EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

DECEMBER 1986 £1·10

8 EXTRA PAGES

DUAL THERMOMETER
AUTOMATIC CAR ALARM
BBC 16K SIDEWAYS RAM
MINI ACTIVE SPEAKER

Plus INDEX FOR VOLUME 15

Newcomers Magazine for Electronic & Computer Projects

£1 BAKERS DOZEN PACKS

Price per pack is **£1.00.*** Order 12 you may choose another free. Items marked (sh) are not new but guaranteed ok.

1. 5 – 13 amp ring main junction boxes
2. 5 – 13 amp ring main spur boxes
4. 5 – surface mounting
5. 3 – electrical switches, white flush mounting
7. 4 – in flex line switches with neons
9. 2 – mains transformers with 6V 1A secondaries
10. 2 – mains transformers with 12V ½A secondaries
11. 1 – extension speaker cabinet for 6½" speaker
13. 12 – glass reed switches
17. 2 – ultrasonic transmitters and 2 receivers with circuit
19. 2 – light dependent resistors
25. 4 – wafer switches – 6p 2 way, 4p 3 way, 2p 6 way, 2p 5 way, 1p 12 way small one hold fixing and good length ¼ spindle your choice
28. 1 – 6 digit counter mains voltage
30. 2 – Nicad battery chargers
31. 1 – key switch with key
33. 2 – aerosol cans of ICI Dry Lubricant
34. 96 – 1 metre lengths colour-coded connecting wire
39. 1 – long and medium wave tuner kit
41. 8 – rocker switch 10 amp mains SPST
45. 1 – 24 hour time switch mains operated (s.h.)
49. 10 – neon valves – make good night lights
50. 2 – 12V DC or 24V AC, 3 CO relays
51. 1 – 12V 2 CO miniature relay very sensitive
52. 1 – 12V 4 CO miniature relay
54. 10 – rows of 32 gold plated IC sockets (total 320 sockets)
55. 1 – locking mechanism with 2 keys
56. 1 – miniature uniselector with circuit for electric jigsaw puzzle
60. 5 – ferrite rods 4" × 5/16" diameter aerials
61. 4 – ferrite slab aerials with L & M wave coils
63. 1 – Mullard thyristor trigger module
66. 1 – magnetic brake – stops rotation instantly
67. 1 – low pressure 3 level switch can be mouth operated
69. 2 – 25 watt pots 8 ohm
70. 2 – 25 watt pots 1000 ohm
71. 4 – wire wound pots – 18, 33, 50 and 100 ohm your choice
77. 1 – time reminder adjustable 1-60 mins clockwork
85. 1 – mains shaded pole motor ¾" stack – ¼ shaft
89. 1 – mains motor with gear box 1 rev per 24 hours
91. 2 – mains motors with gear box 16 rpm
96. 1 – thermostat for fridge
98. 1 – motorised stud switch (s.h.)
101. 1 – 2½ hours delay switch
103. 1 – mains power supply unit – 6V DC
104. 1 – mains power supply unit – 4½V DC
107. 1 – 5" speaker size radio cabinet with handle
112. 1 – heating pad 200 watts mains
114. 1 – 1W amplifier Mullard 1172
115. 1 – wall mounting thermostat 24V
118. 1 – teak effect extension 5" speaker cabinet
120. 2 – p.c. boards with 2 amp full wave and 17 other recs
121. 4 – push push switches for table lamps etc.
122. 10 – mtrs twin screened flex white p.v.c. outer
124. 25 – clear plastic lenses 1½" diameter
127. 4 – pilot bulb lamp metal clip on type
128. 10 – very fine drills for pcbs etc.
129. 4 – extra thin screw drivers for instruments
132. 2 – plastic boxes with windows, ideal for interrupted beam switch
134. 10 – model aircraft motor – require no on/off switch, just spin to start
137. 1 – 6½" 4 ohm 10 watt speaker
142. 10 – 4 BA spanners 1 end open, other end closed
145. 2 – 4 reed relay kits 3V coil normally open or c/o if magnets added
146. 20 – pilot bulbs 6.5V.3A Philips
154. 1 – 12V drip proof relay – ideal for car jobs
155. 3 – varicap push button tuners with knobs
169. 4 – short wave air spaced trimmers 2-30f
172. 10 – 12V 6W bulbs Philips m.e.s.
178. 3 – oblong amber indicators with lilliputs 12V
180. 6 – round amber indicators with neons 240V
181. 100 – p.v.c. grommets ⅜ hole size
182. 1 – short wave tuning condenser 50 pf with ¼" spindle
184. 1 – three gang tuning condenser each section 500 pf with trimmers and good length ¼" spindle
188. 1 – plastic box sloping metal front, 16 × 95mm average depth 45mm
193. 6 – 5 amp 3 pin flush sockets brown
195. 5 – B.C. lampholders brown bakelite threaded entry
196. 1 – in flex simmerstat for electric blanket soldering iron etc.
197. 2 – thermostats, spindle setting – adjustable range for ovens etc.
199. 1 – mains operated solenoid with plunger 1" travel
200. 1 – 10 digit switch pad for telephones etc.
201. 8 – computer keyboard switches with knobs, pcb or vero mounting
206. 20 – mtres 80 ohm, standard type co-ax off white
211. 1 – electric clock mains driven, always right time – not cased
216. 1 – stereo pre-amp Mullard EP9001
232. 2 – 12V solenoids, small with plunger
236. 1 – mains transformer 9V 1 amp secondary C core construction
241. 1 – car door speaker (very flat) 6½" 15 ohm made for Radiomobile
241. 2 – speakers 6" × 4" 4 ohm 5 watt made for Radiomobile
243. 2 – speakers 6" × 4" 16 ohm 5 watt made for Radiomobile
244. 1 – mains motor with gear-box very small, toothed output 1 rpm
245. 4 – standard size pots, ½ meg with dp switch
249. 1 – 13A switched socket on double plate with fused spur
266. 2 – mains transformers 9V ½A secondary
267. 1 – mains transformers 15V 1A secondary p.c.b. mounting
291. 1 ten turns 3 watt pot ¼ spindle 100 ohm
296. 3 car cigar lighter socket plugs
298. 2 15 amp round pin plugs brown bakelite
300. 1 mains solenoid with plunger compact type
301. 10 ceramic magnets Mullard 1" × 3/8 × 5/16
303. 1 12 pole 3 way ceramic wave charge switch
305. 1 tubular dynamic microphone with desk rest
308. 1 T.V. turret tuner (black & white T.V.)
310. 2 oven thermostats
313. 5 sub miniature micro switches
314. 1 12" 8 watt min fluorescent tube white
315. 1 6" 4 watt min fluorescent tube white
318. 1 round pin kettle plug with moulded on lead
453. 2 – 2½ in. 80ohm loudspeakers
454. 2 – 2½ in. 8ohm loudspeakers

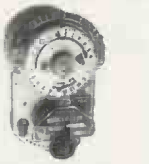
FROZEN PIPES Can be avoided by winding our heating cable around them, 15 mtrs connected to mains cost only about 10p per week to run. Hundreds of other uses as it is waterproof and very flexible. Resistance 60ohms/metre. Price 28p/metre or 15m for £3.95.

MULLARD UNILEX AMPLIFIERS

We are probably the only firm in the country with these now in stock. Although only four watts per channel, these give superb reproduction. We now offer the 4 Mullard modules – i.e. Mains power unit (EP9002) Pre amp module (EP9001) and two amplifier modules (EP9000) all for **£6.00** plus £2 postage. For prices of modules bought separately see TWO POUNDERS.

CAR STARTER/CHARGER KIT

Flat Battery! Don't worry you will start your car in a few minutes with this unit – 250 watt transformer 20 amp rectifiers, case and all parts with data **£14.50** or without case **£18.50** post £2.

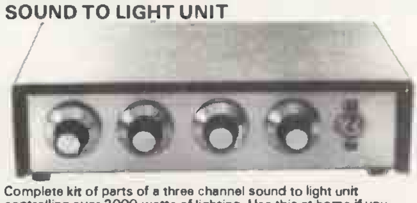


Ex-Electricity Board. Guaranteed 12 months.

VENNER TIME SWITCH

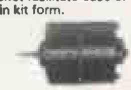
Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only **£2.95** without case, metal case – **£2.95**, adaptor kit to convert this into a normal 24hr. time switch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

SOUND TO LIGHT UNIT



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

12 volt MOTOR BY SMITHS



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

25A ELECTRICAL PROGRAMMER

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

THIS MONTH'S SNIP

OCTOBER SNIP is a 9" black & white video display unit, made in Japan by the Famous Hitachi company their model number H9905 11. It has it's own power supply and display electronics. It is a Professional instrument tested before dispatch. Special snip Price is £10 plus £3 post.

INSTRUMENT TURNTABLE

Very well made with unique coiled arrangement for Hitachi video unit, also suitable for most modern scopes and many other instruments. Price £5 plus £2 post, Our Price 5P72.

LIGHT BOX

This when completed measures approximately 15" × 14". The light source is the Phillips fluorescent 'W' tube. Above the light a sheet of fibreglass and through this should be sufficient light to enable you to follow the circuit on fibreglass PCBs. Price for the complete kit, that is the box, choke, starter, tube and switch, and fibreglass is £5 plus £2 post, order ref 5P69.

TANGENTIAL HEATERS?

We again have very good stocks of these quiet running instant heat units. They require only a simple case, or could easily be fitted into the bottom of a kitchen unit or book case etc. At present we have stocks of 1·2kw, 2kw, 2·5kw, and 3kw. Prices are £5 each for the first 3, and £6.95 for the 3k. Add post **£1.50** per heater if not collecting.
CONTROL SWITCH enabling full heat, half heat or cold blow, with connection diagram, 50p for 2kw, 75p for 3kw.

FANS & BLOWERS

5" **£5 + £1.25** post. 6" **£6 + £1.50** post
4" × 4" Muffin equipment cooling fan 115V **£2.00**
4" × 4" Muffin equipment cooling fan 230/240V **£5.00**
5" Plannair extractor **£5.50**
9" Extractor or blower 115V supplied with 230 to 115V adaptor **£9.50 + £2** post.
All above are ex computers but guaranteed 12 months.
10" × 3" Tangential Blower. New. Very quiet – supplied with 230 to 115V adaptor on use two in series to give long blow **£2.00 + £1.50 post or £4.00 + £2.00 post for two.**

IONISER KIT

Refresh your home, office, shop, work room, etc. with a negative ION generator. Makes you feel better and work harder – a complete mains operated kit, case included. **£11.95** plus £2.00 post.

TELEPHONE BITS

Master socket (has surge arrestor – ringing condenser etc) and takes B.T. plug **£3.95**
Extension socket **£2.95**
Dual adaptors (2 from one socket) **£3.95**
Cord terminating with B.T. plug 3 metres **£2.95**
Kit for converting old entry terminal box to new B.T. master socket, complete with 4 core cable, cable clips and 2 BT extension sockets **£11.50**
100 mtrs 4 core telephone cable **£8.50**

MINI MONO AMP on p.c.b. size 4" × 2" (app.)

Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of **£1.15** each, or 13 for **£12.00**

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£2 POUNDERS*

2P2 –Wall mounting thermostat, high precision with mercury switch and thermometer
2P3 –Variable and reversible 8-12v psu for model control
2P4 –24 volt psu with separate channels for stereo made for Mullard UNILEX
2P6 –100W mains to 115V auto-transformer with voltage tappings
2P8 –Mains motor with gear box and variable speed selector. Series wound so suitable for further speed control
2P9 –Time and set switch. Boxed, glass fronted and with knobs. Controls up to 15 amps. Ideal to program electric heaters
2P10 –12 volt 5 amp mains transformer
2P12 –Disk or Tape precision motor – has balanced rotor and is reversible 230v mains operated 1500 rpm
2P14 –Mug Stop kit – when thrown emits piercing squawk
2P15 –Interrupted Beam kit for burglar alarms, counters, etc.
2P17 –2 rev pr minute mains driven motor, ideal to operate mirror ball
2P18 –Liquid/gas shut off valve mains solenoid operated
2P19 –Disco switch-motor drives 6 or more 10 amp change over micro switches supplied ready for mains operation
2P20 –20 metres extension lead, 2 core – ideal most Black and Decker garden tools etc.
2P21 –10 watt amplifier, Mullard module reference 1173
2P22 –Motor driven switch 20 secs on or off after push
2P26 –Counter resettable mains operated 3 digit
2P27 –Goodmans Speaker 6 inch round 8ohm 12 watt
2P28 –Drill Pump – always useful couples to any make portable drill
2P31 –4 metres 98 way interconnecting wire easy to strip
2P32 –Hot Wire amp meter – 4½ round surface mounting 0–10A – old but working and definitely a bit of history
2P34 –Solenoid Air Valve mains operated
2P38 –200 R.P.M. Geared Mains Motor 1" stack quite powerful, definitely large enough to drive a rotating aerial or a tumbler for polishing stones etc.
2P43 –Small type blower or extractor fan, motor inset so very compact, 230V
2P46 –Our famous drill control kit complete and with prepared case.
2P49 –Fire Alarm break glass switch in heavy cast case
2P51 –Stereo amplifier, 3w per channel
2P55 –Mains motor, extra powerful has 1½" stack and good length of spindle
2P62 –1 pair Goodmans 15 ohm speakers for Unilox
2P64 –1 five bladed fan 6½" with mains motor
2P66 –1 2Kw tangential heater 115v easily convertible for 230V
2P67 –1 12v–0–12v 2 amp mains transformer
2P68 –1 15v–0–15v 2 amp mains transformer
2P69 –1 250v–0–250v 60 mA & 86.3v 5A mains transformer + 50p post
2P70 –1 E.M.I. tape motor two speed and reversible
2P72 –1 115v Muffin fan 4" × 4" approx. (s.h.)
2P75 –1 2 hour timer, plugs into 13A socket
2P82 –9v–0–9v 2 amp mains transformer
2P84 –Modem board with press keys for telephone redialler
2P85 –20v–0–20v ½A Mains transformer
2P88 –Sangamo 24 hr time switch 20 amp (s.h.)
2P89 –120 min. time switch with knob
2P90 –90 min. time switch with edgewise engraved controller
2P94 –Telephone handset for EE home telephone circuit
2P95 –13A socket on satin chrome plate
2P97 –mains transformer 24V 2A upright mounting
2P98 –20m 4 core telephone cable, white outer
2P99 –500 hardened pin type staples for telephone cable
2P101 –15V mains transformer 4A upright mounting
2P105 –capillary type thermostat for air temperature with c/o switch
2P107 –membrane keyboard, telephone type
2P108 –mains motor with gear box giving 110rpm
2P109 –5" wide black adhesive pvc tape 33m, add £1 post if not collecting

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There is a total of over 400 packs in our Baker's dozen range and you become entitled to a free gift with each dozen pounds you spend on these packs.

A classified list of these packs and our latest "News Letter" will be enclosed with your goods, and you will automatically receive our next news letters.

£5 POUNDERS*

5P1. 12 volt submersible pump complete with a tap and switch, an ideal caravan unit.
5P2. Sound to light kit complete in case suitable for up to 750 watts.
5P3. Silent sentinel ultra sonic transmitter and receive kit, complete.
5P5. 250 watt Isolating transformer to make your service bench safe, plus £3 postage if you can't collect.
5P6. 12V alarm bell with heavy 6" gong, suitable for outside if protected from direct rainfall. Ex GPO but in perfect order.
5P12. Equipment cooling fan – mini snail type mains operated.
5P13. Ping pong ball blower – or for any job that requires a powerful stream of air – ex computer. Collect or add £2 post.

5P15 –Uniselector 4 pole, 25 way 50 volt coil
5P18 –motor driven water pump as fitted to many washing machines
5P20 –2 kits, matchbox size, surveilance transmitter and FM receiver
5P23 –miniature (appr. 2½" wide) tangential blow heater, 1·2kw
5P24 –½hp motor, ex computer, 230V, mains operation 1450rpm. If not collect add £3 post
5P25 –special effects lighting switch. Up to 6 channels of lamps can be on or off for varying time periods
5P27 –cartridge player 12V, has high quality stereo amplifier
5P28 –gear pump, mains motor driven with inlet and outlet pipe connectors
5P32 –large mains operated push or pull solenoid. Heavy so add £1.50 post
5P34 –24V 5A toroidal mains transformer
5P35 –modem board from telephone auto dialler, complete with keypad and all ICs
5P37 –24 hour time switch, 2 on/offs and clockwork reserve, ex Elec. Board loading up to 50A. Add £1 post
5P41 –5" extractor fan, very quiet runner (s.h.), gntd 12 mths.
5P45 –pack of 6 cooker clock swtiches
5P48 –telephone extension bell in black case, ex-GPO
5P50 –box of 20 infra red quartz glass enclosed 360W heating elements
5P51 –200W auto transformer 230V to 115V torroidal
5P52 –mains transformer 26V 10A upright mounting, add £2 post
5P54 –mains motor with gear box, final speed 5rpm
5P58 –Amstrad stereo tuner FM and LM and S. AM
5P60 –DC Muffin type fan 18 to 27V, only 3W
5P61 –drill pump mounted on frame, coupled to mains motor
5P62 –2½kw tangential blow heater, add £1.50 post if not collecting

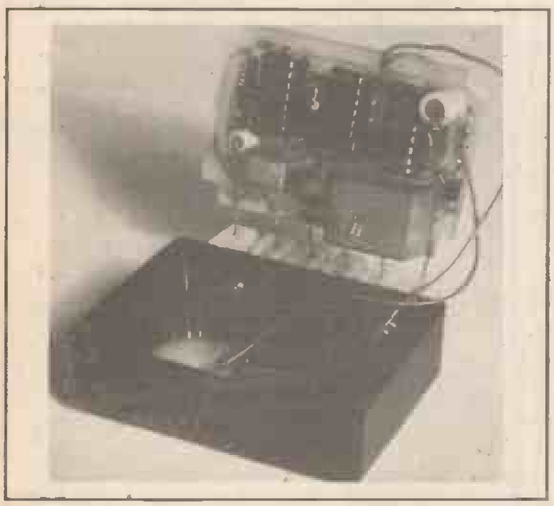
LIGHT CHASER KIT motor driven switch bank with connection diagram, used in connection with 4 sets of xmas lights makes a very eye catching display for home, shop or disco, only £5 ref 5P56.

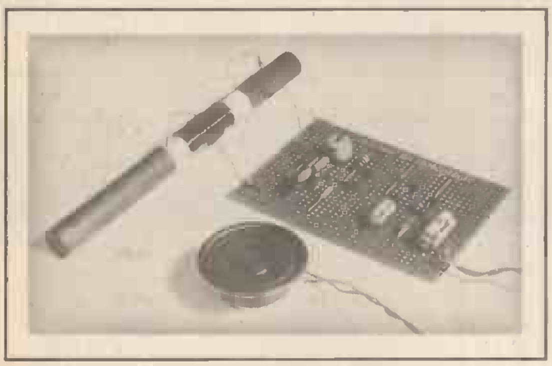
VOL 15 No.12 DECEMBER '86

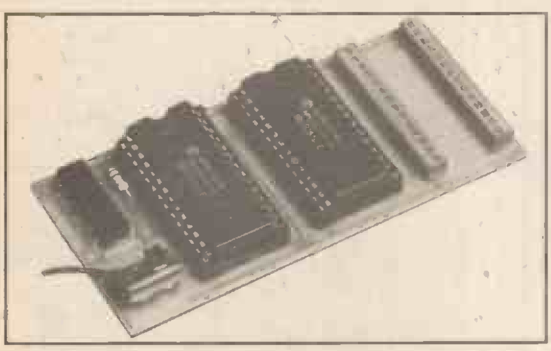
EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

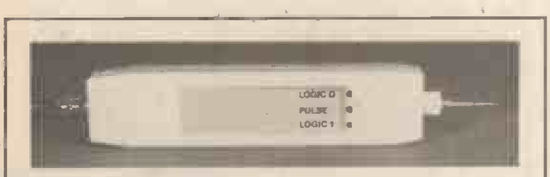
ISSN 0262-3617

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









Projects

Series

Features

Our January 1987 issue will be published on Friday, 12 December. See page 667 for details.

PRACTICAL ELECTRONICS STEREO CASSETTE RECORDER KIT £19.95

+ £2.75 p+p.

★ Noise Reduction System ★ Auto Stop ★ Tape Counter ★ Switchable Eq ★ Independent Level Controls ★ Twin VU Meter ★ Wow & Flutter 0.1% ★ Record/Playback I.C. with Electronic Switching ★ Fully variable recording bias for accurate matching of all tapes, Metal, Chrome, etc.

Kit includes transport mechanism, ready punched and back printed quality circuit board and all electronic parts. i.e. semiconductors, resistors, capacitors, hardware, top cover, printed scale and mains transformer. You only supply the solder and hook-up wire. As featured in P.E. reprint 50p. Free with kit.

Complete with case.

125W HIGH POWER AMP MODULES

AMP MODULE KIT **£12.00** + £1.15 p+p.

AMP MODULE BUILT **£17.50** + £1.15 p+p.

The power amp kit is a module for high power applications — disco units, guitar amplifiers, public address systems and even high power domestic systems. The unit is protected against short circuiting of the load and is safe in an open circuit condition. Supplied with all parts, circuit diagram & instructions.

ACCESSORIES: Stereo mains power supply w/transformer — £12.50 + £2.00 p&p. SPECIFICATIONS: Max output power (RMS): 125W. Loads: 4 — 16 ohms. Frequency response measured @ 100 watts: 25Hz — 20kHz. Sensitivity for 100 watts: 400mV @ 47K. Dimensions: 205 x 90 and 190 x 36mm.

Built and ready-to-use version with all accessories including power supply and case £42.50 + £2.00 p&p.

VHF STEREO TUNER KIT — £8.95

+ £2.50 p+p.

Easy to build 3-band stereo AM/FM tuner kit designed in conjunction with PE. For ease of construction and alignment it incorporates 3 Mullard modules and an I.C. IF. System. FEATURES: VHF, MW, LW Bands, interstation muting and AFC on VHF. Tuning Meter. Two back printed PCBs. Ready made chassis and scale. Aerial: AM — ferrite rod, FM — 75 or 300 ohms. Stabilised power supply with 'C' core mains transformer. All components supplied are to strict P.E. specification. Front scale size: 10½ x 2½" approx. Complete with diagram and instructions.

Mail to: 21 HIGH ST, ACTON W3 6NG. Callers to Acton or 323 EDGWARE RD, LONDON W2. (Open 6 days a week). Please allow 14 days delivery. Payments to RTVC Ltd.

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WAVECHANGE SWITCHES
Lorlin CK 1P 12W; 2P6W; 3P4W; 4P3W 62p

MINIATURE TOGGLES
CK: SPDT 68p; DPDT 1.05; 3PDT 2.30
Low Cost SPDT 50p; DPDT 68p; 3PDT £1.25

STANDARD TOGGLES
Low Cost: SPST 39p; DPDT 49p

STANDARD SCREW TERMINALS
15 AMP, 8 different colours TP1 35p

DIL SWITCHES
Low cost 4-pole 52p; 8-pole 78p
ERG 4-pole 1.35; 8-pole 2.06
ERG C/D 4-pole 2.70; 8-pole 4.16

SENSORS
SBV566 Hall effect 4.49
KPY10 Absolute pressure 26.87
ZKPY12 Relative pressure 29.51
KSY10 Position hall effect 4.32
KTY10 Temperature sensor 1.58
SFH900/2 Position, opto 1.78
K164 NTC Thermistor 6·8 ohms – 470K 17 values 23p
P2390 PTC thermistor for over-current protection for discs 4mm to 26mm dia P.O.A.

FERRITES
. . . galore! See catalogue, send your enquiries!

CRYSTALS
1MHz, 3·6MHz, 4MHz 88p; 8MHz 1.00

DIN 41612 CONNECTORS
96-way plug 1.93; 96-way socket 2.73

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Electrolytic in a huge range from small to large

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SECURITY

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NEW

Control Unit CA 1382

with automatic circuit testing and simple on/off operation.

- Fully automatic siren re-set.
- Audible entry & exit warning.
- Alarm Sounded memory.
- 2 separate loop inputs + 24hr circuits.
- Built-in electronic siren.
- Easily installed, full instructions supplied.

This brand new control panel provides effective and reliable control of all types of security installations. Using advanced electronics, the unit automatically checks the loop circuits every time that it is switched on, thereby reducing the possibility of false alarms and incorrect operation. Using a simple on/off key switch, it is easily operated by all members of the family. Additionally, 24hr personal attack and anti-tamper protection is provided irrespective of whether or not the unit is switched on. Housed in a strong, attractive steel case, the unit is supplied with full operating instructions and 2 keys. Supplied fully built and tested ready for installation.

Also available in kit form with fully built electronics £39.95 + VAT

ONLY **£44.95** + VAT

Lighting Controller DP 3570

only £13.95 + VAT

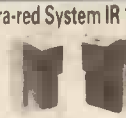
This versatile module provides timed switching of loads up to 3A for pre-set times between 10 secs and 5 mins. the timed period being triggered by the opening or closing of an external loop or switch. The built-in 12V 250mA power supply is available for operating external sensors. Priced only £13.95 + VAT. Suitable plastic enclosure, £2.85 + VAT

500W Quartz Halogen Floodlight FL 500

only £14.95 + VAT

Whilst intended for security lighting applications, this unit is suitable for lighting patios, pathways and gardens etc. Supplied complete with 500W lamp, priced only £14.95 + VAT. Protective grill, £1.95 + VAT

Infra-red System IR 1470



only £25.61 + VAT

Consisting of separate transmitter and receiver both of which are housed in attractive moulded cases, the system provides an invisible modulated beam over distances of up to 50ft operating a relay when the beam is broken. Intended for use in security systems, but also ideal for photographic and measurement applications. Size 80 · 50 · 35mm

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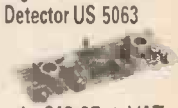

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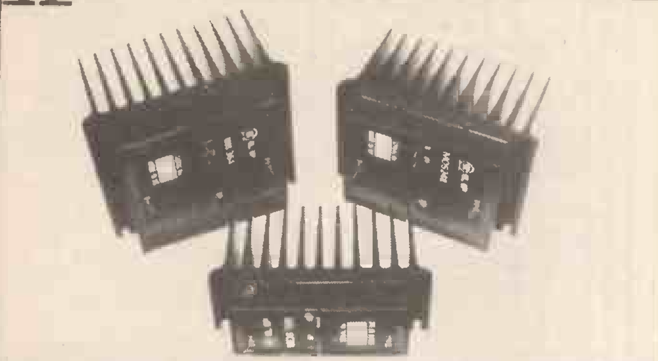

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PSU542	1 HY248	£24.65
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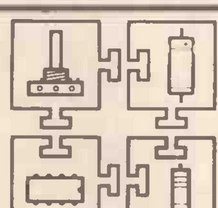

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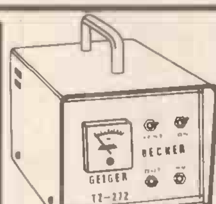

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EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

VOL 15 No 12 **DECEMBER '86**

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It can be very rewarding to edit *Everyday Electronics*—some of the letters of praise we get make it all worthwhile—but it can also be very frustrating! By way of explanation and in the hope that we can eliminate a few problems I want to mention some of our frustrations this month.

SEND MONEY

Many of you send us money, and it is all gratefully received; you send it for p.c.b.s, books, back numbers, binders and subscriptions—either new or renewals. On average we receive about 150 such letters with cheques, PO's and bank drafts each week and very gratifying it is too; however, among these 150 letters there are always a few that cause concern, either because something is wrong with the payment—wrong amount, cheque not signed, cheque made out to the wrong company, cheque not payable in £ sterling or not drawn on a bank with a UK address, PO not a British one—or because there is something wrong with the order—no name and address, no clear description of what is required, address and/or order illegible, order for items we do not supply.

You may by now think I am bleating on about my problems but actually they are often your problems! We now have quite a file of "unidentified payments" (actually it's called the Wally File but we won't rub that in too much). These cheque and bank drafts represent readers' money sent in for the above services without any name or address. Of course we could send them all back to the bank on which they are drawn but the banks are most unhelpful with this (not surprisingly) and often decline to return correspondence to their customers. So please, please make sure you don't get into the "W" file—simply check things before you post them.

If by any chance you have been waiting for your back numbers or subscription copies for more than a few weeks (even months in some cases), can you remember if you included your address with your cheque?

OUR MISTAKES

Of course, we are not perfect ourselves—we make mistakes and occasionally someone somewhere gets the wrong issue or the wrong p.c.b. In these cases, and thankfully they happen very infrequently, we will apologise and send the right one if you let us know what has happened.

Perhaps more embarassing is a mistake in an issue—maybe a component wrongly labelled or not labelled at all, or some aspect of a drawing wrongly shown (see *Please Take Note*). We do check all our articles and drawings carefully each month but we have deadlines to meet and sometimes a mistake gets through, usually to be noticed like a sore thumb as soon as we get finished issues from the printer, when of course it is too late! We will go on trying to eliminate such mistakes; the perfect issue is our aim.

NEW LOGO

From next month the title artwork on our cover will change, we will also have a new style cover—watch out for it at your newsagent.

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Certain back issues of EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY are available price £1.50 (£2.00 overseas surface mail) 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 remittances will be returned. *Please allow 28 days for delivery.* **(We have now sold out of Oct. and Nov. 85 and April 86.)**

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OLD PROJECTS

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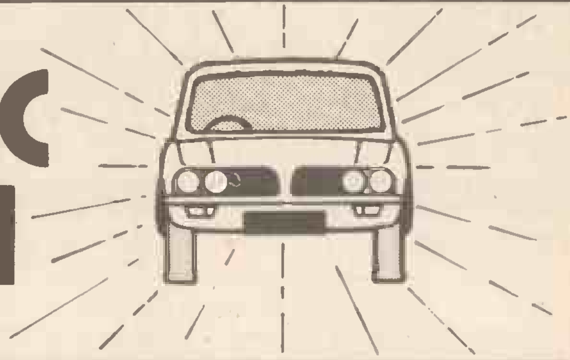
AUTOMATIC CAR ALARM



PAUL HARDING

Protect your car and its contents with this easy to use alarm

Many different methods of detecting illegal entry to a vehicle have been tried, from motion or vibration of the car itself to small voltage drops appearing at different parts of the car electrics. This design uses the large voltage swing that occurs at the earthy end of the courtesy light, as the car door is opened, as a trigger source.

No holes need be cut for keyswitches in the body of the car since the circuit is both fully automatic and is provided with entry and exit delays.

The circuit is enabled and disabled by the ignition switch—it will arm within about ninety seconds of turning the ignition off (the exit delay), and can be disarmed at any time by turning the ignition to Phase 1. To act as a preliminary warning to both authorised and unauthorised users, a buzzer sounds during the entry delay period of approximately twelve seconds. The courtesy light is also held switched on, so that the ignition switch can be found quickly and easily even on wet evenings when the user will far prefer to have the car's door closed.

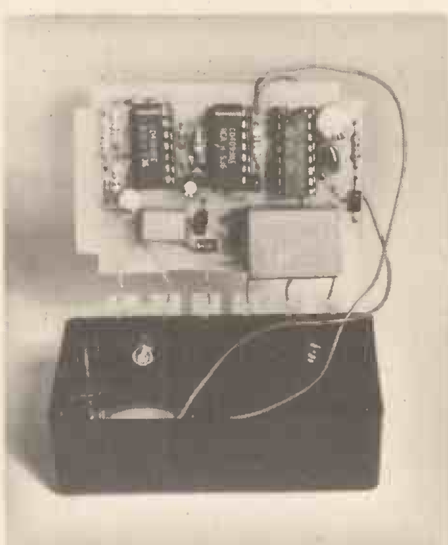
As is required by law, the circuit will switch off after a preset time. This time is set with a link to be either 1·25, 2·5 or 5·0 minutes, approximately. The relays specified for the project are rated at 10A for the horn and 2A for the courtesy light; in most cars this will mean that additional relays will not be needed. The project is suitable for negative earth vehicles only.

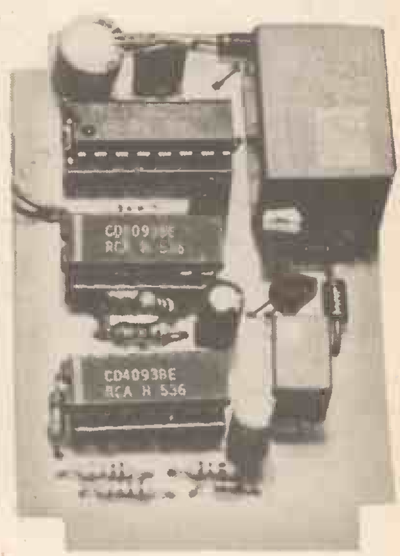
CIRCUIT OPERATION

Consider the block diagram (Fig. 1), and assume that the exit delay has timed out. If one of the car's doors is opened, the courtesy light line becomes active, and the flip flop is set. The entry delay introduces a pause before the main alarm is triggered. If, during this time, the ignition switch is moved to phase 1 the alarm resets and no further action is taken. If this is not done, however, the entry delay will time out, enabling the clock, and hence, via the binary counter, and driver stages, the car's horn.

After a preset number of clock pulses, Qn will swing high and reset the flip flop. If the car door has been closed, the circuit will switch off and rearm itself. If the car door is still open, the above procedure will repeat. To prevent the alarm being triggered as the user leaves the car the exit delay holds the flip flop reset for a short time after the ignition phase 1 line becomes inactive.

The "out of phase" detector is active during the time that the flip flop's output is





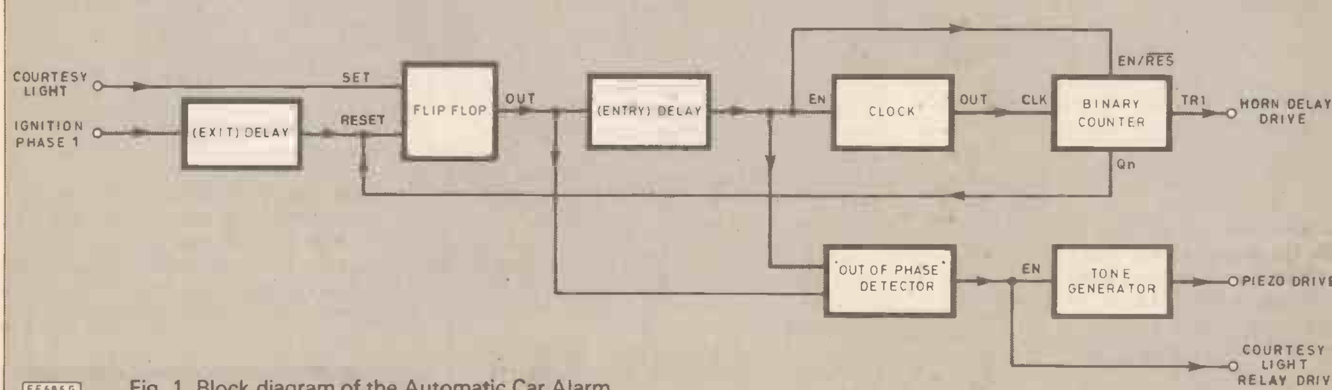


Fig. 1. Block diagram of the Automatic Car Alarm.

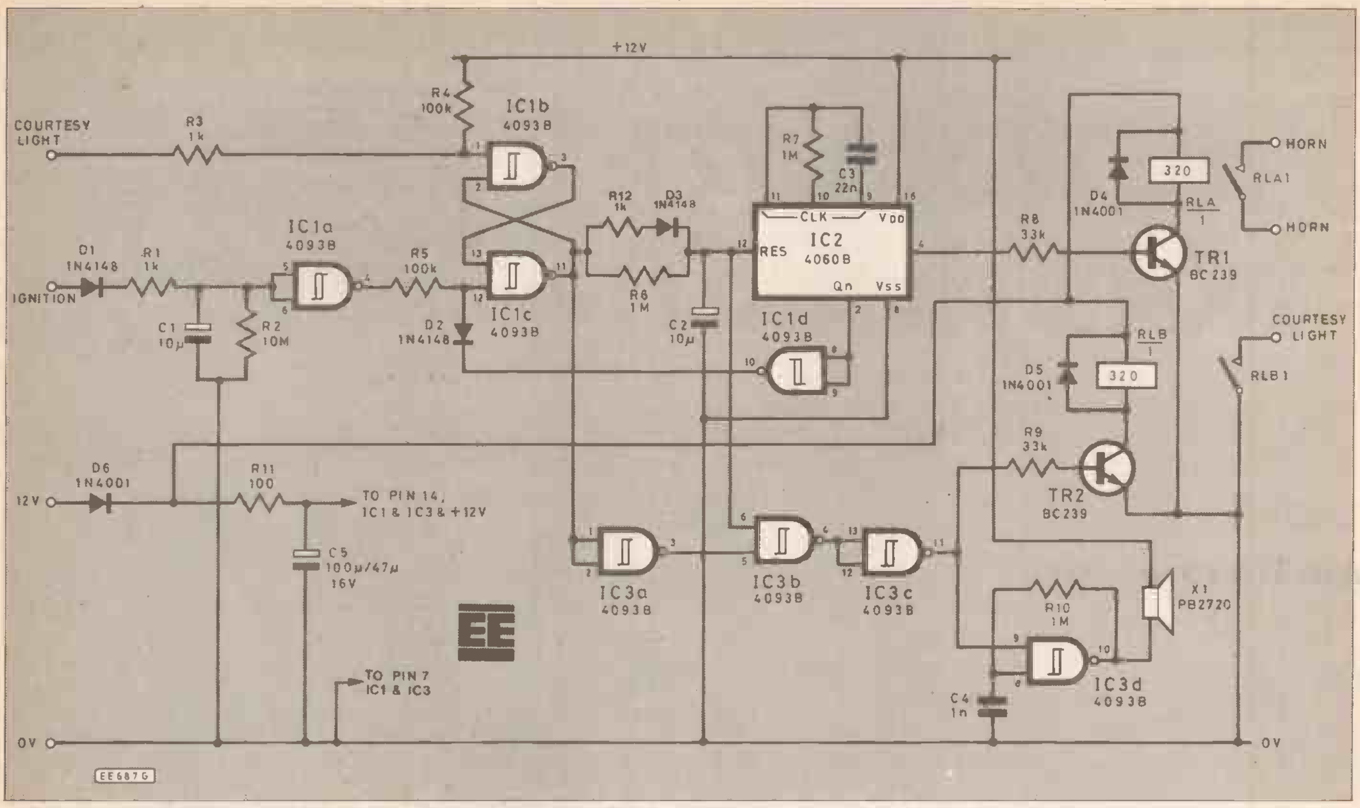


Fig. 2. Complete circuit diagram of the Automatic Car Alarm.

high and the entry delay's output is low, i.e. during the entry delay period. During this time, the warning buzzer is sounding, and the courtesy light is held on regardless of whether the car's door is open or closed.

