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DECEMBER 1980
60p

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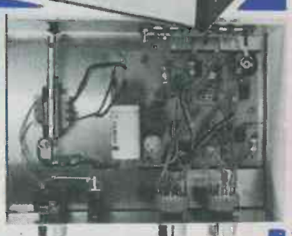

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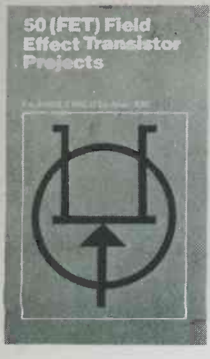

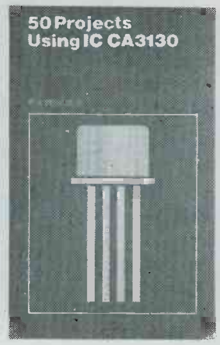

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OUR NEXT ISSUE WILL BE PUBLISHED MID-DECEMBER

DIRECT SUPPLY SERVICE TO READERS

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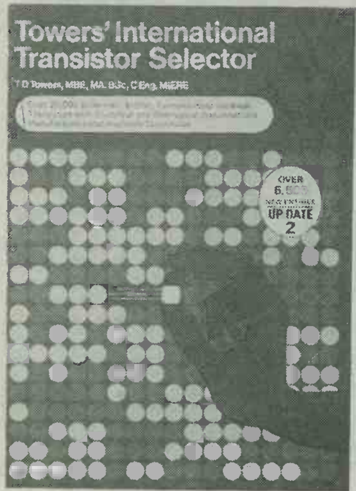

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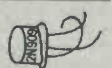

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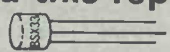

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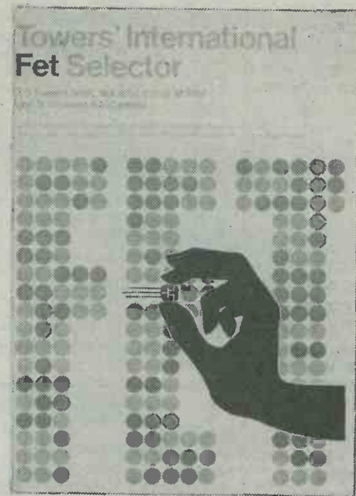

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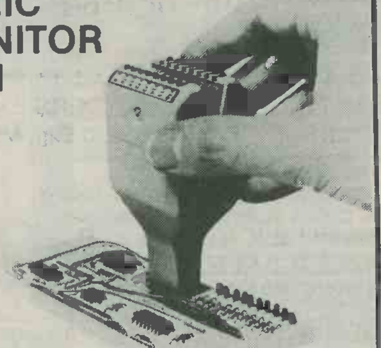

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2v4. 2v7. 3v. 3v6. 3v9. 4v3. 4v7. 5v6. 6v2. 6v8. 8v2. 10v. 11v. 12v. 15v. 18v. 27v. 33v.
2.5WT BZX70, etc. 13p
v75. 1v. 2v4. 3v6. 3v9. 5v6. 6v2. 7v. 7v5. 8v. 9v. 10v. 11v. 14v. 15v. (8p). 20v. 22v. 24v. 26v.
5WT BZV40, etc. 15p
3v3. 3v6. 3v9. 4v3. 4v7. 5v1. 5v6. 6v2. 6v8. 7v5. 8v2. 8v7. 9v1. 10v. 11v. 12v. 15v. 33v. 68v. 120v.
10WT Z5D, ZX, etc. 20p
4v3. 4v7. 5v1. 5v6. 6v2. 6v8. 7v5. 8v2. 11v. 12v. 13v. 16v. 18v. 21v. 22v. 33v. 36v. 39v. 68v. 150v.
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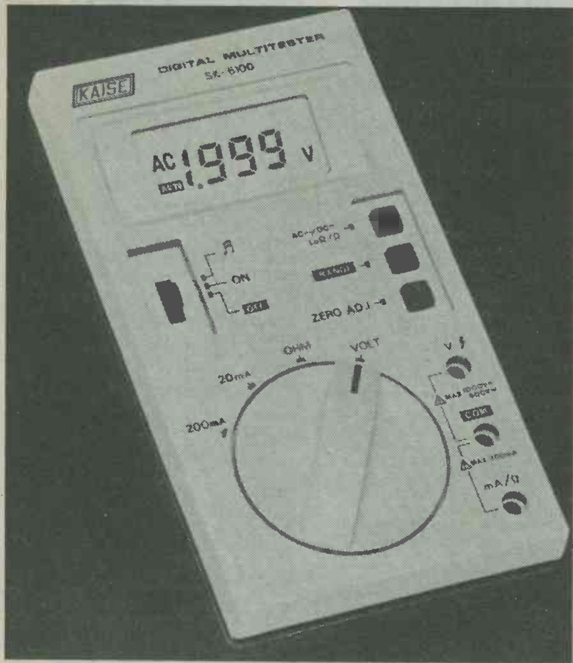
NEWS . . . AND



AUTORANGING, AUTO UNIT DISPLAY DMMs for under £40

A major price breakthrough on Autoranging, 3½-digit DMMs with a unique Auto Unit Display has been announced by Maclin-Zand Electronics, with four models selling from only £39.95, inc. VAT.

Hand-held, rugged, and with ergonomically laid out fascias, the four models offer a range of features you'd be hard put to find on DMMs costing two to three times as much. Zero adjustment; 3½-digit LCD with 200 hrs continuous battery life, Full Autoranging; Auto 'Batt' Warning; Auto Unit Display, plus buzzer for Continuity Test and Over Range Indicator on Models 6110 and 6100. Models 6110 and 6220 measure AC/DC current to 10 A, Models 6100 and 6200 to 200mA.

Available only from Maclin-Zand direct, prices are £39.95 for the 6200, £49.95 for the 6220, £64.95 for the 6100 and £74.95 for the 6110. These price include VAT, batteries, pair of test leads, spare fuse and one year guarantee, but exclude p&p, for which £1.15 should be added. Full information and specs on the range are available from Maclin-Zand Electronics, 38 Mount Pleasant, London WC1X 0AP.

GYR AND LANDIS COMMEMORATIVE PRIZE – 1980

The 1980 Karl Heinrich Gyr and Heinrich Landis Commemorative Prize has been awarded by the Institute of Electrical Engineers to Martin Weston of the BBC Engineering Research Department.

Martin Weston has worked at the Research Department for ten years and has spent much of that time developing the techniques of digital television processing. He has been awarded the Prize for his development of the Electronic Zone-Plate which is proving to be a valuable tool in testing and assessing the performance of digital television systems. The Zone-Plate generates television pictures incorporating periodic gratings of all possible pitches, slopes and rates of movement by electronic means.

The Commemorative Prize won by Martin Weston is awarded annually by the I.E.E. and sponsored by Landis and Gyr Ltd. for practical contributions to the advance of electrical and electronic science and engineering with particular reference to measurement and assessment techniques.

UNIPART AUDIO RANGE

Ten separate Unipart radios, radio/cassette players and cassette players built with technologically advanced quality products that look as good as they shound. Each unit is competitively priced and is backed by Unipart's extensive range of accessories, fitting kits and aerials.

The new Unipart audio range consists of:– 1. A manually tuned AM radio. 2. Two five push button AM radios. 3. A six push button AM/FM radio. A prestige 6 push button AM/FM stereo radio. 5. An under dash stereo cassette tape player. 6. Two manually tuned radio combined stereo cassette tape players. 7. A six station pre-selection AM radio combined with a stereo cassette tape player. 8. A six station, pre-selection AM/FM stereo radio combined with a stereo cassette tape player.

Each audio product will be available at 240 BL distributors, 2,000 other UK distributors, 650 Unipart shops and 130 Unipart centres.

'THE NIGHTINGALE'S' FIRST BROADCAST

A number of readers were very interested in the article 'First Woman Broadcaster Ever' which appeared in our August 1980 issue.

Many readers will therefore probably be interested to learn of the first broadcast by Dame Nellie Melba, known to the world as 'The Nightingale. It was made approximately three months after those of Miss Sayer – the first woman broadcaster ever.

The event was advertised widely in the national press and on 15th June 1920 Dame Nellie Melba went to the Chelmsford Works of Marconi to sing.

Completely unaware of how the 'magic' of broadcasting worked, she was shown the site. When told that her voice would go out from the aerial slung some four hundred and fifty feet above her head from two masts, she said to Arthur Burrows (later BBC's first Director of Programmes) "Young man, if you think I'm going to climb up there, you're quite mistaken."

In the event she sang in the transmitter shed, which today is the high-power test area of Marconi Communication Systems Limited.

Amongst thsoe present at her broadcast were William Ditcham, a Marconi engineer, who had made the world's first broadcast, and Miss Winifred Sayer. Miss Sayer, now 82 years old Mrs Winifred Collins, recalled Dame Nellie, who had two accompanists, kicking back the carpet that had been laid on the concrete floor as it spoilt the acoustics. The microphone was a problem, as it did not have an adequate mouth-piece, so one was improvised from the sides of a Havana-cigar box and the contraption was suspended in front of Dame Nellie, who subsequently autographed and dated it. The microphone and its embellishments is still in the possession of The Marconi Company.

Dame Nellie's broadcast was an immediate success. It was followed up over the next few months by further broadcasts using other famous singers. There were also news and current affairs broadcasts as well as instrumental recitals, and in August 1920 the first broadcast to a ship at sea was made, specifically to the ss Victorian which was taking delegates to an international press conference in Canada. They were daily kept informed of news by a bulletin from Chelmsford.

Still experimental, these broadcasts led to the establishment of '2MT Writtle', just outside Chelmsford, in February 1922 and '2LO Strand' in May 1922. '2LO' was later handed over by Marconi to the newly formed British Broadcasting Company in November 1922.

DESIGN OFFICE REFERENCE

Now available from MCP Electronics on behalf of TRW LSI Products is a new 1980 'short form' catalogue offering the immediate answer to what could well be described as hundreds of Digital Signal Processing Design problems.

Copies of the new 1980 short form are available on request from: MCP Electronics Ltd, 38 Rosemont Road, Alperton, Wembley, Middlesex HA0 4PE.

SEALED NICKEL CADMIUM BATTERIES

The 520/8 range of nickel cadmium sealed batteries, style NR-AA, offered by Symot Limited have a nominal voltage 1.2V and a capacity of 500 mAh. The quick charging rate is 4.5 hours at 150 mA and a life of more than 500 cycles of operation, under normal conditions, is claimed.

The volume is 0.51 cubic inches (8.3 cc) giving an energy density rating of 60mAh per cc.

These batteries are suitable for use up to 45deg. C.

The batteries are fitted with flat contact type terminals and weigh 0.74 ounces (21 gm). A re-sealable type of safety vent is fitted.

Full information can be obtained from: Symot Limited, 22a Reading Road, Henley on Thames, Oxon RG9 1AG.

POCKET POWER FROM TANDY

One of the smallest computers on the market, the new Tandy TRS-80 Pocket Computer, should be available by the time these notes appear.

This latest addition to the Tandy TRS-80 range is only 175mm x 70mm x 15mm and will sell for £119 (including VAT).

It is battery powered which means that a number of programmes can be loaded and retained for up to 300 hours (the life of the battery) even when the power is switched off.

Because it does not rely on a mains supply the new TRS-80 Pocket Computer can be carried around and used almost anywhere.

There are already eight packages of software available to cover varying needs. These include civil engineering, aviation, maths drill, business statistics, real estate, personal finance and a games package. These, too, will be in the shops in late autumn at prices ranging from £8.95 to £13.95 (including VAT).

The Tandy Pocket Computer has a 4-bit CPU consisting of two microprocessors. It can carry 1.9K of user memory (RAM) and a total of 11K of ROM – 7K for the BASIC interpreter and approximately 4K for the monitor.

Using the cassette interface (£17.95), multiple programmes can be loaded from cassette tape without the previous programme being erased.

SUGGESTED CIRCUIT

THE MAGIC HAND

By G. A. French

This article describes a novelty device which can be both instructive and amusing.

On the surface of a wooden or plastic panel is affixed a piece of card cut out in the shape of a hand. A person being introduced to the device is asked to place his hand flat on the panel, so that the fingers and main part of his hand conform with the cut-out and are positioned within its outline. As soon as the hand is fully placed on the cut-out a circuit is completed, this consisting of the lighting of a lamp, the sounding of a buzzer or any other effect favoured by the constructor. At the same time there are no visible or obvious electrical connections or contacts on the panel which the person's hand can touch.

FOIL CONTACTS

Fig. 1(a) shows the cut-out of the card hand as seen from above. On the underside are glued two pieces of kitchen aluminium foil with the approximate shape and size shown in Fig. 1(b), and having two straight edges at the centre spaced from each other by approximately ¼in. When a hand is placed on the top side of the card, the increased capacitance between the two pieces of foil activates the circuit which lights the lamp or produces the alternative effect.

