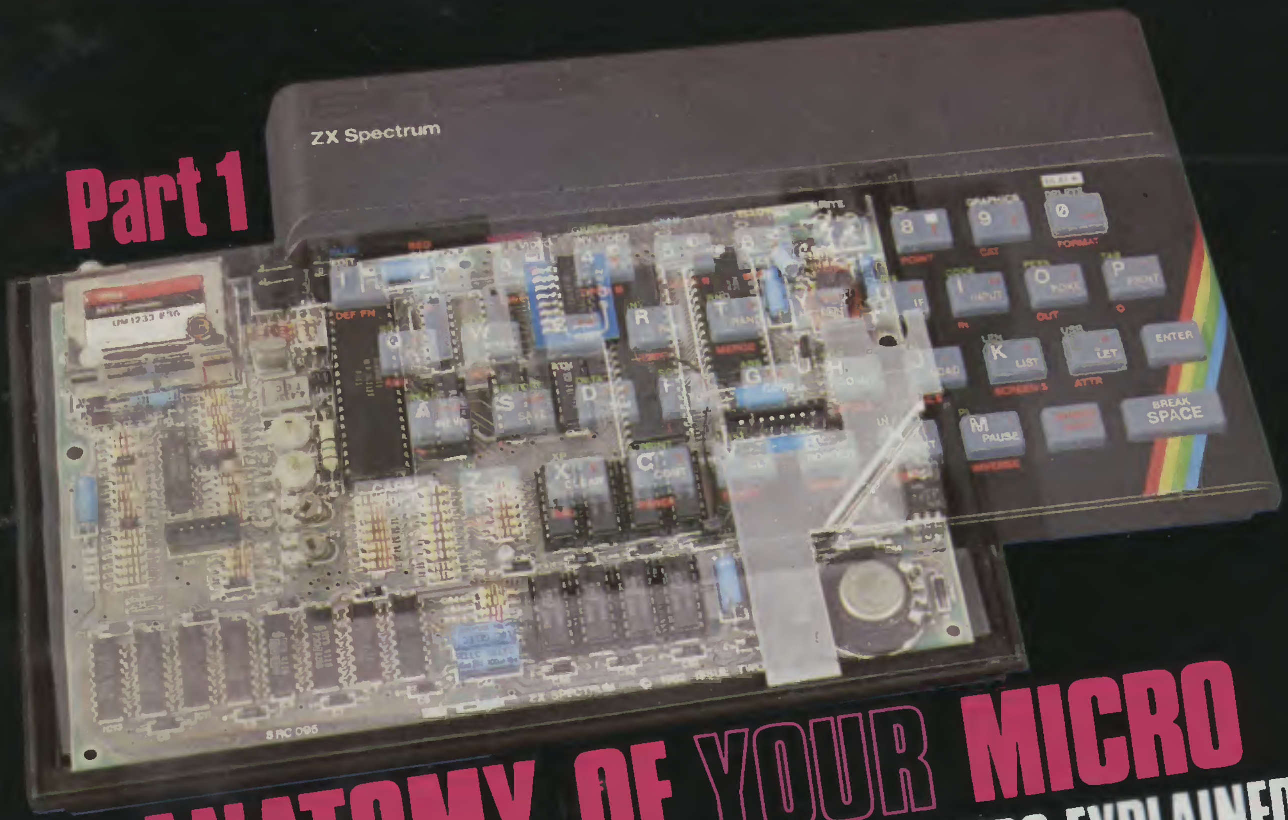
EVERYDAY ELECTRONICS and computer PROJECTS

461

JULY 1984 90p



Part 1

ANATOMY OF YOUR MICRO

COMMON ELEMENTS OF MICROCOMPUTERS EXPLAINED

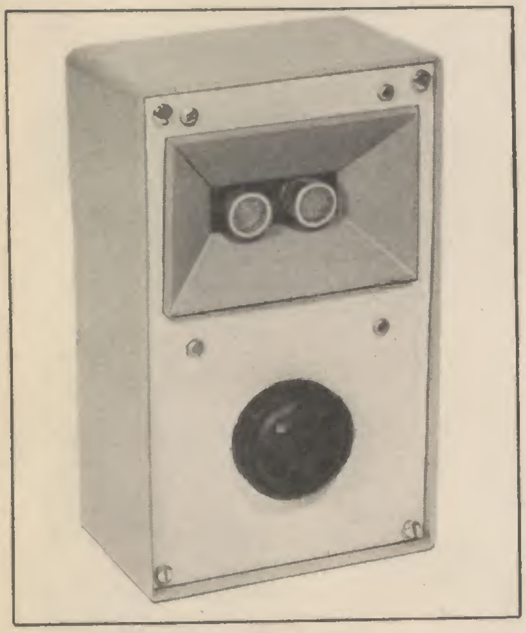
CAR LIGHTS REMINDER
ULTRASONIC ALARM SYSTEM
ELECTRONIC LOCK

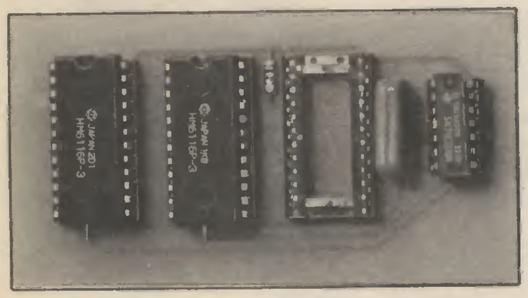
Australia $1.60 New Zealand $1.75 Malaysia $4.95

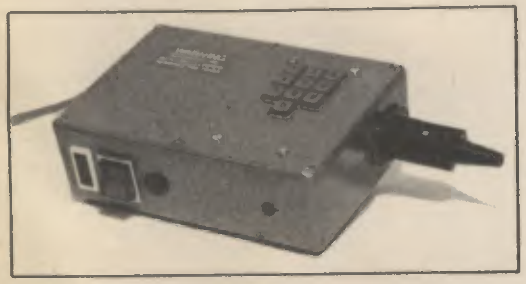
EVERYDAY ELECTRONICS and computer PROJECTS

VOL. 13 NO. 7 JULY 1984

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







Our August 1984 issue will be published on Friday, July 20. See page 447 for details.

PROJECTS

SERIES

FEATURES

Cirkit. A new name

This year Ambit will stop being Ambit. And become Cirkit.

Cirkit is more than just a change of name. It means a better service for you. Faster delivery.

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To: Cirkit Holdings PLC, Park Lane, Broxbourne, Hertfordshire.
I enclose 80p. Please send me your latest catalogue and 3×£1 discount vouchers!
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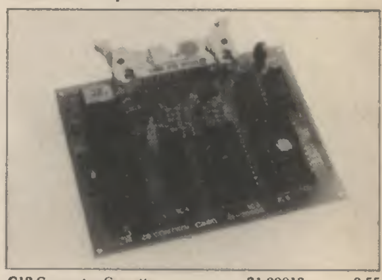
Cirkit
Bigger Stock. Better Service.

EE7

Computer Products

A complete range from Connectors to Board Level product



C12 Computer Cassette	21-00012	0.55
BBC to Centronics Printer	03-10019	7.25
BBC to 25 way D Male	03-10021	4.50
25 way D Socket	10-25200	1.90
25 way D Plug	10-25100	1.30
Cover for 25 way D	10-25322	0.93
20 up Eprom Eraser	40-82100	31.25
Z80 A Industrial Controller	40-82000	49.95
6802 Industrial Controller	40-68020	49.95
6502 Industrial Controller	40-65020	49.95
Z8 Basic/Debug Controller	41-00904	50.00

Nicad Batteries & Chargers

Minimum life 600 (300 PP3 size) full charge/discharge cycles. Batteries must be charged from a constant current source only. All batteries are supplied only with a residual charge and should be charged before used.

				1-9	10-49
AA	1.2V	500mAH	01-12004	0.80	0.74
'C'	1.2V	2.2AH	01-12024	2.35	1.99
'D'	1.2V	4.0AH	01-12044	3.05	2.85
PP3	8.4V	110mAH	01-84054	3.70	3.50

CH1/22 PP3 Charger 11mA for 16 hours
01-00159 4.30

CH8/RX Multi-purpose Charger
01-02204 9.40

Will recharge AA, C, D and PP3 size cells with automatic voltage selection. Will recharge following combination: 6×D, 6×AA, 6×C, 2×PP3, 2×D+2×C, 2×D+2×AA, 2×D+1×PP3, 2×C+2×AA, 2×C+1×PP3, 2×AA+1×PP3.

Battery Adaptor 01-12001 0.96

Sold in pairs: one to convert AA size to C size and one to convert C to D size. Both may be used together to convert an AA to D size.

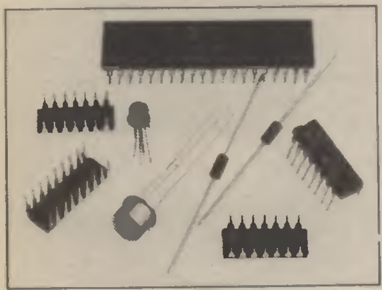
Semiconductors

Linear IC's

LM301AN	DIL version	61-03011	0.44
LM308CN	DIL version	61-03081	0.65
LM311CN	Popular comparator	61-00311	0.46
LM324	Low power quad op amp	61-03240	0.67
LM339N	Low power quad comparator	61-03390	0.68
LM346	Programmable quad op amp	61-00346	3.72
LF347	Quad Bi-FET op amp	61-00347	1.82
LM348	Quad 741 type op amp	61-03480	1.26
LF351	Bi-FET op amp	61-03510	0.49
LF353	Dual version of LF351	61-03530	0.76
LM380N	1W AF power amp	61-00380	1.00
NE555N	Multi-purpose low cost timer	61-05550	0.45

for a better service.

NE556N	Dual version of the 555	61-05560	0.50
uA741CN	DIL low cost op amp	61-07411	0.22
uA747CN	Dual 741 op amp	61-07470	0.70
uA748CN	741 with external frequency comp	61-04780	0.40
HA1388	18W PA from 14V	61-01388	2.75
TDA2002	8W into 2 ohms power amp	61-02002	1.25
ULN2283	1W max. 3-12V power amp	61-02283	1.00
MC3357	Low power NBFM IF system and detector	61-03357	2.85
ULN3859	Low current dual conversion NBFM IF and detector	61-03859	2.95
LM3900	Quad norton amp	61-39000	0.60
LM3909N	8-pin DIL LED flasher	61-39090	0.68
KB4445	Radio control 4 channel encoder and RF	61-04445	1.29
KB4446	Radio control 4 channel receiver and decoder	61-04446	2.75
ICM7555	Low power CMOS version of timer	61-75550	0.98
ICL8038CC	Versatile AF signal generator with sine/square/triangle OPs	61-08038	4.50
TK10170	5 channel version of KB4445	61-10170	1.87
HA12002	Protection monitor system for amps, PSUs, TXs etc	61-12002	1.22
HA12017	83dB S/N phono preamp 0.001% THD	61-12017	0.80
MC14412	300 baud MODEM controller (Eduro/US specs)	61-14412	6.85



Microprocessor & Memories

Z80A	Popular and powerful 8-bit CPU	26-18400	3.40
Z80AP10	2 port parallel input/output	26-18420	2.95
Z80A CTC	4 channel counter/timer	26-18430	2.90
Z8671	Z8 Micro comp. and Basic	26-08671	17.50
6116-3	16K (2kx8) CMOS RAM 200nS	26-36116	6.68
Z6132-6	32K (4kx8) quasi RAM 350nS	26-06132	15.00
4116-2	16K (16kx1) 150nS	26-24116	1.59
2764	64K (8kx8) 450nS	26-02764	9.50
2732	32K (4kx8) 450nS	26-02732	5.70

Voltage Regulators

7805	5V 1A positive	27-78052	0.40
7812	12V 1A positive	27-78122	0.40
7815	15V 1A positive	27-78152	0.40
7905	5V 1A negative	27-79052	0.49
7912	12V 1A negative	27-79122	0.49
7915	15V 1A negative	27-79152	0.49

Transitors

BC182	General purpose	58-00182	0.10
BC212	General purpose	58-00212	0.10
BC237	Plastic BC107	58-00237	0.08
BC238	Plastic BC108	58-00238	0.08
BC239	Plastic BC109	58-00239	0.08
BC307	Complement to BC237	58-00307	0.08
BC308	Complement to BC238	58-00308	0.08
BC309	Complement to BC239	58-00309	0.08
BC327	Driver/power stage	58-00327	0.13
BC337	Driver/power stage	58-00337	0.13
MPSA13	NPN Darlington	58-04013	0.30
MPSA63	PNP Complement to MPSA13	58-04063	0.30
J310	JFET for HF-VHF	59-02310	0.69
J176	JFET analogue switch	59-02176	0.65
3SK51	Dual gate MOSFET-VHF amp	60-04051	0.60
3SK88	Dual gate MOSFET-Ultra lo noise	60-04088	0.99
TIP31A	Output stage	58-15031	0.35
TIP32A	Complement to TIP31A	58-15032	0.35
VN66AF	VMOS Power FET	60-02066	0.95
ZTX3866	E-line version 2N3866	58-03866	0.45
IN4001	Rectifier diode	12-40016	0.06
IN4002	Rectifier diode	12-40026	0.07
IN4148	General purpose silicon	12-41486	0.05

Silicon Controlled Rectifiers

BRY55-100	100V .8A	52-55100	0.50
C106DI	400V 4.0A	52-00106	0.70
C122DI	400V 8.0A	52-00122	1.45

3mm Diameter LEDs

V178P	Red	15-01780	0.15
V179P	Green	15-01790	0.16
V180P	Yellow	15-01800	0.18

5mm Diameter LEDs

CQY40L	Red	15-10400	0.12
CQY72L	Green	15-10720	0.15
CQY74L	Yellow	15-10740	0.15

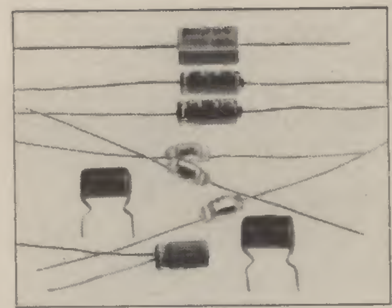
Infra-Red LEDs

CQY99	Emitter	15-10990	0.56
BPW41	Detector	15-30410	1.51

Tri Colour LED

V518	Orange-Green-Yellow	15-05180	0.60

Capacitors



Aluminium Electrolytics Radial PCB Mounting

			Pack of 4
10u	16V	05-10606	0.24
47u	16V	05-47606	0.28
47u	25V	05-47607	0.28
470u	6.3V	05-47705	0.36
470u	16V	05-47706	0.48

Tantalum Beads

			Each
1uf	35V	05-10501	0.18
10uf	16V	05-10601	0.28
47uf	6.3V	05-47601	0.45
47uf	16V	05-47602	0.92

Monolithic Capacitors

		Pack of 3
1n	04-10204	0.39
10n	04-10304	0.42
100n	04-10404	0.45

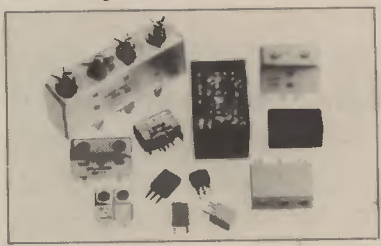
Low Voltage Disc Cermaic

		Pack of 5
1n	04-10203	0.20
10n	04-10303	0.20

Polyester (C280)

		Pack of 3
10n	04-10305	0.18
47n	04-47305	0.24
100n	04-10405	0.24
470n	04-47405	0.51
1uF	04-10505	0.66

R F Components



Filters

CFU/LFB CFW/LFH SERIES

Miniature 455kHz filters. I/P and O/P impedance 2K.

	−6dBW	−40dBW		
LFB6/CFU455H	6kHz	18kHz	16-45512	1.95
LFB12/CFU455F	12kHz	26kHz	16-45515	1.95
LFH6S/ CFW455HT	6kHz	14kHz	16-45525	2.45
LFG12S/ CFW455FT	12kHz	22kHz	16-45528	2.45
CFM2455A Mechanical IF Filters for 455kHz			19-45530	0.77

Crystal Filters 2 Pole Types

10M15A	10.7 Centre Freq.	20-10152	2.10
10MO8AA	10.695 Centre Freq.	20-11152	3.49

Inductors

We offer the complete Toko range of fixed and variable inductors. Over 500 coils from audio to V.H.F. See catalogue for details.

Soldering Irons (Antex)

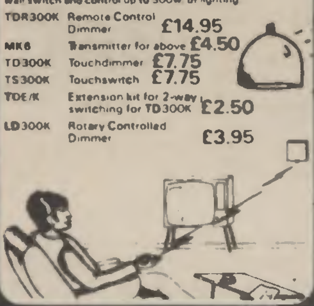
CS240	Iron 240VAC 17 Watts	54-22300	5.20
XS-240	Iron 25W 240V High heat capacity	54-22500	5.40
SK6	Presentation pack of one XS-240 with ST4 stand	54-22510	7.20
MLXS	Handy 12V 15W soldering iron complete with crocodile clips and solder	54-20004	5.60

Please add 15% VAT to all advertised prices and 60p post and packing. Minimum order value £2 please. We reserve the right to vary prices in accordance with market fluctuation.

HOME LIGHTING KITS

These kits contain all necessary components and full instructions & are designed to replace a standard wall switch and control up to 300w. of lighting

TDR300K	Remote Control Dimmer	£14.95
MK6	Transmitter for above	£4.50
TD300K	Touchdimmer	£7.75
TS300K	Touchswitch	£7.75
TDE/K	Extension kit for 2-way switching for TD300K	£2.50
LD300K	Rotary Controlled Dimmer	£3.95



MINI KITS

MK1 ELECTRONIC THERMOSTAT
Uses LM3911 IC to sense temperature (80°C max) and triac to switch heater (1KW). Mains powered. £4.60

MK2 SOLID STATE RELAY
Switches 240V ac motors, lights, heaters from logic/computer circuits. Zero voltage switching, opto isolated. Supplied without triac £2.60

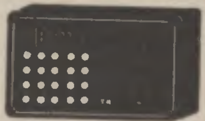
MK4 PROPORTIONAL TEMPERATURE CONTROLLER
Uses "burst fire" technique to maintain temperature to within 0.5°C. Ideal for photography, incubators, wine making, etc. Max. load 3KW (240V ac). Temp. range up to 90°C. £8.50

MK5 MAINS TIMER
Mains powered timer enabling a load up to 1KW at 240V ac to be switched on (or off) for a variable time from 20 mins. to 35 hrs. Longer or shorter periods possible with minor component changes £6.50

MK15 DUAL LATCHED SOLID STATE RELAY
Comprises two MK2s with latch circuit enabling the MK12 kit to control two mains loads independently. Two output triacs not supplied. (See remote control kits.) £4.50

NEW! MK19 DC CONTROLLED AUDIO AMPLIFIER
May be used with virtually any stereo audio amplifier to control bass, volume, treble and balance remotely either using a wire link or the MK11 infra red receiver. A 1 of 10 decoder with LEDS is also included for remote input selection/display. (See remote control kits.) £10.70

MICROPROCESSOR CONTROLLED MULTI-PURPOSE TIMER



Now you can run your central heating, lighting, hi-fi system and lots more with just one programmable timer. At your selection it is designed to control four mains outputs independently, switching on and off at pre-set times over a 7 day cycle, e.g. to control your central heating (including different switching times for weekends), just connect it to your system programme and set it and forget it — the clock will do the rest.

- 7mm LED 12 hour display
- Day of week, am/pm and output status indicators
- 4 open collector outputs for driving relays, triacs, etc.
- 50/60Hz mains operation
- Battery backup saves stored programmes and continues time-keeping during power failures. (Battery not supplied).
- Display blanking during power failure to conserve battery power
- 18 programme time sets
- Powerful 'Everyday' function enabling output to switch every day but use only one time set
- Useful 'sleep' function — turns on output for one hour
- Direct switch control enabling output to be turned on immediately or after a specified time interval
- 20 function keypad for programme entry

NOW ONLY £39.00

- Programme verification at the touch of a button
- Plastic box with attractive screen printed front panel 15 × 10 × 5.5cm

(Kit includes all components, PCB, box, assembly and programming instructions.)
Order as CT6000

XK114 OPTIONAL RELAY KIT
Kit includes one relay, PCB to accommodate up to 4 relays, terminal blocks, etc., to fit inside CT6000 box. Provides up to 4 3amp 240V AC changeover contacts. £3.90

Additional relays £1.65 each

DISCO LIGHTING KITS

DL 1000K
This value for money kit features a bi-directional sequence, speed of sequence and frequency of direction change, being variable by means of potentiometers and incorporates a master dimming control. £15.95

DLZ 1000K
A lower cost version of the above, featuring unidirectional channel sequence with speed variable by means of a pre-set pot. Outputs switched only at mains zero crossing points to reduce radio interference to a minimum. £8.95

Optional opto input DLA1
Allowing audio ("beat") — light response 60p

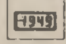
DL 3000K
This 3 channel sound to light kit features zero voltage switching, automatic level control and built-in mic. No connections to speaker or amp required. No knobs to adjust — simply connect to mains supply and lamps (1Kw channel) Only £12.95

24 HOUR CLOCK/ APPLIANCE TIMER KIT

Switches any appliance up to 1kW on and off at preset times once per day. Kit contains: AY-5-1230 IC, 0.5" LED display, mains supply, display drivers, switches, LEDs, triacs, PCBs and full instructions.

CT1000K Basic Kit £14.90
CT1000K with white box (56/131 × 71mm) ... £17.40
(Ready Built) ... £22.50

DVM/ULTRA SENSITIVE THERMOMETER KIT



This new design is based on the ICL7126 (a lower power version of the ICL7106 chip) and a 3½ digit liquid crystal display. This kit will form the basis of a digital multimeter (only a few additional resistors and switches are required — details supplied), or a sensitive digital thermometer (−50°C to +150°C) reading to 0.1°C. The basic kit has a sensitivity of 200mV for a full scale reading, automatic polarity indication and an ultra low power requirement giving a 2 year typical battery life from a standard 9V PP3 when used 8 hours a day, 7 days a week. **Price £15.50**

XK113 MW RADIO KIT

Based on ZN414 IC, kit includes PCB, wound aerial and crystal earpiece and all components to make a sensitive miniature radio. Size: 5.5 × 2.7 × 2cms. Requires PP3 9V battery. IDEAL FOR BEGINNERS. £5.50

3-NOTE DOOR CHIME

Based on the SAB0600 IC the kit is supplied with all components, including loudspeaker, printed circuit board, a pre-drilled box (95 × 71 × 35mm) and full instructions. Requires only a PP3 9V battery and push-switch to complete. AN IDEAL PROJECT FOR BEGINNERS. Order as XK 102. £5.50

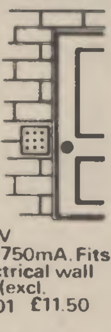
COMPONENT PACKS

PACK 1	650 Resistors 47 ohm to 10 Mohm — 10 per value £4.00
PACK 2	40 × 16V Electrolytic Capacitors 10µF to 1000µF — 5 per value £3.25
PACK 3	60 Polyester Capacitors 0.01 to 1µF 250V 5 per value £5.55
PACK 4	45 Sub miniature Presets 100 ohm to 1 Mohm — 5 per value £2.90
PACK 5	30 Low Profile IC Sockets 8, 14 and 16 pin 10 of each £2.40
PACK 6	25 Red LEDs (5mm dia.) £1.50

LCD 3½ DIGIT MULTIMETER

19 ranges including DC voltage (200 mv-1000 v) and AC voltage, DC current (200 mA-10 A) and resistence (0 — 2M) + NPN & PNP transistor gain and diode check. Input impedence 10M. Size 180 × 140 × 50mm. Complete with battery, test leads and carrying case. **ONLY £32.00**

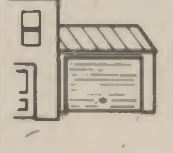
ELECTRONIC LOCK KIT



With hundreds of uses in doors, garages, car anti-theft devices, electronic equipment etc. Only the correct easily changed four digit code will open it! Requires a 5 to 15V dc supply. Output 750mA. Fits into standard electrical wall box. Complete kit (excl. front panel) XK101 £11.50

Electronic lock mechanism for use with the above kit. 70 150 £14.95

INFRA RED GARAGE DOOR CONTROLLER KIT



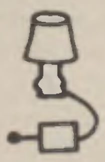
For opening and closing motorised garage doors plus switching garage and drive lights on and off up to a range of 40ft and numerous other applications like controlling lights and TV's etc. in the home. Ideal for aged or disabled persons, this coded kit comprises of a mains powered infra red remote control receiver with a normally open relay output plus two latched transistor outputs; battery-powered four button transmitter and an opto isolated solid state mains switch. As with all our kits, full instructions are supplied.

XK103 £25

Extra transmitters XK105 £10.00

HOME CONTROL CENTRE

This kit enables you to control up to 16 different appliances by means of coded pulses in the mains wiring which may be decoded by special receivers anywhere in the house. The transmitter may be controlled manually or by the computer interface enabling your favourite micro to make your coffee in the morning, switch lights anywhere in the house, or your electric blanket in your bedroom. Just think of the possibilities — and no wiring!



The Kit comprises a transmitter with pre-drilled box and two receivers.

XK112 £42.00
ADDITIONAL RECEIVERS XK111 £10.00

REMOTE CONTROL KITS

These kits have been designed to enable infra red remote control to be incorporated into virtually any application from switching car locks or alarms to controlling Hi Fi or TV. The exact application will determine the interface circuitry (not supplied) between the receiver and the device to be controlled. In many cases this could by a relay or triac. General instructions and applications are supplied with the kits. The kits are coded and provide a high degree of noise immunity and security.

MK18 Transmitter Kit. For use with MK11/MK12 Receivers and MK9/10/13 keyboards. Requires PP3 battery. Size 8 × 2 × 1.3 cms. Range approximately 60ft. £6.80

MK11 Receiver Kit. Mains powered. Provides 10 latched plus 3 analogue outputs. Ideal for controlling audio amplifiers, TV or lighting circuits where control of lamp brightness is required. £13.50

MK13 Transmitter Keyboard £4.35

MK19 DC Controlled Stereo Amplifier Kit. If control of stereo amplifier is required the MK13 may be used providing for remote control of base, treble and volume (or balance). This kit also includes a one of 10 decoder with LEDs for remote selection of programme or channel. May be connected between the pre amp and power amp sections of almost any audio amplifier. £10.70

MK12 Receiver Kit. Mains powered. Provides up to 16 latched or momentary on/off outputs. The latched version is suitable for applications where only one of the 16 outputs is to be on at any one time e.g. TV channel selection. The momentary version provides an output only during transmission. Lines may be latched separately if required (circuit supplied). This may be used in conjunction with the MK15 Dual latched Solid State Relay to switch mains loads, e.g. radio, lights, TV.

MK12 (state latched or momentary)	£13.50
MK9 4 way Transmitter Keyboard	£1.90
MK10 16 way Transmitter Keyboard	£5.40
MK15 Dual Latched Solid State Relay	£4.50

SINGLE CHANNEL UNCODED INFRA RED KITS

MK6 Transmitter — supplied with hand held plastic box. Requires a 9V PP3 battery. Range approximately 20ft. £4.50

MK7 Receiver. Mains powered with triac output to switch up to 500W at 240V a.c. On/off or momentary output available. £10.50

MK16 Mains Powered Transmitter. For continuous operation such as burglar alarms, automatic door operators, etc. Range approximately 6 ft. May also be powered from 9v d.c. £3.50

MK17 12V d.c. Receiver. For use with MK6 or MK16. Relay output with DP 3A change over contacts. May be used as latched, momentary or break beam receiver. Operates from 6-13V d.c. £10.50

WE ALSO STOCK A WIDE RANGE OF ELECTRONIC COMPONENTS

SEE CATALOGUE FOR DETAILS

Send SAE 9" × 6" for our **FREE YELLOW CATALOGUE.** It's packed with a full list of our stock range all at very competitive prices.

Add 65p postage & packing + 15% VAT to total. Overseas Customers: Add £2.50 (Europe), £6.00 (elsewhere) for p&p. Send S.A.E. for further STOCK DETAILS. Goods by return subject to availability.

OPEN 9am to 5pm (Mon to Fri) 10am to 4pm (Sat)

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NEW TECHNOLOGY

OVER THE years of my involvement with the electronics industry many high technology companies have spoken of the difficulties in getting business to accept new ideas and innovations. Of course there are a number of reasons, not the least being that hard headed businessmen need to know that the product is reliable, can be serviced quickly, will not be outdated as soon as they get it and will actually be of benefit to the company. Most of the above reasons take some time to establish and are, in my book, precisely the reasons that the new Sinclair QL will probably not become the business machine Sinclair are marketing it as.

There are, however, a couple of other reasons why new technology is not taken up more quickly. One of these is the poor back-up service, including supply delays and even over-pricing of replacements and add-ons by the suppliers. Many companies find more difficulties once the installations are in operation, simply because they are not flexible enough to reorganise operating procedures to make the best possible use of new equipment. This is often why things like "computer errors" occur on invoicing systems, etc. Take a recent outstanding example of lack of co-ordination within British Telecom—an organisation that does now appear to be moving with the times even though they have a long way to go yet. About a year ago we had a Prestel system in the editorial office, having discovered what we wanted to know about the system and found it rather cumbersome and of little value to the magazine (that is another story) we decided to have it taken out.

Both the installation, operation and removal were reasonably efficient and I felt that BT were just beginning to catch up with the service offered in countries like Canada—of which I have some experience. However, what followed after the removal of the service goes to show that they still need to rearrange some operating procedures and improve their own communications. We were billed for use of the system after its removal, followed by a reminder and a threat to bar our access to the service. Having telephoned the Prestel office each time we were promised things would be sorted out, but now, three months later, we have been billed for a further quarterly rental. Another phone call to Prestel followed by a further reminder and threat to bar our access if we do not pay within seven days.

Once again we called and were informed that the billing was done by a different department and that it would now be sorted out. We hope so, because it would be awful to be barred from a service we do not have! Incidentally we still get the Prestel Directory mailed to us as well.

What I hope, is that as a new generation of computer-oriented youngsters grows up and fills many jobs in the UK, such problems will be overcome. At least the next generation of businessmen will understand the technology, know that, used properly, it will make us more efficient and not be worried about unknown v.d.u. emissions making their hair fall out. With so many of you being computer users perhaps the future of UK industry will be bright.

Mike Kenward

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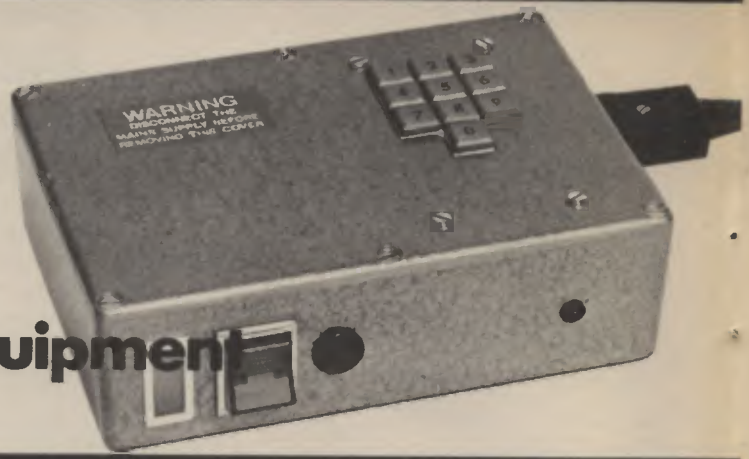
electronic LOCK

For mains operated equipment

W.D. PHILLIPS BSc PhD



THIS device is designed to prevent unauthorised use of mains-operated equipment up to 5A (1·2kW), including microcomputers, CB radio home-base stations, hi-fi systems and video recorders. The codelock unit is connected to the domestic mains supply as shown in Fig. 1. The correct 4-digit code must be entered using the keyboard before power is switched to the protected equipment by means of a 2-pole relay, switching both LIVE and NEUTRAL. The code is selected from 5040 possible combinations during construction and must be entered within a 5-second period in order to operate the device. Although the codelock gives good protection against casual misuse, it can be overcome by a determined person, prepared to cut and rewire the mains supply.

CIRCUIT DESCRIPTION

Figure 2 gives the complete circuit diagram for the codelock. Almost all the work is done by a single integrated circuit, IC1. This is the LS7225 keyless lock i.c., as shown in Fig. 3.

An internal circuit (*power on reset*) sets the device to the "locked" condition when power is first applied. Pins 11–14 provide the 4-digit *sequence input*. Pressing S5 enters the first digit of the code by applying the positive supply voltage (logic 1) to pin 11. At the same time, C3 is charged to supply potential. C3 discharges slowly, the potential at pin 11 gradually declining as charge leaks away. When a critical level is reached, the internal *sequence detector* is reset.

With C3 = 1µF and V_{ss} = 12V, there is a delay of approximately 5 seconds during which the remaining digits of the code must be entered. This is done by pressing S4, S3, and S2. The remaining keyboard switches, S6–S11, are connected to the *unselected input*, pin 10. Logic 1 at this pin immediately resets the sequence detector.

Three important outputs are available from IC1. The *lock indicator*, pin 7, drives an l.e.d. directly, with no need for a series resistor. The l.e.d. is illuminated to indicate that the device is "locked" and becomes extinguished only after entering the correct code. The *unlock output*, pin 8, is used here. This is toggled to logic 1 following a correct entry and remains in this condition indefinitely, being reset only by re-entering the code or switching off the supply. The output from pin 8 drives the relay, RLA1, via R2 and TR1, thereby switching the mains supply. The *momentary unlock output* is not used in this circuit.

MAINS SAFETY

In any project involving connection to the domestic mains supply, very high

Fig. 3 (Right). LM7225 pin connections.

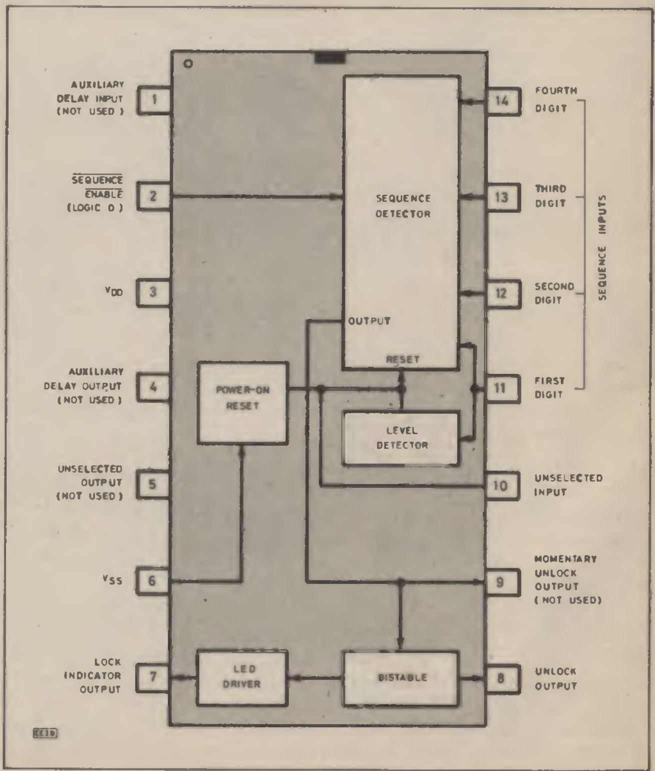
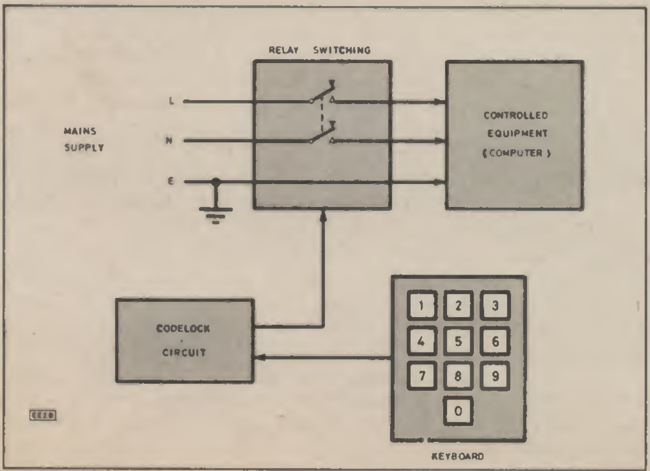


Fig. 1 (Below). Block diagram of electronic codelock system.



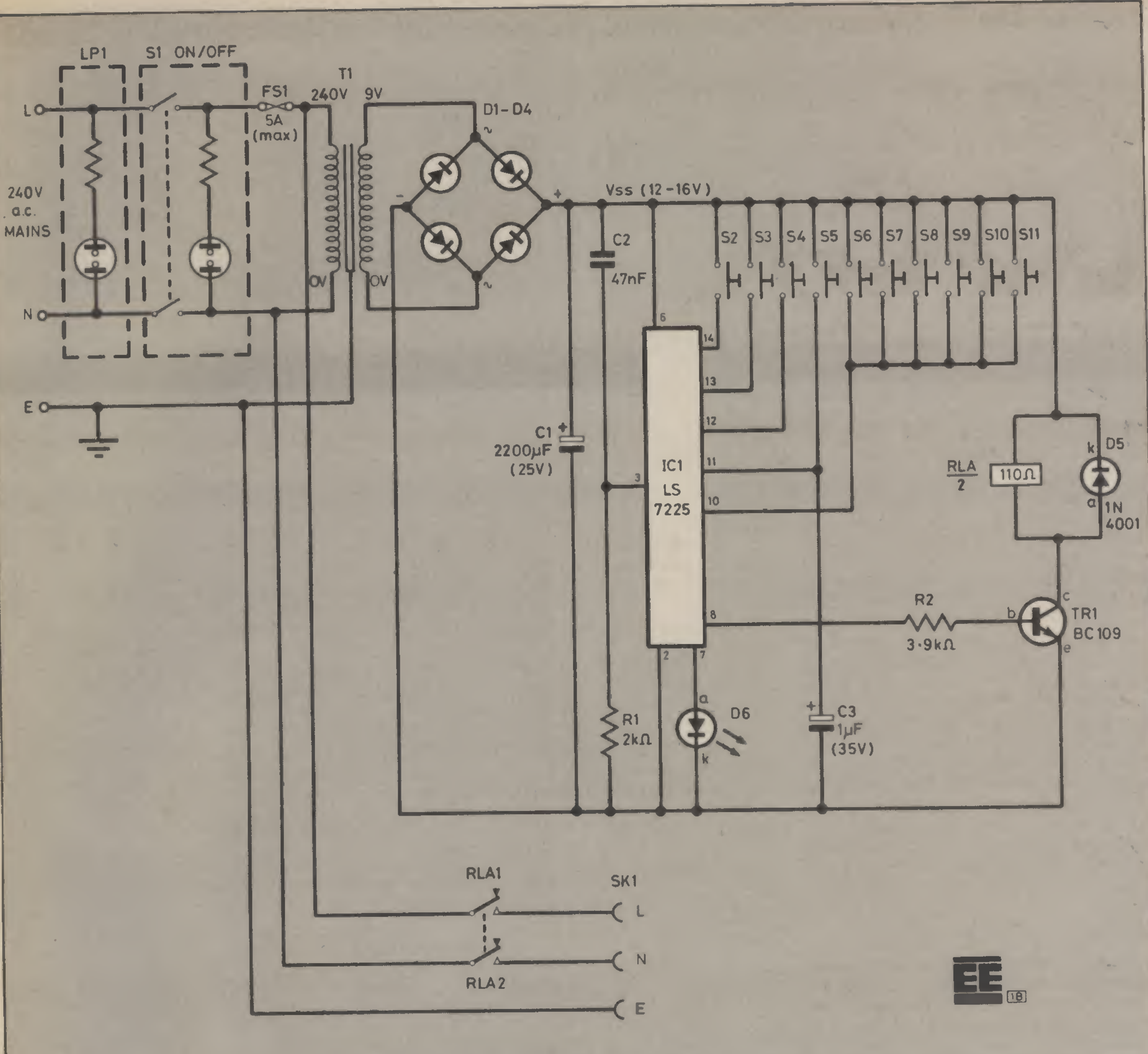


Fig. 2. Circuit diagram of electronic codelock system.

standards of electrical safety are essential. This project incorporates a number of important safety features, following the recommendations of G.C.E. examination boards for O-level and A-level projects:

1. 3-CORE MAINS CABLE AND EARTHED METAL BOX: Metal boxes take longer to drill and to prepare than plastic boxes but they do offer a better standard of safety in the event of constructional errors. Provided the metal of the box is electrically connected to the mains EARTH terminal, any serious fault in the mains wiring is liable to blow the mains fuse and is unlikely to result in electric shock. Less dangerous faults in the low voltage secondary circuit can cause the mains transformer or other components to become warm or hot. While plastic boxes melt, metal boxes can withstand high temperatures and, even in normal operation, they act as heat sinks, helping to dissipate any heat produced.

The mains cable is protected by a sleeved rubber grommet where it passes through the box and must be properly anchored, in this case by a P-clip. All mains wiring inside the box should be carried out using the appropriate colour and thickness of wire.

2. MAINS INDICATOR NEON (LP1): The neon is illuminated as soon as the codelock is plugged in and gives an instant visible warning that parts of the internal circuit are at mains LIVE potential. This is particularly imporant during testing.

3. DOUBLE POLE MAINS ON/OFF SWITCH (S1): Both LIVE and NEUTRAL are switched so that the equipment is properly isolated, making it safe, even if the mains connections are accidentally reversed. In this circuit a d.p.s.t. illuminated switch is used to give a visible indication of mains switching.

4. MAINS FUSE. A 20mm mains fuse to BS4265 is used and is mounted in a screw release fuseholder. The rating of the fuse is best chosen to correspond to the power requirements of the equipment controlled by the codelock. The maximum of 5A must not be exceeded.

CONSTRUCTION

PLANNED ASSEMBLY: All the components used must be sensibly located with an adequate separation between the mains and low voltage parts of the circuit. Equally, all the components must be firmly fixed, including circuit boards, which are securely bolted to the box. Interwiring between components is colour-coded using several different colours of stranded wire, and all the connections are kept short but strain-free. Spaghetti-type wiring in one colour is difficult or impossible to check and must be avoided.

