and −5 volt outputs. This seems to be one of the most useful ports of the computer, but it is one which is little used in practice.

One problem is that the 6 way power port plug is an unusual type, although it is available from some of the larger stockists of BBC accessories. Also, it is often used as the power source for disc drives (which is presumably its intended purpose).

However, many users (including myself) either have disc drives with built-in power supplies, or use a cassette based system. The power port is then available for user add-ons. Connection details for this port are shown in Fig. 6. Note that only four of the six terminals are actually used.

The maximum current available from each output depends on whether you are using a model B or a Master 128. The table provided below gives details of the maximum currents that can be drawn from both versions of the computer.

OUTPUT	MODEL B	MASTER 128
+5 volt	1.25A	0.9A
−5 volt	75mA	75mA
+12 volt	1.25A	1A

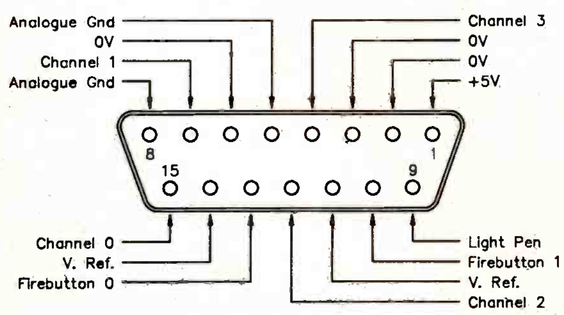


Fig. 3.

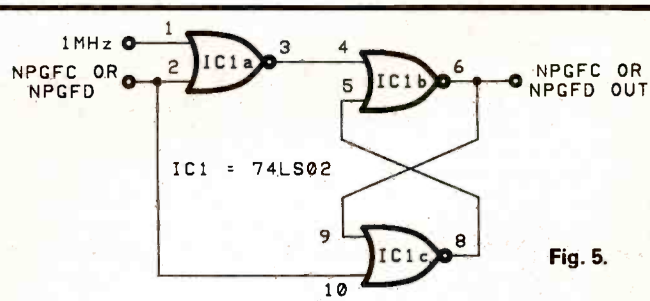


Fig. 5.

Fig. 3. The Analogue Port uses a 15-way D-socket. All four inputs have a full scale value of approximately 1.8V.

Fig. 4. Connection details for the 1MHz Bus. Most of the inputs/outputs are buffered.

Fig. 5. The standard 1MHz Bus deglitch circuit (not needed for the Master 128 incidentally).

Fig. 6. Connection details for the Power Port.

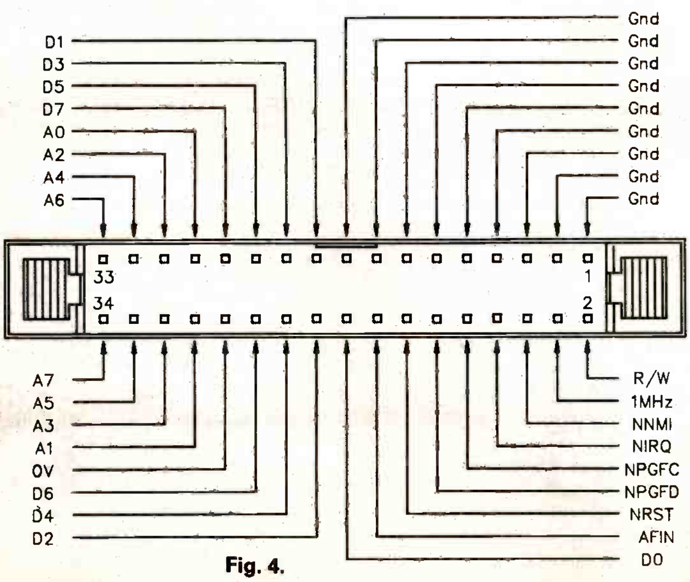


Fig. 4.

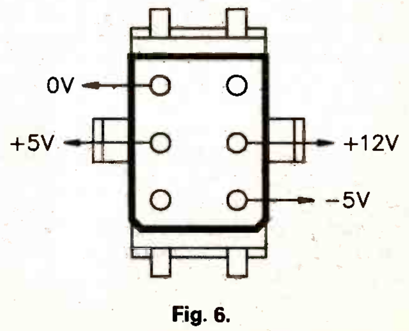


Fig. 6.

...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

BETTER SHORT WAVE LISTENING

Every now and then I return to short wave listening, which I find a fascinating activity. I listen to amateur transmissions of course, but I also like listening to broadcast stations from around the world. It is very satisfying to receive these transmissions on simple home-made receivers, but such equipment must be seen in its proper context—as an *introduction* to the hobby of short wave listening. If one wishes to take up the hobby seriously it is necessary to construct a sophisticated receiver, or to buy a quality commercially made one, although these can be expensive.

My remarks are prompted by the sight of an advertisement by Currys for their World Band Radio which has been reduced in price to £89.99 and which, to my mind, represents value for money.

The particular receiver is the Matsui MR4099. I have a Sangean ATS-803A from Comet which looks absolutely identical, and I have seen other look-alikes in Dixons and Tandy, all with different names and slightly different prices. I can't say for certain that they are all the same but they look like it.