Note that the logic levels referred to above do not necessarily agree with those in the actual circuit.

Looking now at the circuit diagram, Fig. 2: Cars are intrinsically electrically noisy places, and R1 to R4 protect the circuit's inputs from spikes. D6, R11 and C5 remove spikes from, and decouple, the supply lines.

The exit delay function is provided by C1, R2 and IC1a. When the voltage across C1 is greater than the upper input threshold of IC1a, as is the case when the IGN line is high, and for a short time after it goes low, the gate's output holds the flip flop around IC1b, and IC1c reset, and hence C2 fully charged, regardless of the status of the CL line. As C1 discharges, the voltage across it will cross the CMOS lower input threshold, IC1a's output will swing high, and the circuit will arm. D1 ensures that any other items connected to the IGN line do not rapidly discharge C1 as the ignition is turned off, thus disabling the delays.

With the exit delay timed out, circuit operation is as follows: When the car's door is opened, IC1b's output swings high, and IC1c's goes low. This condition is latched. Capacitor C2 starts to discharge through IC1c via R6. When the voltage across C2 reaches the CMOS low input threshold, the combined clock and counter, IC2, is enabled, and the relay is driven from the now pulsing output.

The Qn output of IC2 will go high after $(2^{(n-1)})/16$ pulses as measured at the Q4 output, where n=12, 13, or 14. When this happens, pin 12 of IC1c is pulled low by the output of IC1d via D2, the former's output swings high, and C2 rapidly charges to V_{dd} via D3. The counter is reset, the clock disabled, and the circuit rearms. Taking the IGN line high at any time will have a similar effect. With the component values shown, the turn off time is approximately 1·25, 2·5, or 5·0 minutes, with n=12, 13, or 14, respectively.

The tone generator is a standard Schmitt trigger oscillator driving a piezo resonator, X1. Three of the NAND gates in the circuit are required to be Schmitt trigger types, because they are fed from slowly changing voltages. These are shown with the Schmitt symbol on the circuit diagram. For ease of p.c.b. design, however, all the remaining NAND's are also Schmitt's, although this is not necessary for correct circuit operation.

The relay drivers are standard common emitter switching circuits. Diodes D4 and D5 protect their respective transistors from reverse e.m.f.'s as the relays switch off.

CONSTRUCTION

Construction should not present any problems, assuming a soldering iron with a fairly fine tip is used. Insert and solder the three topside links, into the p.c.b. (Fig. 3), first; one of them is partially covered by IC2 and so must not be forgotten at this stage! The links should be followed by the resistors and diodes. Link 1 on the underside of the board can then be made to the appropriate pad using, preferably, p.t.f.e. insulated wire (the insulation does not melt at normal soldering temperatures). Do not forget R5, R8 and R9, which also mount under the p.c.b. IC sockets are recommended for the i.c.'s. Next come the capacitors and transistors. Ensure that the transistors, diodes, and C1, C2 and C5 are orientated correctly. C5 must have a lead pitch of 2·5mm; if a 100µ device to this specification cannot be found, a 47µ component will suffice.

Lastly, solder in the relays and insert the i.c.'s into their sockets, again ensuring correct orientation. They all point towards the top of the board.

COMPONENTS

Resistors

R1,R3,R12	1k (3 off)
R2	10M
R4,R5	100k (2 off)
R6,R7,R10	1M (3 off)
R8,R9	33k (3 off)
R11	100

All 0·25W, 5% tolerance

Capacitors

C1,C2	10µ radial elect. 16V
C3	22n mylar
C4	1n mylar
C5	100µ or 47µ radial elect. 16V

Semiconductors

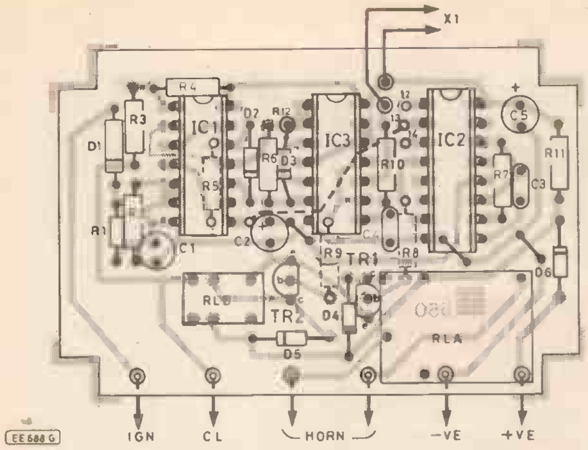
D1 to D3	IN4148 (3 off)
D4 to D6	IN4001 (3 off)
IC1,IC3	4093B Quad 2-input NAND Schmitt (2 off)
IC2	4060B 12-stage ripple-carry binary counter
TR1,TR2	BC239 (2 off)

Miscellaneous

X1	PB2720 or PBN2720 (see text)
RLA	12V 320 ohm coil 10A p.c.b. mounting relay
RLB	12V 320 ohm coil 2A p.c.b. mounting relay

Case, Verobox type 301; printed circuit board, available from the *EE PCB Service* code EE 550; 6-way 5A connector block; mounting hardware; Scotchlock connectors; wire; heatshrink sleeving, etc.

Approx. cost Guidance only **£11.00**



DOTTED COMPONENTS MOUNTED ON UNDERSIDE OF BOARD

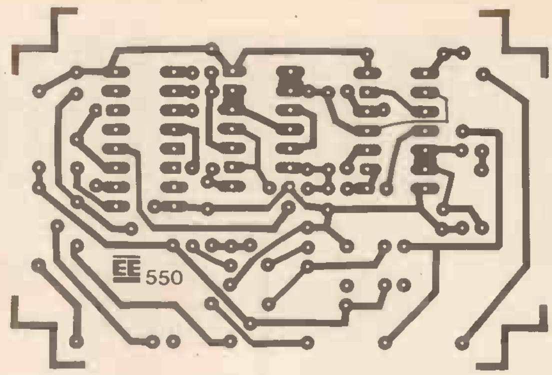
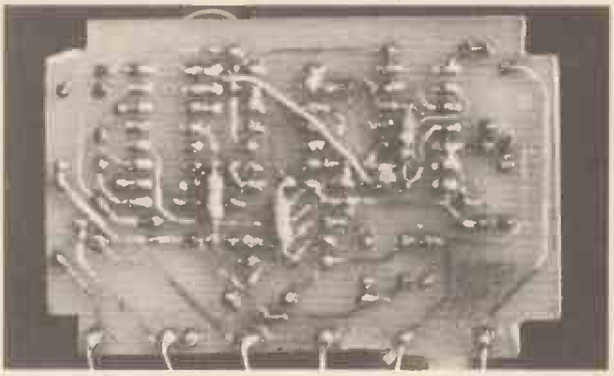


Fig. 3. P.C.B. layout and wiring. The p.c.b. is available from the *EE PCB Service*.



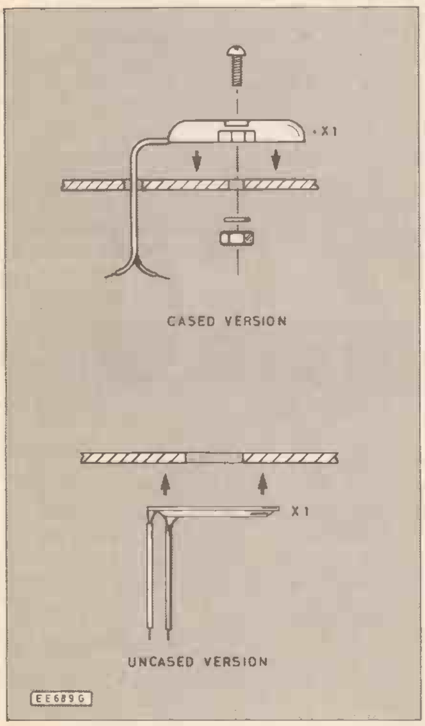


Fig. 4. Mounting details of the two types of piezo-electric sounders.

the top of the board.

If the specified case is used, the connector block can be screwed onto one of its long sides. Cut some small notches along the side of the case. Then, with the completed p.c.b. placed upside down in the case, short lengths of tinned wire (use heavy gauge for the horn and courtesy light connections) can be screwed into one side of the connector block and the other end soldered to the correct pad on the p.c.b., passing over the notches. An adhesive foam pad stuck onto RLA and the case bottom will ensure that the board is mounted securely. It would be wise, however, to test the circuit first.

If the cased version of the piezo-resonator is being used, it can be glued or bolted to the outside of the case and its leads brought inside through a small hole (Fig. 4). The uncased version needs a larger hole cut in the case; its brass face will then glue under the hole. Two fine wires need to be soldered to the uncased resonator, one to the silvered centre, the other to the brass surround. Leave the iron in contact with the silvered face for as short a time as possible.

TESTING

Connect the circuit to a 12V power supply. Connect a multimeter switched to resistance across the two horn connectors. Briefly short the IGN pad to the positive line. Connect the CL pad to ground; the resonator should not sound. A high impedance voltmeter or oscilloscope monitoring pin 5 or 6 of IC1 should show a slowly falling voltage. Using a standard (one megohm) oscilloscope probe the rate of decay will be about ten times faster than it will be in normal use.

As the observed voltage reaches about four volts the buzzer will sound. Remove the CL-ground connection. A short time later a pulse train should be apparent at pin 9 IC2, and the multimeter should indicate alternately an open and short circuit at the horn pads. If not, ensure that C2 has fully discharged, pin 11 IC1 is low, and R6 is not open circuit.

After the appropriate time delay, the circuit should switch off and rearm. An extremely thin pulse will be observed at the Qn output of IC2. Retrigger the circuit by briefly taking CL low. With the multimeter, check that the CL pad is grounded during the time that the buzzer is sounding.

INSTALLATION

The unit should be mounted in a dry place, because the case is not particularly watertight. The most convenient place will probably be near the steering column, since all the required leads will be nearby. The connection diagrams (Fig. 5), although not exhaustive, show the basic idea. Use heavy gauge wire for the horn connections, as they will probably have to carry the full horn current of perhaps 8A.

The easiest way of making the connections to the existing wiring will be with Scotchlock connectors. Alternatively, cut the relevant wire, slip on a length of heat shrink tubing, and solder the new wire and the original two ends together, insulating the joint with the tubing. In locating the correct wires, and annotated circuit diagram for the car will be found very useful. □

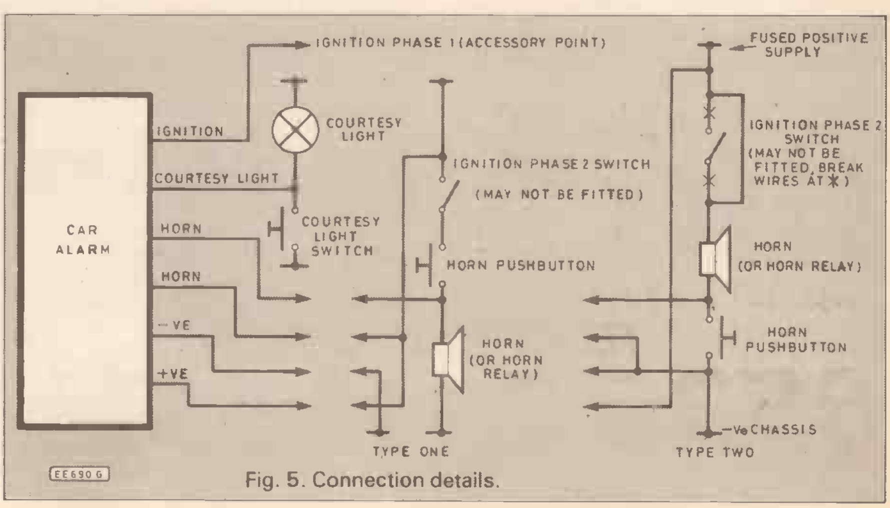
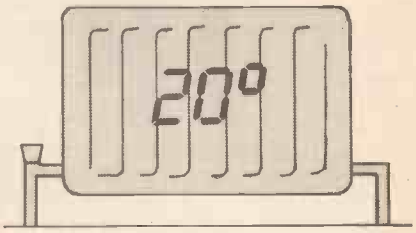


Fig. 5. Connection details.

DUAL READING THERMOMETER



R.A. PENFOLD

Suitable for use in a variety of applications, but primarily intended for balancing central heating radiators

THE original idea behind this thermometer was for a device to permit easy balancing of radiators in a central heating system. With a conventional thermometer at each end of the radiator it is difficult to monitor them both continuously due to the distance of a few feet which separates them. The problem can be considerably eased by having electronic temperature sensors which feed into an electronic unit that displays both temperatures digitally.

It would, of course, be possible to have two independent thermometer circuits with separate displays, but this is a rather expensive solution to the problem. The alternative utilized here is to have a single display with the reading being taken from the sensors alternately. Switching from one sensor to the other is automatic, and a couple of l.e.d. indicators show which sensor is being read at any given time. In practice this system is easy to use, and is not really any less convenient in this respect than having twin displays.

The unit is not restricted to the application outlined above, and it has many other possible uses. It could be used in photographic applications, another use is in heat experiments in schools. Here it is often necessary to monitor two temperatures simultaneously, and for demonstation purposes an electronic instrument with a fairly large and easy to read display is obviously ideal. The unit could also be used in the home to show inside and outside temperatures although it will not read below 0 degrees.

The temperature range covered is 2 to 100 degrees Centigrade, but this can be extended to 2 to 110 degrees Centigrade if desired. The display is a 3½ digit liquid crystal type, giving a resolution of 0·1 degrees Centigrade, although the accuracy of the unit does not require this level of resolution over the full range. However, for comparison purposes a high degree of resolution can be very useful. The use of a liquid crystal display and a low consumption chip to drive it results in the unit having a low enough current consumption to permit economic operation from a small nine volt battery. In fact the majority of the nominal nine milliamp current consumption of the unit is accounted for by the two l.e.d. indicators. The finished unit is very easy to calibrate, and either an accurate thermometer or a good quality digital voltmeter is all that is required.

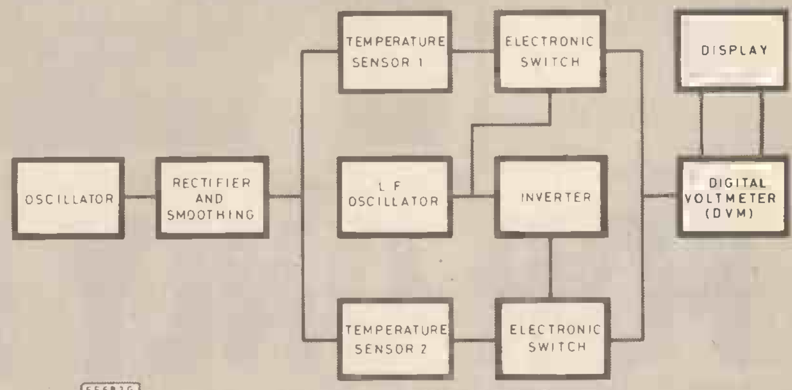
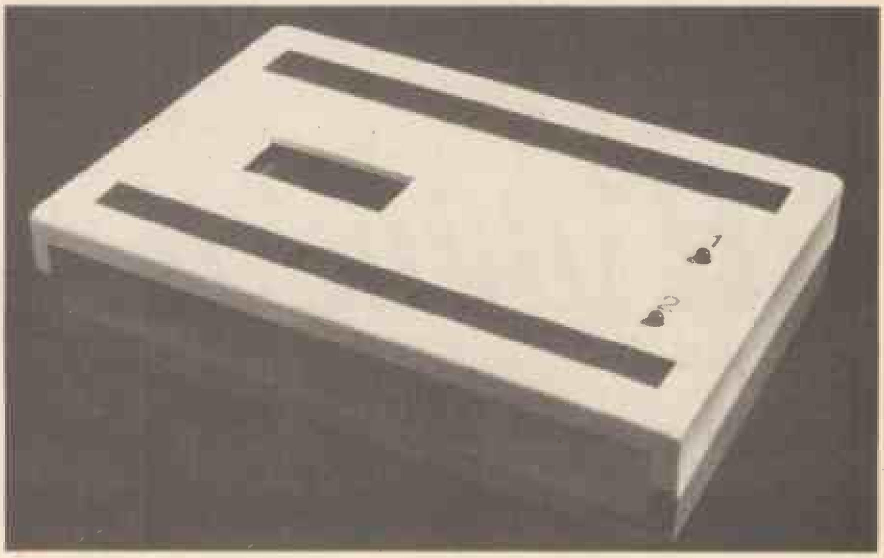


Fig. 1. Block diagram of the thermometer.

SYSTEM OPERATION

A unit of this type is a highly complex piece of equipment, but the use of a digital voltmeter chip as the basis of the circuit dramatically reduces the component count. Most of the components are involved with converting temperature to a linearity proportional voltage, and with the automatic switching between one temperature sensor and the other. Fig. 1 shows the block diagram for the unit.

The temperature sensors are modern integrated circuits designed specifically for this purpose, and they provide an output equal to ten millivolts (0·01 volts) per degree Centigrade. This is very convenient, as with the voltmeter having a full scale value of 1·999 volts, and with the appropriate decimal point of the display switched on, this gives a direct reading in degrees Centigrade with 0·1 degree resolution. With most temperature sensors there is a d.c. offset to balance out, but this problem is



avoided with the particular type used here.

The output of each temperature sensor connects to the input of the digital voltmeter by way of an electronic switch. One of these switches is operated direct from the output of a low frequency squarewave oscillator, and it connects temperature sensor 1 through to the input of the voltmeter during positive output half cycles from the low frequency oscillator. The other switch is fed from the oscillator via an inverter, and it connects temperature sensor 2 though to the input of the voltmeter during negative half cycles from the oscillator. This gives the required alternate switching action at a rate which is governed by the oscillator. The oscillator and inverter drive the two l.e.d. indicators.

The temperature sensors require a supply voltage in the range four to 30 volts, and with the circuit powered from a nine volt battery, on the face of it there is no problem in this respect. In reality things are not as simple as this, and the problem stems from the fact that the negative input to the voltmeter is not at zero volts, but is nominally 2·8 volts below V+. This effectively gives a supply potential of just 2·8 volts for the temperature sensors, which is obviously inadequate.

In order to avoid the need for a second battery, an oscillator, rectifier, and smoothing circuit are used to provide a voltage doubler action. Due to inefficiencies in the circuit this gives a supply potential for the temperature sensors of about +15 volts rather than +18 volts. This boost of about six volts gives a true supply voltage to the temperature sensors of almost nine volts, which is comfortably more than the minimum requirement of four volts.

VOLTMETER CIRCUIT

The circuit diagram of the voltmeter section of the unit is shown in Fig. 2. This is centred on IC1, which is an ICL7106 d.v.m. chip. This is the version of the chip designed for use with liquid crystal displays, and there is also a version of l.e.d. displays (the ICL7107). Where battery operation is required the latter is not a very practical choice due to the relatively high current reqirement of l.e.d. displays.

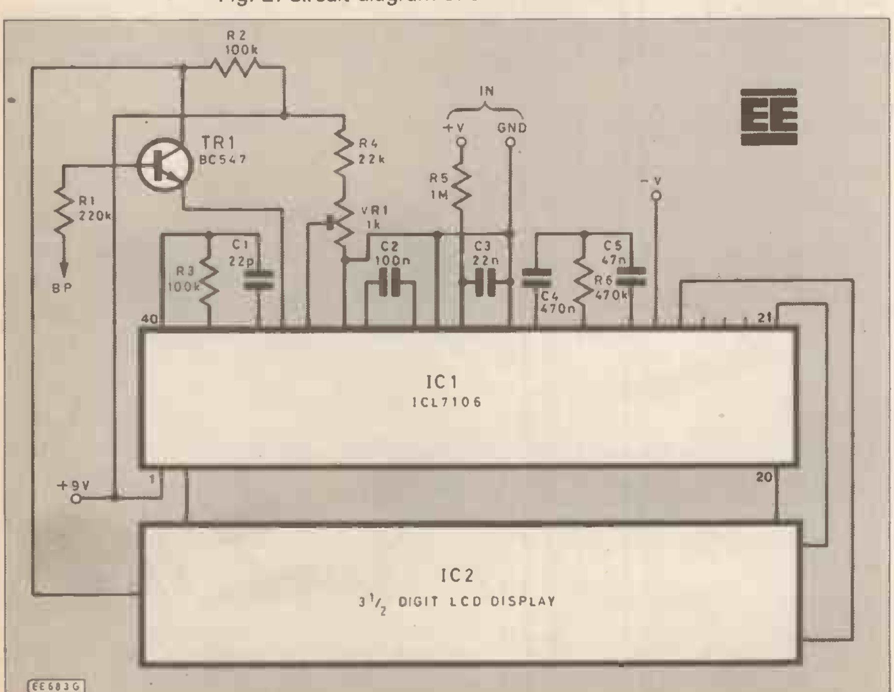
IC1 uses an integration process to provide the voltage to digital conversion. It consists basically of a 3½ digit decimal counter fed from a clock oscillator, plus the integrator and some complex control logic. Looking at its operation in a somewhat over simplified manner, the integrator converts the input voltage to a pulse of proportional duration. The clock signal is allowed to pass to the input of the counter circuit only for the duration of this pulse, and the longer the pulse, the greater the final count that is displayed. The circuit includes latches so that a valid display is always provided, and the counting action is not apparent to the user. The circuit automatically takes several readings per second.

Resistor R3 and C1 are discrete components in the clock circuit. The exact clock frequency is unimportant except in that it controls the number of readings per second. Usually a rate of just two or three per second is used, but in this case a higher rate is preferably. This is due to the switching of the input voltage source, which is not synchronised with the taking of new readings (and cannot easily be synchronised with this). Switching of the input source inevitably occurs during the the course of a reading being taken, rendering that reading invalid. Having a high reading rate results in any invalid readings being almost instantly up-dated by correct readings, and prevents misleading or ambiguous results from being obtained. The specified values give about a dozen readings per second.

Resistor R4 and VR1 are part of a reference voltage generator circuit; VR1 is adjusted to give the circuit precisely the correct level of sensitivity. R5 and C3 form a lowpass filter at the input of the circuit. The purpose of these is to combat noise on the input signal which might otherwise give unstable readings. Most of the other components are concerned with the integrator and the automatic-zero circuit (which avoids the need for any manual zero adjustment).

A simple inverter stage is formed by R1, R2, and TR1. This is used to drive the appropriate decimal point of the display with the inverted BP (back plane) signal. For those who are unfamiliar with liquid crystal displays it should perhaps be explained that they are not driven from a d.c. source like l.e.d. displays, but must be driven with an a.c. signal. A d.c. drive will, in fact, operate segments of a liquid crystal display perfectly well for a while, but "burning" would result after a few hours of operation, rendering the display useless. The normal way of driving a liquid crystal display is to provide the common (BP) terminal with a squarewave signal, and to switch on a segment by taking its input

Fig. 2. Circuit diagram of the voltmeter circuit.



COMPONENTS

Resistors

R1	220k
R2,R3	100k (2 off)
R4	22k
R5	1M
R6	470k
R7	18k
R8,R9	1k (2 off)
R10	10M

All 0·25W 5% carbon

See Shop Talk page 661

Potentiometers

VR1	1k sub-min horizontal preset

Capacitors

C1	22p ceramic plate
C2	100n carbonate
C3	22n ceramic
C4	470n carbonate
C5	47n carbonate
C6	100μ radial elect. 10V
C7	220p ceramic plate
C8,C9	22μ radial elect. 25V (2 off)
C10	330n carbonate

Semiconductors

IC1	ICL7106 d.v.m.
IC2	3½ digit l.c.d. display
IC3,IC7	4001BE CMOS quad 2-input NOR gate (2 off)
IC4,IC5	LM35DZ temperature sensor (2 off)
IC6	4016BE CMOS quad analogue switch
TR1	BC547 silicon *npn*
D1,D2	IN4148 silicon diode (2 off)
D3,D4	TIL209 red l.e.d.s (2 off)

Miscellaneous

S1	s.p.s.t. miniature toggle switch
B1	9V battery (PP3 size)

Case about 205 × 140 × 40 mm; printed circuit board available from the *EE PCB Service*, order code EE 549; two 3·5 mm stereo jack sockets and matching plugs; battery connector; two 40-pin d.i.l. i.c. holders (see text); three 14-pin d.i.l. i.c. holders; wire; solder; pins; etc.

Approx. cost Guidance only £36

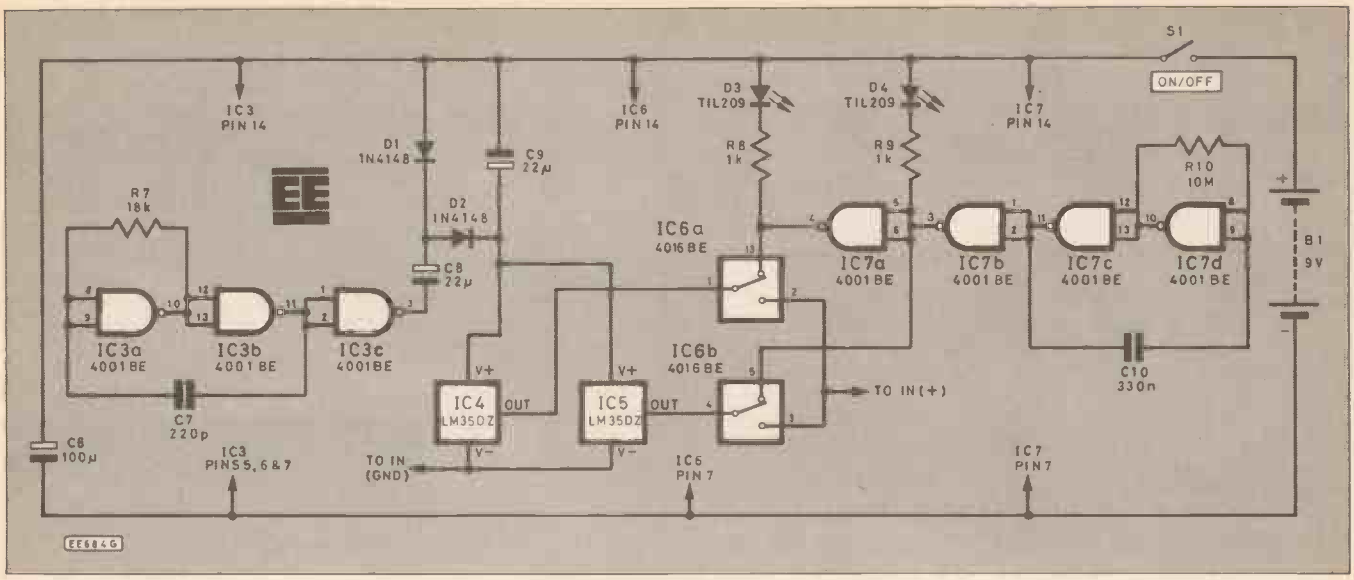


Fig. 3. Sensor and switching circuit diagram.

terminal to an inverted version of the squarewave. The inverted signal is supplied via an electronic switch, and turning this off results in no drive to the segment and switches it off. Although the display segments are being driven with d.c. levels, each segment receives about +5 volts on one drive phase, and about −5 volts on the other phase. This gives what is effectively a 10 volt peak to peak a.c. drive signal.

By inverting the backplane signal and applying it to the appropriate decimal point input, this display segment is turned on continuously while the unit is operating. The ICL7106 provides a squarewave drive signal which has a very accurate one to one mark-space ratio so that there is no significant positive or negative bias in the signals applied to the display, which should, therefore, have a long operating life of many years.

SENSOR AND SWITCHING

The circuit diagram of the temperature sensor and switching sections of the unit appear in Fig. 3. IC6a and IC6b are the two electronic switches, and these are two sections of a CMOS 4016BE quad analogue switch. The other two switches in IC6 are left unused. IC6a and IC6b are connected to give the required s.p.d.t. action in conjunction with inverter IC7a. The other three gates of IC7, which are all wired to act as inverters, operate as a standard CMOS oscillator and buffer stage. R10 and C10 set the operating frequency at approximately one cycle every three seconds. In other words, each temperature sensor is connected through to the voltmeter for roughly 1·5 seconds at a time. The switching time is proportional to the value of C10, and is, therefore, easily altered if desired.

Diodes D3 and D4 are the two l.e.d. indicators, and IC4 plus IC5 are the two temperature sensors. D3 switches on when IC5 is selected—D4 switches on when IC4 is selected. The temperature sensors are LM35DZs which are suitable for use over a 2 to 100 degree Centigrade temperature range. In fact, these sensors seem to work well down to 0 degress, although they are not guaranteed to do so. The range can be extended to a maximum of 110 degrees Centigrade using the more expensive LM35XZ version of the temperature sensor. Both versions of the sensor have a typical quiescent current consumption of only 56 microamps, giving an insignificant level of self-heating and reliable results at low temperatures.

For their operation the sensors rely on the fact that the voltage across a forward biased silicon junction varies in sympathy with the applied temperature, and increases by about 2 or 3 millivolts per degree Centigrade. The LM35** sensors include an amplifier to boost the output to 10 millivolts per degree Centigrade, as well as a circuit to effectively eliminate the large d.c. offset across the sensing element.

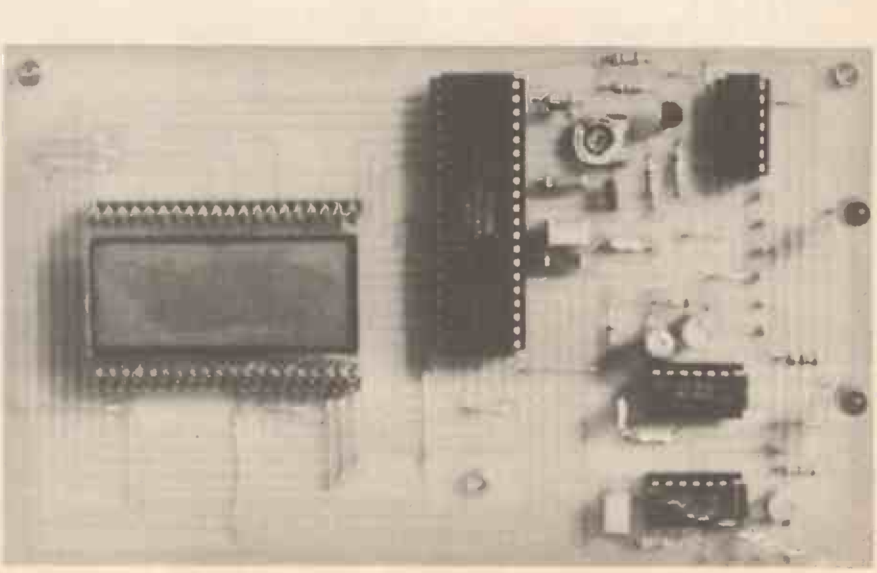
IC3 operates as another CMOS astable and buffer circuit, but in this case the values of the timing components (R7and C7) give an operating frequency of many kilohertz. The output from the circuit is rectified by C8, D1, and D2, and then smoothed by C9. The resulting d.c. potential of about six volts is effectively added in series with the nine volt supply, and used to power both temperature sensors. The supply to the sensors is far from stable, but the sensors are not affected significantly by even quite large supply voltage variations.

CONSTRUCTION

Practically all the components fit onto the printed circuit board, and full details of the board are provided in Fig. 4. Apart from the temperature sensors, the integrated circuits (including the display) are all prone to damage by static charges. Accordingly, they should be fitted in integrated circuit holders and should not be plugged into circuit until all the wiring has been completed.

It is unlikely that a suitable 40-pin socket for the display will be available, since it has 1·3 inch rather than the standard 0·6 inch row spacing. However, it might be possible to obtain two 20-pin s.i.l. sockets, or Soldercon pins can be used. For the prototype a 40-pin s.i.l. socket was cut in two using a hacksaw, to produce two 20-pin s.i.l. sockets. The display has a protective coating over its front surface, and this should be left in place until the unit has been completed, at which point it should be carefully peeled off.

A number of link wires are needed, and



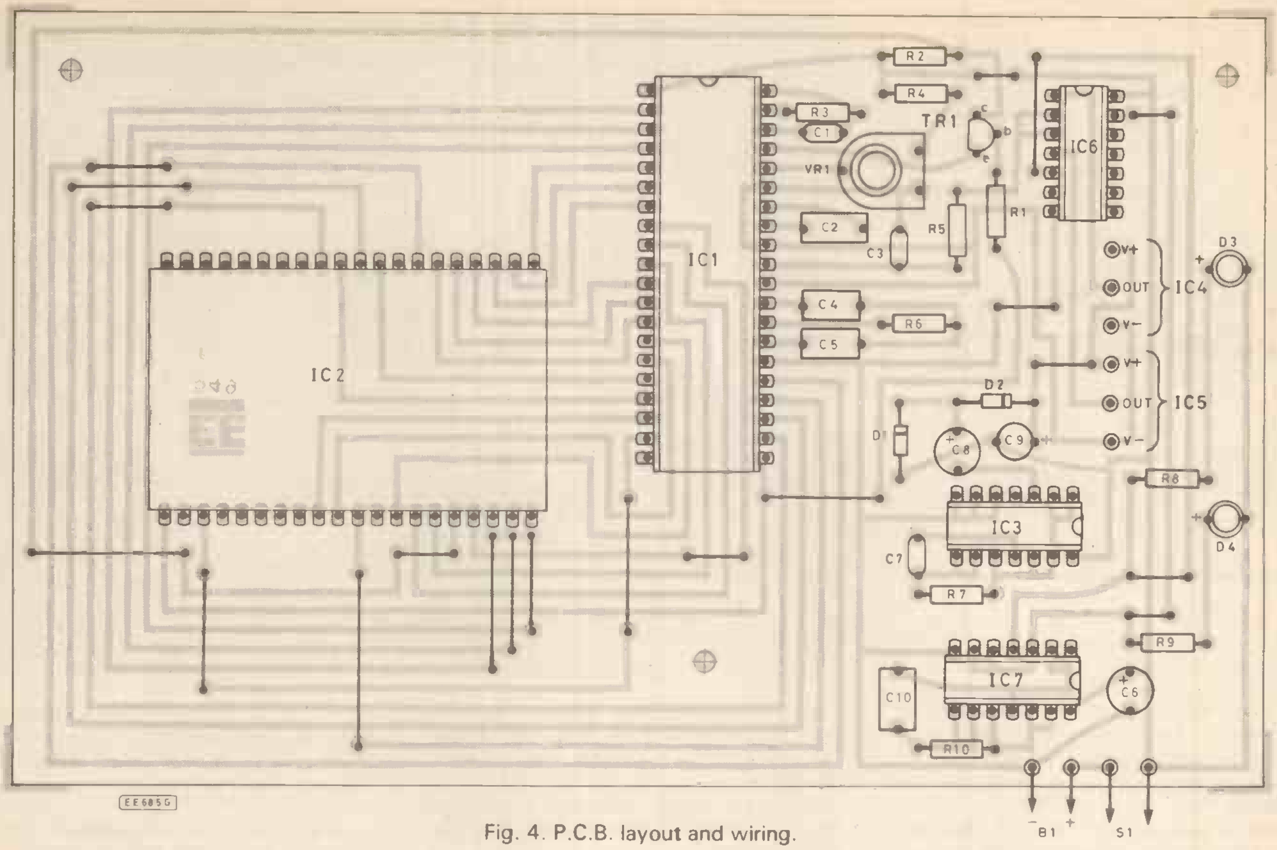
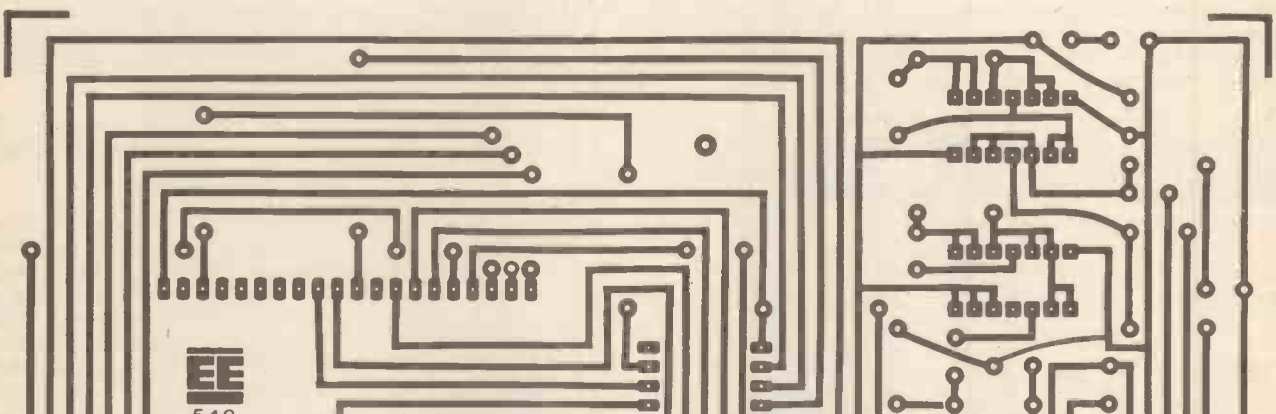


Fig. 4. P.C.B. layout and wiring.