MAIN CIRCUIT BOARD: The two printed circuit boards are shown in Figure 4a and 4b. Begin construction by assembling the main circuit board as shown in Figure 5. It is generally more convenient to insert the low-lying components, including resistors R1 and R2, D5, and the socket for IC1, first, followed by the larger components. Take care to insert the electrolytic capacitor (C1) and tantalum capacitor (C3) with the correct polarity. Do not insert IC1 at this stage. Complete the assembly of the main circuit board by soldering in various colours of flying leads about 15cm long, using stranded wire and ribbon cable, as indicated.

SETTING THE CODE: The keyboard p.c.b. is assembled simply by soldering S2–S11 in position. The code is set using the method illustrated in Figure 6. This shows the wiring matrix of the keyboard viewed from the component side. The switch terminal corresponding to the first digit of the code, in this case 7, is connected by an insulated wire link to the copper track E. In the same way, the switch terminal for the second digit (2) is connected to copper track D, the third digit (5) to track C, and the fourth digit (1) to track B. This sets the code 7251. However, any combination using four different switch terminals can be set, so that constructors can choose from 10 × 9 × 8 × 7 = 5040 different codes. It is a simple matter to reset the code from time to time by rewiring the matrix.

The six "unselected" switch terminals are connected to track F. Track A is connected to V_{ss} and provides the common positive supply to all ten keyboard switches. The insulated wire links must be

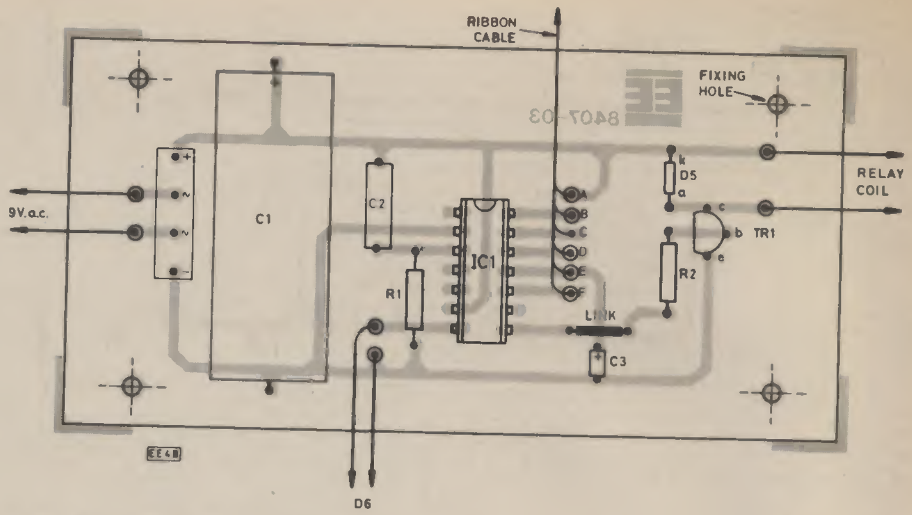


Fig. 5. Main p.c.b. component layout.

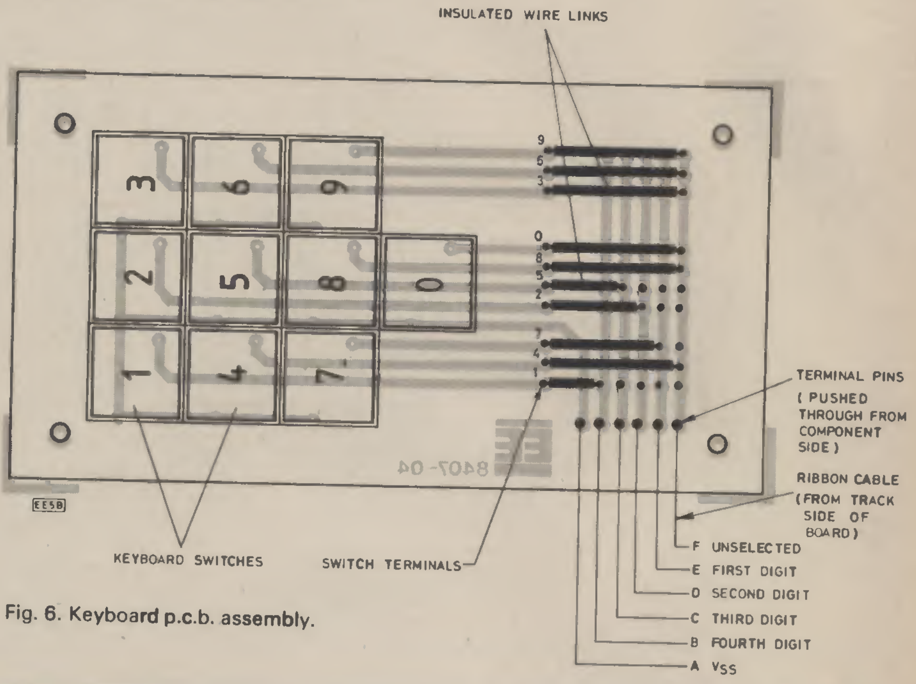


Fig. 6. Keyboard p.c.b. assembly.

COMPONENTS

Approx. cost Guidance only **£16.00**

Resistors
- R1 2kΩ
- R2 3·9kΩ
- All ¼W carbon film ±5%

Capacitors
- C1 2200µF 25V elect. axial leads
- C2 47nF polyester
- C3 1µF 35V tantalum

Semiconductors
- D1–4 200V, 1·6A bridge rectifier
- D5 1N4001 silicon diode
- D6 TIL220 (0·2in red l.e.d.)
- IC1 LS7225 keyless lock i.c.
- TR1 BC109 silicon *npn*

Miscellaneous
- FS1 20mm mains fuse (maximum 5A—see text)
- LP1 240V a.c. mains neon with integral resistor
- RLA1 d.p.d.t. 12V d.c. 110Ω coil
- S1 d.p.s.t. with 240V a.c. neon indicator
- S2–11 (10 off) p.c.b. mounting keyboard switch (RS337-605)
- SK1 shuttered power outlet socket (RS489-245)
- PL1 shrouded plug (RS489-251)
- T1 6VA main transformer, 0–4·5, 0–4·5, or 9V secondary

PRINTED CIRCUIT BOARDS: maincircuit board size 100 × 50mm, keyboard size 100 × 55mm; aluminium diecast box 170 × 120 × 55mm; screw release 20mm fuseholder; sleeved grommet; l.e.d. fixing clip; P-clip; 6A mains cable.

See Shop Talk page 434

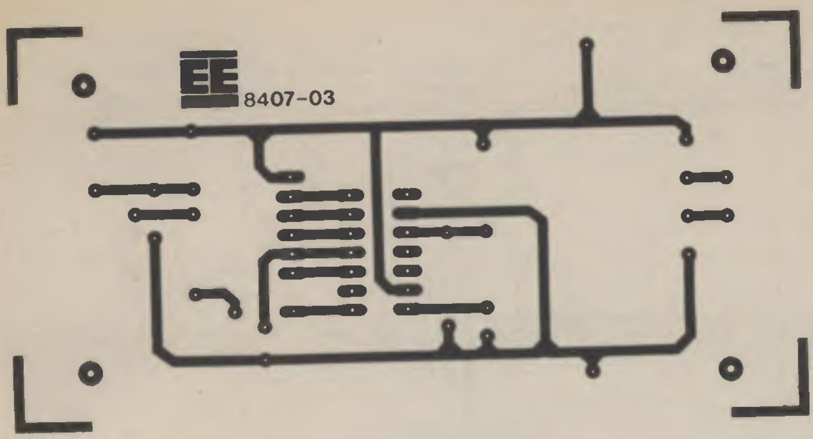
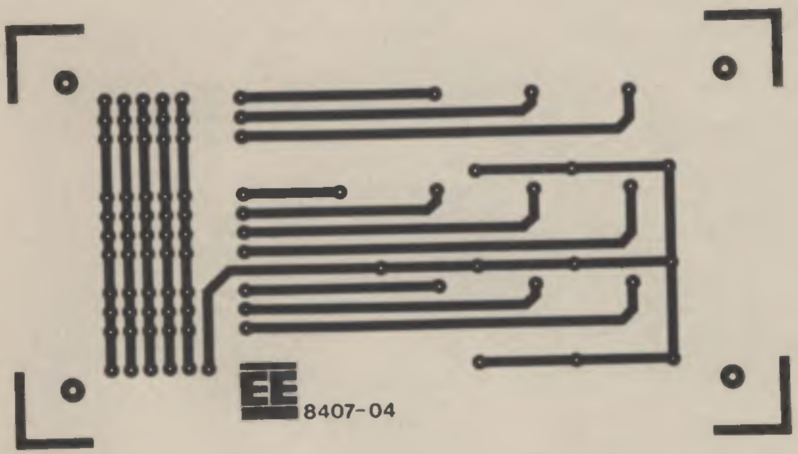


Fig. 4a. Main p.c.b. layout.

Fig. 4b. Keyboard p.c.b. layout.



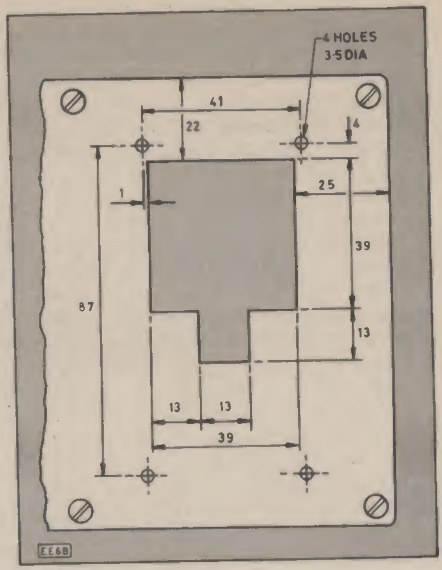


Fig. 7. Top panel drilling details.

kept close to the surface of the p.c.b. so that the completed board can be mounted flush to the inside of the box. To complete the keyboard assembly, terminal pins are pushed through from the component side at the end of each track and soldered in position.

BOX PREPARATION: Drilling details for the aluminum diecast box used in the prototype are given in Figure 7. Mark the box carefuly and check component sizes before you begin. Patience and care taken at this stage will help to ensure a good final appearance. Large areas of metal are best removed using a small hacksaw fitted with a tension file in place of the normal blade. With drilling completed, the box can be cleaned and spray painted if desired.

FINAL ASSEMBLY: Once LP1, S1, the fuseholder FS1, and the transformer T1, have been fitted, the major part of the mains wiring can be carried out (Figure 8). Constructors are advised to check carefully that this is completed correctly. Next, fit RLA1, the output socket SK1 and the main circuit board together with its flying leads. When the board is bolted in position these leads are cut to the correct length, stripped, and soldered to

complete the interwiring procedure. The trickiest part of this procedure is connecting the ribbon cable to the terminal pins projecting from the track side of the keyboard p.c.b. To avoid shorting between these connections, only a short length of wire from the cable should be exposed and the soldered joints should be insulated using PVC tape.

TESTING

One method of circuit testing widely in use is to "switch on and see if it works". With mains-operated equipment this should NEVER be attempted. The proper procedure for testing the completed codelock is as follows.

1. Carefully check all wiring and

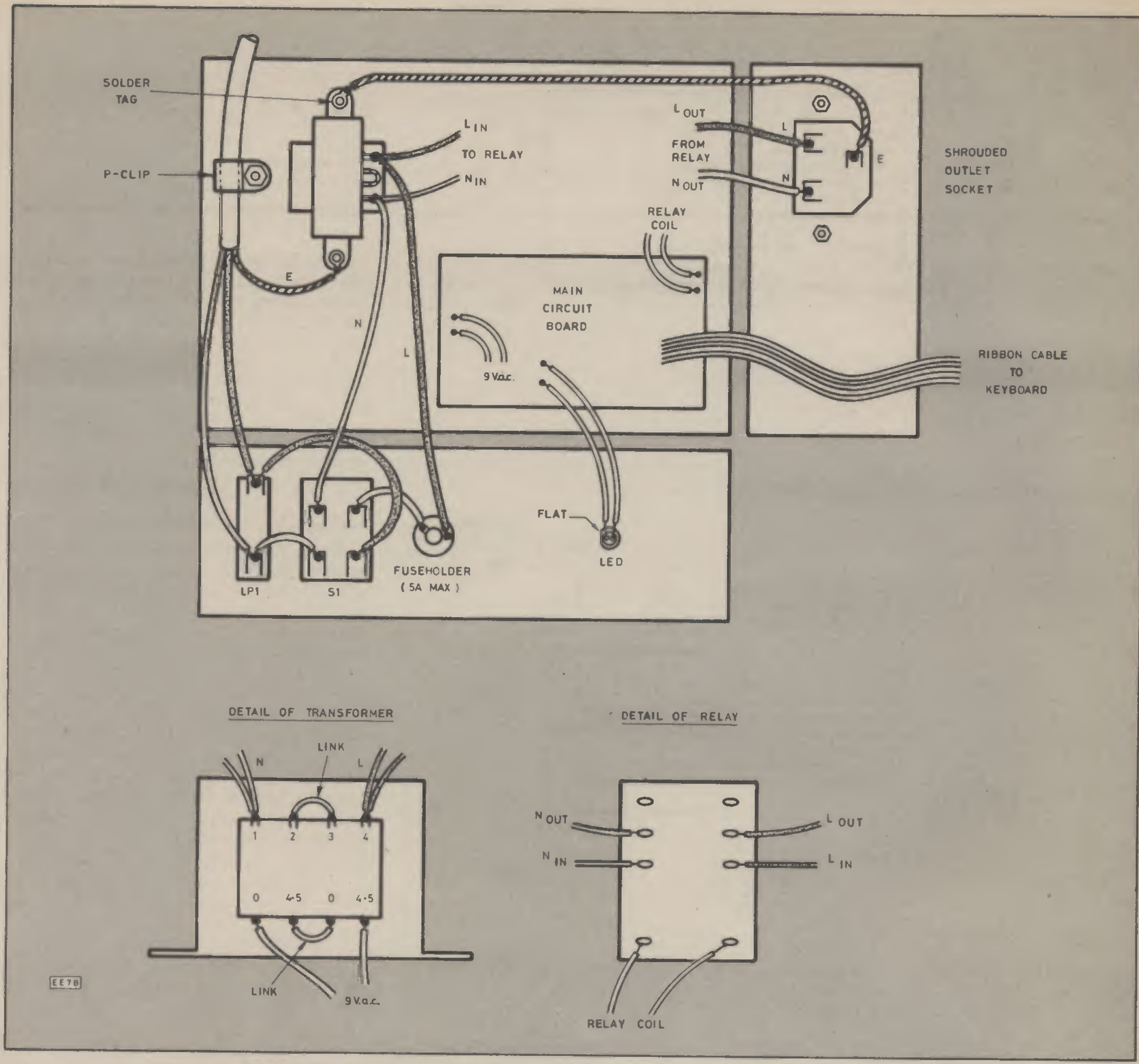


Fig. 8. Codelock wiring diagram.

make sure that the soldered connections on both circuit boards stand well clear or are insulated from the metal box.

2. With a multimeter set to read resistance, check that the exposed metal of the box is directly connected to the EARTH terminal (centre pin) of the mains plug.

3. Remove the mains fuse FS1 from its holder, plug in the mains lead and check the operation of LP1 and S1.

4. Disconnect the mains, replace FS1, and then reconnect the mains supply. Using a multimeter switched to a suitable d.c. voltage scale, check the low voltage power supply across the large smoothing capacitor (C1) on the main circuit board. N.B. KEEP YOUR FINGERS WELL AWAY FROM ANY MAINS WIRING AND HANDLE ONLY THE INSULATED ENDS OF THE METER PROBES. A reading of 12–16V should be obtained.

5. Switch off again, allow time for C1 to discharge, and only then fit IC1 in its socket, checking for correct orientation.

6. Place the lid loosely on the box, switch on again and check that LED1 is illuminated. Now enter the selected code and listen for a slight 'click' indicating relay operation. At the same time, LED1 should be extinguished.

7. If everything is in order, disconnect the mains and screw down the lid of the box. Finally, connect the computer or other codelock controlled equipment via SK1, PL1 and check operation of the complete system.

OTHER APPLICATIONS

The LS7225 is a very versatile device. The circuit given here can easily be adapted for other uses. For example, a general purpose combination lock can be made by using the relay to switch current to a solenoid operated bolt instead of switching the mains supply. Alternatively, the codelock could be used to arm and disarm domestic burglar alarms or other security systems. The quiescent current consumption of the device is extremely low (40μA), allowing battery operation if desired.

Only experienced constructors should attempt such modifications. Interested readers are referred to "PRACTICAL ELECTRONICS", May 1983, pp 26–28 for further information. □

CAPACITANCE COMPARATOR

L.S.COOK

CAPACITORS are manufactured from various materials in many shapes, physical sizes and nominal values, and with tolerances commonly from ±1 per cent to +100/−20 per cent. Very often the value required in a particular position is not critical, but there are limits; so a method determining the approximate value of a suspect capacitor, or one which has lost its markings, can be useful.

The comparator described here readily performs this function, being easy to use and relatively inexpensive.

PRINCIPLES OF OPERATION

Let the value of the unknown capacitance be C and that of an accurately known one be C′. These are incorporated into two separate monostables, using a 556 dual timer i.c., with associated resistances R and R′, respectively, giving "on times" (high output, kRC and kR′C′ where k is a constant. If these are made equal $RC = R'C'$ hence $C = C'R'/R$. C′ and R are known and R′ is the value at a particular setting of a potentiometer, which can be measured or, as will be seen later, a scale can be calibrated directly in capacitance values.

Five ranges are provided, each covering values ten times those in the preceding range (see photographs).

CIRCUIT DESCRIPTION

Fig. 1 shows the circuit diagram. R, referred to above, is R1, 2, 3, 4 or 5 and R′ is the value of VR1 (between its wiper and R6). C′ is C2.

Initially, the outputs (call them outputs A and B from the 556 IC1a, b) are low, so the output of IC2c is high and that of IC2b low, thus triggering both sections of IC1 and taking their outputs high, the reset input of IC1a being held high by IC2a; the trigger inputs then rise. When the output from either monostable drops to zero its effect is momentarily transferred through C5 or C6 to the corresponding input of IC2d and when, and only when, the two zero-bound spikes coincide (i.e., equal "on times" since the monostables were triggered simultaneously) a high output is obtained from IC2d, illuminating D5 via TR1. With output B now low the monostables are retriggered and the cycle is repeated. C9 acts as a reservoir capacitor prevented from discharging through IC2d by D4.

If output A drops before output B, it remains in that state until retriggered. If output B drops first it is possible for IC1b to be triggered again, perhaps more than once (depending on the setting of VR1), before output A drops so when the latter does eventually fall it could coincide with the second, third, etc., fall of output B, thus indicating a false coincidence. To avoid this occurring, when output B falls IC1a is reset via IC2a but not immediately, otherwise a coincidence would automatically be indicated, again falsely; R7 and C4 introduce a suitable delay. R13 and C8 provide a further delay to allow IC2a, and hence the reset input of IC1a, to recover before retriggering takes place. D1, 2, 3 allow C4, 7, 8 to rapidly charge or discharge (as appropriate) when output B rises.

Switch S2 provides a COARSE/FINE control. With the switch open (COARSE) D5 is illuminated for a wide range of values of VR1 to enable its approximate required setting to be located quickly. Closing S2 (FINE) enables a more accurate setting to be found.

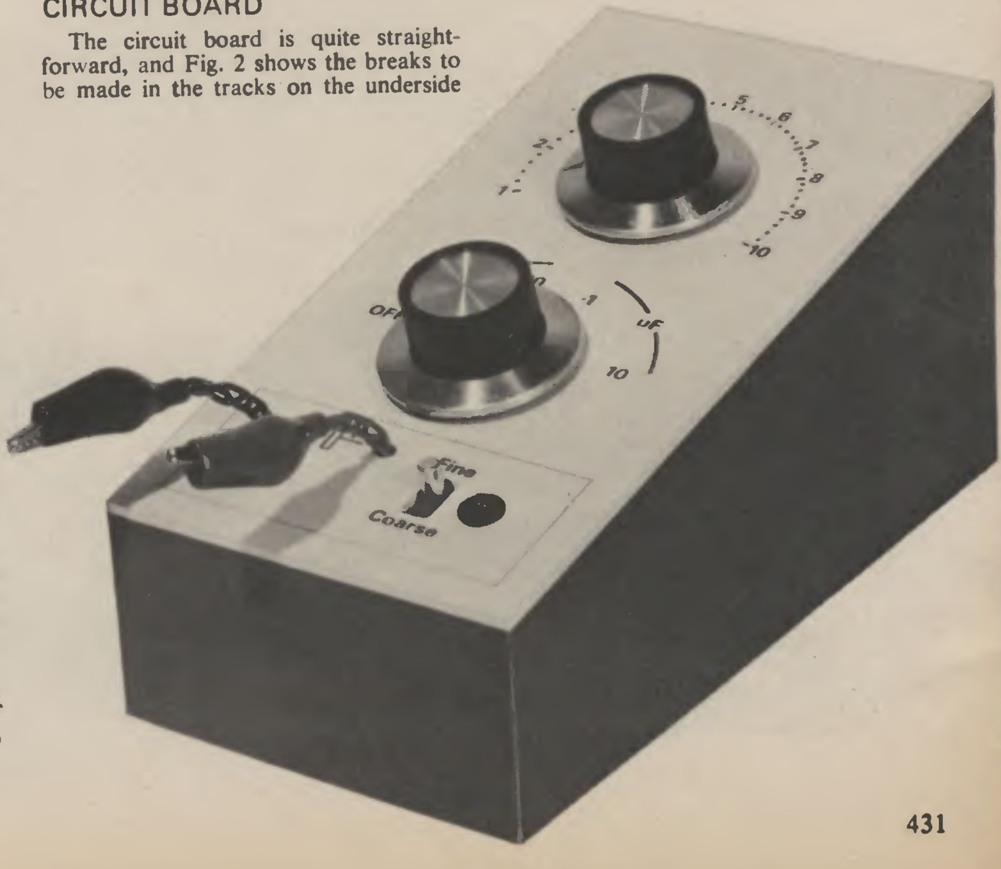
CONSTRUCTION

CIRCUIT BOARD

The circuit board is quite straightforward, and Fig. 2 shows the breaks to be made in the tracks on the underside and the layout of the components on top. Make the breaks, first checking there are twenty-seven, and add the five wire links on the trackside (also shown in Fig. 2). Next, solder in the i.c. holders and the twelve wire links on top, allowing those joining E19–F19 and F25–G25 to stand above the board in order to attach flying leads. Then add the resistors, capacitors (remembering C10 is polarised) and finally the semiconductors. Leave the flying leads until their lengths are known.

INTERWIRING AND CASE

In the prototype, the circuit board and all the remaining components are mounted on a removable panel (3mm plywood) with a section arranged to sit in a rectangular hole in the top of the case. Fig. 4 shows this panel with all the interwiring details. The circuit board is screwed onto pillars attached to the panel and lies above C2; alternatively, it could be bolted to the panel using spacers of a suitable length. Ensure that the screws used do not short adjacent tracks. Cut the shafts of VR1 and S1 to the required length, filing a flat side if necessary, before mounting these components.



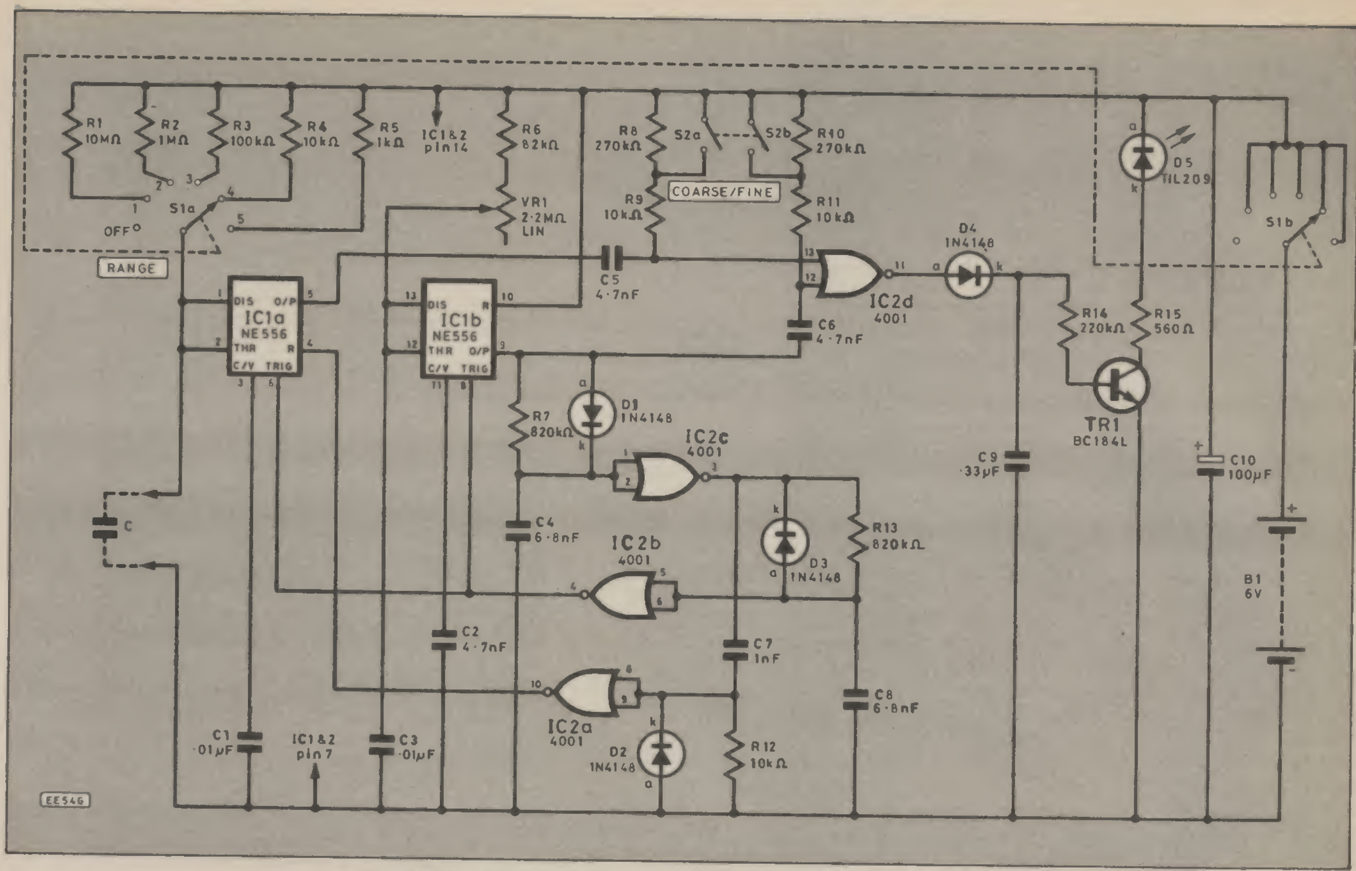


Fig. 1. Complete circuit diagram of the Capacitance Comparator.

COMPONENTS

Approx. cost
Guidance only **£9**

Resistors

R1	10MΩ
R2	1MΩ
R3	100kΩ
R4	10kΩ
R5	1kΩ
R6	82kΩ
R7,13	820kΩ (2 off)
R8,10	270kΩ (2 off)
R9,11,12	10kΩ (3 off)
R14	220kΩ
R15	560Ω

R1–5 ±1% metal film 0·4W (or ¼W)
R6–15 ±5% carbon film ¼W

Capacitors

C1,3	10nF ceramic (2 off)
C2	4·7µF ±1% polystyrene
C4,8	6·8nF ceramic (2 off)
C5,6	4·7nF ceramic (2 off)
C7	1nF ceramic
C9	33nF polyester (C280)
C10	100µF 10V electrolytic radial leads

Various close tolerance types for calibration purposes (see text)

Semiconductors

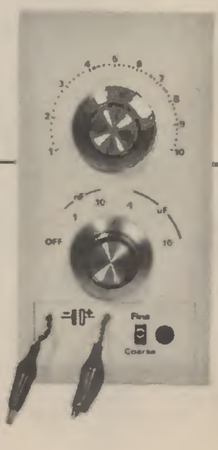
D1–4	1N4148 silicon diode (4 off)
D5	TIL209 3mm red l.e.d.
TR1	BC184L *npn* silicon
IC1	NE556 dual timer
IC2	CMOS 4001 quad 2-input NOR gate

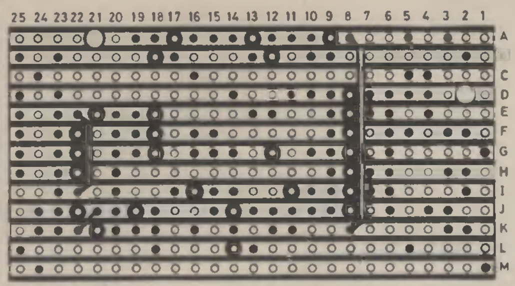
Miscellaneous

VR1	2·2MΩ linear potentiometer
S1	6-way, 2-pole rotary switch
S2	d.p.d.t. miniature slide switch
B1	HP7 1½V cells (4 off)

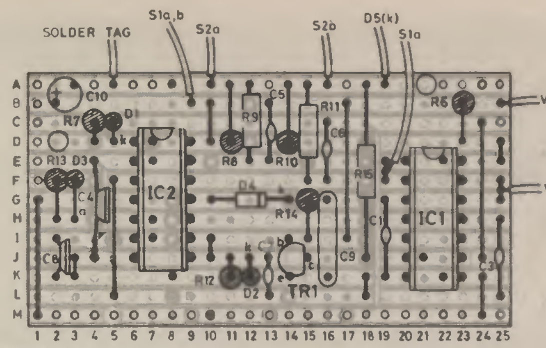
0·1in matrix stripboard, 13 strips x 25 holes; 14-pin d.i.l. holders (2 off); battery holder (4 x HP7 square) and connector; 3mm l.e.d. clip; miniature crocodile clips (1 red, 1 black); connecting wire, rigid and flexible; pointer knobs (approximately 37mm and 25mm diameter); case, minimum internal dimensions: length 142mm, width 64mm (back), 32mm (front); 6BA nut, screw (13mm), washer, solder tags (2 off); screws for slide switch.

See Shop Talk page 434





EE556A Fig. 2. Track-side of the circuit board.



EE556B Fig. 3. Component layout (actual size).

The dimensions of the case (also 3mm plywood) are given in Fig. 5. Glued butt joints are used, with short lengths of 12mm square wood strengthening the four vertical corners. These do not quite reach the bottom of the case and provide points for screwing on a base panel and rubber feet. Ensure they do not obstruct the removable component panel. The case is covered with an adhesive plastic film.

Alternatively, the case could be a suitable sized plastics box, the components being mounted on the underside of the lid with a similar layout to that shown.

Whatever case is used, complete the wiring as shown in Fig. 4, adding flying leads to the circuit board before fixing the latter and attach crocodile clips to the test leads. Screw on the removable panel (if used) using spacers as necessary and add suitable pointer knobs. The battery holder just fits in the prototype, but if found to be loose a piece of foam rubber will hold it in place.

CALIBRATION

There are two alternative methods for calibrating the comparator. The first requires a reliable resistance measuring device that can measure up to about 2MΩ. The resistance to be measured is the section of VR1 in use, that is from its wiper to R6. (Leave IC1 out of the circuit when doing this.) Points numbered 1 to 10 on the dial are given by resistances of 212766Ω and its multiples (for example, 212766Ω for "1", 425532Ω for "2", etc.) rounded to about two significant figures in practice. Further division of the scale can be estimated sufficiently accurately for this instrument. The "1" then corresponds to the lowest capacitance in the selected range and the "10" to the highest.

It could be that a multimeter is the only resistance measuring device available and the accuracy of this, particularly for the higher values, may well be questionable. The second method of calibration, although involving some expense, may be considered preferable. Using the 1μF to 10μF range (the i.c. is now inserted and the battery connected) measure the capacitances of several 1 per cent tolerance capacitors within this range and mark the dial accordingly, again estimating the intermediate values. (Remember that 1 per cent polystyrene capacitors are generally considerably less expensive than equivalent silvered mica types.) If this method of calibration is employed, a 5 per cent polystyrene capacitor will suffice for C2.

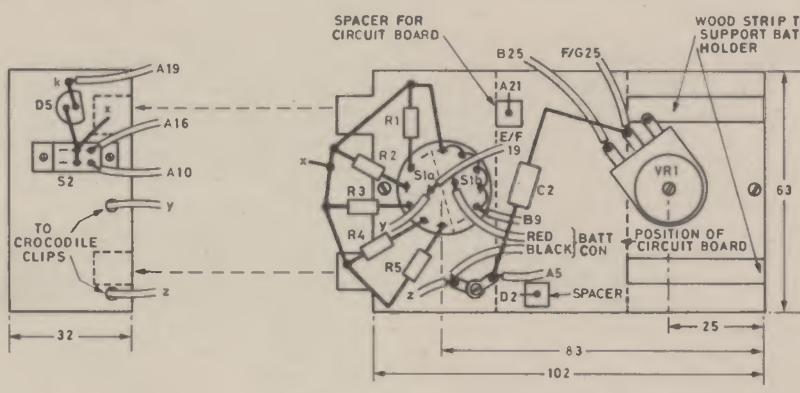


Fig. 4. Components and wiring on the "removable panel". The two sections are glued or screwed together with suitable spacers between. Identical thickness spacers are used between the panel and the case top.

RANGES

Potentiometer VR1, C2 and R1 to R5 have been chosen to produce the ranges described earlier, with continuity from one to the next. If the actual value of VR1 is well below its nominal one the top end of the scale could be lost. In this case R1 to R5 could be reduced to 82052, 8·2kΩ, etc., or C2 increased to 5·6μF.

USING THE COMPARATOR

Grip the leads of the capacitor under test in the crocodile clips observing polarity where applicable. Switch to COARSE and scan the dial on each range until the l.e.d. lights. Then switch to FINE, readjust the setting of VR1 to obtain the brightest steady light and read off the required value. Do not touch the capacitor or leads when doing this.

Some residual capacitance must be expected, but it is significant only on the lowest range. To estimate its value, measure a few close tolerance capacitors from 100pF to 1μF. The differences between these known values and the readings obtained can be averaged to give the required figure. (On the prototype it is around 20pF.) Remember to allow for this when using the lowest range; alternatively, mark a second scale on the dial.

To measure values below 100pF the scale could be extended, but a more reliable result may be obtained by first measuring the value of a capacitor of, say, about 150pF then repeating with this and the one under test in parallel. Subtraction gives the required figure, automatically cancelling the resident capacitance.

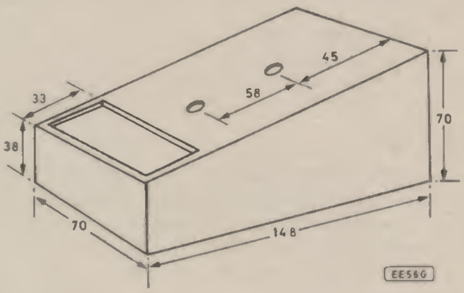


Fig. 5. Case dimensions. The circuit board stands 18mm off the panel, screwed onto pillars of wood, or bolted using spacers.

A similar method can be used for values greater than 10μF measuring a 10μF capacitor first, then this in series with the one under test. The required value can be obtained from the series connection formula.

Note that the value of R5 (top range) is below that recommended for the resistance in this position (5kHz), but no error has been detected as a result. □

SHOP TALK

BY DAVE BARRINGTON

Catalogue Received

The new 28-page **TK Electronics** catalogue contains several new items of interest. Also, it is interesting to note that not only have they put their stocks on computer but the catalogue has been produced by the same machine.

The readout or "printing" is very clear (for a printout) and easy to read, and is another example of the excellent progressive service this company runs.

Amongst new products added to their listings are a new range of telephone connectors and a collection of security accessories. These include pressure mats, door/window contact sets, window tape connectors, bell box and passive infra-red detection unit.

Copies of the TK Electronics "Yellow Catalogue" are available free from **TK Electronics, Dept EE, 11-13 Boston Road, London W7 3SJ. A** self-addressed envelope (9in x 6in) would be appreciated.

Link Up

With the sales of video recorders and home computers now running into millions, the Reeler TV extension cable from **Pullway** will undoubtedly find many applications around the home.

Apart from the common domestic application, it is a god-send for the growing band of home computer and video game users. Here a portable TV is often used as a monitor, or even the family colour set is usurped, to display programs or play games.

By using the extension lead, would-be games "masters" and budding programmers need not run the risk of headaches or blurred vision from being too close to the screen.

For the caravanner, camper and boating enthusiast the extension reel will also prove an asset where storage space is often at a premium. They can position their remote aerial for optimum reception without yards of unwieldy cable, and, after use, the cable can be rewound and stored in any convenient small space.

Moulded in tough ABS plastics, the Reeler incorporates a carrying handle with integral socket and moulded coaxial plug. It is available in two capacities of either 30 or 45 feet of standard 75-ohm coaxial cable and has a recommended selling price of £7.95, including VAT.

For details of local stockists readers should write to: **Pullway Ltd., Dept EE, Venn House, 11 Clayton Road, Hayes, Middlesex.**

Change of Name

With all the recent changes at Ambit International and their opening of new premises at Portsmouth and Broxbourne, we have just received news that the component side of their operation is now trading under the name of **Cirkit.**

The change of name coincides with an increased product line (10,000 items now stocked) and the introduction of a range of Cirkit constructional kits, graded for the student, expert and enthusiast.

They have also issued a new catalogue which covers such items as: computer connectors and printers; microprocessors and memories; voltage regulators and semiconductors. Their listings of capacitors and r.f. components is probably one of the most extensive amongst component suppliers.

Copies of the new Cirkit catalogue cost 80p and may be obtained from: **Cirkit Holdings PLC, Dept EE, Park Lane, Broxbourne, Herts.** Included with each catalogue are three £1 discount vouchers.

CONSTRUCTIONAL PROJECTS

Electronic Lock

The LS7225 "keyless" lock i.c. used in the *Electronic Lock* is a P–MOS device which performs the code sequencing. Also included, within the device but not used, is an auxiliary delay facility.

The LS7225 integrated circuit is available from TK Electronics or RS Components, Order code: 304-554. It should be pointed out that RS will NOT supply to the general public but must be ordered through a local stockist.

Most of our advertisers now stock suitable keypads for the "master" combination keyboard.

Ultrasonic Burglar Alarm

The 40kHz transducers used in the *Ultrasonic Burglar Alarm* are usually sold in pairs and can be purchased with pin or phono plug connectors. The ones required are of the pin type. These are available from: **Riscomp, Rapid, Enfield** and **Maplin.**

The warning sounder, X70 W06, is available direct from: **Avionic Systems (Heathrow) Ltd., Dept EE, Viscount Way, Hounslow, Middx TW6 2JW.** The TOKO coil, CAN1A350ER, is stocked by **Cirkit.**

Car Lights Warning

Almost any type of 12V d.c. buzzer would be suitable for the *Car Lights Warning* project.

If difficulties are experienced in locating the MCR102 thyristor for this circuit, then it would appear that the C103YY from RS would be an alternative device.