Although it is the bottom end of the market for this type of receiver, the facilities available are very good. PLL synthesized tuning with digital display; band scanning; nine station presets; full frequency coverage from 150 to 29,999kHz; signal strength indicator; r.f. attenuator; narrow and wide audio filters; an external antenna socket; a beat frequency oscillator (b.f.o.) to enable single sideband and c.w. (Morse) signals to be received; an l.c.d. quartz clock; and more.

SYNTHESIZED TUNING

After years of hit and miss with cheaper "domestic" style short wave radios I took a long time before finally deciding to get a synthesized receiver. I knew that while traditional sets have smooth and continuous tuning, synthesized tuning progresses from one frequency to another in discrete steps, and that the "fine tuning" in the set I was interested in jumped frequencies 1kHz at a time. This posed no problem in receiving broadcast stations but I also wanted to listen to amateur stations using s.s.b. and c.w., where precise tuning is important. I was therefore unsure if my needs would be met except by buying a more expensive set having much smaller incremental steps.

Fortunately, my son decided to buy a Sangean so I was able to try it out at leisure to see just how it performed. I discovered that after selecting a frequency within 1kHz of an amateur s.s.b. or c.w. station it was possible to tune in the station with the b.f.o. quite satisfactorily, and on the strength of those tests I bought a set myself.

Gone are the days of trying to find that elusive station I heard last week on the 31 metre band. Now, with the aid of one of several books available listing station frequencies and times it is possible to punch in the appropriate frequency on the push button key-pad —and there is the station I want. The pre-set tuning provides instant access to my favourite stations around the world, or to the amateur bands.

ANTENNA IMPROVEMENT

The built in telescopic antenna is excellent for most purposes, but, if like me, you want to listen to everything then some better antenna arrangement is required. There is provision for an external antenna but simply plugging a long wire into the antenna socket may result in overloading the set and an inability to separate the several stations which suddenly seem to be on the same frequency.

One possible solution is to use an antenna tuning unit which will make the antenna more selective, but as the set is clearly not designed to cope with over-strong signals my preferred solution is a home made active antenna which actually has a telescopic antenna shorter than the radio's own built-in one.

This unit has a simple a.t.u. and an r.f. amplifier circuit using a single BC109 transistor. It is possible to peak strong signals by adjusting the a.t.u. controls with the amplifier switched off. With the amplifier switched on, amplification can be adjusted to the precise level necessary to minimise unwanted interference while still bringing in the wanted signal, including weak signals not receivable on the set's own antenna. My active antenna was "knocked up" in a few minutes.

HOME-MADE ACCESSORIES

The World Band Radio is a "portable" and as such does not have a built-in mains power supply. Consumption is heavy and batteries are expensive. However, there is a socket for an external 9V supply so it shouldn't be too much trouble to make up a small purpose-built power supply.

While it is not designed as a "communications" receiver, I have little doubt that I could use it as such by connecting up some of the external units I have for my amateur bands receiver, such as a very narrow band audio filter, a good quality a.t.u., a transmit/receive switch, and a converter for amateur v.h.f. and perhaps u.h.f. reception. It obviously wouldn't perform as well as a receiver specially designed for the amateur bands, but for a fraction of the price one couldn't quite expect that!

In the days when "state of the art" equipment was commonly home-constructed entire receiving or transmitting stations were often home-made. Nowadays, such equipment represents a major project for home constructors, undertaken by the dedicated few. As I have tried to indicate, however, it is quite feasible for today's hobbyist to make up reasonably simple accessories to improve the performance of an already sophisticated receiver.

Of course more expensive models of the same type may give a better performance than the World Band Receivers described here. They may be more sensitive, have better rejection of unwanted signals, more memories for pre-set tuning, finer incremental tuning and include additional features. However, for anyone interested in making a start on serious short wave listening without paying the very high prices asked for some sets, the receiver(s) mentioned here are good performers.

JAPANESE LICENCE EXAMS

Japan is in the process of changing its amateur radio licence examinations to multiple-choice format. It is also changing its Morse code test which under international regulations are mandatory for h.f. licensing.

Previously it was necessary to pass tests in both sending and receiving code. In future there will be a receiving test only although Japanese amateurs still have to learn two codes. The requirement for the second class licence, for instance, will be 50 characters per minute in Japanese Morse and 60 characters per minute in International code.

BUREAUCRACY

I reported in previous columns the farcical situation whereby new regulations prohibit licensed radio amateurs from constructing transmitters for the 10 metre amateur band, while at the same time they can obtain special permission from the DTI to make such equipment on the strength of their holding an amateur radio licence.

There has apparently been such a concerned response from members of the Radio Society of Great Britain that "this topic has been brought right to the top of the list of matters for discussion with the DTI."

It seems that the DTI now plan to publish a special authority in the *London Gazette* concerning this matter. The final wording has not yet been agreed says *Radio Communication*, the journal for the RSGB, "but in principle we see the authority alleviating most of the problems envisaged by readers of note 'aa' ". (Note 'aa' is the offending footnote in the new licence document which has caused all the trouble.)

While it sounds even more like a situation from "Yes Minister!", the RSGB is confident that "the anticipated authority" will be published "very soon".

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The books listed have been selected as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

For another selection of books see next month's issue.

MORE BOOKS NEXT MONTH – MORE BOOKS NEXT MONTH – MORE BOOKS NEXT MONTH

AUDIO & MUSIC

SYNTHESIZERS FOR MUSICIANS
R. A. Penfold
Modern synthesizers are extremely complex, but they mostly work on principles that are not too difficult to understand. If you want to go beyond using the factory presets or the random poking of buttons, this is the book for you.