The circuit of the device is given in Fig. 2. Here, ICl is a 555 oscillating in the standard astable mode at a frequency of around 200kHz. Its output at pin 3

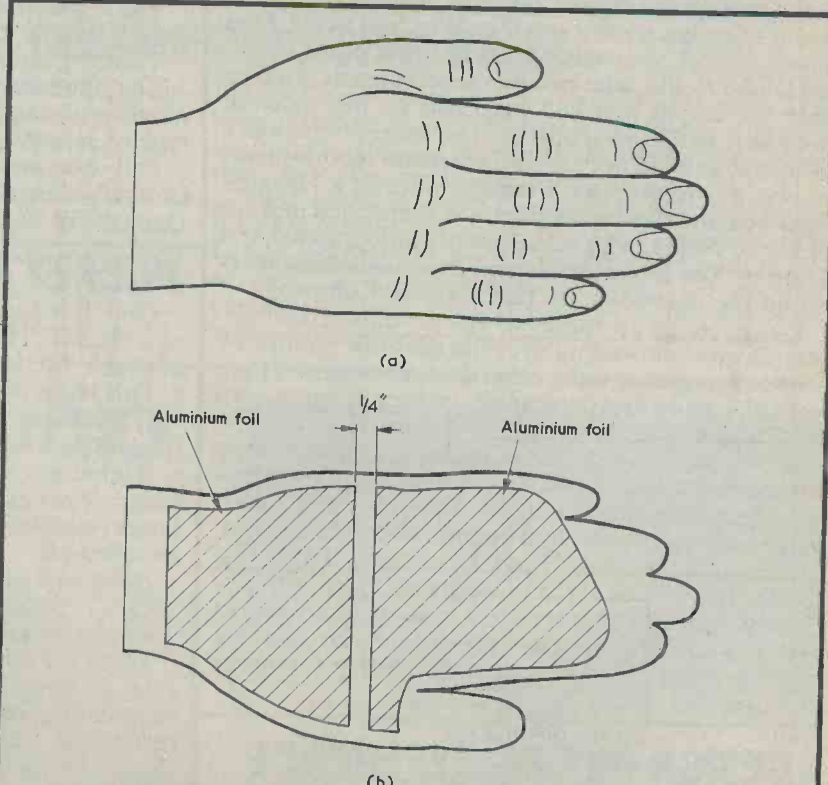


Fig. 1(a). A piece of card, cut out and marked up to resemble a hand, is mounted on an insulated panel. The circuit causes a relay to be energised if a person's hand is placed over the card hand.

(b). On the underside of he card are two pieces of aluminium foil. Placing a hand on the card increases the capacitance between them.

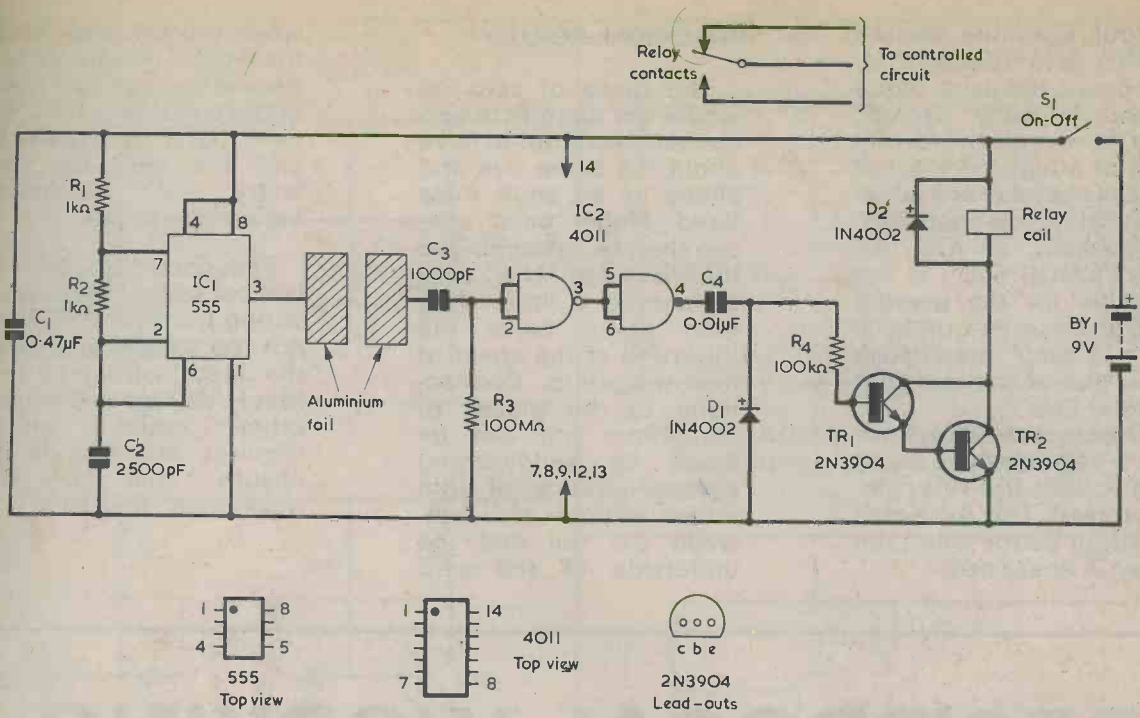


Fig. 2. The circuit of the "Magic Hand". IC1 is a standard 555 oscillator whose output, when the capacitance between the two pieces of foil is sufficiently high, is passed through the two NAND gates of IC2.

connects directly to one of the pieces of aluminium foil shown in Fig. 1(b). The other piece of foil connects via C3 to the inputs of a NAND gate in a CMOS 4011 i.c., the NAND gate output connecting to a second NAND gate. Both gates are employed as inverters. The inputs of the first gate are kept low by R3, and the output of the second gate is similarly low. Normally, the stray coupling between the 555 output and the first NAND gate inputs is too low to have any effect on the NAND gate. When, however, a hand bridges the two pieces of foil, the increased capacitive coupling takes the NAND gate inputs sufficiently high on positive pulses from the 555 to produce corresponding low pulses at the NAND gate output. The output of the first NAND gate is fed to the second NAND gate, which provides any further amplification that may be needed. Thus, when a hand is placed over the two pieces of foil an output at 200kHz, with the maximum amplitude which a CMOS NAND gate is capable of providing, is produced at the output of the second NAND gate.

The use of the two NAND gates in this manner ensures that, as the capacitance between the two pieces of foil is increased, there is a level of capacitance at which the second NAND gate commences, fairly abruptly, to produce a 200kHz output. There is not a gradual increase in 200kHz output as would be given with a normal linear amplifier.

RECTIFIER CIRCUIT

When it is present, the 200kHz output of the second NAND gate is applied to the shunt rectifier circuit consisting of C4 and D1, and a rectified positive voltage appears at the junction of these two components. This voltage is applied via R4 to the base of TR1, whereupon TR1 turns on and causes the relay to energise. The relay contacts then switch on the lamp or cause the alternative effect to be given. The relay de-energises again as soon as the hand is taken away from the pieces of aluminium foil.

Apart from R3, the components are all standard types. The author employed ten 10MΩ resistors connected in series to produce the 100MΩ required in R3. Higher value resistors could similarly be connected in series to produce approximately the value required. The relay employed with the prototype circuit was an "Open Relay" with 410Ω coil, and this is available from several suppliers including Maplin Electronic Supplies. The diode specified for D1 has reduced efficiency at 200kHz but it functions adequately in the present circuit where there is a relatively low impedance output from the second NAND gate. Diode D2 is, of course, the usual diode found in relay circuits, and it prevents the formation of a high back-e.m.f. across the relay coil when the relay de-energises. Incidentally, an ICM7555 (the "CMOS 555") is not suitable for the present circuit since its output is at a higher impedance than that of the standard bipolar 555.

The current drawn from the 9 volt supply is about 15mA with the relay de-energised. This increases to about 35mA when the relay is energised.

PRACTICAL POINTS

The piece of card on which the hand is drawn should be cut out to have about the same size and shape as an adult male hand. Finger nails, etc., can then be inked in. The thickness of the card should be a little more than about twice the thickness of the cover of this magazine. Connections to the pieces of aluminium foil can be made by sandwiching several strands of thin tinned copper wire between the foil and the underside of the card when the foil is glued to the latter. The wire is then passed through two holes in the panel on which the card hand is mounted, and the electronic circuitry is positioned behind the panel.

The circuit should be laid out so that the output wiring from the 555 does not too closely approach the input wiring to the first NAND gate. The only other point which requires attention is to ensure that C1 is positioned close to IC1.

■

RECIPROCAL WORKING

By G. B. Brown

Rapid results from your calculator

Even the less expensive general purpose electronic calculators can make short work of solving electronic calculations. What are probably three of the most useful key functions here are the square (x^2), the square root ($\sqrt{x}$) and the reciprocal (1/x) keys. If your calculator has these three keys then it is capable ot quickly working out most of the simple electronic problems you are liable to encounter. The key I would like to concentrate on in this short article is the reciprocal key, since it can provide useful short cuts in working out such things as cycle length and frequency in RC oscillators.

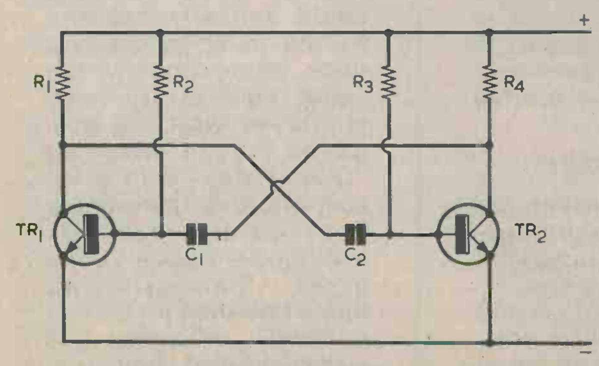


Fig. 1. The standard multivibrator. Frequency is controlled by the values of R2, R3, C1 and C2.

MULTIVIBRATOR

Take the familiar multivibrator of Fig. 1. During the multivibrator cycle TR1 is turned off for part of the time and TR2 is turned off for the remainder of the cycle. The length of time each transistor is turned off depends on the values of the resistor and capacitor connected to its base. Mathematically, the length of time when TR1 is turned off is approximately equal to 0.7 times the time constant of R2 and C1, and the length of time when TR2 is cut off is approximately equal to 0.7 times the time constant of R3 and C2.

Before proceeding further a word of warning. When each transistor is initially turned off in the cycle its base goes negative of the negative rail by nearly the full supply voltage. If this voltage exceeds the transistor base-emitter junction reverse breakdown voltage no harm results, but the junction behaves like a zener diode and upsets the timing calculations. Nearly all modern silicon transistors have base-emitter breakdown voltages of the order of 6 volts or more, so if you want the multivibrator of Fig. 1 to run at around its calculated frequency it's a good idea to use a supply of 6 volts or less. And now to the calculations.

TR1 cut-off time is approximately equal to 0.7 times the time constant of R2 and C1, i.e. it is equal to 0.7 X R2 X C1. Useful units are megohms, microfarads and seconds. Let's say that, as in Fig. 2(a), R2 is 220kΩ (=0.22MΩ) and that C1 is 0.047μF. We press the calculator keys to give:

0.7 X 0.22 X 0.47 =

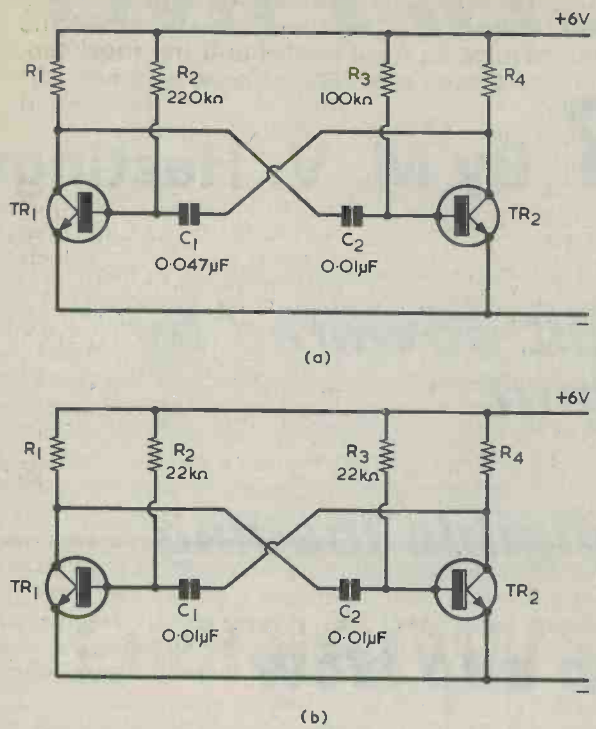


Fig. 2(a). Multivibrator with a calculated frequency of 126Hz (b). Square wave multivibrator having a frequency of 3.25kHz.

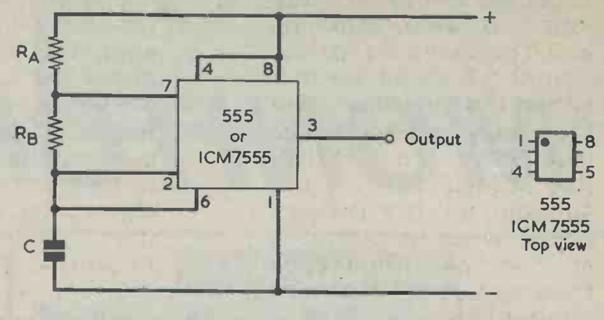


Fig. 3. Astable multivibrator incorporating a 555 or an ICM7555

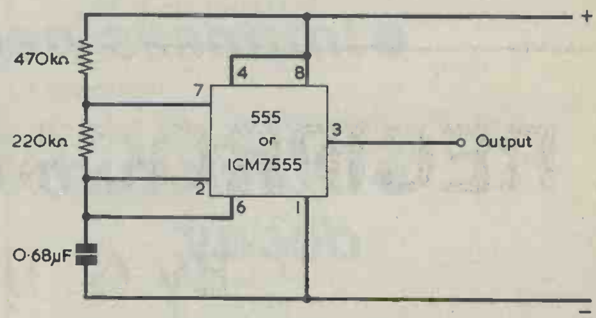


Fig. 4. The astable with typical timing component values.

and we find that the time is 0.00724 second to three significant figures. If we next say that R3 is 100kΩ (=0.1MΩ) and C2 is 0.01μF, the time when TR2 is off calculates as 0.0007 second. Total cycle time is 0.00724 plus 0.0007, which equals 0.00794 second.

And the frequency? Press the 1/x button and you'll find that it is 126Hz to three significant figures.

When R2 equals R3 and C1 equals C2 the total cycle time is approximately 1.4CR. Let's assume that R2 and R3 are 22kΩ(=0.022MΩ) and that C1 and C2 are 0.01μF. See Fig. 2(b). The key sequence:

1.4 X 0.022 X 0.01 =

gives 0.000308 second. Pressing the reciprocal key gives the frequency, which is 3250Hz, or 3.25kHz.