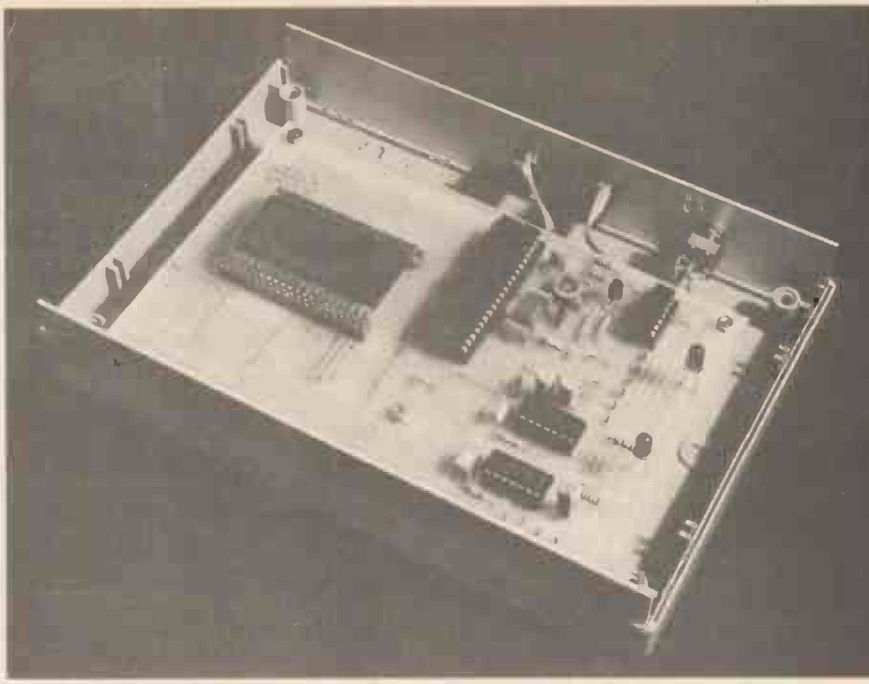
these are made from 20 or 22s.w.g. tinned copper wire. Where several wires run close together they must be drawn quite taut, or p.v.c. sleeving should be used to make sure that there is no risk of any accidental short circuits. It is essential that the capacitors are all miniature printed circuit mounting types or they will not fit onto the board easily, and there would be a risk of them preventing the lid of the of the case fitting into place properly. D3 and D4 are left with quite long leadout wires so that they protrude several millimetres above the display. Virtually any l.e.d.s can be used for D3 and D4, but as they operate at fairly modest currents high brightness types are preferable.

A case measuring 205 by 140 by 40 millimetres is an excellent choice for this project. The printed circuit board is mounted on the base panel using 6BA or M3 screws about 25 millimetres long. Threaded spacers totalling about 19 millimetres in length are used over each screw to hold the board at a suitable height, bringing the display almost to the same level as the top panel of the case. A rectangular cutout to act as a display window must be made in the top panel, together with a couple of holes for the l.e.d.s. These must be carefully positioned so that they accurately match up with the l.e.d.s and the display when the lid of the case is put into place.

The rectangular cutout for the display can be made using a fretsaw or a miniature round file, with a small flat file being used to finish it off neatly. The size of the cutout is

19 by 50 millimetres. It is advisable to fit some thin transparent plastic behind the display window to protect the front of the display against accidental scratches.

The sensors can be wired to the printed circuit board using two lengths of twin screened cable with the outer braiding of each cable carrying the "V−" connection. Rather than using direct connection to the board it is likely to be more convenient in use if the board is connected to a couple of three-way sockets fitted on the rear panel, and the leads from the sensors are fitted with matching (and correctly connected) three-way plugs. On the prototype stereo 3·5 mm connectors are used, but any type of three-way connector should be perfectly suitable. Whichever method of connection is used, the cables can be many metres long if necessary. The on/off switch can be mounted on the front panel or the rear panel, as preferred.



ADJUSTMENT AND USE

Start with VR1 at a roughly mid setting. When the unit is switched on the display should show a realistic but not necessarily a very accurate reading, and the two l.e.d.s should flash on and off alternately with an "on" time of around 1·5 seconds. Switch off immediately and recheck all the wiring if either or both of these conditions are not met.

If all is well, one way of calibrating the unit is to measure the output voltage from one of the sensors using an accurate digital multimeter, and to then adjust VR1 for the corresponding reading. For example, if the measured voltage is 0·249 volts, VR1 would be adjusted for a display of 24·9 degrees. VR1 must be adjusted very carefully in order to obtain exactly the required reading, but adjustment is not so critical as to merit the use of a multiturn potentiometer.

A more accurage method is to calibrate the unit against a precision thermometer. With the thermometer and the sensors placed side-by-side and allowed to settle to the same temperature for a minute or so, simply adjust VR1 for a display reading which matches the temperature indicated by the calibration thermometer.

If the sensors are to be used in liquids it is essential that they be fitted into protective probes, such as small test tubes. Some silicon grease can be used to give a good thermal contact between sensor and tube, but it will always take at least a few seconds for the sensors to adjust to any large changes in temperature. If the sensors are not be used in liquids it is a good idea to at least insulate each leadout wire using insulation tape so that there is no danger of accidental short circuits arising. □

Robot Roundup

NIGEL CLARK

EMU-IMU

As the year draws to a close and the days get shorter there is a growing optimism among the purveyors of small robotic devices. Nothing very flash but there has been a steady pick-up in orders, admittedly from a very low level, but it has persuaded a number of companies to take some action.

From LJ Electronics, makers of the Atlas, comes the EMU robotic trainer, with a price in the region of £300 it is described as a low-cost training aid. It has three powered axes, base, shoulder and elbow, a further two at the wrist which can be moved manually, either rotated or up and down, and a gripper.

It is powered by d.c. motors with direct mechanical linkages to the movement axes and a cable linkage for the gripper opening and closing. It can be controlled from any micro with an 8-bit user I/O port.

The arm has software packages included in the price developed for the Emma 11, LJ's micro, and BBC B, which allows all the usual sequence input, edit, relay and storage on cassette, disc or EPROM, simultaneous drive on all three movement axes and gripper and direct control from the keyboard.

It has a reach of 230mm and can lift a maximum 100gms. The working envelope is limited by base movements through 90 degrees, shoulder 90 degrees, elbow 60 degrees, gripper rotation 360 degrees and 40 degrees up and down.

Just to confuse the issue slightly L. W. Staines, makers of the Ogres, are intending to launch an arm with the acronym of IMU which stands for Industrial Manipulation Unit. IMU is a four-axis arm with an optional gripper selling for between £500 and £600. Development work is still being carried out on it and it is hoped to have it ready for the Hi-Tech exhibition at the Barbican, London, in January.

It is again planned to be a simple learning device with a single extendable limb moving up and down, left and right and a rotating wrist. The power is provided by d.c. servos with a worm and screw drive. It can work with any micro with a parallel port and software is being written for the BBC B and Commodore.

OFFICIAL

The other arms which were announced some time ago have been given their official launches, Alfred II from Robot City Technology and the RTX from Universal Machine Intelligence. The RTX SCARA robot arm has been around since last year but the launch has been delayed to allow time to get the production correct. Now at a price of about £3,000 it is ready for its intended markets of education, health care and light industry. Powered by servos, feedback is supplied by optical encoders and the machine is strong enough to lift 2kg. It can be linked to any micro with an RS232 port and software is available for the IBM PC.

Alfred II is a larger, stronger version of Alfred I (originally published in EE; Nov, Dec 84 and Jan 85), the five-axis articulated arm powered by servos with toothed belt drive. Alfred II has an onboard Z80-based processor which can accept up to 200 steps and can also be controlled via the serial port by the BBC B and Spectrum.

The Memoco Electron, the programmable version of Tomy's Armatron is now available for the Amstrad. An interface was built for a special order from Spain and has been put on general sale at a price of £80. The cost is higher than the £50 for the C64, BBC B and Spectrum because of the lack of a port on the Amstrad.

The five axis Memoco arm, plus gripper is selling for about £130. Although sales are steady, further improvements are being delayed because of pressure of work. However, Bob French, who runs the company said he was hoping to attract a technician and salesman to help give him time to develop a buggy which could be used to make the Electron mobile. It is an idea he first mentioned more than a year ago.

In the eagerly-awaited stakes, Staines' Troll appears to have been sidelined for the moment. The last news was that this two-armed robot using the Ogre technology was waiting for the grippers to be completed. That is still the situation and Staines says that they do not know when it will be completed.

Further work depends on how the robot market develops and the company is keeping a watch on the situation.

COLLOQUIUM

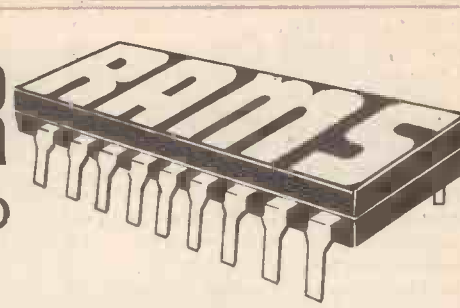
The colloquium on personal robots in the home organised by the Institution of Electrical Engineers in the summer, which was addressed by your correspondent, was not an outstanding success. Only a small number of people turned up to hear the speakers, including most of the well-known names in the industry.

However, Robin Bradbeer, of IGR, who organised the event, said he was hoping to arrange another next year and that he had some ideas for attracting more interest. By contrast the previous day's colloquium on personal robots in education attracted a great deal of interest with a number of talks on how robots were being used in schools.

The EMU Robot Trainer

The RTX SCARA robot arm

SEMICONDUCTOR



JOE PRITCHARD

In a recent article for EE & EM, we examined the semiconductor ROM (Read Only Memory). In this article, we'll take a look at Semiconductor RAMs, or Random Access Memory.

WHAT IS A RAM?

A RAM is simply a device that can store sequence of binary digits—"1"s or "0"s, or BITS—that can be read back as required, the time needed to retrieve a certain bit of information being the same no matter where in the RAM that bit of information is. In this definition, a RAM can be a magnetic disc, or electronic memory. However, the term RAM has come to mean a semiconductor device, capable of storing information, the contents of which can be read or changed on request. Indeed, some writers have suggested that the phrase "Readily Alterable Memory" is more descriptive than the one we used above, for this is effectively what a RAM is; a memory device whose contents can be altered quickly and easily.

With very few exceptions, which will be described later, RAMs lose their contents when the power is removed, and are thus described as VOLATILE memory devices. RAMs have become important components in recent years, as the home computer "boom" has burst upon us. A RAM may have between as few as 16 and as many as several thousand different "words" in it, each word being a collection of bits which is accessed as a single "set" of data.

Common word lengths are 1-bit, 4-bits and 8-bits. The selection of a given word is done by putting a pattern of electrical signals, usually 0V and 5V, representing 0's and 1's respectively, on to a set of inputs to the RAM called the ADDRESS LINES. When this is done, the word held at that address can be accessed on a series of lines called the DATA LINES. A RAM usually has data lines that are common to both input and output operations, but a few RAMs have Input Data lines and Output Data lines, the Input lines used to write to the chip and the Output lines used to read from the chip.

HAVING WORDS

Whether a RAM is written to or read from depends upon the status of the CONTROL LINES of the RAM, which tell the RAM whether a read or write operation is required. RAMs are often described in terms of the number of bits they can hold, or in terms of the number of words they can hold and the word length.

Thus a 16384 bit RAM would be able to hold 16384 bits of information. This could be arranged as 16384 * 1, in which there would be 16384 separate 1 bit words, 4096 * 4, which would contain 4096 separate 4-bit words, or 2048 * 8, which would contain 2048 separate 8-bit words.

The number of bits in the word decides the number of data lines that the RAM chip will have. The number of separate words in the RAM decides the number of address lines that the RAM will have. For a RAM chip with N address lines, there will be 2↑N different words in the RAM.

In addition to the inputs and outputs to the RAM that we've already seen, there can also be CHIP SELECT lines, which, when taken to a particular logic level, enable or disable the RAM. These are used to allow the RAM to be used anywhere within the Memory Map of the computer of which the RAM is part.

For example, if we have a 2048 * 8 RAM in a microcomputer system, the obvious set of addresses for the RAM to be accessed at are addresses 0 to 2047. But the use of Chip Select lines would allow the same RAM to be addressed at any 2048 byte block of the computer's memory space, the Chip Select lines being switched to the appropriate logic levels by the address lines of the microcomputer. We'll see an example of this later.

STATIC AND DYNAMIC RAMS

Having looked at the general characteristics of RAMs, it's time to look at the real devices. The RAM family is made up of two groups, called STATIC and DYNAMIC RAM chips. The essential difference is in the way in which the bits are stored, but this leads to differences in the circuitry needed to support the RAMs in computer circuits.

Simply put, in a dynamic RAM the bits of data are effectively repeatedly rewritten to the RAM. In a static RAM the bits are written to the RAM once, and they can then be forgotten about until the data is read or changed.

We'll now look at how these two groups of RAM chips work, their relative advantages and disadvantages, and how real RAM chips can be used. Of these two types, Static RAM is the easiest to understand and use; so, being a fan of the easy life, I'll start with them.

STATIC RAM

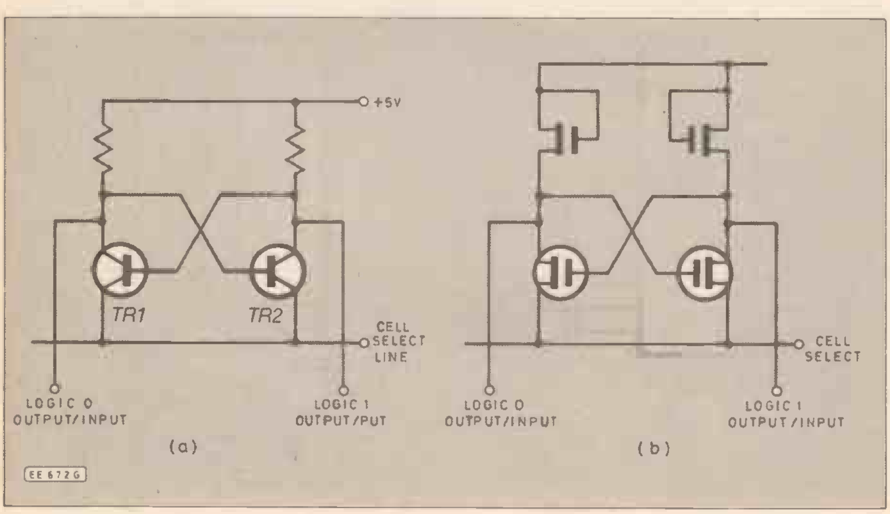
The basic "building brick" of a Static RAM is shown in Fig. 1. Such a "CELL" is capable of holding a single bit of information, and is the humble Flip Flop circuit.

It can be made using either Bipolar technology, Fig. 1a, in which the active components are bipolar transistor, or MOS technology, Fig. 1b, in which FETs are the active components. Note how in MOS technology the resistor part of the circuit is formed by a suitably biased FET.

Let's see how these "cells" can be put together to form a RAM chip. As many of these cells as there are bits to be "remembered" are needed, and they are arranged in a grid as shown in Fig. 2. The "Column" and "Row" signals are derived from the Address Lines, and are used to access a single cell or group of cells, depending on the number of bits in the RAM word.

The way in which these control signals are use to actually access a given cell depends upon the RAM in use. For example, if Bipolar Technology has been used to build

Fig. 1. Basic "building brick" for a Static RAM. (a) bipolar technology, (b) MOS technology.



the RAM, it's common to see the transistors used having more than one emitter; two of the emitters are used as "Row" and "Column" inputs to the cell. A third emitter can be used as the "0" and "1" lines, in place of those shown in Fig. 1.

Once selected, a Read/Write control signal decides what the operation is to be. For a write, the two bit lines are used to input data in to the flip flop. If a "1" is present on the input data line to the RAM, a +5V signal is applied to TR2. A "0" requires a +5V signal to be applied to TR1 via the "0" bit line. The business of sorting out which bit line is to be used for a given cell is done by the Control Electronics of the RAM chip.

For a read operation, the bit lines allow the status of the flip flop to be read; if bit line "1" is high, the cell is storing a "1", and if bit line "0" is high, it's storing a zero. Circuitry within the RAM, known as SENSE AMPLIFIERS, then make the appropiate output data line "high" or "low", depending upon the status of these lines.

Once a cell is set to a value, it will hold that bit until it is changed or the power is removed. This ability is due totally to the flip flops used to hold the bits, and the flip flops also provide the disadvantages of Static RAM.

The flip flop requires that at any time one of the two transistors in the circuit will be turned on. This consumes current, and Dynamic RAMs do not have this requirement for a large "standing current" drain. However, this can be reduced with MOS Static RAMs.

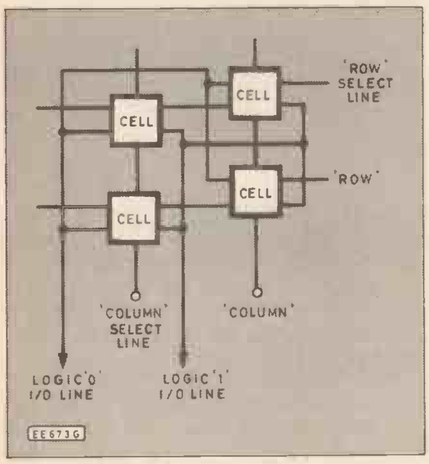


Fig. 2. Matrix of "cells" put together to form a RAM chip.

Another disadvantage is that each cell requires two transistors on the integrated circuit that will be the RAM. Until recently, this led to Static RAMs being rather small affairs in terms of bits of storage when compared with Dynamic RAMs.

In a Dynamic RAM, only about a quarter to a third of the space is needed to store the same number of bits, thus allowing the Dynamic RAMs to store more information in a given space. Large Static RAMs were available, but at a price. This led to Static RAMs being used in small systems until recently, when falling prices and increasing density has led to cheaper and larger Static RAMS, thus leading to revived interest in the device.

A good example of the way in which Static RAMs are used in smaller systems and Dynamic RAMs in larger ones occurred in the Sinclair ZX-81. The basic 1K machine had its RAM implemented with Static Devices. However, the Sinclair 16K Rampack used Dynamic devices to keep costs down.

A further advantage of Static Devices is their speed of operation; they are faster than their Dynamic counterparts.

THE 6810

Let's now take a look at a couple of examples of Static RAM, starting with an OAP of the Static RAM world, the 6810. This is shown in Fig. 3. It is a 128 * 8-bit Static RAM which was originally designed to support the 6800 microprocessor. Yes, that is 128 bytes; not much in these days of 128K QL machines!

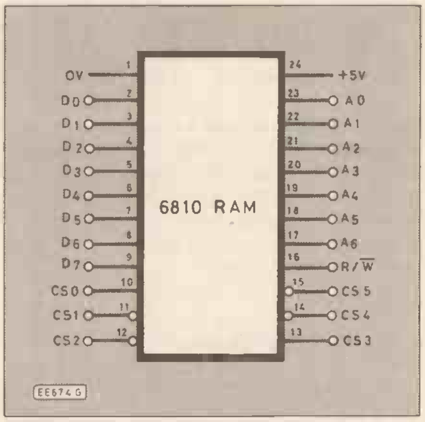


Fig. 3. Pin functions for the 6810 Static RAM.

However, it's a nice chip to use to learn about Static RAM with. It has eight data lines, which are used for both input and output, and seven addresses lines. There are six chip selects, CS0 and CS3 being active high and CS1, CS2, CS4 and CS5 being active low.

Thus for the chip to be enabled, and data transferred, CS0 and CS3 must be at logic 1 and CS1, CS2, CS4 and CS5 should be at logic 0. The address can then be set up on line A0 to A7 and the operation carried out.

The R/W line is high for a read or low for a write. If the chip is disabled, then the data lines will "float" (have no effect on anything else connected to the data bus) as they are implemented in tri-state logic. The inputs and outputs are all TTL compatible, and only a single 5V supply is needed.

The worst ACCESS TIME, which is the time needed to read data from memory, is about 450nS, and the best about 250nS. The practical upshot of this is that the chip would be useless in fast microprocessor circuits unless means were available to "slow down" the microprocessor chip until the memory was ready! As with many RAMs, you pay more for the faster versions of the chip.

THE 6116

The 6116 chip is a more recent addition to the Static RAM clan, and is of more use in microcomputer systems. It is a 16384 bit device arranged as 2048 words of 8-bits, and for this reason is often called a 2K RAM.

The pin functions for the 6116, together with a typical circuit for its use, is shown in Fig. 4. The other chips provide the Chip Select signal. The $\overline{WE}$ pin is the Write Enable pin, and when taken to a logic low allows data to be written to the RAM. There is one Chip Select at Pin 18, which is active low.

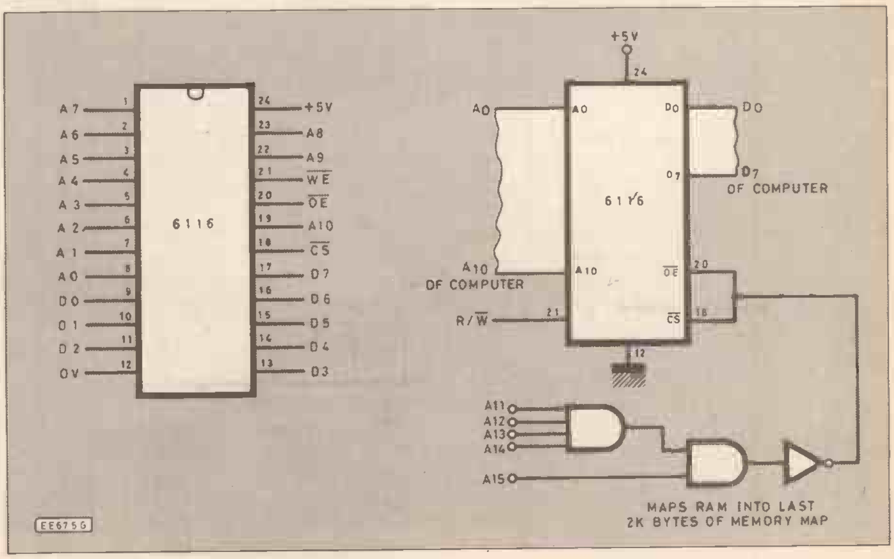
The only difference between this chip and the 6810 in terms of control signals is the presence of the Output Enable connection at pin 20. This must be low for data to be output from the RAM. In Fig. 4b it's simply driven by the logic signal that we're using as Chip Select, thus enabling the output only when the chip is selected.

The 6116 has other nice features; it's pin compatible with 2K EPROMs, thus allowing you to swap between the two types of memory without rewiring the circuit. All the signals are compatible with TTL signals, and it's fast. Access times range between 100nS and 250nS.

The speed of a particular chip is often specified by a suffix to the part number; thus 6116-15 would indicate a chip with a 150nS access time. There are, by the way, no problems about using a chip faster than that specified in a given design, it's just more expensive!

Finally, there have been attempts with this chip to keep power consumption within reasonable limits. CMOS technology has been used to fabricate the chip, and this gives a power consumption of microwatts when the chip is not active, and about 10mW to 20mW when the chip is in operation.

Fig. 4. Typical pin functions for the 6119 Static RAM together with a "practical" circuit arrangement.



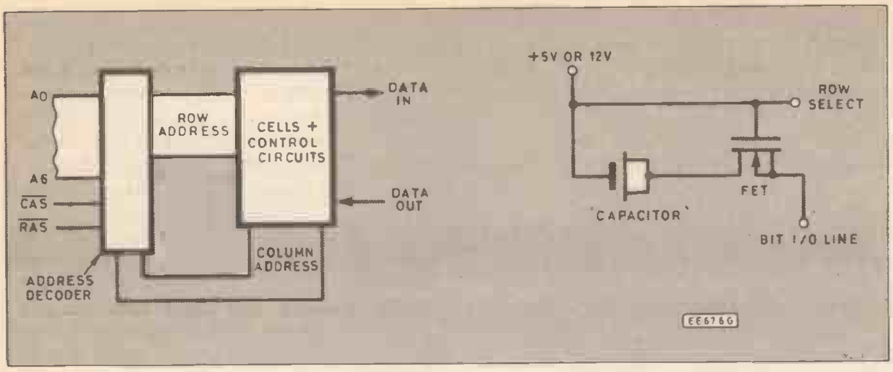


Fig. 5(a). Simplified view of the 4116 Dynamic RAM and (b) typical Dynamic RAM "cell".

NO VOLATILE STATIC RAMs

As was mentioned earlier, it's possible to get Non Volatile RAM. Historically, the earliest way of doing this was to take a CMOS RAM, such as a 6116, and equip it with a backup power supply which often consisted of a couple of Lithium batteries. As the standby power drain is in the microwatt region, this arrangement was very useful, allowing the RAM thus powered to keep its memory when all around it were losing theirs for around 10 years!

Commercial units look like small boxes with the same pin-out as the 6116 RAM, so they can plug straight into circuit boards designed for 6116s. A similar system is used in the 6802 Microprocessor chip, which has 128 bytes of on-board RAM which can be maintained by "battery backup".

However, a recent development has been the use of EEPROM technology (see last month's issue) in RAMs, where each cell of the Static RAM is backed up with an EEPROM cell. Data can be transferred between the two memory types when required by applying suitable control signals to the chip. The disadvantage with this memory at the moment is the price and the small memory size, typically 256 * 4 bit, but this could easily change in the near future. A typical example is the Xicor X2212 chip.

DYNAMIC RAM

The Dynamic RAM chips use charge retention to hold bits, rather than a circuit that effectively remembers a voltage. This has the advantages that power consumption is low. However, the amount of "peripheral" electronics required to keep the memory happy is rather high.

A "cell" from a Dynamic RAM is shown in Fig. 5. As you can see, it's simply a capacitor and a single f.e.t. Dynamic RAMs are fabricated only in MOS; bipolar devices are not suitable for any application involving charge. The cell holds a "1" as a tiny charge, in the region of 10 E-15 coulombs, and a "zero" as an absence of charge.

Most Dynamic RAMs are arranged as several thousand 1-bit words, although a 16384 * 4 bit Dynamic RAM is available. Typical sizes are between 4096 * 1 and 262144 * 1. The word length of one bit can mean that for small RAM requirements, such as 2K, you will need eight dynamic chips, one for each bit of an 8-bit word, as opposed to a single 6116 Static RAM!

However, for larger RAM sizes there is little contest. The difference in the number of cells you get into a Dynamic Chip as opposed to the number of cells you get into a Dynamic Chip as opposed to the number of cells you can get on a Static Chip is due to the smaller size of the Dynamic Cell, using one transistor as opposed to two. This tends to make large Dynamic RAMs cheaper than large Static RAMs.

Addressing of individual cells is done in a similar way to that in which Static Cells are addressed. Fig. 6 shows a typical Dynamic RAM i.c., the 4116, and if you study it and remember that it is a 16384 bit RAM you will soon realise that there aren't enough address lines! We need 14 separate lines to give 16384 individual addresses, as required by this RAM, and we have only seven.

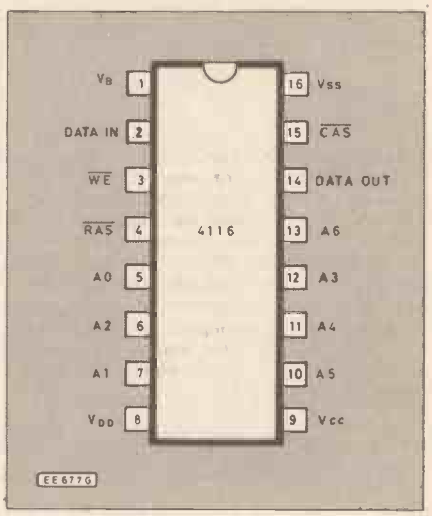


Fig. 6. Pin functions for the 4116 Dynamic RAM.

The CAS (Column Address Strobe) and RAS (Row Address Strobe), are the solution to this apparent problem. The address is given to the RAM in two parts, the Row Address and the Column Address. The relevant address bits are put on the address bus and then either RAS or CAS is taken low to signal to the RAM which part of the address is required.

This timing of strobe pulses makes the use of Dynamic RAM difficult for the amateur building a system to their own design, and requires additional components to look after the timing. The requirement for the address to be written to the RAM in two parts slows down the operation of the RAM. For the 4116 RAM, for example, an access time of 375nS is typical.

Although the Dynamic RAMs have lower power consumption than many Static RAMs, they still need some power. Typical figures, for the 4116 RAM, are 300mW or so when active and around 10mW on standby. Another problem associated with some Dynamic RAMs is there requirement for extra supply voltages in addition to +5V and 0V. For example, −12V is not commonly found around digital circuits and often requires generating specially for the RAM!

CHARGE RETENTION

The charge retention method of holding information has a problem; the charge decays within a few milliseconds if left to its own devices. Herein lies the problem with Dynamic RAM. The charge, or absence of charge, in each cell must be regenerated, or REFRESHED, every now and again to ensure that the memory doesn't forget what is in it.

The Refresh is carried out by additional electronics, and thus adds to the cost and complexity of a Dynamic RAM board. Some Dynamic RAMs have the refresh circuitry built as part of the chip, but for the others the refresh circuitry must ensure that every cell of the RAM is refreshed every 2mS or so.

Dynamic RAMs are built so that each Read operation refreshes the cell read, and this is the basis of the refresh operation. The Dynamic RAM is arranged in a grid, as Fig. 6b shows, and it's not feasible to expect each RAM cell to be read from within the 2mS period as part of a program. No, we have to be a little more organised, and Refresh circuitry simply ensures that each cell is refreshed within the necessary time.

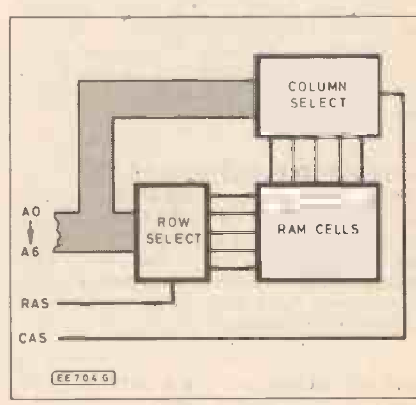


Fig. 7. Simplified "grid" arrangement for a Dynamic RAM.

There are a couple of ways of doing this; the most obvious is that the Refresh should be done all at once, each row of cells being refreshed one after each other. This will take a finite time, and the microprocessor using the memory will be forbidden to access the memory while the Refresh is taking place. Therefore, the Refresh action slows down the computer by a tiny amount.

The other way is to refresh the memory a row at a time, with the microprocessor getting access to the memory when the refresh is not taking place. This spreads out the refresh action.

The refreshing of memory requires some additional circuitry called the REFRESH CONTROLLER, and there are chips, such as the Intel 3222, which are designed to do this.

REFRESH CONTROLLER

The task of the Refresh Controller is to refresh each row in each Dynamic RAM on a regular basis, and to ensure that while the refresh is taking place the microprocessor does not try and access the memory at the same time. Each row is addressed by the Refresh Circuitry putting the Row address onto the RAM address bus, and then the row is refreshed by a modified read action.

In many microcomputer systems, the Refresh is carried out at times when the microprocessor is not using the Dynamic RAM; these times can be worked out by using the control lines of the microprocessor, although a good knowledge of the microprocessor is needed. One interesting feature of the Z80 microprocessor is that it contains a special Refresh Register which, in conjunction with some of the control lines of the Z80, can be used to do an automatic, or transparent, refresh of the memory. This is one reason why Dynamic RAMs have found wide use in Z80 based systems.

The Dynamic RAM, despite its extra requirements, will remain popular especially in systems requiring large memories—16 or 32-bit microprocessors, for example. They aren't as easy as Static RAMs for the amateur to use, although there are Dynamic RAMs around which have the Refresh circuitry and circuitry for strobing the Row and Column addresses on to the chip actually built in to the i.c. This makes them almost as easy to use as Static RAMs.

Apart from turning up in dedicated RAM chips, there are devices that combine RAM functions with microprocessor I/O operations. An example of this is the rather prosaically named 6532 RIOT. In addition, microprocessors occasionally contain RAM.

The development of memories will continue, of course, and we'll probably soon have Magnetic Bubble memories available to the amateur and other such esoteric technology. However, for the time being our memories will be of the type we've seen in the last two successive articles, and I hope that the articles have been of interest to you. □

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PART 6 Junction transistor as an amplifier

IN PREVIOUS parts we have used the junction transistor as a *switch*. We have considered it only as being in one of two states:

1) OFF; No base current, therefore no collector current

2) ON; Ample base current, therefore maximum collector current. In this state the transistor is said to be *saturated*.

When the transistor is being used as an amplifier, it is operated under conditions which lie between the two extreme states described above. To be used effectively as an amplifier, its base current must be large enough to begin to turn it on, yet not so large as to saturate it.

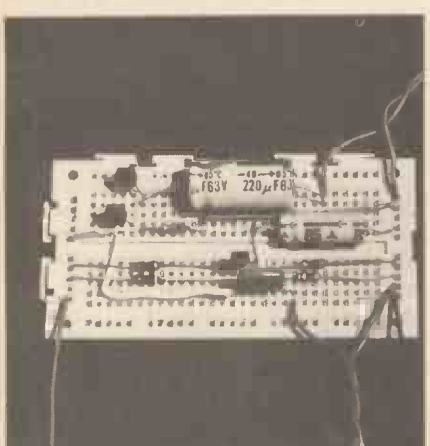
Within this range the collector current is proportional to the base current. The ratio between these two currents is known as the *gain* of the transistor.

$$\text{Gain} = \frac{\text{Collector current}}{\text{Base current}}$$

Depending upon the type of transistor, the collector current may be from 25 to 800 times greater than the base current. Small changes in the base current cause large changes in the collector current so the transistor acts as a *current amplifier*.

There are exceptions to this general rule. When the collector voltage is less than 1V, the transistor does not have proper operating conditions and gain is smaller. Another obvious exception is that, if the collector current is *already* as great as the transistor can pass (the transistor is *saturated*) an increase of base current produces no further increase in collector current.

Layout of components on the "breadboard" version of the Simple Intercom Amplifier.



SIMPLE INTERCOM AMPLIFIER

A circuit for a simple Intercom Amplifier is shown in Fig. 6.1. In this project we shall see how to use a transistor as an amplifier. We shall use it to amplify the tiny currents that come from a crystal microphone when the crystal is made to vibrate by sound. The amplified current is then used to drive an earphone or small loudspeaker, which may be in another room. This circuit will also form the basis for a Simple Diode Radio Receiver to be described later.

HOW IT WORKS

Resistors R1 and R2 (Fig. 6.1) act as potential dividers, giving a potential at *A* that is enough to supply a base current to the transistor TR1 and make a *steady* collector current flow in resistor R3. Transistor TR1 is on, but not saturated.

When a sound is made close to the microphone, a small current is generated. This increases and decreases the charge on capacitor C1 very rapidly, in phase with the vibration of the sound.