It covers the principles of modern synthesis—linear arithmetic as used by Roland, phase distortion (Casio), Yamaha's frequency modulation, and sampling—and then describes how the instruments are adjusted to produce various types of sound—strings, brass, percussion, etc. The theoretical side of synthesis is treated in an easy to understand way—the technical information being restricted to what you need to know to use your instrument effectively.

168 pages **Order code PC105** **£6.95**

AUDIO
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.
Analysis of the sound wave and an explanation of acoustical quantities prepare the way. These are followed by a study of the mechanism of hearing and examination of the various sounds we hear. A look at room acoustics with a subsequent chapter on microphones and loudspeakers then sets the scene for the main chapter on audio systems—amplifiers, oscillators, disc and magnetic recording and electronic music.

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INTRODUCTION TO DIGITAL AUDIO
Ian Sinclair
Digital recording methods have existed for many years and have become familiar to the professional recording engineer, but the compact disc (CD) was the first device to bring digital audio methods into the home. The next step is the appearance of digital audio tape (DAT) equipment.

All this development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.

This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory is avoided, other than to state the end product

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MAKE MONEY FROM HOME RECORDING
Clive Brooks
Now that you've spent a fortune on all that recording gear, MIDI and all, wouldn't it be nice to get some of it back? Well here's the book to show you how.

It's packed with money making ideas, any one of which will recoup the price of the book many times over. Whether you have a fully fledged recording studio at home, or just a couple of stereo cassette recorders and a microphone, you'll be able to put the ideas in this book into practice and make money.

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GETTING THE MOST FROM YOUR MULTIMETER
R.A. Penfold
This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

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ELECTRONICS TEACH-IN
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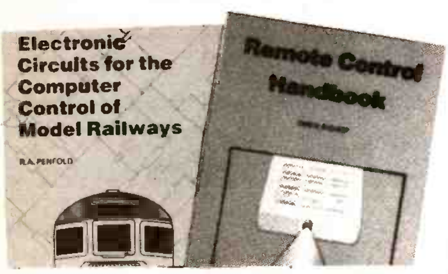

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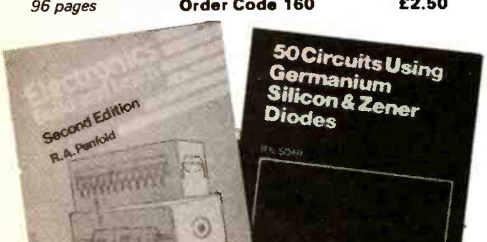

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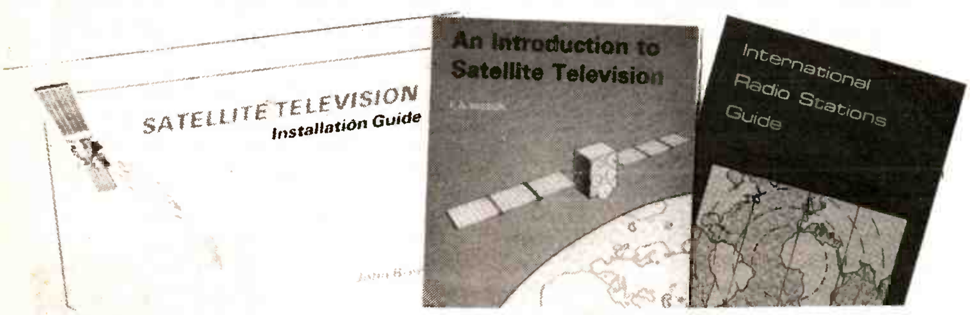

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ACTUALLY DOING IT!

by Robert Penfold

A LOT of would-be project constructors seem to be put off by doubts about their ability to get projects to work properly. It would be nice to be able to advise prospective constructors that there was nothing at all to worry about, and that they are guaranteed perfect results every time.

Things are never that simple in the real world though, and you are quite definitely not guaranteed perfect results every time. At least, not at the first attempt, without a little checking for errors. Letters from readers requesting help in getting projects to function properly testify to the fact that some constructors get seriously stuck on a project from time to time.

Looking at it in a more positive way, how many hobbies are there that the raw beginner can walk straight into and get everything right first time? Part of the fun of electronics construction is the challenge of getting the finished unit up and running. If you were guaranteed perfect results every time and at the first time of trying, I suspect there would be very few people building electronic projects.

MATTER OF CHOICE

If you start with a simple project though, the chances of getting your first project up and running are very good. There is an obvious temptation to jump straight in and start on an ambitious project, but to do this would almost certainly be a big mistake.

If you are the type of person who is quite willing to accept that the unit may well not function first time, and that you may need to gain more experience on other projects before returning to the unit and getting it functioning, then you may as well go straight in at the "deep end".

We suspect that quite a few are prepared to do things this way though. A first time failure can be very off-putting, and is best avoided. Find the most simple project you can. If you can not find a very simple project that is of much use to you, then build one that is of limited use to you. It will be worth it just for the experience you gain.

Having said that, choose a project having a function that you fully understand. It is much better to build a mundane but easily understood project like an egg timer, than something like a simple piece of test equipment which has a purpose that you do not really understand. It is not unknown for letters to be received from readers who have clearly misunderstood the precise function of a project, and where the project is not doing what they expected rather than failing to work properly!