555 AND ICM7555

The usefulness of the reciprocal key becomes more apparent when we deal with oscillators incorporating the 555 and ICM7555. The basic oscillator circuit is shown in Fig. 3 and frequency is given by:

$$f = \frac{1.46}{(RA + 2RB)C.}$$

Units can be megohms, microfarads, seconds and Hertz.

Now, the most cumbersome part of the right hand side of the equation is the (RA + 2RB)C and it is a good plan to work this out first. After that we invert it and *then* multiply by 1.46. Here's the key sequence:

2 X RB = + RA = X C = 1/x X 1.46 =.

The "equals" keystrokes in the middle of the sequence are needed to get the calculation, as it progresses, into the calculator register. Let's try the example of Fig. 4, with RA being 470kΩ (=0.47MΩ), RB being 220kΩ (=0.22MΩ) and C being 0.68μF. We press:

2 X 0.22 = + 0.47 = X 0.68 = 1/x X 1.46 =

and we arrive at a frequency of w.36Hz.

Using the reciprocal key in this manner takes quantities from below the fraction bar and produces their values when shifted above the fraction bar. If we hadn't used the reciprocal key we would have had to do something like work out (RA + 2RB)C, write the result on a piece of paper (or, in a more expensive machine, store it), clear, key in 1.46 and then divide by the result we had noted (or stored).

Reverting to the equation we have just solved, how do we find the total cycle length corresponding to the frequency of 2.36Hz? That's easy. We just press the reciprocal key again, and the calculator tells us that it is 0.424 second. ■

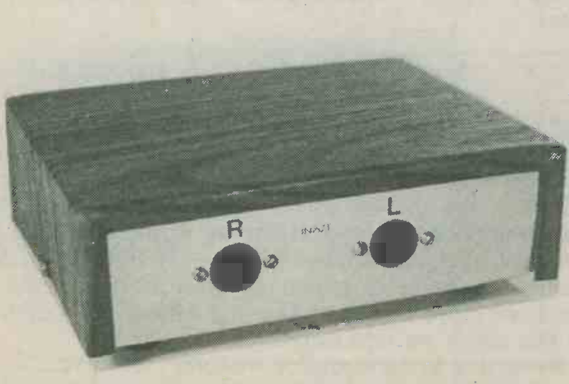
ADD-ON CLIPPING MONITOR

By M. V. Hastings

- *Monitor circuit powered by amplifier output*
- *Imposes negligible loading*
- *Quick turn-on and slow decay.*

If an audio amplifier is overdriven, the output signal becomes distorted due to the inability of the amplifier to provide a sufficiently large output volrage swing. The peaks of the signals are flattened by the overloading, causing a type of distortion which is known as "clipping".

Overdriving an amplifier is unlikely to damage the amplifier itelf, although this is still possible with some designs, and the main result is increased distortion. The severity of this distortion depends on how hard the amplifier is overdriven and to a certain extent on the nature of the programme material. Although there may be a significant loss of fidelity, it still may not always be obvious to a listener that clipping is taking place.



The monitor inputs are taken to two 2-way DIN sockets mounted on the rear panel.

One danger given by clipping is that the distortion causes the generation of new signals, most of which will be at high frequencies. If the speakers employed in the system incorporate tweeters, the amount of power fed to the tweeters can be considerably increased by the clipping. It is possible, with the amplifier driving the speakers hard, that the tweeters will be fed with signals approaching or even exceeding the maximum power that they can handle. Indeed, clipping can (and does) sometimes lead to tweeters being burnt out.

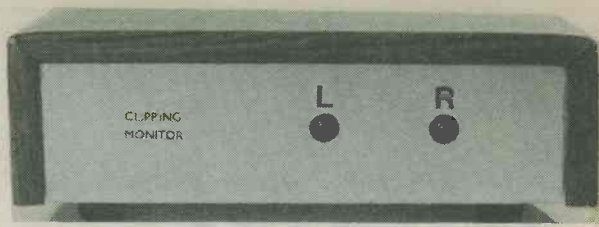
OVERLOAD INDICATOR

It is not uncommon these days for an amplifier to be fitted with an output power meter, or l.e.d. overload indicators, either of which give a visual warning when the amplifier is being overdriven. It is not difficult to add clipping indicators to an amplifier which does not already have this facility built in, and a simple add-on clipping monitor forms the subject of this article.

The monitor has two l.e.d. indicators, one to monitor each stereo channel of the amplifier. The appropriate l.e.d. flashes on if clipping occurs in the channel being monitored. The circuit is connected to the two outputs of the amplifier, or across the two speakers, and no other connection is required. Furthermore, the circuit is powered by the signals taken from the amplifier and does not require a battery or other form of power supply. The additional loading imposed on the amplifier by coupling the monitor to it is negligiblily low.

The two monitoring channels are identical and are not interconnected with each other in any way. If a mono amplifier is to be monitored, only one monitoring channel needs to be constructed.

The unit is powered by the amplifier output which it monitors, and the only items mounted on the front panel are the two clipping indicator l.e.d.'s.



THE CIRCUIT

The circuit of one monitoring channel is shown in Fig. 1. This breaks down into three basic sections: an adjustable attenuator at the input, a full-wave rectifier which rectifies the output from the attenuator, and a voltage detector flashing circuit which is actuated by the rectified signal voltage.

The output from the amplifier is applied to R1 and R2 in series. R1 is a current limiting resistor which reduces the risk of damage to the amplifier in the event of a fault or constructional error. R2 is adjusted to suit the particular amplifier with which the monitor is to be used and it can be set to the required level for any amplifier having a maximum peak-to-peak output swing of at least several volts. Quite small amplifiers are capable of providing an output of this magnitude.

The signal voltage tapped off at R2 slider is fed to the full-wave rectifier consisting of D1 to D4, the rectified voltage being smoothed to a small extent by the fairly low value reservoir capacitor, C1. Since C1 is charged from a fairly low source impedance the voltage across it quickly responds to any rise in the input voltage. Its discharge path is through the voltage detector section, because discharge back to the input circuit is blocked by the bridge rectifier. If there is a sudden and short increase in signal level, C1 charges quickly and then discharges slowly.

The purpose of the voltage detector flashing circuit is to turn on the l.e.d. indicator D7, when the voltage across C1 exceeds a certain threshold level. It incor-

COMPONENTS

Resistors
(All fixed values ¼ watt 5% unless otherwise stated)

R1 2-off 10Ω
R2 2-off 470Ω pre-set potentiometer, 0.25W horizontal
R3 2-off 3.9MΩ
R4 2-off 100KΩ
R5 2-off 390Ω

Capacitors

C1 2-off 3.3μ electrolytic, 10V Wkg.
C2 2-off 0.1μ polyester, type C280

Semiconductors

IC1 2-off ICM7555
D1-D4 8-off IN4001
D5 2-off IN4148
D6 2-off IN4148
D7 2-off TIL220 (see text)

Sockets

SK1 2-off 2-way DIN socket

Miscellaneous

Case (see text)
Veroboard, 0.1in. matrix
2-off panel-mounting bushes (for D7)
Nuts, bolts, wire, etc.

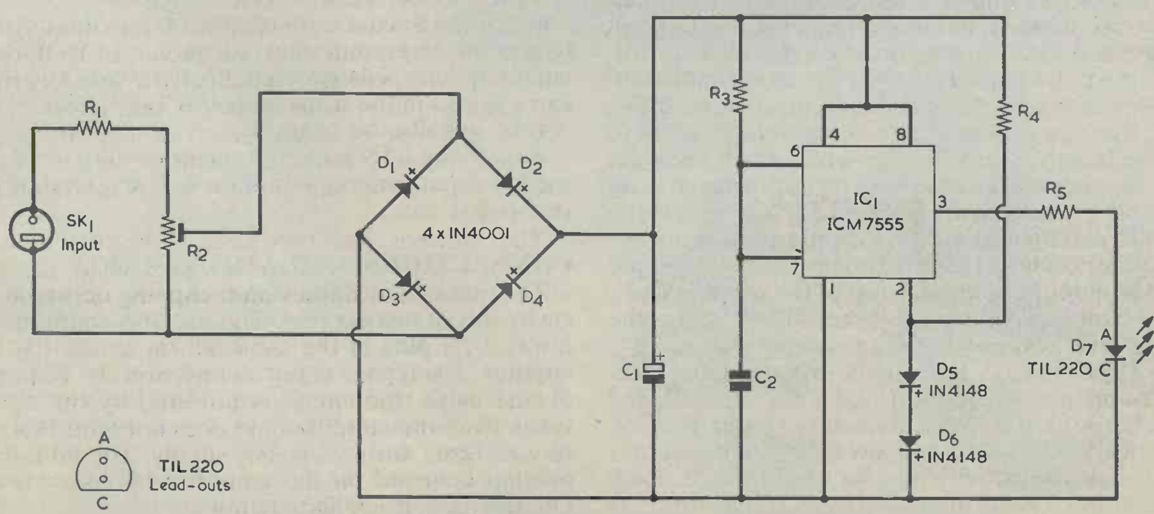
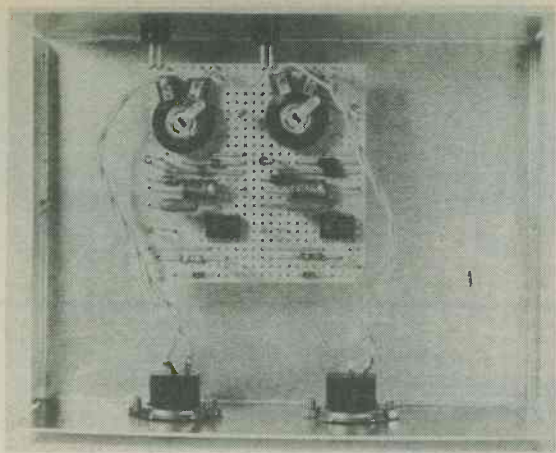


Fig. 1. The circuit of one channel of the clipping monitor. The other channel is ientical. R2 is set up such that l.e.d. D7 flashes when the associated amplifier output is at, or very close to, clipping level.



All the components apart from the input sockets are assembled on a Veroboard panel. This is secured inside the case by the front panel moutings for the two l.e.d.'s.

porates an ICM7555, which is the CMOS version of the well-known 555 timer i.c. and has the advantage here of requiring a supply current in the order of tens of microamps. This is very much lower than the current consumption of the standard 555. Only a limited drive current is available from C1 and the use of an ICM7555 ensures that as much of this current as possible is used to drive the l.e.d., with only a very small current being lost in the i.c.

The i.c. is employed in a standard 555 monostable configuration, in which a positive output pulse appears at pin 3 when the trigger input at pin 2 is taken below one-third of the supply voltage. The duration of the output pulse would (with a steady supply voltage to the i.c.) be theoretically 425mS.

The two forward biased silicon diodes, D5 and D6, act as a voltage regulator and apply a voltage of about 1.2 volts to pin 2. If the voltage across C1, which is the supply voltage for the ICM7555, exceeds 3.6 volts the monostable is triggered since pin 2 is then at less than one-third of this supply voltage. Pin 3 goes positive and current flows throught the l.e.d. via R5. In practice, the l.e.d. may not always turn on for the theoretical 425mS pulse period given by the monostable timing components, because the l.e.d. current now drawn from C1 may cause the voltage across this capacitor to fall. The length of time during which the l.e.d. stays alight depends on the nature of the input signal from the amplifier but it will still be lit for a long enough period to clearly indicate that clipping has occurred.

R2 is adjusted so that the monostable is triggered when the amplifier output is just at the clipping level. Output voltages which are even sligtly below the clipping level will not actuate the monostable.

The ICM7555 i.c. is available from Maplin Electronic Supplies. Two TIL220 l.e.d.'s are required, and these are red l.e.d.'s with a diameter of 0.2in. they are not critical components and any other similar l.e.d.'s of reasonable sensitivity may be used instead. Each l.e.d. requires a panel mounting bush. Capacitor C1 is specified in the Components List as having a working voltage of 10 volts. It will be quite in order here to use a 3.3μF electrolytic capacitor having a much higher working voltage, such as 63 volts.

CONSTRUCTION

All the components are assembled on a Veroboard panel of 0.1in. matrix having 25 holes by 25 copper strips. This has to be carefully cut out from a larger size by means of a small hacksaw. (As will be explained shortly, a board having the same number of strips but with more holes and more breaks in the strips may be required if the constructor wishes to adopt a method of mounting which differs slightly from that used by the author.)

The board is next prepared by making the ten breaks in the copper strips which are shown in the layout diagram of Fig. 2. In each channel, four of the breaks isolate the two rows of i.c. pins from each other whilst the fifth break isolates the input connection at R1 from the remainder of the circuit. The components and link wires are then soldered into place, with the i.c.'s being connected last. Although the ICM7555 is a CMOS device it does not need the special handling precautions normally associated with CMOS integrated circuits.

If the unit is to be used with a mono amplifier only one monitor circuit has to be built, and this can be assembled on a board having 25 holes by 12 copper strips.

The completed board is small enough to fit into most small cases. The prototype is housed in a metal case type TP2, available from Maplin Electronic Supplies, which measures approximately 152 by 114 by 44mm. This has a vinyl cover with a teak woodgrain finish which blends will with most hi-fi equipment. As can be seen form the photographs the two l.e.d.'s appear at the front panel, and their bushes are mounted in holes having their centres spaced by 1.3in. The l.e.d. lead-out wires are bent at right angles, so that when the l.e.d.'s are secured to the front panel the Veroboard panel is horizontal. The board is quite light, and the only support provided for it with the prototype was given by way of the l.e.d.'s in their panel-mounting bushes. Constructors who would prefer a further mounting point could initially employ a board with 25 strips by 28 holes, the 3 extra holes extending to the right of the board as it is shown in fig. 2. A third anchoring point could then be given by drilling a 6BA clear hole at the extreme right of strip "M", and then passing a 6BA bolt, with a suitable spacing washer, through a matching hole in the case bottom. A 6BA nut is then fitted on top of the board. It is most important that all parts of the monitor circuit be fully isolated from the metal case and three extra breaks in the strips, at holes "L25", "M25" and "N25" will also be needed.

Two 2-way DIN sockets, one for each channel, are used as input sockets, and these are mounted on the rear of the case.