Atom EPROM Simulator

The 2K by 8 static CMOS RAM memory i.c.s used in the *Atom EPROM Simulator* are currently listed by **Rapid Electronics** and **Cirkit.**

We cannot envisage any component buying problems for the *CB Mini Power Supply* or the *Capacitance Comparator.*

ENFIELD ELECTRONICS

208 Baker Street, Enfield, Middlesex. EN1 3JY. Tel: 01-366 1873

Access | BARCLAYCARD VISA

TRANSISTORS

				BF198	14p	TIP29C	45p	2N1304	80p
				BF199	14p	TIP30A	40p	2N1305	80p
				BF200	35p	TIP30B	50p	2N1307	70p
AC125	30p	BC183C	12p	BF224B	20p	TIP30C	45p	2N1308	80p
AC126	30p	BC183L	12p	BF244B	35p	TIP31	38p	2N1613	36p
AC127	30p	BC183LB	12p	BF256	35p	TIP31A	40p	2N2222A	30p
AC128	30p	BC184	12p	BF257	35p	TIP31B	40p	2N2369A	28p
AC132	90p	BC184B	12p	BF258	35p	TIP31C	45p	2N2646	68p
AC141	30p	BC184L	12p	BF259	35p	TIP32A	40p	2N2904A/5A	30p
AC142	30p	BC186	30p	BF594	40p	TIP32C	40p	2N2906A	60p
AC176	30p	BC187	30p	BF595	30p	TIP36C	140p	2N2907A	30p
AC187	30p	BC212A	14p	BFR39	20p	TIP41A	50p	2N2926G	12p
AC188	30p	BC212L	12p	BFR79	30p	TIP41B	50p	2N2926R	12p
AD149	80p	BC213	12p	BFR80	30p	TIP42A	60p	2N2926Y	12p
AD161	45p	BC213B	12p	BFX29	30p	TIP42B	65p	2N3053	30p
AD162	45p	BC213L	12p	BFX84	30p	TIP120	80p	2N3054	75p
BC107	12p	BC214	12p	BFX85	30p	TIP121	80p	2N3055E	60p
BC107A	14p	BC214B	14p	BFX87	30p	TIP142	120p	2N3442	150p
BC107B	14p	BC214L	12p	BFX88	30p	TIP2955	70p	2N3615	200p
BC108	12p	BC237	18p	BFY50	28p	TIS43	36p	2N3702	12p
BC108A	14p	BC238B	18p	BFY51	25p	TIS44	40p	2N3703	12p
BC108B	14p	BC307	18p	BFY52	25p	TIS90	30p	2N3704	12p
BC108C	14p	BC308	14p	BFY90	80p	TIS91	30p	2N3705	12p
BC109	12p	BC327	16p	BRY39	40p	VN10KMA	75p	2N3706	12p
BC109B	14p	BC328	16p	BSX20	30p	VN66AF	95p	2N3707	12p
BC109C	14p	BC337	16p	BSX29	35p	VN88AF	110p	2N3708	12p
BC140	35p	BC338	16p	BU105	170p	ZTX107	12p	2N3710	12p
BC141	35p	BC441	36p	BU205	200p	ZTX108	12p	2N3711	12p
BC142	35p	BC461	36p	BU208A	220p	ZTX109	12p	2N3771	200p
BC143	35p	BC477	40p	MJ2955	90p	ZTX300	15p	2N3772	200p
BC147	12p	BC478	40p	MJE340	50p	ZTX301	18p	2N3773	200p
BC148	12p	BC517	45p	MJE371	90p	ZTX302	20p	2N3819	25p
BC157	12p	BC547	15p	MJE2955	110p	ZTX303	20p	2N3820	45p
BC158	12p	BC548	15p	MJE3055T	80p	ZTX304	20p	2N3823	50p
BC159	12p	BC549	16p	MPSA06	25p	ZTX330	35p	2N3866	100p
BC160	50p	BC556	20p	MPSA56	30p	ZTX500	18p	2N3903	15p
BC161	45p	BC557	16p	MPSU05	65p	ZTX501	18p	2N3904	15p
BC167	15p	BC558	16p	MPSU56	60p	ZTX502	18p	2N3905	15p
BC168	12p	BC559	16p	OC22	150p	ZTX503	18p	2N3906	15p
BC169	12p	BCY70	20p	OC23	150p	ZTX504	30p	2N5172	30p
BC170	20p	BCY71	20p	OC26	100p	ZTX531	30p	2N5194	80p
BC171	13p	BCY72	23p	OC28	200p	ZTX550	30p	2N5457	42p
BC172A	12p	BD131	50p	OC36	220p	2N696	35p	2N5458	48p
BC173	13p	BD132	50p	OC41	75p	2N698	45p	3N128	85p
BC177	20p	BD133	60p	OC42	75p	2N699	40p	3N140	85p
BC178	20p	BD135	50p	OC70	60p	2N706A	26p	3N141	85p
BC179	25p	BD136	40p	OC76	60p	2N708	30p	3N163	110p
BC181	23p	BD137	40p	OC81	60p	2N914	36p	3N201	110p
BC182	12p	BD138	40p	OC82	60p	2N918	30p	3N202	125p
BC182B	14p	BD139	45p	OC84	50p	2N930	30p	40406	80p
BC182L	12p	BD140	45p	TIP29	30p	2N1131	30p	40407	80p
BC183	12p	BF194	14p	TIP29A	35p	2N1132	30p		
BC183B	12p	BF195	14p	TIP29B	50p	2N1303	80p		

TTL

		7417	28p	7447	75p	7486	35p	74119	70p	74160	65p	74190	58p
		7420	20p	7448	55p	7489	140p	74121	35p	74161	55p	74191	55p
		7422	28p	7450	21p	7490	37p	74122	41p	74162	46p	74192	55p
7400	18p	7425	28p	7451	20p	7491	45p	74123	41p	74163	46p	74193	55p
7401	18p	7426	28p	4753	21p	7492	40p	74126	70p	74164	46p	74194	52p
7402	18p	7427	30p	7454	21p	7493	41p	74132	65p	74165	60p	74195	52p
7403	18p	7428	30p	7460	21p	7494	41p	74135	50p	74166	60p	74196	55p
7404	18p	7430	26p	7470	25p	7495	41p	74141	51p	74167	185p	74197	55p
7405	18p	7432	26p	7472	25p	7496	41p	74144	250p	74170	195p	74198	95p
7406	32p	7433	35p	7473	30p	7497	60p	74145	575p	74173	120p	74199	95p
7407	32p	7437	30p	7474	35p	74100	95p	74147	125p	74174	65p	74221	60p
7408	25p	7438	30p	7475	40p	74104	58p	74148	65p	74175	65p	74279	60p
7409	25p	7440	23p	7476	35p	74105	58p	74150	70p	74176	46p	74284	95p
7410	18p	7441	51p	7480	30p	74107	30p	74151	46p	74177	55p	74285	95p
7411	25p	7442	40p	7481	110p	74109	30p	74153	46p	74180	50p	74366	64p
7412	26p	7443	71p	7482	70p	74110	41p	74154	81p	74181	121p	74390	325p
7413	26p	7444	95p	7483	58p	74111	70p	74155	46p	74182	70p	74393	100p
7414	37p	7445	71p	7484	81p	74116	70p	74156	46p	74184	105p		
7416	28p	7446	71p	7485	75p	74118	65p	74157	35p	74185	105p		

LS TTL

		74LS27	40p	74LS83	85p	74LS138	165p	74LS169	90p	74LS243	80p	74LS293	55p
		74LS28	20p	74LS85	60p	74LS139	80p	74LS170	85p	74LS244	140p	74LS353	90p
74LS00	40p	74LS30	40p	74LS86	65p	74LS147	135p	74LS173	80p	74LS245	180p	74LS362	110p
74LS01	40p	74LS32	50p	74LS90	35p	74LS148	160p	74LS174	120p	74LS247	80p	74LS365	80p
74LS02	35p	74LS33	22p	74LS93	30p	74LS151	60p	74LS175	65p	74LS248	80p	74LS366	50p
74LS04	60p	74LS37	50p	74LS95	56p	74LS153	55p	74LS181	130p	74LS249	80p	74LS367	95p
74LS05	36p	74LS38	47p	74LS96	125p	74LS154	220p	74LS183	195p	74LS251	45p	74LS368	150p
74LS08	60p	74LS40	35p	74LS107	52p	74LS155	80p	74LS190	75p	74LS253	45p	74LS373	80p
74LS09	21p	74LS42	65p	74LS109	36p	74LS156	75p	74LS191	75p	74LS257	85p	74LS374	80p
74LS10	20p	74LS49	22p	74LS112	32p	74LS157	140p	74LS192	75p	74LS258	50p	74LS375	70p
74LS11	45p	74LS51	22p	74LS113	36p	74LS158	95p	74LS193	50p	74LS259	80p	74LS386	244p
74LS12	36p	74LS54	21p	74LS114	32p	74LS160	45p	74LS194	50p	74LS260	45p	74LS390	80p
74LS13	25p	74LS55	150p	74LS122	45p	74LS161	50p	74LS195	50p	74LS266	55p	74LS393	150p
74LS14	160p	74LS63	60p	74LS123	160p	74LS162	50p	74LS196	65p	74LS273	160p	74LS395	98p
74LS15	20p	74LS73	65p	74LS124	125p	74LS163	50p	74LS197	65p	74LS275	160p	74LS398	170p
74LS20	30p	74LS74	30p	74LS125	95p	74LS164	75p	74LS221	130p	74LS279	55p	74LS541	130p
74LS21	20p	74LS75	30p	74LS126	35p	74LS165	130p	74LS240	110p	74LS280	140p	74LS629	200p
74LS22	20p	74LS76	30p	74LS132	100p	74LS166	150p	74LS241	160p	74LS283	70p	74LS669	160p
74LS26	20p	74LS78	25p	74LS136	35p	74LS168	200p	74LS242	50p	74LS290	55p	74LS670	120p

CMOS

		CD4015	46p	CD4035	55p	CD4054	100p	CD4093	40p	CD4503	46p	CD4569	80p
		CD4016	30p	CD4038	125p	CD4060	80p	CD4099	140p	CD4511	52p	CD4572	80p
		CD4017	40p	CD4040	50p	CD4066	30p	CD4160	75p	CD4512	60p	CD4581	80p
CD4000	15p	CD4018	52p	CD4041	50p	CD4068	20p	CD4161	75p	CD4514	140p	CD4582	80p
CD4001	15p	CD4019	30p	CD4042	45p	CD4069	20p	CD4162	75p	CD4515	200p	CD4583	60p
CD4002	15p	CD4020	52p	CD4043	46p	CD4070	16p	CD4163	75p	CD4516	65p	CD4584	60p
CD4006	60p	CD4021	46p	CD4044	46p	CD4071	18p	CD4175	75p	CD4518	52p	CD4585	110p
CD4007	16p	CD4022	46p	CD4045	120p	CD4072	18p	CD4402	75p	CD4520	60p	CD40100	200p
CD4008	45p	CD4023	20p	CD4046	55p	CD4075	25p	CD4412	75p	CD4528	81p	CD40106	80p
CD4009	30p	CD4024	40p	CD4047	46p	CD4076	60p	CD4419	75p	CD4538	100p	CD40109	100p
CD4010	35p	CD4025	18p	CD4048	45p	CD4077	30p	CD4445	75p	CD4539	78p	CD40114	200p
CD4011	15p	CD4026	100p	CD4049	30p	CD4078	25p	CD4446	75p	CD4541	100p	CD40174	80p
CD4012	20p	CD4027	25p	CD4050	30p	CD4081	25p	CD4449	75p	CD4555	60p		
CD4013	25p	CD4028	45p	CD4052	70p	CD4082	25p	CD4501	35p	CD4561	110p		
CD4014	55p	CD4029	55p	CD4053	60p	CD4085	72p	CD4502	70p	CD4568	80p		

LINEAR

		CA3090	415p	LM339	80p	LM3911	140p	SAA5020		TDA1008	347p	TL074	117p
		CA3130	105p	LM348	90p	LM3914	285p	SN76013N	295p	TDA1022	570p	TL081	40p
CA1310E	185p	CA3140	52p	LM358	62p	LM3915	285p	TAA621A	290p	TDA1024	120p	TL082	65p
CA1350E	90p	CA3240	125p	LM380	85p	LM3916	285p	TAA661B	175p	TDA2002	150p	TL083	92p
CA3020	230p	ICM7555	105p	LM381	170p	MC1458	70p	TBA120B	70p	TDA2003	345p	TL084	65p
CA3028	110p	ICM7556	200p	LM382	130p	MC1488	80p	TBA120S	68p	TDA2020	350p	UA748	40p
CA3035	270p	LF347	200p	LM384	160p	MC1489	90p	TBA120U	98p	TDA2030	340p	ZN414	95p
CA3043	305p	LF351N	55p	LM386	100p	NE555	20p	TBA540Q	161p	TDA2102		ZN424	150p
CA3055	85p	LF353N	100p	LM387	140p	NE556	55p	TBA651		TDA2522		ZN425	400p
CA3065	150p	LM224	150p	LM389	110p	NE564	405p	TBA800		TDA9400		ZN426	345p
CA3080	80p	LM301	30p	LM732	55p	NE566	173p	TBA810S	110p	TL061	50p	ZN427	715p
CA3081	225p	LM308	100p	LM747	75p	NE567	161p	TBA820	81p	TL062	75p	ZN1034	230p
CA3085	145p	LM311N	81p	LM1458	45p	NE570	391p	TBA920Q	175p	TL064	150p	ZN1040	750p
CA3086	65p	LM318N		LM3900	70p	NE571	387p	TCA270S	171p	TL071	50p		
CA3089	230p	LM324	50p	LM3909	92p	SAA5010		TDA1004	345p	TL072	60p		

RIBBON CABLE

(Priced per ft)

WAYS	COLOUR
10	26p
20	53p
26	76p
34	100p

DIODES

		OA200	9p	1N5060	18p
AA119	15p	OA202	9p	1N5062	20p
AA215	16p	1N823	5p	1N5400	11p
BAX13	10p	1N914	5p	1N5401	12p
BY100	30p	1N916	6p	1N5402	14p
BY127	18p	1N4000	5p	1N5403	15p
BY133	20p	1N4001	5p	1N5404	16p
BY206	30p	1N4002	5p	1N5405	17p
BY207	30p	1N4003	6p	1N5406	18p
BY299	40p	1N4004	6p	1N5407	22p
BYX10	18p	1N4005	7p	1N5408	25p
OA47	10p	1N4006	7p	1S44	5p
OA90	8p	1N4007	8p	1S921	7p
OA91	8p	1N4148	5p	1S922	7p
OA95	8p	1N4448	6p	1S923	7p

D CONNECTORS

	MALE	FEMALE
9 way	75p	100p
15 way	100p	1140
25 way	140p	195p

D-CONNECTOR COVERS

9 way	110
15 way	110
25 way	125

I.C. SOCKETS

LOW PROFILE D.I.L Type	Price	TURNED PIN D.I.L. Type	Price
8 pin	10p	8 pin	35p
14 pin	12p	14 pin	50p
16 pin	14p	16 pin	60p
18 pin	18p	18 pin	65p
20 pin	24p	22 pin	75p
22 pin	25p	24 pin	80p
24 pin	30p	28 pin	100p
28 pin	32p	40 pin	150p
40 pin	35p		

RECHARGEABLE BATTERIES

HP2, 1.2v, 4.0AH	£3.95
HP2, 1.2v, 1.2AH	£2.60
HP11, 1.2v, 1.2AH	£2.40
HP7, 1.25v, 500mAH	£1.00
AAA, 1.2v, 180mAH	30p
PP3, 8.4v, 110mAH	£4.50

ZENER DIODES

BZX61C/1.4 watt: 3V3, 3V6, 3V9, 4V7, 5V6, 6V2, 7V5, 8V2, 10V, 11V, 12V, 13V, 15V, 18V, 20V, 22V, 24V, 27V, 30V, 33V, 36V, 39V, 43V, 47V, 56V, 68V, 75V, 82V, 100V, 180V, 200V 16p each

BZY88C/0.4 watt: 1V3, 2V7, 3V, 3V3, 3V6, 3V9, 4V3, 4V7, 5V1, 5V6, 6V2, 7V5, 8V2, 9V1, 10V, 11V, 12V, 13V, 15V, 16V, 18V, 22V, 24V, 27V, 30V, 33V, 36V 10p each

LEDs

5mm:	Red	10p	113:	Red	
	Green	13p		Red	20p
	Yellow	13p		Green	25p
3mm:	Red	10p		Yellow	25p
	Green	13p	323	Tri.	
	Yellow	13p		Red	20p
CQX21:	Red flashing	65p		Green	25p
251:	Rect/stack			Yellow	25p
	Red	20p	503:	Square	
	Green	25p		Red	20p
	Yellow	25p		Green	25p
				Yellow	25p

REGULATORS

LM304H	180p	UA723C	77p	78H12 (3A/5V)	
LM309H	80p	7805A	50p		460p
LM309K	130p	7812A	50p	78L05	35p
LM317K	350p	7812Kc	121p	78L12	35p
LM317T	130p	7815A	50p	78L15	35p
LM320/5	65p	7818A	50p	78L18	35p
LM320/12	65p	7824A	50p	78L24	35p
LM320/15	65p	7905A	55p	78L62	35p
LM320/24	65p	7912A	55p	79L05	45p
LM337T	180p	7915A	55p	79L12	45p
LM1469	324p	7918A	55p	79L15	45p
UA78P (8A/5V)	450p	7924A	55p	79L18	45p
				79L24	45p

ALUMINIUM BOXES

3 1/16" × 19 3/8" × 9 3/8"	
80 × 50 × 25	80p
100 × 65 × 50	1.20
100 × 70 × 40	1.20
100 × 100 × 40	1.20
135 × 70 × 40	1.20
135 × 105 × 40	1.40
180 × 125 × 65	1.95
205 × 155 × 75	2.50

VERO PLASTIC BOXES

White 71 × 49 × 25	60p
Blk 71 × 49 × 25	60p
Blk 120 × 80 × 35	1.10
Blk 180 × 110 × 55	1.75

VERO BOARDS

127 × 63	1.10
95 × 63	95p
431 × 63	3.17
127 × 95	1.20
95 × 95	1.15
431 × 95	4.20
454 × 119	5.50
63 × 25	pk of 5 1.30

THYRISTORS

				600mA/200V	45p	5A/400V	60p
				1A/50V	40p	5A/600V	70p
BT101	104p	T05 1A/400V	104p	1A/100V	45p	5A/800V	80p
BT102	104p	2N1599	40p	1A/200V	50p	7A/100V	55p
BT106	104p	2N4441	170p	1A/400V	60p	7A/200V	60p
BT107	132p	2N4444	150p	1A/600V	75p	7A/400V	70p
BT108	143p	2N5060	36p	1A/800V	90p	7A/600V	80p
TIC44	20p	2N5061	33p	3A/50V	46p	7A/800V	90p
TIC106D	40p	2N5062	42p	3A/100V	53p	10A/50V	55p
TIC106M	77p	2N5063	47p	3A/200V	58p	10A/100V	60p
TIC126D	99p	2N5064	47p	3A/400V	71p	10A/200V	65p
TIC206D	80p	600mA/20V	21p	3A/600V	79p	10A/400V	70p
TIC226D	90p	600mA/30V	24p	3A/800V	99p	10A/600V	88p
TIC246D	130p	600mA/100V	30p	5A/50V	43p	10A/800V	115p

TRIACS

2A/200V	50p
2A/400V	60p
2A/600V	60p
4A/400V	60p
6A/100V	80p
6A/200V	80p
6A/400V	90p
8A/400V	80p
10A/100V	80p
10A/200V	100p
10A/400V	110p
10A/400P	100p

BRIDGE RECTIFIERS

1A/50V	30p	6A/50V	75p
1A100V	30p	6A/100V	75p
1A/200V	35p	6A/200V	80p
1A/400V	40p	6A/400V	100p
2A/50V	35p	10A/200V	200p
2A/100V	45p	10A/400V	200p
2A/200V	50p	25A/200V	250p
2A/400V	55p	25A/400V	300p

Dalo Etch resist £1.10

SOLDER

20 swg. 3 core

500g 495p

POTENTIOMETERS

Carbon track, ¼ watt log & linear values:

Range	Price
470R-2.2MR (single track)	40p
4.7K-2.2MR (dual gang)	100p
4.7K-2.2MR (single gang D/P switch)	90p

SLIDER POTS

60mm track, log & linear values:

Range	Price
5K-500K	80p

PRESETS

Pre-set pots ¼ watt

Range	Price
50R-4.7MR (mini vert. & horiz.)	10p

RESISTORS

High stability, ¼ watt, 5%

Range	Price (1-99)	(100+)
1R-10MR	2p	1p

High stability, ½ watt, 5%

Range	Price (1-99)	(100+)
1R-10MR	3p	1.5p

CAPACITORS

CERAMIC 1pF, 2p2, 2p7, 3p3, 3p9, 4p7, 5p6, 6p8, 8p2, 10pF, 12pF, 15pF, 18pF, 22pF, 27pF, 33pF, 39pF, 47pF, 56pF, 68pF, 82pF, 100pF, 120pF, 150pF, 180pF, 220pF, 270pF, 330pF, 470pF, 560pF, 680pF, 820pF, 1000pF, 1n5, 1n8, 2n2, 3n3, 3n9, 4n7, 5n6, 6n8, 8n2, 10nF, 22nF, 47nF, 100nF 6p each

MYLAR: 100V 1nF, 2n2, 3n3, 4n7, 6n8, 10nF 7p each. 15nF, 22nF, 33nF, 47nF 9p each. 68nF, 100nF 11p each. 220nF 15p. 330nF 18p. 470nF 20p.

POLYSTYRENE 22pF, 47pF, 68pF, 82pF, 100pF, 120pF, 150pF, 220pF, 270pF, 330pF, 390pF, 470pF, 680pF, 820pF, 1000pF, 1200pF, 1500pF, 1800pF, 2000pF, 2200pF, 3300pF, 4700pF, 5600pF, 10nF 8p each

TANTALUM BEAD 3V: 100uF, 150uF, 220uF, 330uF 64p each. 470uF 110p. 680uF 160p. 6V3: 6u8, 12p. 10uF 13p. 33uF 33p. 47uF 25p. 100uF, 220uF 77p each. 470uF 160p. 10V: 15uF, 22uF 20p each. 33uF 33p. 47uF 40p. 68uF 63p. 220uF 110p. 16V: 2u2, 3u3 20p each. 4u7, 6u8 25p each. 10uF 32p. 22uF 35p. 16V: 33uF 40p. 47uF 60p. 100uF 95p. 220uF 105p. 25V: 15uF, 22uF 40p each. 47uF, 68uF 60p. 35V: 0.1uF, 0.22uF, 0.47uF 16p each. 1uF, 1u5 18p each. 2u2 25p. 3u3, 4u7 20p each. 6u8 30p. 10uF 40p. 47uF 60p.

ELECTROLYTIC Axial or Radial 16V: 10uF, 22uF, 33uF 10p each. 47uF, 68uF, 100uF 12p each. 125uF, 220uF 14p each. 330uF 18p. 470uF 24p. 680uF 36p. 1000uF 30p. 1500uF 40p. 2200uF 50p. 25V: 1uF, 10uF, 22uF, 47uF 10p each. 100uF 12p. 220uF 20p. 470uF 30p. 1000uF 40p. 2200uF 55p. 4700uF 115p. 35V: 120uF, 250uF 20p each. 40V: 6u8 10p. 470uF 30p. 1000uF 45p. 50V: 0.47uF, 1uF 8p each. 1uF (small) 12p. 220uF 35p. 63V: 1uF, 2u2, 4u7 7p each. 10uF, 22uF 10 each. 47uF 12p. 100uF 20p. 220uF 30p. 100V: 4.7F 48p. 160V: 10MF 32p. 250V: 0.01uF, 0.047uF, 0.1uF 10p each. 0.22uF 11p. 0.47uF 12p. 1uF 18p. 2u2 26p. 10uF 23p. 1000uF 35p. 400V: 0.47uF 35p. 600V: 0.022uF, 0.047uF 30p each. 0.22uF, 67p. 1000V: 0.0022uF 27p. 0.022uF, 0.1uF 39p each.

POLYESTER C280 250V .01, .022, .033, .068, .1 8p. .15, .22, .33 10p. .47 12p. .68 20p. 1uF 26p. 2.2 50p.

SILVERED MICA 2p2, 3p3, 5pF, 10pF, 18pF, 20pF, 22pF, 25pF, 27pF 13p each. 30pF, 33pF, 39pF, 47pF, 50pF, 56pF, 68pF, 75pF, 82pF, 100pF, 120pF, 150pF, 180pF, 200pF, 220pF, 250pF, 270pF, 300pF 15p each. 330pF, 390pF, 470pF 19p each. 500pF, 560pF, 680pF 22p each. 820pF 24p. 1000pF 27p. 1500pF 32p. 1800pF 42p. 2200pF 45p. 2700pF 48p. 3600pF 55p. 3900pF 68p. 4700pF 83p. 5000pF 98p. 6800pF 115p. 8200pF 120p. 10000pF 125p.

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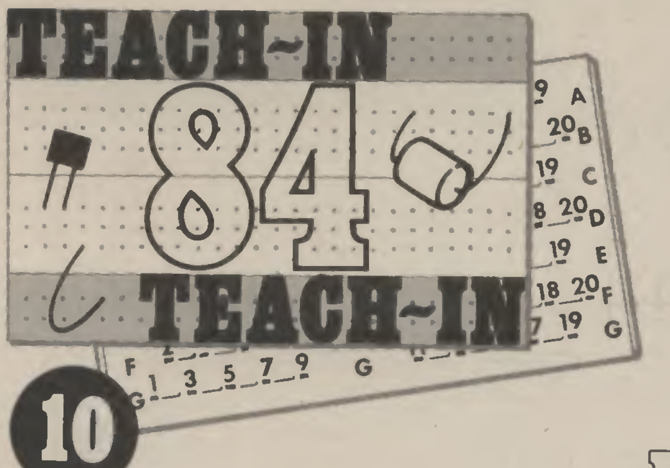


A TWELVE-PART HOME STUDY COURSE IN THE PRINCIPLES AND PRACTICE OF ELECTRONIC CIRCUITS. ESSENTIALLY PRACTICAL, EACH PART INCLUDES EXPERIMENTS TO DEMONSTRATE AND PROVE THE THEORY.
USE OF A PROPRIETARY BREADBOARD ELIMINATES NEED FOR SOLDERING AND MAKES ASSEMBLY OF CIRCUITS SIMPLE.
THE IDEAL INTRODUCTION TO THE SUBJECT FOR NEWCOMERS. ALSO A USEFUL REFRESHER COURSE FOR OTHERS.

By GEORGE HYLTON

DIGITAL CIRCUITS

THIS month we look at a few digital circuits and indulge in a bit of philosophy on the art of designing things.

As I explained earlier, it's not the intention of this series to go into logic circuits as such. That's well covered in other articles. All the same, some of the digital integrated circuits developed for computing and similar uses can quite easily be adapted for use in analogue or linear circuits.

EXPERIMENT 10.1

COMPLEMENTARY INVERTER

Let's start by building a simple circuit which illustrates some aspects of digital electronics. In Fig. 10.1, two bipolar transistors TR1 and TR2, one *pnp* and the other *npn*, are connected "back to back" across the power supply. Circuits in which devices of opposite polarity work together like this are called "complementary" circuits.

The component layout is given in Fig. 10.2.

With S1 in position 2, bias current flows out of the base of TR1 (the *pnp* transistor) through R1 and R2 and into the base of TR2. Both transistors therefore have the same bias current and both are turned on.

What voltage does the meter read? In an ideal world, with identical transistors, the circuit would be perfectly symmetrical and the collectors would sit at just half Vcc. In the real world, one transistor has a higher gain and the output voltage is driven as far positive or as far negative as it can go. The meter reads either HIGH (nearly 9V) or LOW (nearly zero).

Moving S1 changes the situation. In position 3, TR1 is turned on harder and the output must go HIGH. In position 1, TR2 is turned on and the output is LOW.

If you connect a pair of l.e.d.s as shown and switch S1 back and forth they light alternately.

Note that the output goes low when the input is high and vice-versa. This reversal of the input signal is called inversion and the circuit is an inverter. Its symbol is an "amplifier" triangle with a small circle at the apex. (As with op-amps, the supply voltages are usually omitted from the diagram.)

Inverters are common building bricks for more complex circuits. They exist in integrated circuit form in all the common "families" of digital i.c.s.

Some of these families (TTL, ECL, and so on) are designed round bipolar transistors; others (CMOS, NMOS) round field-effect transistors. It so happens that CMOS (pronounced like "sea moss") lends itself well to the sort of uses we are concerned with, so let's take a look at a CMOS inverter (Fig. 10.3).

CMOS INVERTERS

It could hardly be simpler. TR1 and TR2 are field-effect transistors, of opposite polarity. They are connected like TR1 and TR2 in Fig. 10.1, except that no biasing resistances are needed. Each transistor acts as a "load" for the other.

Note that in Fig. 10.3 TR1 and TR2 are drawn as discrete f.e.t.s, that is, with enclosing circles. This is to help identification and comparison of these devices with the ordinary transistor symbol. In

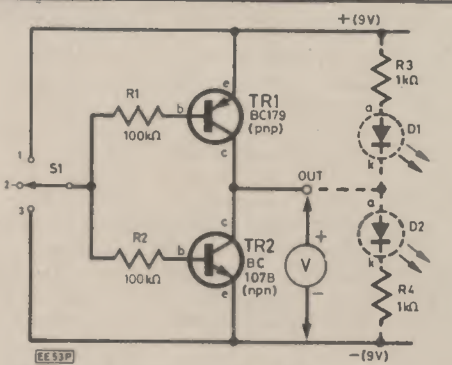


Fig. 10.1. Circuit to illustrate inverter action, with two transistors, one *pnp* and one *npn*, connected "back-to-back" as a complementary pair.

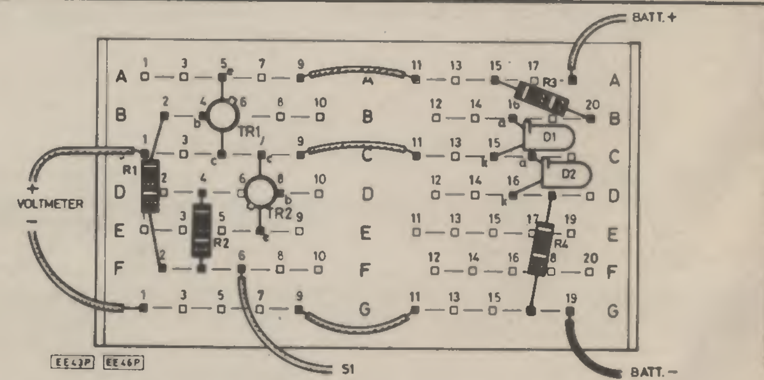


Fig. 10.2. Layout for Fig.10.1 using EBBO discrete module. Note that the layout shows the final circuit: the l.e.d.s and the link between points C9 and C11 are not needed for the first experiment.

actual fact we shall be using f.e.t. transistors that are elements within an integrated circuit, and such elements are normally drawn without any enclosing circle. The pin numbers given in Fig. 10.3 relate to the i.c. type 4069UB.

The three electrodes of a field-effect transistor (f.e.t.) have different names from those of bipolar transistors:

The SOURCE (s) of a f.e.t. corresponds to the EMITTER.

The GATE (g) corresponds to the BASE.

The DRAIN (d) corresponds to the COLLECTOR.

There is another connection, to what's called the substrate, but this is usually connected internally to the source and you don't have to worry about it.

F.e.t.s are controlled by applying voltages to their gates. No gate current flows, so the f.e.t. has virtually infinite input resistance.

The two polarities of f.e.t. are:

n-channel, corresponding to *npn*, requiring a positive drain voltage.

p-channel, corresponding to *pnp* and requiring a negative drain voltage.

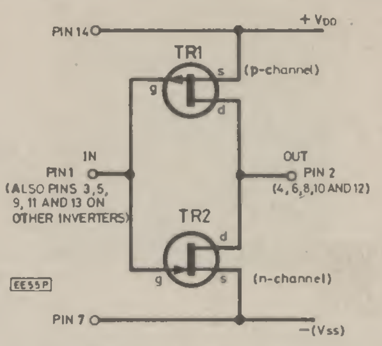


Fig. 10.3. CMOS inverter as contained in the 4069UB i.c. (Numbers refer to 4069 pins.)

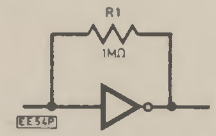


Fig. 10.4. Biasing a CMOS inverter for use as an amplifier.

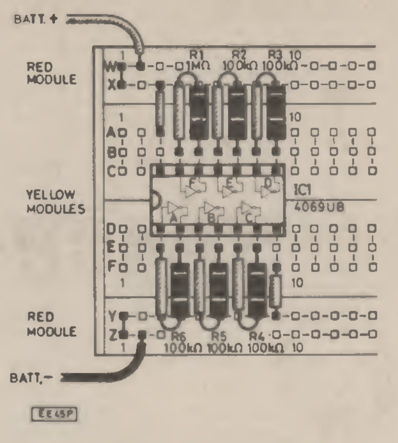


Fig. 10.5. EBBO i.c. layout for biasing experiment. The positions of the six inverters are shown on IC1 outline.

BIASING F.E.T.S

Biasing the kind of f.e.t.s used in CMOS is similar to biasing bipolars. To turn on a f.e.t. its gate-source bias (V_{GS}) must have the same polarity as its drain-source voltage (V_{DS}). So for an *n*-channel f.e.t., V_{GS} is positive and for a *p*-channel f.e.t. V_{GS} is negative.

F.e.t.s which require this kind of bias to turn them on are called enhancement-mode f.e.t.s.

There are other kinds, including depletion-mode f.e.t.s, which turn on without any bias; that means gate and source are at the same voltage. Indeed, they usually need a reverse bias to keep their drain current down to a safe value. We shan't use any depletion-mode f.e.t.s but you may well come across them as discrete transistors in radio and TV receivers and audio amplifiers.

In a CMOS inverter when the input goes high the output goes low and vice-versa. In digital electronics inverters are driven from high to low with no intermediate states. The output is always either close to V_{DD} or close to V_{SS} as the power supply rails are called.

INVERTERS AS AMPLIFIERS

For our purposes it's more useful to turn each f.e.t. half-way on. They then cooperate to act as a single-stage push-pull voltage amplifier. To arrange this, all you need do is connect a resistance from output to input (Fig. 10.4). The output voltage then adjusts itself to roughly half the supply voltage. Since there is no current through the added resistance the voltage at the input is the same as at the output.

SAFETY PRECAUTIONS

The f.e.t.s in CMOS (called MOSFETS, where MOS stands for metal-oxide-silicon) can be destroyed by static electricity of the kind that builds up on one's clothing in dry weather. To avoid discharging yourself through a CMOS i.c., follow this safety rule: Before handling the i.c. or working on a circuit which incorporates it, touch the table-top or the "earth" line Vss.

HEX INVERTER

You can buy a CMOS i.c. which contains six inverters, like the one in Fig. 10.3, for a few tens of pence. It's the hextuple ("hex") inverter type 4069. Letters may be added; for example, HEF4069UB. The "front" letters are the manufacturer's code. "UB" at the end (or sometimes "A") means that the circuit is "unbuffered". This means that the inverter is not followed, inside the i.c., by an extra amplifier.

Many CMOS circuits are buffered (B). This means that there is a buffer amplifier to prevent the inverter from being affected much by its load. A buffered CMOS inverter has three circuits like Fig. 10.3 in each of its six inverters. Three stages are needed because two would invert twice and turn the inverter into a non-inverter. The third inverts again and restores the status quo.

Don't try to use buffered CMOS for your experiments. Because of its very high gain it has a habit of oscillating instead of amplifying.

EXPERIMENT 10.2

SETTING UP

Use two yellow EBBO modules, sandwiched between two red ones (Fig. 10.5). Put a blue (discrete component) module beneath these. The red modules are terminal strips, each with two rows. Connect the two rows of the upper strip together and use it as the positive (+9V) supply rail. Similarly, connect the rows of the lower strip for use as the negative (Vss) rail.

It would be convenient to begin circuit assembly by inserting the 4069UB i.c. into the board to act as a marker for the connections. But this would increase the risk of static damage while you are setting up.

Instead, insert an i.c. holder (14-pin d.i.l. holder). The empty holder then becomes the marker and you put the i.c. itself in the holder when everything else has been completed.

Connect the negative supply line Vss before you start. This is very important when mains power units are used in place of a battery; the rule for connecting the "earthy" or common line is: first in, last out. Working on an "unearthed" circuit can allow mains leakage currents to flow through f.e.t.s and damage them.

Connect a 100μF, 25V capacitor between positive and negative rails (use the spare holes on the battery holder). This reduces stray a.c. voltages which might creep from one part of the circuit to another via the power supply, with upsetting results.

First connections to the i.c. socket are battery negative (–) to pin 7 and positive (+) to pin 14. Now connect the output of each inverter back to its input via a resistor (Fig. 10.4).

You'll probably find it convenient to bend the resistors into "hairpins" and cut off part of one lead to match the bent one. Short direct connections, when needed, can be made with bare wire, but you don't need any at the moment.

"Earth" yourself to the negative line, insert the 4069UB and connect the battery. Measure the voltage at each output; that is, pins 2, 4, 6, 8, 10 and 12. All should be within about 1V of 4·5V, demonstrating that the added d.c. feedback resistors have had the desired effect of setting the outputs near the half-supply-voltage mark. (In my case they were all 5V, but individual i.c.s vary.)

If you run into trouble, switch off, check all connections, make sure the i.c. is plugged in the right way round and that each pin is really in. (It's quite easy to bend back a pin on the i.c. or the holder by accident. Check.)

It's unlikely that a hex inverter will fail on all six amplifiers, but if one happens to develop an internal short between V_{DD} and V_{SS} it will remove battery voltage from the rest. If all connections are correct but you still have problems try a different 4069UB.

EXPERIMENT 10.3

OSCILLATORS

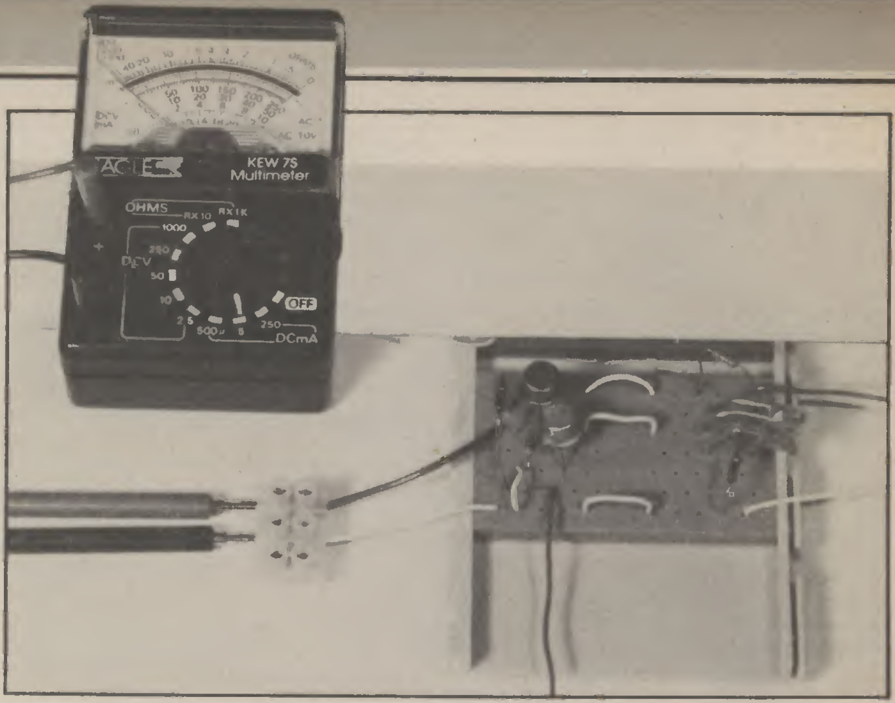
We'll now turn the amplifiers labelled F and E on Fig. 10.5 into a square-wave oscillator (Fig. 10.6a). This generates a low frequency (about 6Hz), audible as clicking in your crystal earphone. (Connect the earphone between any point and the negative rail.)

Next we'll use amplifier D as a buffer (Fig. 10.6b). If R2 = R3 the gain is very nearly 1. With this kind of feedback the signal voltage at amplifier D input is very much reduced, as you can check with your earphone: compare volumes at pins 9 and 8.

EXPERIMENT 10.4

SINE-WAVE OSCILLATOR

Our next step is more ambitious. It will call for more connecting points than the EBBO i.c. module can conveniently provide. So we'll off-load the extra connections on to the "discrete" module, Fig. 10.8. Your circuit is Fig. 10.7. This is a sine-wave oscillator and buffer. To get a



good sinewave, VR1 is set so that the circuit just oscillates steadily. The frequency is about 1·6kHz.

EXPERIMENT 10.5

GATES

Now we'll make the two frequencies interact. To do this we'll use another standard digital circuit, a "gate". A CMOS gate is a sort of switch which is opened or shut by applying a large voltage (for example, the full battery voltage) to its control terminal.

The gate we'll use is part of a 4001UB integrated circuit. Its symbol (Fig. 10.9) shows two inputs (1, 2) and one output (3). The little circle at the apex indicates that it's an inverting gate. That is, its output goes low when its input is high. Which input? In this case, either.

The 4001 contains four such gates. Their outputs go high if neither input 1 or input 2 is high. So this type of gate is

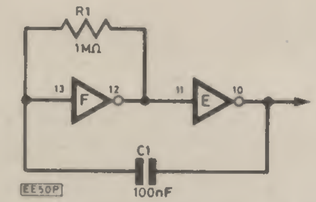


Fig. 10.6(a). Square-wave oscillator made from two inverters ("F" and "E") of a 4069 (IC1). Frequency about 6Hz.

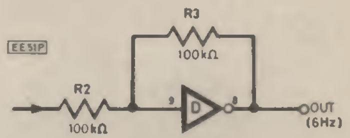


Fig. 10.6(b). Unity gain buffer amplifier (inverter "D").

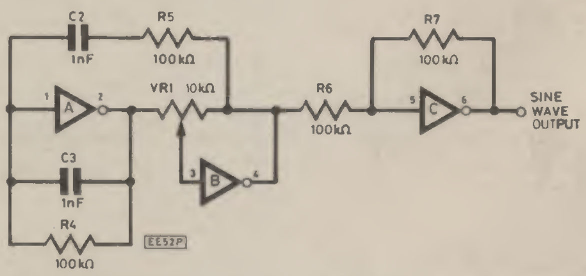


Fig. 10.7. Sine-wave oscillator using two inverters ("A" and "B") followed by unity-gain buffer "C". VR1 sets the amplitude, which is greatest when the spindle is turned fully anti-clockwise.

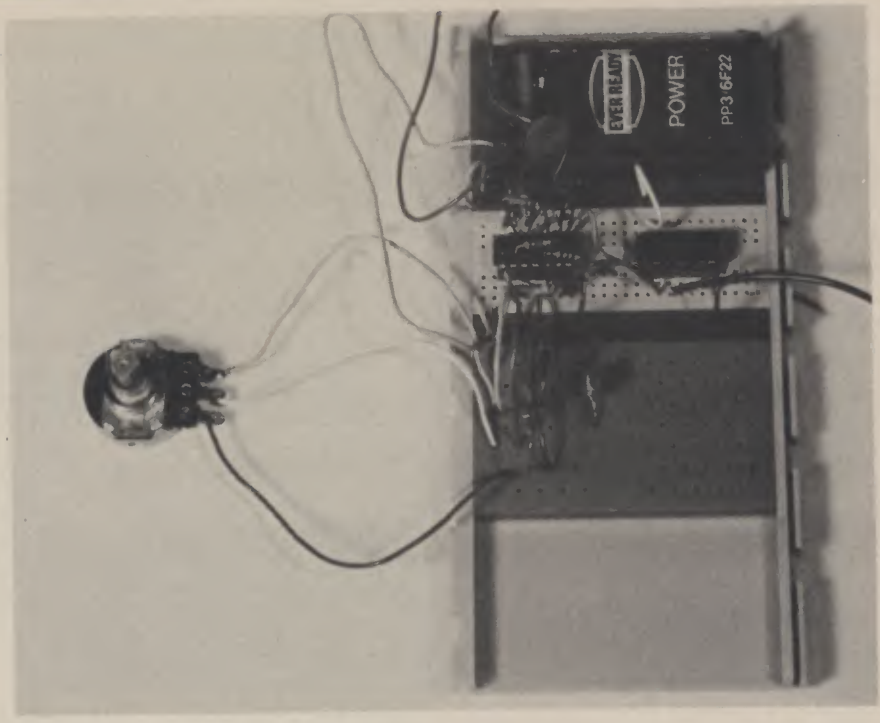
called a NOR gate, and in this case it's a 2-input NOR Gate.