We would strongly advise any beginners *against* building *mains* powered projects. Apart from the dangers involved if a mistake should be made during the construction of a mains powered project, it is much easier and safer to fault-find on a project which is powered from a humble PP3 size 9 volt battery. There is no need to worry about touching a "live" wire when testing a project powered from a low voltage battery, as there is no dangerous wiring to touch.

I cannot claim to be a great proponent of ready-made printed circuit boards.

However, for your initial projects there is a definite advantage in choosing projects which can be built on ready-made boards. These make it very easy to construct projects, and really do minimise the risk of making mistakes.

THE RIGHT PARTS

Having chosen a project you must obtain the right components. You may be able to obtain a kit of parts at a good price, or you might have to order them as individual components. I have given this advice several times before (as have many others), but it is still worth repeating.

Even if you happen to live near a large component store, the chances of obtaining all the components you require from one source is small. There is such a wide range of components available today that no one shop can stock them all.

An essential part of an electronics hobbyist's tool kit is at least three of the mail order component catalogues that are available. Some of these cost little or nothing, while some of the larger ones might cost about £2 or so.

The more expensive catalogues are well worth the money. Apart from removing a lot of frustration when searching for components, they contain a lot of useful data, photographs of components—a plethora of useful information in fact. My advice is to obtain as many component catalogues as you can.

If a component proves to be difficult to track down, check for a footnote in the components list or information about sources of supply within the article itself. In the case of *Everyday Electronics* you should consult the *"Shoptalk"* feature which gives details of sources of any hard to obtain components used in that month's projects.

Do read the article through thoroughly at least once! There is a steady flow of readers' letters requesting information that is either included in the article, or could be found elsewhere in the same issue of the magazine. Some points of detail may be unclear when you read the article, but these will normally become clear when you have a set of components and are ready to start construction.

THE RIGHT CHECKS

What do you do if you decide to build a project and it fails to work? Prevention is better than cure, and you should strive not to get into this position. Heeding the advice given above should help, as will learning to solder before you build your first project, rather than afterwards.

Soldering was covered in a recent *Actually Doing It* article, and we will not cover the same ground again here. Just bear in mind that the vast majority of faults on newly constructed projects are caused by poor soldering of one kind or another. Taking things slowly and carefully during construction can avoid a lot of searching for "dry" joints and solder blobs later on.

The obvious problem for the beginner when fault-finding is that he or she is unlikely to have any test equipment to help locate the fault. There is a lot to be said for having an array of test equipment, but a lot of fault-finding can be undertaken using nothing more than a 20k/volt analogue multimeter.

Assuming for the moment that you do not even have a multimeter, most of the fault-finding must be in the form of a visual inspection. Initially this simply means rechecking all the wiring for errors such as diodes or polarised capacitors (electrolytic and tantalum types) connected around the wrong way. The markings on modern components can be a bit confusing at times—make sure you have correctly identified all the components and that none have been accidentally swopped over.

If all the components seem to be present and correct, the next step is to search for solder splashes, "dry" joints, broken components, etc. Even if you have perfect vision, a magnifying glass is virtually essential for checking most circuit boards.

Magnifiers are available from some of the larger component stores, but these usually come as part of a "helping hands" type tool which has a stand and clips which hold the board for you. These are very good for visual checks of boards, but for the more intricate boards the higher magnification of a lupe type magnifier is very useful.

These are sold by some of the larger photographic shops for checking slides and negatives. They generally provide a magnification of about 8 or 10 times. This should be sufficient to track down the smallest of solder splashes.

At least, it will track them down if they are visible at all. Finished circuit boards tend to get covered with a fair amount of excess flux, and this can cover over blobs of excess solder. If there is any flux in evidence it is a good idea to clean it away using one of the special aerosol cleaners, or methylated spirits will usually work quite well.

An alternative to checking for short circuits visually is to use a continuity tester. This is a simple electronic device which can be used to check that there is no connection between parts of a circuit which should not be linked (i.e. adjacent pads and tracks). It can also be used to test for broken tracks.

If you adopt this method of checking, either use a multimeter switched to a middle resistance range, or use a continuity tester that is specifically designed for testing circuit boards. This is a rather slow and painstaking method of searching for short circuits, but it is still one that I favour.

It has the big advantage of being very reliable. I have occasionally discovered short circuits using a continuity tester after a thorough visual inspection failed to bring the offending pieces of solder to light.

Whatever you do, under no circumstances use a continuity tester comprised of something like a torch bulb or an electronic buzzer connected in series with a battery. A setup of this type operates at currents which are too high for many modern semiconductors to handle safely. Using a tester of this type you could easily destroy every semiconductor device in the circuit!

DRY JOINTS

Sometimes "dry" joints are physically very weak, and simply pulling the bodies of resistors, diodes, capacitors, etc. away from the board with moderate force will bring them to light. You will find that the weak joint gives way and one leadout pulls away from the board. This will also show up any joints you have forgotten to solder (something that is more easily done than you might think).

Unfortunately, "dry" joints are not necessarily mechanically weak. What can happen is that a leadout wire gets coated with flux, and then a blob of solder forms around it. The flux might be holding the blob of solder securely in place, but it will also be insulating the leadout wire from the solder and the copper track.