CONNECTIONS AND ADJUSTMENTS

The unit is connected to the amplifier or the speakers by way of two suitable lengths of twin cable, with a 2-way DIN plug at the cable which connects to the monitor. The type of connector fitted at the other end of each cable must be chosen to suit the amplifier or speakers. Some amplifiers have outputs for two sets of speakers, and if the second pair of outputs is otherwise unused the monitor can be fed from these. On many amplifiers the outputs are taken from screw terminal using spade type connectors, and with these it is usually not difficult to take two connections from each terminal. It is quite common for loudspeakers to have provision for two methods of connection, and

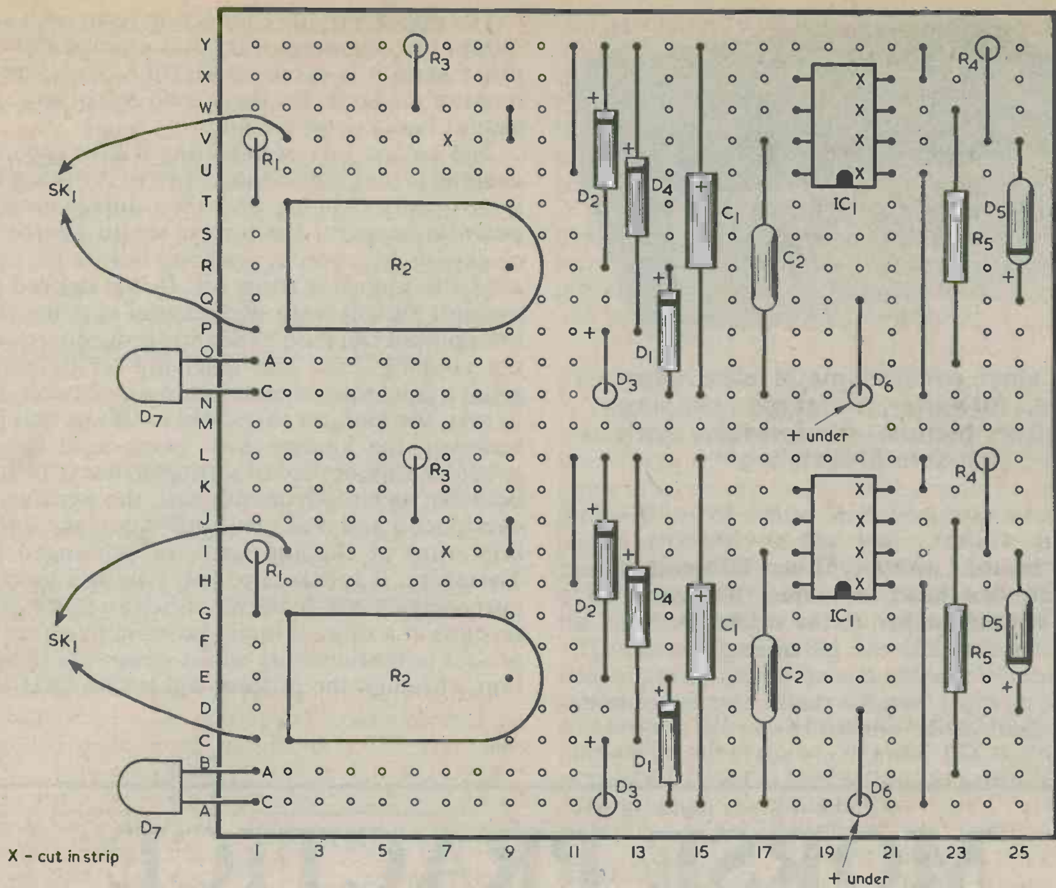
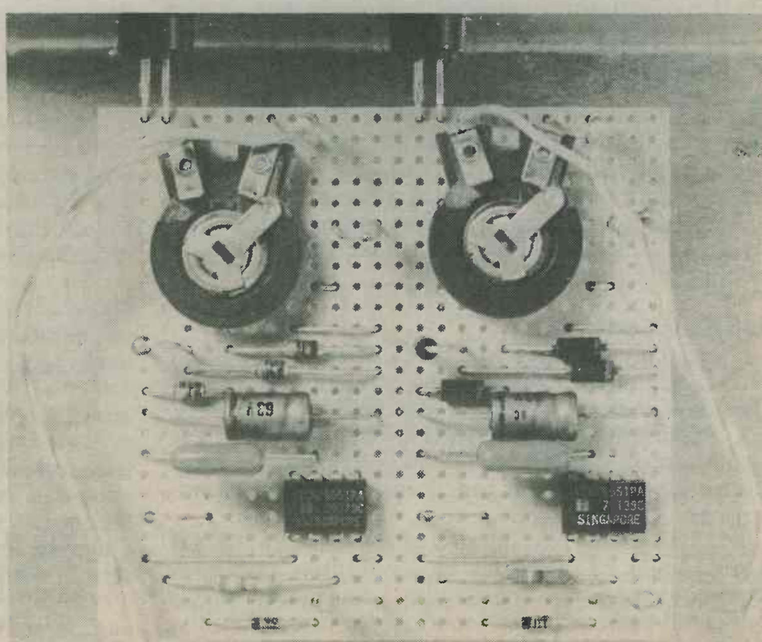


Fig. 2. The components for the two channels are assembled on a Veroboard panel with the layout shown here.

Close up view of the Veroboard assembly.



The vinyl covered metal case employed for the prototype clipping monitor blends comfortably with modern hi-fi styling.

they might be fitted with, say, 2-way DIN sockets and screw terminals. If, for example, the input to a speaker is normally taken to the screw terminals, an output for the monitor can be taken from the DIN socket. Finding suitable take-off points from the outputs for the monitor inputs is really a matter of initiative on the part of the constructor.

The polarity of the connection from each amplifier output to each monitor input is unimportant. On the other hand it is essential that the conections to the monitor are such that there is no risk of any amplifier output being short-circuited.

The easiest way of adjusting R2 for each monitor channel is to drive the amplifier to the point where it is obviously clipping and then adjust each pre-set potentiometer for the lowest sensitivity (as far in a clockwise direction as possible) before the appropriate l.e.d. indicator turns off. If it is desired that the monitor should warn of potential clipping the amplifier output can then be slightly reduced to just below the clipping level and each pre-set potentiometer given a final fine adjustment in a clockwise direction to take the monitor threshold to this output level. If, however, the loudspeakers being used incorporate tweeters, this method of setting up has to be modified because, as already mentioned, the tweeters can be overloaded and may even suffer damage if the amplifier runs at clipping level for prolonged periods. Therefore, if speakers of this type are used, do not purposely overdrive the amplifier for more than a few seconds at a time. It is still possible to set up the two pre-set potentiometers whilst observing this precaution, although the process will take a little longer. ■

MORSE PRACTICE BUZZER

By P. Fletcher

Schmitt NAND gate oscillator.

The circuit shown in Fig. 1 is for a morse code practice oscillator having a frequency of around 1kHz. It can of course function as an oscillator in other applications. Current consumption from the 9 volt battery is about 0.2mA when the key is up, and increases to about 1.7mA with the key down. The second current figure assumes that the headphones have a total resistance of 4,000Ω, i.e. 2,000Ω per phone. Headphones with a total resistance of 2,000Ω can also be used, with a corresponding increase in key-down current. Low resisttance headphones should not be used.

OSCILLATOR

The circuit employs two gates of a quad 2-input NAND Schmitt trigger i.c. type 4093, and the oscillator itself is given by the gate associated with pins 1, 2 and 3. Schmitt trigger NAND oscillators are rarely encountered in the pages of this journal and a brief description of oscillator functioning will not, in consequence, be out of place here.

Fig. 2(a) shows pins 1 and 2 of the Schmitt NAND gate coupled to the slider of a potentiometer connected between the supply rails. A voltmeter, M1, is connected between the potentiometer slider and the negative rail, and a second voltmeter, M2, between

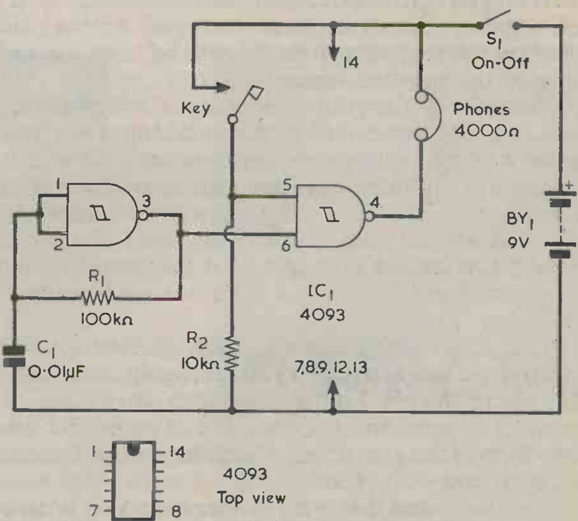


Fig. 1. The circuit of the morse practice oscillator. The headphones are high impedance magnetic types. The oscillator can, of course, be employed in other applications.

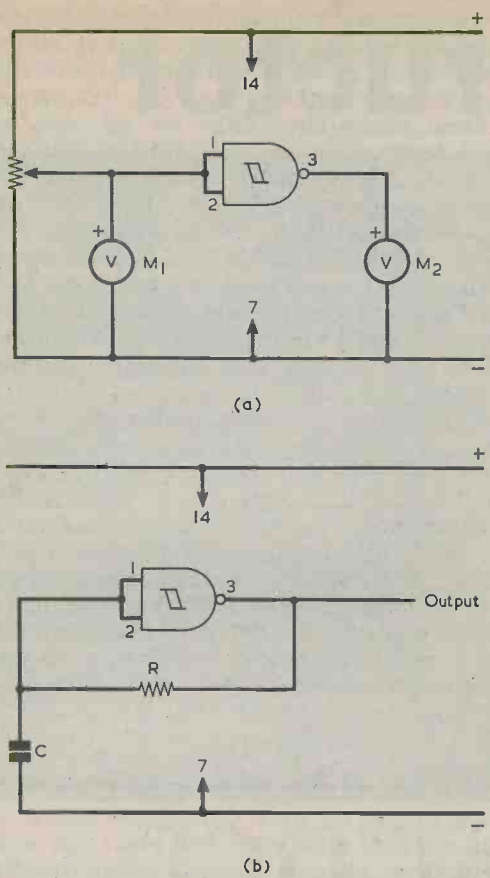


Fig. 2(a) Evaluating the transfer characteristic of the 4093 gate connected to pins 1, 2 and 3.
(b) Adding a resistor and a capacitor makes the gate an oscillator.

the pin 3 output and the negative rail. Since pins 1 and 2 are connected together, the NAND gate functions as an inverter. If the slider of the potentiometer is at the negative end of its track the pin 3 output, indicated by the second voltmeter, will be high, i.e. at or close to the positive supply rail.

The slider of the potentiometer is slowly advanced from the negative end of its track, taking pins 1 and 2 positive. At a certain gate input potential the pin 3 output will suddenly go low, i.e. at or close to the negative rail. This input voltage will be indicated by M1, and we will call it VA. The pin 3 output will remain low as the movement of the potentiometer slider continues, until it is fully at the positive end of the track.

If, next, we slowly take the potentiometer slider negative we will arrive at a voltage, again indicated by M1, where the pin 3 output suddenly goes high. This second voltage can be called VB. The output then stays high as the potentiometer slider continues to the negative end of its track.

It will be found that VB is lower than VA. With a 9 volt supply, VA can typically be of the order of 6 volts and VB of the order of 5 volts, so that there is a difference of about 1 volt between them. This represents the hysteresis effect associated with the classic Schmitt trigger.

In Fig. 2(b) we remove the meters and the potentiometer and add a resistor and capacitor as shown. We now have an oscillator. At switch-on, the capacitor is discharged so that the gate inputs are low and the gate output is high. The capacitor commences to charge via the resistor until the voltage across it reaches VA, wherupon the pin 3 output suddenly goes low. The capacitor now discharges through the resistor until the voltage across it falls to VB. The pin 3 output then suddenly goes high again and the capacitor once more starts to charge. As a result, we have an oscillator with a near-square wave output at pin 3, and with the capacitor alternately charging to VA and then discharging to VB.

FREQUENCY

The length of the oscillator cycle is very approximately equal to the time constant of the resistor and the capacitor. In seconds, this is the product of resistance in megohms multiplied by capacitance in microfarads. The resistance and capacitance values in the oscillator circuit of Fig. 1 are 100kΩ and 0.01μF, giving a time constant of 0.001 second. The reciprocal of 0.001 is 1,000, and so the oscillator frequency is in the region of 1kHz.

The second gate in Fig. 1 is a buffer amplifier, and it is enabled when the key is closed. When the key is opened, the pin 5 input of the gate is taken low by R2, whereupon the pin 3 output is always high regardless of the voltage on the pin 6 input. The headphones are returned to the positive rail so that they consume no current when the key is up.

ASSEMBLY

There are two remaining gates in the 4093 and their inputs are all taken to the negative rail. Their outputs appear at pins 10 and 11, and no connections are made to these pins.

Pin 5 of the second gate is maintained at a fairly low impedance to the negative rail by R2 but, even so, care should be taken to see that the leads to the key are kept clear of high voltage wiring, such as mains leads. The only other precaution is to ensure that C1 and R1 are positioned fairly close to the i.c. pins to which they connect. As the 4093 is a CMOS device it must be wired into the circuit with a soldering iron having a properly earthed bit.

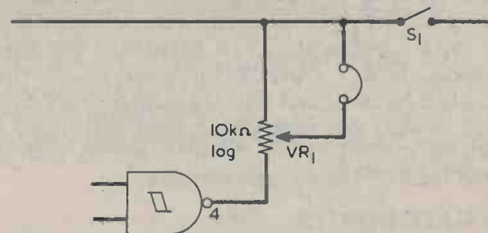


Fig. 3 A volume control can be incorporated between the pin 4 output and the positive rail.