Insert the 4001UB integrated circuit (IC2) onto the yellow module, to the right of IC1. See Fig. 10.10.

If input 1 is driven low, for example, by connecting it to Vss) and input 2 is connected to the output of the sine-wave oscillator, then a 1·6kHz square-wave appears at pin 3, provided that the sine-wave input is big enough. What is happening is that positive peaks of the sinewave drives the gate output low, negative ones high. The crests of the wave are flattened in the process, turning the sinewave into a rectangular wave. The gate output goes low, high, low, high . . . at 1·6kHz. If input 1 is now connected to V_{DD} (that is, driven permanently high) the 1·6kHz output is suppressed because the high on input 1 makes the output permanently low.

Now connect the output of your square-wave oscillator (Fig. 10.6a) to input 1. This makes input 1 sometimes high and sometimes low. When low, the sinewave on input 2 can switch the gate on and off. When high the sinewave has no effect. The result is that the output is 1·6kHz periodically turned on and off at 6Hz. The sound in your earphone is a rapid sequence of "pips".

You can change the frequency of either oscillator by changing the R or C values. Increasing R or C reduces the frequency. In the sine-wave oscillator (Fig. 10.7), use equal values for R4, R5 and C2, C3. If the sinewave is set to about 4kHz and the square to about 20Hz the combined output is a passable imitation of the ringing of an electronic telephone, if you turn the circuit on and off in the correct rhythm.



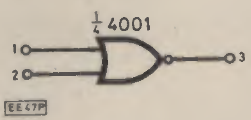


Fig. 10.9. A 2-input NOR gate. Four such gates are contained in the 4001 i.c., as shown on the accompanying EBBO layout (Fig. 10.10).

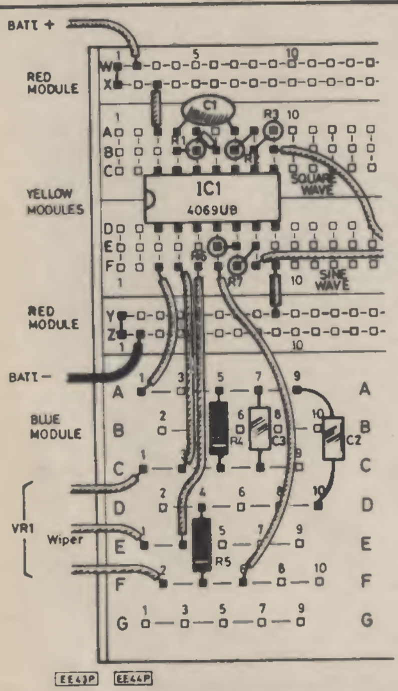


Fig. 10.8. Complete EBBO i.c. board layout for square and sine-wave oscillators and buffers, Fig. 10.6 and Fig. 10.7, respectively.

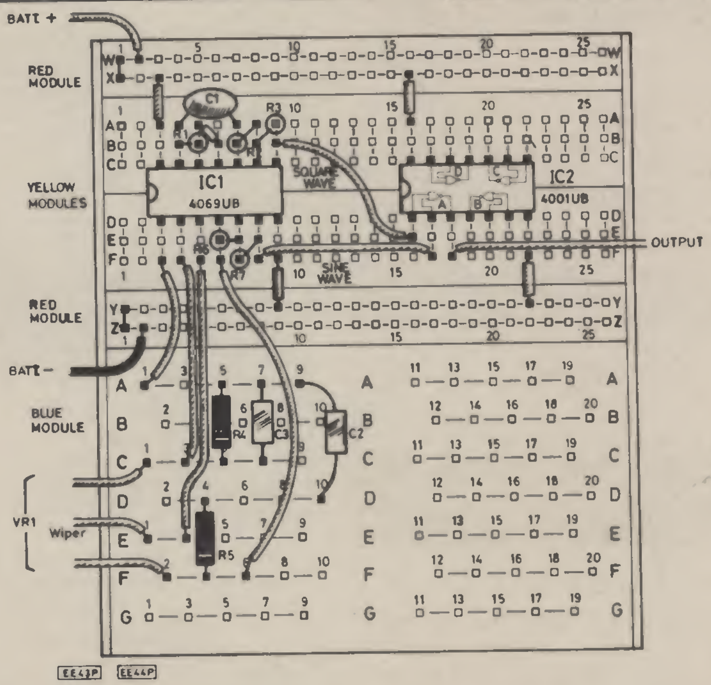


Fig. 10.10. The EBBO i.c. board layout for the 4001UB.

USE YOUR IMAGINATION

Gates are very useful to the experimenter. In Fig. 10.11 a 2-input NOR gate (as in the 4001) has audio applied to one input and a "high" to the other via R1 and R2. Result: no audio output because the "high" on input 2 keeps the output low. If terminals A and B are connected together this removes the high from input 2 and audio reaches the output.

One possible use for this circuit is as an audible "continuity tester". If A and B are used as test terminals, when they are connected to opposite ends of a conductor audio reaches the output, indicating that the conductor is intact.

Clearly, the circuit could be used as an alarm, activated by closing a contact between A and B. It can check the polarity of a diode, connected across A and B. Sound emerges only if the anode is connected to A and the cathode to B, not the other way round.

For this sort of job it is useful to connect a loudspeaker to the output. Ordinary moving-coil loudspeakers cannot be used, but you can use a piezo-electric "sounder", which is a sort of grown-up version of a crystal earphone, tuned to particular frequencies. (An inexpensive type, the Toko PB2720, works well at about 4kHz.)

Note that R2 and C1 protect the gate against static; R2 limits the current and C1 absorbs much of the charge.

No doubt you can think of other possible uses. You get four gates in every 4001, at a cost of (at the time of writing this) about 15 pence. Incidentally, I've been rather slipshod with mine, because I've left the unused gates disconnected.

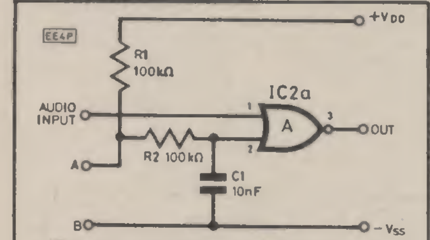


Fig. 10.11. This gate arrangement can be made to do many useful jobs.

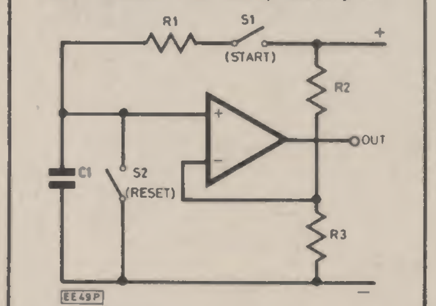


Fig. 10.12. Essentials of a timer circuit. Closing S1 allows C1 to charge via R1. Closing S2 discharges C1 and so resets the circuit. In timer i.c.s the functions of S1 and S2 are performed electronically.

It's good practice to connect unused inputs permanently to the + or − line to avoid the possibility of stray voltages getting to them.

Gates can be used as amplifiers. Connect the two inputs together and add a feedback resistance from output to input just as we did with the 4069. Two gates with strapped inputs can be used to make oscillators.

NAND GATES

There's another common type of gate, the NAND gate. Its output goes low only when all its inputs are high. These can also be connected as amplifiers. A cheap example in i.c. form is the 4011 quadruple 2-input NAND gate.

TIMERS

There are lots of integrated circuits designed for special purposes. Some are too specialised for general use, but there are many which are very adaptable. One such is the "timer" i.c.

The essence of a timer is illustrated in Fig. 10.12. Here a sort of differential amplifier, called a voltage comparator, has one input maintained at a steady voltage, the "reference voltage" via the divider, R2, R3. The other input receives the voltage across a capacitor C1 which at present is discharged. When S1 is closed, C1 charges via R1. When the charge voltage reaches the reference voltage the output of the comparator switches from low to high. The time taken depends on the value of R1 and C1 and on the reference voltage.

The change in output can be made to activate useful functions like switching an appliance on or off. It can also be made to operate a "reset" circuit which acts like S2 to discharge C1. In this case, the circuit can be made to go on charging and discharging C1. It is an "astable" circuit, an oscillator.

For practical purposes it is convenient to start the timing cycle by applying a voltage pulse rather than by throwing a switch like S1. So timer i.c.s incorporate a "start" or "trigger" facility. A type 555 timer i.c. with all these facilities can be bought for about 25 pence. You'll often see this particular i.c. used in designs in this magazine.

COUNTERS AND FREQUENCY DIVIDERS

It is easy to make two-state circuits which are put into one state by one input pulse and stay in that condition until a second pulse is applied to return them to their original state.

When driven by a sequence of input pulses these circuits give out just half as many output pulses. That is, they divide the number of pulses by two. Two such circuits, one driven by the other, divide by 4, three by 8 (= 2 × 2 × 2) and so on, doubling up every time.

It is possible to divide by intermediate numbers by arranging feedback which resets the divider when the appropriate pattern of states appears in the chain of two-state circuits. Thus a "divide by 16" circuit can be reset at 10. It then becomes a divide-by-ten, otherwise called a Decade Counter. Three decade counters in succession divide by 1,000 (= 10 × 10 × 10).

The basic "divide by two" element is called a binary counter (or sometimes a "flip-flop" or a "bi-stable").

Quartz crystal clocks contain long chains of binary counters. Quartz, when vibrated, generates a voltage. This can be picked up by electrodes, amplified, and fed back to sustain oscillation at the natural frequency of the piece of quartz, which can be very stable. In quartz clocks and watches a frequency is chosen which when divided by a chain of binary counters gives one output pulse per second. For example, 4,194,304Hz yields 1Hz when divided by 2 twenty-two times.

In superhet radio receivers a quartz frequency can be used as the "local oscillation". By dividing the frequency one crystal can be made to yield a multiplicity of frequencies, to give, say, one tuning point every 100Hz.

LOGICAL DESIGN

The starting point for any design is to analyse the requirement very carefully, step by step. Unless you are quite certain what a piece of equipment is intended to do you are unlikely to be successful in making it. At this stage the design is not electronic at all, but rather a written specification.

Suppose, for example, that you want to make a touch-operated switch. The electronics is easy. Indeed, you can get i.c.s to do the job. But the i.c. does only the electronic part. You, the designer, have to make sure that the electronics are compatible with the physical part, the finger on the pad.

You might, for example, use the idea of allowing a tiny current to flow from the pad through the finger and to earth. Very tiny currents (much too small to be noticed) can be used. But what if the person who touches the pad is wearing plastic boots which insulate him from earth?

Thinking of this may steer you in the direction of making a touch-pad split into two parts, so that the finger allows current to flow from one part to the other. If you settle on this solution, you must ensure that the current is sufficient, by making actual tests on fingers, in dry conditions as well as moist ones, and so on. And you must ensure that an accidental accumulation of dirt on the pad doesn't allow enough current for a false operation.

You must also think about what might happen in unusual circumstances. One solution to the touch-switch problem is to make the pad sensitive to the heat of the finger. This, in a particular case, caused a disaster. Somebody used heat-sensitive buttons to summon lifts in a tower block. When the block caught fire the heat activated the controls and brought lifts full of people to the floor where the fire was raging.

HUMAN FACTORS

That cautionary tale illustrates the need to take all factors into account. Often the most important factors are the human ones. Designs must be compatible with the people who are to use them. Nobody (I hope) would give his grandmother a radio whose tuning control was so stiff that her poor old arthritic fingers couldn't turn it. But why have a tuning knob anyway? If the old dear never listens to anything but Radio Two wouldn't a single-station set be better?

It's surprising how often professional designers forget to think carefully about how their equipment is likely to be used. Recently I went shopping for a small bedside radio.

It should be obvious to any designer that small radios are likely to be used on bedside tables. It should then be apparent that such a radio is likely to be used in the dark. Many of the sets I looked at had to be rejected because their design was of the elegant slimline type which is doomed to be knocked over in the dark, when you wake up, realise you've left the radio on and sleepily fumble for the off switch. I eventually chose one which was not only broad-based but had a tuning l.e.d. which shows up in the dark.

Commercially, good "human engineering" should pay off. Consumer advice organisations draw attention to design deficiencies so a bad design must suffer. Your designs, I hope, will always be good ones.

Next month: New developments.

CHECK YOUR PROGRESS

Questions on *Teach In 84 Part 10*
Answers next month

Q10.1 Ten inverters are connected in cascade; that is, output of the first to input of the second, and so on. If the input to the first is high what is the output of the last: high or low?

Q10.2 A 3-input NOR gate has all inputs tied together. A resistance of 10kΩ is connected from output to input. If V_{DD} = 10V, what is:
(a) the approximate output voltage
(b) what is the output voltage if the resistance is increased to 10MΩ?

Q10.3 In the sine-wave oscillator circuit (Fig. 10.7) what would be the likely effect of increasing R4 and R5 to 1MΩ?

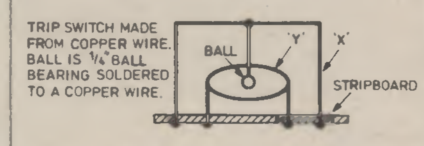
ANSWERS TO PART 9

Q9.1 About 160μA. There is 0·5V (500mV) across R4, which must be passing 150μA. (mV/kΩ = μA). If V_{BE} for TR2 is 0·7V, its base is at 0·7V + 0·5V = 1·2V. This leaves 7·8V across R2, which passes 7·8μA (V/MΩ = μA). About 0·8μA of this is TR2 base current; the rest is TR1 collector current. The total is then 157μA or 160μA in round terms.

Q9.2 There are two answers: 39MHz and 21MHz. Each yields a difference frequency of 9MHz when "mixed" with a 30MHz input signal. In the same way, with any given oscillator frequency there are always two signal frequencies which give the same i.f. The unwanted signal frequency, called the image frequency, must be heavily attentuated by a signal-frequency filter preceding the frequency-changer, or it will cause interference. Using a high i.f. makes this easier by placing the image frequency far from the wanted-signal frequency. But to get adequate selectivity at an i.f. of 9MHz calls for an expensive i.f. filter of the quartz-crystal type.

CIRCUIT EXCHANGE

A project for beginners, using the 555 timer.

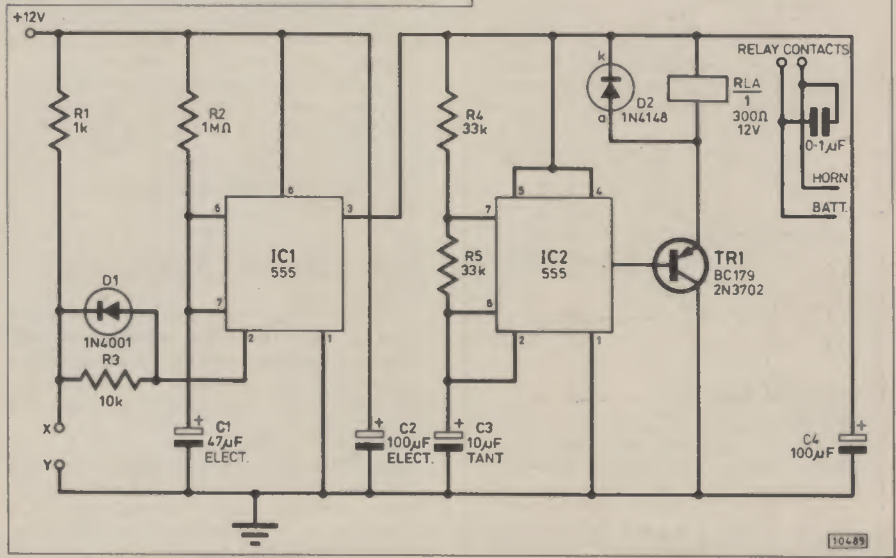


MOTORCYCLE ALARM

In this circuit a 555 timer (IC1) is used as a monostable, and when triggered by pin 2 being brought low, drives another 555 (IC2) which is wired as an astable. The output from IC2 turns TR1, and thus the relay on and off. This gives a series of bursts of the horn for a time set by R2 and C1. Pin 2 can be triggered by a ball bearing tilt mechanism, as shown in the diagram.

This unit can also be used in cars by wiring the trip switch wire to the courtesy light. Pin 2 will be held high via the lamp, and will be triggered by the car door being opened. If this method is used it will be necessary to install an isolation switch outside the car.

G. Bamford,
Cleckheaton,
West Yorks.



FOR YOUR ENTERTAINMENT

BY BARRY FOX

Video Dropouts

Dust is the big enemy of modern electronics. Recently I visited the Agfa tape factory in Munich and was reminded yet again of the lengths manufacturers must go to if they are to keep their product dust free.

Early domestic video tape suffered seriously from "dropout". That's a white blip on the screen caused by a gap in the magnetic coating.

Remember that on a modern video recorder the helical scan tracks are always under 50 microns in width and often half that or even less. That means the track is always narrower than a human hair.

So, if a speck of dust (or fleck of human hair!) gets into the tape coating it will mean that for a split second the video head is reading dirt instead of magnetic coating. As dirt is non-magnetic this means that there will be a (momentary) complete loss of signal.

Video recorders have a dropout compensator which is a small analogue memory, to fill in short gaps. But it can't cope with more than one line of the picture.

A line takes 64 microseconds to scan. When there is dropout shorter than a picture line the compensator just pulls out the last line of memory and uses it again.

Obviously if the dust speck is larger, the compensator is defeated. That's when you see a white blip on the screen—it's just a hole in the recording that the memory can't fill and disguise.

The standard requirement for domestic VHS video tape is usally no more than 50 dropouts a minute, each lasting no longer than 15 microseconds. When you bear in mind that on a VHS recorder the heads are scanning at a rate of 4·85 metres a second (which is 4·85 microns a microsecond), a 15 microsecond dropout is equal to a 73 micron fault in the coating—that's still not much wider than a human hair.

Most tape companies aim for a much lower, or better, dropout rate than the minimum standard requirement of fifty a minute. Agfa, for instance, aims for below 20 dropouts a minute on high grade tape and below 35 a minute on standard grade. Counting is of course electronic, and automatic, on cassettes sampled from the production run.

Incidentally, this helps clear up the age-old question; what is the difference between standard and high grade video tape? When I asked JVC's Japanese engineers once, they told me "high grade is better". When I asked in reply: "You mean standard grade is worse", they became very flustered!

Down To Earth

All modern tape plants seal off vital areas of the coating machine where the hot mix of plastics binder and magnetic coating is applied to the thin, transparent plastics base film. This way any dust in the factory air cannot get into the coating mix or settle on the tape while it is still sticky.

The factory itself must also have a very clean atmosphere. In fact factory is the wrong word. Most modern tape plants are more like hospitals. If visitors are allowed anywhere near the tape coating facility, they have to pass through an air shower which blasts any dust from their body. Or they must don protective clothing, hats and shoes. Often both precautions are taken.

At Agfa in Munich I noticed an interesting extra precaution. All the floors near the coating area are made of conductive material which is earthed by thick copper wires.

There are two reasons for this. If there is any build up of static in a building, there can easily be a spark. You know what happens in a dry centrally-heated atmosphere where there is a nylon carpet. Every time you touch metal there's a spark.

In a tape coating plant, where there are potentially explosive solvents in use, a spark could be very dangerous. Also a build up of static can mean a build up of dust. So it makes sense on both counts to earth everything from the floor upwards.

Microchip Clean-Up

The anti-dust precautions needed in a tape plant are as nothing compared to those in a microchip factory. Toshiba in Japan has only now explained what it does to keep dust out of its VLSI plant at Kawasaki, near Tokyo.

It is at Kawasaki that the planning and production of 4-megabit, and even 16-megabit memories using micro lithograph technology to draw circuit lines 0·5 microns wide is carried out. That's 100th the width of a human hair.

This needs "super" clean rooms with dust limited to less than one particle of 0·1 micron size, per cubic foot of air. This is "Class 1" cleanliness. Compare this with around one million particles of such size in a cubic foot of air in a city street, or between 10,000 and 100,000 in a home or office.

The super clean air atmosphere is achieved by very dense air filters and a laminar air flow that comes down from the ceiling and is absorbed through the floor. Wherever possible sterile robots are used to operate machines and carry chips, rather than humans which have the nasty habit of shedding particles of skin and hair, however clean they may be.

Computer Time

I bought some computer equipment recently. It was like travelling in time back to the early days of the hi fi consumer boom. The ignorance of the people selling expensive equipment is beyond belief.

Several shops could not demonstrate a £500 printer to me because they quite literally didn't have the right connecting lead. Without the right connecting lead even the most expensive printer in the world is just a heap of useless junk.

One shop had the printer I wanted on demonstration and the salesman knew he had to alter the series of d.i.p.-switches to get it working properly. What he did was flip the switches randomly to see what happened.

Repeatedly, I suggested that he check with the instruction book. Only in desperation, after ten minutes of futile switch flicking, did he give in and try reading the instruction book. A specialist shop had Centronics and RS 232 plugs in stock, but not made-up leads.

All this is fine for the devoted computer enthusiast who avidly reads the specialist magazines and treats computing as a hobby. But Heaven help the small business that believes all the hype and tries to buy a personal computer for use as a business tool.

No wonder so many people have paid over the odds to buy an IBM PC. It's quite simply that they want to buy a *total system* from a well-known name which they feel they can trust.

My bet is that the hobbyist market will soon saturate. There is a limit to the number of people who want to play with computers as a hobby, rather than use them. There is also a limit to the number of computers any one hobbyist will buy.

It's what created the boom in hi fi music centres and rack systems. Astute electronics companies started to offer hi fi systems that needed no extra leads or technical knowledge to connect up. It's what made the video boom take off so fast, once it started.

Although a video recorder is by far the most complex piece of mechanical and electronic equipment you'll find in any home, it is remarkably simple to operate. Only the clock and timer need care and skill to understand.

Some people never use the timer on their video recorder or even set the clock. When a service engineer visited one home recently he asked why they had a piece of black tape over the window for the clock l.e.d. It was blacked out, the owners said, because it kept flashing "8s". No-one had ever learned how to set it to the right time!

Friendly Vampire

Although computer firms keep talking about their equipment being "user friendly" most of it is still as friendly as a vampire. Of course when today's school children, who are weaned on computers, grow up and become businessmen and women it won't matter. But for many years yet there will still be a vast population of business people who are too old to have learned computing at school. They represent a vast untapped market for the computer equivalent of a hi fi music centre or domestic video recorder.

For what it is worth, my bet is that it will be the Japanese who cash in on this untapped market by offering low cost computers that are as easy to use as a music centre or video recorder. If you don't believe me, just remember what happened in the video market.

It was Philips who launched the first videocassette recorder, ten years ago. But it was the Japanese who waited a few extra years, learned by Philips's mistakes, and launched the VHS and Beta systems which now dominate the market. In fact Philips is now starting to manufacture VHS format recorders under licence from the Japanese and will be selling them in Europe by the end of this year.

EVERYDAY ELECTRONICS PRINTED CIRCUIT BOARD SERVICE

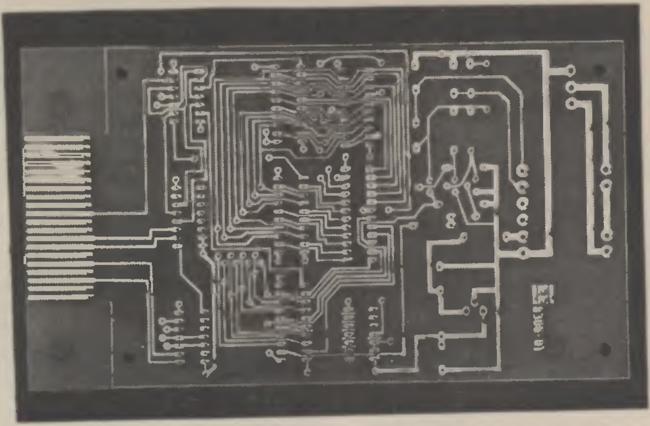
Printed circuit boards for certain EE constructional projects are now available from the EE PCB Service, see list. These are fabricated in glass-fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for overseas air-mail. Remittances should be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

We regret that the ordering codes for the August projects have been incorrectly quoted in the Sept-Oct issues. Correct codes are given here.

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.

Readers ordering both p.c.b.s *and* software cassettes may send a single cheque/PO for the combined amounts listed.

NOTE: Please allow 21 days for delivery. We can only supply boards listed here.



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

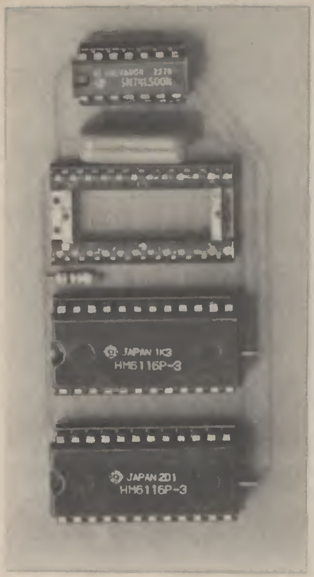
*Set of four boards.

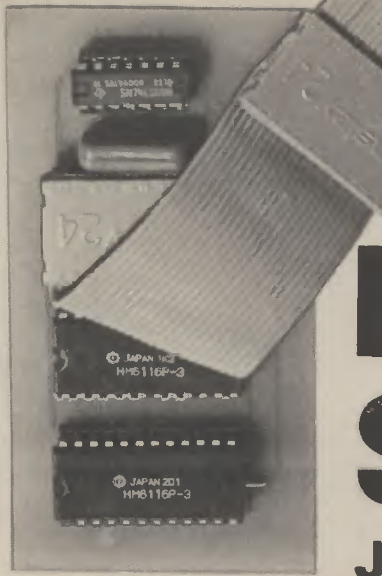
**Calibrated with C1, VR1 and IC3 fitted.

M.I.T.—Microcomputer Interfacing Techniques, 12-Part Series.

PROJECT TITLE	Order Code	Cost
— JUNE '83 —		
Eprom Programmer, TRS-80	8306-01	£9.31
Eprom Programmer, Genie	8306-02	£9.31
Eprom Programmer, TRS-80 & Genie	8306-03	£1.98
— JULY '83 —		
User Port Input/Output *M.I.T. Part 1*	8307-01	£4.82
User Port Control *M.I.T. Part 1*	8307-02	£5.17
— AUGUST '83 —		
Storage 'Scope Interface, BBC Micro	8308-01	£3.20
Car Intruder Alarm	8308-02	£5.15
High Power Interface *M.I.T. Part 2*	8308-03	£5.08
Pedestrian Crossing Simulation *M.I.T. Part 2*	8308-04	£3.56
Electronic Die	8308-05	£4.56
— SEPTEMBER '83 —		
High Speed A-to-D Converter *M.I.T. Part 3*	8309-01	£4.53
Signal Conditioning Amplifier *M.I.T. Part 3*	8309-02	£4.48
Stylus Organ	8309-03	£6.84
Distress Beacon	*8309-04	£5.36
Distress Beacon Pocket Version	8309-05	£3.98
— OCTOBER '83 —		
D-to-A Converter *M.I.T. Part 4*	8310-01	£5.77
High Power DAC Driver *M.I.T. Part 4*	8310-02	£5.13
Electronic Pendulum	8310-03	£5.43
— NOVEMBER '83 —		
TTL/Power Interface for Stepper Motor *M.I.T. Part 5*	8311-01	£5.46
Stepper Motor Manual Controller *M.I.T. Part 5*	8311-02	£5.70
Digital Gauss Meter	8311-03	£4.45
Speech Synthesiser for BBC Micro	8311-04	£3.93
Car On/Off Touch Switch	8311-05	£3.11
— DECEMBER '83 —		
4-Channel High Speed ADC (Analogue) *M.I.T. Part 6*	8312-01	£5.72
4-Channel High Speed ADC (Digital) *M.I.T. Part 6*	8312-02	£5.29
TRS-80 Twin Cassette Interface	8312-03/09	£7.43
Environmental Data Recorder	8312-04	£7.24
Touch Operated Die (Dot matrix)	8312-05/06	£4.34
Touch Operated Die (7-segment)	8312-05/07	£4.34
Continuity Tester	8312-08	£3.41

PROJECT TITLE	Order Code	Cost
— JANUARY '84 —		
Central Heating Pump Delay	8401-01	£3.33
Biological Amplifier *M.I.T. Part 7*	8401-02	£6.27
Temp. Measure & Control for ZX Comprs		
Analogue Thermometer Unit	8401-03	£2.35
Analogue-to-Digital Unit	8401-04	£2.56
Games Scoreboard	8401-06/07	£9.60
— FEBRUARY '84 —		
Eprom Programmer/ROM Card for ZX81	**8402-01	£7.84
Oric Port Board *M.I.T. Part 8*	8402-02	£9.56
Negative Ion Generator	**8402-03	£8.95
Temp. Measure & Control for ZX Comprs Relay Driver	8402-04	£3.52
— MARCH '84 —		
Latched Output Port *M.I.T. Part 9*	8403-01	£5.30
Buffered Input Port *M.I.T. Part 9*	8403-02	£4.80
VIC-20 Extension Port Connector *M.I.T. Part 9*	8403-03	£4.42
Commodore 64 Extension Port Connector *M.I.T. Part 9*	8403-04	£4.71
Digital Multimeter Add-On for BBC Micro	8403-05	£4.63
— APRIL '84 —		
Data Acquisition "Input" *M.I.T. Part 10*	8404-02	£5.20
Data Acquisition "Output" *M.I.T. Part 10*	8404-03	£5.20
Data Acquisition "PSU" *M.I.T. Part 10*	8404-04	£3.09
Timer Module	8404-05	£3.58
A.F. Sweep Generator	8404-06	£3.55
Quasi Stereo Adaptor	8404-07	£3.56
— MAY '84 —		
Simple Loop Burglar Alarm	8405-01	£3.07
Computer Controlled Buggy *M.I.T. Part 11*		
Interface/Motor Drive	8405-02	£5.17
Collision Sensing	8405-03	£3.20
Power Supply	8405-04	£4.93
— JUNE '84 —		
Infra-Red Alarm System	8406-01	£2.55
Spectrum Bench PSU	8406-02	£3.99
Speech Synthesiser *M.I.T. Part 12*	8406-03	£4.85
Train Wait	8406-04	£3.42
— JULY '84 —		
Ultrasonic Alarm System	8407-01	£4.72
Atom EPROM Simulator	8407-02	£3.08
Electronic Code Lock		
Main board	8407-03	£2.70
Keyboard	8407-04	£3.24





Atom EPROM Simulator

J.R.W. Barnes

A LARGE number of EPROM programmer circuits have been published over the last two years. A simple programmer can be constructed for about twenty pounds. But, to develop EPROM-based software is a very lengthy procedure. To blow an EPROM takes fifty milliseconds per location, for example, a 2532 4K EPROM takes about four minutes. EPROMs must also be erased, this requires a special ultra violet lamp in its protective housing. These often cost several times the cost of the programmer. When de-bugging the software three or four EPROMs are required so that some can be erased while others are being programmed. The whole system can be very expensive.

ALTERNATIVE SOLUTION

An alternative to using EPROMs for program development is presented in this article. An adapter has been designed so that RAM can replace ROM. The unit plugs into a 2532 socket and the only other connection required is to the READ/WRITE line. Programs either machine code or Basic can be written and run in the EPROM socket. Once the program has been proved it can be transferred to an EPROM.

Another significant advantage is that an assembler can be used to assemble the machine code directly to where it is going to be used. The alternative is to assemble the machine code elsewhere and then relocate the program by hand. In the case of the 6502 this relocation has to change the addresses of look up tables and jump instructions. Although the unit was originally designed for an Acorn Atom it should be possible to use the unit with several other computers.

CIRCUIT DESCRIPTION

The complete circuit is shown in Fig. 1. It is centred around IC1 and IC2, these are 2K by eight static CMOS RAM integrated circuits. A third integrated circuit, IC3, is used to provide address decoding. The truth table for the circuit enable lines is shown in Table 1. Neither of the memory circuits must be enabled if the chip select line of the host socket is high. If the chip select is low then the memory selected is dependent on the state of the highest order address line. This was implemented by four two-input NAND gates.

A11	CE	$\overline{\text{SELECT}}$ 1	$\overline{\text{SELECT}}$ 2
0	0	0	1
0	1	1	1
1	0	1	0
1	1	1	1

EE58P

Table 1
Truth table for the circuit enable lines

Capacitor C1 provides supply decoupling. Resistor R1 is a pull up resistor on the READ/WRITE line.

The circuit obtains its power from the host computer.

CONSTRUCTION

CIRCUIT BOARD

The circuit was built on a printed circuit board 100 x 50mm. The track layout is shown in Fig. 2 with the component layout shown in Fig. 3. If readers decide to make their own circuit board great care must be taken where the tracks go between the pins of the integrated circuits.

It is strongly recommended that sockets are used for the integrated circuits. Construction should begin with the wire links under the integrated circuits. The sockets and the other components should then be soldered in place. A Veropin can be fitted for the READ/WRITE line. Care should be taken with the orientation of the integrated circuits.

The prototype was not housed as during use it was fastened with double-sided adhesive pads to the bottom of the Atom. A second piece of printed circuit board material was bolted to the underside of the first, using spacers, to provide protection. A 24-way jumper lead is required to connect the circuit to the ROM socket, this can either be home-made or purchased from a supplier. It should not be longer than 30 centimetres.

INSTALLATION

As the circuit is mainly of CMOS normal handling precautions should be taken. When the unit is not in use it is advisable to keep the spare connector in a piece of anti-static foam.

The unit is connected with the jumper cable to the ROM socket, the utility ROM socket is normally used, but the floating point socket may also be utilised.

A thin piece of flexible connecting wire is connected from pin 34 of the 6502 to the READ/WRITE pin on the board.

TESTING

The RAM test program in "Atomic Theory and Practice", page 92, was used to test the memory, run the program, and test the memory from #A000 to #AFFF. This test should show the memory to be all right. If this test fails then carefully check the board for whiskers of solder between the tracks and the pads.

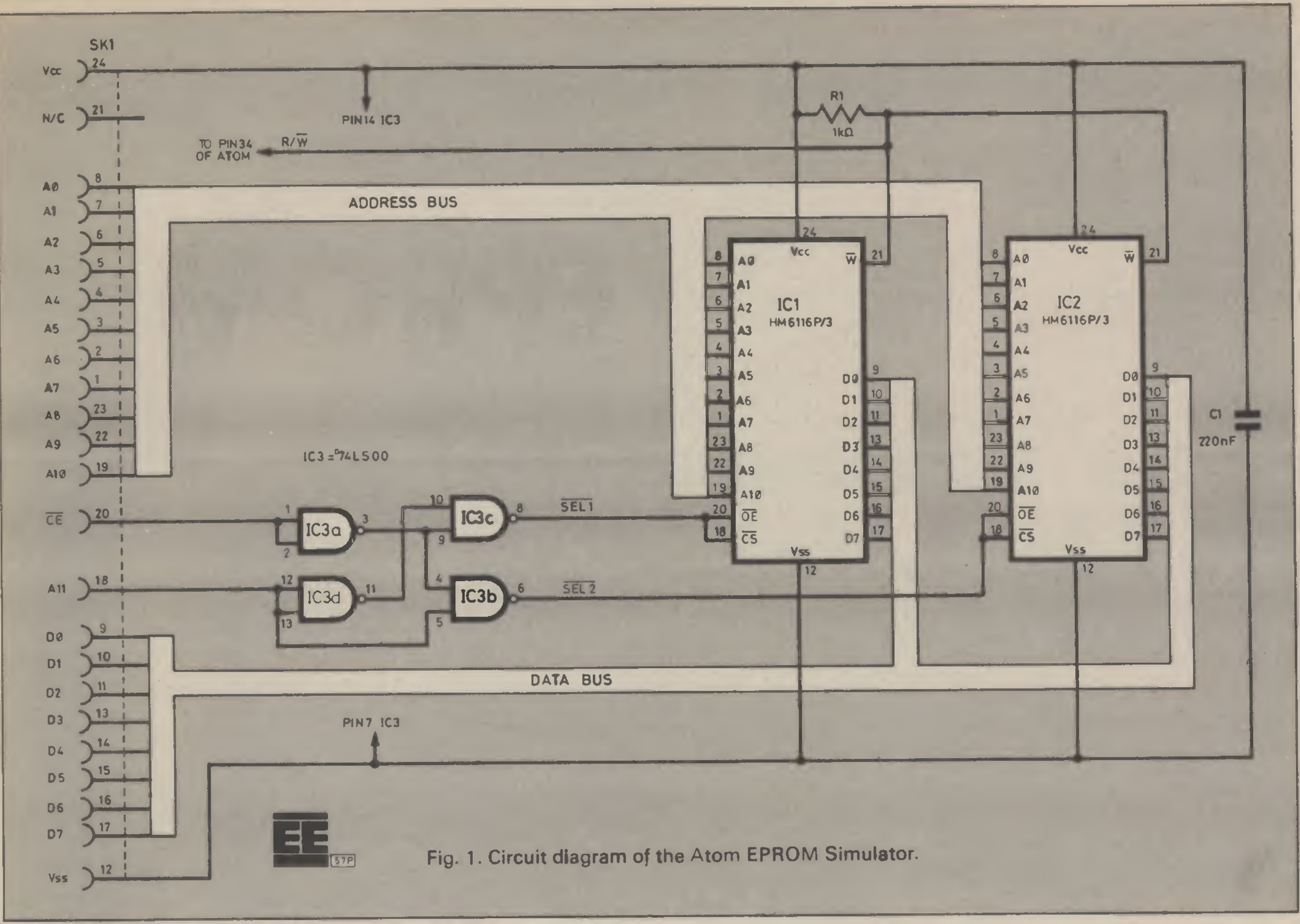


Fig. 1. Circuit diagram of the Atom EPROM Simulator.

COMPONENTS

See Shop Talk page 434

Resistor
R1 1kΩ

Capacitor
C1 0·22µF

Semiconductors
IC1,2 HM6116 2K by eight CMOS memories (2 off)
IC3 74LS00 Quad 2-input NAND gate

Miscellaneous
Single-sided p.c.b. 100 x 50mm, *EE PCB Service,* Order code 8407-02; 24-pin d.i.l. sockets (3 off); 14-pin d.i.l. socket; jumper cable 24-way 30cm long.

Approx. cost Guidance only £18.00

Fig. 2. Printed circuit board design.

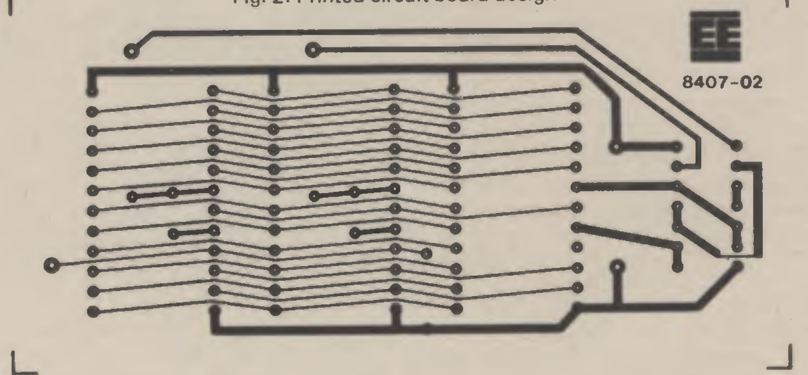
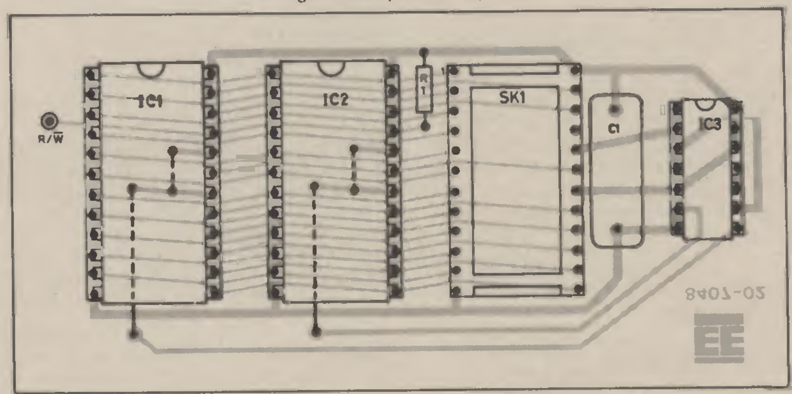


Fig. 3. Component layout.



USE

Basic programs can be written into the new memory by setting the text pointer to #A0.

?18=#A0 (return)

NEW (return)

A Basic program can now be typed into the new memory and RUN. It should be noted that the text space pointer has to be reset if the "break" key is pressed.

Machine code can be assembled into the new memory by setting the location counter, P to #A000 prior to assembling. For example:

```
10 REM RANDOM NOISE
20 DIM LL(2), NN(1),P(−1)
30 C=#B002
35 FOR N=1 TO 2
40 P=#A000
50[
60:NN0 LDA L;STA C
70 AND @#48; ADC @#38
80 ASL A;ASL A
90 ROL L+2; ROL L+1; ROL L
100 JMP NN0
120]
130 NEXT
140 LINK NN0
150 END
```

Table 2
Program example for setting the location counter

When you have written your own software and you are sure that it is correct, an EPROM programmer can then be used to store the memory from #A000 to #AFFF in a 2532.

Commercial software such as the "Wordpack ROM" and the various utility ROMs may be SAVE on tape using the following command:

*SAVE"NAME"A000 B000

with the ROM in the utility socket. The software can then be load back into the ROM/RAM unit described here and then run in the normal way. To load the software use:

*LOAD"NAME"A000

This is one way of avoiding the need for a ROM selector board. □

COUNTER INTELLIGENCE

BY PAUL YOUNG

Profile Of A Specialist

Last year I included in some of my articles, potted biographies of one or two of the better known component suppliers. It was a fascinating task, and one that, apart from general interest, I am sure was helpful to the would be entrepreneur, who wished to take up this line of business.