The only certain way to check for dry joints is to use a continuity tester to make sure that there is a connection between each leadout wire on the top side of the board, and the relevant track on the underside. This type of testing is a bit awkward as you are having to work on opposite sides of the board simultaneously.

A visual inspection will often reveal any "dry" joints that are present. Be very suspicious of any joint which seems to be infested with an unusually large amount of flux. Be even more suspicious of a joint which does not have the correct mountain type shape. "Dry" joints are usually more rounded and globular in shape.

A further tell-tale sign is that "dry" joints tend to have a dull finish, perhaps even showing signs of cracking and crazing on the surface. A good soldered joint normally has quite a smooth and shiny surface.

If you should discover a bad joint, remove all the solder from it. Then clean off the flux from the end of the leadout wire by scraping it with the blade of a penknife, gently filing it, or something of this type. Also clean off the pad if it is contaminated with flux, and then try resoldering the joint.

EASIWIRE

I have assumed that you will build projects on a custom printed circuit board or stripboard. These days there is the alternative of the Easiwire wire-wrapping method of construction. Obviously bad soldered joints and solder blobs do not arise when using this construction medium.

There can be problems though, although these are relatively easy to spot. The most likely problem is a wire which has not been cut off close enough to the first or last joint. This leaves a piece of wire which can easily come into contact with other wires or joints. The Easiwire equivalent of a solder splash in other words.

Another potential problem is careless wire-wrapping resulting in a turn of wire going round more than one joint. A third potential problem is that of broken wires. The wire used in the Easiwire "pen" is very thin and can be broken by careless wire-wrapping.

Fortunately, all these problems are easily spotted if you make a visual inspection of the board. The nature of Easiwire construction is such that repairs are easily carried out where necessary. Rather than trying to patch-up the wiring it is probably best just to remove the offending wire altogether, and then replace it with a new run of joints.

MULTIMETER

There is insufficient space available here to even scratch the surface of testing using a multimeter, but if you have a suitable instrument the first test is always to determine whether or not the power is getting through to the circuit board. Faults in on/off switches are not exactly unknown, and a broken lead in a battery connector probably ranks quite comfortably as the most common fault in battery powered euipment.

Sooner or later practically every project constructor searches for a fault only to discover that the unit is not switched on or no battery has been fitted! Last but by no means least, there is always the possibility that the battery is flat.

WRITING FOR HELP

In the last resort you can always write to the magazine or book publisher with a request for help. If you simply say that the project is not working, and provide no details of how the project performs, about the best you can hope for is some general advice of the type provided in this article.

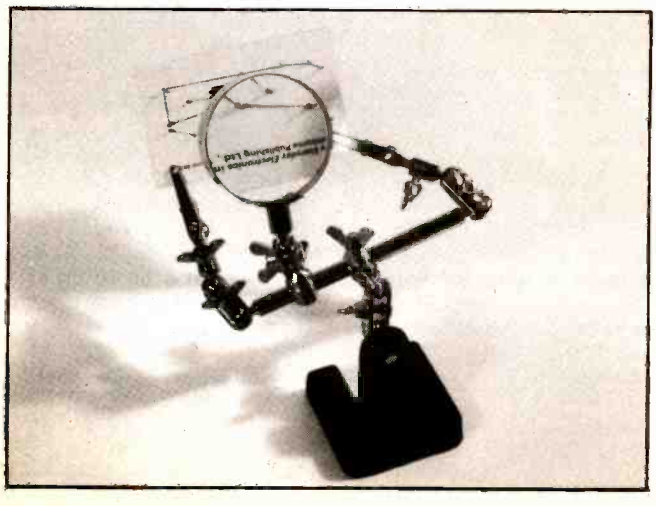
If you provide some specific information about what happens when the unit is switched on, then you stand a much better chance of getting specific information about what is likely to be wrong with the project. If nothing at all happens after switch-on, then say so. Even this is better than nothing to go on at all.

If you have a multimeter, take a list of test voltages, and specify what type of meter they were taken with. Obviously no project designer can guarantee to diagnose a fault correctly by "mail order", but the more information you supply the better your chances of obtaining a useful reply.

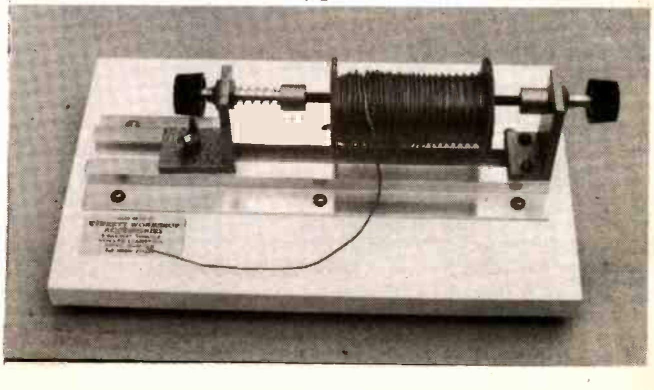
If possible your letter should be typed or produced using a computer and printer. If it is hand written try to make it as legible as possible. Provide as much information as possible, but be reasonably brief and to the point. Do not expect a quick reply if you send a letter several pages long, written in illegible hand writing, and containing a dozen or so obscure questions.