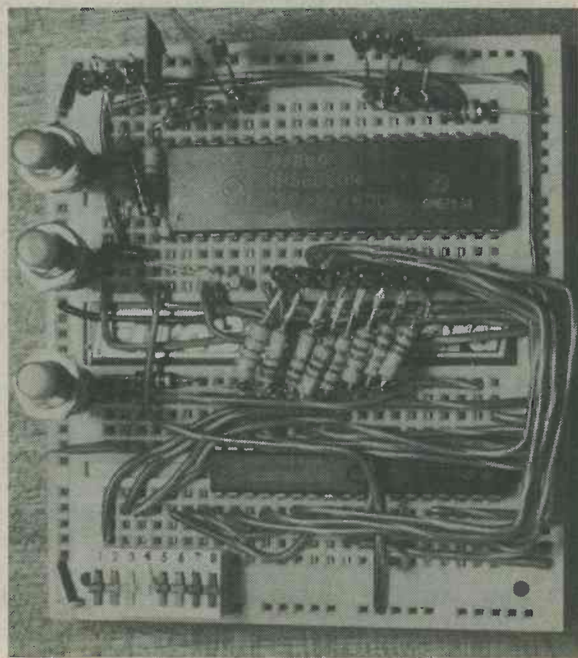
The 1kHz output in the headphones is quite loud and, if desired, a volume control can be added. This simply consists of a 10kΩ log potentiometer, wired up as shown in Fig.3.

The INStructor

Part 5

By Ian Sinclair

A PRACTICAL INTRODUCTION TO MICROPROCESSORS



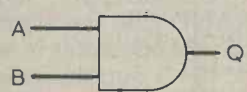
Universal Logic Operations

An important point about the microprocessor is that it can be used as a "universal logic chip". That needs a fairly detailed explanation. We can build logic circuits using gates and flip-flops to control machines, make calculations and add a form of intelligence (the ability to make decisions) to existing gadgets. These logic circuits can be replaced by a microprocessor system, provided that we can write a suitable program and have enough memory to store it. In other words, anything we can do with "hardware" – gates and flip-flops on a printed circuit board – we can do with "software" – a program for microprocessors. Every microprocessor must therefore be able to cary out the standard logic operations for which we use gates and flip-flops in a hard wired circuit. This month, we're going to look at a few of these operations.

LOGIC GATE INPUTS

Before we start, though, there's one important point. We're fairly accustomed to logic gates with two inputs, like the gates whose symbols are shown in Fig. 1. How do we represent these inputs on the eight data lines of the microprocessor?

The answer is that we use the microprocessor to provide us with eight separate gates, using each data line as a separate gate input. We then simulate the number of inputs to each gate by the number of times we carry out the logic action. Let's make that clearer by an example, Suppose



AND

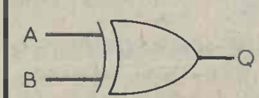
A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

(a)

OR

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

(b)



XOR

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	0

(c)

Fig.1.

we want to instruct the microprocessor to "AND" three bits. We choose a data line for the bits, DO will do as an example. We feed in the first of the three bits into DO, using a load immediate, then follow this by an AND instruction, and then the second bit into DO. We then need another AND instruction, and the third bit into DO. When this is displayed, the bit at DO on the readout l.e.d.'s will be the AND of the three bits we have separately fed in. While we're doing this, we can AND seven more lots of bits on the other data lines as well.

Now we can try a two-byte AND. The program in Fig. 2 uses a LDI instruction to load in the byte 11001010, and follows up with AND-immediate (11010100) on the data byte 10111001. Now this isn't arithmetic – it's logical AND, so that there's no carry involved but just the AND-ing of corresponding bits. The law of ANDing is that 1 and 1 gives 1, any other combination gives zero. We can therefore expect the answer at DO to be 0, because the DO bits were 0 and 1 respectively, and so on for each bit separately. We can display the result in the usual way to check what has happened.

AND-ing is a very useful way of comparing patterns. Suppose, for example, you have a set of bits you want to recognise. This might be the correct combination to open a lock, a code for printing the letter B on a video screen, or anything. If you repeatedly AND an input byte with the one you want, the only time that the byte in the accumulator doesn't change is when it is AND-ed with an identical byte, and you can instruct the microprocessor to carry out some action (open the door, activate a character generator) when this happens. Since microprocessors operate fast, you can check a byte against several thousand others in a fraction of a second.

Back to the breadboard. The program in Fig. 3 carries out the OR operation on the two bytes 10011011 and 01000001. The law of the OR gate is that the output is 1 if either **or both** inputs are at 1, so we expect the answer 11011011.

The simple OR gives a 1 at the output when both inputs are 1, and this is sometimes not wanted. The exclusive OR (XOR) excludes this state and its truth table is as shown in Fig. 1(c). We can carry out XOR operations on bytes in the microprocessor and Fig. 4 shows a program for XOR-ing 10011001 with 11001100. Decide for yourself, using the truth table, what the result of this should be, and then try it out on the program. XOR-ing is very commonly used for pattern recognition, because if a byte is ZOR-ed with itself the result is zero.

LOGIC INVERSION

In quite a lot of logic circuits we find inversion useful, and we make use of NAND and NOR gates. These logic actions are not needed as often as we might think, it's just that these gates are convenient to make and use. For most logic circuits it's the AND and OR which are needed, but it is certainly useful to be able to get NAND and NOR. The NOT part of the action is inversion or complementing, so that we should be able to obtain a NAND result by complementing the output of an AND. The problem is, how do we do it?

```
RESET
LDI       11000100
BYTE      11001010
ANI       11010100
BYTE      10111001
DISPLAY
```

REMEMBER: The display routine consists of setting 11001000 and pressing GO twice. This displays the binary number in the accumulator.

Fig. 2.

```
RESET
LDI       11000100
BYTE      10011011
ORI       11011100
BYTE      01000001
DISPLAY
```

Fig. 3.

```
RESET
LDI       11000100
BYTE      10011001
XRI       11100100
BYTE      11001100
DISPLAY
```

Fig. 4.

Some Ways Of Using AND and XOR

Using XOR

Byte input	11011100	
XRI with	11111111	
produces	00100011	which is the complement of the first byte.

Using AND

Byte input	11011110	
AND with	00001111	
produces	00001110	so removing the upper part of the byte (called the upper nibble).

Using XOR

Byte input	10110011	
XRI with	10110011	
produces	00000000	this is a way of "recognising" a byte; any other input would leave a number in the accumulator.

Fig. 5.

RESET	
LDI	11000100
BYTE1	11001010
ANI	11010100
BYTE2	10111001
XAE	00000001
CAE	01111000
DISPLAY	

Fig. 6.

There's no obvious way, until you start to look at the action of the extension register, because the only complementing instructions are the complement and add ones. We can't get the result of an AND operation in the accumulator and then complement it – there's no instruction for doing this directly.

A suggested program is shown ing Fig. 6. We reset, so making sure that the extension is reset, and then load in a set of bits to be NAND-ed. We then AND immediately with the other set of bits, so that the accumulator now contains the AND result. Following this with XAE causes the AND result to be loaded into the accumulator. Now if we use the instruction CAE (01111000) we can complement the number in the extension register, so producing the NAND, and add it to the number (which is zero) in the accumulator. We can display the result and satisfy ourselves that it is the result of a NAND.

Two points have to be watched carefully here. One is that the extension must be cleared before this program starts, because any number which is present in the extension register will be added in to the result at the CAE stage. We've cleared the extension by resetting before the start of the program, but at other times we might not be able to do this and we would have to clear the extension register by loading a byte of zeros into the accumulator and exchanging with the extension. The other point is that the final operation is a complement and add, so that the carry/link bit will be automatically added in. Once again this has not affected us, because we had reset, but in the middle of a long program we would need to clear the carry/link bit before starting the NAND operation. Now try for yourself to write and test a program to give the NOR operation, which is OR followed by NOT. If you're a glutton for punishment, you can follow that up by an XNOR, which is the XOR followed by NOT.

We've dealt now with all the immediate instructions, meaning all the double byte instructions which are followed immediately by the data to which they refer. That doesn't mean that we're finished with double byte instructions because there's quite a number of these we shall be returning to. Before we start on the single byte instructions, though, there's one unusual instruction, which as far as I know, is peculiar to the 8060. It's the DLY instruction, which simply lets the microprocessor tick away for some time before going to the next step. In other words, it introduces a time delay. On other microprocessors this has to be done by a procedure called a "counting loop". In a counting loop a number is loaded into the accumulator and is decremented (meaning 1 is subtracted) on the next step. The number is then checked, and if it isn't zero it's decremented again and compared. This is done over and over again until zero is reached, then the microprocessor goes to the next program step. On the 8060, the DLY instruction does this for you. It's a double byte instruction, with the second byte measuring the amount of delay. The rules for finding the delay are a bit complicated (Fig. 7), but the important point is that the greater the size of the number which follows the DLY instruction, the longer is the delay before the microprocessor goes to the next step.

If the clock frequency crystal is controlled, we can use the delay for time measurement, producing time readings in hour, minutes and seconds, providing of course we have the memory and the program set up to do so. On our machine we can make use of DLY to measure the clock frequency, so providing the way to a useful method of measuring frequency without the use of an oscilloscope. The program is shown in Fig. 8. The DLY instruction is loaded and then the data switches set to 11111111, so as to load in the number 255 (unsigned numbers are used here) whenever the GO button is pressed. Now if we start a stopwatch at the instant when we press GO, or press GO just as the seconds indicator of a watch is at zero, we'll find that the address l.e.d.'s go out when the GO switch is pushed and don't come back on until the delay is finished. Stop the watch or note the number of seconds when this happens, and you have the total delay time. To find the frequency, divide 524332 by the delay time and the answer is frequency in Hertz!

The reasons are not too complicated. The 255 (decimal) byte causes a delay of 524332 clock cycles, and dividing this by the time taken gives the number of clock cycles per second, which equals frequency. If the clock is a fast one, of

Calculating the delay time for the INS8060: If (AC) is the number in the accumulator and (disp) is the displacement number (the second byte of the instruction) then the delay is:

13 + 2 × (AC) + 2 × (disp) + 512 × (disp) microcycles.

The time of a microcyle (the unit used by the microprocessor) is 4 clock cycles. If, for example, a 1MHz clock is used, the clock cycle time is 1 microsecond, and the microprocessor microcycle time is 4 microseconds.

Fig. 7.

RESET	
DLY	10001111
Disp	11111111

Now find out how long it takes before the address l.e.d.'s come on again!

Fig. 8.

SINGLE-BYTE INSTRUCTIONS

Mnemonic	Code	Meaning
LDE	01000000	Load accumulator from extension register
XAE	00000001	Exchange contents of accumulator and extension
ANE	01010000	AND extension with accumulator, result in accumulator
ORE	01011000	OR extension with accumulator, result in accumulator
XRE	01100000	XOR extension with accumulator, result in accumulator
DAE	01101000	Decimal-add extension to accumulator, result in accumulator
ADE	01110000	Binary-add extension to accumulator, result in accumulator
CAE	01111000	Complement-and-add extension to accumulator, result in accumulator
SIO	00011001	Serial input and output
SR	00011100	Shift contents of accumulator right one place
SRL	00011101	Shift right with link
RR	00011110	Rotate right
RRL	00011111	Rotate right with link
HALT	00000000	Pulses halt signal (no effect unless gating arranged)
CCL	00000010	Clear carry/link bit in status register
SCL	00000011	Set carry/link bit
DINT	00000100	Disable interrupt
IEN	00000101	Enable interrupt
CSA	00000110	Copy status register to accumulator
CAS	00000111	Copy accumulator to status register
NOP	00001000	No operation (used to leave spaces in a program so that additions can be made later)

NOTE: Three sets of single-byte operations (pointer-register operations) have been omitted from this list – they will be dealt with later.

Fig. 9.

course, there may not be time to operate a stopwatch but for low frequencies it works quite well. We're not stuck with the frequency which the microprocessor generates for itself, either, because if we remove the oscillator components and connect XIN on the 8060 to the output of gate 3, then a frequency fed in at one input of gate 3 (with the other input connected to +5V) will clock the microprocessor. The 8060 is one of the few microprocessors which will operate at frequencies as low as 100Hz or so – and if you used the full delay at this frequency you would have to wait almost nine minutes! The upper limit is 4MHz, but at that frequency you couldn't time even a full delay with a stopwatch. In a microprocessor system with a memory this is easily solved by following one delay instruction with another. The delay is a favourite method of using the 8060 to generate musical notes. This is done by setting a bit in the status register to 1, delaying, setting the bit to zero, delaying, then starting over again. This sets and resets the bit at a rate decided by the delay, so generating a frequency which can be amplified and fed to a speaker.

THE CAS INSTRUCTION

Now to other matters. We have to start looking at some of the single byte instructions which we've neglected so far. Quite a few single byters have appeared, and NOP, CAE, CCL and SCL have all been used in programs. Fig. 9 reminds you of these. There's another, CAS, which is used to copy the byte in the accumulator into the status register without erasing the byte in the accumulator.

Now the CAS instruction is a particularly useful one, for reasons which you'll not appreciate unless you know several types of microprocessor i.c. fairly well. On a lot of microprocessors the only way you can get a useful output is by connecting up another i.c. to the data lines. The 8060 allows us to take three single bit outputs from the status register to pins labelled FLAG 0, FLAG 1, FLAG 2. these are, as you would expect, the bits at positions 0, 1 and 2 in the status register. If we want the voltage at the FLAG 0 pin to go to 1, we load the number 00000001 into the accumulator, and then follow with CAS, which copies this pattern into the status register, setting all the bits which can be set (see later on this one!) to zero, but bit 0 is set to 1.

Similarly, loading 00000010 will set bit 1, and 00000100 will set bit 2. Since there are three outputs, we can even switch eight circuits! How? The circuit of Fig. 10 shows how – the three flag outputs feed an octal counter, so that any combination of 1's and 0's on the flags produces a 1 on one of the counter output pins!

We can try out the flag operation by using our spare l.e.d. and the program in Fig. 11. Start by using the spare l.e.d. to monitor FLAG 0; this is done by linking B2 on the Eurobreadboard to B21.