A small current flows to and fro between C1 and the junction between R1 and R2. This small current alter-

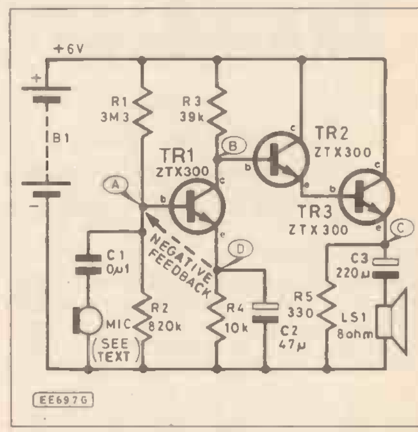
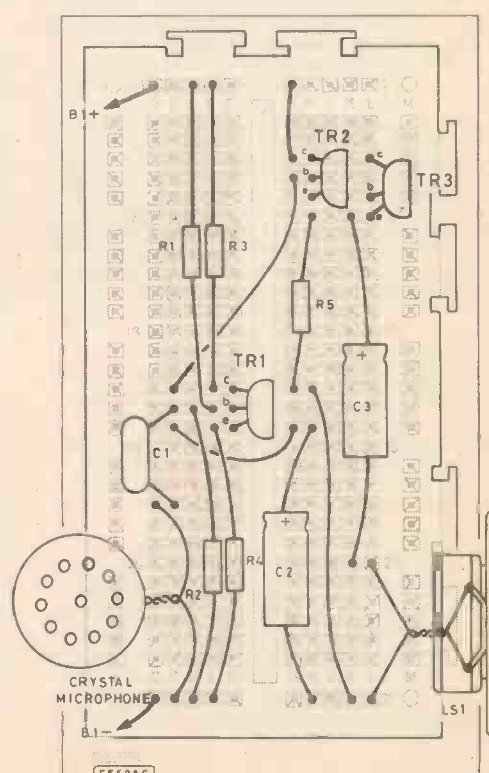
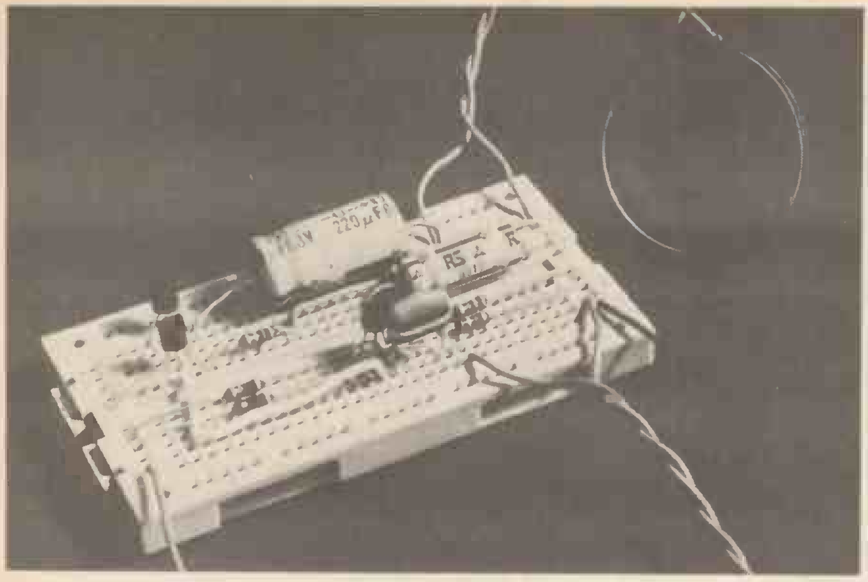


Fig. 6.1. Complete circuit diagram for the Simple Intercom Amplifier.

Fig. 6.2. Demonstration breadboard layout for the Simple Intercom Amplifier.





nately increases and decreases the base current in phase with the sound vibrations. Small changes in base current bring about corresponding changes in the collector current of TR1.

Since this is a larger current, the *changes* are greater. The current through R3 is no longer steady. It varies in phase with the sound. As the current through R3 increases and decreases the potential difference across R3 increases and decreases. This means that the base current to TR2 varies in phase with the sound. The two transistors TR2 and TR3 are connected so as to produce very high gain (see Fig. 6.6). The large collector current through TR3 therefore varies in phase with the sound waves. This means that the potential at point *C* varies considerably. As the potential at *C* rises and falls, the charge on capacitor C3 is alternately increased and decreased, in phase with the sound. The variations in the charge on C3 cause currents to flow through the loudspeaker. These currents cause the loudspeaker to produce a sound very similar to the sound originally picked up by the microphone.

As a point of interest, note the function of resistors R3 and R5 in this circuit. Variations of current through R3 cause variation in voltage (potential) at point *B*. These variations are larger than those originally produced by the microphone. A transistor such as TR1 is a *current* amplifier. The circuit consisting of TR1, R3 and other components is a *voltage* amplifier. In a similar way TR3 and R5 constitute a second voltage amplifier.

COMPONENTS

Resistors
R1 3M3
R2 820k
R3 39k
R4 10k (see text)
R5 330
All $\frac{1}{4}$W ±5% carbon

See Shop Talk page 661

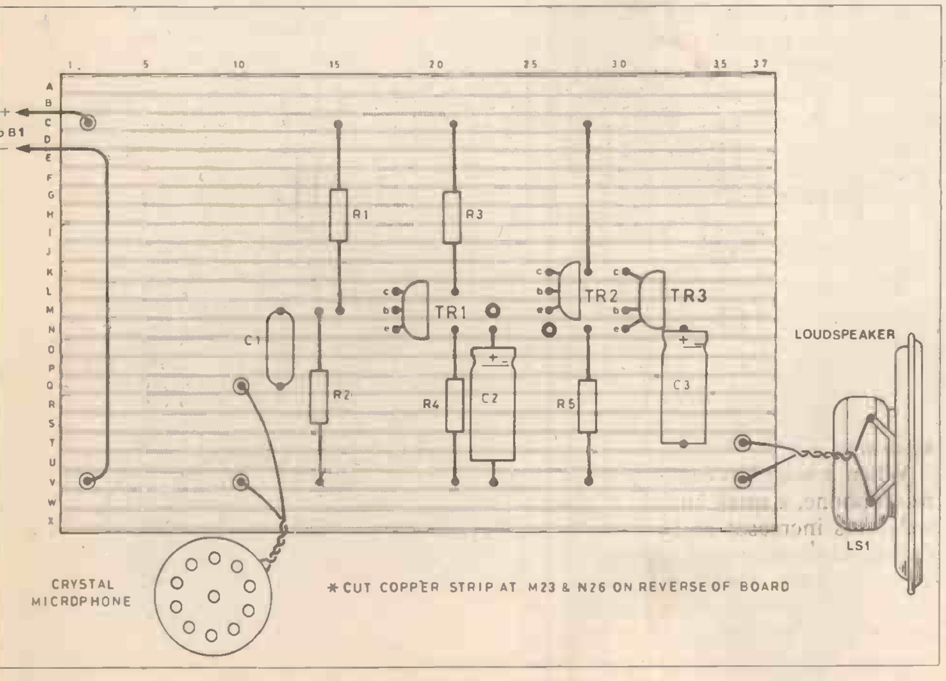
Capacitors
C1 0µ1 polyester
C2 47µ elect. 10V
C3 220µ elect. 10V
C4 10n polyester (if diode radio is to be connected)

Semiconductors
TR1-TR3 ZTX300 *npn* transistor (3 off)

Miscellaneous
Breadboard or 0·1in. matrix stripboard, 24 strips × 37 holes; crystal microphone or mic. inset; 8 ohm loudspeaker (crystal earpiece preferred for radio version); 1mm terminal pins (6 off); connecting wire, including several metres twin speaker lead for intercom version; battery box for four "D" type cells.

Approx. cost Guidance only £5

Fig. 6.3. Stripboard component layout for the Simple Intercom Amplifier. Remember to make the breaks in the underside copper tracks at points M23 and N26.



CONSTRUCTION

The Simple Intercom Amplifier circuit may be assembled on the experimental breadboard (Fig. 6.2) or on a piece of 0·1in. stripboard, (having 24 strips × 37 holes (Fig. 6.3). The main point to watch out for here is that all the connections are properly made. This circuit is rather more complicated than the earlier ones in this series, so there is more chance of making a mistake.

Check everything carefully before you switch on the battery. When you switch on, you should hear a fairly loud click from the loudspeaker. Now take the speaker to another room and connect it to the circuit using a long pair of wires. The intercom is ready for action.

Instead of the microphone you may use a crystal pick-up cartridge from a record player. If you can get an old record deck that has a crystal cartridge, you can use this circuit to complete the system and can listen to your favourite discs whenever you want.

Turn over for a Simple Diode Radio Receiver

SIMPLE DIODE RADIO RECEIVER

The amplifier can also be connected to the Simple Diode Radio Receiver described in *Part 1—Fig. 1.3* EE July 86. You need a connection from the cathode (k) of D1 (Fig. 1.3) to capacitor C1 of Fig. 6.1. You also need a connection running from the "earth" side of the radio circuit to the 0V line of the amplifier circuit.

The method of connecting the radio to the amplifier is shown in Fig. 6.4, and Fig. 6.5 shows how to accommodate the radio circuit on the stripboard version of the amplifier. No additional breaks in the underside copper strips are required.

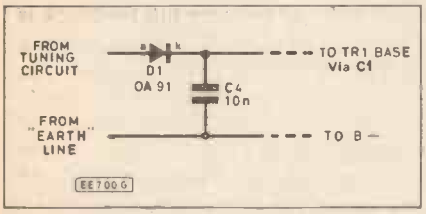
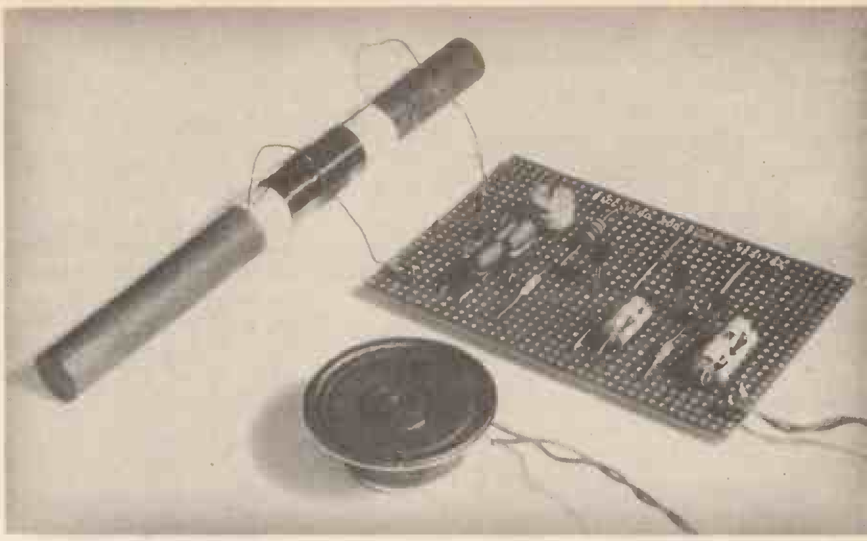


Fig. 6.4. Connecting the "radio" circuit (see Part 1) to the amplifier.

Now the tiny currents from the diode are amplified and the circuit produces a current powerful enough to drive the speaker. However, unless you have a good aerial, the volume of sound from the speaker may be too faint to be heard clearly.

If this is so, try using an earpiece (as used with a portable radio set) in place of the speaker. This will cut out external noise and enable you to hear the stations more easily.



One of the problems with this simple circuit is that it is not *selective*. In other words it is not easy to tune to just one station at a time. For this reason you may obtain best results during daytime, when there is less interference from foreign stations. On the other hand it is fun to listen to foreign stations, provided that you do not mind hearing several at once!

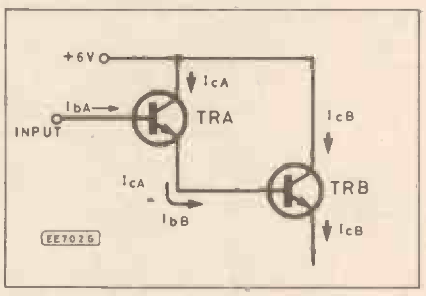


Fig. 6.6. One method of obtaining high gain is to use the Darlington pair configuration.

HIGHER GAIN

One way of obtaining high gain is to connect two transistors as shown in Fig. 6.6. This configuration of two transistors is known as a *Darlington pair.*

A very small current, I_{bA}, to the base of TRA causes a larger current, I_{cA}, to flow from the emitter of TRA. This becomes I_{bB}, flowing to the base of TRB. It causes an even larger current, I_{cB}, to flow from the emitter of TRB. If the transistors have the same current gain, *h*, then:

$$I_{cA} = h \times I_{bA}$$

and $I_{cB} = h \times I_{bB} = h \times I_{cA} = h^2 \times I_{bA}$.

Thus the gain of this circuit is h^2. For example, if the gain of each transistor is 100, the gain of the pair is 10,000.

This arrangement is particularly useful for sensitive switching circuits and amplifiers.

Gain of the pair =
gain of TRA × gain of TRB

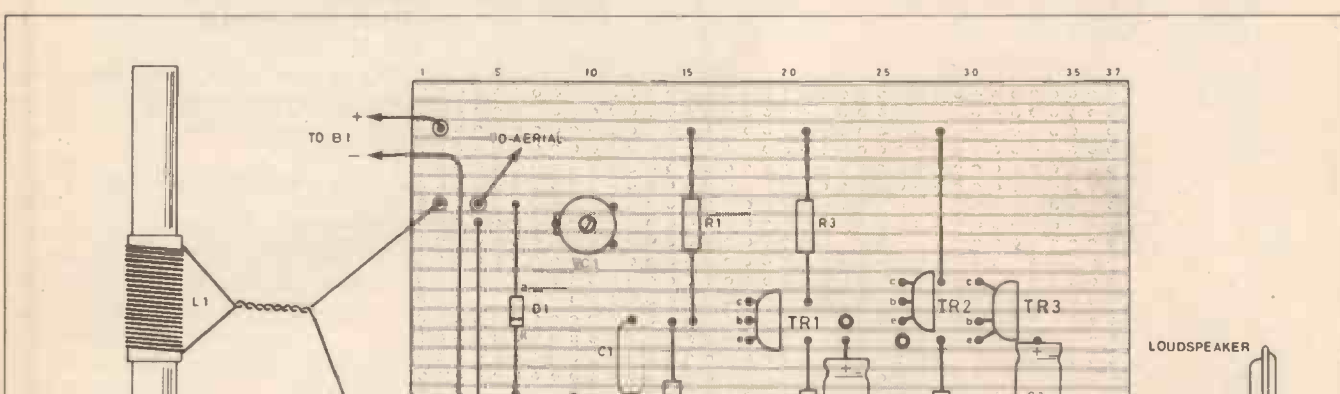


Fig. 6.5. Stripboard component layout for building the Simple Diode Radio Receiver. The full circuit for the radio section appeared in Part 1 (July '86). The loudspeaker can be replaced by an earphone.

FEEDBACK

This month's circuit provides a good example of feedback. As described in Part 3 (EE Sept '86), feedback occurs when we take a signal from one stage of a circuit and feed it back to an earlier stage.

In the *Electronic Candle* (Part 3), the light signal was fed back to the LDR that first turned the lamp on. Result—the lamp stayed on. This was called *positive feedback*, because the signal fed back tended to increase the action that first caused it.

With this month's audio amplifier circuit you can obtain feedback by putting the microphone close in front of the loudspeaker. Any small sound made nearby is picked up by the microphone, amplified by the circuit, produced as a louder sound from the loudspeaker, picked up again by the microphone, amplified again . . . and so on. This produces positive feedback.

The result is that the system goes into oscillation and a loud and generally unpleasant screeching sound is heard. This effect often occurs in public address systems, when the volume is turned up too much. The only cure is to break the feedback loop, either by turning the volume down, or by positioning the speakers or microphone so that the microphone can not easily pick up the sound coming from the speakers.

NEGATIVE FEEDBACK

A more useful type of feedback for amplifiers is *negative feedback*. Part of the output signal is fed back in such a way that as output *increases*, the signal fed back tends to *reduce* the output. This effect prevents the output becoming too great, and so prevents the sound from being distorted.

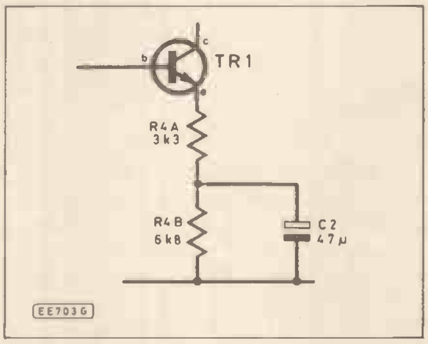


Fig. 6.7. Modifying the circuit of Fig. 6.1 to give increased negative feedback.

In the amplifier circuit, Fig. 6.1, the components concerned with feedback are resistor R4 and capacitor C2. The amount of the collector current of TR1 depends on the p.d. between its base and emitter. If base potential (at *A*) increases, collector current increases and the current through R4 increases.

The effect of this is to raise the p.d. across R4. This makes the emitter potential (at *D*) rise, which acts to reduce the base-emitter p.d. In short, as the base potential rises, emitter potential rises too, tending to cancel out the difference. This is a kind of negative feedback, since it *reduces* the effects of changes of base potential.

However, in this circuit the amount of amplification is limited and we can not afford to have too much negative feedback. This is the reason for having capacitor C2 in the circuit. If you remove C2 from the circuit, you will find that the gain of the amplifier is much reduced because full feedback is allowed. Capacitor C2 helps smooth out the changes in emitter potential at *D*, and so reduces the feedback effect.

We have only a limited amount of feedback because, with this simple amplifier it is more important to have high gain than to have high fidelity. To slightly increase the negative feedback, which gives better reproduction (though less gain), R4 can be replaced by two resistors, with C2 across only one of them—see Fig. 6.7.

Next Month: Introducing the Multivibrator.

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NEW · NEW · NEW · NEW

PRODUCTS

NEW · NEW · NEW · NEW

POCKET MULTIMETER

A POCKET size Digital Multimeter, hardly bigger than a credit card, from **AB European Marketing** sits inside its own plastic wallet complete with permanently attached test probes and operating instructions.

The meter, weighing less than 80g, has a $3\frac{1}{2}$ digit display and a rotary mode selector incorporating an on/off switch. This enables easy selection of a.c./d.c. voltage ranges, resistance and continuity and diode testing. It is fully autoranging in all modes.

Warning indicators visually tell the user when the batteries are running low and which measurement mode the meter is in. An audible tone indicates a low resistance path in the continuity test mode.

Despite the meter's small size, it is claimed that its rugged design enables it to be used in a wide range of applications from computer maintenance, television repair, fault finding and motor repair.

The Digital Multimeter retails for £24.60, excluding VAT and p&p, and further information may be obtained from:

AB European Marketing,
Dept EE, Forest Farm
Industrial Estate,
Whitchurch, Cardiff CF4 7YS.

SCOPE FOR DIGITAL MEMORY

THE new **Maplin** ID-4850 Digital Memory Oscilloscope is designed to increase the power and versatility of both oscilloscopes and personal computers. The interface adds testing capabilities to any IBM PC or PC compatible computer, enhancing the computer function as a workstation.

The supplied software enables the user to maintain full control of the DMO from the computer keyboard by means of a waveform on the CRT monitor. These waveforms can be stored for reference or hard copies of all screen displays can be printed-out, together with the print utilities contained within the operating system.

To add the ID-4850 capability to a personal computer, an IBM PC or PC-compatible computer containing at least 128K and a $5\frac{1}{4}$in. floppy disc drive, colour graphic card and a RS232 connector will be required. It can also be used as an interface to enhance a low bandwidth 5MHz scope into a 50MHz dual-trace digital storage scope, with a fast 7-nanosecond rise time.

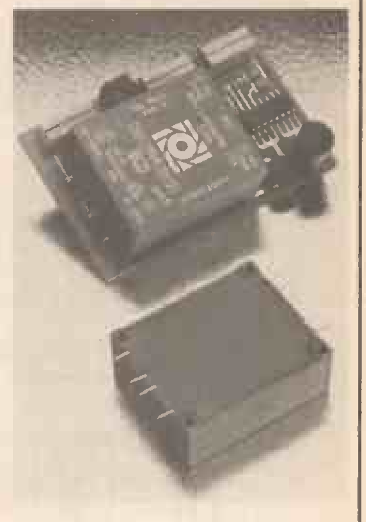
The Maplin ID-4850, which is a Heathkit product is available in kit format for £434.74 or fully assembled for £649.99, both prices exclusive of VAT.

For further technical details contact:

Maplin Professional Supplies,
Dept EE, PO Box 777,
Rayleigh, Essex SS6 8LU.

SURFACE MOUNTED TRANSFORMERS

WHAT are claimed to be the first power supply transformers to be added to the ever increasing choice of surface mounted devices (SMD's) are now being marketed by **Avel-Lindberg.**



The Avel type OB/SM flatpack transformers range from 1·8 to 24VA. Dual 50/60Hz primary windings can be series or parallel connected for 120V or 240V operation. The dual secondary windings give 5V, 6V, 8V, 9V, 12V, 15V and 18V r.m.s. in parallel, and 10V, 12V, 16V, 18V, 24V, 30V and 36V r.m.s. when series connected.

The non-concentric twin primary and secondary windings are wound on separate bobbins which, it is claimed, gives maximum isolation and low interwinding capacitance. It is also claimed that the core construction and winding configuration achieve a near toroidal characteristic.

For full technical details and prices write to:

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Dept EE,
South Ockendon,
Essex RM15 5TD.

RAPID EVALUATION

A NEW evaluation board in double extended Eurocard format, which enables users to evaluate and demonstrate the use of multiple Inmos transputers, is now available from **Rapid Silicon**.

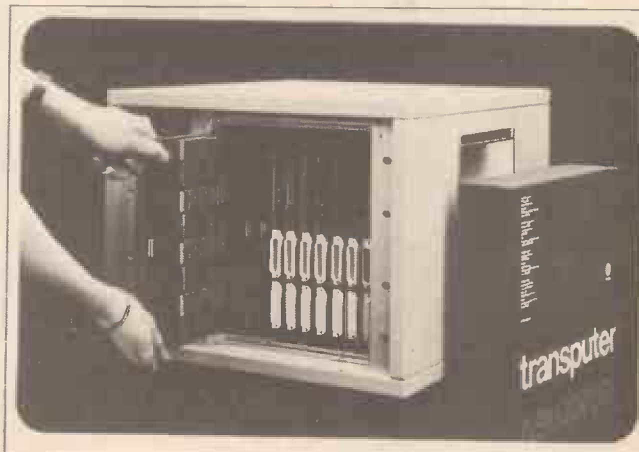
Known as the IMS B003, the board contains four 32-bit IMS T414 transputers to provide a powerful processing tool. Each transputer has its own 256K byte dynamic RAM. In addition, eight standard Inmos serial links are provided, allowing the user to build an array of transputers by connecting other boards.

A 96-way DIN connector is incorporated and the board also has an l.e.d. error indicator and switches for link speed selection. Connection cables for the power supply, links, reset and transputer development systems are all included.

Applications for the B003 can be developed on an IBM PC AT/XT, Digital VAX or MicroVAX, or a Stride computer using the OCCAM language.

Full details of the IMS B003 multiple transputer evaluation board and other Inmos transputer products are available from:

Rapid Silicon,
Dept EE, Rapid House,
Denmark Street,
High Wycombe,
Bucks HP11 2ER



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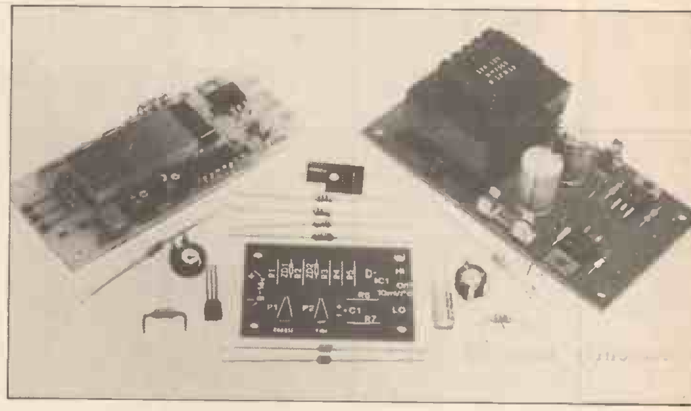

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PSU

The PS209 Mains Power Supply module provides two separate 9V stabilised outputs at up to 250mA each. The unit is ideally suited for use with the Digital Voltmeter Module and the Temperature Measuring Kit. Supplied built and tested the module measures 104 × 54 × 37mm.

TEMPERATURE KIT

The DT10 Temperature Measuring Kit provides an output d.c. voltage of 10mV per degree centigrade over the range from −10°C to 100°C. It uses an integrated circuit in a TO92 plastic encapsulation as the sensing device which may be used at considerable distances from the module without loss of accuracy. It is also possible with the module to employ a number of remotely located probes using an appropriate selector switch. The kit is easy to construct and measures just 52 × 35 × 25mm when complete.

These items are manufactured in the UK, supplied with full data sheets and are covered by a money back guarantee.

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...Beeb...Beeb...Beeb...Beeb...

... digital to analogue converter ...

FOR the vast majority of applications that require analogue inputs the analogue port of the BBC machines is well able to cope, and as we have seen in previous articles in this series, it can be expanded to have considerably more than four channels if desired. Its one major drawback is the slow conversion rate, with a maximum of only about one hundred readings per second being possible. There are few practical applications that require something in excess of this figure, but this is little comfort if you wish to use the BBC machine in one of these. Another limitation of the BBC computer's analogue port is that it only provides inputs, and there is no analogue output: This is perhaps a more serious omission as there are numerous control applications which require fairly precise control of speed, position, or whatever, and simple on/off control via a digital output line is then inadequate for the task.

There is no shortage of ports for expansion purposes on the BBC computer, and it is not difficult to add a high speed analogue to digital converter, and (or) an analogue output. This type of expansion enables the machine to be easily used in a wide range of control applications, as well as audio digitizing systems. The latter includes applications such as digital sound sampling and playback, and using the computer as a simple digital storage oscilloscope.

Analogue Output

We will consider both analogue to digital and digital to analogue converter circuits in this and the subsequent *Beeb Micro* article, but we will start with digital to analogue circuits as these are the more simple of the two processes, and are certainly the more simple of the two from the interfacing point of view.

One of the best general purpose digital to analogue converters currently available is the Ferranti ZN426E. This is a relatively simple and inexpensive type, but this makes it very straightforward as far as interfacing to a computer is concerned, and its degree of accuracy is more than adequate for most purposes.

A detailed description of how the ZN426E functions would be out of place here, and it is a subject that has been covered in previous issues of this magazine. It consists basically of a highly stable 2·55 volt reference source, some electronic switches, and a complex resistor network known as a R-2R type. Sending values from 0 to 255 gives a range of output voltage from zero to the reference voltage potential, or 0 to 2·55 volts, which means that the output voltage increments in 10 millivolt (0·01 volt) steps.

It is important to realise that unlike an ordinary potentiometer which, in theory anyway, has infinite resolution, a digital to analogue converter has a rigidly defined level of resolution. The higher the number of inputs it uses, the larger the range of output voltages available, and the higher the degree of precision that can be achieved. For most purposes an 8 bit type with its 256 output levels is perfectly adequate, and in an application such as motor speed control the variation in speed from one value to the next would be very small (probably too small to be noticed). Similarly, with something like a computer controlled audio gain control, even a dynamic range as wide as 100dB could be accommodated in increments of under 0·5dB, which would give no noticeable stepping of the volume.

In fact, in both these applications 8 bit resolution would be more than was really needed, and a lower resolution converter could be used. These days 8 bits is about the lowest resolution that can be obtained, but an 8 bit type can be effectively converted to a lower resolution converter simply by connecting one or more of the least significant inputs to earth and using fewer output lines of the computer port. There may be no real advantage in doing this, but if the lines that are freed can be utilized for other purposes, then it is obviously worthwhile doing so.

There are some critical applications where 8 bit resolution is inadequate, and audio digitizing is one such example. Higher resolution converters are available, but tend to be rather expensive, especially in applications that require both digital to analogue and analogue to digital conversion. They are also more difficult to interface to an 8 bit microcomputer, although many 10 and 12 bit converters have provision for 8 bit interfacing. It is sometimes possible to make more effective use of 8 bit resolution and to obtain satisfactory results without having to resort to more expensive converters, and in audio digitizing this can be achieved using audio compression and expansion techniques. This is a subject that we will consider in more detail in a later article.

D/A Converter Circuit

The circuit diagram of a digital to analogue converter based on the ZN426E is shown in Fig. 1. This can be driven from the user or printer ports of the BBC computer. The ZN426E has no built-in data latch, and it can therefore only be driven successfully from a port which provides latching outputs. It can not be driven direct from the 1MHz Bus, but it could be used with this port if it was to be driven via the simple 8 bit output port that was described in an earlier article. In actual fact it can be driven from any 8 bit latching output port, and it is usable with computers such as the Commodore 64, VIC-20, and Memotech MTX machines as well.

The circuit is very simple indeed, with the digital to analogue converter chip (IC1) doing practically all the work, and requiring little in the way of discrete components. R1 and C1 are the load resistor and decoupling capacitor for the internal 2·55 volt reference source, which is a shunt type regulator. It is a high quality and highly stable type though, and although it is possible to use an external reference voltage, there would normally be no point in doing so.

IC2 is an operational amplifier which is connected to act as a non-inverting unity voltage gain buffer stage. The output impedance of IC1 is fairly high, and the purpose of IC2 is to provide a low impedance output which is little affected by normal loading. IC1 can only provide output currents of up to a few milliamps, and its maximum output voltage is 2·55 volts. Many practical applications will consequently require further buffering and (or) voltage amplification in order to produce an adequate output voltage swing and drive current. However, this is something that must be tailored to suit the intended application of the circuit.

Potentiometer VR1 is an offset null control, and it enables errors in the output voltage at low output levels to be trimmed

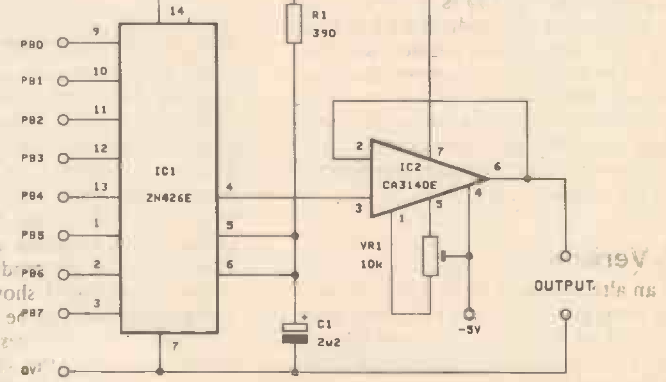


Fig. 1. A simple digital to analogue converter that can be driven from the user or printer ports.

SINEWAVE GENERATION PROGRAMME

```
 10 REM SINE FUNCTION GENERATOR
 20 REM USE WITHOUT 2nd. PROCESSOR
 30 ?&FE62=255
 40 DIM CODE 50, STORE 510
 50 STOREPAGE=&71:SPEED=&72
 60 ?STOREPAGE=STORE DIV 256+1
 70 ?(STOREPAGE-1)=0
 80 CLS
 90 IF B% GOTO 320
100 PRINT "Please wait..."
110
120  PROCfill
130
140 P%=CODE
150 [OPT 2
160 LDY #0
170 SEI
180 .OUTLOOP
190 LDA (STOREPAGE-1),Y
200 STA &FE60
210 LDX SPEED
220 .INLOOP
230 DEX
240 BNE INLOOP
250 INY
260 JMP OUTLOOP
270 ]
280
290  *K.10 OLD|M RUN|M
300 B%=TRUE
310
320 PRINT "Please enter speed factor"
330 PRINT "1-255, higher is slower"
340 INPUT ?&72
350 PRINT "Press any key to start output"
360 REPEAT UNTIL GET
370 PRINT "Press <BREAK> to stop"
380 CALL CODE
390 END
400
410 DEF PROCfill
420  offset=0
430 FOR V=0 TO 2*PI STEP PI/128
440    offset?(?STOREPAGE*256)=SIN(V)*127+128
450    offset=offset+1
460   NEXT V
470 ENDPROC
480
490 REM enter "B%=FALSE" before
500 REM re-running program
```

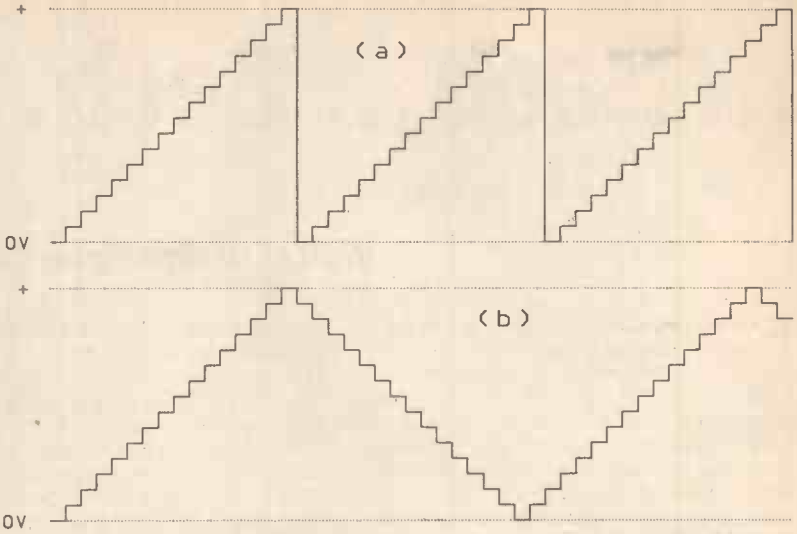


Fig. 3. Digital synthesis of (a) a ramp signal and (b) a triangular waveform.

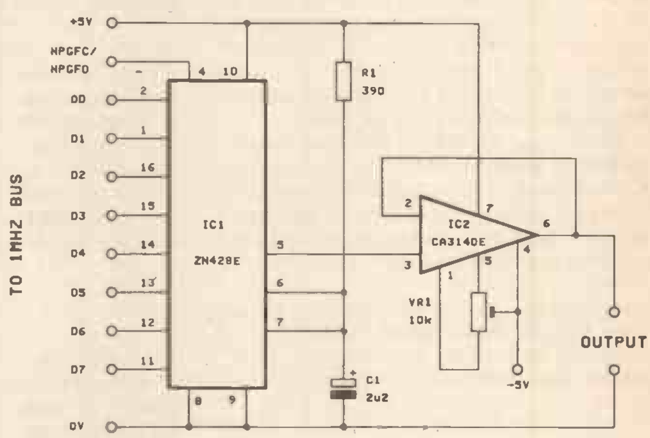


Fig. 2. A D/A converter for the 1MHz Bus. The +5V and −5V supplies can be taken from the power port.

out. This is just a matter of outputting a value of zero to the converter, and then adjusting VR1 to give an output of 0 volts. In many applications the small errors caused by voltage offsets in IC2 will not be of any significance, and VR1 can then be omitted. In fact the negative supply rail will not then be needed, and pin 4 of IC2 can instead be connected to the 0 volt supply rail.

Assuming the unit is driven from the user port, first a value of 255 is written to data direction register B at address &FE62 to set all the user port lines as outputs, and then values to be written to the converter are sent to address &FE60. If the circuit is driven from the printer port, a value of 255 is written to data direction register A at address &FE63, and data for the converter is written to address &FE61.

Bus Version

As an alternative to driving the circuit of Fig. 1 from the 1MHz Bus via a data latch, the circuit of Fig. 2 can be used. This is based on the ZN428E rather than the ZN426E, and these two devices are virtually the same apart from the fact that the ZN428E has a built-in 8 bit data latch. It can therefore be directly interfaced to the buses of a computer, with its 'Enable' input being fed with a negative latching pulse from the address decoder. In the case of the BBC machines, this pulse can be supplied by the cleaned up NPGFC or NPGFD line, or by one of these lines after further decoding with the lower half of the address bus (see the *BEEB Micro* article in the October 1986 issue of this magazine for details of interfacing to the 1MHz Bus).

Sound Generation

The basic circuits shown here are of little value on their own, and for most practical applications will require extra hardware. One application in which a basic digital to analogue converter can be used is sound generation, where a series of values are repeatedly sent to the converter so as to generate the required output waveform. The waveforms are produced from a series of steps, and Fig. 3 shows how ramp and triangular signals can be produced.

Using the full 8 bit resolution the distortion produced by the steps in the output signal can be kept down to under one per cent, and some of the distortion products will be in the ultrasonic range and therefore inaudible. Unfortunately, even using an assembly language program it is only possible to output values at a high enough rate to use the full 8 bit resolution at frequencies of up to a few hundred Hertz. At higher frequencies larger steps have to be used, giving increased distortion. At low frequencies the steps are too small to show up on an oscilloscope display, but at frequencies of several kilohertz or more the waveforms can clearly show their digital origins. As far as the sound is concerned though, the distortion products are largely too high in frequency to be audible, and results are perfectly acceptable.

With the right software it is possible to produce anything from simple pulse signals, to more complex waveforms such as sinewaves or even multiple tones. It is certainly an interesting area for experimentation. The accompanying program is a good starting point, and it produces a sinewave output at a range of frequencies which goes from the subsonic to around 500Hz. The basic technique is to store 256 values in a page of memory (things are much easier if no page boundaries have to be crossed) and then to repeatedly output these in sequence at a rate which gives the required output frequency.