Finally, any letter that requires a reply ***should*** be accompanied by a stamped addressed envelope (or international reply coupons in the case of overseas readers).

Checking a solder joint with a magnifier attached to a "helping hand" jig.



Holding small solder reels is just one of many uses for the Everett Multi-Purpose work jig.



PCB SERVICE

Printed circuit boards for certain constructional projects (up to two years old) are available from the 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: The PCB Service, *Everyday Electronics* Editorial Offices, 6 Church Street, Wimborne, Dorset BH21 1JH. Cheques should be crossed and made payable to *Everyday Electronics (Payment in £ sterling only.)*

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

NOTE: *Boards for older projects–not listed here–can often be obtained from Magenta Electronics, 135 Hunter St., Burton-on-Trent, Staffs DE14 2ST. Tel: 0283 65435 or Lake Electronics, 7 Middleton Close, Nuthall, Nottingham NG16 1BX. Tel: 0602 382509.*

NOTE: please allow 28 days for delivery. We can only supply boards listed in the latest issue. Boards can only be supplied by mail order and on a payment with order basis.

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200MHz Digital Frequency Meter	548	£5.14
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(Software Cassette)	551S	£3.88
Random Light Unit – JAN '87 -	552	£5.88
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Mini Amp	554 & 555	£5.68
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DOWN TO EARTH

BY GEORGE HYLTON

FILAMENT LAMPS

YEARS AGO I lived in a house where the electric light bulbs had a curious habit of failing in groups. They would run for months without trouble then, within hours, several would burn out. At first I thought it was just coincidence, but after it had happened three or four times it became obvious that it wasn't.

What precipitated these bulb failures? The clue came from something else connected to the mains: our TV set. It was an old valve TV and was wearing out. Result: the picture didn't quite fill the screen. Usually, that is. Sometimes, however, the picture got bigger and brighter, temporarily.

It was during one of these bright spells that a light bulb failed. This time, instead of just fitting a new bulb I took out my meter and checked the mains voltage. It was 265V instead of the nominal 240V. Not much of an increase (about 10 per cent) but evidently enough to finish off a bulb which was already nearing the end of its life. I concluded that, once in a while, our mains voltage peaked for a time then fell back to normal for a long period.

BRIGHTNESS VERSUS LIFE

It may seem improbable that a mere 10 per cent increase in voltage should have such a marked effect on filament life. I was rather dubious myself, at the time, but there seemed to be no other explanation.

Years later I received a catalogue from a specialist lamp stockist (International Lamps of Hertford) which confirmed it. Their formula for predicting filament life goes like this. Divide the voltage which the lamp is designed to run at by the actual applied voltage.

Raise the answer to the twelfth power. The result is a number which compares the actual life with the normal life.

In my case the voltage ratio was 240/265=0.906. The twelfth power of this is 0.3. In other words, the 10 per cent increase in voltage reduces filament life to 30 per cent of normal. (See Fig. 1.)

Looked at from the opposite direction, it is clear that by under-running a filament its life can be greatly extended. So why don't we? The answer is to be found in another formula, which says that the relative light output is proportional to the same voltage ratio raised to the power of 3.5. On this basis a 10 per cent reduction in voltage gives rather more than a 30 per cent reduction in light output.

This may be quite tolerable in cases where the lamp is low-power and not much light is needed anyway, as is often the case with dial lamps. But for house lighting the loss of brightness may not be acceptable, especially as it is accompanied by a distinct yellowing of the colour. The design voltage evidently gives a compromise between life and brightness.

In any case, even if you accept the reduced life and over-run a filament the increased brightness may not last. The bulbs of filament lamps become blackened on the inside. This is due to the filament throwing off particles of tungsten.

This effect is accelerated at increased filament temperatures. Indeed, it is one cause of lamp failure. The particles don't come evenly from all over the filament but tend to be emitted by "hot spots". At these points the filament thins and breaks.

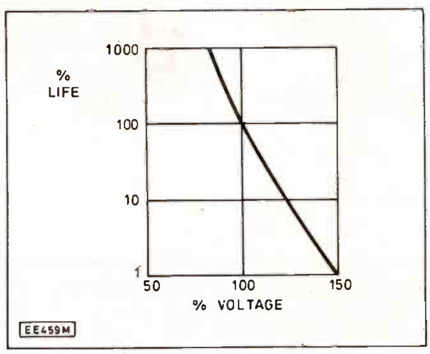

Fig. 1. How the life of a filament lamp varies with operating voltage. The '100' axes are for normal rated conditions.

QUARTZ HALOGEN

The high-tech answer to the blackening problem is the quartz halogen lamp. This is filled, in addition to the usual inert gas, with the vapour of a halogen element such as iodine. This acts as a transport system to carry the lost tungsten back to the filament.

The filament can be run at a higher temperature, giving increased brightness and a whiter light. To make the lamp work properly the bulb must be run very hot, so it's made from fused quartz rather than glass.

Now common in car headlamps and projector lamps these quartz halogen bulbs are gradually penetrating into other areas. You may well use them yourself, so it's worth pointing out one fact which is important when the lamp is controlled by a triac or similar switching device.

The inrush of current which flows when voltage is first applied to a cold filament is even ***greater*** for one of these lamps than for an ordinary filament lamp. The triac has to be able to handle perhaps ***30 times*** the normal running current for a few milliseconds.