Continuing this trend, I made my way recently to the premises of Radio Component Specialists of 337 Whitehorse Road, Croydon, to meet John Ladd. This company is undoubtedly well known to our readers through their extensive advertising. I had met John Ladd many years ago through our business connections.

The first fact that emerged was, that we were both war-time pilots and we had both continued flying for several years after the war. John is still flying, when business interests permit, and holds a current private licence and an instrument rating.

Unfortunately, these revelations, hindered rather than helped my enquiries, because it meant inevitably we kept on digressing from electronics to aeroplanes. The time flew by, and, "At the end of the day", as the politicians and union leaders say with monotonous regularity, I found myself with only a few notes recorded. Naturally, with our readers in mind, I shall concentrate on the electronic prowess of our subject.

Radio was John's hobby before the war and he soon became proficient enough to take on a part-time job with a radio shop in South Croydon. His next advancement came in 1938 when he was appointed Service Manager for Drubel Radio Distributors. He had then reached the ripe old age of 15½.

In 1939 the war intervened and by 1941 John was flying. He was made a Flying Instructor in 1942. Later he was sent to do a course on heavy bombers, only to find by the time it was completed there was a surplus of bomber pilots.

The result was they sent him off to do a conversion course on *Typhoons* which were being used as fighter bombers. By the time that was finished so were the hostilities.

He returned to Drubels as a salesman which kept him busy for the next five years. In 1951 he went into partnership with Mr. Harold Livesey in a firm called Televox Radio Services. In 1954 he started on his own at 307A Whitehorse Road, Croydon. In 1955 Frank Jackson was taken on and later was made a partner. In 1959 he moved to his present address and in 1964 he acquired the firm of Baker Speakers.

At this point I was able to tell John a story about Baker Speakers that was unknown to him. Many years ago I visited the Baker factory and was intrigued to see a huge tank of goldfish. I was told they were used to test the high frequency response. John then introduced me to Eric Coppard who has been in charge of the Baker Speaker section since 1947. He was able to confirm my story of the fish test.

I asked John if he had had any lucky breaks that set him up. He said no, just steady progress, although the advent of commercial television when everyone wanted to buy Band Three Converter kits certainly gave the business a push in the right direction.

Sound Approach

His undoubted success is due to sticking to sound policies, which I could sum up as follows:

(1) Buy your premises (essential).

(2) Limited objectives. Expand gradually and don't over-trade.

(3) Concentrate on one or two aspects and do them well. In John's case, audio, hi fi and large wattage amplifiers, including disco equipment. He also stocks an impressive range of standard components which is listed in his 20-page brochure.

(4) Give good service after-sales and always have at least one technical person on hand. John not only does this but gives a 12-month guarantee on all the goods he supplies.

Like the rest of us, John has felt the effects of the recession and the diversification caused by Home Computers but much of his business comes from good-will and recommendation. He has been in business for 30 years and I am sure he will be there for many years to come.

Weathering The Storm

I was naturally very pleased to receive several letters from readers on the subject of Ionisers. There is a divergence of opinion as to whether colour televisions emit positive ions.

Having been in the business for 15 years, Medion Ltd. of Oxted in Surrey say, "We can reassure readers that colour televisions do not emit positive ions". But they go on to say, "that in the vast majority of sets they tested, the television screens built up a large static charge, this resulted in no negative ions, and some 1000 positive ions per cubic capacity at typical VDU operator distance. In the case of the VDU operators this can result in headaches, lethargy, and sore eyes."

Fortunately Medion concludes, "The output of even the smallest negative ioniser is sufficient to suppress the screen charge and to maintain a healthy ion level." They also manufacture an atmospheric ion analyser which can measure the amount of positive or negative ions in a room or in the atmosphere. The price is £1495.

Another reader, Graham Lewis, kindly sent me a leaflet from a firm which markets an ioniser under the name, Mountain Breeze Air Ionisers. They make the claim, "If you feel the difference before and after a thunderstorm, you have already experienced the effect of air ionisation."

I asked Mr. P. Laws, Manager of Medion Environmental Division what the implication of this was, and he explained that before the storm breaks, there is a heavy build up of positive ions, after the lightning it is reversed, resulting in a large surplus of negative ions. They say you learn something new every day, I think in electronics it is more likely to be every hour.

Changing Times

I suppose it had to happen. The Japanese have made a watch with a built-in computer. Made by Seiko, it can memorise 2000 characters, store 100 words in two languages and costs around £200.

At the other end of the scale, I noticed my Garage offering five function watches for sale at £1.49. "How much to change the battery?" I asked the lad. Back came the answer, "£1.50 Guv". I give up, this high finance is too difficult to work out!

AUGUST FEATURES...

MICROWAVE ALARM SYSTEM...

Built into a hi fi speaker cabinet, this microwave doppler intruder alarm has a range of 8m, yet is completely self-contained, requiring no external wires. The unit measures only 245 × 155 × 155mm.

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Ever needed a third hand in the kitchen? This is it—a useful project with lots of practical applications. A timer which can switch mains appliances up to 5A, with a fully adjustable time setting.

TEMPERATURE INTERFACE for BBC...

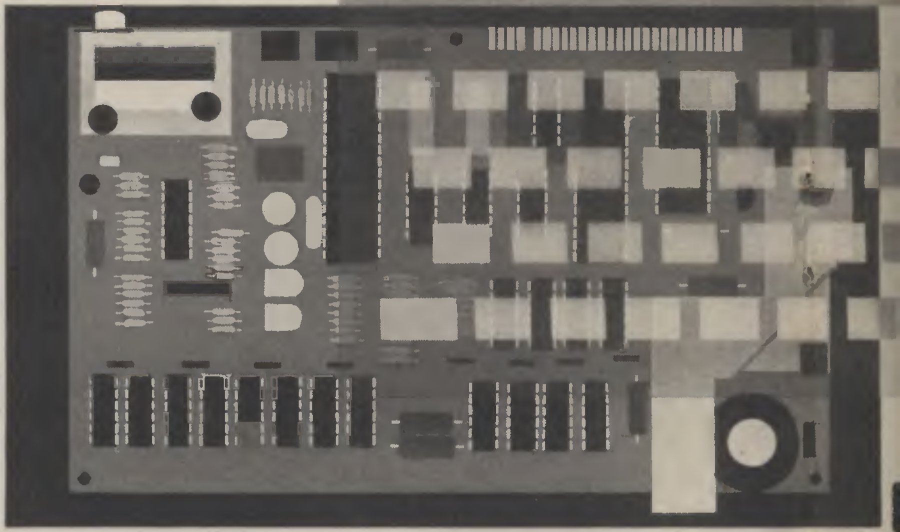
Using the machine's own four channel A to D converter this article shows how a simple temperature interface can be made with good linearity and accuracy over a temperature range of –50° to +150° Centigrade.

FEATURE ARTICLE: WHAT IS RADIATION?

EVERYDAY ELECTRONICS and computer PROJECTS

AUGUST 1984 ISSUE ON SALE FRIDAY, JULY 20

ANATOMY OF YOUR MICRO



THERE are now more microcomputers per person in the UK than in any other country. But what really goes on underneath the keyboard? This series begins by examining the internal workings of a typical microprocessor—the "heart" of any microcomputer. Later parts will consider how memory space is allocated and how it can be used, and the requirements for interfacing to cassette recorder, disk or TV display.

Of all the devices which have been produced as a result of microelectronics, the microcomputer is the one which seems to have made the greatest impact on the average person. Of course, there are digital watches and clocks, there are pocket calculators in a multitude of designs, and many of the circuits in radio sets and TVs are based on microelectronics, but these developments have been largely taken for granted. They have never roused the public interest to the same extent as has the micro. A glance at the newsagent's shelves, which today carry well over a dozen popular magazines devoted to microcomputing, confirms the extent of this interest. Interest in micros is not only more widespread than interest in other aspects of microelectronics, but is more intense. People rarely want to know what goes on inside a digital watch or a TV set, but they *do* want to know what is happening inside their micro. Perhaps it is the way in which a micro seems to be almost human at times—be it clever, stupid, helpful, or just plain awkward!—that makes us think there is "something" there which we want to know more about.

This is the reason for trying to introduce you to what goes on inside the typical home computer. We know it does not *really* have its own personality, but it does have a complicated assembly of electronic circuits which are somehow made to behave in this almost-human fashion. It is the anatomy of these circuits which is the subject of this article. Although the circuits themselves are complicated, the principles by which they operate are relatively simple. We shall be concentrating on the principles rather than on the details, and only a minimal knowledge of electronics will be assumed.

BINARY SIGNALS

Although you can "talk" to your micro using a language such as BASIC, which has many ordinary English words, the circuits of the micro really understand only two words—true and false. These words have exactly opposite meanings, and no half-truths are possible. As might be expected, an electronic circuit does not recognise these words as such. Instead, it recognises distinct voltage levels. Micros are normally based on TTL circuits, and these recognise two voltage levels, which we refer to as "high" and "low". A "high" voltage is one between +2V and +5V (the maximum). A "low" voltage is one between 0V (the minimum) and 0·8V. Having to respond to only two different voltages, the TTL circuits can be designed to be fast-acting and extremely reliable. They can also be manufactured very cheaply, which is one reason that micros are so popular today.

"True" and "false" are opposites. So are "high" and "low", in the sense used above, for the circuits do not recognise any in-between voltages. If we make "high" equivalent to "true" and "low" equivalent to "false", we can now talk to the micro by feeding high or low voltages to the input terminals of its circuits. Sometimes this is done by pressing a key. The key is pressed, giving a closed circuit, or not pressed, giving an open circuit. There is nothing in between. Repeatedly, we find this idea of two opposites, with no in-betweens. Everything is in *twos*—everything is *binary*.

This leads us directly to a way of expressing numbers to the computer. If we take "true" (or "high") to mean "1" and "false" (or "low") to mean "0", we can send numbers to the micro. Such numbers consist only of "1"s and "0"s, but this binary system is capable of expressing numbers of any size. Binary numbers tend to have more digits than their decimal cousins, as can be seen in Table 1. When we speak of the digits which make up a binary number, we usually call them "bits", which is short for "Binary digITS".

Not only do we express numbers in binary form, but we also design the circuits so that they accept certain combinations of bits as instructions. For example, the number "01001100" instructs the relevant part of the micro to jump from one part of its program to another. Whether a number is taken to be a number or a coded instruction depends upon what stage the micro is at in its cycle of operations.

For most purposes, including sending coded instructions, it is sufficient to have

PART ONE
OWEN BISHOP

numbers with up to eight bits. This allows them to have 256 different values (0 to 255, inclusive). We can code up to 256 different instructions in this way. If we want to use values greater than 255 in our calculations, there are ways of representing larger numbers as several 8-bit binary numbers. An 8-bit binary number or code is called a *byte*.

Having seen some of the essential features of how the parts of a micro can communicate with each other or with the user electronically, we are ready to see what parts there are and what they each do.

Table 1. Binary Numbers and Their Equivalents in Decimal

BINARY	DECIMAL
0	0
1	1
10	2
11	3
100	4
101	5
110	6
1000	8
1111	15
10000	16
100000	32
1000000	64
10000000	128
11111111	255
100000000	256
10000000000	1024 (1K)
1111111111111111	65535

Table 2, Features of Popular Micros, from Ace to ZX-81

NAME	MPU	ROM (K)	RAM (K)	SPECIAL FEATURES
Ace	Z80-A	8	3	Uses FORTH
Amstrad CPC464	Z80	16	64	Built-in cassette deck
Apple II	6502	12	48	
Apple IIe	6502A	16	64	
Atari 400	6502	8	16	Sound gen.
Atari 800	6502b	8	48	Sound gen.
Atari 1200	6502	8	64	GTIA graphics chip (256 colours) Sound gen.
Atom	6502	8	2	
BBC micro (Model B)	6502	32	32	6522 I/O, D-to-A
Colour Genie	Z80	16	16	Sound gen.
Commodore 64	6510	26	64	Sound gen. Video chip
Dragon 32	6809	16	32	
Electron	6502	32	32	Sound gen.
Epson HX-20	6301	32	16	Portable, l.c.d. display
Lynx	Z80-A	16	48	
Oric Atmos	6502A	16	16	Sound gen.
NewBrain	Z80-A	18	32	Portable l.e.d. display
Sharp MZ-80A	Z80	4	48	No resident language
Sharp MZ-80B	Z80-A	2	64	No resident language
Sord M5	Z80-A	8	4	Sound gen.
Tandy Colour	6809E	16	16	
TRS-80	Z80	12	16	
TI-99/4A	9900	16	16	Sound gen.
VIC-20	6502	16	5	Video Interface Chip
ZX-Spectrum	Z80-A	16	16	
ZX-81	Z80-A	8	1	

THE HEART OF THE MICRO

At the heart of the micro is the microprocessor. This is a complex integrated circuit which controls all other parts of the micro and does most of the work besides. There are dozens of different kinds of microprocessor (or MPU), but two types in particular, the 6502 and the Z80 are commonly used in personal micros (see Table 2). We will look inside the 6502 to see what it contains.

Like all MPUs used in personal micros, the 6502 is an 8-bit device. That is to say it handles eight bits (or one byte) at a time. It has a number of registers, each of which holds a byte (Fig. 1.1). Each register consists of a set of eight bistable circuits (or flip-flops) which can be in one of two states. In one state (flipped) it can be said to hold a "1", in the other (flopped) it can be said to hold a "0". Once again, we come across the binary idea. A flip-flop has no in-between state. Depending on the state of each flip-flop, a register can hold the equivalent of any one of the 256 binary numbers or codes.

The most important register is the *accumulator*. This holds the number upon which the MPU is currently working. Numbers can be transferred between the accumulator and other parts of the micro. While the number is in the accumulator, it can have other numbers added to it, for example, or be operated on in many other ways. Additions and other arithmetical and logical operations are done by the arithmetic logic unit (ALU). This is where the main activity of the microcomputer takes place.

The X and Y registers can also be used for holding numbers, which can be operated on in various ways. A major part of the activity of the MPU consists of passing numbers between the ALU, the accumulator and the X and Y registers. All these operations are supervised by the control circuits. The operations involved are actually very simple. In order to do anything worth while, the MPU has to do very many operations in succession at extremely high speed. To help it work as quickly as possible, the registers are connected to a set of eight lines, known as the *data bus*. Data can be transferred between registers a byte at a time. This bus also goes to the terminal pins of the MPU (via the data bus buffer) and joins to the data bus of the micro (Fig. 1.2). This carries data (numbers or instructions) between the MPU and the other parts of the computer.

The program counter is the register by which the MPU remembers how far it has got in its program. A program with only 256 steps would not be a very extensive one, so this register stores two bytes, allowing it to hold binary numbers up to 65535. The fifth register is the processor status register. The bits held here act individually as "flags" or indicators. For example, one of them is the *carry flag*. When this is "1" it indicates that the result of the previous addition left a "1" to be carried over to the next addition.

The "zero" flag is set to "1" whenever the result of any operation leaves all zeros in the register concerned. Information stored in this register is very useful for certain types of calculation and logical operation.

THE CLOCK

With so many numbers being transferred in and out of the MPU and between the various registers, it is essential that all these operations are synchronised. This is the function of the clock, a crystal-controlled oscillator (Fig. 1.3). The frequency of the crystal is usually several megahertz, so that the time taken by one cycle of operation of the MPU is of the order of 1 or 2 microseconds. This is why the micro is able to perform so many operations so very quickly, which is the key to its apparent cleverness. It is not so much that it can do complicated and clever things, but that it does long sequences of very simple things extremely quickly, without making mistakes.

OP CODES

We have seen that the MPU has the facilities for performing a range of operations on numbers taken into its registers from other parts of the micro, but how does it know which operations to perform? Its instructions are stored in the memory of the computer as a series of bytes. There is more to say about memory later, but let us assume that, when the MPU wants to know what to do next it is able to go to the part of its memory indicated in its program counter register and there find an instruction. It reads this byte in one operation, for the eight bits of it can be transferred to the instruction register of the MPU along the eight lines of the data bus. Let us suppose that the byte it receives is "10101001". Because the MPU is at the stage of its operation when it is looking for an instruction, it interprets this byte as an instruction, not as a number. It puts it in the instruction register. Since this is a coded instruction to the MPU to perform an operation, we refer to this byte as an *op code*. This particular op code tells the control circuit of the MPU that it is to take a number from memory and put it into its accumulator. Which number? Given this op code, the number is to be found stored in memory in the location immediately following that in which the op code itself was stored. So the MPU increments its program counter and goes back to memory and receives the next byte along the data bus. This time it is expecting a number and the byte it receives is put into the accumulator and treated as a number, not as an op code.

Some op codes are sufficient on their own; the code "10011000", for example, tells the MPU to transfer the contents of the Y register to the accumulator. Other op codes are followed by two bytes, both to be taken as numbers. Such a code is the "jump" code mentioned earlier. It is

Any microcomputer *system* requires an input facility (keyboard), a display for output (TV), and some long-term storage medium (cassette or disk).

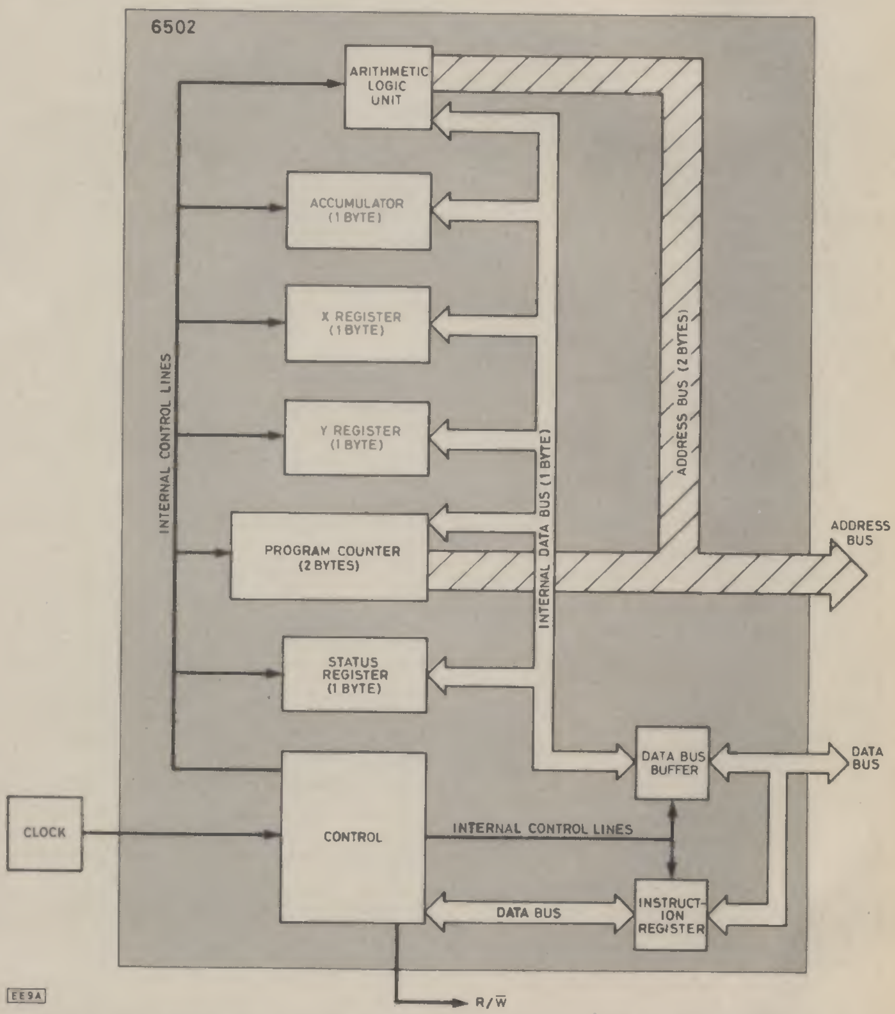


Fig. 1.1. The main sections of the 6502 microprocessor. Arrowheads indicate direction of control, or flow of data.

followed in memory by two bytes, to be put into the program counter, so that the MPU then jumps to the part of memory specified by these two bytes.

From the above, it can be seen that the MPU is programmed by a sequence of bytes stored in a given order in the memory of the micro. Some of these bytes are op codes and the others are numbers. Some of the numbers are values being used in calculations, while others are the addresses of different locations in memory.

ADDRESSING

We have touched upon the idea of addressing earlier, and now will examine it in more detail. If memory is to hold many bytes and the MPU is to be able to take in these bytes as data or instructions, or perhaps send out data to be stored in memory, it follows that it must be possible to identify every location in memory in which a byte can be stored. This identifying number is what is called its *address*. As we have seen, the program counter holds 16 bits, so an address can be any number between 0 and 65535 (Table 1). Each location in memory must be informed when the MPU wants to receive data from it or put data in it. We therefore need a 16-line bus, the *address bus*, to which all parts of the computer's circuits are connected (Fig. 1.2). Each part responds when and only when its own address is present on the bus. When we say that an address is "present on the bus" we mean that the voltages on the 16 lines are "high" or "low" corresponding to the pattern of "1"s and "0"s which make up the address.

The address bus runs from the MPU to all other parts of the micro. In particular, it goes to the integrated circuits which make up memory, and to circuits concerned with the keyboard, the video screen and the input/output ports. We shall deal with all these later, and will also consider how a device knows when its address is on the bus.

READING AND WRITING

The address bus gives the MPU control of the flow of data in the system, for it is only when the address of a given device has been put on the bus that the device can become active. In addition to this bus, the MPU has a number of control lines, collectively known as the *control bus*. One of these lines controls the direction in which data flows—this is the "read/write" line, usually shortened to $R/\overline{W}$. It is a convention that when a line is normally held in the "high" state, but is made "low" for a given action to occur, we draw a bar over the name of that line. The MPU can read from memory when the line is high, and in order to write to memory, it takes the line low.

Next Month: The control of data flow, and how memory is partitioned into areas.

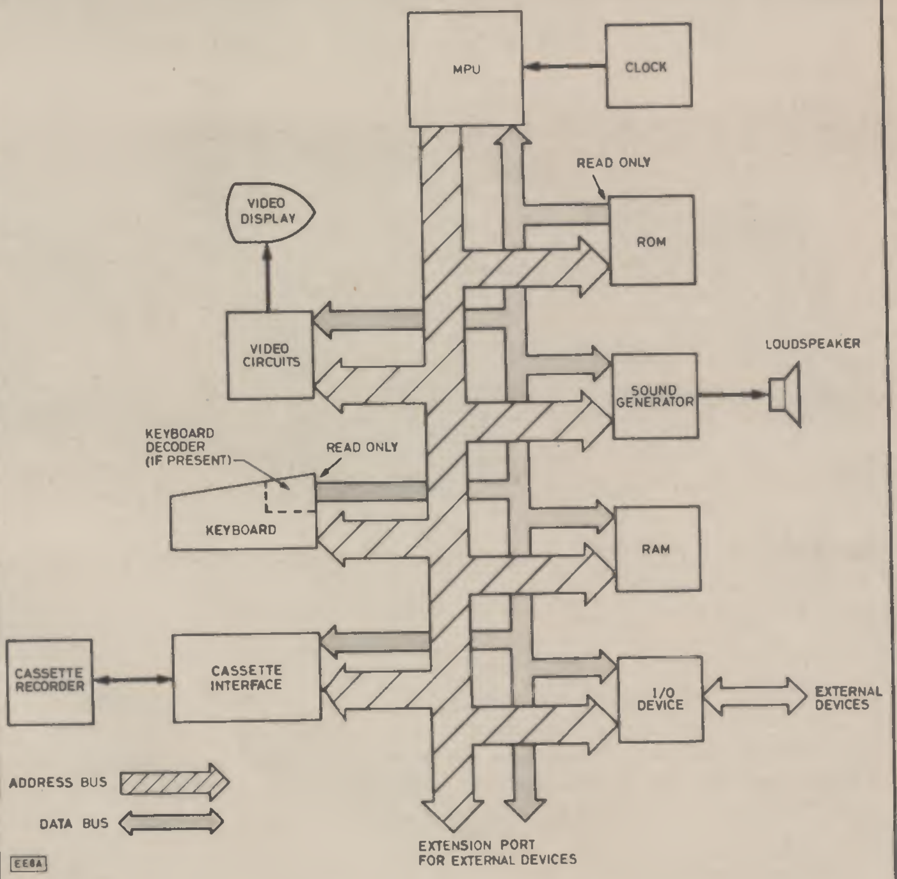


Fig. 1.2. The anatomy of a typical micro.

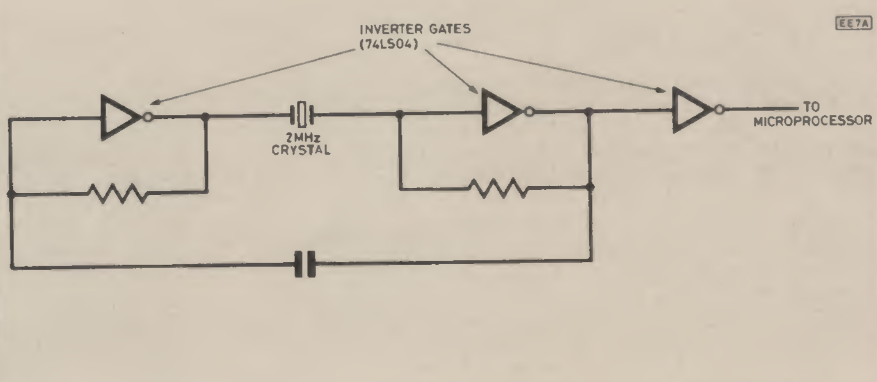
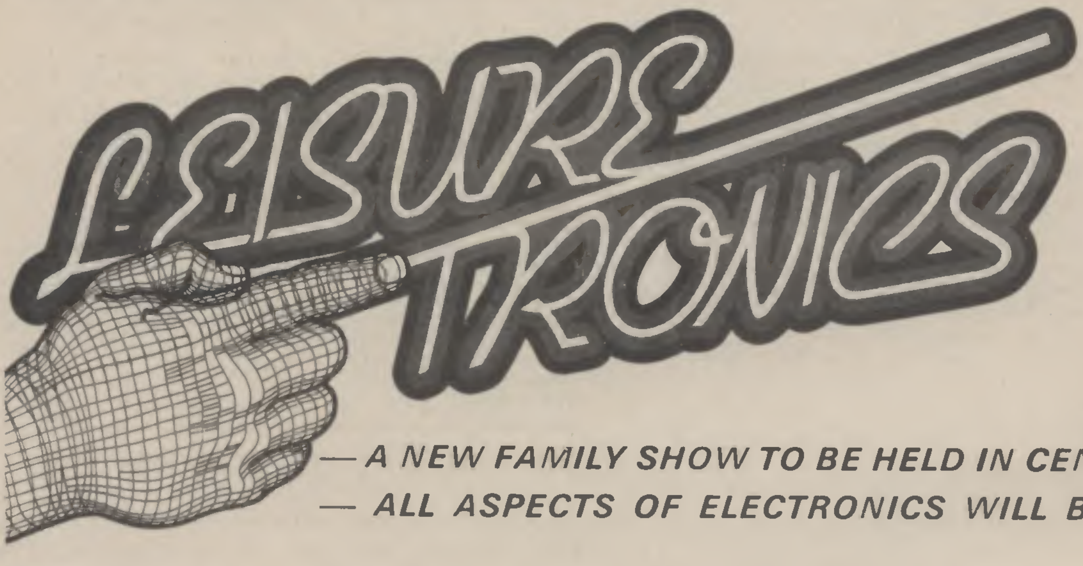


Fig. 1.3. Typical crystal-controlled clock for a microprocessor system.

EVERYDAY news ... from the world of



— A NEW FAMILY SHOW TO BE HELD IN CENTRAL LONDON
— ALL ASPECTS OF ELECTRONICS WILL BE ON DISPLAY

AN important new event has just been announced for the autumn showtime season and EVERYDAY ELECTRONICS, in conjunction with our sister publications, will be there.

Recognising the importance of this new show we have agreed to join forces with other publications and sponsor this exciting addition.

Called ***Leisuretronics***, it promises to be a truly *all* electronics family show that will highlight the impact "amateur" involvement has had on the application of electronics today and also point the way to future developments.

To be held in the heart of London—***8 to 11 November***—at the Royal Horticultural Hall, Victoria; the show will present items from the field of radio controlled models to electronic music; ham radio to hi fi; robots to photography; a synthesiser to satellite broadcasting; and electronic games and computing to disco and light shows.

Special features will be mounted by the organisers to give visitors the opportunity to see the latest developments in most of the above areas in "live" action.

Although this is a completely new event, the Organisers, Trident International Exhibitions have many years' experience in putting on this type of public exhibition. Commenting on the new event, David Timmins of Trident said, "We are confident that Leisuretronics will prove to be an excellent market-place for companies to reach new customers and for the enthusiast to discover and explore new ideas!

"The technology of electronics has brought new life to many leisure-time activities and Leisuretronics aims to combine all elements of the hobby industry into a totally new and imaginative show that will excite and attract a large audience."

Being only a short "bike ride" from Westminster, who knows, perhaps some of the M.P.s, from all parties, might like to come along and see what is really happening in the world of electronics now!

ROYAL AWARDS

Prestel, British Telecom's world-leading communications system has received the Queen's Award for Technological Achievement.

The Queen's Award goes to the Videotex Section of British Telecom's research laboratories at Martlesham Heath, Suffolk and Prestel Headquarters in the City of London.

DESIGN AWARDS

A combined plotter and display system, for several applications, including bank note design, and with a digitiser incorporated for automated cartography, has won a 1984 Design Council award for Laser-Scan Laboratories Ltd. of Cambridge.

Executive Award

Following on from its 1983 Award for the Perfector telex system, STC Telecommunications of Brighton have won the 1984 Award for Executel, a sleek desk-top unit that combines telephone, electronic diary and telex terminal.

RAINBOW TOPS

Claimed to be the world's second largest computer manufacturer, Digital Equipment Co. Ltd. have "loaned" five Rainbow 100 personal computers to assist in the retraining of unemployed and redundant people attending a TOPS course at the South Bank Polytechnic, London.

The course entitled *Information Technology and Salesmanship* aims to teach students to use computer technology and to acquire the associated selling skills. The students are taught BASIC and learn to use four applications packages (provided by Digital), including word processing, accounting, spreadsheet and database functions. During the course the students also complete a project.

Summer School

Nottingham University is the venue for the Information Technology Summer School being run by the Information and Word Processing Association, from 17 to 19 July.

This is the fourth of the annual Summer Schools, for which an excellent reputation has been established. The programmes are specially designed to be of value to delegates from both industry and education, providing a forum where teachers and lecturers can exchange ideas and discuss the latest developments in IT with managers and professionals from the business world.

The summer schools are always popular events and intending delegates would be well advised to book early.

Electromusic Calls The Tune

The British company, Electromusic Research has just produced its first MIDI package for the BBC Computer.

Miditrack is a manual (step) input program that enables music composition on up to six tracks, with full memory assignment of 7500 notes for the number of tracks selected.

Each Miditrack will store details of note pitch, dynamics, length and style as well as voice change and other parameters. Traditional note input is entered from the BBC B keyboard in order to avoid coding unfamiliar to the musician. Full on-screen editing features are included.

Quality Offer

In support of the National Quality Campaign, The British Standards Institution is now offering its well-known Handbook 22 Quality Assurance at a special price of £8 per copy. This offer is made possible through the help of the Department of Trade and Industry who want to see this publication in the hands of as many British companies as possible. The Handbook is usually priced at £78 to non-members of BSI and £39 to members.

The number of copies available on this special offer is limited and buyers are urged to place orders as swiftly as possible. They should send cash with order to BSI Sales Department, Linford Wood, Milton Keynes, MK14 6LE.

Orders should be submitted on official company headed paper, signed by the chief executive, and cheques should be made payable to the British Standards Institution.

Colchester based microcomputer company Dataview is participating in Britain's first International Garden Festival in Liverpool.

Dataview has joined forces with Stack Computers of Liverpool to display the latest developments of the microcomputer industry.

The London Borough of Ealing will become the first user of a new leisure activity booking system launched by Quota Computer Associates Ltd.

INMOS has appointed Celdis Italiana SpA as their distributor in Italy. A member of the successful UK based Unitec Group, Celdis Italiana, is the leading high technology components and systems distributor with offices throughout Italy.

Computer Calls

British Telecom have announced that they are to go ahead with a major computing development programme to provide new business information systems for use in its local offices.

The new system, to be known as customer service systems (CSS), will be fully integrated and controlled locally. Each district will have its own computing centre, and there will be about 30 in all.

The initial systems development will be undertaken by a joint team of BT and Logica staff with support from McKinsey and Co.

THE PEOPLE'S COMPUTER

The hi-fi and television manufacturers, Amstrad have launched what they call "The People's Computer" claiming that it will bring the home computer within reach of almost every family in the country.

The subject of this claim is called the CPC464; a complete system priced at £229 and featuring a built-in cassette recorder, its own monitor, 64K of RAM and just one mains lead: the power supply for the computer is in the monitor.

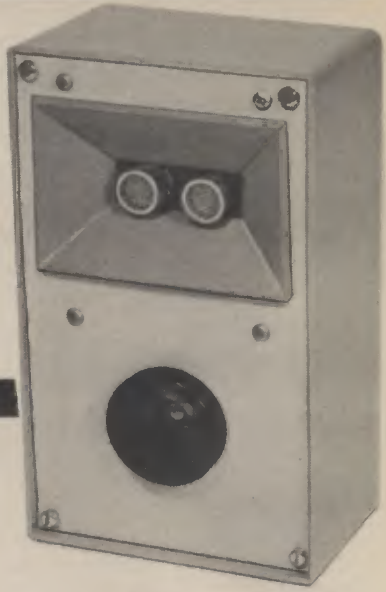
There will be four models in the CPC464 range: System 1, keyboard with built-in cassette and green monitor (£229); System 2, keyboard and a colour monitor (£329); System 3, keyboard, disc drive and green monitor (£429); System 4, keyboard, disc drive and colour monitor (£529).

All models of the CPC464 will be available from traditional stockists like Rumbelows, Dixons, Comet and Boots.

ULTRASONIC BURGLAR ALARM

I.F.H. GOULT

Part 2 of the Surveillance series



THE Ultrasonic Burglar Alarm has been designed to provide a simple low cost unit which is self-contained, operating from an internal battery. Any person crossing the ultrasonic beam will trigger a screeching piezo-electric sounder mounted in the unit. A relay may be used instead of the sounder to operate an alternative alarm.

The unit is designed to be placed across the access to a room, or across the hallway or stairs. By careful placing it can be arranged that household pets will not trigger the alarm. A beam-break device also has the advantage of enabling movement in other areas away from the guarded access.

Being portable it could also be used to prevent unwelcome visitors in your hotel room when on holiday, without inhibiting your own movement within the room. The unit also illustrates many basic electronic principles, each of which is fully explained in the following circuit description.

Its range is deliberately limited to around two metres, for use across a doorway or landing, in order to eliminate the possibility of false alarms.

CIRCUIT DESCRIPTION

The circuit diagram is illustrated in Fig. 1. First, the transmitter. IC2 contains four CMOS NOR gates. Two of these are connected as a multivibrator oscillator. VR1 is adjusted to set the frequency of oscillation to 40kHz. The output from the multivibrator is connected to the two remaining gates as illustrated. An ultrasonic transducer is connected between these two gate outputs. When one output is positive the other is negative and vice-versa. Hence the transducer has a signal applied to it alternating at 40kHz. A metallic diaphragm in the transducer vibrates at the input frequency to create air pressure waves at the ultrasonic frequency of 40kHz, in a similar manner to a loudspeaker producing pressure waves at audio frequencies. The geometry of the transducer radiates these waves in a narrow beam. If the input to pin 1 of IC2 is maintained at logic state 0, i.e. zero volts, oscillation will be continuous. If input is allowed to go to logic state 1, i.e. a positive potential, the gate will give no output and oscillations will be inhibited. In order to conserve battery life, the oscillator and hence the transducer is pulsed on for a small period a few times a second.

IC1 consists of four semiconductor switches with high input resistance on-off control. Two of these switches are interconnected to form an astable multivibrator. Capacitor C14 is alternatively charged and discharged by switches b and c.

Resistors R25 and R23 in conjunction with C14, control the recovery time for this capacitor. This is best understood by reference to the waveforms a, b, and c in Fig. 2. Resistors R23 and R25 are chosen to give a negative pulse to provide logic 0 (zero volts) to the input pin 1 of IC2 for a period of one millisecond, seven or eight times per second. This enables a burst of oscillations and consequent transmission during this pulse period.

RECEIVER & AMPLIFIER

If the unit is placed facing an opposite wall or door, the ultrasonic waves will be reflected back to the receiving transducer. This acts in a similar manner to a microphone. A metallic diaphragm in the transducer produces an electrical output at the frequency of the received signal. This 40kHz signal is amplified by transistors TR1, TR3 and TR4, each operating at a very low current—a fraction of a micro-amp base current and about 10 micro-amps collector current. This low current operation enables series operation due to the comparatively high input resistance of the base. Battery drain is also minimised.

A parallel resonant circuit is introduced between the second and third amplifiers and presents a high impedance to 40kHz, but cuts down all other frequencies. This reduces circuit noise and inhibits low frequency transient signals from banging doors and other similar sources of mechanical vibration.

Emitter follower TR9 provides a low impedance drive for both the amplitude detectors. Assuming switch a of IC1 to be closed, the signal detector diodes D3 and D4 will rectify the signal to give a negative d.c. potential at the gate of the field effect transistor TR2.

The d.c. level will be dependent on signal amplitude. TR2 acts as a variable resistance. The more negative the gate the less current is allowed to pass from source to drain and hence the greater is the apparent resistance between the source and drain for a given voltage. Increasing the effective resistance of TR2 lowers the gain of the amplifier TR1. This automatic gain control sets a constant signal level at the output of TR4 independent of the average received signal level. The comparatively large capacitor C4, together with the 10MΩ resistance R11, ensure that once the AGC level at the gate of TR2 has settled, subsequent to switch on, it will not respond to fast changes of signal level. The time constant at the gate is the product of C4 and R11 which is 47 seconds.

A second signal level detector is formed by the transistor TR5. TR5 pumps current into C10 for each positive cycle of the 40kHz signal enabling C10 to become positively charged. Diode D5 prevents the mean d.c. voltage at the base of TR5 from going negative. The positive potential at C10 will remain constant provided the signal level is constant.

SPECIFICATION

Compact and portable self-contained unit.
Battery operated.
Effective Range: 3 metres.
100dB alarm sounds when intruder crosses protected zone.
Alarm resets after sounding for one minute.
Alternative relay may switch external load.

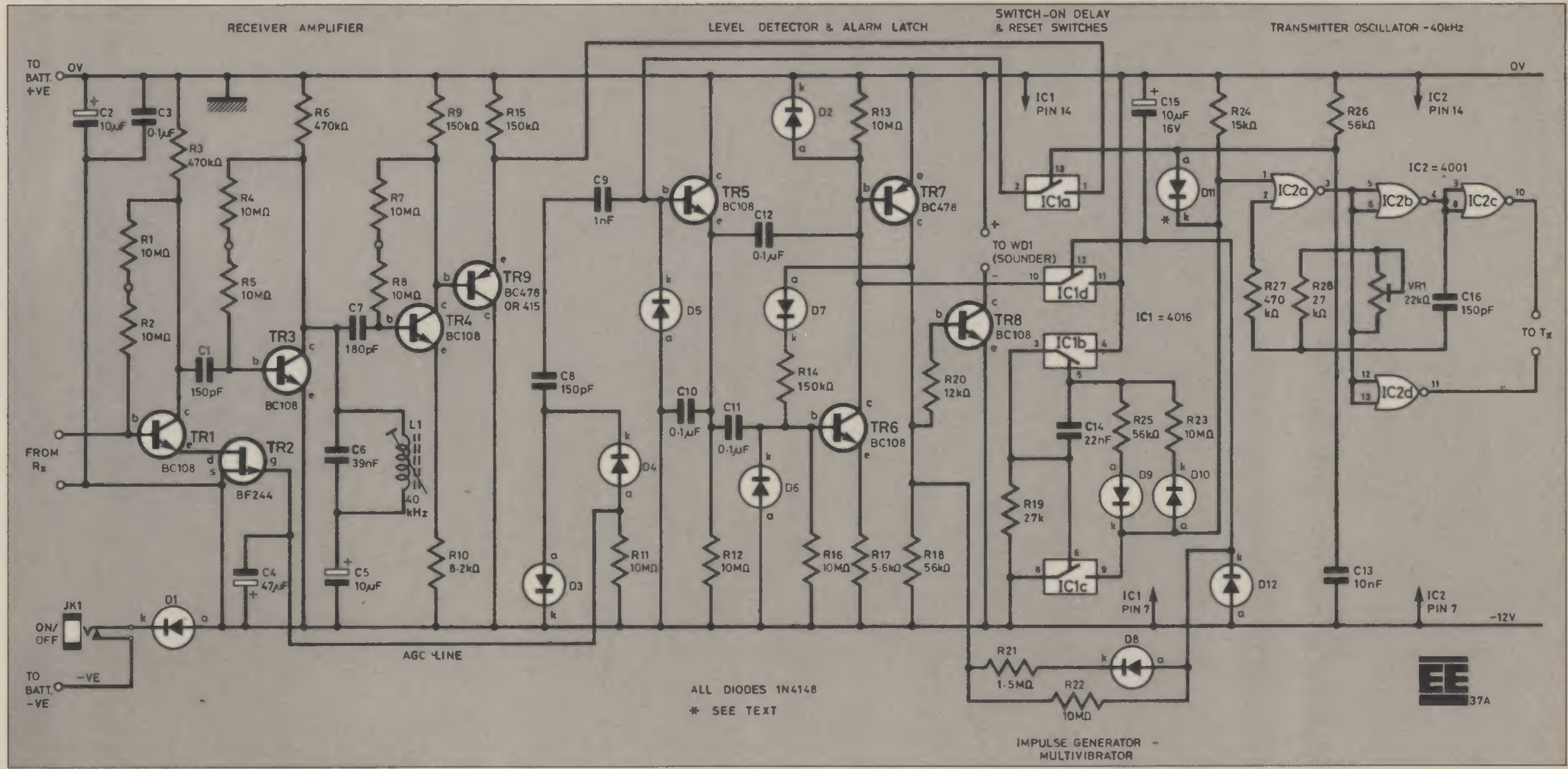


Fig. 1. Complete circuit diagram for the Ultrasonic Burglar Alarm. References Rx and Tx are the receiver and transmitter transducer input/output points.