DIGITAL Trouble Shooting
Part Two

MIKE TOOLEY BA

Welcome to our new nine part series on Digital Troubleshooting which aims to provide readers with a practically biased introduction to the diagnosis of faults within digital equipment. The series should also be of interest to anyone wishing to update their knowledge of modern digital devices and circuitry.

THE first part of our series on *Digital Troubleshooting* dealt with integrated circuits, TTL and CMOS logic circuits, and power supplies. This month we shall be introducing some basic logic gates. We also focus our attention on what is arguably the most versatile tool in digital fault finding; the logic probe! We conclude, as usual, with our *Digital Test Gear Project* which, this month, features the construction of a logic probe which can be used for logic tracing in both CMOS and TTL circuits.

SYMBOLS AND LOGIC DIAGRAMS

The newcomer to digital circuitry is often bewildered by the fact that digital circuitry looks quite different from analogue circuitry. This is perhaps not surprising when one remembers that digital circuits may be almost completely devoid of such commonplace components as resistors, diodes and transistors! The reason, of course, is simply that digital circuits are invariably composed of i.c. building blocks (logic gates, bistables, memories, etc.) and, with the exception of the occasional decoupling capacitor, relatively few discrete components are required.

Readers will doubtless recall that we justified the use of integrated circuits on the grounds of cost effectiveness and reliability. The use of such devices has, however, brought with it a radical new approach to electronics; that of treating electronic circuitry as a number of interconnected building blocks.

This, admittedly simplistic, approach lends itself well to fault diagnosis; it merely becomes necessary to identify, locate, and replace the particular block (usually a single i.c.) which has actually failed. In order to do this, however, it is well worth developing an understanding of the logical function and electrical characteristics of each of the basic blocks. Not only will this information be instrumental in actually pinpointing a failed device but it can also be invaluable when unravelling more complex problems.

DIGITAL SIGNALS

Before we examine some of the basic logic gates used in digital circuits we should first mention the essential characteristic which distinguishes digital circuits from their analogue counterparts. Readers will doubtless be well aware that, in electronic circuits, signals are represented by voltages or currents. Signals in digital circuits exist only in discrete steps or "levels"; intermediate states are disallowed. Furthermore conventional (positive) logic is based on only two states. These are commonly referred to as "logic 0" and "logic 1" or simply "low" and "high".

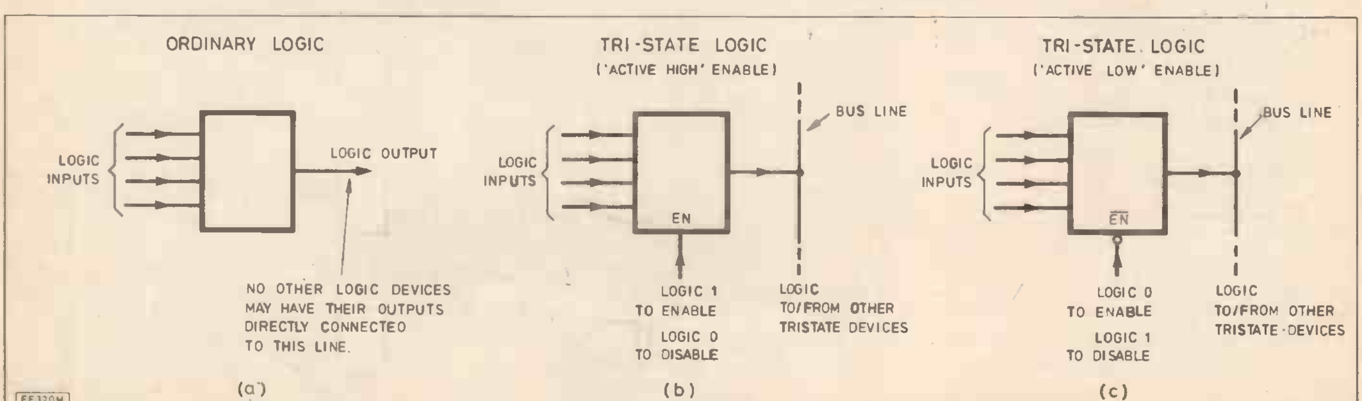
Signals in analogue circuits, on the other hand, can adopt an infinite number of voltages or current levels and the transition between them is usually smooth rather than abrupt as in the case of digital circuits where voltages or current changes occur very rapidly.

TRI-STATE LOGIC

More complex digital devices which are designed specifically for use in microprocessor or microcomputer systems are usually designed so that they are compatible with a multiple connecting arrangement known as a "bus". Since several outputs may be linked to several inputs in such an arrangement there is a danger that conflicting logic levels will appear simultaneously on the bus.

To overcome this problem, we require logic devices which are not only capable of generating logic 0 and logic 1 outputs but can also disconnect themselves from the bus when required. This "high impedance" condition effectively represents a third state and

Fig. 2.1. Comparison of ordinary and tri-state logic devices.



consequently such devices are said to belong to a family known as "tri-state" logic.

Tri-state devices have an input (usually called enable, EN, or chip select, CS) which activates the device. Such an input may be "active high" (the output of the gate is valid when the enable or chip select input is taken to logic 1) or may be "active low" (the output of the gate is valid when the enable or chip select input is taken to logic 0). On the symbol of the device a small circle is used to denote an "active low" enable or chip select input (see Fig. 2.1).

LOGIC LEVELS

Logic levels are simply the range of voltages used to represent the logic states 0 and 1. Not surprisingly, the logic levels for CMOS differ markedly from those associated with TTL. In particular, CMOS logic levels are relative to the supply voltage used (recall that this can be anything from 3V to 15V!) whilst the logic levels associated with TTL devices tend to be absolute. The following table usually applies:

	CMOS	TTL
Logic 1	more than $\frac{2}{3}V_{DD}$	more than 2V
Logic 0	less than $\frac{1}{3}V_{DD}$	less than 0·8V
Indeterminate	between $\frac{1}{3}$ and $\frac{2}{3}V_{DD}$	between 0·8V and 2V

(Note: V_{DD} is the positive supply associated with CMOS devices)

NOISE MARGIN

In a perfect world there would be no uncertainty nor any ambiguity about the logic levels present in a digital circuit. Unfortunately, this is seldom the case since spurious signals (or "noise") are invariably present to some degree. The ability to reject noise is thus an important property of logic devices. This is, of course, particularly true where the digital system is to be used in a particularly noisy environment (such as a steelworks or shipyard).

The ability of a logic device to reject noise is measured in terms of its "noise margin" and is defined as the difference between:

(i) the minimum values of high state output and input voltage and,

(ii) the maximum values of low state output and input voltage.

The noise margin for standard 7400 series TTL is usually 400mV whilst that for CMOS is $\frac{1}{3}V_{DD}$, as shown in Fig. 2.2.

LOGIC GATES

The British Standard (BS) and American Standard (MIL/ANSI) symbols for some basic logic gates are shown in Fig. 2.3. It is fair to say that, in the U.K., the MIL/ANSI standard has overwhelming support and very few manufacturers adhere to the recommended BS symbols.

We shall now briefly consider the action of each of the basic logic gates depicted in Fig. 2.3:

BUFFERS

Buffers do not affect the logical state of a digital signal (i.e. a logic 1 input results in a logic 1 output whereas a logic 0 input results in a logic 0 output). Buffers are normally used to provide extra current drive at the output but can also be used to regularise the logic levels present at an interface.

INVERTERS

Inverters are used to complement the logical state (i.e. a logic 1 input results in a logic 0 output and vice versa). Inverters also provide extra current drive and, like buffers, are used in interfacing applications.

AND GATES

AND gates will only produce a logic 1 output when all inputs are simultaneously at logic 1. Any other input combination results in a logic 0 output.

OR GATES

OR gates will produce a logic 1 output whenever any one, or more, inputs are at logic 1. Putting this another way, an OR gate will only produce a logic 0 output whenever all of its inputs are simultaneously at logic 0.

NAND GATES

NAND gates will only produce a logic 0 output when all inputs are simultaneously at logic 1. Any other input combination will produce a logic 1 output. A NAND gate, therefore, is nothing more than an AND gate with its output inverted! The circle shown at the output denotes this inversion.

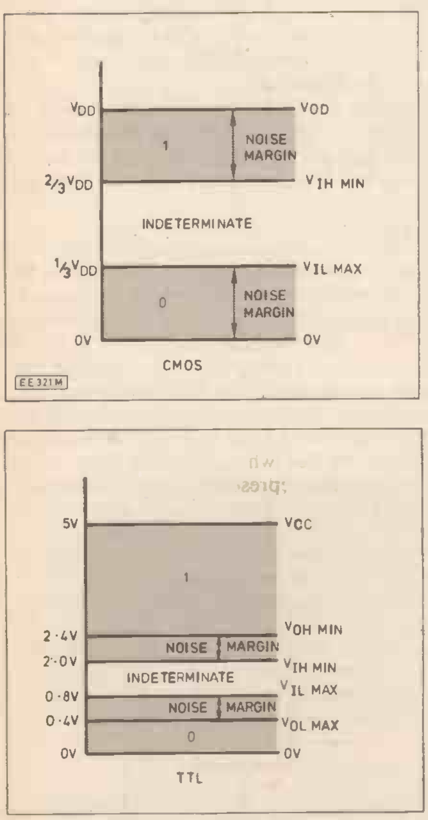
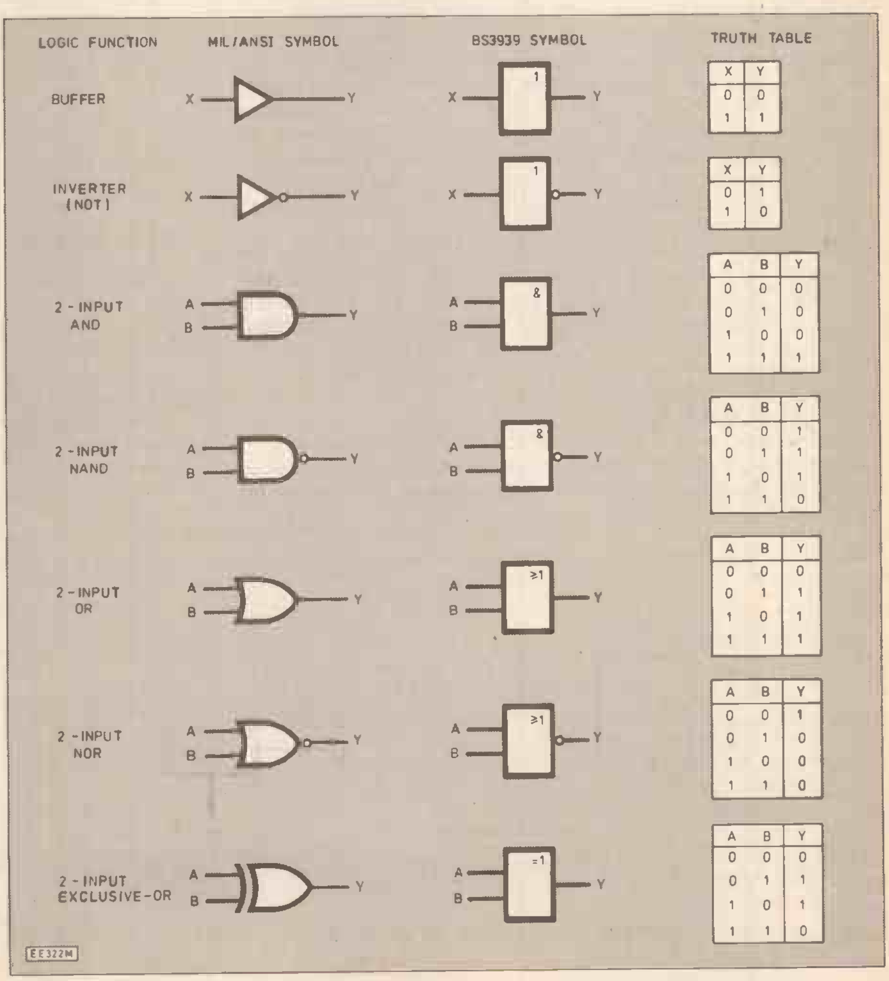


Fig. 2.2 (above). Logic levels for CMOS and TTL.

Fig. 2.3 (right). Logic symbols and truth tables for some common logic gates.



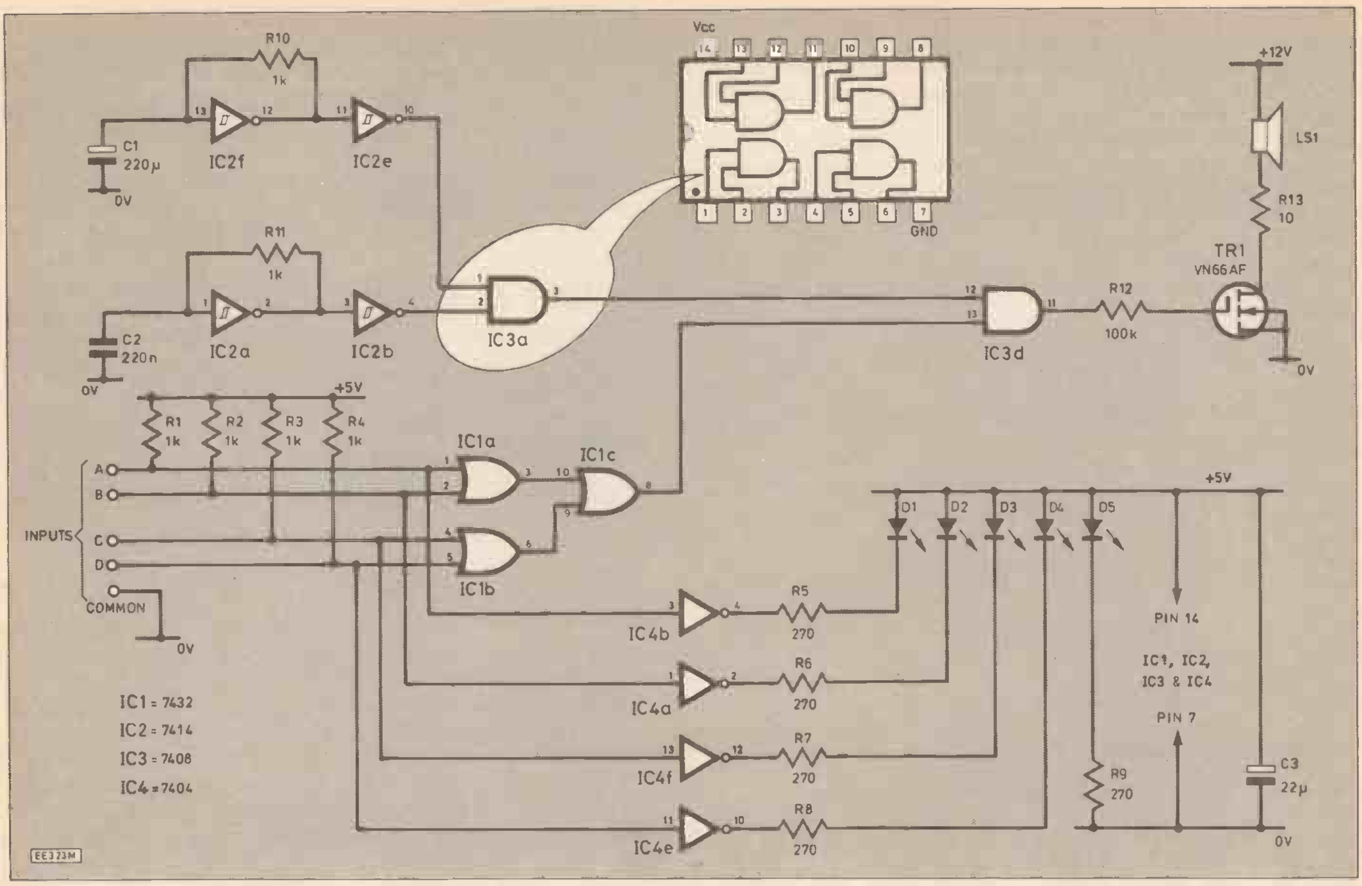


Fig. 2.4. Circuit diagram for a 4-input Intruder Alarm.

NOR GATES

NOR gates will only produce a logic 1 output when all inputs are simultaneously at logic 0. Any other input combination will produce a logic 0 output. A NOR gate, therefore, is nothing more than an OR gate with its output inverted. A circle is again used to indicate inversion.

EXCLUSIVE-OR GATES

Exclusive-OR gates will produce a logic 1 output whenever either one of the inputs is at logic 1 and the other is at logic 0. Exclusive-OR gates produce a logic 0 output whenever both inputs have the same logical state (i.e. when both are at logic 0 or both are at logic 1).

Readers should note that, whilst inverters and buffers each have only one input, exclusive-OR gates have two inputs and the other basic gates (AND, OR, NAND and NOR) are commonly available with up to eight inputs.

TRUTH TABLES

Truth tables provide a handy method of illustrating the function of a logic gate. Truth tables, like those depicted in Fig. 2.3, show the state of the output of the gate resulting from all possible input conditions. For a logic gate with n inputs, there are 2^n possible input conditions. Hence a two-input gate will have four possible input states, a three-input gate will have eight possible input states, and so on.

INTRUDER ALARM

Now let's return to our main theme by putting into context what we have learned so far. Fig. 2.4 shows the circuit of an intruder alarm system which has four inputs. Each input is driven from a normally closed switch which links the input to "common" thus generating a logic 0 state at the respective input. When the switch is opened the logic state at the input concerned changes from logic 0 to logic 1 and this activates the alarm for as long as the input circuit is broken.

Four l.e.d.s, each driven by an inverter, are used to indicate the logical state of the alarm's inputs whilst a fifth l.e.d. is used to indicate that the supply is present. The output of the alarm is used to activate a loudspeaker warning device, LS1, which is pulsed "on" and "off" using audible and low frequency signals respectively generated by two Schmitt oscillators, IC2a, IC2f and associated timing components, C1/R10 and C2/R11. (A Schmitt gate performs the same logical function as its conventional counterpart but offers improved switching characteristics.)

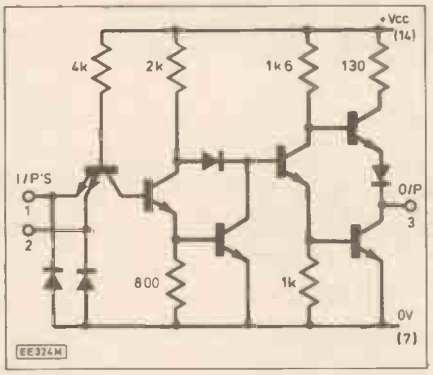


Fig. 2.5. Internal circuit of the logic gate IC3a.

IC3a is just one of the four AND gates contained within the 7408. In this circuit only one other of the 7408's gates is used and the other two gates are simply left disconnected or "floating". The inputs of IC3a (square waves of different frequency) are applied to pins one and two whilst the pulsed output appears at pin three.

The inset shows how the circuit diagram relates to the 14-pin d.i.l. package which houses IC3 and, going one stage further, Fig. 2.5 shows the internal circuitry of the logic gate itself. The +5V and 0V supply rails are common to all four AND gates within the device. Furthermore, in common with the majority of 14-pin d.i.l. devices, these rails are connected to pin-14 (+5V) and pin-7 (0V).

LOGIC STATE TRACING

In general, if any of the internal components fail within a logic gate the entire chip will have to be replaced. The task of identifying a gate which is failing to perform its logical function can be accomplished by various means but the simplest and most expedient is with the aid of a logic probe. This invaluable tool comprises a hand-held probe fitted with l.e.d.s to indicate the logic state of its probe tip.

Whereas a pulse of relatively long duration, say one second or more, can be readily detected using a logic probe which only provides logic 0 and logic 1 indications, a short duration pulse (of say $\frac{1}{10}$ second or less) can only be detected when the probe incorporates circuitry which stretches the pulse so that a third l.e.d. remains illuminated for sufficient time to be seen.

Logic probes normally derive their power supply from the circuit under test and are invariably connected by means of a short length of twin flex fitted with insulated crocodile clips. Whilst almost any convenient connecting point may be used, the leads of an electrolytic decoupling capacitor or the output terminals of a regulator both make ideal connecting points which can be readily identified.

Now, let's assume that our alarm circuit fails to produce an audible output regardless of the state of any of its inputs. Assuming that a logic probe was to hand we could adopt the following procedure for locating the fault:

1. Check the +5V and +12V supply rails. If either is low or missing, check the power supply along the lines suggested last month.

2. Disconnect all four inputs thereby placing logic 1 levels (via the "pull-up" resistors, R1 to R4) on the inputs of IC1a and IC1b. Now examine the state of D1 to D4; if any of these is not illuminated remove and replace IC4.

3. Check that a logic 1 appears at pins three, six, and eight of IC1. If not, remove and replace IC1. (Note that IC1a, IC1b, and IC1c jointly constitute a four-input OR gate). Pin eight of IC1 should go high whenever any one, or more, of the alarm inputs goes high. If this is not the case, remove and replace IC1.

4. Transfer the logic probe to IC3d and examine the state of its inputs and outputs; pin 13 should be high, whilst pins 12 and 11 should both be pulsing. If pin 12 of IC3 is permanently held low or high proceed to step 6, otherwise proceed to step 5.

5. If pin 11 of IC3 is not pulsing whilst pin 13 is high and pin 12 is pulsing, remove and replace IC3. If pin 11 is pulsing, proceed to step 8.

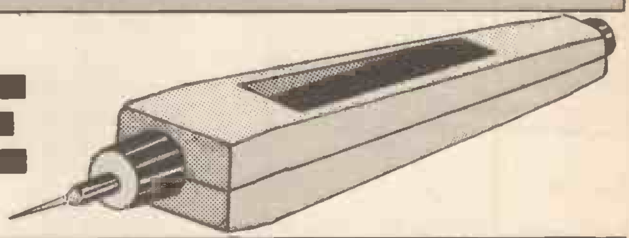
6. Transfer the logic probe to IC3a and check the state of its inputs and outputs; pins one, two and three should all be pulsing. If either (or both) of the inputs of IC3a are permanently held low or high, proceed to step 7. If pin three is not pulsed whilst pins one and two are pulsed, remove and replace IC3.

7. Remove and replace IC2. If this fails to effect a cure, check the timing components, C1/R10 and C2/R11.

8. Disconnect the supply and check LS1 and R13 using a multi-range meter on the ohms range. If neither is faulty, remove and replace TR1.

Next month we shall be dealing with bistable and monostable circuits. Our next *Digital Test Gear Project* is a versatile logic pulser designed for use in conjunction with the logic probe described this month.

LOGIC PROBE



MIKE TOOLEY BA

THIS month's *Digital Test Gear Project* deals with the construction of a Versatile Logic Probe. This handy device is invaluable for logic state tracing in digital circuits and has been designed for compatibility with both CMOS and TTL devices.

CIRCUIT DESCRIPTION

The complete circuit of the logic probe is shown in Fig. 1. IC1, a dual comparator, is used to detect the voltage level at the probe tip by comparing it with voltages produced in the potential divider, R1 to R4. When connected to a normal 5V TLL supply, the voltage appearing at the junction of R1 and R2 is approximately 2·5V whilst that at the junction of R3 and R4 is 1·2V. In the absence of any input (i.e. when the probe tip is left "floating"), the voltage appearing at the inverting input of IC1b and the non-inverting input of IC1a will be the same as that appearing at the junction of R2 and R3 (i.e. approximately 2·3V).

The inputs of IC1 are arranged so that the output of IC1a (pin one) will go low whenever a logic 0 appears at the probe tip whilst the output of IC1b (pin seven) will go low whenever a logic 1 appears at the probe tip. In either case, the respective l.e.d. (D2 or D1) becomes illuminated to indicate the state of the probe tip. In the absence of either a logic 0 or logic 1 input (i.e. an indeterminate, open-circuit, or tri-state condition) both of the outputs of IC1 will go high and neither of the l.e.d.s will be illuminated.

IC2 is a 555 timer operating in monostable mode (we shall be fully describing this arrangement in part four of the series) and is used to provide the necessary pulse stretching facilities. The monostable timing period is initiated by means of a negative going (falling) edge formed by either C1 or C2 in conjunction with R9 or R10, respectively. This falling edge will occur whenever either one of the outputs of IC1 goes low.

SPECIFICATION

Input resistance at probe tip: 400k approx.

Stretched pulse duration: 200ms

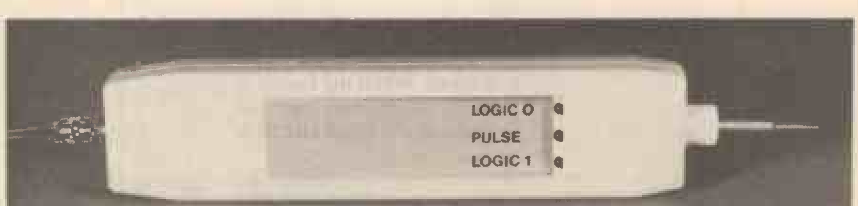
Minimum detectable pulse width: 50ns

Maximum input signal frequency (TTL): 6MHz

Power supply requirements:
TTL 4·5V to 5·5V at less than 30mA
CMOS 3V to 15V at less than 60mA

Threshold voltages:

TTL logic 1	2·5V (General purpose version)	2·4V (TTL only version)
TTL logic 0	1·2V (General purpose version)	1·2V (TTL only version)
CMOS logic 1	60% of supply (General purpose version)	70% of supply (CMOS only version)
CMOS logic 0	30% of supply (General purpose version)	30% of supply (CMOS only version)



The monostable timing period (and time for which D3 will remain illuminated) is governed by the timing components, R11 and C3. The logic probe supply is decoupled by means of C4 whilst D4 has been included in order to protect the probe from inadvertent reversal of the supply.

COMPONENTS

Resistors

R1	15k
R2,R3,R9,R10	4k7 (4 off)
R4,R5	10k (2 off)
R6	470k
R7,R8,R12	270 (3 off)
R11	22k

All resistors are 0·25W ±5% carbon

See Shop Talk page 661

Capacitors

C1,C2	100n (2 off)
C3	4µ7 tantalum 16V
C4	10µ p.c. elect. 16V

Semiconductors

IC1	LM393
IC2	555 Timer
D1 to D3	Red l.e.d. 3mm diam. (3 off)
D4	1N4001

Miscellaneous

8-pin low profile i.c. sockets (2 off); probe case measuring 140mm × 30mm × 20mm approx; single-sided 1mm terminal pins (3 off); Veroboard 0·1 inch matrix measuring 95mm × 63mm approx. (see text).

Approx. cost Guidance only £7.25

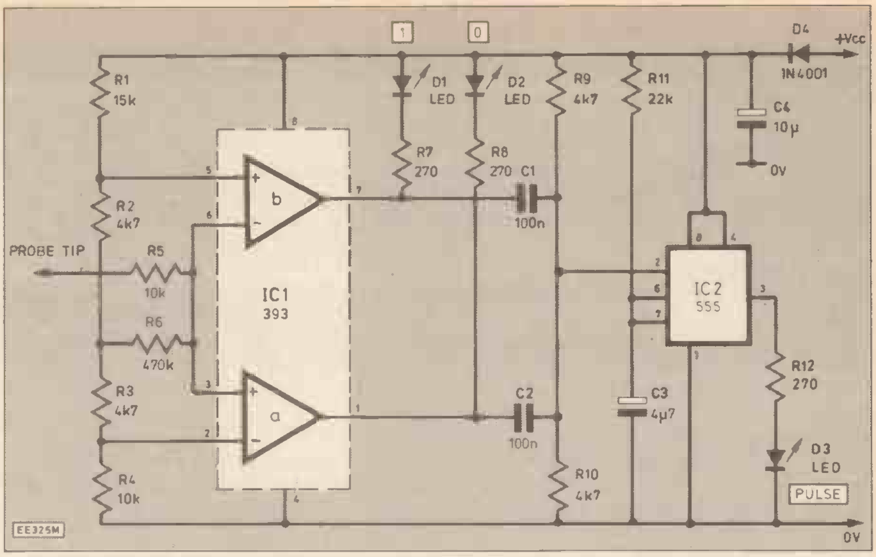


Fig. 1. Complete circuit diagram for the EE Versatile Logic Probe.

CONSTRUCTION

All components for the logic probe are mounted on a piece of Veroboard comprising nine strips by 37 holes. This can be cut from the standard size Veroboard used in this series (24 strips by 37 holes); the remainder being saved for next month's *Digital Test Gear Project*.

The Veroboard layout of the logic probe is shown in Fig. 2. Readers should note that a total of 23 track breaks are required and these should be made using a spot face cutter. If such a tool is unavailable, a sharp drill bit of appropriate size may be substituted.

The following sequence of component assembly is recommended; i.c. sockets, terminal pins, links, resistors, diode, capacitors, and l.e.d.s (leaving sufficient lead length to permit the l.e.d.s to appear in the apertures provided in the upper half of the probe case). The supply lead should now be connected, taking care to ensure the correct polarity (red crocodile clip/striped lead to positive).

Before inserting the two integrated sockets into their holders and mounting the Veroboard in its final position, constructors should very carefully check the components, links, and track breaks. Furthermore, it is also worth checking that all of the polarised components (including l.e.d.s, diode and electrolytic capacitors) have been correctly oriented. Constructors should also carefully examine the underside of the Veroboard for dry joints, solder splashes, and bridges between adjacent tracks.

When the board has been thoroughly checked, the integrated circuits should be inserted into their holders (taking care to ensure correct orientation). The circuit board should then be mounted in the base of the probe case (no mounting hardware is required as the board should be held snugly in place when the two probe case halves are mated together). The probe tip mounting boss should now be connected to the probe input using a short length of insulated wire and the tip screwed in place.

TESTING

The logic probe should be tested using a current limited 5V supply of the type normally employed with TTL and CMOS circuits (see last month). Connect the logic

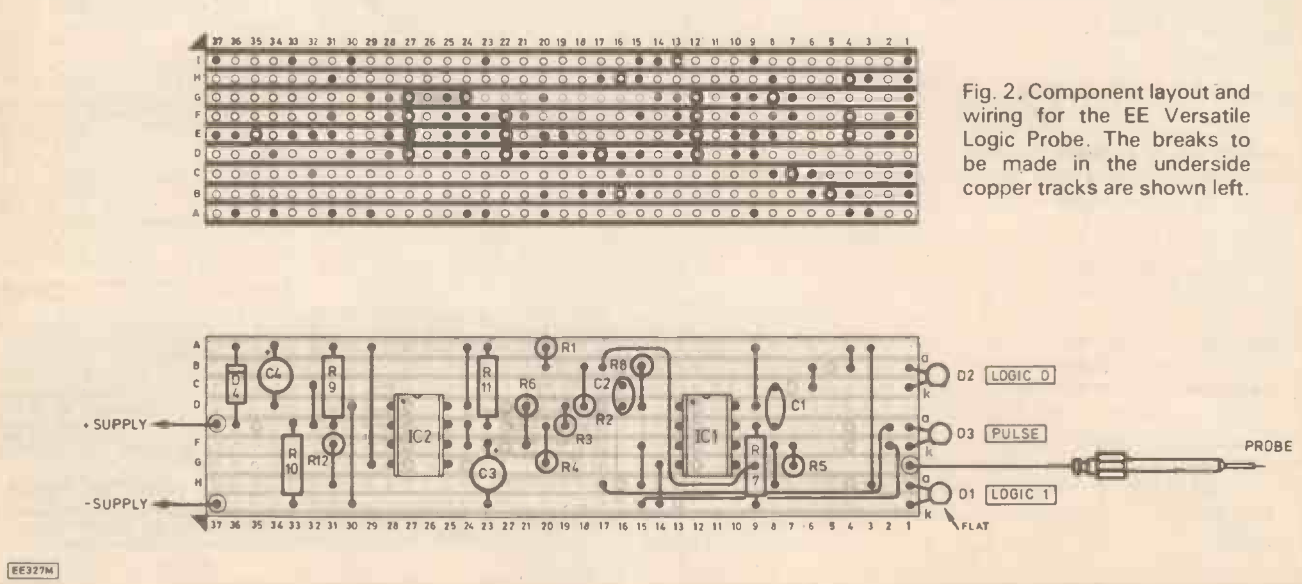
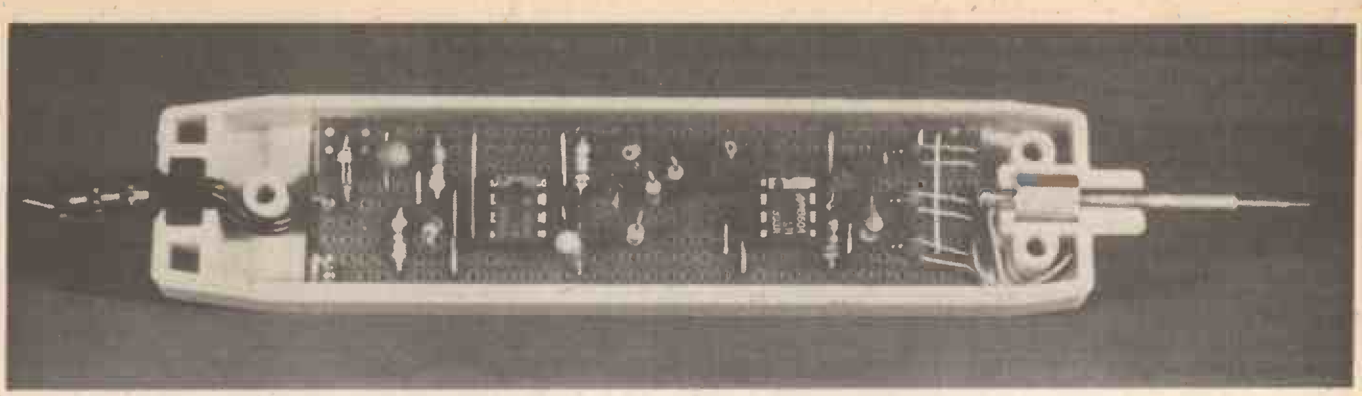


Fig. 2. Component layout and wiring for the EE Versatile Logic Probe. The breaks to be made in the underside copper tracks are shown left.



probe's supply lead to the power supply (taking care to observe correct polarity) and ensure that the probe tip is left unconnected. In this condition none of the l.e.d.s should be illuminated.

Now connect the probe tip to the 0V line. D3 ("pulse") should flash momentarily (indicating a change in logical state at the probe tip) whilst D2 ("logic 0") should become illuminated. Finally, connect the probe tip to the +5V line. D3 should again flash momentarily but this time D1 ("logic 1") should become illuminated.

If the logic probe should fail to produce these indications, the circuit board should be removed from the probe case and carefully checked with particular emphasis on the orientation of polarised components (l.e.d.s, diode, electrolytic capacitors, and integrated circuits) and on the placement of links and breaks.

Resistor	Logic family		
	General purpose (CMOS/TTL)	CMOS only	TTL only
R1	15k	8k2	18k
R4	10k	8k2	8k2

Note: In neither case should the value of R2 or R3 be altered!

MODIFICATIONS

We have already stated that the logic levels for TTL differ from those associated with CMOS devices. The threshold voltage levels used by the logic probe must therefore represent something of a compromise. Where the probe is to be used exclusively for one type of logic or the other, the component changes shown above are recommended. □

NEWS ...from the world of electronics

DRIVING BY SATELLITE

"Riding the airwaves" takes on a new meaning with the development of a satellite automobile navigation system

THE FIRST practical automobile navigation system using satellites has been developed jointly by Mitsubishi Electric and Japan Radio Co. Philips of Holland are also developing a European system, but to date there has been no news on how far forward their proposed system is or when it is likely to be operational.

Scheduled to be introduced commercially in 1989, the system automatically pinpoints the exact location of the car and guides the driver safely to his destination. Even in a strange area the driver need have no fears of getting lost.

The System

The high accuracy of the system is obtained by a combination of a global positioning system (GPS) and a stand-alone navigation system, which consists of a GPS receiver, geomagnetic sensor, speed sensor, flat antenna, control unit, map generator and colour cathode ray tube (CRT) display that shows the car's position on a map.

The GPS can pinpoint a car's location with an accuracy of 100 metres wherever it may be by receiving information simultaneously from three or four satellites. The combination of the GPS with the stand-alone navigation system which is based on information obtained by the geomagnetic and speed sensors allows pinpointing the position of a car even in a tunnel or between high-rise buildings where radio reception from satellites may be poor or even impossible.

Conventional stand-alone navigation systems cannot be so precise because positioning errors are made and accumulate due to changes in driving conditions.

In the future, a total information system will be developed for a more comfortable driving environment with reduced psychological burdens on the driver. It will have a computer to control a display panel and all separate systems, such as self-diagnosis, driving information, air conditioning, television, audio and mobile phone systems. Operation, display and monitoring of these systems will be done on a single CRT display.

Navigation systems, which tell the driver where he is, are part of this information system.

"Cockpit" display for the Mitsubishi Satellite Automobile Navigation System.

CELLULAR GROWTH

The Department of Trade and Industry and the Ministry of Defence announced that the number of radio frequencies available for use by cellular radio in London is to be increased by using frequencies currently allocated to the Ministry of Defence.