STATUS REGISTER

Bit:	7	6	5	4	3	2	1	0
Use:	Carry/link	Overflow	SB	SA	IE	F2	F1	F0

To set flags (example): LDI 00000101
CSA (this sets flags 2 and 0)

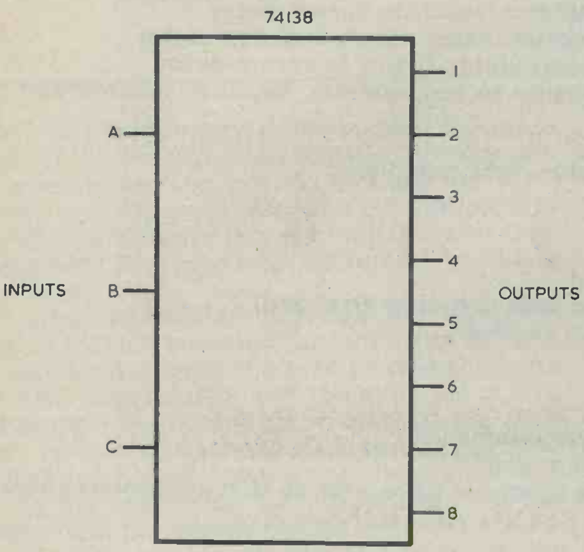


Fig. 10.

RESET	
LDI	**11000100**
BYTE1	**00000001**
CAS	**00000111**
LDI	**11000100**
BYTE2	**00000010**
CAS	**00000111**

(Use the spare l.e.d. to monitor the FLAG outputs.)

Fig. 11.

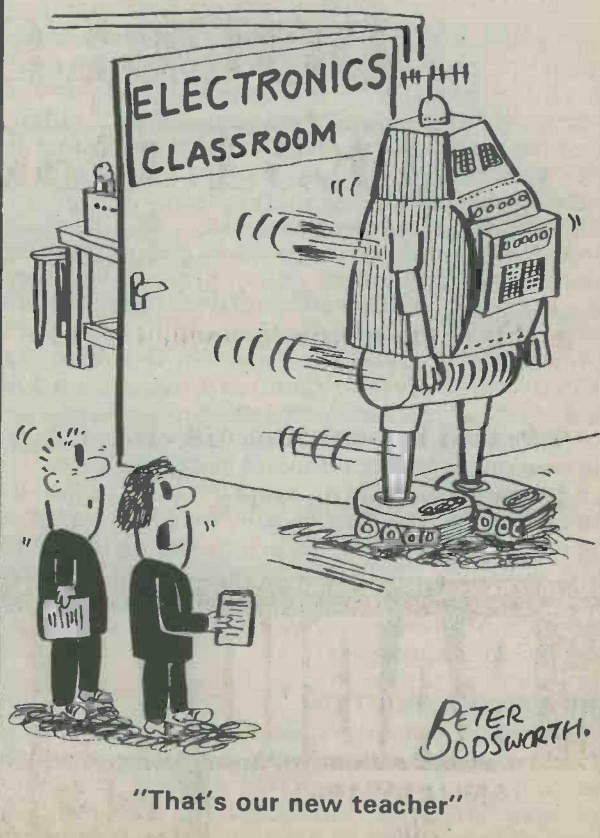
A long link wire can be used and it doesn't need to hug the board. Now load in the number 00000001 and follow up with CAS (00000111). The l.e.d. should light and stay lit. Unlike some outputs, which load for only one clock cycle, the bits of the status register are latched, so they'll stay at their 1 or 0 setting until the setting is changed. Now load in 00000010 and CAS again, as shown. The l.e.d. will go out, but when the far end of the link wire is moved from B2 (the FLAG 0 output) to A1 (the FLAG 1 output), the l.e.d. lights, showing that FLAG 0 has been reset to zero, and FLAG 1 set to 1. When 00000100 is loaded and CAS'd, then FLAG 1 will go out, but shifting the link to A2 will show that the FLAG 2 output is at 1. Check for yourself that all three flag outputs are at 1 when the number 00000111 is loaded in and copied to the status register.

One instruction we'll spend no time over is HALT. This is a byte of zeros, and it doesn't stop the microprocessor working! What it does do is to cause a 1 to appear on the D7 line at a time when the microprocessor is neither reading nor writing memory. At the same time, a negative pulse appears on the pin marked NADS. If we gate and latch these two outputs, we can cause the microprocessor to halt when this instruction appears by wiring the latch to the CONT input. With CONT low the microprocessor stops without resetting any registers. With CONT taken high again the microprocessor starts operating once more. Few microprocessor units use the HALT instruction because, at the end of the program, the microprocessor has to be kept running in order to display the results.

Next month – Shifting, Rotating and Serial input/output.

(To be continued)

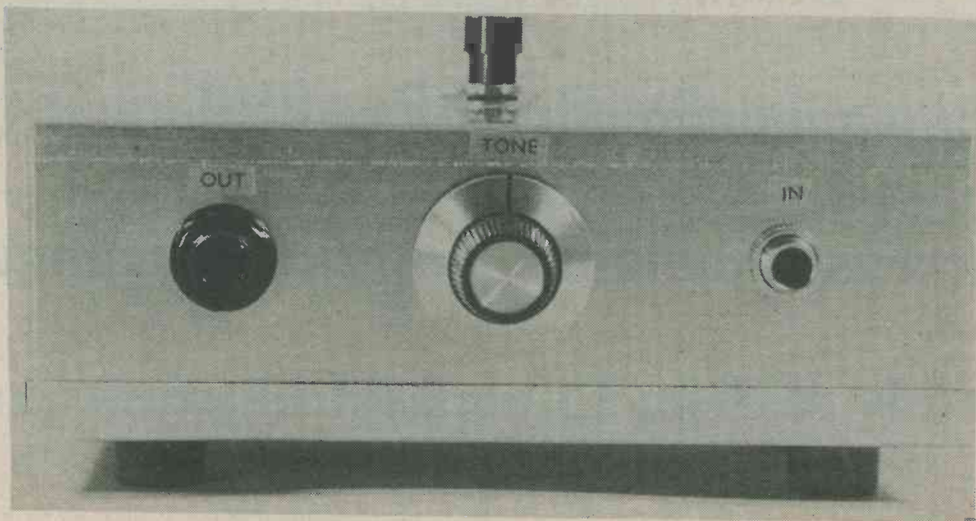
The previous series on Microprocessors by Ian Sinclair, Databus series 1-11, appeared in our issues August 1979 to July 1980. Copies are still available from our Back numbers Department.



"That's our new teacher"

IN OUR NEXT ISSUE

FUZZ BOX



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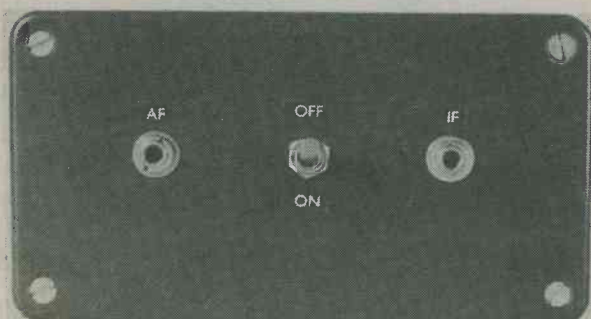

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RADIO & ELECTRONICS CONSTRUCTOR

JANUARY 1981
60p

OPTO COUPLED VOLUME EXPANDER

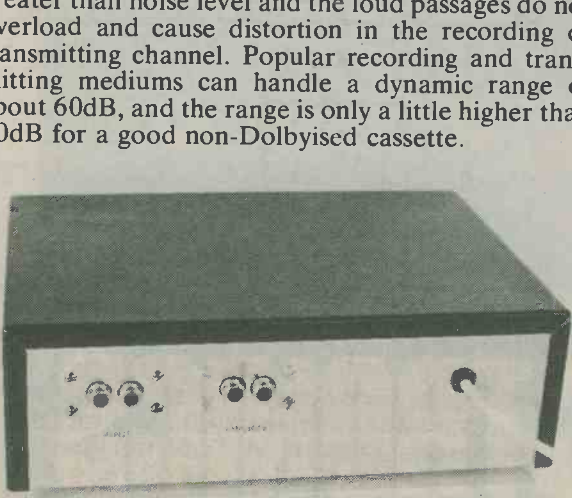
By R. A. Penfold

Increases dynamic programme range.

Adds realism to orchestral music.

Although a volume expander may be an unfamiliar item of equipment to many readers, it is by no means a new or even recent invention. The purpose of a volume expander is to increase the dynamic range (the difference between maximum and minimum signal levels) of a processed audio signal. In other words, an expander causes quiet passages to be made quieter and loud passages to be made louder.

This is not a gimmick but represents a serious attempt to compensate for loss of dynamic range during a recording or a transmitting process. The type of audio signal which suffers most, with which a volume expander offers its most useful effect, is classical orchestral music which, in its original form, can have a dynamic range of over 70dB. This dynamic range has to be reduced if the signal is to be recorded or transmitted in order that the quiet passages are adequately greater than noise level and the loud passages do not overload and cause distortion in the recording or transmitting channel. Popular recording and transmitting mediums can handle a dynamic range of about 60dB, and the range is only a little higher than 50dB for a good non-Dolbyised cassette.



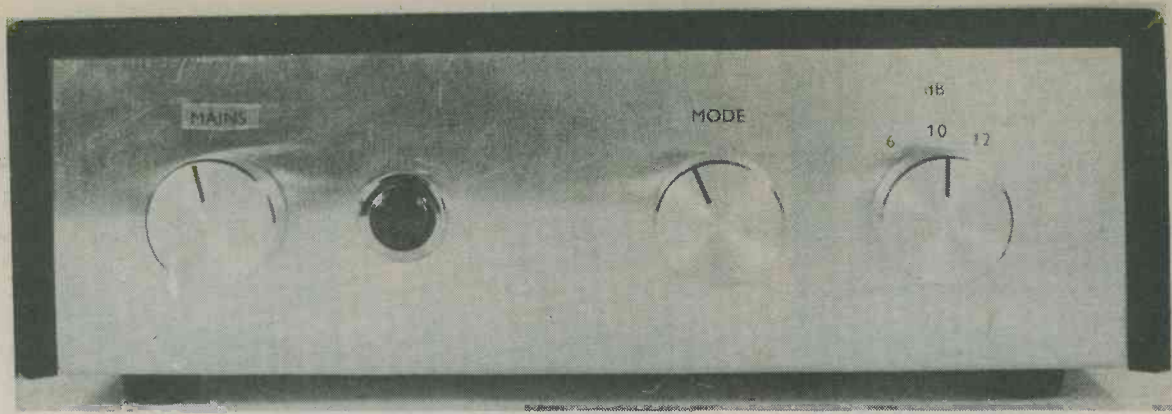
The rear panel of the expander. The input and outputs appear at dual phono sockets.

With a professional recording the reduction in dynamic range, or "compression", is provided manually by the recording engineer. For amateur recordings it is more usual for an automatic recording level circuit or an audio limiter to provide the compression. However skilfully or otherwise the compression is applied, the result must have an adverse effect on the signal because of the reduction in contrast between quiet parts of the performance and loud climaxes.

Volume expansion is the opposite of compression and enhances the level of loud musical passages. Noise level is at the original level with quiet passages and increases with loud passages but this is not noticeable because it is masked by the loud passages themselves. An effective increase in subjective signal-noise ration results.

It must be stressed that a volume expander cannot restore the dynamic levels to precisely their original values as this would require an expansion law which exactly reciprocated the compression law. Since the latter is unknown and is probably different for each recording or transmission, an exactly correct expansion law is not practicable. However, even though an expander provides only approximate correction it can still give effective and acceptable results in practice. For best results it should give little or no expansion at low dynamic levels, and the expansion should be smoothly introduced and increased over the medium and high dynamic levels. Normally, the reproducing amplifier volume control is set to a lower level than would be appropriate for non-expanded music. As a result, the quieter passages are reproduced at a lower level whilst the expansion increases the volume of the louder passages.

The earliest form of volume expander, employed with valve amplifiers, merely consisted of a light bulb connected across the loudspeaker! The bulb filament had a low resistance with quiet passages because it was fairly cool, and the amplifier output was reduced because of the extra loading. At higher volume levels



The front panel layout of the volume expander. The mains on-off switch is to the left, with PL1 on its right. The remaining two controls are S1 and S2.

tched expansion selected 6dB, 10dB and 12dB.

the bulb's filament heated up and its resistance increased, resulting in reduced loading on the amplifier and an increased output. Such an arrangement could not be employed with modern transistor amplifiers, which have extremely low output impedances and with which the output voltage is only affected marginally by output loading. Also, in order to give truly acceptable results an expander needs to respond very rapidly to changes in dynamic level, and a light bulb type of expander tends to be too slow due to the thermal inertia of the filament.

VOLTAGE CONTROLLED AMPLIFIER

Somewhat more sophisticated circuitry is therefore required and the block diagram of Fig. 1 shows the arrangements employed in the expander described in this article.

The broken line in Fig. 1 encloses a voltage controlled amplifier or v.c.a. This incorporates an operational amplifier with the signal input applied via a cadmium sulphide photocell to its inverting input and with a feedback resistor, R1, from the output to the inverting input. The voltage gain of the amplifier is equal to R1 divided by the resistance of the photocell.

The input signal is also applied to an active rectifier followed by a buffer stage. The active rectifier both half-wave rectifies the signal and amplifies it, and the resultant d.c. signal is applied to the l.e.d. and its series resistor, R2. Under low signal conditions the l.e.d. will either fail to light or will glow very dimly. In either instance it will have no effect on the photocell resistance which, under these conditions, can be assumed to be approximately equal to the value of R1. (In the practical circuit the photocell is shunted by a resistor having the same value as R1.) The operational amplifier therefore has a voltage gain of approximate unity. Higher signal levels cause the l.e.d. to light up quite brightly, with a consequent decrease in photocell resistance and increase in operational amplifier voltage gain. Thus, the gain of the v.c.a. is controlled by the voltage applied to the l.e.d. and R2.