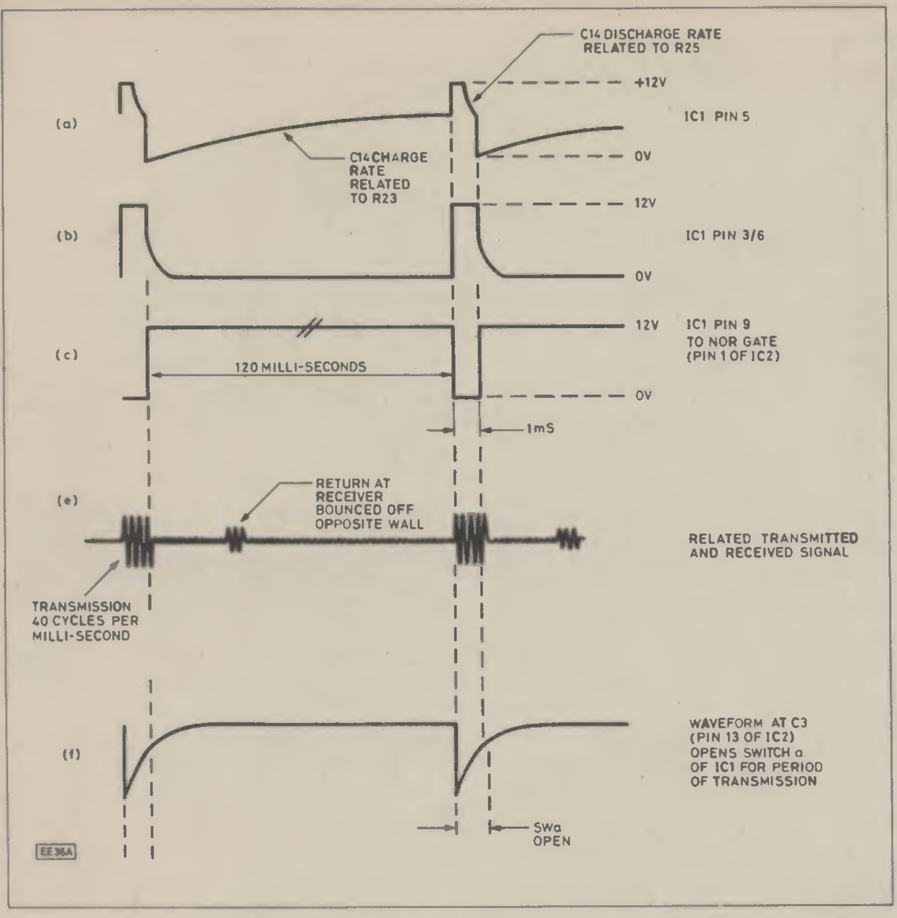


Fig. 2. Timing diagram of the Ultrasonic Burglar Alarm.

A change in signal level due to the disturbance of the ultrasonic beam will change the positive potential on C10, which in conjunction with R12 has a time constant of only one second, allowing change of signal level to give a change of voltage on C10 before the automatic gain control, with its longer time of response, is able to change.

It is important that the detectors respond only to the received pulses and not to the transmitter pulse, part of which leaks directly into the receiver. Hence the detectors are cut off from the amplifier output by switch a of IC1 during the transmission period. The waveform diagram, Fig. 2 shows the various switching sequences of switches a, b and c.

ALARM LATCH

When there is a stable d.c. level on C10 there is no changing signal applied via C11 to either TR6 or TR7. There is no base current applied to either transistor and they both remain cut off. The collector of TR6 is at the positive supply voltage and the collector of TR7 is at the negative supply voltage. There is therefore no current drive to the alarm output transistor TR8.

Should there be an increase of level on C10 due to an increased received signal resulting from reflections from a person between the unit and the reflecting surface, this will be applied via C11 to the base of the *npn* transistor TR6 causing it to conduct, supplying base current to the *pnp* transistor TR7, which will also conduct. The collector of TR7 will move positive supplying current through diode D7 to the base of TR6 holding both transistors in their conducting state. The positive potential at TR7 collector switches on transistor TR8 to provide a continuous current through the sounder or relay coil.

A reduction in signal level will switch on TR7 by applying a negative going signal onto its base. The resulting positive potential on the collector will switch on TR6 via diode D7 to latch on the alarm.

TIMING CIRCUITS

When the alarm is triggered and latched, TR7 is conducting; voltage at its collector is positive. C15 will slowly charge positively through R22, the time constant of C15 R22 being 220 seconds. C15 will have charged sufficiently positive to activate switch d of IC1 in approximately one minute. Closure of switch d connects TR7 base to its emitter, switching off the current through TR7 and consequently switching off TR6 and the alarm driver TR8. The collector of TR7 returns to zero volts. C15 will now discharge towards zero volts through D8, R21 and R18 in series; after a few seconds switch d will open allowing the alarm latching circuits to respond to any further variations of received signal.

COMPONENTS

See **Shop Talk** page 434

Resistors

R1,R2,R4, R5,R7, R8,R11, R12, R13,R16, R22,R23	10MΩ (12 off)
R3,R6, R27	470kΩ (3 off)
R9,R14, R15	150kΩ (3 off)
R10	8·2kΩ
R17	5·6kΩ
R18,R25, R26	56kΩ (3 off)
R19,R28	27kΩ (2 off)
R20	12kΩ
R21	1·5MΩ
R24	15kΩ

All resistors $\frac{1}{3}$W carbon film ±5%

Potentiometers

VR1	22kΩ

Capacitors

C1,C8, C16	150pF metallised ceramic plate (3 off)
C7	180pF metallised
C2,C5, C15	10µF/16V tant. bead (3 off)
C4	47µF tant. bead
C3,C10, C11,C12	100nF monolithic ceramic (4 off)
C6	39nF polycarbonate
C9	1nF monolithic ceramic
C13	10nF monolithic ceramic
C14	22nF monolithic ceramic

Semiconductors

D1–D11	1N4148 (11 off)
TR1,3,4, 5,6,8	BC108 or BC238 (6 off)
TR2	BF244
TR7	BC478
IC1	4016
IC2	4001

Miscellaneous

L1	TOKO coil type CAN1A350ER (Ambit)
JK1	2·5mm chassis socket as switch (use jack plug as keyswitch)
Rx	40kHz ultrasonic receiving transducer
Tx	40kHz ultrasonic transmitting transducer
X1	Sounder X70 W06 (from Avionics)
Relay (optional)	12V (Ambit No. 46-70050)
Battery holder	(Ambit No. 01-06108)

Battery connector for PP3
14-pin d.i.l. i.c. sockets (2 off)
P.c.b.
Plastic box with metal panel (150 × 90 × 50mm) (Ambit No. 2192751)
Fixing screws for p.c.b. (4 off)

Approx. cost Guidance only **£17.00**

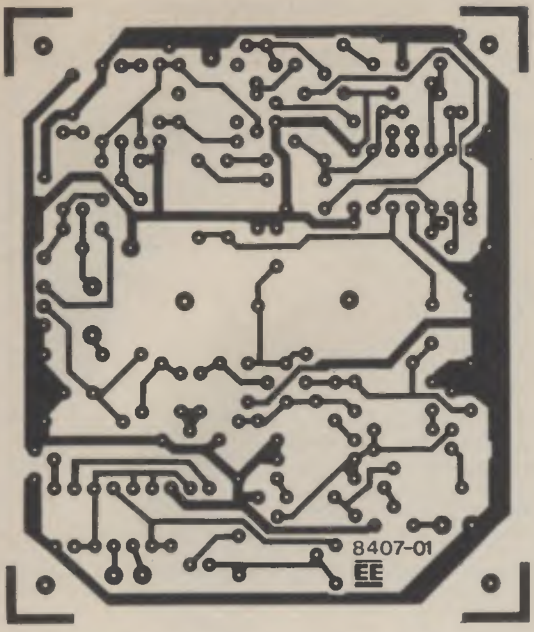


Fig. 3. Actual-size master pattern for the Ultrasonic Burglar Alarm. This board is available from the *EE PCB Service,* Order code 8407-01.

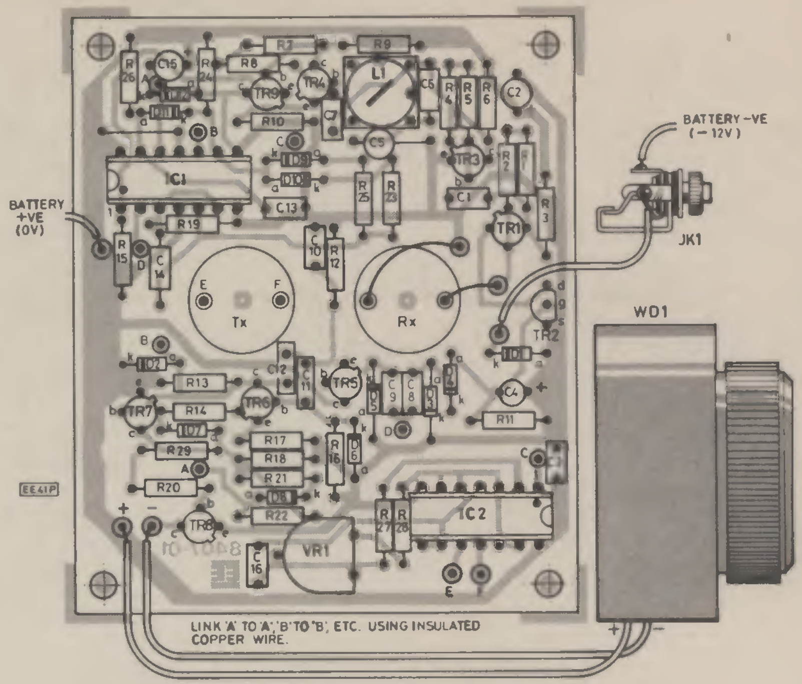


Fig. 4. Layout of components on the topside of the p.c.b. and interwiring to the jack socket/switch and warning device.

Switch d also inhibits the operation of the alarm latching circuits for about 30 seconds after initial switch-on, allowing the signal level to settle to its steady state. The negative terminal of C15 is initially positive on switch-on. This holds switch d closed to prevent TR7 conducting and latching on the alarm. C15 discharges to zero voltage through D8, R21 and R18 in series allowing switch d to open, and the detectors to activate the alarm latch circuits for any variation of received signal level.

CONSTRUCTION

MAIN CIRCUIT BOARD

Construction of the main circuit board is relatively simple using the printed circuit board in conjunction with the illustrated layout. Care should be taken to see that the diodes are all inserted with the correct polarity, i.e. the cathode, which is marked with a bar on the diode is connected into the position marked +. Note also that IC1 and IC2 are MOS devices. They should be handled with care, removed from their packing and mounted directly into their respective IC mounts.

Electrostatic discharge can damage TR2. Before applying the soldering iron to TR2 the iron should be disconnected from the mains or other power source so that it is completely isolated. It should be momentarily touched onto the earth track (0 volts) before being applied to the pins of TR2. It would also be advisable to mount TR2 before mounting C4 and to ensure that C4 is completely discharged by shorting its leads together just before mounting. An isolated iron should also be used when mounting the other two components connected to the gate of TR2, namely R11 and D4—it would be preferable to mount R11 before mounting TR2.

POWER

The unit runs from a 12 volt battery supply. Current consumption on standby is about 400μA. Using eight MN 1500 alkaline batteries this should give standby operation of around 2,000 hrs. Battery consumption is increased by about 100 times during alarm and it is therefore important, once satisfactory operation is established, to minimise the test time.

The tag on the screen of coil L1 on the inside of the p.c.b. should be cut off. The transducers should be cemented into the holes provided, again care being taken to ensure that the transmitter and receiver are correctly connected. They should stand proud of the p.c.b. the base with the two terminals being flush with the component side of the board. It is recommended that they are assembled into the front panel as illustrated. The 45 deg. inset prevents ultrasonic energy being reflected from objects alongside the unit.

Internal view of the Ultrasonic Alarm, showing the large piezo electric sounder, p.c.b. mounted directly on the front panel, and the miniature jack socket which can be used as a "disarm" switch by the holder of the plug.

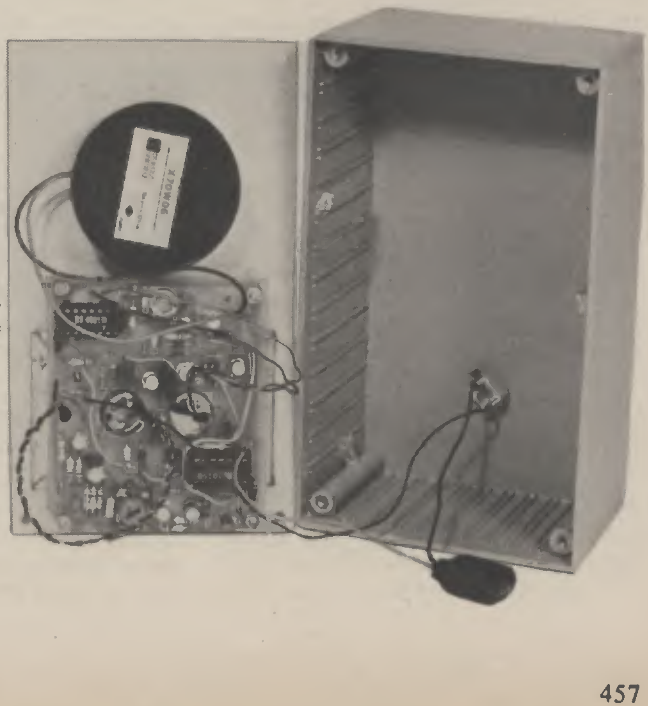
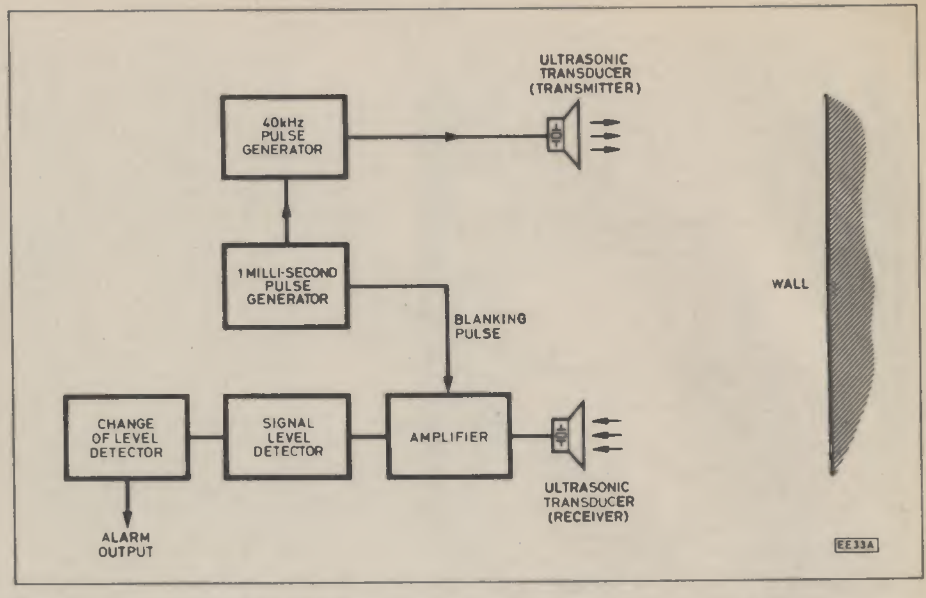


Fig. 5. Block diagram of the Ultrasonic Burglar Alarm. This type of alarm has a limited range. This particular unit is directed primarily at the educational application.



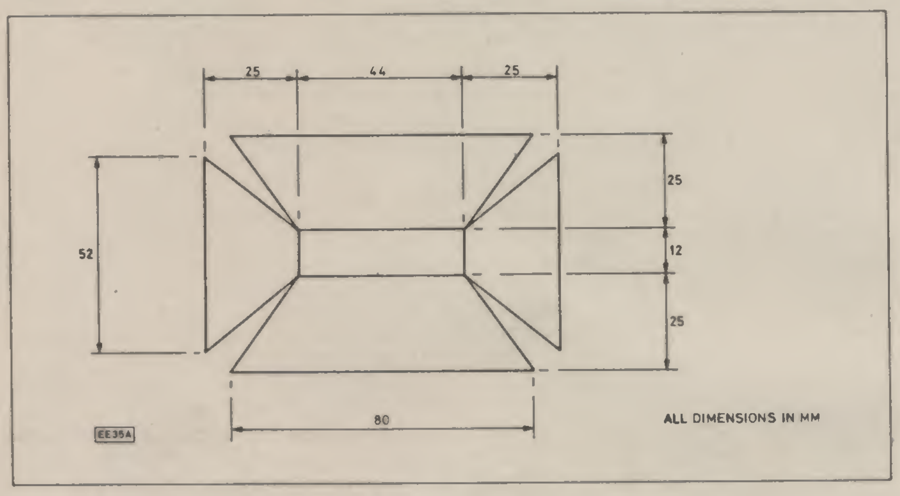


Fig. 6. Window, or horn for the transmitter/receiver aperture. This could be made of stiff card or plastic sheet.

To save the cost of a key on-off switch a 2·5mm jack socket is proposed; the unit is switched off by inserting the jack plug. Front panel cut out and drilling dimensions are shown for the box proposed in the parts list. If the relay is used instead of the sounder, no hole is required and the relay may be glued to the sounder position. The relay coil is connected to the alarm output and the relay contacts may be brought out through a DIN connector, or jack plug and socket.

OPERATION & SETTING UP

The use of an oscilloscope is recommended for setting the transmitter and receiver frequencies. An alternative procedure is described in case an oscilloscope is not available.

USING AN OSCILLOSCOPE

Temporarily remove IC1. Connect the earth of the oscilloscope to the supply line. Using Y1 input, observe the signal waveform at the output pins 10 and 11 of IC2. This square wave output may be set to 40kHz by adjustment of VR1 to give a period of 25μs for one complete cycle.

Alternatively place the unit approximately one metre from a reflecting surface. Observe the waveform at the collector of TR1. Adjust VR1 to give maximum signal. This will be at the optimum operating frequency of the transducers, namely 40kHz.

TUNING

The coil L1 may now be tuned. Observe the waveform at the emitter of TR8. Adjust the ferrite core of L1 to give a maximum output as observed on the oscilloscope. Fit IC1. Synchronise the oscilloscope using the waveform at pin 9 of IC1. Note waveforms as illustrated in Fig. 2a, b, e and f.

The received signal pulse level at the detectors will now be constant at about 3–4 volt peak-to-peak, this level being determined by the automatic gain control. The effect on level can be noted by pointing the unit at various reflecting surfaces. Note that it is not possible to tune the transmitter and receiver when the a.g.c. is in operation.

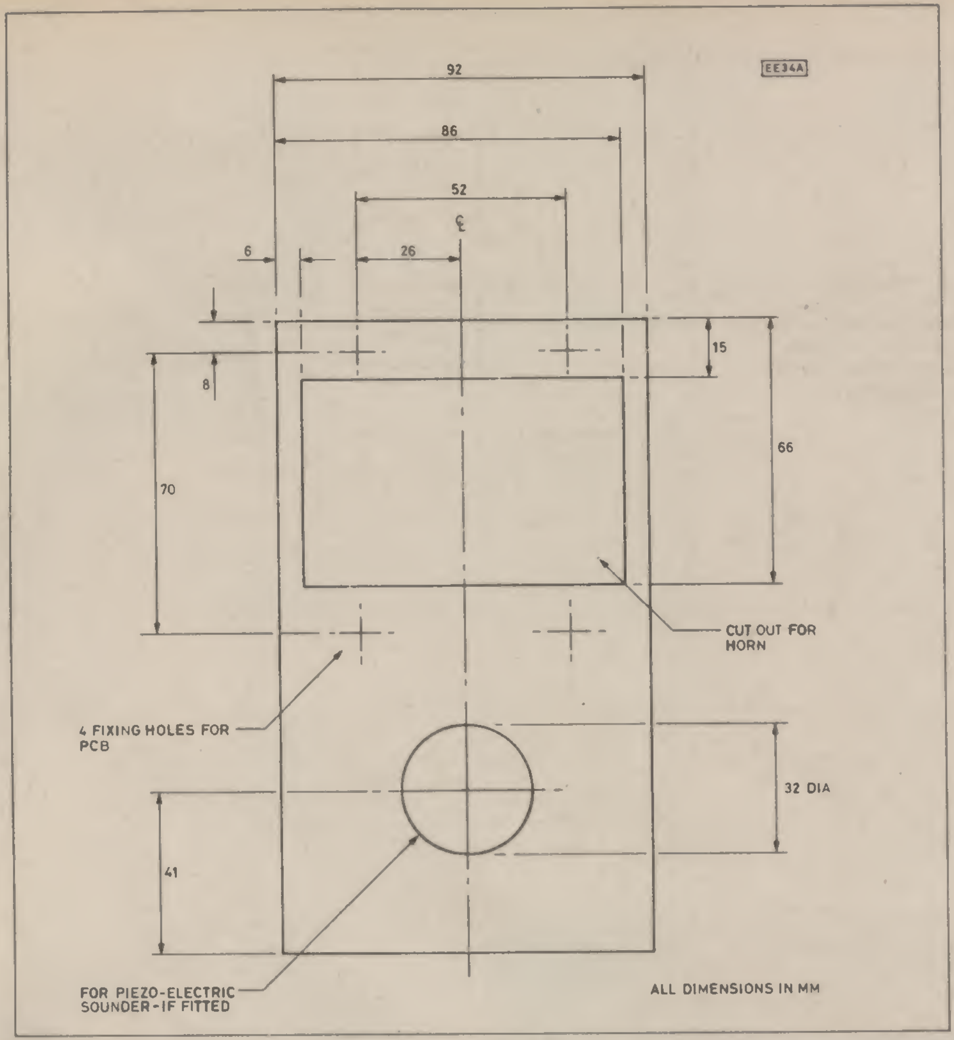
SETTING WITHOUT AN OSCILLOSCOPE

Temporarily remove IC1. Place unit about a metre from reflecting surface. A high resistance voltmeter on the a.g.c. line (negative end of C4), referenced positive clip to GND (0V) will facilitate adjustment alternately of VR1 and L1 for maximum reading. After refitting IC1, a fine adjustment of VR1 and L1 may be necessary. The unit will need to be fairly close to a reflecting surface to obtain a reasonable reading on the a.g.c. line.

SITING

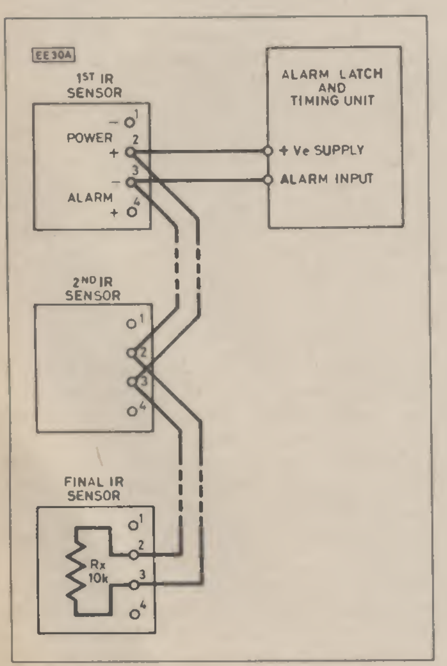
Ideally the unit should be sited with an uninterrupted "view" of the opposite wall or closed door. Range is deliberately limited to a couple of metres for reliability. Beyond this distance there will be a passage near the wall where the reflection from a body will be neither more nor less than that from the wall allowing a "gate" through the beam. A radiator or window directly opposite the unit will cause fluctuations of the received level due to reflections from air of different density and should be avoided. □

Fig. 7. Front panel cutting details.



INFRA-RED ALARM

ADDITIONAL NOTES

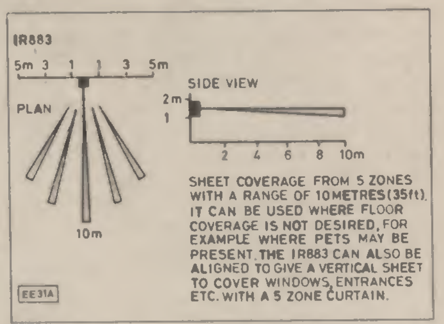


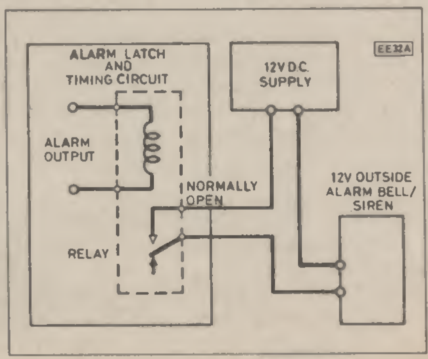
The *Infra-red Alarm System* published last month can incorporate several sensors connected to a single alarm latch unit. Here are some notes on how to do this, and a couple of additional notes on the system's use.

Any number of additional IR Sensors can be added to give greater coverage of the protected premises. The sensors may be wired in parallel but it is recommended that they are wired in sequence as illustrated. Only one resistance Rx should be used. This should be connected to the last sensor in the sequence, then if any of the connecting wires are cut the alarm will be triggered.

An alternative IR Sensor for use with household pets, IR 883, limits the sensitive zones to approximately 3ft. provided it is sited at a height of 3ft. 6ins. or above. The limit of the sensitive zone will have to be established by trial and error, tilting the sensor slightly as necessary.

The alarm system may be used to set off an outside alarm or siren. The relay specified in the components list has its coil connected to the alarm output as illustrated. The relay contacts act as an ON-OFF switch, switching the 12 volt d.c. supply to the outside alarm when the alarm and latching circuit is triggered.





NEW · NEW · NEW · NEW PRODUCTS NEW · NEW · NEW · NEW

BENCH POWER

A FAMILY of four high performance bench power supplies, the GPL series, has been introduced by **Gresham Powerdyne.** The series offers a choice of single, dual and triple output models featuring excellent voltage and current regulation.

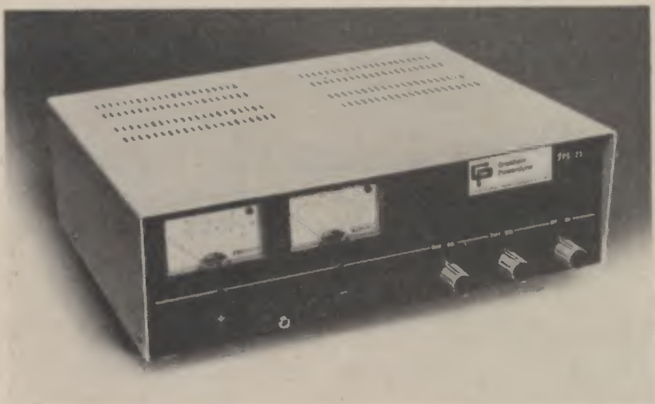
The smallest model in the series is the GPL 20, a lightweight unit offering a variable 0V to 30V at 1A maximum output plus a fixed 5V output (1A max). It also features variable current limiting.

The GPL 23, a triple output unit, features two independent variable outputs each of 0V to 30V (2A max) with a choice of constant current or constant voltage modes. In addition, it has a fixed 5V, 3A output rail facility.

Although it is a single output instrument providing 0V to 40V at up to 1A, the model GPL 25 features variable current limiting and two front panel meters for simultaneous indication of voltage and current. Largest unit in the series is the GPL 28, which offers a single 0V to 60V, 2A output with dual tracking (0V to 30V, 2A) facilities as standard.

Further technical details of the complete range of Gresham power supplies can be obtained from:

Gresham Powerdyne Ltd.,
Dept EE, Osborne Way,
Station Road, Hook, Hants.



DIGITAL PANEL METER

THE DPM60 digital panel meter from **Lascar Electronics** features liquid crystal display, auto-zero, auto-polarity, and a logic switched 200mV or 2V f.s.d., giving a resolution of 10μV. Other features include programmable decimal points, digital hold, low battery indication, continuity indication and a 10mm 4½-digit high contrast l.c.d. readout.

The panel meter can be readily scaled by the user to indicate amps, volts, ohms and other units. Supplied complete with mounting bezel, clips and connector, it will suit many applications in portable and bench instruments.

The DPM60 is available in kit form and costs £29.95 inclusive. More information can be obtained from:

Lascar Electronics Ltd.,
Dept EE, Module House,
Whiteparish, Salisbury,
Wilts SP5 2SJ.

SLIMLINE SCOPE

THE new V-222 oscilloscope from Hitachi is a 20MHz dual-trace model incorporating a 6in rectangular c.r.t. in an ultra-lightweight slimline format and is being marketed by **Reltech Instruments.**

An alternate sweep magnifier enables any section of a waveform to be expanded ten times and displayed simultaneously with the un-magnified signal. A d.c. offset control and offset measurement socket allow a digital voltmeter to be used to monitor voltages on the screen, whilst a low impedance signal output socket enables a frequency meter or counter-timer to be connected.

The 'scope has a sensitivity of 1mV/cm and a maximum sweep speed of 20nsec/cm. Fully variable gain and sweep rate controls have un-calibrated warning lights to avoid accidental measurement errors. Full *XY* mode and *Z* modulation facilities are provided.

The V-222 oscilloscope comes complete with two ×1, ×10 switchable probes. Price in the UK is £340 plus VAT, a lower specification version is also available at £295 plus VAT.

Reltech Instruments,
Dept EE, Coach Mews,
St. Ives, Huntingdon,
Cambs PE17 4BN.

KIT TIME

THREE new kits have recently been announced by **Vellerman (UK) Ltd.** They are a microprocessor Precision Timer K2584, a Codelock K2585, and a Programmable controller Module K2591.

The Precision Timer, which includes housing, transformer and sheet keyboard, has four programs which can vary from one second to 99 minutes 99 seconds. The timer counts down to zero and activates the output which can also be manually switched on or off.

Running programs can be stopped, interrupted or continued. This makes the unit ideal for dark room timing, process control and light control.

The Codelock has two memory levels, each level capable of storing 20 numbers of six digits. The memory contains a CMOS RAM, which is fed by a battery in case of power failure. All the numbers therefore, are retained even if a mains failure were to last a month.

The codelock has a sheet keyboard as a front panel and its applications include: protection of machines, protection of rooms where only authorised personnel may enter, entry systems for flats, offices and homes, and burglar protection in general.

The Programmable Controller Module is designed to control measurements of temperature, humidity, acid and chlorine levels. It has a 24-hour clock, four programmable registers and a display for the input signal.

The input signal can be made up of an analogue voltage from 0 to 999mV d.c. This measure value reads and displays by the means of an A/D converter and an interface with the central processor.

The module compares the input signal with the values which are programmed in the memory, and switches on an output relay. Switching occurs with a precision of 10mV to the input signal.

Full technical details and prices are available from:

Vellerman (UK) Ltd.,
Dept EE, PO Box 30,
St Leonards-on-Sea,
East Sussex TN37 7NL.

ELECTRON ADD-ON

A SWITCHED joystick interface for the Electron microcomputer has been developed by **First Byte Computers**, and should be available now from good High Street retailers.

A free conversion tape is supplied with the interface, to allow games such as "Killer Gorilla" and "Cyclon Attack" to be played under joystick control. Also, major software houses are now writing games programs intended for use with this add-on.

The plug-in cartridge takes all standard "Atari-Style" joysticks, which are cheaper and more popular than analogue joysticks.

FBC intend to launch an extensive advertising campaign, and to demonstrate the new interface at home computer shows during 1984.

FBC Ltd,
Dept EE,
10 Castlefields,
Main Centre,
Derby.

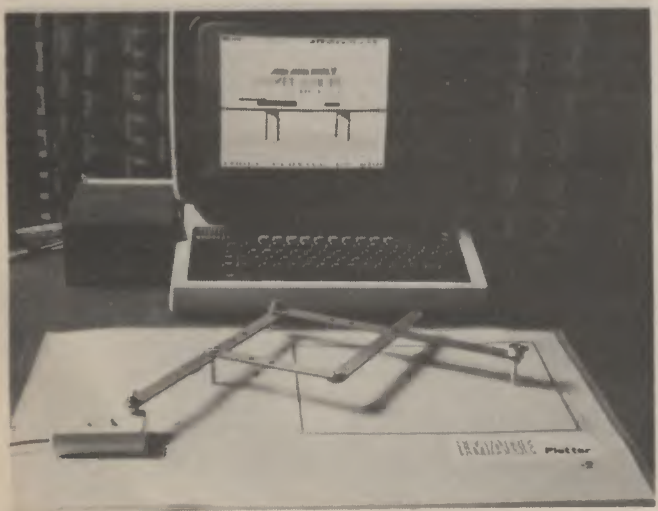
PANTOGRAPH FOR THE BBC B

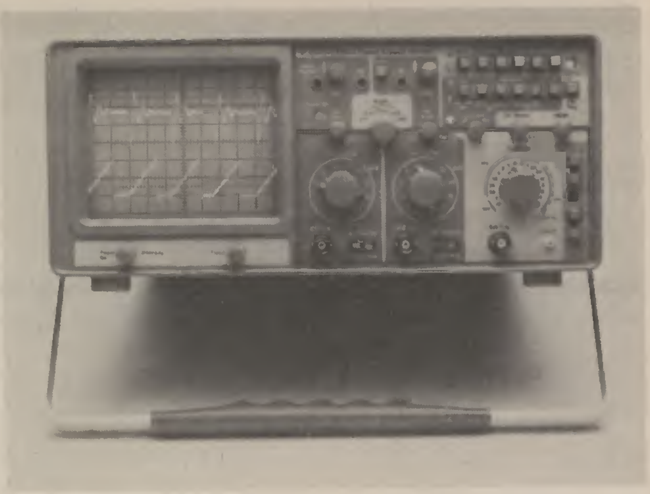
A NEW add-on for the BBC model B allows the reproduction of drawings, maps, and diagrams at an affordable price. The Image Plotter comes with calibration sheet and handbook and has a recommended retail price of £49.95.

Even the most complex shapes can be enlarged or reduced, and shown in any colour. If a printer is available, a hard copy can be made, or the image can be stored on disk or cassette.

The plotter comes ready assembled, is made of aluminium, and software is available on disk or cassette. Available at present through mail order only.

Reekie Technology Company,
Dept EE, Beaufort Road,
Off Richmond Road,
East Twickenham,
Middlesex TW1 2PH.





DIGITAL STORAGE OSCILLOSCOPE

ALL the facilities of a 20MHz dual-trace oscilloscope with the option of switching into digital storage mode; this is the latest offering from **Gould Instruments**, called the OS1400 series.

Gould claim it is the first instrument of its type to retail at under £1000, and point out that it is entirely U.K.-designed and manufactured.

Used as a normal oscilloscope, the 1400 has continuously variable sensitivity from 2mV/cm to 25V/cm, and timebase variable from 0·5μs/cm to 0·2s/cm.

In storage mode, the OS1400 can sample at rates from 0·5s per sample to 0·5μs per sample, and there are three display modes. Pre-trigger viewing of from 0% to 100% of the display is available in roll mode, and the display can be expanded by ten times after storage.

Gould Instruments Ltd,
Dept EE, Roebuck Road,
Hainault,
Ilford,
Essex.

60 WATT MOBILE AMPLIFIER

BAKER Loudspeakers Ltd, announce the addition of a new mobile amplifier to their comprehensive range of disco/public address equipment.

With the accent on portability this amplifier weighs only 12 pounds and measures only $15\frac{1}{2}$ × $8\frac{1}{2}$ × 6 inches yet can deliver 60 watts R.M.S. into 4 ohms with distortion less than 2% at full output. A special feature is it's ability to operate from a 12 volt car battery if the normal 200/240 volt mains supply is not available or added safety is required in an outdoor location.

Housed in a robust case that is both attractive and functional the unit has four separate volume controls (for 4 channel mixing) plus a master volume control, a mains switch and bass and treble controls that give a wide ±10dB variation over the 80-12KHz ±3db claimed frequency response. Four high gain inputs are provided (3 at 20mV 50KΩ plus magnetic phono 3mV) and two standard jack socket loudspeaker outlets for 4, 8 or 16 ohms plus terminals for 100 volt line.

This English made amplifier is fully protected against short and open circuits and is guaranteed for 12 months. The unit costs £89 (plus £3 if ordered by post), including VAT.

Baker Loudspeakers Ltd.,
337 Whitehorse Road,
Croydon,
Surrey.
01-684 1665

RADIO WORLD

BY PAT HAWKER G3VA

New licences

During the past few months nearly 4000 amateur (Class B) licences have been issued in the UK with the new "number one" in the callsign (G1AAA, etc.) plus a lesser number of "G4" Class A licences. This is a remarkable indication of the current interest in the hobby.

Less easy to determine is the number of enthusiasts who, after going to the trouble and expense of obtaining a licence, either fail to renew it a year or two later, or else retain their licence but put their equipment away and thereafter make few appearances on the bands. Certainly the drop-out rate is much higher than it used to be, and appears to be higher among Class B operators than those who, after taking a Morse test, are free to use h.f. as well as v.h.f. bands.

In the UK you can get a good idea how long an amateur has held his present licence from his callsign. Most of those with personal "two-letter" callsigns, such as mine, date back to the 1930s or even 1920s. There are a few exceptions since close relatives can apply to take over a callsign and sometimes a club will seek and obtain the callsign of a prominent former member.

Two-letter callsigns with a GB prefix are allocated to repeaters. A "G2" (plus three letter) callsign similarly dates back to 1939 or earlier when these call-letters were issued to persons holding what were called "artificial aerial" licences, permitting holders to build and experiment with transmitters provided that they did not connect an aerial.

The G-Men

The "G3" (three letter) callsigns began to be issued in 1946 and the sequence was completed in 1971, reaching the G3N series roughly 25 years ago in 1958 to 1960. The "G4" (three letter) series began in 1971 and is not yet exhausted but has now reached the G4X sequence.

The first Class B licences in 1964 started with the "G8" (three letter) series (at first these licences covered only 430MHz and above, and there was limited demand). The G8Zs were exhausted in 1981 but the following "G6" (three letter) sequence lasted only until the autumn of 1983, although some callsigns in this sequence were issued many years earlier to those interested in amateur television transmission.

A "G" prefix, of course, means the station is in England; if the owner moves to Scotland it becomes GM, Northern Ireland GI, Wales GW, and so on. The "G5" (three letter) callsigns are held by foreign amateurs operating the UK and have been much put out by a suggestion that soon their callsigns may be changed into the "British nationals" sequences.

Amateurs who have held the same callsign for many years intensely resent any suggestion that they could lose their "identity". I must admit that I was not altogether pleased when a repeater in Buckinghamshire acquired GB3VA!

Baby Broadcasters

Last year the Federal Communications Commission (FCC) conducted an enquiry into the proposals to issue in the USA amateur radio licences without a Morse code examination, akin to the Class B VHF-only licences issued in the UK. However, the FCC invariably invites comments on such proposals before implementing them.

The result was that over 5000 comments were filed with the FCC running 20-to-1 *against* the proposal which has now been dropped. In the USA even the "novice" amateur licence requires a five words-per-minute code test.

The FCC is now considering a new class of CB licence—a "hobby class" licence that would permit computer hobbyists to establish radio links for the transmission of data. For as long as I can recall most of us have never been ashamed of being called "radio amateurs" although not everyone relishes the sobriquet of "ham" operators.

The international regulations define the amateur radio services and it seems surprising that the Radio Society of Great Britain appears to accept the curious notion that amateur-radio enthusiasts now "suffer" from the alternative use of the word "amateur" in a derogatory sense and have been inviting suggestions of what the hobby should be called! But I hope they do not revive a term of abuse used in the 1930s for 7MHz phone operators: "baby broadcasters".

Cable In A Twist?

It has been suggested that the only people likely to make real money out of cable television in Britain in the near future are either the market researchers with their high-cost reports or the organisers of the seemingly endless series of conferences, seminars and exhibitions. For all the talk it still looks like being many months before the first of the 25–30 channel systems opens—possibly the one being installed by Rediffusion in Guildford as a "shop window" for its star-switched but all coaxial-cable system.

Meanwhile, satellite-distributed channels have started up on the existing low-capacity systems, on which the "must-carry" rules for broadcast channels have been waived provided that the subscribers are given an aerial capable of providing good quality off-air signals.

The $64,000 question is whether the premium TEN film channel will prove capable of attracting and retaining a significant percentage of those served by cable or who are "passed by cable". Most people agree that the earlier, less ambitious, attempt to provide a film channel on a few British cable networks, without satellite-distribution, was far from an unqualified success with only about 5 to 25 per cent of connected households prepared to pay the monthly subscription.

Door-to-Door Selling

In the USA it has been found that aggressive door-to-door selling is needed, and cable operators then have to worry about the "churn rate", the term used to describe the people who fail to renew their monthly subscriptions. Since British cable firms are convinced that an initial "connection fee" would discourage people from subscribing, a high churn rate soon adds up to a great deal of money buried uselessly in the ground. A buzz term in cable and DBS at the moment is "conditional access" implying a system whereby a viewer who has not paid his monthly sub can be denied access to the channel without the need to remove the decoder.

Surprisingly, one of the most rewarding series of lectures and discussion on cable has been a series of lunch-time lectures at the National Film Theatre in London during February and March. For 60p a time, one heard more balanced and realistic views from both cable people and politicians on the opportunities and problems of cable than at many of the high-cost trade seminars.

However, nobody is finding it easy to predict what percentage of British viewers, with four off-air channels, a substantial licence fee, and with a quarter of homes already having the extra choice provided by a VCR machine, will be willing to pay for "basic" cable channels. Neither are they prepared to predict the numbers willing to pay extra for "super-basic" channels, or extra still for "premium" channels each of which could cost up to £10 per month. It would still be cheaper than frequent visits to the cinema, but how many people these days are regular cinema-goers?