This decision should enable the maximum traffic capacity of the two cellular radio systems in the Central London area to be more than doubled. The need for further frequencies has been brought about by the rapid success of cellular radio in the UK.

The speed of uptake, particularly in the London area, has exceeded expectations. In order to avoid unacceptable "airwave" congestion in the future, the Department has agreed that the frequencies immediately below those used for cellular radio, presently allocated to the MOD, may in future be used by the London cellular radio operators. This is provided certain restrictions are adhered to.

Initially, a further 200 channels are to become available to each operator, compared with 300 channels at present. Ultimately, if demand justifies it, a further 120 channels could be made available making a total within Central London of up to 620 for each operator.

The second national UK Atari Computer show is to be held in London in November.

The *Atari Christmas Show* will be held at the Royal Horticultural Hall, Westminster, London, on November 28 to 30.

A new exhibition entitled *Satellite Communications* is to be included in "The British Electronics Week 1987", the premier UK show organised by Evan Steadman.

COMPUTER GOES TO UNIVERSITY

A contract worth more than £½ million for the University of York's new computing system has been awarded to the Digital Equipment Company (DEC). DEC, who also supplied the University's existing system ten years ago, competed with five other companies for the contract.

A large number of computer terminals will be connected to the system of the York campus to serve more than 15,000 potential users ranging from academics, students to administrative staff. It is expected that running costs, including staffing, will amount to more than £½ million a year.

British Telecom have announced a pre-tax profit of £502 million for the first quarter ended June 30, 1986. The profit represented an increase of 12 per cent over the corresponding period last year. Earnings per share at 5.1 pence were 21 per cent higher.

TRANSATLANTIC LINK

A British company is claiming a world first for providing a computer link to allow users on both sides of the Atlantic to chat to each other using their micros. Microlink are offering this facility via satellite to New York at, they claim, approximately half the transatlantic phone charge.

The new service is the result of a deal struck with Mnematics of America. With the help of its new partner, Microlink has set up a gateway which enables the exchange of messages between micros in the US and the UK.

SHOP TALK

BY DAVID BARRINGTON

Count Down

Following on from the highly successful and popular design of a portable *Geiger Counter* published in the pages of EE (Aug '86), **Becker-Phonosonics** have just added a new ready-built version to their range of general purpose radiation monitors.

Designed specifically for non-professional users who are interested in locating radiation sources within the environment, the TZ-272 uses the same industry-standard Geiger-Muller detection tube and features an integral and extendable dual-function probe for background and close-quarter monitoring. The unit has a built-in loudspeaker, a rate detection meter and an output socket suitable for linking to a computer for count analysis.

The geiger tube is built into the unit and housed in a wide aperture primary mount containing an extendable tube. For normal radiation detection the unit is used with the tube retracted and protected by an end cap. For greater sensitivity the cap is removed and a secondary tube extracted and extended, allowing the tube to be placed closer to the source.

Powered by a 9V battery, at less than 20mA, or mains, via battery eliminator, the TZ-272 Geiger Counter weighs less than 1Kg and cost £89.32, including VAT and UK delivery charges (Overseas charges extra). Payment is accepted by credit card, postal order, cheque or international bank draft.

For more details of the range of Geiger Counters, including a pocket version, send a 9in. x 4in. stamped self-addressed envelope to **Becker-Phonosonics, Dept EE, 8 Finucane Drive, Orpington, Kent, BR5 4ED. Tel 0689 37821**. Overseas enquiries are welcome, but should include a payment of £1 (or five international reply coupons), to cover catalogue postage.

Catalogues Received

The 1987 edition of the Greenweld Components catalogue has just been released. It contains 80 pages of electronic components and equipment ranging from humble resistors to sophisticated oscilloscopes.

Also included are order forms, £1.50 redeemable discount vouchers and a special "Bargain List". The catalogue cost just £1 including post.

As an added incentive, there's the opportunity for every customer who spends £10 or over to enter a free monthly draw for a 3-day break at a hotel of their choice. Anyone spending over £200 automatically receives two vouchers for this same break.

Copies of the 1987 Greenweld Catalogue may be obtained from: **Greenweld Electronics Ltd., Dept EE, 443 Millbrook Road, Southampton, SO1 0HX.**

The latest edition of the Electrovalue Catalogue (Oct '86-Jan '87) contains 56 pages and is of a handy A5 "pocket" size. Nearly all the pages carry illustrations of the vast range of products stocked.

Although the catalogue may not contain as many pages as some others in the market place, Electrovalue have used their many years experience as component suppliers and crammed it full of items that the dedicated experimenter and constructor is likely to need. This includes a good range of transistors and integrated circuits. There is plenty of test equipment and tools to choose from.

They also specialise in stocking a large range of Siemens products, these include ferrite cores and capacitors. They are even in a position to obtain the more specialised items on a "small quantity" order basis.

Another item of interest was a listing of "Denco" products. These coils are often specified in radio projects and readers have, in the past, had difficulties in locating a local stockist for these items.

The catalogue is available *FREE* of charge from: **Electrovalue Ltd., Dept EE, 28 St Judes Road, Englefield Green, Egham, Surrey, TW20 0HB.** A 230mm x 160mm approx. stamped self-addressed envelope would be appreciated.

CONSTRUCTIONAL PROJECTS

Dual Reading Thermometer

The ICL7106, $3\frac{1}{2}$ digit A to D converter chip used in the *Dual Reading Thermometer* is listed by Omega, Rapid and Electromail. The temperature sensor i.c.s type LM35DZ, stocked by most component suppliers, operate over a range of 2°C to 100°C. The range can be extended to 110°C by using the more expensive LM355XZ version.

It is unlikely that a suitable 40-pin socket for the display can be found, since it has 1·3in. instead of the standard 0·6in. row spacing. It is suggested that Soldercon pins be used, or possibly two 20-pin single-in-line (s.i.l.) sockets.

16K Sideways RAM

Readers may experience some difficulties in sourcing the Static RAM type 6264LP-15 used in the *16K Sideways RAM*. These devices are carried by Magenta, Electromail, Cirkit and Rapid Electronics.

A complete kit, including the printed circuit board (£13.35 inclusive of VAT, p&p), is available from **Magenta Electronics, Dept EE, 135 Hunter Street, Burton-on-Trent, Staffs, DE14 2ST.**

The Software Cassette (£4.95) and the printed circuit board may be purchased through our PCB Service—See page 682.

Automatic Car Alarm

The p.c.b. mounting relays called for in the *Automatic Car Alarm* must have contacts rated at 10A and 2A respectively. The ones used in our prototype model were purchased from Maplin, order codes YX97F and BK47B.

Other types of relay could be used but they may not fit on the p.c.b. However, the relay could be mounted to the side of the board and the coil contacts "hard wired" to the board. Remember that the switch contacts must be rated as above.

The Scotchlock connectors should be available from most car accessory shops.

Mini Active Speaker

The dual J-FET op-amp (TL072) and the power amplifier (TDA2030) i.c.s. used in the *Mini Active Speaker* project are stocked by most component suppliers.

Suitable power amplifier p.c.b.s may be purchased from Electromail—code 434 576—68p each, plus VAT and a £2 carriage charge. If you ordered all the components this would make the £2 charge seem more reasonable. The loudspeakers are available from **Wilmslow Audio**, 35–39 Church St, Wilmslow, Cheshire SK9 1AS. Tel: 0625 529599.

Intercom Amp/Simple Radio Receiver

This month's chapter of *Exploring Electronics* offers the choice of two "experimental" projects. All of the components for the *Intercom Amp* and the *Simple Radio Receiver* are standard off-the-shelf items and should not cause buying problems.

For those readers who only wish to build these circuits on a breadboard basis, a suitable "test bed" would be the same circuit block used in our recent Teach In '86 series. These solderless circuit blocks are available separately and readers should look through the advertisements in this issue.

A suitable loudspeaker for these projects is currently being advertised by J & N Bull Electrical under their "£1 Bakers Dozen Packs"—code 454 (2 speakers).

Eight-Channel ADC

Readers undertaking to build the circuit for the *Eight-Channel ADC* —see *On Spec* —should have no difficulties in sourcing components.

The high speed, 8-bit 8-channel ADC CMOS chip type 7581 is currently stocked by Electromail, Omega and Maplin. We would point out that this chip is not cheap (from £15 to £20) and care should be exercised when handling this device.

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16K SIDEWAYS RAM

TIM PARKER

A cheaper alternative to buying a complete sideways RAM board

THERE are many different sideways RAM boards on offer to the BBC micro user nowadays. However, these tend to be a little expensive if all you require is 16K of RAM to develop sideways ROM software ready for transferring to EPROM. The design presented here is a reasonably small unit which plugs directly into one of the spare ROM sockets inside of the BBC computer and allows up to 16K of software to be developed in RAM before "blowing" it into an EPROM. This method eliminates the need to keep erasing EPROMs if the software does not function as it should (and it usually doesn't!) the first time.

Ease of construction and installation were considered important factors in the design of the module, which is evident from there only being one external connection to be made to the computer. Cost was also considered important and this is kept low by using readily available components. Only three chips are required and two of these are the RAM devices themselves. The third chip is a standard LS TTL device which is needed to ensure that the correct RAM chip is accessed at the appropriate time.

CIRCUIT DESCRIPTION

The complete circuit diagram is shown in Fig. 1. Do not be misled by its simplicity, this really is all that is needed. Two 6264 8K by eight bit RAM chips are used connected in parallel to give 16K by eight bit configured as 8K lower and 8K upper RAM. The only other chip is a 74LS14 hex Schmitt inverter and is used to enable either the lower 8K or the upper 8K accordingly.

Pin 20 of the 6264 RAM chip is the $\overline{CS}$ (Chip Select) line as found on most other memory devices. This pin must be taken to a logic 0 (low) in order for the chip to be active. In addition the 6264 also has a CS line (pin 26) which must be taken to a logic 1 (high) for the chip to become active. Both of these pins must have the appropriate logic on them at the same time in order for the chip to operate and this feature is made use of in this application.

IC1 and IC2 are 8K devices so only one can be active at any time. This function is performed by IC3. When memory from

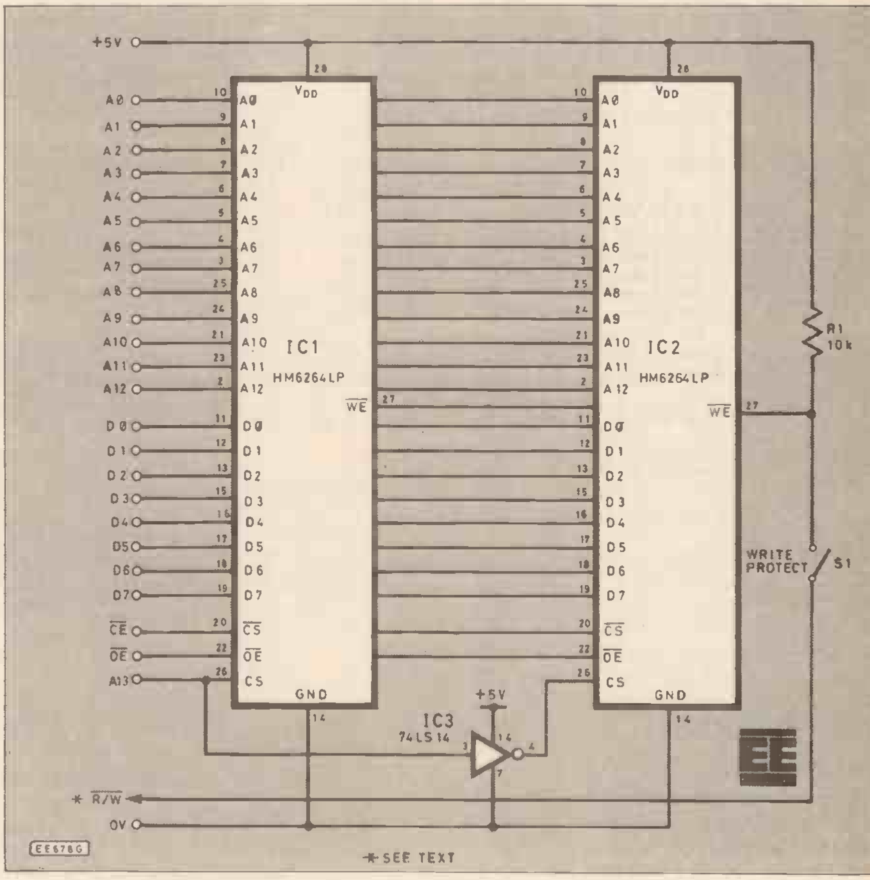
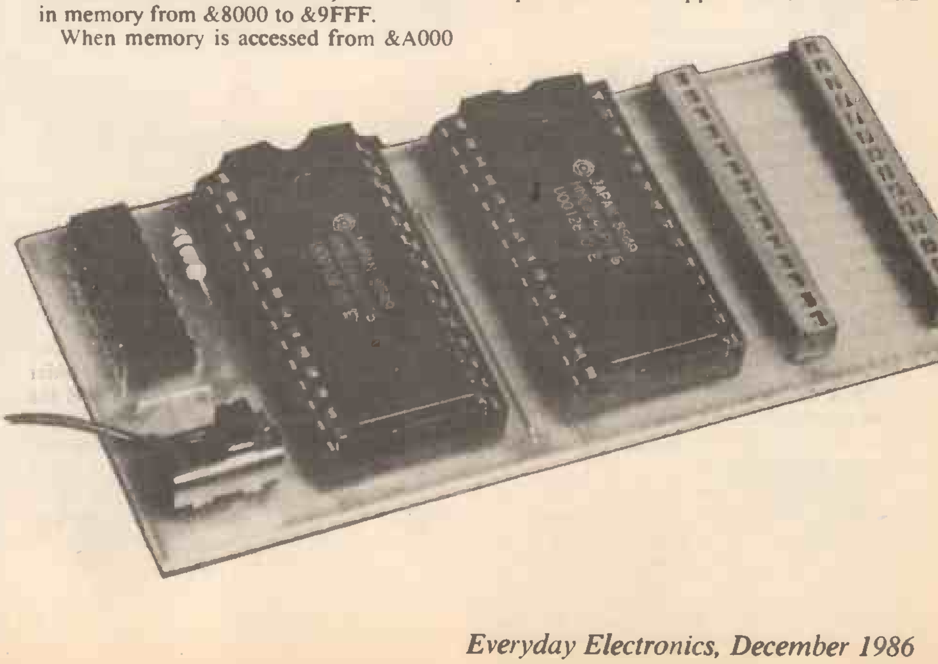


Fig. 1. Circuit diagram of the 16K Sideways RAM.

&8000 to &9FFF is being accessed the computer address line A13 is low. This is inverted by IC3 and applied to pin 26 of IC2 thus enabling the chip and giving us the lower 8K area. In other words, IC2 resides in memory from &8000 to &9FFF.

When memory is accessed from &A000 to &BFFF the computer address line A13 goes high and enables IC1. Once again IC3 inverts A13 and pulls pin 26 of IC2 low, thus disabling it. This now means that IC1 operates as the upper 8K of RAM and



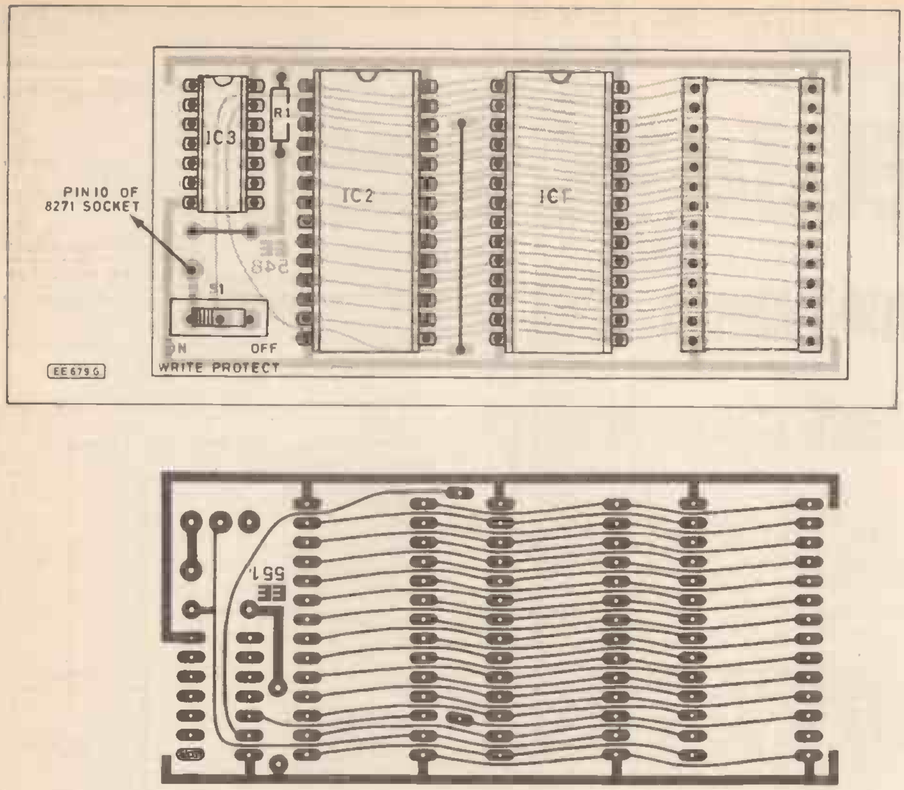


Fig. 2. P.C.B. layout and wiring for the sideways RAM.

COMPONENTS

See **Shop Talk** page 661

Resistor
R1 10k $\frac{1}{4}$ Watt Resistor

Semiconductors
IC1,IC2 HM6264LP-15 8K static RAM (2 off)
IC3 74LS14 hex Schmitt inverter

Miscellaneous
S1 p.c.b. mounting slide switch
28 pin i.c. sockets (2 off); 28 pin turned pin i.c. socket (see text); printed circuit board and software cassette, available from the *EE PCB Service*, Order Code EE551; 300mm of single stranded insulated wire

Approx. cost Guidance only **£13**

occupies memory from &A000 to &BFFF, which incidentally is the highest allowable memory location for any sideways ROM or RAM.

There is one minor problem with plugging RAM into a sideways ROM socket inside the BBC micro, and that is the provision of a write strobe in order to program it. This pulse is not connected to the ROM sockets and we must obtain one from elsewhere in the computer. Unfortunately there is a flaw if it is taken directly from the CPU. The problem is that the R/$\overline{W}$ (Read/$\overline{W}$rite) signal is still valid when the data bus has changed, which leads to spurious and unpredictable results. Fortunately we can obtain a R/$\overline{W}$ pulse from another chip inside the computer which has the advantage of being gated with the 2MHz processor clock and gives us the correctly timed write pulse we require.

Having obtained the write line we must connect it to the $\overline{WE}$ (Write Enable) pin of the two RAM chips. This is done via switch S1 which acts as a simple write protect switch. When the switch is closed it applies the R/$\overline{W}$ strobe to pin 27 of IC1 and IC2 thus enabling them to be written to. When the switch is open, the R/$\overline{W}$ strobe is disconnected and resistor R1 holds pin 27 of the two ICs high preventing accidental (or intentional!) writing to the RAM.

CONSTRUCTION

The design is built on a single sided printed circuit board the layout of which is shown in Fig. 2. Begin by soldering in the two wire links followed by R1 and IC3. It is recommended that i.c. sockets are used for the two RAM chips and these should be soldered to the board next. This requires some careful soldering as there is very little space between the i.c. pads and the tracks running in between them.

A good quality 28-pin turned pin i.c. socket is required for insertion into the ROM socket. Normal long pin wire wrap sockets have rather thick pins and these tend to splay out the ROM sockets in the computer. This leads to unreliable connections to the ROMs if one is inserted into a socket which has had a wire wrap socket forced into it then later removed. A possible cheap alternative is to use a 0·1 inch 23-way edge connector (the type used for ZX-81 peripherals) cut to a lower profile. This is then cut down to 28 way and in half along its length. These two halves are then soldered in place of the 28 pin socket.

Although the p.c.b. is designed to have a small low profile slide switch mounted on board to perform the write protect function, there is no reason why two lengths of insulated wire cannot be soldered to the board and the switch mounted in a more convenient place. If this method is used it must be remembered that it is the computers internal R/$\overline{W}$ signal on these wires and if they are too long it is possible to pick up other stray pulses from inside of the computer which could lead to data corruption in the system, and not necessarily just in the sideways RAM. Finally, solder about 300mm of single stranded insulated wire to the board as shown in the layout.

INSTALLATION

Before plugging the board into the computer give it a thorough check for any solder bridges that may have occurred during construction, especially between the i.c. pads where space is minimal. Once you are satisfied everything is all right it can be fitted inside the computer as follows.

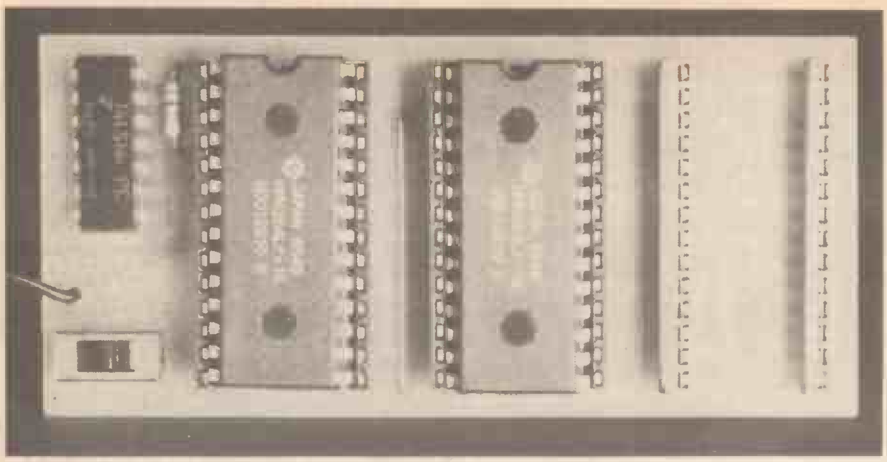
Switch off the BBC micro and remove the top half of the casing. This is done by removing the two screws found on the outer edges of the back of the case (on some older models these are marked "FIX") and the two larger headed ones underneath the keyboard at the front of the case, the top half of the case can now be lifted clear of the bottom. Next, remove the two screws securing the keyboard in place, lift the keyboard slightly and gently pull it towards the front of the case. There is no need to remove the connector between the keyboard and the main board as there is enough room available for what we want to do.

The following information refers to a BBC micro with no extra ROMs except perhaps for a DFS ROM, if this is the case there will only be two spare ROM sockets instead of the usual three found on tape based machines.

At the bottom right hand side of the main board are the ROM sockets. Actually only four of the five sockets are for sideways ROMs, the one on the far left is the Operating System and must not be moved. The socket we require is the one on the far right and there are two main reason for this. Firstly, this is the highest priority ROM socket which means if a language ROM is present here it will have the first chance to initialise itself on power-up or when BREAK/CTRL-BREAK are pressed. If ROM priority is not important the unit can be installed in any of the other available spare sockets. Secondly, the size of the RAM module is such that it will sit comfortably over the top of the rest of the ROMs without over-hanging the left hand side. If this socket is occupied it is a simple matter of carefully "shuffling" all of them to the left by one socket.

The module can now be plugged into the vacant socket. It may be a tight fit (especially if the socket was already empty) but should go in if it is rocked slightly to and fro. The flying lead for the R/$\overline{W}$ signal can now be connected. Remove about 5mm of insulation from the end of it and push in into pin 10 of the 8271 disc controller chip, this is the large (40 pin) i.c. located three chips in from the left hand side of the main p.c.b. about half way down the board. If you do not have this chip fitted it is simply a matter of pushing the lead into pin 10 of the i.c. socket. If the 8271 is in place, push the wire in between the pin and the socket.

Once the module is in place it is necessary to slide a small piece of cardboard or other insulating material underneath the board between the RAM module and the ROMs,



warning! do not switch the computer on until this is done. There are three diodes directly above the operating system ROM which have the computers 0V rail connected to them and since the track at the top of the RAM board is connected to the +5V rail, the BBCs power supply unit will be short circuited if the power is applied without the insulation in place. Replace the keyboard on its locating lugs but do not secure it in place yet. Switch on the micro and if all's well the usual start-up message should appear, if not switch off immediately, remove the board and re-check the soldering, also check orientation of the components. If the start-up prompt does appear, the keyboard and casing can be reassembled. All that remains now is to program the RAM with the machine code routines you require.

SOFTWARE

As the board is designed to be built and installed by the novice, it is not possible to *LOAD code directly into the RAM or write machine code programs that will assemble the code into the RAM area. The ability to do this would involve too much "fiddling about" inside the computer for the inexperienced. Space does not permit the software listing to be published here. However a cassette containing software which enables code that is assembled into the computers main memory to be written into the sideways RAM with relative ease is available through the *EE PCB Service*, see page 682. The software is self documented with instructions on how to use it and includes a few utilities to help get you started. □

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Wanted: Quarter inch 8-track tape heads (record/play + erase) or two sets of 4-track cassette heads. S. Powell, Fircroft, Feniton, Honiton, Devon EX14 0DE.

Wanted: Information how to program Kay DRM-1 Memory Rhythm Machine. Reasonable for disabled OAP Home use. Mr. W. E. Turner, 5 Alexandra St., Thorne, Doncaster, S. Yorks DN8 4EE.

Wanted: Mushroom user/printer port for Acorn Electron operating data. Costs paid. Contact: Jones, Tel: 0767 40220.

SX200N scanning RX plus antenna/MPU £200. ARA30 active antenna £80. Datong AD370 active antenna £50. Mr. N. Porter, 23 Calder Court, Britannia Road, Surbiton, Surrey KT5 8TS. Tel: 01-390 2650.

ZX/Spec sound board, with details, £5. Speech board £5. Keyboard with 74 Hall effect keys £10. Ben. Tel: 021-525 9772.

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150W switchmode PSU, +5V @ 13A, +12V @ 1A, +12V @ 1·5A, +24V @ 1·7A, −12V @ 0·2A. Perfect working order £29. Tel: 0245 59027 after 6.00 p.m.

300 P.W., P.T. magazines 1946-1966. Fair condition. Hence £10. Buyer collects—London. Tel: 01-359 2313.

Wanted: Circuit diagram or photocopy for Scopex 14D-10 scope. A. P. Gauci, 1a Brantwood Close, The Drive, Walthamstow, London E17 3DY.

Wanted: November 1984 Electronics Monthly. Good price paid. N. J. Sutcliffe, 63 Manor Road North, Hinchley Wood, Esher, Surrey KT10 0AB. Tel: 01-398 1233.

Tandy: 8MHz single beam oscilloscope, with leads, £60 o.n.o. 43 St. Pauls Road, Stockingford, Nuneaton CV10 8HW.

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JANUARY '87 ISSUE ON SALE FRIDAY, DECEMBER 12

Actually Doing it!!

UNDOUBTEDLY one factor which tends to put off newcomers to the hobby from actually building a project is the doubt in their minds as to whether they can successfully complete it. Probably most people who take an interest in electronics eventually take the plunge and give it a try, and immediately run up against the problem of obtaining the components, or perhaps more to the point, obtaining the right components. Things were much easier about twenty years or more ago when there were relatively few components to choose from, and most electronic projects were based on just a few of the more popular types. I suppose that even today a study of a few circuit diagrams in this magazine would reveal that most of the projects were based on a relatively small number of components, with certain integrated circuits and resistor values cropping up time and time again. On the other hand, in practically every project there is one or more unusual component, and it is this factor that partially accounts for the steady increase in the number of different components that are available. The other is the large number of variations on components of a different type, with numerous almost identical transistors, capacitors of various styles, resistors of different power ratings, tolerance and composition, and so on.

WHERE TO BUY

Electronic component shops are not exactly found on every high street in the country, and even if you do have a local electronics shop (even a large one) it is unlikely to be able to provide all your component needs. Electronics construction is very much a mail order hobby, and without a selection of component catalogues you are likely to find it tough going to obtain the components for anything but the most simple and mundane of projects.

A selection of catalogues is likely to cost several pounds, which may seem like a lot of money, but with the three or four of the biggest catalogues you will have a total of well over a thousand pages. It is tempting to simply buy one of the larger catalogues in the hope that this will list every component that you will require. The range of available components is so wide these days that this is unlikely to be the case, and there are big gaps in the ranges of virtually every supplier. For example, several of the larger catalogues list very little in the way of inductors, coils, and transformers, whereas other suppliers specialise in these and offer a wide selection of them.

By taking a few hours to carefully look through some electronics catalogues you can certainly learn a great deal about the practical side of electronics. Most of the larger catalogues are well illustrated, and will help to familiarise you with what the various components look like. There have been few electronic catalogues produced which do not more than justify the asking price, and in some cases there are discount vouchers which can be used to recover some or all of the cost when ordering components.

It is worth studying the catalogues to build up a good knowledge of what components are available from each supplier. This can save a lot of time when searching through the catalogues to find your requirements. Perhaps one day there will be a computerised and continuously updated components directory to make things easy, but in the meantime components have to be tracked down the hard way. There is often some help, with sources for unusual components being provided in the book or magazine concerned (*Shop Talk* in this magazine being a good example). At one stage the response to the "See Shop Talk" note which accompanies each components list was so underwhelming that they were all printed up-side-down to make them more noticeable. You can save a lot of wasted time and effort by reading the relevant section of *Shop Talk*, and any component which is not mentioned there should be readily available from a number of sources.

An important function of catalogues is to provide data on the components that are being sold. Some catalogues include data such as transistor and integrated circuit leadout data, and this can be extremely useful. If a piece of vital constructional information is missing from a book or magazine article the catalogue from which the component in question was bought will often provide the missing information.

Component catalogues generally have information on the physical characteristics of the components, and this can be an important factor to take into account. Generally speaking, the physical shape and size of a component is of secondary importance, and provided it has the right electrical characteristics it will work. Being more practical and less theoretical about things, most projects are currently constructed on custom printed circuit boards, and components must be of the right physical type if they are to fit onto the board correctly.

The variations that occur in components of the same electrical specification are quite surprising, and I have, for example, had 1µ 63V electrolytic capacitors in a range of sizes from about 5 by 2 millimetres to about 15 by 12 millimetres. Some variation in size is usually quite tolerable, and there is not normally any difficulty in using a component that is smaller than the one for which the board is designed. Using much larger components is more difficult, especially if there are a number of them to fit onto the board. Provided you buy good components from a reputable retailer you should always be supplied with good quality components of modern manufacture. Although at one time there were a lot of problems with old or poor quality components (or even total duds) being marketed as new and guaranteed, in recent times I have purchased components from a number of mail order retailers, and they have all been of excellent quality.

There are many inexpensive packs of components available, and in many ways these are very good and represent excellent value for money. They are probably better suited to experienced constructors who are able to sort out the good from the bad and indifferent, than to a beginner who could have problems with many of the components. The components in these bargain packs are sometimes fairly old, and consequently quite large by current standards. These are often perfectly usable, and are a useful source of cheap components for the experimenter, but there could be difficulty in trying to fit them into a modern design.

CAPACITORS

Capacitors come in a variety of types, as far as electrical characteristics are concerned there are two basic types—polarised and non-polarised. When it comes to construction the difference is that the polarised capacitors have to be fitted the right way round, whereas the non-polarised capacitors can be fitted either way round. By far the most common type of polarised capacitor is the electrolytic type, and these usually have the two leadout wires clearly identified by "+" and "−" signs on the body of the component. The constructional diagrams should similarly identify the two leadout wires, or at least identify the appropriate lead with a "+" sign.

With axial style electrolytics there is usually an indentation towards one end of the component's body, as in Fig. 1(a), and this indicates the positive ("+") terminal. The other style of electrolytic is the radial or PC (printed circuit) type, as shown in Fig. 1(b).

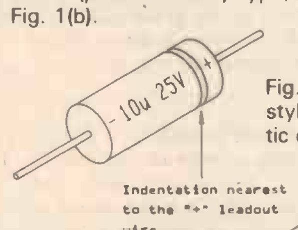


Fig. 1a. Axial style electrolytic capacitor.

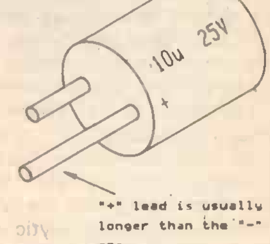


Fig. 1b. The radial or PC (printed circuit) type of electrolytic capacitor.

The axial type are intended for horizontal mounting, whereas the radial type are designed for vertical mounting. It is not difficult to fit a printed circuit type where the board is designed to take an axial component, provided the component has reasonably long leads. However, the component will protrude far further above the board than an axial type would, and in some instances this could make it difficult to fit the finished board inside the case unless it is possible to manoeuvre the component so that it lies flat against the board.

It is generally quite easy to mount an axial capacitor vertically, but it might be

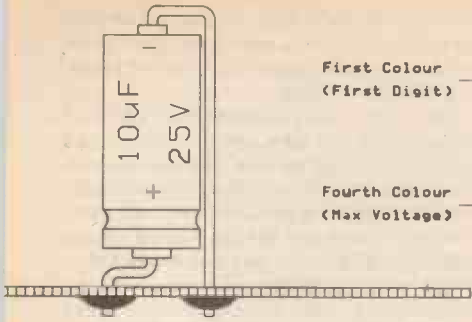


Fig. 2. Mounting a radial component in place of an axial one.

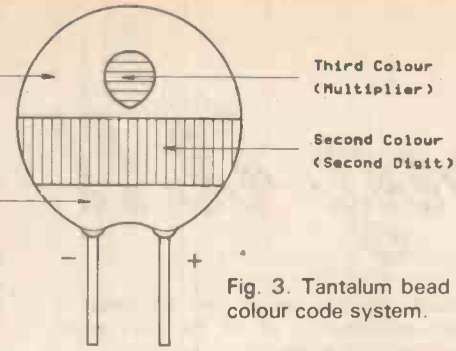


Fig. 3. Tantalum bead colour code system.

COLOUR	BAND 1	BAND 2	SPOT	BAND 3
BLACK	—	0	×1	10V
BROWN	1	1	×10	—
RED	2	2	×100	—
ORANGE	3	3	—	—
YELLOW	4	4	—	6.3V
GREEN	5	5	—	16V
BLUE	6	6	—	20V
VIOLET	7	7	—	—
GREY	8	8	×0.01	25V
WHITE	9	9	×0.1	3V
PINK	—	—	—	35V

necessary to do some forming of the leadout wires, as in Fig. 2, so that the component is kept within its allotted area of the board. It is advisable to fit the longer leadout wire with a piece of p.v.c. sleeving to minimise the risk of accidental short circuits. This method of mounting is physically less strong than using the right type of component, and I would strongly recommend the use of modern miniature electrolytics of the appropriate type wherever possible. Many modern printed circuit designs have very compact component layouts, and trying to use unsuitable components, apart from giving a rather messy looking finished article, will also give poor reliability.

TANTALUM CAPACITORS

There is actually a type of electrolytic capacitor which is non-polarised, but these are something of a rarity, and you are unlikely to ever use one in a project. Obviously they can be connected either way round, and represent no difficulty from the constructional point of view.

You are much more likely to encounter tantalum capacitors, or "tantalum beads" as they are often called, due to their very rounded bead-like shape. These are polarised capacitors which are used where the performance of electrolytic types is inadequate. Electrolytic capacitors generally have very high tolerances, poor temperature stability, large physical size, and quite high leakage levels. In most of their normal applications this does not matter, but some critical applications require superior performance in one or more of these departments, and a tantalum capacitor is then the normal choice. In fact there are now superior grade miniature electrolytics which can be used where ordinary electrolytics are inadequate, but where a tantalum type is specified for a project I would not recommend the use of any form of electrolytic component.

All the tantalum capacitors I have obtained recently have had their value and polarity marked on them in the usual way, but in the past it was common for a system of colour coding to be used. There are almost certainly still components of this type in circulation, and you may well encounter some of them. Fig. 3 helps to explain this system of colour coding.

This is very similar to the system of resistor colour coding, with the first two bands indicating the first two digits of the value, and the third colour indicating a multiplier. However, note that the third colour in the code is the spot, and not the third coloured band. The latter indicates the maximum operating voltage for the component. Unlike resistor colour coding, this system does not show the tolerance of the component. Note that a secondary role of the coloured spot is to indicate the polarity of the component (the "+" lead is the one on the right when looking at the side of the component which carries the spot). Details of the tantalum colour coding system are given in the table shown above.

As an example, the colour coding yellow (4), violet (7), white (×0.1), grey (25V), would be a 4μ7 (47 × 0.1 = 4.7) 25 volt component.

It would be reasonable to ask what happens if a polarised capacitor is connected the wrong way round? In the case of tantalum types, they are easily damaged by reverse voltages and the destruction of the component would be quite likely. Electrolytics are generally somewhat tougher, and in a circuit where the d.c. voltage across the component is very low the component might work perfectly well. It would be likely to have a high leakage current though, which would be reflected in the performance of the circuit. At worst, where a large smoothing capacitor in a power supply is fitted the wrong way round, there is a strong possibility of the component getting seriously overheated or even exploding! So make sure you observe polarity markings when fitting components.