LOW POWER LAMPS

In electronics nowadays, l.e.d.s are used in preference to filament lamps when all that's needed is an indicator. Light emitting diodes (l.e.d.s) are usually even less efficient than filament lamps, which themselves have efficiencies of around 8 per cent, but for indication it doesn't matter. L.e.d.s can produce enough light when the current is only a few miliamps: the best a filament lamp can offer is around 10mA. Also, l.e.d.s are cheaper.

Nevertheless, low-power filament lamps still have their uses, some of which exploit the fact that the resistance of a filament changes with current. For applications which utilise this it is generally desirable to use lamps of the smallest rated currents. It's a pity that these are hard to find on the hobbyist market.

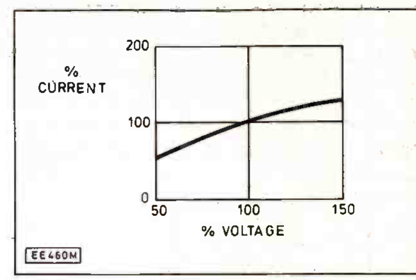

Fig. 2. As the voltage is raised the current through a lamp filament does not increase in proportion.

NON LIGHT USES

A bright lamp can have a resistance twenty or more times its cold resistance. As the voltage is increased, the resulting increase in resistance prevents the current from rising in proportion (Fig. 2). The lamp behaves as a rough sort of current stabilizer, which works with a.c. or d.c.

There are uses for this. In general they involve under-running the filament, so life is extended and it is practicable to use a wire-ended bulb soldered into circuit. Lamps like this can be very small (match head size).

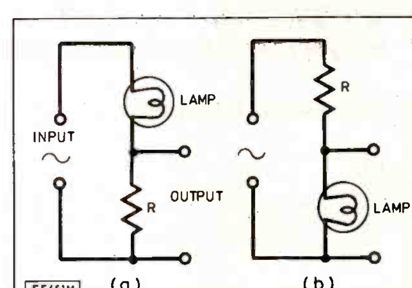

Fig. 3. Current-dependent voltage dividers. In (a) output variations are less than input variations. In (b) they are greater.

If a lamp is connected in series with an ordinary resistor (Fig. 3) to form a voltage divider, the division ratio is current-sensitive. It changes as the filament grows hotter or colder. If the circuit is driven by audio frequency signals it can produce compression or expansion of the dynamic range.

In (a), the range is compressed,

because output does not rise linearly with input. In (b) the effect is to exaggerate level changes. When cold (low inputs), the attenuation is large; when hot, not so large. So the loss decreases as the signal increases, giving "contrast expansion".

If the filament is run at dull red it responds rather sluggishly to changes. This is an advantage. If response were instantaneous the resistance would change over an audio cycle and cause distortion.

Nowadays, chips can be made which do the job better, but one cannot always find the right chip for a particular need, so a knowledge of lamp circuitry may come in handy. Most of the lamp tasks can, it must be said, be done better by thermistors, but the most suitable type of thermistor (miniature bead) is now very expensive.

The main limitations of lamps is that they need a lot of current and they give only a limited range of resistance change. Nothing can be done about the current (apart from using the lowest current lamp you can find) but the resistance change can in effect be exaggerated by using the lamp as one arm of a bridge set near balance (Fig. 4).

If a simple bridge (Fig. 4a) is set to balance when the filament is cold (no signal) then when the signal arrives and the filament resistance increases the bridge becomes unbalanced and gives an output. This is contrast expansion, since the unbalance increases with signal level.

If the bridge is set off-balance in the no-signal condition then the arrival of signals either increases the unbalance or decreases it, depending on the direction of the unbalance. If the signal drives the bridge towards balance, it gives compression. (It must be pointed out, however, that very large signals will drive the bridge right through balance into a new unbalance condition. The designer must ensure that such large signals can't be applied.)

If the bridge is driven by a mixture of a.c. and d.c., the d.c. can be adjusted to set the degree of unbalance. If the d.c. is itself made to depend on signal level then the a.c. level need not be great enough to have any direct effect on filament temperature.

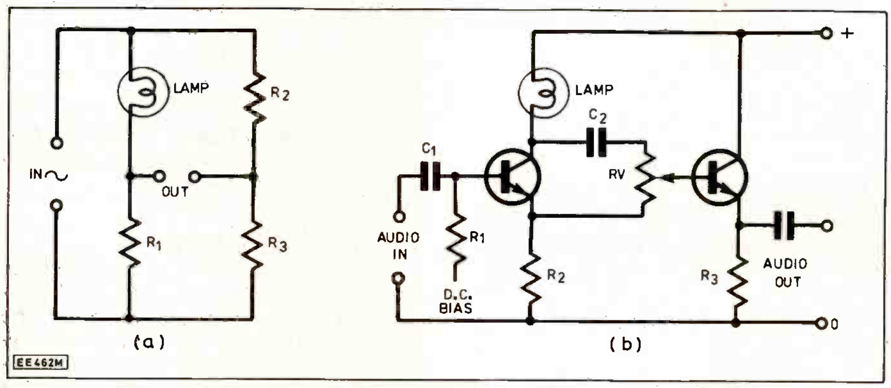

Fig. 4. Lamp bridge circuits exaggerate the effects of changes in lamp resistance.

If you'd like to experiment, try the transistor-driven bridge (Fig. 4b). This can be operated with a.c. or d.c. control.