The most depressing forecast comes from the research firm CIT suggesting that the number of British homes cabled in 1990 may actually be less than in 1980, when 1·6 million homes were on commercial cable networks.

High-Speed Satellite

Congratulations to the team at the University of Surrey who built and tested out their new UOSAT amateur radio satellite carrying scientific and educational experiments in a matter of a few months—possibly the quickest time from planning to launch for any new satellite yet!

Launched into low Earth orbit by NASA on March 1, 1984, at 17.59 UT, the first beacon signals were received at 19.49 UT on 145·825MHz although it will take some time to check out all systems on this second bird from the Surrey woods.

OSCILLATORS

A variety of different types of resistance capacitance feedback oscillators, all having wide use, are described in this short series. Some of the circuits are based on discrete semiconductors, others on familiar i.c.s. In addition to theory of operation, design pointers for particular needs and applications are given. Each part in the series also includes a detailed circuit for a practical project.

Part Two: USING THE 555 AND ICM7555

By J. R. DAVIES

THE MAIN uses for the 555 and the ICM7555 are as a timer and as an oscillator. The 555 is a well-established i.c. incorporating bipolar circuitry, whilst the more recently introduced ICM7555 is a CMOS version which requires a considerably lower supply current. The 555 and ICM7555 are pin-compatible and are directly interchangeable in many, but by no means all, applications.

555 OPERATION

The internal circuitry of the 555 is shown in simplified form in Fig. 2.1. An internal potential divider between the positive (Vcc) and negative (ground) rails consists of three equal resistors, each having a nominal value of 5kΩ.

Reference voltages of two-thirds supply voltage and one-third supply voltage are available as shown, the first being applied to a voltage comparator coupled to pin 6 of the device and the second to another comparator connected to pin 2.

The reference voltages may be altered, if desired, by applying external connections to pin 5. For most applications, pin 5 is left open-circuit or is coupled to the negative rail via a bypass capacitor.

An internal transistor provides a discharge function at pin 7. When this transistor is turned off pin 7 is virtually open-circuit, and when the transistor is turned on pin 7 is effectively short-circuited to the negative rail.

The comparator outputs are fed to a flip-flop which controls the internal discharge transistor. Also controlled by the flip-flop is an output stage coupling to pin 3. The voltage on pin 3 is high (close to or at the positive supply rail potential) when the discharge transistor is turned off and is low (close to or at the negative rail potential) when the discharge transistor is turned on.

Pin 4 is the reset pin and is normally only employed when the 555 is used for timing applications. For oscillator applications, pin 4 can be left open-circuit. It is preferable, however, to connect it to the positive rail as this completely disables the reset facility and ensures the reset circuitry cannot affect oscillator operation.

Alternatively, pin 4 can be used to enable or inhibit the 555 when used as an oscillator. If pin 4 is high the oscillator runs normally, and if pin 4 is low the oscillator stops with the output at pin 3 low and the discharge transistor turned on.

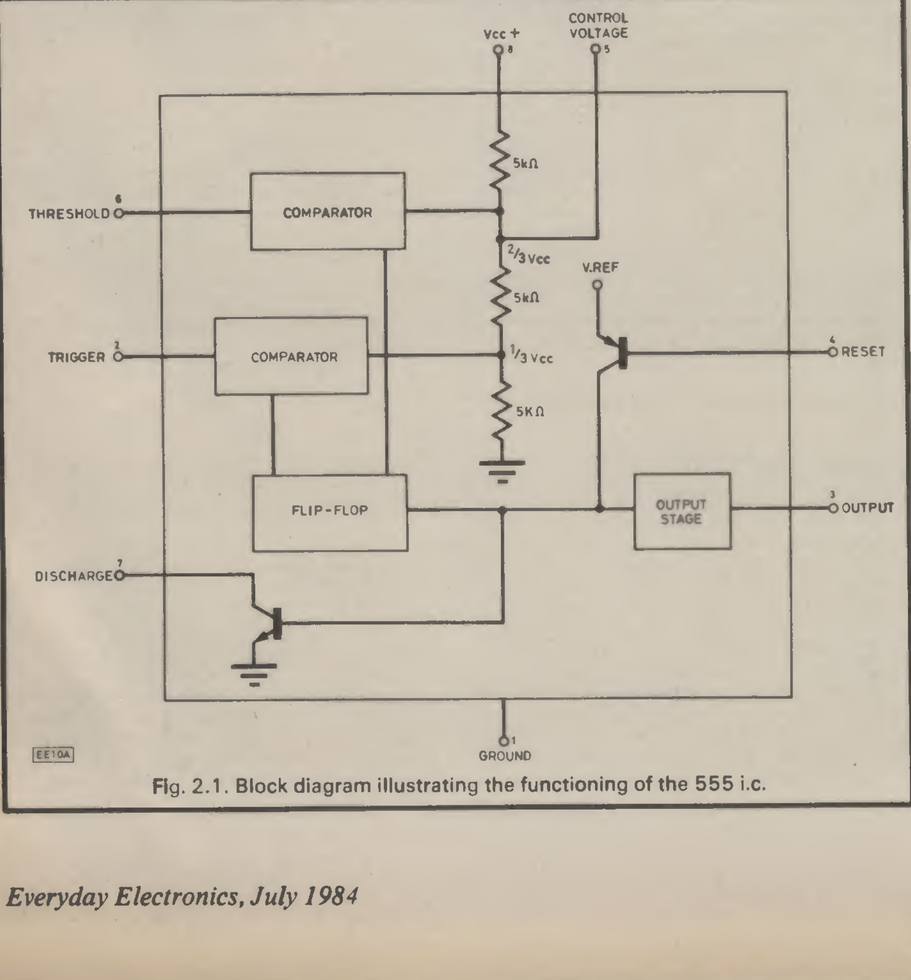


Fig. 2.1. Block diagram illustrating the functioning of the 555 i.c.

SUPPLY RANGE

The supply voltage range for the 555 is 4·5 to 16 volts and its current consumption is of the order of 6mA at 9 volts. To that current has to be added any current flowing in an output load and in the frequency control components. When the 555 output is high it can source load currents up to 200mA, and when it is low it can sink currents up to the same value.

The ICM7555 has precisely the same pin functions as the 555 and it has a supply voltage range of 2 to 18 volts. The supply current requirement is very much lower, being typically 40 to 50μA only from a 9-volt supply. With an 18-volt supply it can sink output currents up to 100mA, the maximum sink current reducing, roughly proportionately, with supply voltage. The output source current capability is much lower.

We shall consider the output performances of both the 555 and the ICM7555 in more detail later in this article. Although the ICM7555 uses CMOS circuitry, all inputs and outputs are fully protected against damage by static voltages, and it does not need the special handling procedures normally associated with CMOS devices.

OSCILLATOR CIRCUIT

The basic 555 and ICM7555 oscillator circuit is shown in Fig. 2.2. Pins 2 and 6 are connected together and to the external capacitor C. Two external resistors, RA and RB, couple the capacitor to the positive supply rail, with their junction connected to the discharge pin, pin 7.

When power is applied, pin 7 is open-circuit and the capacitor commences to charge via RA and RB. The i.c. output at pin 3 is high. When the voltage across the capacitor reaches two-thirds of the supply voltage the threshold comparator trips the flip-flop, causing the internal discharge transistor connected to pin 7 to turn on and the pin 3 output to go low.

The capacitor now discharges into RB on its own until the voltage across it falls to one-third of the supply voltage. The trigger comparator then trips the flip-flop to its previous state, causing the discharge transistor to turn off and the output to go high. The capacitor charges once more via RA and RB until, again, the voltage across it reaches two-thirds of the supply voltage.

The cycles proceed in this manner with the capacitor voltage changing continually between one-third and two-thirds of supply voltage. Since the reference voltages are derived from the supply and the capacitor charge and discharge currents are proportional to supply voltage, the frequency of oscillation is independent of the supply voltage. Note that the output voltage is high when the capacitor charges, and is low when the capacitor discharges.

FREQUENCY CALCULATION

The charge time in the oscillator cycle is equal to 0·685(RA + RB)C, and the discharge time is equal to 0·685(RB)C. Total time for one cycle is therefore 0·685(RA + 2RB)C and frequency is the reciprocal of this, or

$$\frac{1 \cdot 46}{(RA + 2RB)C}$$

As with the symmetric multivibrator of *Part One*, convenient units to work with are megohms, microfarads, seconds and hertz.

To take an example, let us say that RA is 820kΩ, RB is 220kΩ and C is 0·47μF. The total cycle time is:

$$0 \cdot 685(0 \cdot 82 + 0 \cdot 44)0 \cdot 47$$

A calculator soon tells us that this works out as 0·406 second to three significant figures. The reciprocal gives a frequency of 2·47Hz.

Fig. 2.3 (a) shows an oscillator with a calculated frequency of 4·85kHz, and Fig. 2.3 (b) shows one with a calculated frequency of 0·0221Hz and a calculated cycle length of 45·2 seconds. Table 2.1 gives calculated frequencies for different values of (RA + 2RB) over some seven decades of frequency, and will be found helpful in arriving at suitable component values for a specific frequency.

The 555 will oscillate satisfactorily for values of (RA + 2RB) up to 10MΩ and down to values of 1kΩ. The ICM7555 draws lower input currents at pins 2 and 6 and will operate satisfactorily with values of (RA + 2RB) ranging from 100MΩ to 1kΩ.

If C is an electrolytic capacitor it is preferable to limit (RA + 2RB) to some 500kΩ with either i.c. This will ensure that capacitor leakage current does not significantly affect oscillator functioning.

OUTPUT PERFORMANCE

The internal output transistors in the 555 have the circuit configuration shown in Fig. 2.4. When the 555 output is low, transistors TRA and TRB are turned off, whilst TRC is turned on. Fig. 2.5 (a) shows the voltage between pin 3 and the negative rail for different currents flowing in a load connected between pin 3 and the positive rail when the supply voltage is 9 volts.

At currents below 40mA the voltage drop across transistor TRC ranges from less than 0·1 volt to some 0·4 volt. At around 50mA the voltage drop increases sharply to around 1·5 volts and then increases to 2 volts at 100mA.

When the 555 output is high, transistors TRA and TRB are turned on, with TRC turned off. Both TRA and TRB are emitter followers with the results that for currents above 0·15mA (at which 0·6 volt is dropped across the 3·9kΩ resistor) the voltage drop across TRB must be at least 1·2 volts because of the voltage drop

Table 2.1: 555 AND ICM7555 FREQUENCIES

(RA + 2RB)	0·01μF	0·022μF	0·047μF	0·1μF	0·22μF	0·47μF	1μF	2·2μF	4·7μF	10μF
1kΩ		66·4kHz	31·1kHz	14·6kHz	6·64kHz	3·11kHz	1·46kHz	664Hz	311Hz	146Hz
3kΩ	48·7kHz	22·1kHz	10·4kHz	4·87kHz	2·21kHz	1·04kHz	487Hz	221Hz	104Hz	48·7Hz
10kΩ	14·6kHz	6·64kHz	3·11kHz	1·46kHz	664Hz	311Hz	146Hz	66·4Hz	31·1Hz	14·6Hz
30kΩ	4·87kHz	2·21kHz	1·04kHz	487Hz	221Hz	104Hz	48·7Hz	22·1Hz	10·4Hz	4·87Hz
100kΩ	1·46kHz	664Hz	311Hz	146Hz	66·4Hz	31·1Hz	14·6Hz	6·64Hz	3·11Hz	1·46Hz
300kΩ	487Hz	221Hz	104Hz	48·7Hz	22·1Hz	10·4Hz	4·87Hz	2·21Hz	1·04Hz	0·487Hz
1MΩ	146Hz	66·4Hz	31·1Hz	14·6Hz	6·64Hz	3·11Hz	1·46Hz	0·664Hz	0·311Hz	0·146Hz
3MΩ	48·7Hz	22·1Hz	10·4Hz	4·87Hz	2·21Hz	1·04Hz	0·487Hz	0·221Hz	0·104Hz	0·0487Hz
10MΩ	14·6Hz	6·64Hz	3·11Hz	1·46Hz	0·664Hz	0·311Hz	0·146Hz	0·0664Hz	0·0311Hz	0·0146Hz

Calculated frequencies for (RA x 2RB) and capacitance

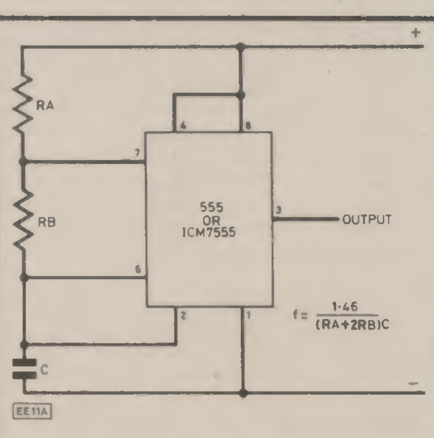


Fig. 2.2. The basic oscillator circuit for the 555 and the ICM7555.

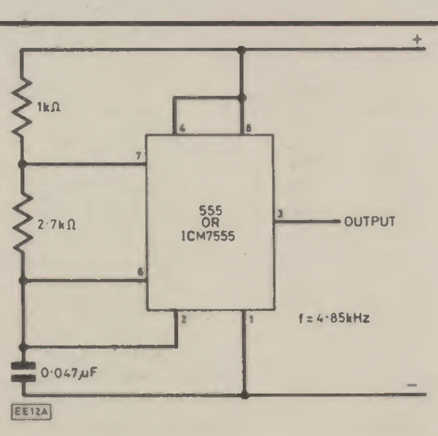


Fig. 2.3(a). A practical example of a 555 or ICM7555 oscillator circuit.

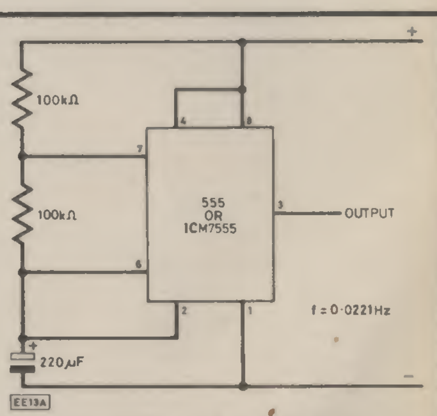


Fig. 2.3(b). The 555 and ICM7555 will oscillate at very low frequencies. The calculated cycle length here is 45·2 seconds.

in each of the two base-emitter junctions. The voltage drop for source currents up to 100mA is shown in Fig. 2.5 (b).

Since, for currents up to around 40mA, there is a much lower voltage drop in the 555 when it is providing a sink current than there is when it provides a source current, it is often more desirable to have the 555 drive a load which is connected between its pin 3 and the positive rail. The load current then flows when the 555 output is low.

The ICM7555 is specified as sinking output currents of up to 100mA maximum with a supply of 18 volts. With a 9 volt supply the maximum sink current to be expected is a little over 50mA, and a representative current-voltage curve is shown in Fig. 2.6 (a).

The source current capability of the ICM7555 is quite limited and, as can be seen from Fig. 2.6 (b), about 7 volts are dropped in the device at 10mA when the power supply is 9 volts. For load currents in excess of a few milliamps it is obviously better to use the ICM7555 in the sink current mode.

Both the 555 and ICM7555 outputs are compatible with TTL and CMOS inputs. TTL inputs require an input current in the order of microamps only when the input is high, and can be readily driven by the ICM7555. And, of course, CMOS inputs require negligibly low input currents for both the high and low states.

OUTPUT WAVEFORM

We observed, when discussing Fig. 2.2, that when capacitor C is charging in a 555 or ICM7555 oscillator circuit the output is high, and that when the capacitor discharges the output is low.

Since the capacitor charges via the two resistors RA and RB in series, and discharges only via the single resistor RB, it follows that the period in the output cycle when the output is high must always be longer than the period when the output is low. This effect is shown in Fig. 2.7. As can be deduced, the ratio of the high voltage period to the low voltage period is equal to (RA + RB):RB.

For some applications it is desirable that the output be a 50:50 square-wave, with the output high in each cycle for the same length of time that it is low. This can be very nearly achieved by making RA very much lower in value than RB. If, for instance, RA were 1kΩ and RB 100kΩ the duty ratio (the ratio between the high period and the total cycle period) becomes 101:(101 + 100), which equals 50·25 per cent.

Duty ratios of 50 per cent or less can be given by inserting two silicon diodes, as shown in Fig. 2.8. Capacitor C then charges through RA and D1 and discharges through D1 and RB. Ignoring the 0·6 forward voltage drop in each diode,

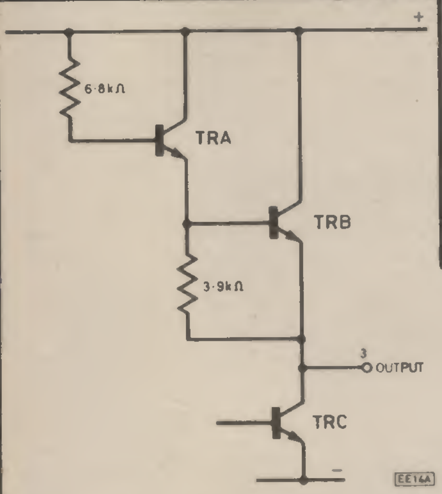


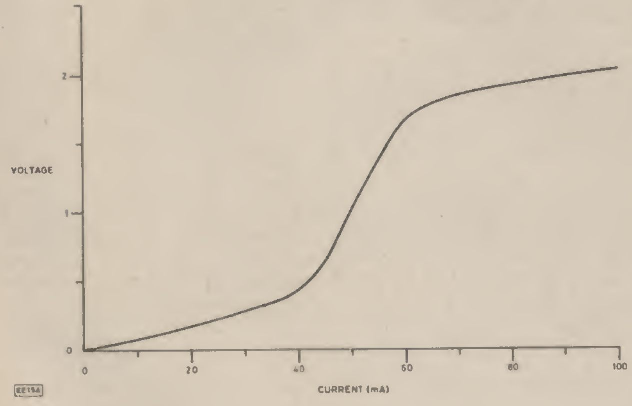
Fig. 2.4 (left). The internal output circuitry of the 555.

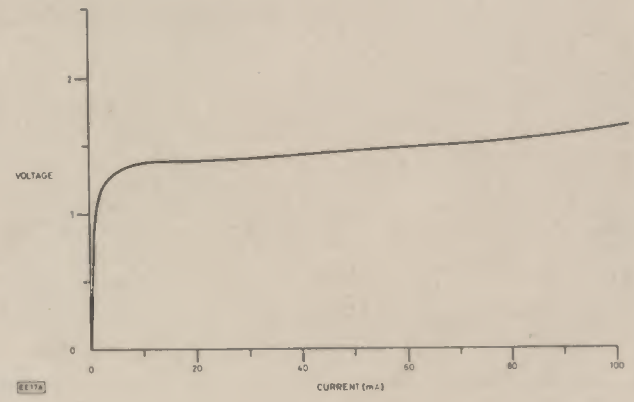
Fig. 2.5a (below left). Representative curve illustrating the voltage dropped in the 555 output stage when it sinks currents up to 100mA. Supply voltage is 9 volts.

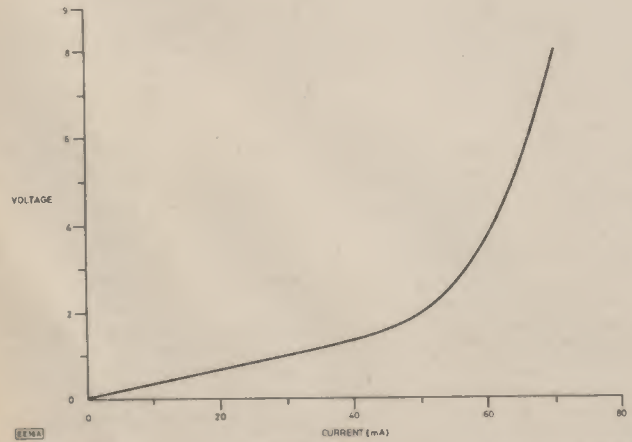
Fig. 2.5b (below right). 555 voltage drop for source currents up to 100mA.

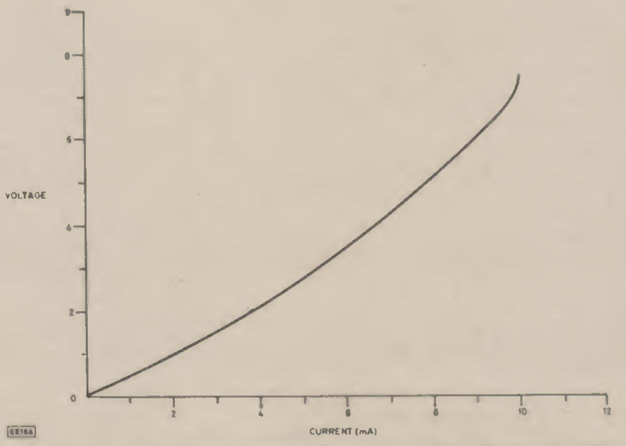
Fig. 2.6a (bottom left). ICM7555 output voltage drop for sink currents up to 70mA, with a supply of 9 volts.

Fig. 2.6b (bottom right). The ICM7555 has a limited output source current capability.









the period in the cycle when the output is high is equal to 0·685(RA)C and the period when the output is low is equal to 0·685(RB)C. To find frequency, the two periods are added and the sum inverted.

INVERTER FUNCTION

When pins 2 and 6 of a 555 or ICM7555 are connected together and are taken below one-third of the supply voltage, the output at pin 3 is always high. The output is always low when pins 2 and 6 are taken above two-thirds of the supply voltage. This fact enables a 555 or ICM7555 to function as an inverter, using the circuit shown in Fig. 2.9.

If the output of IC1 in this circuit has a duty ratio of, say, 70 per cent, the output of IC2 will have a duty ratio of 30 per cent. This arrangement enables duty ratios of less than 50 per cent to be achieved without the introduction of the two diodes of Fig. 2.8. An ICM7555 will drive a 555 employed as an inverter and this fact may be of assistance when it is desired to provide high load currents whilst using very high values for RA and RB in the ICM7555 oscillator circuit.

A useful trick for obtaining a 50:50 square-wave from the 555 or ICM7555 is to simply add a third resistor, RC, to RA and RB, as shown in Fig. 2.10. The i.c. gives a 50:50 output when RA is equal to RB and RC is equal to four times RA or RB. The added resistor causes the capacitor charging time to be shorter than that given by RA and RB on their own, and the discharge time to be longer than that given by RB on its own.

The operating frequency with this circuit is about 12·5 per cent higher than the frequency which would be given with RC removed from the circuit. With the circuit shown in Fig. 2.10 the total cycle period is approximately equal to 1·8(RA)C and the frequency to

$$\frac{0{\cdot}55}{(RA)C}$$

CHECKING THE DUTY RATIO

It is possible to check the duty ratio of a 555 or ICM7555 without an oscilloscope. All that is required is to slow down the oscillator by connecting a high value capacitor across C.

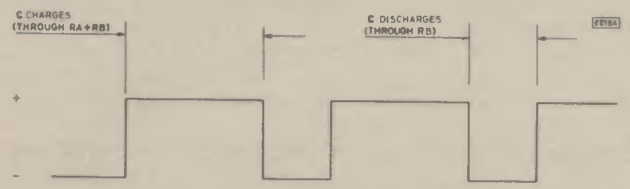


Fig. 2.7 (left). With the basic oscillator circuit of Fig. 2.2, the output is always high for a longer period in the cycle than when it is low.

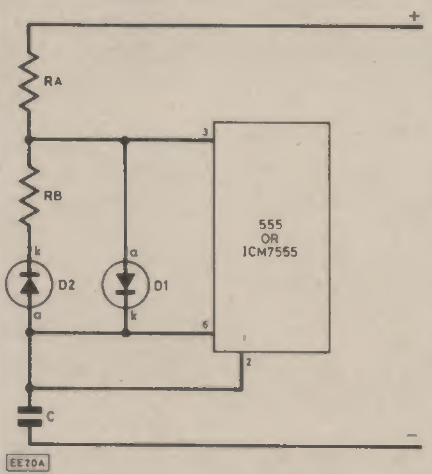


Fig. 2.8. It is possible to obtain duty ratios of less than 50 per cent by adding two silicon diodes. The capacitor charges through D1 and discharges through D2.

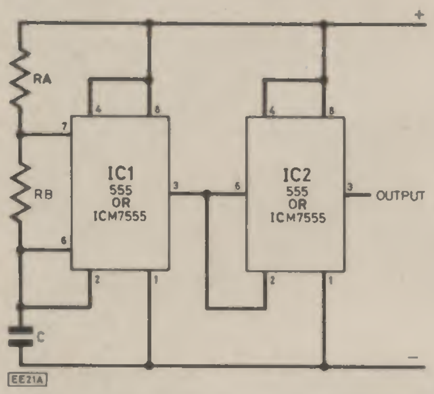


Fig. 2.9. Another way of obtaining duty ratios of less than 50 per cent is to employ a second 555 or ICM7555 as an inverter.

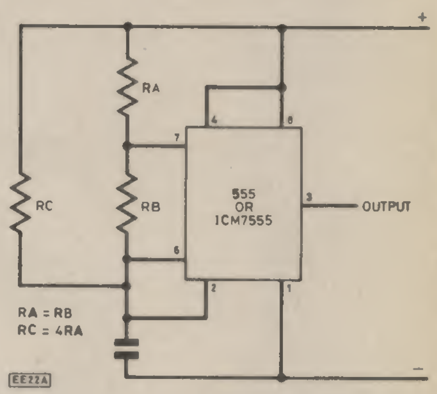


Fig. 2.10. If a third resistor is added and the resistor values are as shown here, the 555 or ICM7555 produces a 50:50 square-wave.

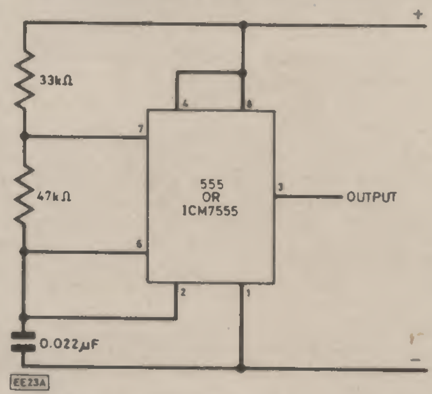


Fig. 2.11(a). An oscillator with a calculated frequency of 523Hz.

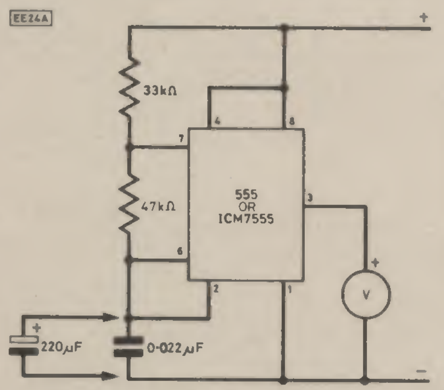


Fig. 2.11(b). The output waveform can be monitored with a voltmeter if the oscillator is slowed down by temporarily connecting a large value capacitor across the frequency control capacitor.

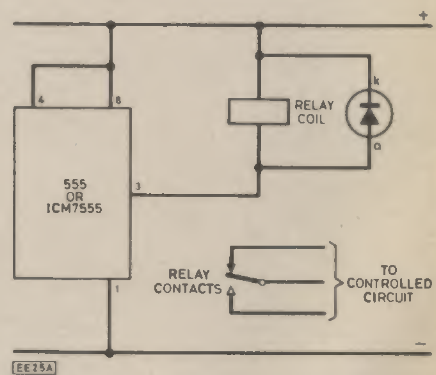


Fig. 2.12. With a very low frequency 555 or ICM7555 oscillator, external high current circuits can be controlled with the aid of a relay.

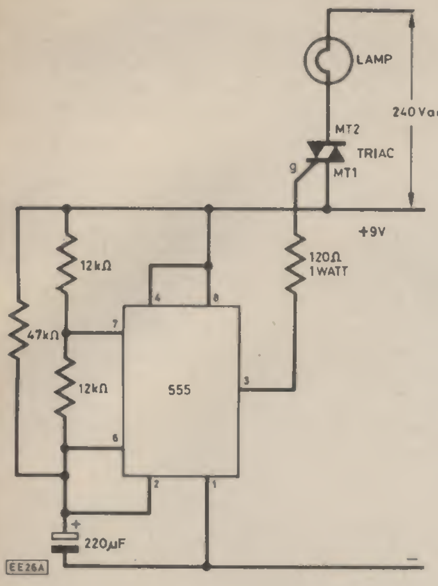


Fig. 2.13. In this circuit a 555 turns on a triac when its output is low.

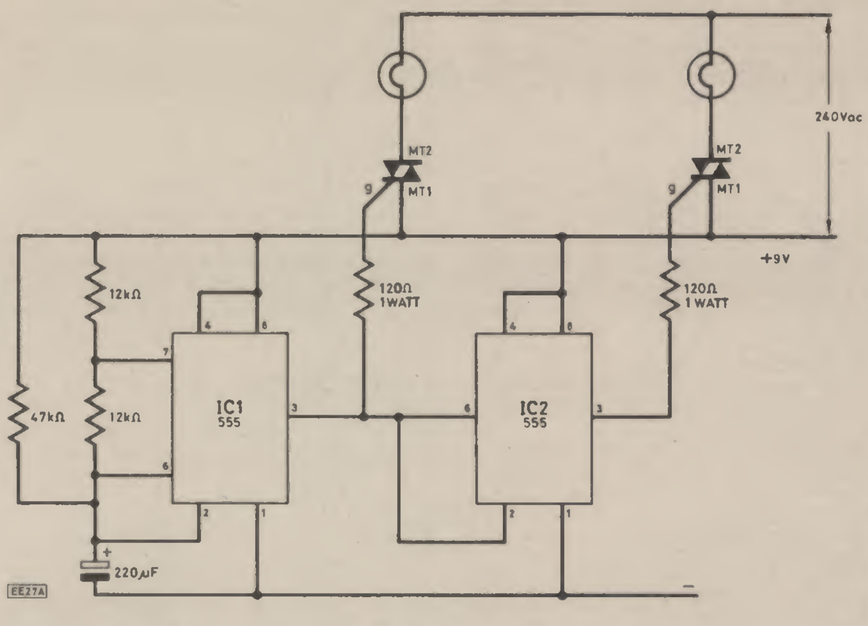


Fig. 2.14. Two 555s are used here to turn on two lamps, or sets of lamps alternately.

As an example, Fig. 2.11 (a) shows an oscillator with a calculated frequency of 523Hz. If a 220µF capacitor is temporarily connected across C, as in Fig. 2.11 (b), the calculated running frequency falls to 0·0523Hz with a total cycle length of 19 seconds.

The lengths of the high and low output periods in each cycle can then be assessed by connecting a voltmeter between the i.c. output and the negative rail and timing the periods with the aid of a watch.

Remember that, when the high value capacitor is initially applied, the i.c. output goes high for a longer period than it will subsequently do in the following cycles. This is because the capacitor has to charge from zero to two-thirds of supply voltage before the regular cycles commence.

APPLICATIONS

There are a large number of applications for the 555 and ICM7555. Both may be used as oscillators giving a useful performance up to 100kHz, and can function as a.f. tone generators, logic clocks and in many other circuits.

When running at very low frequencies, either i.c. can be caused to turn on and off relatively heavy current circuits, such as lamps in an advertising display, by connecting the output to the coil of a relay, as in Fig. 2.12. The relay should be capable of energising reliably at a coil voltage of slightly less than the supply voltage, and reasonable figures for coil resistance would be such that energising current is less than some 50mA with the 555 and less than 20mA with the ICM7555.

Using a 9-volt supply (and ignoring voltage drop in the i.c.) these currents correspond to coil resistances of about 180Ω and 450Ω, respectively. Higher relay energising currents within the capabilities of the i.c.s could, of course, be used if desired.

The diode shown in Fig. 2.12 can be any small silicon diode or rectifier, and it prevents the generation of a high reverse voltage across the relay coil when the relay is released.

Fig. 2.13 shows a 555 turning on a triac when its output is low. A triac gate current of around 50mA is given and, since the circuit operates in two of the more sensitive triac quadrants (MT2 positive or negative with gate negative) this current should be satisfactory with most small triacs. Gate current can be increased further, if necessary, by reducing the value of the resistor connecting to pin 3 of the 555.

Adding a second 555 as an inverter, as illustrated in Fig. 2.14, allows two lamps, or sets of lamps, to be turned on and off alternately. The frequency control component values give a nominal 50:50 output at approximately 0·2Hz with a total cycle length of about 5 seconds. The cycle length may be increased by increasing the value of the capacitor, or reduced by reducing that value.

THE 556

A variant of the 555 is the 556 i.c. This is a 14-pin device which contains two 555s in one package, with pin 7 as the negative supply pin for both and pin 14 as the positive supply pin.

The functions for one of the 555s are available at pins 1 to 6, and those for the other 555 at pins 8 to 13. The pin allocations are shown in Fig. 2.15.

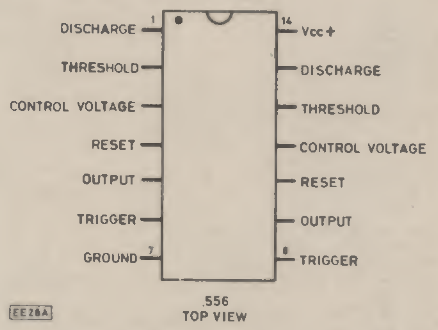


Fig. 2.15. The 556 i.c. comprises two 555s in a single package.

OSCILLOSCOPE CALIBRATOR

A practical project which can employ either a 555 or an ICM7555 is shown in Fig. 2.16. In this circuit, switch S1 selects positive-going pulses having an amplitude of 1V, 100mV or 10mV, and these can be applied to an oscilloscope to set up its *Y* axis voltage calibration. The oscilloscope input couples to the Common and D.C. output terminals for a direct coupling, or to the Common and A.C. output terminals for an a.c. coupling.

IC1 produces a nominally 50:50 square-wave with a frequency of approximately 1kHz. IC2 is a 5-volt regulator which holds the emitter of TR1 steady at a fixed voltage of 5 volts ± 4 per cent. When IC1 output is high, TR1 is cut off since its base-emitter junction is reverse biased by about 4 volts. (IC2 output remains regulated for zero output current or small currents to the 9-volt positive rail.)

TR1 turns hard on when IC1 output goes low and its collector current flows through the chain of resistors, VR1,

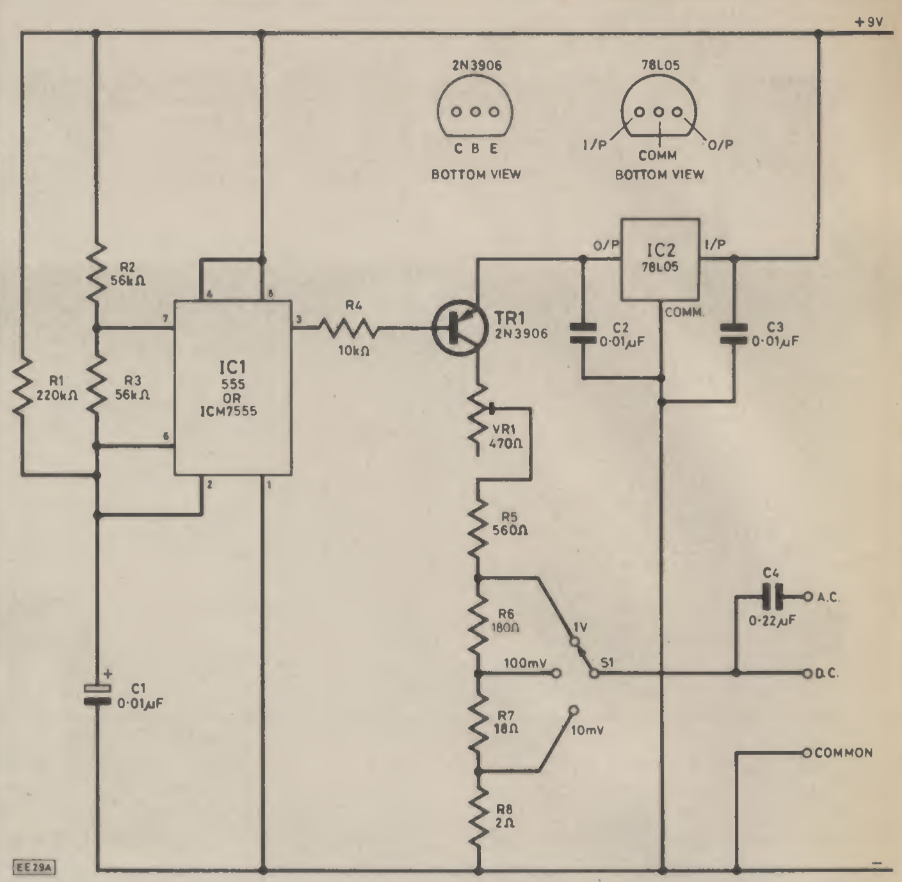


Fig. 2.16. A practical project. This circuit produces positive-going pulses of known amplitude to enable an oscilloscope to be calibrated.

R5–R8. VR1 is adjusted to make this collector current precisely 5mA. In consequence, 10mV is built up across R8, 100mV across R9 and R7, and 1V across R8, R7 and R6. These voltages are tapped off by S1.

After VR1 has been adjusted, the current in the resistor chain maintains its value because the collector-emitter voltage of TR1, when turned on, is always less than 0·1 volt, and because the transistor is supplied by the voltage regulator. The current drawn from the 9-volt supply is about 9mA with a 555, or about 5mA when using an ICM7555.

There are no critical features in the assembly of the circuit, apart from the fact that C2 and C3 should be positioned close to IC2.

SETTING-UP

Potentiometer VR1 is adjusted in the following manner. Set S1 to the 1V position and connect a voltmeter capable of giving a clear reading of 1 volt between the Common and D.C. terminals. Temporarily short-circuit R1. This takes pins 2 and 6 of IC1 high and drives pin 3 low, turning on the transistor. Adjust VR1 until the voltmeter indicates exactly 1 volt. Remove the short-circuit across R1, whereupon the calibrator is ready for use.

For optimum accuracy, R6, R7 and R8 should be 1 per cent resistors. If difficulty is experienced in obtaining a close tolerance 2Ω resistor for R8, this can consist instead of a 1 per cent 2·2Ω and a 1 per cent 22Ω resistor in parallel.

Part Three of this series will discuss the use of digital CMOS devices in RC oscillator circuits.

PLEASE TAKE NOTE

Circuit Exchange *(June 84)*

Digital Capacitance Meter

The connection from IC6 pin 11 and IC7 pin 6 can be used to extend the range of the display to two digits, by the addition of extra counter and driver i.c.s.

C.B. Mini Power Supply

T.R. de Vaux Balbirnie

HAND-HELD CB transceivers having an output of 2 watts are of interest to outdoor enthusiasts wishing to extend their hobby beyond home and car. Tests show that portable units are surprisingly good for home-base use. Naturally, they are limited compared with the 4-watt equipment but range is rarely a problem if a good outdoor antenna is employed. Hand-held CB units have a socket for this purpose.

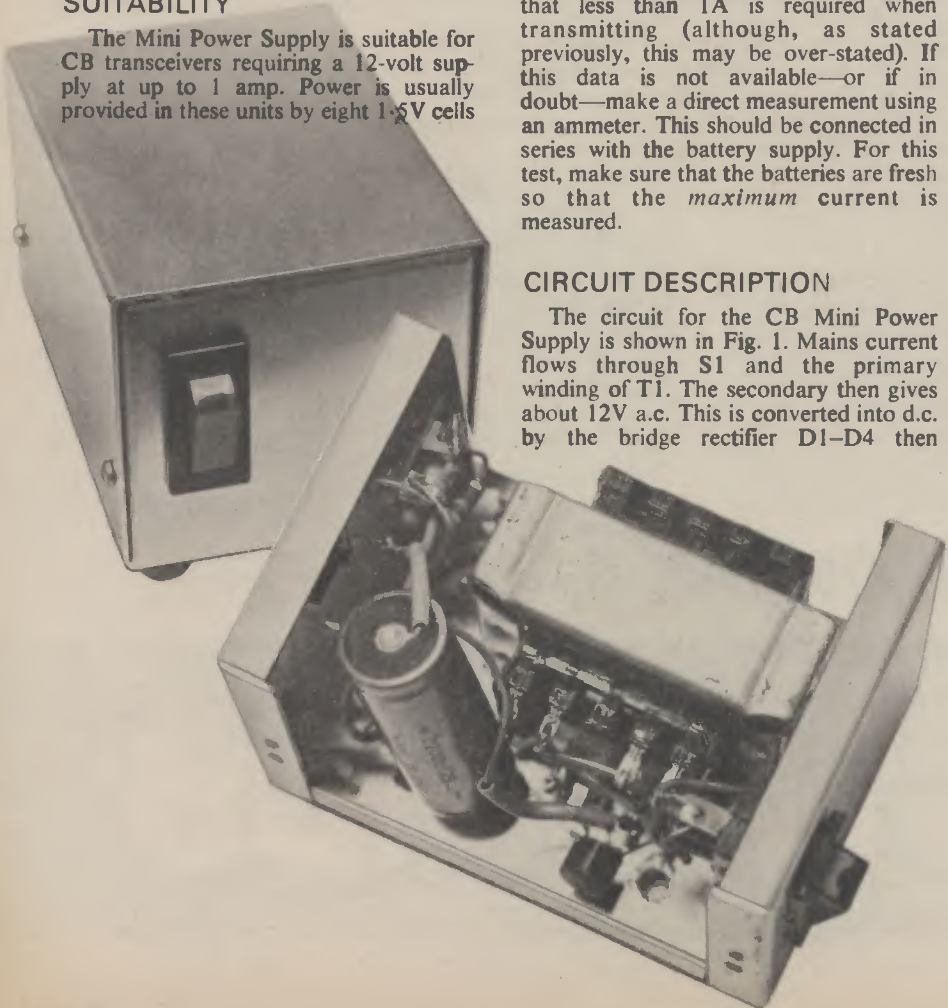
For home use it makes sense to use a mains-operated power supply to maintain maximum power output and to conserve the rather short life of the batteries. Such a power supply is the subject of this article.