Robert Penfold

PLEASE TAKE NOTE

FET VOLTMETER *(April 1986)*

Page 197, Fig. 1. Resistor R16 should be disconnected from Pin 2 of IC1 (leaving R18 and C2 still connected), and reconnected to the other end of C2; i.e. to the junction of C2, R14 and R15.

This error was carried through to the component layout (Fig. 4), and hence the end of R16 not connected to VR1 should be moved 4 rows further away.

OPTICALLY ISOLATED SWITCH *(November '86)*

Page 575, Fig. 4. The triac should be designated **CSR1** and *not* IC1, as shown. Also, terminal 2 (MT2) is the centre pin of this device.

CAR FLASHER WARNING *(November '86)*

Page 612, Fig. 1. IC1 is a 741 operational amplifier i.c. We apologise for omitting the type number from the circuit and components list.

a regular feature for the Spectrum Owner...

by Mike Tooley BA

THIS month (and in the hope of giving you a brief respite from the Christmas festivities!) we shall be describing the construction of an eight-channel analogue to digital converter. Before we get started, however, there is just time to wish you all a very happy Christmas and take a look at the last of three BASIC interpreters for the Spectrum in the form of LASER BASIC.

LASER BASIC

LASER BASIC was written by Kevin Hambleton, published by Oasis Software, and marketed by Ocean as part of their "i.q." range of "Interactive Software". LASER BASIC promises to provide the "secret of advanced games programming"—a somewhat rash claim but one which is not altogether unfounded, as we shall see!

The neatly presented package comprises two cassette tapes together with a comprehensive manual. Loading takes some considerable time (largely attributable to a lengthy BASIC loader which provides several options, including saving to microdrive). Once loaded, one is somewhat disappointingly presented with the familiar Sinclair screen complete with flashing keyword cursor.

It is important to stress at the outset that LASER BASIC is primarily concerned with sprite graphics and thus differs substantially from the other two enhanced BASIC interpreters previously reviewed in this column. Futhermore, LASER BASIC does not produce stand-alone programs. In order to do this, users will require a matching compiler (available from Oasis).

New commands provided by the LASER interpreter are preceded by a full-stop. Care must, however, be taken to avoid inserting any spaces within extended commands. As an example, the following program moves sprite number four across the screen; XORing the sprite into, and out of, each column location:

```
10 .SET=0: .SPN=4: .ROW0: .COL=-4
20 BORDER 1: BRIGHT 1: INK 6: PAPER
1: CLS: .ATOF
30 FOR I=-4 TO 32
40 .PTXR: .COL=I+1: .PTXR
50 PAUSE 4
60 NEXT I
70 STOP
```

Besides the graphics extensions, LASER BASIC also provides a few "toolkit" commands. These include .RMK (a REM stripper), .TRON and .TROFF (a trace facility), and .RNUM (a renumbering command).

The way in which parameters are passed to LASER BASIC's graphics routines is somewhat unusual. Each graphics command uses a particular subset of the 10 graphics variables. Some commands require up to five parameters and, in most cases, more time would be spent evaluating the five expressions than actually executing the command.

More often than not, only one or two parameters need to be re-evaluated between successive executions of a command and LASER BASIC sensibly only requires those parameters which actually need to be changed. This, of course, results in a much faster speed of execution than would otherwise be possible.

LASER BASIC provides for 16 sets of the 10 graphics variables, selected using the .SET command. The variables include such items as SPN (sprite number), ROW, COL, HGT, LEN, etc. The short mnemonics employed represent a good compromise between speed of keyboard entry (LASER BASIC commands all involve single keystroke entry) and a format which can be easily memorised.

LASER BASIC is supplied with an extremely good manual (approximately 90 A5 pages) which contains numerous examples and commented code for more than 30 well chosen demonstration routines. Also supplied with the package is a Sprite Generator program by Paul Newnham, two very extensive sprite libraries, and a game written in LASER BASIC.

Other than procedures, LASER BASIC does not offer much in the way of powerful control structures, de-bugging and string handling commands possessed by its two main rivals, BETA BASIC and MEGA BASIC. Prospective purchasers should also be aware that another Oasis product, "White Lightning", provides an arguably superior graphics development environment based on the FORTH language. As a devotee of FORTH, I much prefer White Lightning, however, LASER BASIC does make a good starting point for someone wishing to develop sprite oriented software from BASIC.

Oasis is at Dept. E.E.,12 Walliscote Road, Weston-super-Mare, Avon BS23 1UG.

Eight-Channel Analogue to Digital Converter

In a previous instalment of *On Spec* I described the construction of a *Simple Analogue to Digital Converter* (ADC) for the Spectrum. This interface, based on the ADC0804 chip, suffers from a number of limitations, not the least of which is that it only provides for a single analogue input channel. It is not surprising, therefore, that several readers have written to ask if there is any way of adding further inputs to this unit.

The obvious answer to such a question would be simply that of using a number of CMOS analogue switches connected to the input of an ADC0804 single-channel ADC. Individual analogue inputs could then be connected when required or, alternatively, the software could be arranged so that the input channels are successively sampled. A four-channel ADC would require four analogue switches whilst an eight-channel unit would need eight analogue switches.

In either case an output latch would be necessary in order to provide temporary storage for the data applied to the control inputs of the analogue switches. Unfortunately, such an arrangement would probably necessitate the use of more than six d.i.l. integrated circuits and construction using simple matrix board techniques could be something of a headache. A far better solution would be that of making use of a multi-channel ADC (such as the 7581).

The 7581 ADC

The 7581 is an 8-bit 8-channel ADC which incorporates its own internal 8 × 8 dual-port RAM. The device employs successive approximation techniques and results are stored internally until required. Conversion of a single channel takes 80 clock periods with a complete scan through all eight channels taking 640 clock cycles. (Readers should, however, note that the clock referred to is NOT the Spectrum's 3·5MHz system clock!.)

When channel conversion is complete, the successive approximation register's contents are transferred into the appropriate internal RAM location. The contents of this RAM can later be examined by placing the appropriate binary address pattern on the A0, A1 and A2 lines whilst, at the same time, taking the CS line low.

To ensure that memory updates only occur when the host microcomputer is not addressing the converter's memory, automatic interleaved direct memory access (DMA) is provided by on-chip logic.

Multi-Channel ADC

The complete circuit diagram of a 7581-based ADC for the Spectrum is shown in Fig. 1. Address decoding for the $\overline{CS}$ line is provided by IC2 and IC3. This arrangement ensures that the output of the 7581 is only

COMPONENTS

Resistors

R1	270	R4	1k
R2	1k	R5	10k
R3	470	R6	470

All 0·25W 5% carbon

See Shop Talk page 661

Capacitors

C1,C5	10µ p.c.b. elec. 16V (2 off)
C2,C3	10n disc ceramic (2 off)
C4	1n polystyrene
C6,C7	10n polyester (2 off)
C8,C10	10µ p.c.b. elec. 16V (2 off)
C9	10µ p.c.b. elec. 25V

Semiconductors

D1	Red l.e.d.
D2,D3	1N4001 (2 off)
D4	BZY88 C9V1
IC1	7581 8-bit 8-channel ADC
IC2	74LS30 8-input NAND
IC3	74LS14 Schmitt Hex Inverter
IC4	555 Timex

Miscellaneous

Low-profile d.i.l. sockets: 1 × 28-pin, 2 × 14-pin, and 1 × 8-pin; 10-way 0·1in. pitch p.c.b. mounting input connector; stripboard, 0·1in. pitch, measuring approx. 80mm × 80mm; 28-way open end double-sided 2·54mm (0·1in.) pitch edge connector (e.g. Vero part number 838-24826A).

Approx. cost Guidance only **£28**

placed on the data bus when address lines A0 to A4 are all high with the $\overline{RD}$ and $\overline{IORQ}$ simultaneously low.

The remaining three address lines (A5 to A7) used for conventional I/O port addressing are taken to the 7581's address inputs. This arrangement results in the address allocation set out in Table 1.

Table 1: Address Allocation

Channel No.	Address (binary)	(dec.)	(hex.)
1	00011111	31	1F
2	00111111	63	3F
3	01011111	95	5F
4	01111111	127	7F
5	10011111	159	9F
6	10111111	191	BF
7	11011111	223	DF
8	11111111	255	FF

IC3e and IC3f act as a simple buffered Schmitt oscillator which provides a square wave input to the 7581 at a frequency of approximately 2MHz (the precise frequency of this signal is unimportant). The negative reference voltage required by the 7581 is provided by IC4, a 555 timer operating as an astable oscillator. This device produces a square wave output at approximately 10kHz which is fed to a voltage doubler arrangement provided by diodes D2 and D3. The negative rectified output is held constant at approximately 9V by means of a Zener diode shunt regulator, D4.

Construction

Like most of our previous projects, the Eight Channel ADC is assembled on a piece of stripboard measuring approximately 80mm × 100mm. The precise dimensions of the board are unimportant provided that it has a minimum of 28 tracks aligned in the vertical plane sufficient to allow the mounting of a 28-way double sided edge connector. This connector should be fitted to the lower edge of the board and will require five holes across the full width of the stripboard so that the board stands vertically when the connector is mated with the Spectrum.

Before soldering any of the components (including i.c. sockets) it is important to allow some clearance for the rear overhang of the case. For the Spectrum this gap should correspond to 8 rows of holes (20mm approx.) whilst for the Spectrum Plus the gap should be increased to 12 rows of holes (30mm approx.).

Component layout is generally uncritical though considerable economies can be made by carefully planning the layout in advance of mounting the components and i.c. sockets. Readers are advised to carry out this exercise on paper first (using, if desired, the layout sheet provided with our '*On Spec Update*').

Great care must be taken to ensure that all unwanted tracks are cut (including, in particular, those which link the upper and lower sides of the 28-way connector). A purpose designed "spot-face" cutter is ideal for this purpose or, if such a tool is not obtainable, a small sharp drill bit may be used.

Links on the underside of the board should make use of appropriate lengths of miniature insulated wire (of the type normally used for wire wrapping). Readers requiring further information on the connector should refer to March 1985 '*On Spec*' or send for the '*Update*'.

When the stripboard wiring has been completed, the integrated circuits should be inserted into their respective sockets (taking care to ensure correct orientation of each device) and the entire board should be very carefully checked before attempting to connect it to the Spectrum. Note that the Spectrum should always be disconnected from its supply before either connecting or disconnecting any interface module. If all is well, when power is re-applied, the normal copyright message should appear. If not, disconnect the power, remove the interface and check again!

If you have any comments or suggestions, please send them to:

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

P.S. Don't forget to include a large (A4 size) stamped addressed envelope if you would like to receive a copy of our 'Update'!

Next month: We shall deal with testing and using the Eight-Channel ADC. We shall also be "taking the lid off" Hisoft's COLT compiler and providing a few hints for those wishing to drive a parallel printer from our Z80-PIO interface.

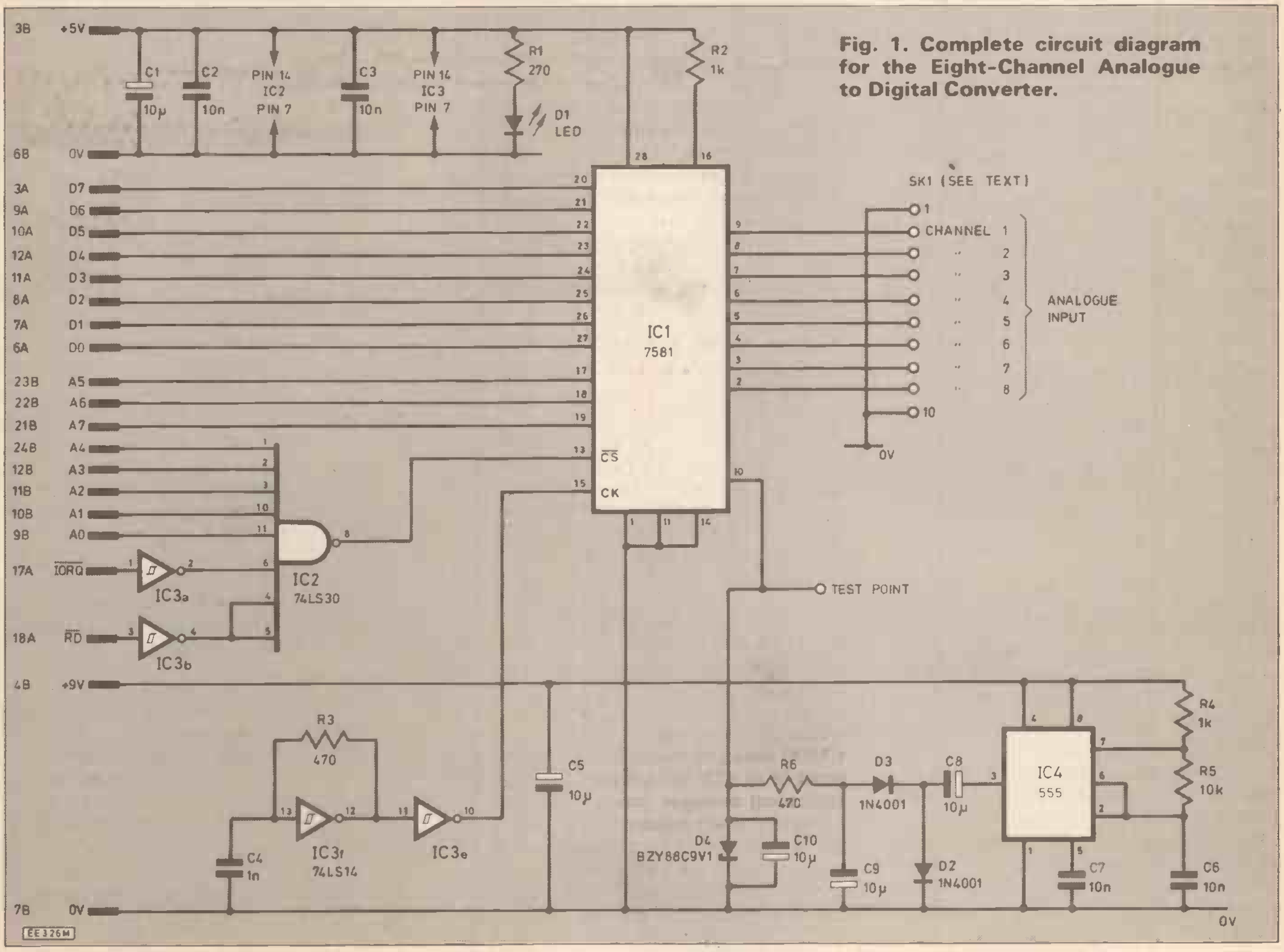
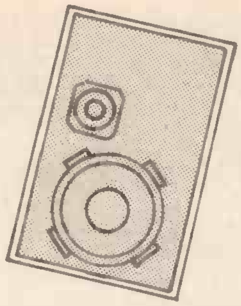


Fig. 1. Complete circuit diagram for the Eight-Channel Analogue to Digital Converter.

MINI ACTIVE SPEAKER



J.P. MACAULAY

An active speaker that is compact but which produces excellent sound quality

THIS project was the result of the writer moving into a flat! This necessitated a complete rethink of the audio system and these speakers were the result. The main problem for flat dwellers is a relative lack of space. This means that large speaker systems are definitely out.

In fact there is little to recommend large speakers except of course for their relatively extended bass response. Their disadvantages are more obvious, women particularly tend to frown upon them even if they sound excellent. The aim was to produce a pair of no compromise speakers which would leave a reasonable amount of floor space in the flat.

Small speakers have a lot to recommend them from the performance point of view. For starters a smaller frontal area produces better sound dispersion and hence better imaging. Secondly the cabinet panels, being smaller, don't contribute so much colouration to the sound.

DESIGN PHILOSOPHY

Before delving too deeply into the techniques used in this project it will be as well to examine the design philosophy in more detail. Having lived for some years now with active speaker systems the author was well aware of their virtues. Normal "passive" speaker systems employ complex crossover networks to divide the amplifier's signal for feeding into the drivers. This is fraught with difficulties from the engineering point of view.

It is simply hopeless to design such a crossover network on the assumption that the speakers are pure resistive loads. It is an unfortunate fact of life that speaker units are very complex electrical loads. The result is that as often as not the crossover network modifies the response of the speaker itself in unpredictable ways. Even in these days of computer aided design the crossover network component values have to be adjusted empiricly to obtain optimum results.

Even when this has been done successfully the resulting speaker system will be inefficient due to the insertion loss of the crossover. Also any of the possible advantage to be gained from the amplifier's low output impedance damping the cones will be lost.

In an active speaker the situation is radically different. The crossover is achieved with standard electronic filters. As these terminate into the resistive load of an amplifier input the vagaries of the speaker's electrical load are irrelevant. Textbook perfect crossovers are achieved without undue effort on the designer's part.

By directly driving the speakers from the amplifier output's a high damping factor is automatically achieved. This means that the cone is controlled far more closely than in a passive speaker with consequently improved transient response. Tweeters are also better controlled and, because these require less power, there is always a lot of headroom in reserve for musical peaks.

The direct interconnection of the speakers and amplifiers also leads to a far more efficient unit. If the equivalent passive crossover were to be used in this design a 40W per channel amplifier would be required to give the same power level.

Another good reason for going active is that the power frequency distribution curve for speech and music peaks at about 200Hz. In a passive system if the amplifier clips then the tweeter is subjected to high level distorted signals. In the active system the ill effect are confined to the woofer.

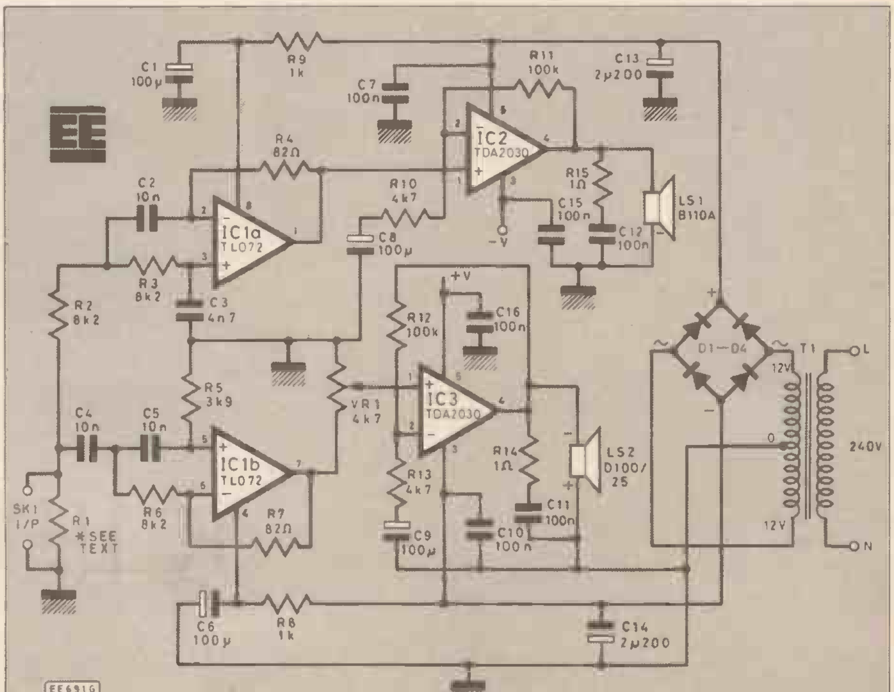
Now all these advantages add up to the superior sound quality but they would be wasted unless the drivers chosen were capable of equally good performance. The drivers for this design are the KEF B110A woofer and the Audax HD100/25 tweeter. The woofer, a 5·25 inch driver, is world renowned for its linearity and lack of colouration. The tweeter is somewhat less well known but its performance fully complements that of the B110A.

Interfacing the speakers is easy. All that is required is an existing amplifier's output signal and a source of mains electricity. Alternatively the speakers may be directly driven from the output of a preamplifier. They require an input of 500mV r.m.s. for full output.

CIRCUIT DESCRIPTION

The circuit consists of two distinct parts. Before describing these in detail it will be as well to consider how the speakers are interfaced to the existing equipment.

Fig. 1. Complete circuit diagram of the Mini Active Speaker.



The major disadvantage of commercially available active systems is that they can be quite difficult to connect up to the rest of the system. For simplicity these speakers are designed to be driven directly from the output sockets of an existing amp. As the existing amp will have unwanted voltage gain an attenuator, simply a two resistor divider is interposed between the main amp. and the speakers.

The amplifier will see a relatively high impedance load. This is a good thing from the point of view of fidelity since the output stage will then operate in class A and hence the signal provided will be less distorted.

COMPONENTS

See Shop Talk page 661

Resistors

R1	see text
R2,R3,R6	8k2 (3 off)
R4,R7	82 (2 off)
R5	3k9
R8,R9	1k (2 off)
R10,R13	4k7 (2 off)
R11,R12	100k (2 off)
R14,R15	1 (2 off)

All 0·25W ±5% unless stated

Potentiometer

VR1	4k7 log

Capacitors

C1,C6	100µ elect. 25V radial (2 off)
C3	4n7
C2,C4,C5	10n polyester (3 off)
C7,C10	100n, ceramic or polyester (2 off)
C8,C9	100µ elect. 25V (2 off)
C11,C12	100n ceramic (2 off)
C13,C14	2,200µ elect. 25V (2 off)
C15,C16	100n ceramic (2 off)

Semiconductors

IC1	TL072
IC2,IC3	TDA2030 (2 off)
D1-D4	100V, 1·5A bridge rectifier

Miscellaneous

T1 12–0–12V 1A secondary, 240V primary transformer
LS1 B110A Kef speaker
LS2 HD100/25 Audax tweeter
SK1 phono socket
Control knob; small aluminium heat sink panel 150mm × 75mm approx; Veroboard 14 strips by 20 holes; two p.c.b.s available from Electromail order code 343 576. Plywood panels, all exterior quality 12mm; 2 off 305mm by 230mm; 2 off 305mm by 180mm; 2 off 206mm by 156mm.

NOTE: Two complete sets of the above are required for a pair of speakers (for stereo).

Approx. cost Guidance only £55 each

The filter circuitry at the input of the speakers will also see a nice low drive impedance which helps to reduce the noise level. Looking at the circuit proper, with reference to Fig. 1, input signals are fed across R1 (this resistor is 4k7 for use on an amplifier output or 47k when the unit is driven by a pre-amp). From here they enter the 2nd order filter networks built around IC1, a TL072 op-amp. This device was chosen both for its high slew rate and its low noise.

Filters are characterised by their slope. The first order filters (one *R* and one *C*) have a rolloff of 6db per octave. Second order filters have double this rolloff, 12db per octave; 3rd order filters rolloff at 18db per octave and so on.

CROSSOVERS

There is a continous debate in hi.fi. circles as to what the optimum order filter for crossovers is. The higher the order the greater the attenuation of out of band signals. However this is only part of the story. The higher the filter order the more phase shift and ripples in the passband become a problem. Second order filters have been used in this design after a great deal of experimentation with 3rd and 4th order types. They appear to give the best all round performance at least with these drive units and crossover frequency.

Choosing the crossover frequency itself can also be fraught with difficulties. One of the advantages of using a smaller woofer is that the transient response is superior to the usually encountered 8inch types. The reason for this is not difficult to find. The smaller the cone the less mass it has, other factors being equal. This means that it can respond more quickly to the input signal. Because its momentum is less there is also less spurious output when the signal is removed.

Bextrene coned drivers are not renowned for their extended high frequency response and the B110A is no exception. It is however sensibly flat, used on its own to about 3·5kHz.

Thereafter the response rolls off at 12db per octave due to mechanical factors. On the other hand the tweeter chosen, the Audax D100/25 is flat from about 1·5kHz to 20kHz. A soft dome tweeter has been chosen as this type of driver is essentially free from resonant modes which tend to plague the hard dome types.

Getting back to the circuit the crossover is built around IC1. The configuration used is entirely conventional and provides the optimum "Q" of 0·7. The response is therefore of the Butterworth type and provides maximum rolloff and minimum phase shift. IC1a is used, in conjunction with R2,R3,C3 and C2 to provide the low pass filter whilst IC1b,R5,R6,C4 and C5 provide high pass filtering.

For reasons of stability R4 and R7 are connected between the outputs and inverting inputs of IC1a and IC1b respectively. Decoupling is provided for the positive and negative lines by R9,C1 and R8,C6.

POWER AMPLIFIERS

The power amplifiers are the well known TDA2030 chips. These have several advantages over discrete transistor designs in this application. Firstly because of the very close matching of the output devices within the chip the distortion at low levels is extremely small. This is often the Achilles heel of discrete power amps whose distortion level tends to increase at these levels.

Secondly an equivalent power and performance amplifier would be quite an elaborate circuit which would add nothing to the project but extra cost. Looking again at Fig. 1 both amplifiers are identical except for the potentiometer VR1. This acts as a straightforward volume control and is required because of the difference in sensitivity between the drive units.

Tweeters tend to be more sensitive than woofers because of the difference in moving mass between them. It is theoretically possible to compensate for this by using a simple resistive divider between the two. This has not been done because component tolerances elsewhere in the circuit might upset the balance.

There is however a much more important reason for using a pot for this task. Flat response in an anechoic chamber is one thing but the average lounge is another! If the listening room has heavy drapes and soft carpeting the sound from an optimumly flat speaker will sound lacking in top. On the other hand if the furnishing is sparse the sound will be top heavy. Also the matter of personal choice enters into this equation. Some people like lots of top others prefer none; with this design the choice is yours!

As both amplifiers are identical discussion will be confined to IC2. This chip is essentially an op. amp. with a high power output stage. Direct coupling from the output of IC1 causes no problems as both are at ground potential plus or minus a few millivolts.

The input signals are fed into the non-inverting input. The overall feedback loop is formed by R11 and R10. The voltage gain is set by the ratio of the values of these components. Capacitor C8 appears to be a dead short to the signal but to d.c. it looks like an open circuit.

In this way the d.c. gain is held at unity. R15 and C12 form what is known as a Zobel network. This is necessary because the speakers contain a considerable amount of inductance. This means that at high frequencies the impedance of the speaker is many times its nominal value. In fact every speaker is a quite complex electrical load and this can cause problems for the chip unless something is done to compensate. The Zobel network does just this and makes the speaker look to the output stage more like a pure resistance.

A split rail power supply is required to power the electronics and this is done in a conventional way using a centre tapped transformer T1. The raw a.c. is rectified by D1 to D4 and smoothed by C13 and C14 to the centre tap. No switching has been provided as the speakers have been designed to be switched on and off via the a.c. outlet normally provided on the existing amplifier. If separate switching is required it is a simple matter to add an on off switch to the mains input.

The only other point left to be discussed is the fact that the tweeter is phase inverted to the woofer. This is done to maintain an even response across the crossover region. If the tweeter were not reversed there would be a "hole" in the response at the crossover frequency.

CONSTRUCTION

Construction starts with the cabinets. These are made from 12m plywood. This is slightly more expensive than the normally

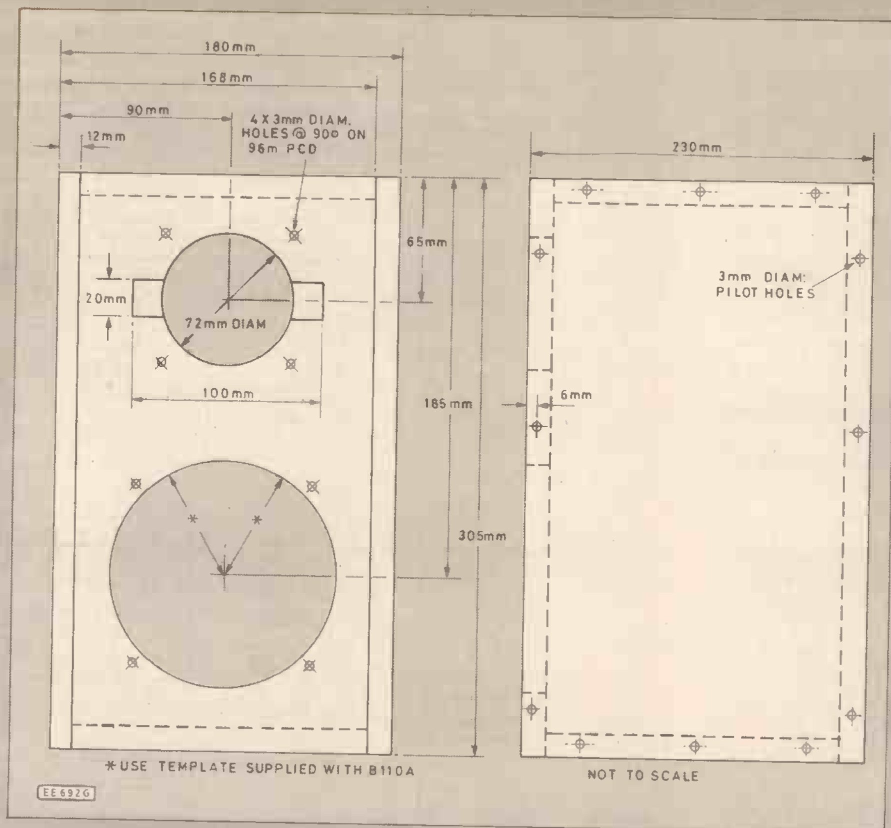


Fig. 2. Cabinet construction details—two are required for stereo.

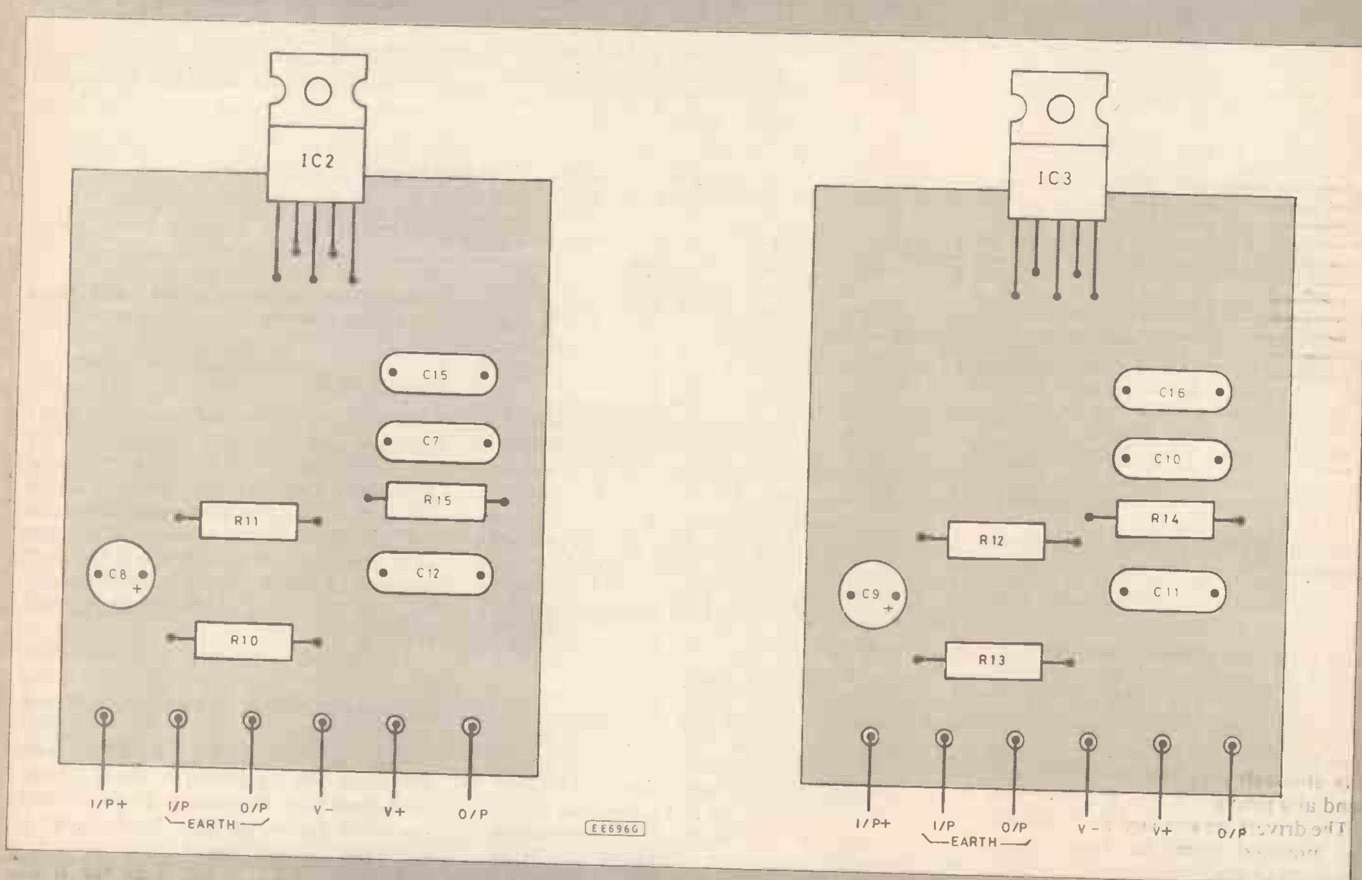


Fig. 3. The component layout on the Electromail printed circuit boards.

encountered high density chipboard but is a great deal more easy to work with. The author is not the best handyman so the design is deliberately simple. The most laborious part of the job is screwing the panels together.

The fundamental requirement, as in all woodworking projects, is to get the panels cut accurately. There is nothing worse than having to plane down panels! Most large d.i.y. stores and woodmerchants will cut panels to size for a small fee.

Having cut the panels the next task is to assemble them into the cabinet. This is done by gluing the panels together, excluding the rear panel upon which the electronics is assembled. The adhesive used is a matter of taste but the author has found that Thixofix contact adhesive works well in this application.

The areas of contact between the panels are smeared with the adhesive. After about five minutes these are then brought together. At this point they can be slid into position. Firm pressure is then applied to the joint and the panels are permanently attached.

The cabinet details are shown in Fig. 2. Having glued the panels the hard work begins. To strengthen the cabinet the panels have to be screwed together. The best way to do this is to drill 3mm pilot holes. Countersink these holes with a countersink bit before driving the screws home.

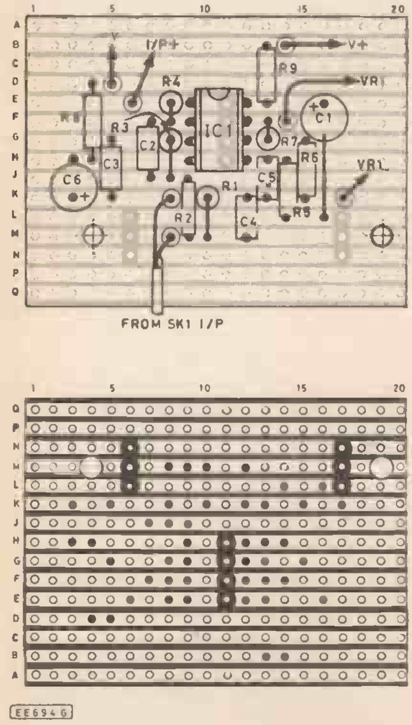


Fig. 4. Layout and wiring of the pre-amp on Veroboard.

The next task is the hole cutting on the front baffle. Again Fig. 2 shows the details. A jig saw attachment will make easy work of this although they can be hacked out by hand at a pinch.

The drivers are attached next. The B110's are mounted from the front using the captive nuts and bolts provided. Make sure the sealing gasket provided is placed under the speaker. The tweeter is mounted with four, ½inch number 8 shelf tapping screws. Before attaching the drivers solder the leads to the terminals. These should be reasonably thick gauge to ensure low series impedance. 16/0·2 wire or 5A twin core mains lead is ideal. Leave the wires about 300mm long to facilitate easy fitting to the p.c.b.'s.

To stop the panels vibrating some form of damping must be applied. Bitumous pads are often used for this purpose but the writer has found that ceramic tiles, stuck to the interior of the cabinet are just as effective, and less expensive. These are stuck into position either with some more Thixofix or alternatively Araldite rapid.