As will be gathered, the increase in gain is dependent upon the input signal amplitude and so a full expansion effect is provided. Greatest expansion occurs when the buffer stage offers its full voltage output and this results in an operational amplifier gain of about 4 times. In consequence, the unit can give a maximum expansion of some 12dB, and this is about the highest level of expansion that can be usefully provided in practice.

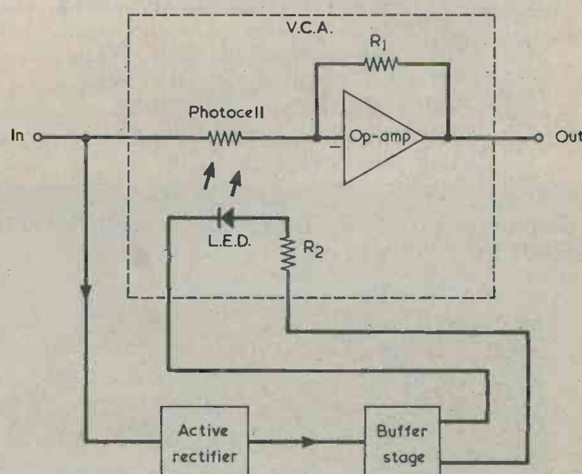
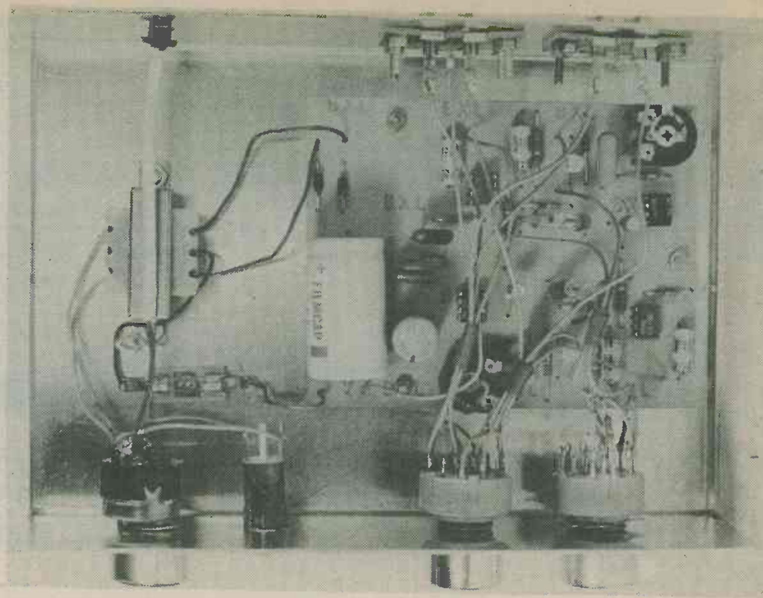


Fig. 1. Basic operation of the volume expander. The voltage gain of the op-amp is equal to R1 divided by the resistance of the photocell. When increased voltage is applied to the l.e.d. and R2, the l.e.d. glows more brightly and causes the resistance of the photocell to decrease.

The layout inside the metal instrument case.



COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
- R1 2-off 150Ω
- R2 2-off 100kΩ pre-set potentiometer, 0.25 watt horizontal
- R3 2-off 180kΩ
- R4 2-off 18kΩ
- R5 2-off 47kΩ
- R6 2-off 120kΩ
- R7 2-off 22kΩ
- R8 2-off 22kΩ
- R9 2-off 120kΩ

Capacitors
- C1 2-off 0.22µF polyester, type C280
- C2 2-off 0.47µF electrolytic, 10V. Wkg. (see text)
- C3 2-off 10µF electrolytic, 10V. Wkg.
- C4 2-off 10µF electrolytic, 10V. Wkg.
- C5 1000µF electrolytic, 25V. Wkg.
- C6 0.1µF polyester, type C280
- C7 0.1µF polyester, type C280
- C8 100µF electrolytic, 25V. Wkg.

Semiconductors
- IC1 2-off CA3140E in 8 pin d.i.l.
- IC2 2-off 741C in 8 pin d.i.l.
- IC3 7812
- TR1 2-off BC108
- D1 2-off TIL220
- D2 1N4001
- D3 1N4001

Transformers
- T1 mains transformer, secondary 12-0-12V. at 100mA

Photocell
- PCC1 2-off ORP61

Switches
- S1 4-pole 3-way miniature rotary with adjustable end stop (set for 2-way)
- S2 4-pole 3-way miniature rotary (only 2 poles used)
- S3 d.p.s.t. rotary toggle

Fuse
- FS1 100mA cartridge fuse, 20mm.

Neon
- PL1 panel-mounting neon with integral series resistor

Sockets
- SK1 dual phono socket
- SK2 dual phono socket

Miscellaneous
- Metal instrument case (see text)
- Chassis-mounting fuseholder, 20mm.
- 3 control knobs
- Printed circuit board
- Nuts, bolts, wire, etc.

The volume expander should have a fast attack rate so that it responds quickly to rises in dynamic level, and a slightly slower (although still quite fast) decay time. A quick reduction in resistance and a slightly slower increase in resistance are innate characteristics of the cadmium sulphide photocell employed, and these comfortably meet the attack and decay requirements. A simplification of the circuit results because there is then no need to incorporate timing components. A further advantage of the opto-coupled circuit is that it introduces negligibly low quantities of noise and distortion.

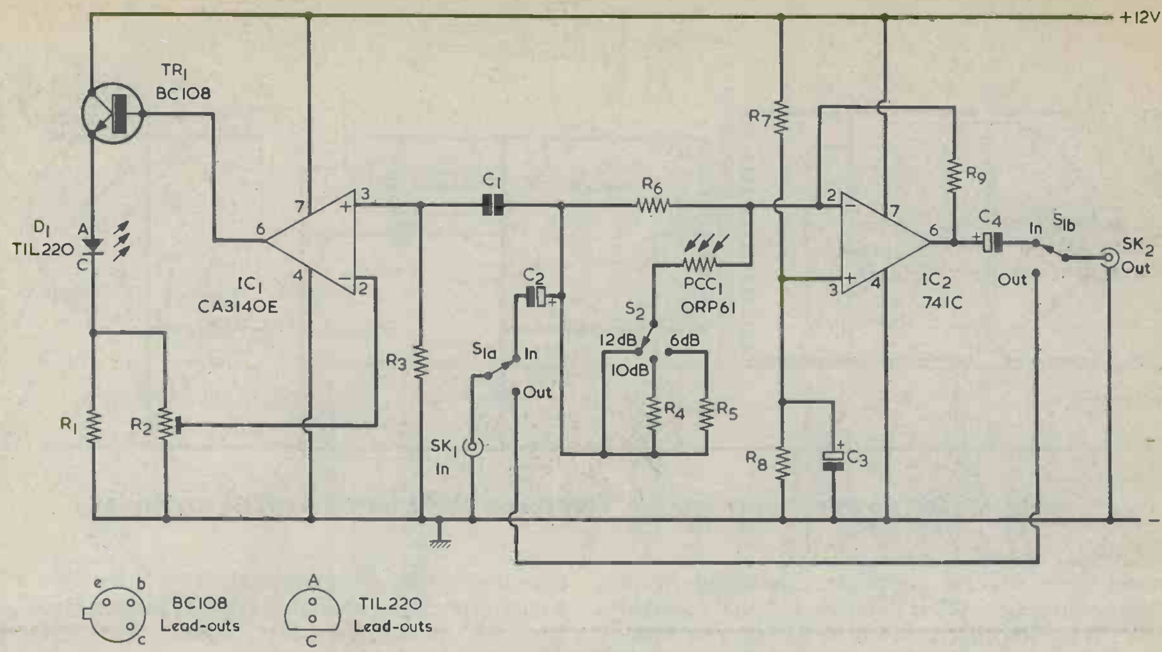


Fig. 2. The circuit for one channel of the volume expander. The other channel is identical.

THE CIRCUIT

The expander is intended to handle stereo signals and the circuit for one of the two channels is given in Fig. 2. It is normal practice for the two channels of the stereo signal to be processed separately.

IC2 is the inverting mode operational amplifier of Fig. 1 and its non-inverting input is biased to half the supply voltage by R7 and R8. C3 filters out any hum or noise which might otherwise be applied to the non-inverting input.

Under low signal conditions the photocell, PCC1, has a resistance of many megohms, whereupon the voltage gain of IC2 is determined by the equal value resistors R9 and R6. The voltage gain is therefore unity. At high signal levels the resistance of PCC1 falls to about 40kΩ, boosting the voltage gain in IC2 by about 4 times, or 12dB. The full level of expansion is not always required, and S2 can be adjusted to insert either R4 or R5 in series with PCC1, whereupon the boost is reduced to approximately 10dB or 6dB respectively.

C2 and C4 provide input and output d.c. blocking. S1(a)(b) can be set to bypass the expander, if desired, so that normal operation can be obtained without having to disconnect the expander from the hi-fi system.

IC1 is the active rectifier. The input signal is applied to its non-inverting input via C1, and this input is biased to the negative supply rail by R3. As a result, IC1 amplifies positive-going half-cycles only. The i.c. output connects to the emitter follower, TR1, which drives the l.e.d., D1. Negative feedback to the inverting input is obtained from the slider of R2. This feedback path is chosen because it is necessary to take the baseof TR1 positive by about 2.2 volts to overcome the forward voltage drop in its base-emitter junction and the forward voltage drop in the l.e.d. if the latter is to light up. Low level input signals are therefore given a high degree of amplification until the output of ICI takes the base of TR1 up to the 2.2 volt level. The feedback circuit then takes over and limits the gain to a level dependent upon the setting of R2 slider. The circuit permits the illumination level in the l.e.d. to follow signal amplitude smoothly. If the negative feedback had been taken from the output of IC1, there would have been an abrupt signal level at which the l.e.d. commenced to light up.

The curge of Fig. 3 shows the expansion characteristic of the prototype with S2 in the "12dB" position. The precise characteristic obtained will, of course, vary slightly between different units, and it also varies considerably with different setting in R2.

The TIL220 employed for D1 is a red l.e.d. with a diameter of 0.2in. It is available from a number of suppliers. The ORP61 required for PCC1 can also be

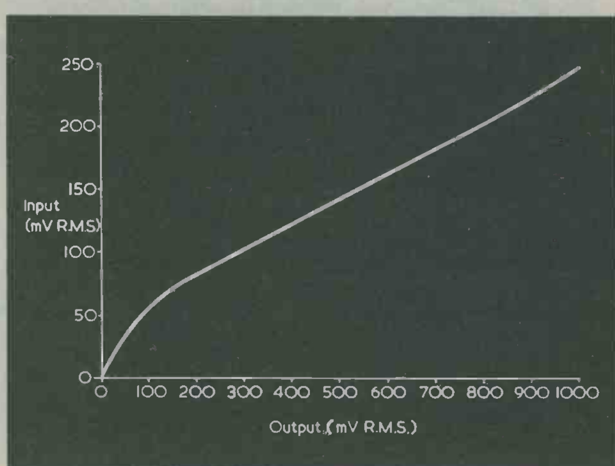


Fig. 3. Curve showing the expansion characteristics given by the prototype.

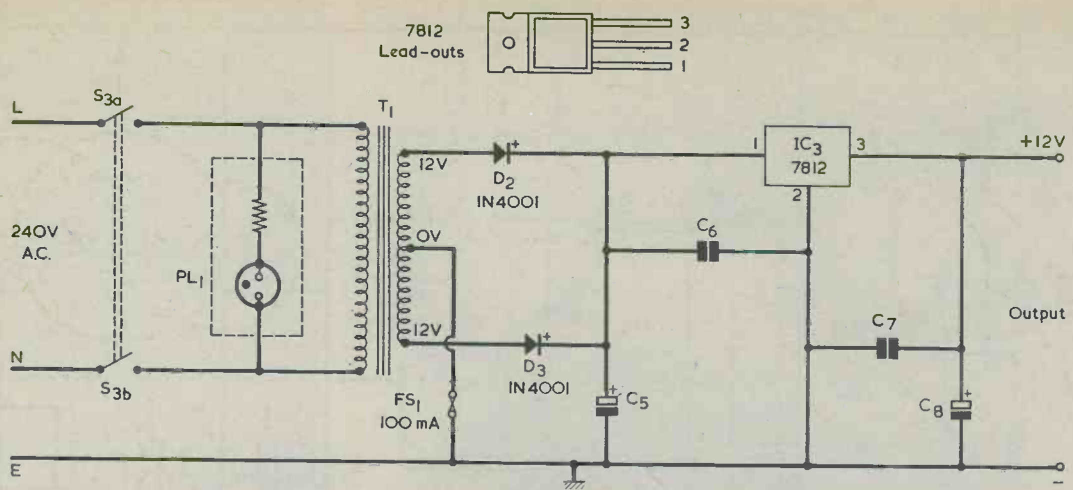


Fig. 4. The power supply section. This feeds both channels of the expander.

obtained from several suppliers, including Maplin Electronic Supplies. C2 is listed as 0.47μF electrolytic. 10V. Wkg. In practice it will be in order to employ a 0.47μF electrolytic capacitor having a much higher working voltage than this, even as high as 250 volts.

POWER SUPPLY

A well smoothed 12 volt supply is required, and the maximum mean current consumption is about 50mA. This is obtained with the regulated circuit of Fig. 4. The mains on-off switch is S3(a)(b) and PL1 is a panel-mounting neon indicator with integral series resistor intended for 240 volt a.c. operation.

The transformer secondary voltage is full-wave rectified by D2 and D3, with C5 providing a considerable amount of smoothing. Protection is provided by fuse FS1, which is rated at 100mA. Although there is an initial surge of current at switch-on as C5 charges, it was found with the prototype that a quickblow type of fuse was quite suitable and seemed to be perfectly capable of withstanding the surge. IC3 is a 12 volt voltage regulator which provides an extremely well smoothed output. C6 and C7 provide stability and ensure a good transient response, and C8 gives final smoothing of the output. IC3 does not require a heat sink in this circuit.