SUITABILITY

The Mini Power Supply is suitable for CB transceivers requiring a 12-volt supply at up to 1 amp. Power is usually provided in these units by eight 1·5V cells or ten nickel cadmium batteries. The *Harrier WT2* is one such example requiring approximately 500mA in the "transmit" mode and about 70mA when switched to "receive". In this respect, the manufacturer's leaflet seems to over-rate the current requirement.

The project is described as "mini" since it provides sufficient current for the intended purpose with only a little reserve. In this way, the physical size and cost are kept low. Ready-built units are made with mobile equipment in mind. They can supply a higher current and usually operate at about 13·8V. The higher output voltage could damage hand-held equipment.

Before constructing the power supply, read the manufacturer's leaflet to check that less than 1A is required when transmitting (although, as stated previously, this may be over-stated). If this data is not available—or if in doubt—make a direct measurement using an ammeter. This should be connected in series with the battery supply. For this test, make sure that the batteries are fresh so that the *maximum* current is measured.



CIRCUIT DESCRIPTION

The circuit for the CB Mini Power Supply is shown in Fig. 1. Mains current flows through S1 and the primary winding of T1. The secondary then gives about 12V a.c. This is converted into d.c. by the bridge rectifier D1–D4 then smoothed by means of C1. This provides about 16V d.c. Regulation is achieved by IC1 so that a steady 12V is obtained at the output whatever the current drawn by the CB equipment. IC1 also gives short circuit, overload and thermal protection.

The mains switch, S1, incorporates a neon indicator. C2 and R1 ensure correct operation of IC1. *Note:* The case of the project, being metal, is connected to the negative of the output so simplifying much of the wiring.

CONSTRUCTION

Use the aluminium case specified in the parts list. The specified transformer fits the case comfortably with plenty of ventilation space all round. Holes should be made for S1 and for the input and output wires. These latter holes must be fitted with rubber grommets.

Mount T1 and IC1 as shown (see photograph). Note that IC1 makes metal-to-metal contact with the case so providing the common negative connection. For this reason, the centre tag of IC1 is not used and may be cut off short if desired. When mounting T1, include a solder tag beneath one of the fixings for earthing later. A further solder tag is used for the negative connection of C1 and the bridge rectifier. Solder C2 and R1 in parallel to the piece of tag strip. Mount this in position (see photograph) noting that one side of C2 and R1 are connected to the case. The output connections are also made to these tags.

MAINS LEAD

Pass the mains inlet wire through the grommet and make the soldered connections to S1. A neutral connection is needed here for the neon indicator to work. From S1, connections are made to the 240V primary of T1. In the prototype a connection was needed between the two 120V primary windings (Fig. 2).

Solder the earth wire of the mains lead to the solder tag at T1. This earths the case and the transformer core. ***This is essential safety procedure—on no account use this project on a non-earthed supply.***

Complete all wiring (Fig. 2). Check for short circuits. Bend component leads as necessary to allow a free flow of air. Tie string tightly around the inlet and output

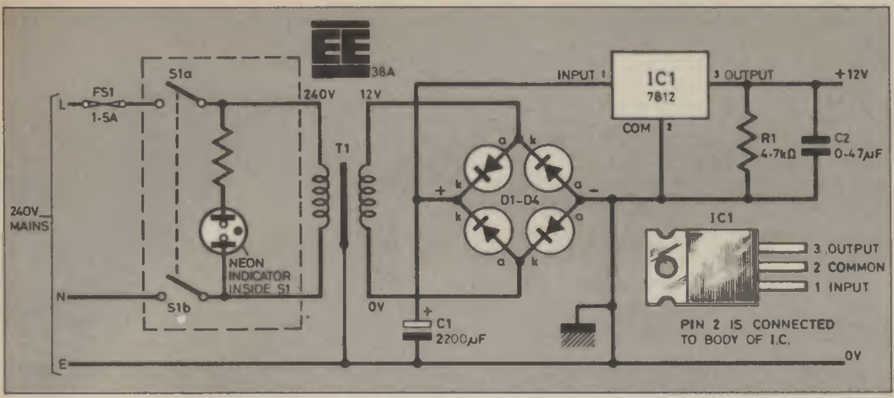


Fig. 1. Complete circuit diagram for the CB Mini PSU.

wires where they enter the case to provide strain relief. Pull the leads to make sure that connections are not dislodged.

Using great care, drill four or five 6mm holes in the base of the box to provide ventilation. These holes must obviously be clear of any wiring or components. Fit the feet on the case. These are necessary not only to prevent scratching of the work surface but also to allow ventilation. Mount the lid on the case slightly higher than normal by lengthening the fixing holes slightly. This will leave 2 or 3mm gaps at the front and rear. These will also assist with ventilation.

CONNECTING TO THE CB EQUIPMENT

The best way of connecting the output wires to the CB is to use two dummy batteries. Hand-held units usually use HP7 (AA) size batteries. Dummies of this size are freely available. Making certain that the correct polarity is observed, use one for the positive and one for the negative connection. It is not necessary to remove the bridge linking the two ends of the dummy batteries together, in fact this may by used to accept the soldered connection.

Insert the dummy batteries in the extreme positions normally occupied by the real batteries. Unless the back is to be left off while operating the CB it will be necessary to file a corner off so that the connecting wire may pass with it in place.

If the power supply delivers a continuous 1A output it will become quite warm after a long period of operation. In normal use, there will be periods of receiving as well as transmitting and the current requirement on "transmit" will probably fall well short of 1A anyway. In practice, the case of the prototype remained fairly cool. When using for the first time, however, a frequent check should be made on the temperature of the case. A poor quality component for T1 could cause overheating. □

COMPONENTS

See Shop Talk page 434

Resistor

R1 4·7kΩ ½W carbon ±5%

Capacitors

C1	2200μF elect. 16V or higher
C2	0·47μF—any rating above 12V

Semiconductors

IC1	7812 12V/1A regulator
D1–4	50V 1A silicon bridge rectifier

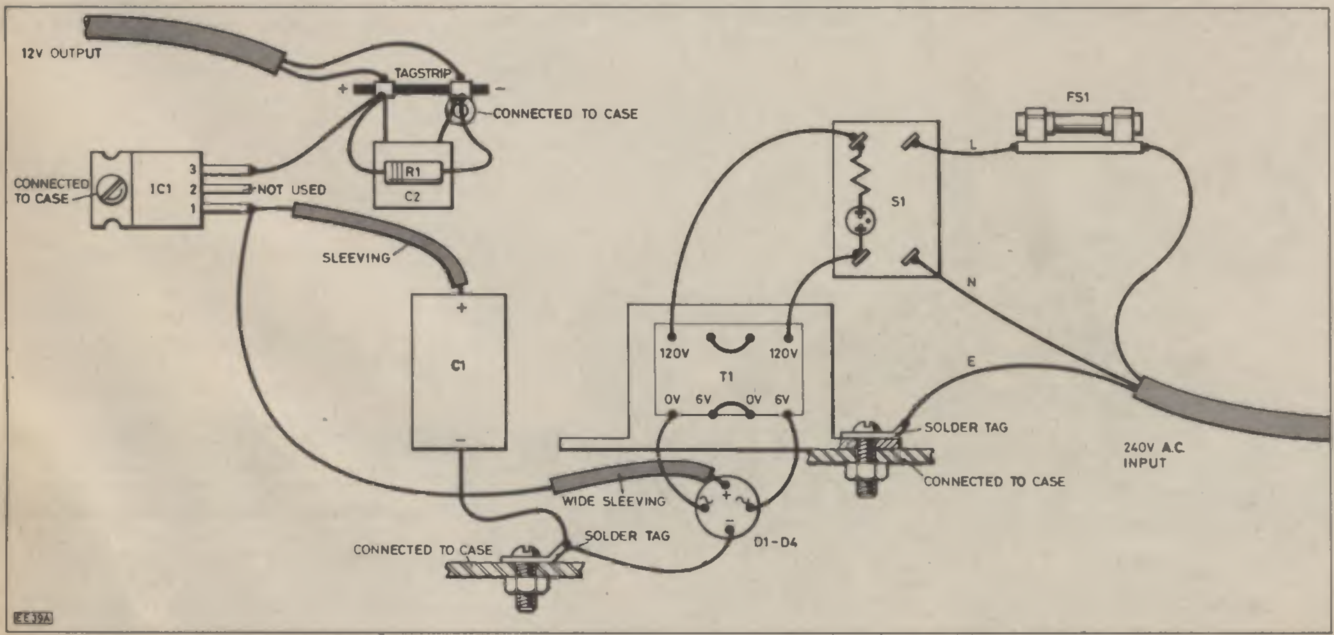
Miscellaneous

T1	Mains transformer with 240V (or 2 off 120V) primary. 12V (or 2 off 6V) secondary. 1A rating. RS type 207–633.
S1	Double-pole mains rocker switch with neon indicator
FS1	1·5A fuse (and holder).
AB28 case	aluminium. 102 × 70 × 64mm approx.

Two sections of tag strip; solder tag—2 off; rubber grommets—2 off; 3A 3-core mains cable; 2-core output wire; feet for case—4 off; connecting wire; solder; sleeving; dummy batteries—2 off; open construction type (see text).

Approx. cost Guidance only £10.00

Fig. 2. Wiring diagram. Note that pin 2 of IC1 is internally connected to the metal tab.



CAR LIGHTS WARNING

H.B.Foster

THIS unit has been designed to warn drivers to put their lights on when the amount of daylight falls below a preset level and also to remind them to switch off their lights at the end of a journey should the ignition be switched off before the lights; if parking lights are required then the ignition should be turned off and the lights switched off then on again. The design also includes a charging circuit indicator so that the buzzer will not operate at low light levels if the charging circuit is not supplying current to the battery.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Car Lights Warning is shown in Fig. 1. The light dependent resistor R1, the preset VR1 and the resistor R2 form a potential divider across the 12 volt supply. The resistance value of the LDR increases as the light level falls, causing the voltage at point A to fall. This falling voltage forward biases the base/emitter junction of TR1 switching TR1 on and therefore TR2 via R3. The voltage at the emitter of TR2 is applied to the buzzer WD1 via D4 and to the gate terminal of CSR2 via R7.

The resistors R7 and R8 together with the capacitor C2 form a time delay of between 18 and 20 seconds after the engine has been turned on. After this time the thyristor CSR2 fires and the buzzer is energised.

Once the alarm has been activated it can be disabled by switching on the car lights which will turn TR1 off via the positive voltage applied through D3 to its base. As TR1 turns off the base current to TR2 is reduced and TR2 turns off, removing the supply to the buzzer and turning off CSR2. The buzzer would remain on if current was allowed to flow straight to it from the lighting circuit so TR3, CSR1, R3, R4, R5 and C1 are used to form a delay circuit to enable CSR2 to be shut down. Diode D4 is used to isolate the gate of CSR2 when it is required to park with the lights on otherwise the buzzer will sound again.

As soon as the ignition is turned on CSR3 fires but has no effect on TR4 until the ignition is switched off again and providing that the lights are on, TR4 will conduct, supplying gate current to CSR4 regulated by R10 and R11, firing the device, and turning the buzzer on again.

DIODE PROTECTION

Diode D1 isolates the lighting circuit from the ignition circuit as well as reducing any spikes that may be generated by the ignition circuit. Diodes D5, D6, D7 and D8 are all used as isolators and diode D2 protects the base/emitter junction from any pulses present when the lights are switched on. D9 is included to hold TR3 off when driving with the lights on as it was found that leakage current through C2 can sometimes trigger CSR2 on.

STRIPBOARD

The components are mounted on a piece of stripboard measuring 18 strips by 26 holes. The component layout and track breaks are shown in Fig. 2.

After the components have been soldered into position the case can then be drilled and the light dependent resistor (R1), the two l.e.d.s (D10 and D11), and the two in-line fuses fitted and wired to the stripboard. Check there are no solder shorts on the board and that all the track breaks are completely cut through.

INSTALLATION AND SETTING UP

The unit should be mounted into position using double sided tape and placed where daylight can fall directly onto the LDR. Before finally fixing the unit into position it should be set up correctly. Because the output from different charging circuits can vary by as much as 3 volts a 220kΩ preset can be used in place of R7 to set the operation of the buzzer. A final value of R7 between 150kΩ and 180kΩ should be suitable for most cars.

The two supply leads to the circuit should go to the light switch and the ignition switch. Because it is not always possible to wire directly to both these switches the wiring diagram of the car should be studied to decide the best place to make the connections.

When the unit is in position and it is dark outside the engine should be started and VR1 adjusted to bring on the buzzer. The rest of the operation of the circuit can then be tested. □

SPECIFICATION

For use on negative earth vehicles only
Working voltage 10–16 volts d.c.
Current consumption:
- @ 14V (no lights) 6mA
- @ 14V (with lights) 8·5mA
- @ 14V (parking lights on) 3mA

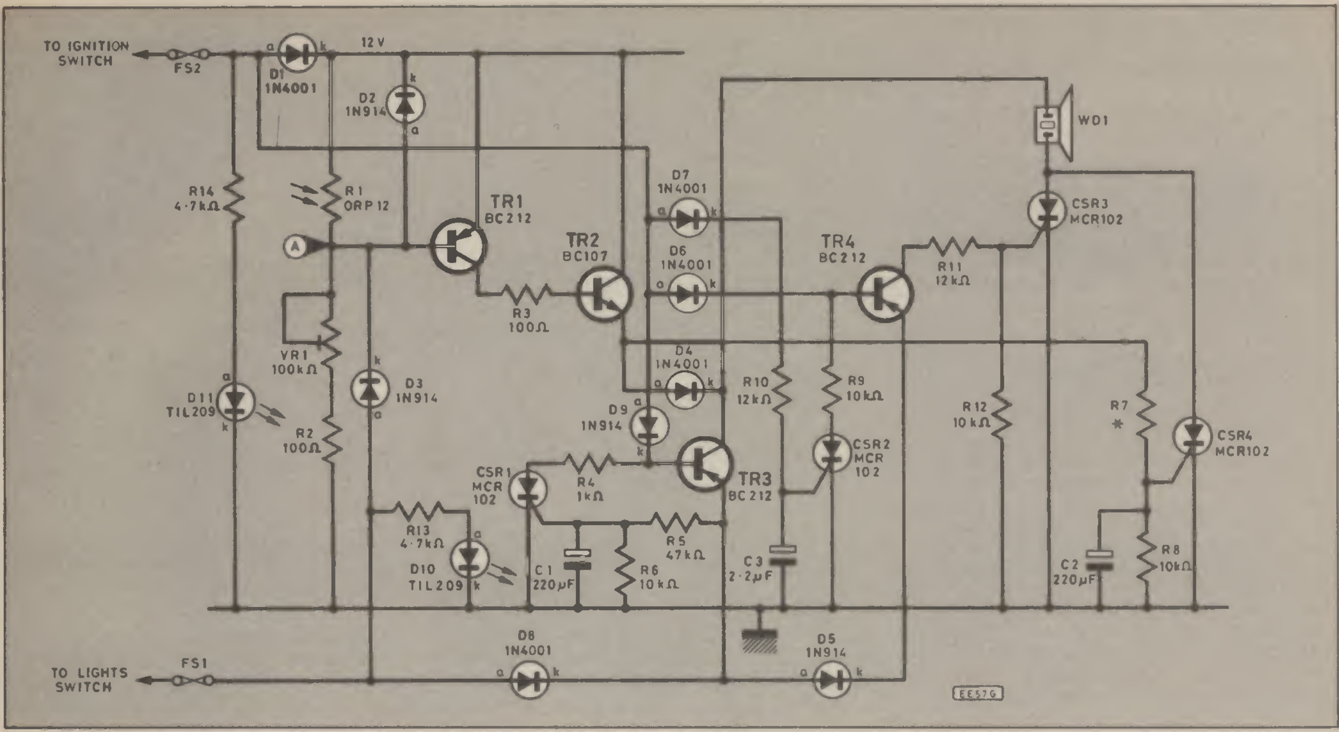
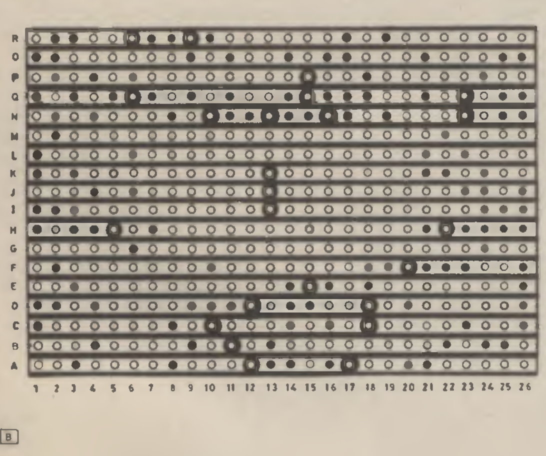


Fig. 1. Circuit diagram of the Car Lights Warning.



See **Shop Talk** page 434

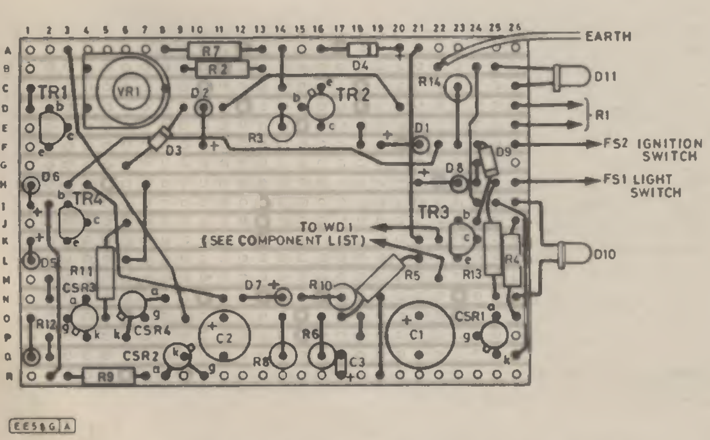


Fig. 2. Stripboard and component layout.

COMPONENTS

Resistors

R1	ORP 12 light dependent resistor
R2,3	100Ω (2 off)
R4	1kΩ
R5	47kΩ
R6,8,9,12	10kΩ (4 off)
*R7	220kΩ
R10,11	12kΩ (2 off)
R13,14	4·7kΩ (2 off)
VR1	100kΩ hor. min. preset

All resistors ¼W 5% carbon

Capacitors

C1,2	220µF 16V radial elect. (2 off)
C3	2·2µF 16V radial elect.

Semiconductors

D1,4,6,7,8	1N4001 (5 off)
D2,3,5,9	1N914 (4 off)
D10,11	TIL209 red l.e.d. (2 off)
TR1,3,4	BC212 (3 off)
TR2	BC107
CSR1,2,3,4	MCR102 (4 off)

Miscellaneous

FS1,2	100mA fuse (2 off)
WD1	12V d.c. buzzer Maplin FL40T

Panel mounted in-line fuse holder (2 off)
Plastic case 78 × 50 × 25mm
Stripboard 18 strips by 26 holes
* See setting up procedure

Approx. cost Guidance only **£11.00**

SQUARE one FOR BEGINNERS

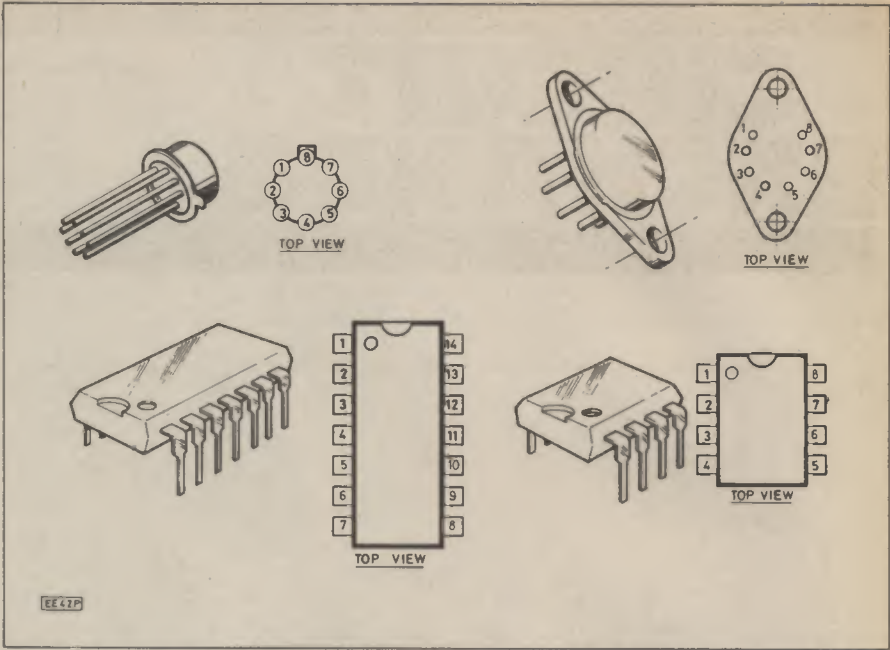


Fig. 1. Pin numbering for linear i.c.s. Metal cans have either a tag or a wider pin spacing to identify pin 8. Dual-in-line packages have a notch and/or a depression to indicate pin 1.

THE COMPONENTS LIST for any constructional project will nowadays usually include some integrated circuits (i.c.s). There are hundreds of different i.c.s now available, costing anything from a few pence to several pounds; generally, the cost reflects the complexity of the device, but very popular complex devices (such as microprocessors) are relatively cheap.

Integrated circuits may be considered as falling into one of two categories; linear, or logic, and it is under these headings that they are usually advertised by component suppliers. The suppliers' catalogues should be consulted for details of power supply requirements and connections for any particular i.c., but it is possible to give some general information, and to explain the numbering system. For beginners, simple projects are obviously best, and the regular *Circuit Exchange* feature should provide plenty of good ideas.

LINEAR INTEGRATED CIRCUITS

These have been designed to provide, in one package, a commonly-required function; examples include general-purpose amplifiers, voltage regulators and video amplifiers. A very popular device is the 555 precision timer; although essentially this circuit simply provides a time delay, home constructors have found hundreds of applications for it. General-purpose amplifiers include the 741 and 748, and all the devices are available from a number of manufacturers in various package types.

The letters associated with the number indicate the maker and the packaging: common prefixes include LM and NE. The letter after the number, if any, indicates the package type, for example H for a metal can, and N for a dual-in-line package. Because different manufacturers have different conventions, it is the type number which is normally referred to in the text. For example, if a "555 timer" is specified, the device could equally well be LM555CN (National), CA555CE (RCA), or NE555N (Signetics).

Once this is understood, pin numbers on the package can be related to the circuit diagram connections, and a working project can be completed without having to know what is actually inside the i.c. Some common package types for linear i.c.s are shown in Fig. 1.

LOGIC CIRCUITS

Most of the logic i.c.s used in projects have 14 or 16 pins and are housed in a standard dual-in-line package (Fig. 2). Unlike linear circuits, which may require a number of different power supply connections, TTL (Transistor-Transistor Logic) i.c.s work on only two levels: +5 volts and ground (zero volts). For all standard TTL i.c.s, +5 volts is connected to pin 14 (or pin 16 for a 16-pin package), and zero volts to pin 7 (or pin 8). The functions of the other pins depend on the device, but Fig. 3 shows the inputs and outputs for a quad 2-input AND gate. It is called a quad gate because there are actually four separate, independent gates inside the chip. So a design

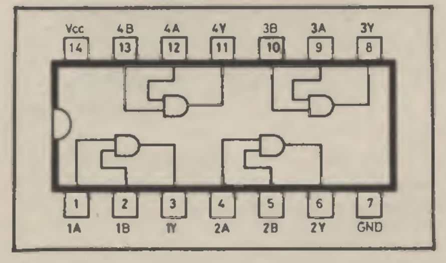


Fig. 3. Internal connections for a 7408 or 74LS08 quad 2-input AND gate.

which required eight such gates, for example, would only need two i.c.s.

The part number is made up of a manufacturer's prefix (usually SN), followed by the number 74 for standard circuits (54 for a wide temperature range), and then the number which indicates the type of circuit. An '08, as shown, is a quad AND gate, while an '02 is a quad NOR gate. The final letter shows the package type, which is usually plastic dual-in-line, indicated by the letter N or P.

Finally the letters "LS", as in SN74LS08N: this stands for "low-power Schottky" and means that the i.c. is a fast-switching type. There are other families of TTL (for example very low power and super-fast) but either LS TTL or standard TTL is usually specified for projects. Different families should not, as a rule, be mixed.

CMOS

These digital integrated circuits are designed for use where low power consumption is required, or where the power supply may be "noisy" (random fluctuations in voltage level). This makes them ideal devices for some applications, but CMOS operates more slowly than TTL. The part number is made up of a manufacturer's prefix (e.g., MC1 for Motorola), followed by four digits beginning with "4" to indicate function, and then one or more letters to show the package type. A plastic dual-in-line quad 2-input NAND gate could be MC14011BCP (Motorola) or CD4011BE (RCA) or CD4011BCN (National). The number which specifies the function is 4011, and it is this which the supplier advertises.

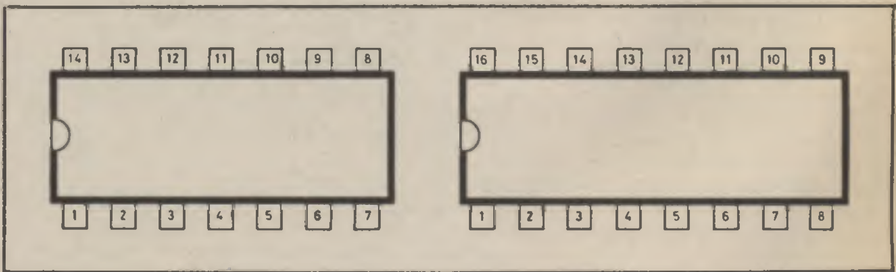
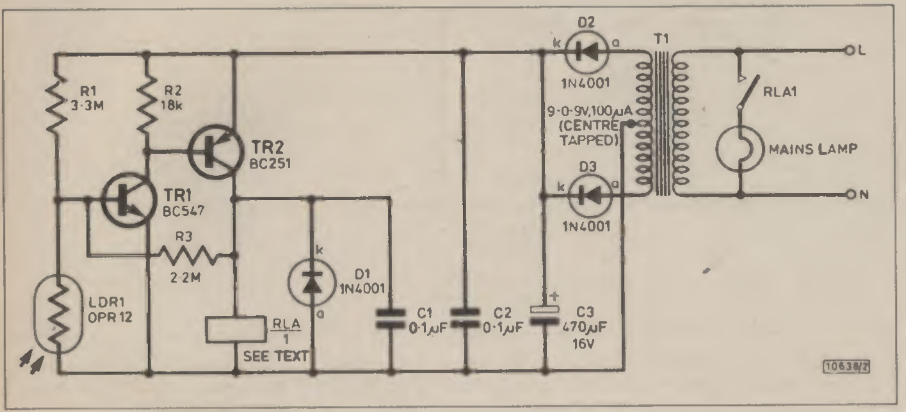


Fig. 2. Dual-in-line 14-pin and 16-pin TTL i.c.s have a notch at the end of the package to identify pin 1.

CIRCUIT EXCHANGE

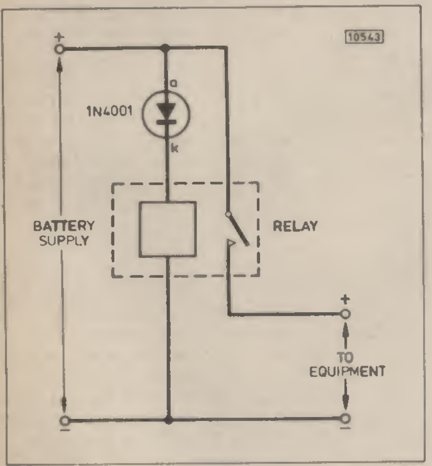
This is the spot where readers pass on to fellow enthusiasts useful and interesting circuits they have themselves devised. Payment is made for all circuits published in this feature. Contributions should be accompanied by a letter stating that the circuit idea offered is wholly or in significant part the original work of the sender and that it has not been offered for publication elsewhere.



SIMPLE PHOTOELECTRIC SWITCH

This circuit requires very few components and is therefore cheap to build, yet despite its simplicity is able to switch at very low light levels, the level being set by R1. Whenever possible the l.d.r. should be kept away from the lamp being controlled to prevent feedback. If difficulty is experienced then R3 can be lowered to increase the difference between Switch-On and Switch-Off light levels, and may also solve feedback problems. None of the component values or types are critical, except that the relay should have a minimum resistance of 185 ohms.

R. Ormston,
Southampton,
Hants.



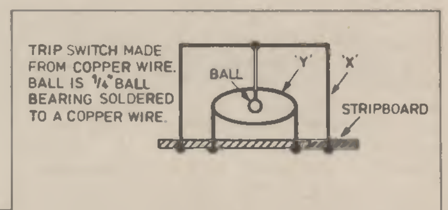
REVERSED BATTERY PROTECTION

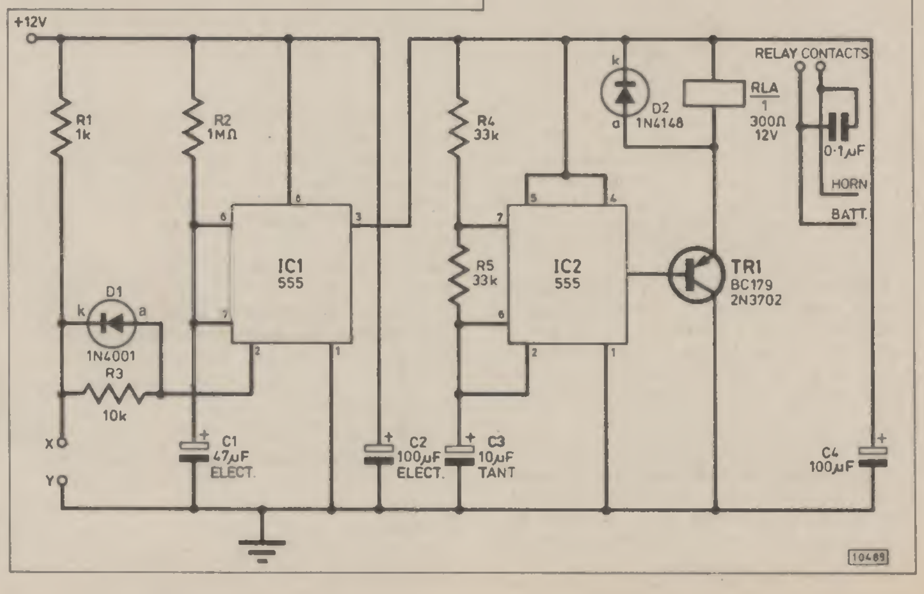
When constructing portable electronic equipment, it is often advisable to have some form of protection should the battery be connected the wrong way around.

A diode connected in series with one of the supply lines will do, but has the disadvantage of producing a forward volt drop of about 1V. A neater solution, which produces no drop in the supply, is to use a relay, as in the circuit shown.

With the battery connected correctly, the diode conducts, operating the relay, and applying power to the equipment. Should it be reversed, the diode blocks the flow of current through the relay coil preventing it from switching on.

P. Thompson,
Lennoxton,
Glasgow.





MOTORCYCLE ALARM

In this circuit a 555 timer (IC1) is used as a monostable, and when triggered by pin 2 being brought low, drives another 555 (IC2) which is wired as an astable. The output from IC2 turns TR1, and thus the relay on and off. This gives a series of bursts of the horn for a time set by R2 and C1. Pin 2 can be triggered by a ball bearing tilt mechanism, as shown in the diagram.

This unit can also be used in cars by wiring the trip switch wire to the courtesy light. Pin 2 will be held high via the lamp, and will be triggered by the car door being opened. If this method is used it will be necessary to install an isolation switch outside the car.

G. Bamford,
Clackheaton,
West Yorks.

CIRCUIT EXCHANGE

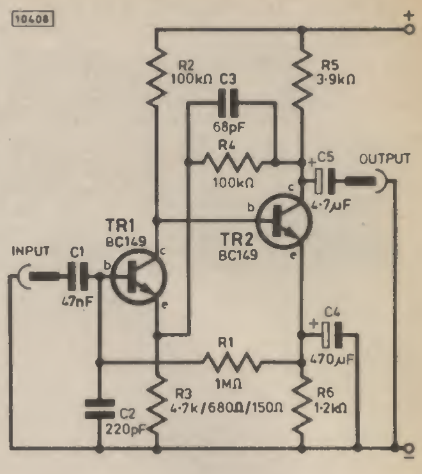
LOW NOISE HIGH GAIN PREAMPLIFIER

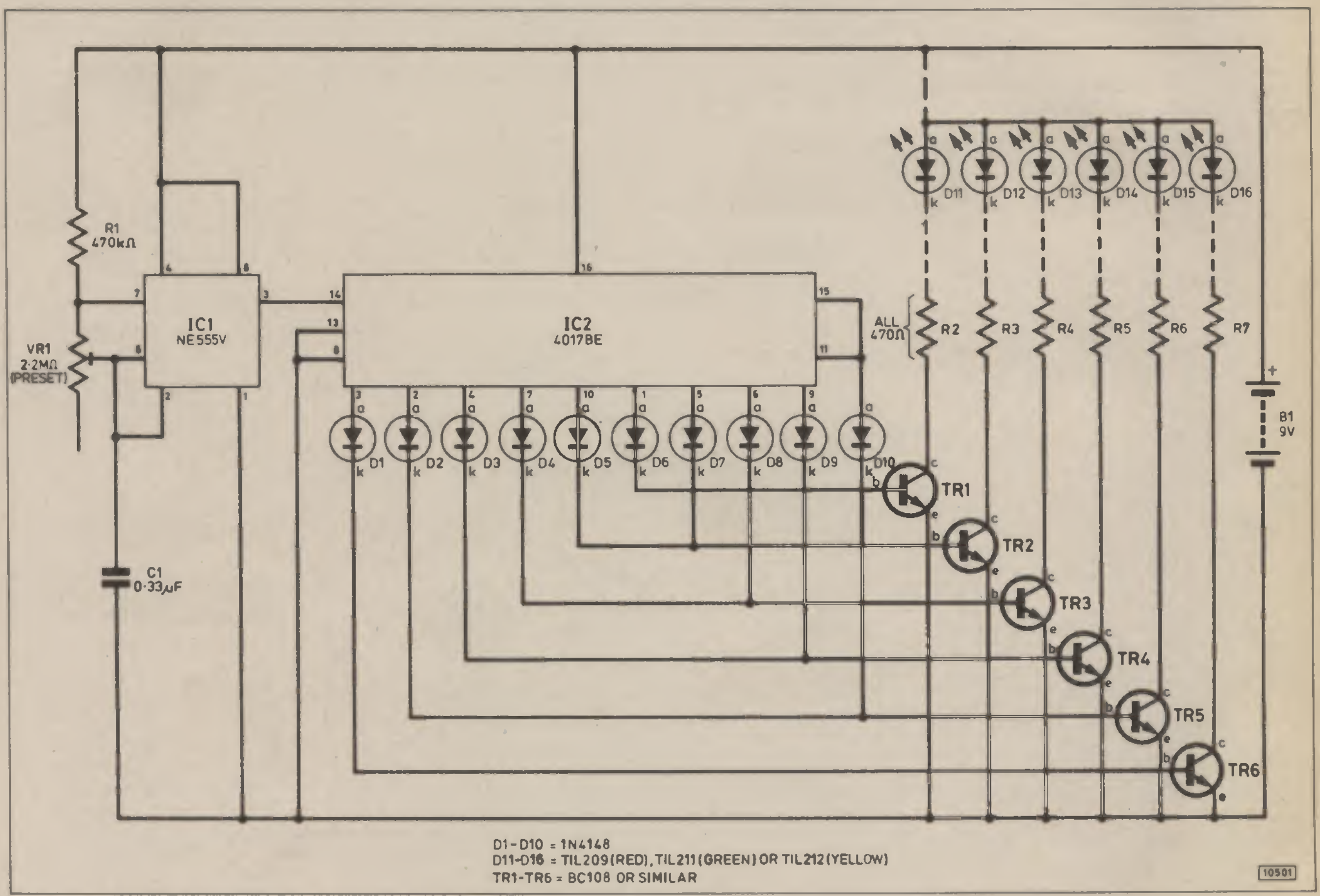
This useful circuit has pre-programmable high gain and can be used for many applications. The gain of the circuit will be set at ×30, ×160 or ×700, by selecting R3 to be 150Ω, 680Ω or 4·7kΩ, respectively. The output of the circuit is suitable for most power amplifiers and may also be used to drive headphones independently of power amps.

A small 9V battery can be used as a power supply and because of the low current consumption of the circuit, the life of such a battery will be long. However, if you wish to use this preamplifier with a power amplifier it is better to use the P.A. power supply. In this case the use of a noise filter is essential.

When using the filter R6 should be 1·2kΩ minimum for a 12V supply. If higher voltages are being used then this should be increased to 4·7kΩ. The maximum supply voltage should be 18V.

Kamel Alizadeh,
Tehran,
Iran.





FLASHING DECORATION LIGHTS

This circuit was designed last Christmas to improve on the stationary, rather drab decorations in the living room with the aid of flashing lights arranged to give the appearance of one light moving back and forth. The heart of the circuit is IC2, a CMOS decade counter divider with ten decoded outputs. Therefore, with each positive pulse given to pin 14 (the clock input), the output from one pin drops, and the next pin in the series rises to supply voltage. The pulses are provided by IC1, a 555 timer, wired up to give astable square waves from the output pin. The resistance across pins 6 and 7 is variable so that the frequency of the pulses can be altered to a pleasing value.

The first six outputs of IC2 are connected via signal diodes to the bases of six transistors controlling l.e.d.s, so that with the first six pulses the l.e.d.s are lit in order. To give the appearance of the light moving back, the seventh output is connected to the transistor base from the fifth, the eighth to that of the forth and so on. Pin 11 (the tenth output) is also connected to pin 15 (reset) to allow continuous operation. The l.e.d.s situated in order across the room are joined to the main circuit by seven wires; one from each cathode and one for the supply line. The bundle of wires, which incidentally diminish to two at the farthest end, is easily hidden amongst other decorations if bound together and covered with dark insulation.

M. Allen,
Pinner,
Middlesex.

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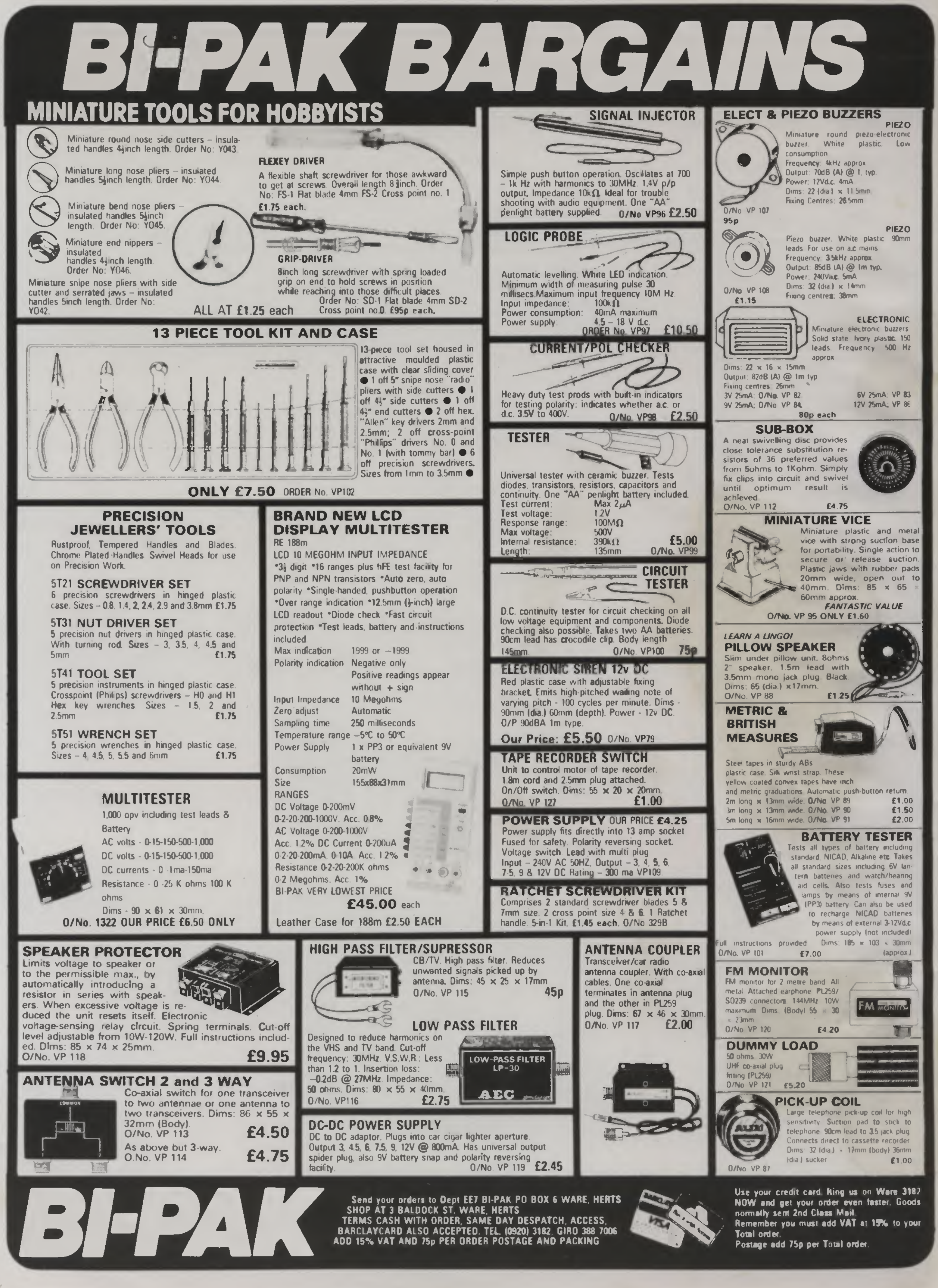

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