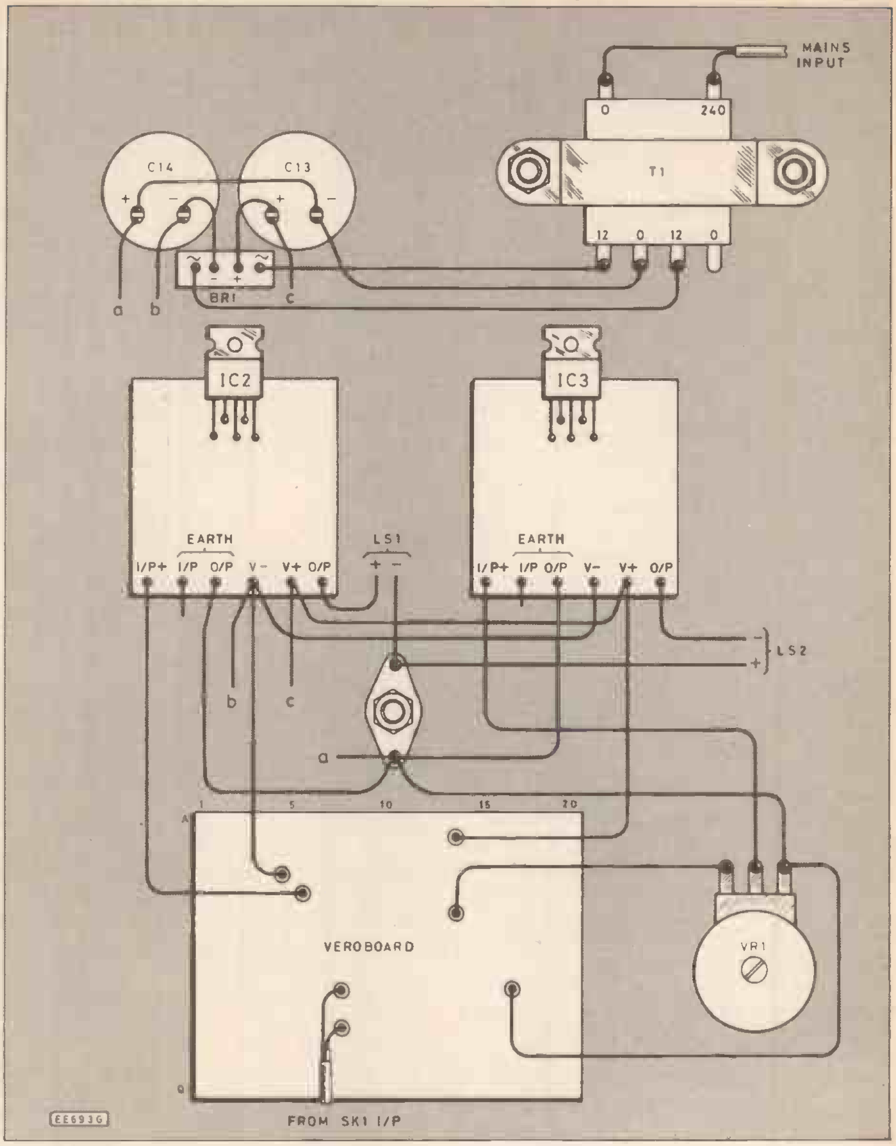


Fig. 5. Interwiring of the boards and other components in the Mini Active Speaker.

CIRCUIT BOARDS

Once this stage has been reached the cabinet can be put to one side and work can get started on the electronics. This is very straightforward as shown in Figs. 3, 4 and 5. The only points to watch are that all the polarised components are correctly orientated and that no dry joints have been made. The amplifiers and filters are assembled on their respective p.c.b's. The interconnections are shown in Fig. 5. The p.c.b.'s, transformers and heatsinks are attached to the back panel with short self tapping screws.

DAMPING

Before connecting the speaker leads the damping material must be added to the cabinet. Ideally a piece of BAF wadding 300mm by 600mm rolled up and inserted vertically is required. If this is not available a piece of fibre glass wadding could be used. Failing this four ounces of cotton wool well teased out to fill the cabinet will work well. If you use the fibre glass don't forget to wear gloves!

The last task to complete the construction is to connect the speaker leads; observe the polarities shown. At this point the speaker can be tested.

Apply power, apart from a slight pop on switch on nothing should be heard. If you get a loud hum disconnect the power and search for the wiring fault. Assuming all is well apply an input signal.

Adjusting VR1 should alter the tonal balance of the speaker. Assuming all is still well the back panel can be screwed into place. The project is now complete. □

FOR YOUR ENTERTAINMENT

BY BARRY FOX

Wedge-Pulling

If you were trying to phone a London telephone number on the 600 exchange (for instance St. Bartholomew's Hospital) one lunchtime late in August, and couldn't get through or were cut off, take heart. There was nothing wrong with your equipment. British Telecom was installing the first major System X all-digital telephone exchange at Wood Street in the City of London ready for the "Big Bang".

The switch to new technology, called "wedge-pulling", relied on an almost comic procedure. For a month before the changeover BT engineers pushed 4,700 small plastic wedges between contacts in the Strowger electromechanical relays which had been switching calls since 1947. Another 4,700 wedges were pushed into contacts connected to the GEC System X exchange next door. All the wedges were neatly tied together by string. At 13.27, to the command "Gentlemen cut out the old equipment" bow-tied BT engineers pulled the strings to disconnect all calls. Three minutes later, at another "Gentlemen" command, they pulled the next batch of strings to send all calls on a digital route. Subscribers had been warned in advance not to make calls at changeover time, but inevitably some tried and were cut off.

It has to be said that the ceremony, and surrounding publicity, was BT's way of restoring public confidence in the System X project. Although System X is good news, it has had a chequered history.

It began in the 70s when the Post Office paid £350 million to a string of outside contractors. In 1982 BT rationalised the project by making GEC and Plessey sole suppliers. The project still ran badly behind schedule; BT admits to 15 months. Thorn-Ericsson won the order to supply a rival digital system. Iain Vallance is BT's Chief of Operations, and next main boss at BT after Sir George Jefferson steps sideways. He says BT is "doing its damnedest to catch up" on the System X schedule. Of the future, says Vallance, "the way orders are placed will depend on performance".

Wood Street was the 71st System X exchange and one new digital exchange now goes into service every working day. By the end of the year one million subscribers should be digitally switched; by the end of the decade the number will have risen to 12 million, half the network. In London the 328, 489, 620 and 600 exchanges are now digital.

Subscribers on these exchanges should immediately notice an improvement; fewer wrong numbers and crackly lines. The mechanical switches in a Strowger exchange can misroute calls and the 50 volt d.c. signal being switched is easily distorted by dirt on the relay contacts. Unless faults develop the contacts are routinely cleaned only once a year. In a digital exchange the switching is by microchip with no contacts to get dirty.

For businesses, digital switching allows the direct connection of data links like BT's Integrated Digital Access, IDA. It also offers everyone far faster speech call routing—but only if subscribers change their telephones. Old style exchanges work with dial pulses at a rate of 10 a second. The new digital exchanges can work either with dial pulses or with multi frequency, MF, touch tones. MF tones are musical notes which the telephone emits when the number is keyed. With an MF phone and digital exchange the subscriber is connected almost instantly. With a pulse phone on a digital exchange, connection speed is limited by the agonisingly slow pulse rate.

BT now has to educate the trade and public about MF. Most phones currently on sale generate pulses. Some are switchable or available with MF circuitry at a premium price of a few pounds. One shop selling telephones close to the Wood Street exchange on wedge-pulling day had mainly pulse phones on display and had not been told in advance by BT that the local line was switching over to digital and MF operation.

Digitising exchanges doesn't help people get lines if there aren't any. In the bad old days of five years ago a quarter of a million people were waiting for a phone. Now, says BT, you can usually get one within 10 days—especially in the mainly residential north, south and west areas of London. The problems begin in the City of London, the West End and Westminster where there are long waiting lists. BT admits to up to 11 weeks. Disgruntled businesses say it is longer.

Big Bang

The kicker is that demand for telephones in the City of London is 5 times what it was last year, due mainly to the Big Bang. Demand in London's West End is up too, because firms hoping to capitalize on BB have been moving in. When a small office building is pulled down and replaced by a skyscraper, the lines already laid under the ground will not be adequate. In Australia they get round the problem by time-multiplexing several lines on a single wire pair. BT either routes lines through less crowded areas, which means the calls must travel several extra miles, or frequency-multiplexes two lines on a single copper cable, by stacking them in frequency.

When this does not work the only option left is to lay extra cables. Eventually there is no room in the ducts for extra cables. Hence BT's long term policy to replace copper with optical fibre, which has a much wider bandwidth and can thus carry more calls per strand. BT claims to have more optical fibre already laid than any other network in the world.

At BT's Annual General Meeting this year, at the Birmingham National Exhibition Centre, Sir George Jefferson took the unusual step of talking politics. He urged 1·5 million shareholders to lobby against the Labour plan to renationalise BT. Don't make us a "political football" he pleaded.

Whatever the rights and wrongs of nationalisation, it seems dangerous to mess around with BT so soon. The Post Office became BT in 1980 and BT only left the public sector in October 1984. BT's talk of improved profits and better service for customers (which seems justified) prompts a question. If BT's management can do so well now, why couldn't they have done better before? Sir George has been boss for six years. It is only six years ago that the Post Office and BT had a quarter of a million people on its waiting list. It seems only yesterday that the PO and BT were excruciatingly arrogant and self-satisfied. There is nothing like the threat of competition, whether between a couple of greengrocers or between BT and Mercury, to get things moving.

2010

Arthur C. Clarke talked recently at the National Film Theatre in London about his work in films. His first was "2001: A Space Odyssey" with Stanley Kubrick; then "2010: Space Odyssey II" with Peter Hymans.

Clarke turned out to be a surprisingly nervous speaker, with the infuriating habit of answering questions by just giving the title of one of his many books and saying the audience should buy it and read it. He would do well on British chat shows!

Some interesting insights did however slip through the net of non-communication. "I never saw a complete screenplay of '2001'—I don't even know if one ever existed," he explained when quizzed about some of the obscure but apparently meaningful content. It turns out that some of this was not half as meaningful as it seemed. For instance, the magic size ratio of the monoliths 1:4:9 "meant nothing at all" confirms Clarke.

And what about the folklore story that the wicked computer in 2001 was named HAL as a dig at IBM, because the letters are adjacent in the alphabet?

"Complete nonsense," says Clarke, "HAL was simply an acronym for something I have now forgotten."

I asked Clarke how he came to publish his now famous article in the October 1945 issue of *Wireless World* on "extra terrestrial relays". This was the article which predicted the use of satellites in geostationary orbit for world communication. At the end of the war Clarke was working on microwave radar, in the three and ten centimetre bands. It was used for ground approach aircraft landing systems. He was also a member of the Interplanetary Society and looking at peaceful uses for rockets and the type that Germany had been raining onto London.

He published the maths which showed that a transponder in a satellite circling the earth with an orbit radius of 42,000km would make a full round tour every 24 hours and so appear stationary. It could also transmit to nearly half the Earth's surface.

Clarke didn't patent his idea. It would have been pointless, because patent law doesn't extend into space and any patent filed in 1945 would have expired of old age before satellites were launched into what is now called the Clarke orbit. *Wireless World* paid him £15 for the article which is quite a fee for changing the course of communications history!

Clarke himself benefits from this. He lives in Sri Lanka, formerly Ceylon, and writes scripts for Hollywood. He doesn't have to leave his island home because he squirts the text direct from a Kaypro computer down a telephone line and satellite link to the film studios in California.

...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

XMAS GREETINGS!

At Christmas, amateur radio still goes on. Not so many operators seem to be on the air as usual, but the ultra-enthusiastic, plus those jaded by a surfeit of festive fare, manage to put in an hour or two at the rig, finding others only too willing to listen.

Over the years, I confess, I have managed to slip away from the family festivities to chat with fellow-amateurs late on Christmas Eve or Christmas night. I have, of course, always closed down long enough to avoid causing r.f. burns to Santa's reindeer as he hitches them to my rooftop antenna before paying his usual visit to the household below.

Everything is more relaxed than usual, and there are some very pleasant contacts at this time. In the week that follows, everyone is busy finding others they haven't worked for a long time, exchanging traditional greetings, and catching up with their news. Amateur radio is always enjoyable, but it's extra nice at Christmas.

STRAIGHT KEY NIGHT

During December, many clubs have "Christmas" events—dinners, social evenings, special meetings, and there are a number of organised activities on the air.

The G-QRP club, for instance, holds a week long "QRP Winter Sports" event, starting on Boxing Day. This simply means that QRP operators spend as much time on the air as they possibly can, finding and working fellow low-power buffs in the many countries where the club has its members—and achieving some quite remarkable results in the process.

New Year's Eve features an American tradition which has spread into Europe—Straight Key Night. Morse code operating is still practised today, but many use automatic keys, generating streams of dots and dashes electronically. Few use the old-fashioned up-and-down hand key, but on SKN the old keys are brought out, dusted down, and put back into use, ensuring that this much-respected old-time form of communication is not entirely forgotten.

As well as looking back, amateurs look forward. Any time now, the 11-year sunspot cycle will reach its lowest point. From then on, radio conditions will begin to improve, something all amateurs are looking forward to. For that alone, within our hobby, the new year will be one to celebrate.

SAFE DRIVING

A proposed addition to the Highway Code, announced by the DoT, has implications for radio amateurs amongst other mobile-radio users. This will be rule 49a, which says, "Do not use a hand-held microphone or telephone handset while your vehicle is moving, except in an emergency.

You should only speak into a fixed, neckslung, or clipped-on microphone when it would not distract your attention from the road. Do not stop on the hard shoulder of a motorway to answer or make a call, however urgent".

As far as most amateurs are concerned, this is already standard mobile-operating practice. Not only do they have their microphones fixed in their vehicles, but they also have transmit/receive controls mounted on their steering wheels to ensure that radio operation does not result in "hands-off" driving.

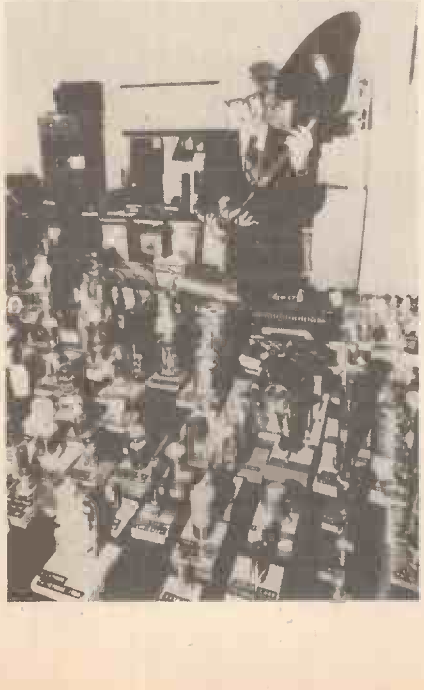
In fact, the Radio Society of Great Britain has a safety code for mobile operation, which could well be adapted for use by other mobile users.

This covers the construction and secure installation of equipment; the construction and height of antennas (maximum 4.3m above the ground); safe wiring within the car; fuses and battery isolation; the need for a single, easily accessible, changeover switch performing all functions; attachment of the microphone to the vehicle; non-use of a hand microphone or double-headphone; making adjustments, band-changing, etc, only when the vehicle is stationary; illumination of essential equipment controls in the dark; no logging when the vehicle is in motion; switching off all equipment when the vehicle is fuelling, or is near petrol tanks, or explosives normally detonated by electricity, e.g. in a quarry; and the need to carry a fire extinguisher.

MUSEUM OF COMMUNICATION

The concept of transmitting electromagnetic waves for communications purposes goes back well over a hundred years. In successive pioneering activities over this time, amateurs have played their part and, on occasion, have led the way. With such a background to our hobby there is now an interest in the history of radio, and all that led to its discovery.

Harry Matthews with a few of the museum's 6000 vintage valves.



A number of museums exist to provide a permanent home for relics of those days, and offer interesting presentations to those with even the slightest acquaintance with the subject. Probably the largest collection is in the Science Museum in London, but around the British Isles there are a number of smaller museums which I hope to mention from time to time.

In Edinburgh, for instance, there is the Museum of Communication, located in the James Clerk Maxwell Building of the city's University. This small museum is, in effect, the tip of an iceberg, because tucked away in store are three tons of potential exhibits, including 6000 pre-1960's valves!

Back in 1973, Harry Matthews, a founder member of staff in the University's Electrical Engineering Department, saw an old radio chassis on the kerbside, awaiting the dustman, and realised that this was happening all over the UK. This observation stimulated the idea of making a collection which, over the years, has grown to its present size.

EXPERIMENTAL WORK

The museum, housed in the Physics Department, outlines the progress of electrical communication, from experiments with electrical machines to developments arising from the work of Morse and Bell, leading to wired telegraphy and telephony.

The ideas of Faraday, developed mathematically by Maxwell, and confirmed experimentally by Hertz, resulted in the commercial introduction of radio by Marconi. The invention of the valve, and its evolution, led to TV, radar, telemetry, and radio-astronomy. The discovery of the transistor began the dramatic reduction in equipment size, leading to integrated circuits.

Exhibits covering these fields, many dating from well before 1900, include friction machines, induction coils, crystal receivers, valves and early valve receivers, microphones, headphones, loudspeakers, picture machines, medical equipment, and electrical measuring instruments.

A display of communications equipment includes a number of military sets, such as the AR88 receiver and the 1154 transmitter, which were popular with radio amateurs on the "surplus" market immediately after WW2, and which are now becoming increasingly scarce and "vintage".

A large complex of museums is planned along the shore of the Forth, near Edinburgh, featuring local industries etc, and, in due course, the Museum of Communication will be finding its place in this ambitious project. In the meantime it is open to the public in its present location daily, from 9 a.m. to 7 p.m., admission free. A small library is available for serious researchers, and evening visits for groups can be arranged by telephoning Mr Matthews, now the museum's curator, on 0506-824507.

RANDOM NUMBER GENERATOR

N.P. NAUGHTON

THERE is much evidence to suggest that the "form book" is no guide to success on the football pools. This is why so many people adopt door numbers, birthdays or other random ways of making match selections – and often win! Others frequently do not have time to study form. This project offers a simple, time-saving method of producing random numbers from 1 to 55 for standard pools coupons and also numbers from 1 to 90 for playing bingo with the family or some local group, perhaps.

When the project's pools/bingo switch is in the desired mode, the select button is pressed and after this is released a random number appears in the display. *Although there may be some repetitions of numbers,* these should not be so numerous as to be bothersome. A double zero which sometimes occurs is ignored.

The project uses 74LS TTL i.c.s and all components are readily obtainable from most suppliers.

PRINCIPLE OF OPERATION

Driven by a clock pulse generator operating at around 50kHz, the main logic circuitry of Fig. 1 counts up to 56 or to 91 several hundred times per second. After a burst of clock pulses from S1 to the counting circuits, the display freezes on the number corresponding to the last particular pulse counted so that selected numbers are quite random.

Every number from 1 to 55 or 1 to 90 exist for an equal period resulting in there being no bias towards or against any particular one. Numbers 56 and 91 are used purely to produce reset pulses and are much too short lived to be seen in the display.

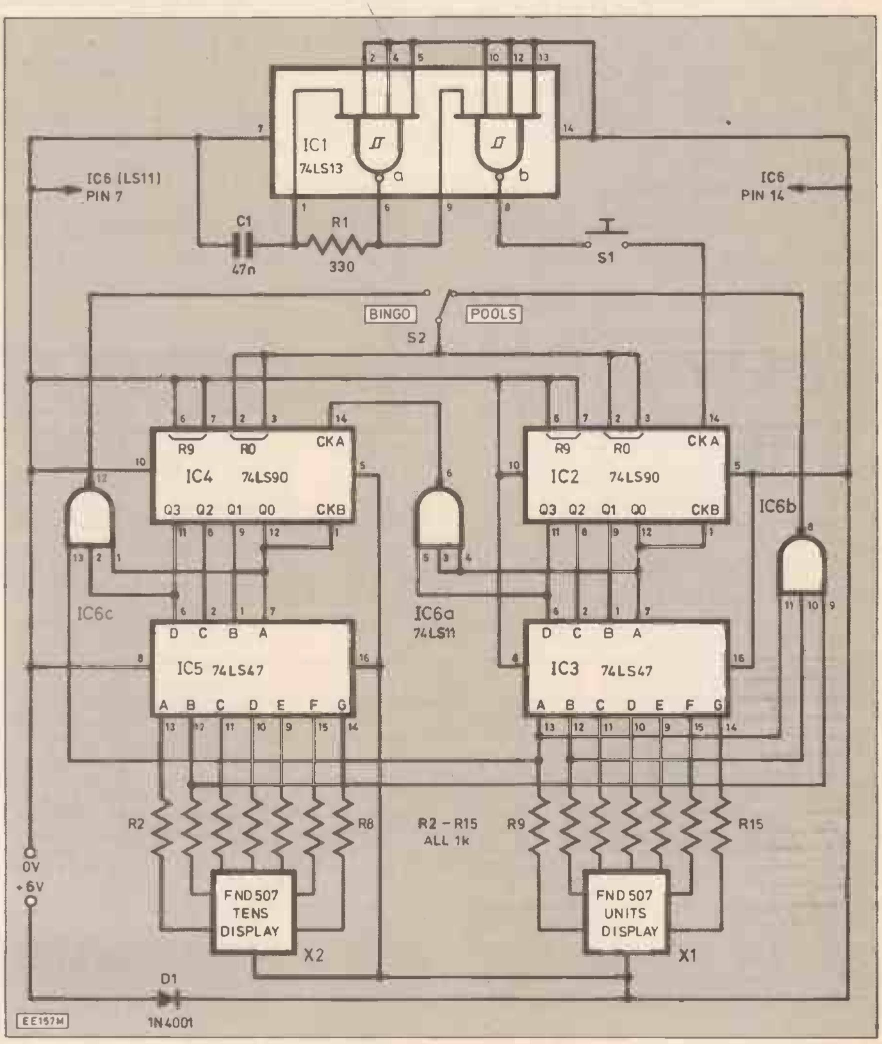


Fig. 1. Circuit diagram of the Random Number Generator.

CIRCUIT DESCRIPTION

In the circuit of Fig. 1, IC1 is the versatile 74LS13 dual NAND Schmitt Trigger. The first half of this is connected in the multivibrator mode and with the values of C1 and R1 given, oscillates at a fixed frequency of about 50kHz. The second half acts as a pulse shaper ensuring clean pulses which are applied, via S1, to the CK A input of the decade counter IC2. This i.c. operates as a units counter alongside IC4 which counts tens.

It will be helpful to keep in mind that IC2 does not respond to the leading (positive going) edge of a pulse applied to CK A. A pulse is counted only on its trailing (negative going) edge. Also, a 74LS90 can only count if at least one Reset 0 pin and one Reset 9 pin are low. So long as this last condition is true, IC2 repeatedly counts incoming pulses in decades, from 0 to 9. At any instant, the number thus far counted appears at the Q0, Q1, Q2 and Q3 outputs and these BCD voltage levels are applied to the inputs of IC3.

IC3 is a BCD-to-Seven Segment Decoder Driver designed to drive common-anode l.e.d. numerals. Table 1 shows how this i.c.

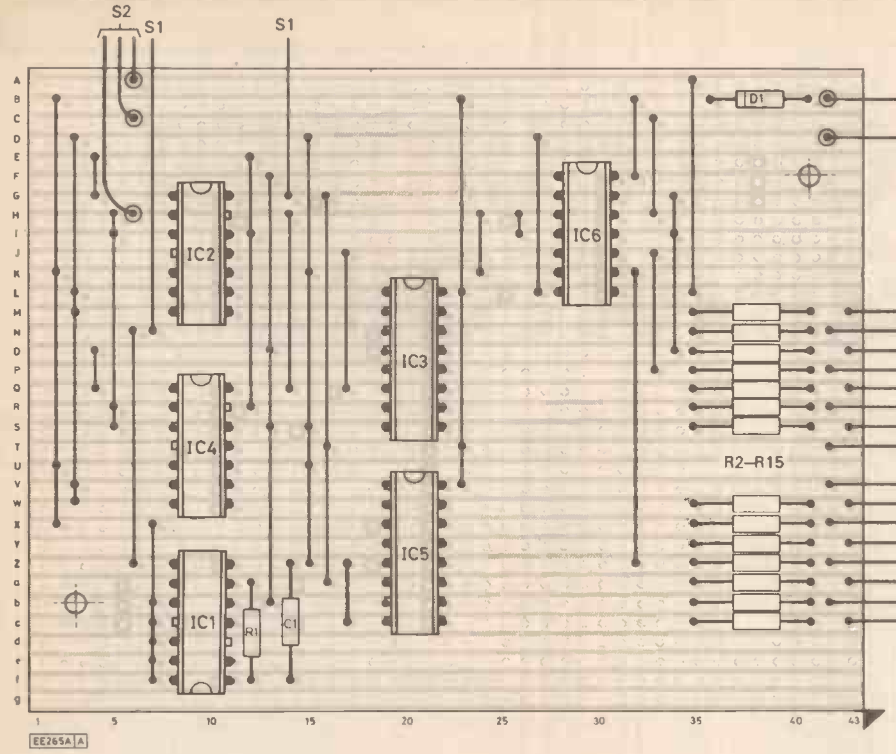
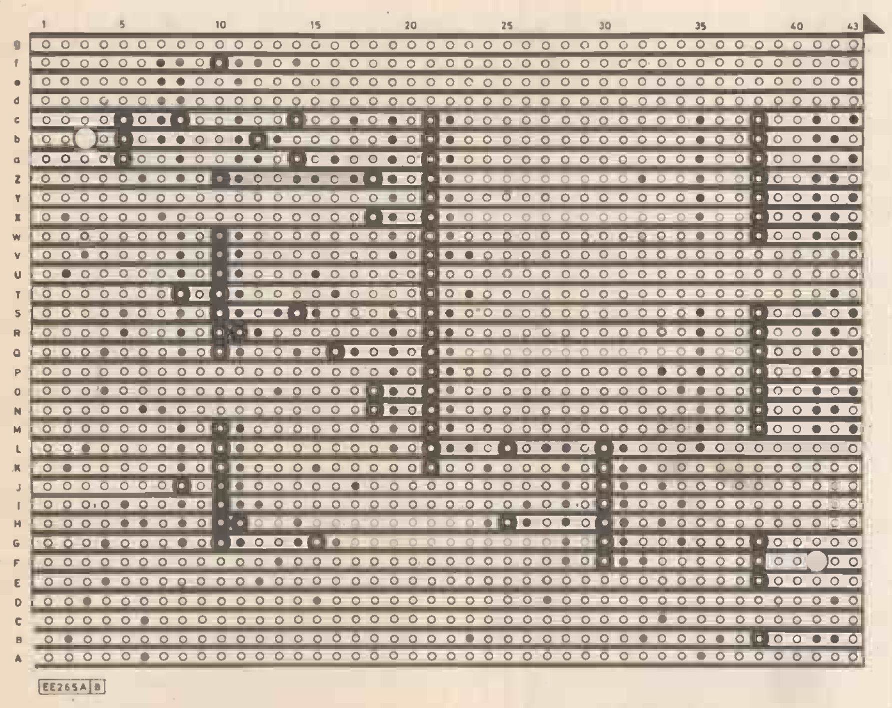


Fig. 2. Component layout and Veroboard hole cutting details for the Random Number Generator main circuit board.



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RESETTING

The 74LS47 is functionally identical to the older 7447 it replaces and both i.c.s compose sixes and nines without "tails", that is, segments a and d, respectively, are not illuminated. This simplifies the problem of resetting the counters at the required times.

All reset 0 inputs must go high in order to reset both counters to 0. When S2 is in the Pools position, all reset 0 inputs receive the output of AND gate IC6b whose three inputs utilise decoder outputs. Remember that unilluminated segment outputs are high and a study of the tables will show that counting from zero—at least one low is always present on an input of IC6b until the count reaches 56. When this happens, IC6b turns on, both counters are reset to 0 and, momentarily, stop counting. However, number 56 cannot exist in the display for more than the few nanoseconds it takes to reset the counters. Because resetting produces two zeros in the display, IC6b turns off and its output returns all reset 0 inputs to low so that counting is resumed. When S2 is switched to Bingo, IC6c controls resetting. Further study of the Tables 1 and 2 and

INPUTS			OUTPUT	
0	0	0	0	OFF
0	0	1	0	OFF
0	1	0	0	OFF
0	1	1	0	OFF
1	0	0	0	OFF
1	0	1	0	OFF
1	1	0	0	OFF
1	1	1	1	ON

composes decimal numbers from the BCD input levels. The 74LS47 is an active low driver which simply means that a segment is illuminated only when its associated output is low. X1 displays the counted units.

In order to create a Carry pulse for the tens counter, the Q0 and Q3 outputs of IC2 are routed to the three inputs of IC6a which is connected as a two input AND gate. When the IC2 count reaches 9 (see Tables 1 and 2) IC6a turns on and its output sets up a high positive level on the CK A input of IC4. But when IC2 resets to 0, IC6a turns off and the high level on CK A goes to low. This negative transition is the trailing edge of the carry pulse which is then counted as mentioned earlier. IC5 decodes the tens which are displayed by X2.

Table 1. (Below) BCD codes.

Table 2. (Right) Reset codes.

	D	C	B	A	a	b	c	d	e	f	g
0	0	0	0	0	0	0	0	0	0	0	1
1	0	0	0	1	1	0	0	1	1	1	1
2	0	0	1	0	0	0	1	0	0	1	0
3	0	0	1	1	0	0	0	0	1	1	0
4	0	1	0	0	1	0	0	1	1	0	0
5	0	1	0	1	0	1	0	0	1	0	0
6	0	1	1	0	1	1	0	0	0	0	0
7	0	1	1	1	0	0	0	1	1	1	1
8	1	0	0	0	0	0	0	0	0	0	0
9	1	0	0	1	0	0	0	1	1	0	0

the circuit reveals that IC6c turns on only when the count reaches 91. At this time, the counters are reset in the manner described for count 56.

Operating S2 also resets the counters. This is because unconnected TTL inputs go high and for some brief instant during switching, the switch arm is somewhere between and not touching either of the two contacts. All reset inputs therefore go high during S2 switching and so the counters are reset.

Diode, D1 is a silicon type and its purpose is to drop the 6V supply to the 5V or so necessary for TTL.

CONSTRUCTION

In order to facilitate construction, an all-parallel method of wiring is used for the main circuit board, and the numeric display is built as a sub assembly. The main board is 0·1 inch pitch stripboard, 43 holes by 33 strips. This includes a spare strip and rows of holes to cover edge damage or provide an alternative route in the event of a minor constructional disaster.

Begin by drilling the two 6BA clearance holes used for mounting the main board. Next, make all the circuit breaks and, afterwards, brush the strips thoroughly to remove copper swarf. (The writer finds an old, cut-down shaving brush ideal for this.)

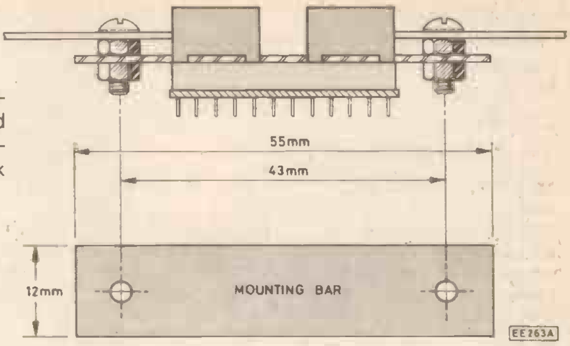
It is strongly recommended that the board now be closely inspected, preferably using some kind of optical magnifier. The importance of close visual inspection cannot be over emphasised particularly with stripboard. Only when you are satisfied that all breaks are true breaks and all stubborn bits of copper have been removed should you proceed.

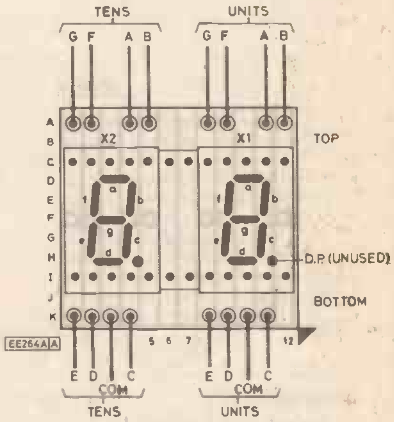
The i.c. holders and components are mounted next, ensuring that these are positioned exactly as shown in Fig. 2. With the board now well "signposted", the wire links can be fitted. To avoid making awkward little links, a single bare wire is used to connect pins 10, 11, 12, 13, and 14 of IC1. Thread this wire under and over through the holes as shown. Covered or sleeved wire is used for the rest of the links and after every few links made, double check that these are in the correct holes. Corrections are better made at this stage than after completion.

The display board is 0·1 inch pitch stripboard 11 holes by 12 strips. Having made (and inspected) the breaks fit the 24-pin holder for the display i.c.s. Sixteen lengths of thin flex about 7 inches long connect the display to the main circuit but first solder these to the display board. Similarly, suitable lengths of flex may first be soldered to the switches. It will help to avoid wiring errors if the display i.c.s. are now correctly inserted in their holder. The top from the bottom of the display can then be distiguished at a glance whilst the connections are now made to the main board. After the switches have been connected, resist the temptation to twist any wires into neat cords. To do so would be to add extra stray capacitance which, at the frequencies involved, could give rise to anomalies. However, twisted flex can be used for connection to the external battery or power supply and this will complete the electrical work.

Any suitable box may be used to house the completed assembly but a standard aluminium case measuring 105 × 133 × 38mm was used for the prototype. The aperture for the numeric display was made by first drilling a ¼ inch hole, enlarging this with a file, and, finally, shaping the aperture with a small flat file. It will be found that the display i.c.s are a tight fit in the holder and because this is a low profile type, there will be a gap between the holder and the i.c.s. Into this gap is slid the display mounting bar, the dimensions of which are given in Fig. 3. Where necessary, the bar holes may be elongated or enlarged which, together with free lateral movement of the display, should absorb any small drilling and filing errors. A piece of stripboard was used to make the prototype bar but any material of sufficient rigidity will serve.

Fig. 3. Constructional details of the display board assembly including Veroboard layout and track cutting details.





COMPONENTS

Resistors

R1	330
R2–R15	1k (14 off)
All resistors ¼ watt 10%	

Capacitors

C1	47n poly.

Semiconductors

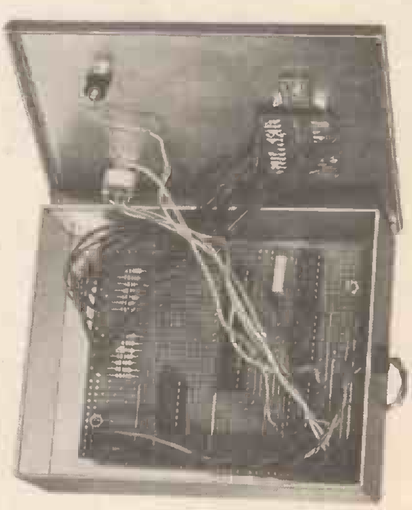
D1	1N4001
IC1	SN74LS13
IC2,IC4	SN74LS90 (2 off)
IC3,IC5	SN74LS47 (2 off)
IC6	SN74LS11
X1,X2	FND 507 (2 off)

Miscellaneous

S1	miniature non-locking push to make
S2	s.p.d.t. miniature toggle

D.i.l. holders 14-pin (4 off), 16-pin (2 off), 24-pin (1 off) (low profile types); 0·1 inch stripboard, 11 holes by 12 strips and 43 holes by 33 strips; 6BA nuts & bolts; ¼ inch grommet; 7/0·2mm flex; aluminium case.

Approx. cost Guidance only £4.50



Sadly, since this article was written, the author has passed away. The Editor and staff of *Everyday Electronics* offer their condolences to his family.

TESTING

Ensure that all i.c.s are correctly inserted before connecting to the 6V supply, then, using crocodile clips, connect a 1000µ electrolytic across C1 (plus sign to pin 1 of IC1). This will reduce the clock frequency to about 1Hz or so. Holding down the Select button will then enable the constructor to check that all numbers are formed correctly; appear in correct sequence; and, lastly, that resetting appears to occur after numbers 55 and 90. As has been explained, resetting numbers 56 and 91 will not be seen. □

PCB SERVICE

Printed circuit boards for certain constructional projects are now 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 and Electronics Monthly Editorial Offices, 6 Church Street, Wimborne, Dorset BH21 1JH. Cheques should be crossed and made payable to Everyday Electronics. *(Payment in £ sterling only.)*

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

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

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

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Tape 1 (Teach-In parts 1, 2 and 3), Tape 2 (parts 3, 4 and 5) and Tape 3 (parts 6, 7, 8 and 9) are available for £4.95 each (inclusive of VAT and postage) from Everyday Electronics and Electronics Monthly, 6 Church Street, Wimborne, Dorset BH21 1JH. **IMPORTANT** *State BBC or Spectrum; add 50 pence for overseas orders; allow 28 days for delivery.*

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VOLUME 15 INDEX

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Published on approximately the third Friday of each month by Wimborne Publishing Ltd., 6 Church Street, Wimborne, Dorset BH21 1JH. Printed in England by Benham & Co. Limited, Colchester, Essex. Distributed by Seymour, 334 Brixton Road, London SW9 7AG. Sole Agents for Australia and New Zealand - Gordon & Gotch (Asia) Ltd.; South Africa - Central News Agency Ltd. Subscriptions INLAND £13 and OVERSEAS £15 payable to "Everyday Electronics" Subscription Department, 6 Church Street, Wimborne, Dorset BH21 1JH. EVERYDAY ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

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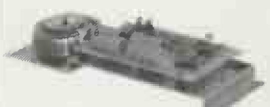

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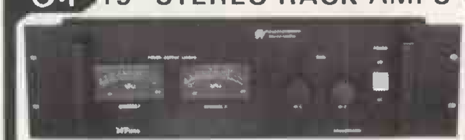

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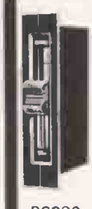

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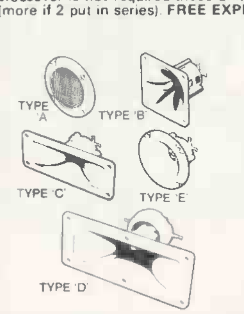

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