If resistor R2 is chosen to have the same resistance as the lamp then a linear R_v gives balance with the slider at the mid point.

FLICKER

When driven by a.c., the filament receives maximum power near the peaks and minimum near the zero-crossings of the input waves. Its temperature tries to follow these changes, but it takes time for the metal of the filament to heat and cool so it can't follow perfectly.

At low frequencies (such as mains frequency) the resulting flicker (two peaks per cycle) is not visible to the eye, but it is there. Turntable speed checkers of the striped-disc type do work under filament lamps.

If, for some purpose such as signalling over a light beam, it is desirable to increase the flicker, this can be done by over-running the lamp. Heat loss and light radiation increase as the fourth power of the temperature, so a white-hot filament flickers more than a red-hot one.

If driven by pure a.c. the flicker frequency is double the input frequency. To produce audio flicker with low distortion the filament should be heated to the right temperature with d.c. and the audio superimposed at a lower current.

Such a light modulation system is inefficient, but it is possible to transmit speech from an over-run torch bulb if a large amount of treble boost is applied to compensate for the thermal inertia of the filament. I saw it done, many years ago, at a science fair at Cambridge. I wonder what the bright young people who demonstrated it are doing now.

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1(a) R=900Ω, I =11mA

(b)

$$R^t=\frac{1}{\frac{1}{10^3}+\frac{1}{5\times10^3}+\frac{1}{10^4}}$$

$$=\frac{1}{0.001+0.0002+0.0001}=\mathbf{769\Omega}$$

or

$$\frac{10k\times5k}{10k+5k}=\frac{50k}{15k}=3.33k$$

$$\therefore R^t=\frac{3.33k\times1k}{3.33k+1k}=\mathbf{769\Omega}$$

I=13mA

(c) 6k, 1.66mA

2. 1A

3(a) increase
same
(b) decrease
same
(c) same
decrease
(d) same
increase

4. It would overheat (and probably be destroyed).

5(a) $R_t=500+\frac{200k\times20k}{200k+20k}=500+1.18k$

=18.68k

(b) 11.45k

(c) 2.68mA for (a) and 4.37mA for (b)

6. It would stay at the same brightness—provided the voltage source could supply the extra current to pass through the resistor.

7. (a) 5k
(b) 50k
(c) 500Ω

8. half

9(a) 120V
(b) 80V
(c) 120W
(d) 1A

Note that the relationship between the four quantities can be seen from the results.

10. I_1 would be greater than I_2 because the resistance in the I_1 branch is less than that in the I_2 branch.

PLEASE NOTE:
The front cover of the Greenweld Spring Catalogue Supplement, presented free with EE last month, should have shown the Greenweld logo at the top. We appologise for this omission.

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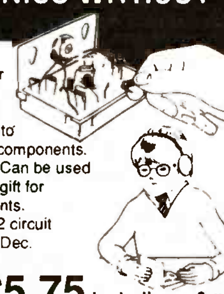

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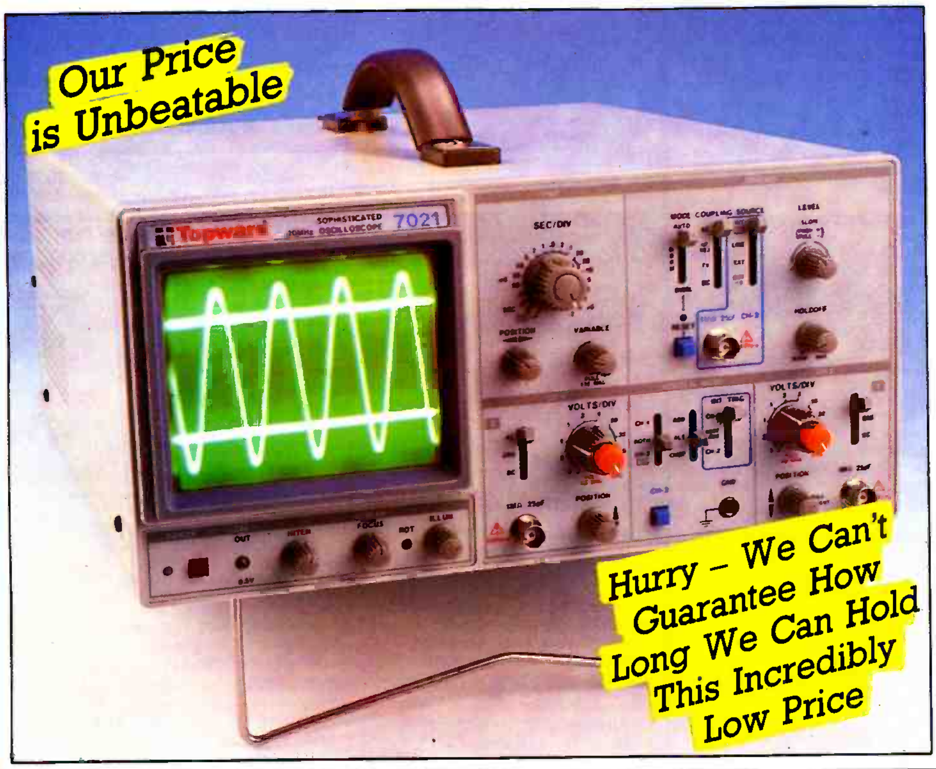

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