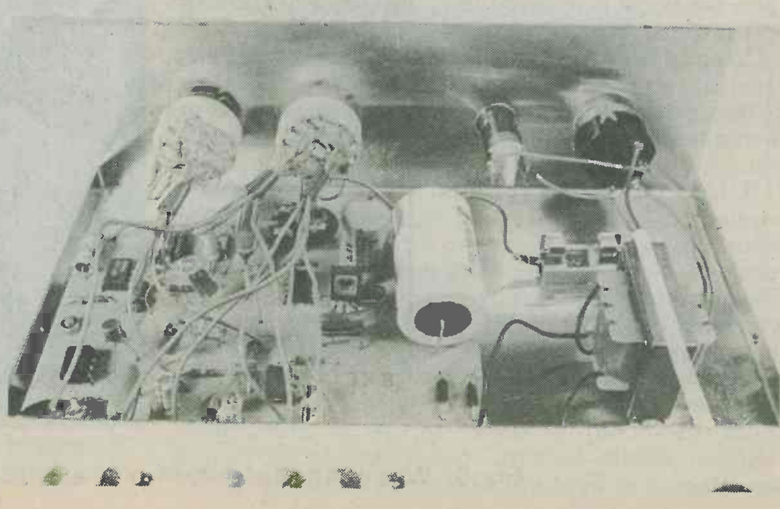
CONSTRUCTION

The author's unit was housed in a metal instrument case measuring approximately 8 by 5½ by 2½in. This is a case type BC3, available from Harrison Bros., P.O. Box 55, Westcliff-on-Sea, Essex, SS0 7LQ. It is advisable to obtain the mains transformer, or at least ascertain its dimensions, before ordering the case, to ensure that it can be accommodated. The front panel layout can be seen in the photographs. S3 is mounted on the left, with PL1 to its right. Balancing these on the right are S1 and S2, with S2 being at the extreme right. On the rear panel are the two input sockets (one for each channel) and the two output sockets, with the input sockets on the left as seen looking at the rear panel. Dual phono sockets are used. A hole on the right hand side of the rear panel is fitted with a grommet and takes the 3-core mains cable. The cable must be secured inside the case by a suitable plastic or plastic-faced clamp.

The photograph of the interior shows the layout of components. The mains transformer and fuseholder are secured to the case bottom, with a solder tag under one of the mains transformer mounting nuts. If the transformer has tags on the top of its body, and if there is any risk of these closely approachng the inside surface of the case lid, a piece of thin s.r.b.p. should be glued to the inside of the lid at the appropriate position.

Fig. 5 shows the wiring inside the case. Except for the power supply components, there are 2-off of each

A view of the interior from the rear.



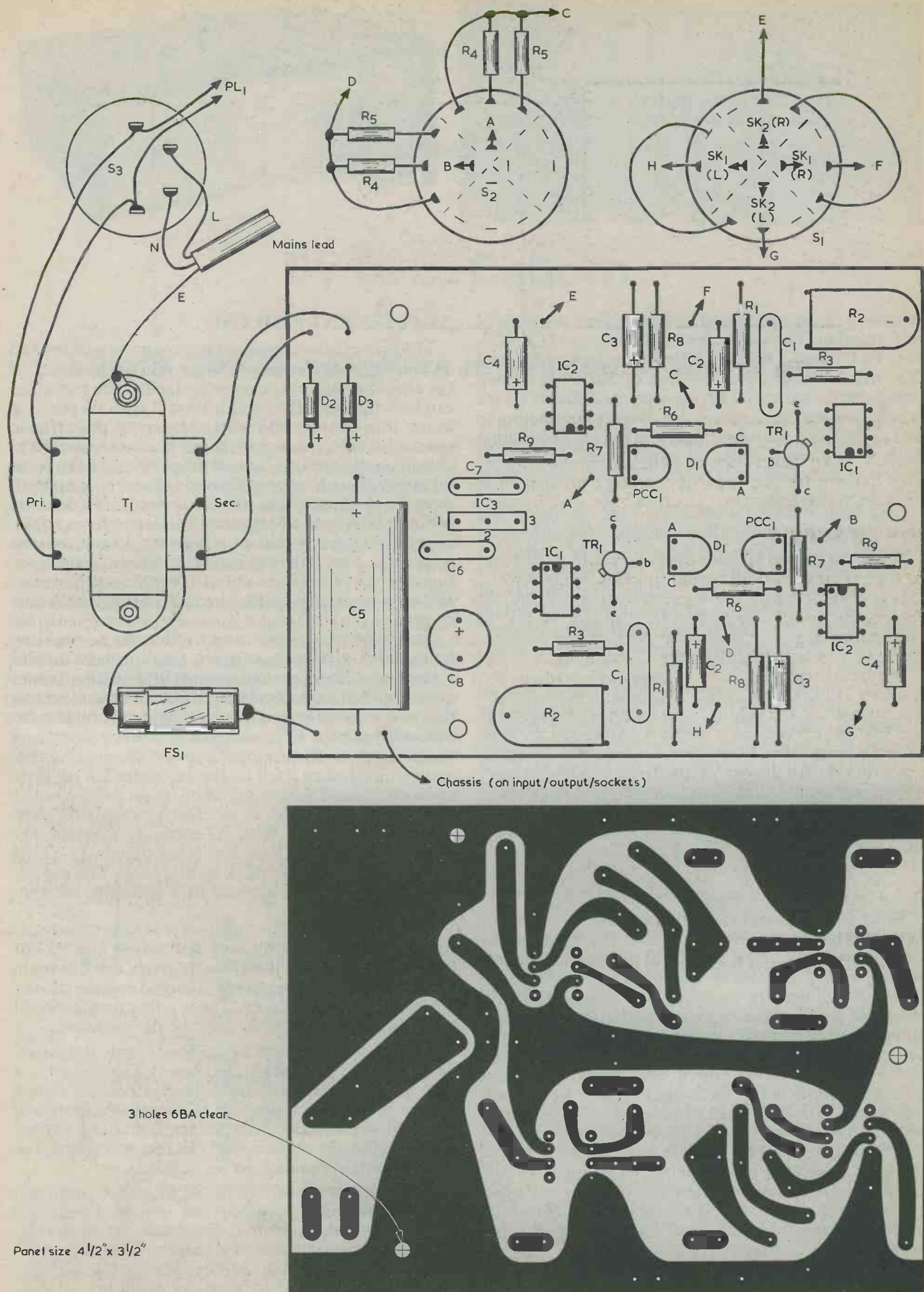


Fig. 5. Wiring up and details of the printed circuit board.

The ready-made instrument case ensures that mechanical construction requirements are kept to a minimum.

resistor and capacitor, and both are given the same R or C number. The same comment applies to IC1, IC2, D1, PCC1 and TR1. With the exception of R4 and R5, which are fitted at the tags of S2, all the small components are wired up on a printed circuit board which is reproduced actual size. Before connecting to any of the three switches, ascertain the tag positioning with a continuity tester or ohmmeter. With some switches the relative tag positioning may differ from that shown in Fig. 5.

The printed board is secured to the bottom of the case by means of three 6BA bolts and nuts with metal spacing washers. Two of these washers provide a chassis connection to the board. There is also a wired chassis connection from the board to the chassis tags on the input and output sockets. The board should not be finally mounted in place until all the connections from it to external components have beem completed.

Components on the board which require special mention are the CA3140E i.c.'s, the l.e.d.'s and the photocells. The CA3140E has a PMOS input stage which is susceptible to damage by high static voltages. It should be kept in its protective packaging until it is to be wired into circuit and it should then be handled as little as possible. Preferably, the two CA3140E's should be the last items to be fitted to the board and they should be soldered into circuit with an iron having a reliably earthed bit. Alternatively, i.c. holders can be soldered to the board and the CA3140E's fitted into these afterwards.

With each pair of D1 and PCC1, the two components should be positioned so that the light output from the l.e.d. is aimed directly at the photo-sensitive surface of the photocell. The photocell has side-on illumination, and the sensitive side is indicated by a coloured dot on the component body. The photosensitive element is clearly visible above this, well to the top of the component. The l.e.d. has what is effectively a built-in lens, and it emits maximum light energy forward in the direction opposite to its lead-out wires. It is quite easy to position each l.e.d. and photocell at 45 degrees to the board suface, to that they are at right angles to each other with the end of the l.e.d. as close to the sensitive element of the photocell as is possible. Their alignment is not especially critical as the l.e.d. is a large component which gives a strong light output over a comparatively large area.

Unscreened wires connect the tags of S1 to the input and output sockets. These are designated "L" and "R" in Fig. 5. Connections may be made to the corresponding left and right sockets as seen looking at the rear of the case.

ADJUSTMENT AND USE

The unit can be connected between a tape deck and an amplifier, or between a tuner and an amplifier. If the amplifier has a tape monitor facility the expander can be wired into this, and it should then be possible to use it in conjunction with any normal programme source including a record deck. It is not possible to obtain good results by connecting the unit between a record deck with magnetic cartridge and an amplifier. Acceptable results here can only be given if a suitable pre-amplifier is used ahead of the expander, and the expander output is fed to a high level input on the amplifier. The unit works satisfactorily with input signal levels of between about 100mV and 1V r.m.s., and so is compatible with virtually any standard hi-fi system.

Empirical means are used to find the best setting for each R2. If the potentiometer is adjusted too far in a clockwise direction the gain of IC1 will be inadequate and full expansion will not be obtained. Setting the potentiometer too far anti-clockwise will give excessive gain in IC1, with full expansion occurring too abruptly and at too low a level. The first adjustment will manifest itself by the expander having little or no effect, and the second adjustment will cause the action of the expander to be clearly audible on most programme sources. With R2 correctly adjusted, D1 should light up dimly on low level signals, reaching full brightness only on peak level signals. The expansion should then be applied in a smooth and non-obvious manner.

When used in a stereo system it is best to initially connect up one channel only and adjust the R2 for that channel. When it has been given the optimum setting, the other channel is connected and the second R2 set for correct balance. These adjustments should be carried out with S2 in the "12dB" position.

The expander will not function correctly if the case lid is removed and the printed board is subjected to a high ambient light level, since the photocells will then be too brightly illuminated. However, the unit will work quite normally with the printed board shaded from bright light sources, and this fact will enable the two R2 potentiometers to be adjusted.

In use, the best position for S2 with each particular programme source can only be found by trial and error. It should be borne in mind that not all sources will benefit from the use of expansion, and that only a few really need the full 12dB expansion. Using excessive or unnecessary expansion can result in the music sounding unnatural. As was stated at the beginning of this article, the programme source most likely to benefit is classical orchestral music. ■

MULTI-OPTION CHIP

By R. J. Caborn

Single CMOS i.c. offers many logic functions.

When we deal with CMOS digital i.c.'s we expect a single device to offer exactly what it is designed to do. For instance a 4011 contains four 2-input NAND gates and that's all we anticipate finding in it. The only time we don't use the gates as NAND gates is when we connect their inputs together and use them as inverters. NAND gates are NAND gates, and that's that!

But there is one CMOS i.c. lurking in the lists which can provide a multiplicity of functions. It can be used as a triple inverter, it can be used as a single high current inverter, and it can be employed to drive separate loads from single f.e.t.'s inside the chip. Not only are these functions readily available but the chip will also act as a 3-input NOR gate or as a 3-input NAND gate. All these applications are available by simply choosing the requisite interconnections between the i.c. pins.

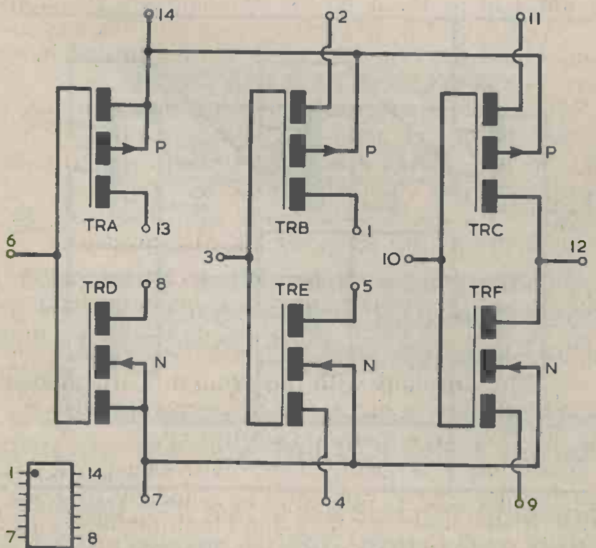


Fig. 1. The internal circuitry of the CMOS 4007 Dual Complementary Pair Plus Inverter i.c.

VERSATILE CHIP

The versatile chip with all these options is the 4007, and it has the internal circuitry shown in Fig. 1. Its official title is "Dual Complementary Pair Plus Inverter". The two complementary pairs are TRA, TRD and TRB, TRE. The inverter is given by TRC and TRF and employs normal CMOS operation. When the inverter input at pin 10 is high, i.e. close to or at the positive supply rail, TRC is turned off and TRF is turned on, resulting in a low output at pin 12. And when pin 10 is low, i.e. close to or at the negative rail, TRF is turned off and TRC is turned on, producing a high output at pin 12.

Whatever the function, pin 14 of the device always connects to VDD, the positive supply rail. Similarly, pin 7 always connects to the negative supply rail, or VSS.

TRA, TRB and TRC are P-channel f.e.t.'s, and TRD, TRE and TRF are N-channel f.e.t.'s. The thin line at the left of each f.e.t. symbol is the gate, and the centre of the three thick line rectangles is the f.e.t. substrate. As can be seen, all the P-channel substrates connect internally to pin 14, and all the N-channel substrates connect internally to pin 7. This is exactly what is required for correct f.e.t. functioning and from now on we can forget about the substrates, knowing that these are all properly connected, and concentrate on device functioning in terms of the remaining f.e.t. electrodes, the drains and the sources.

TRIPLE INVERTER

What is probably the most obvious application for the 4007 is to use it to give three inverters. One inverter, employing TRC and TRF, is already there. If we join together pins 13 and 8, TRA and TRD give us another inverter. Joining pins 1 and 5 produces a third inverter incorporating TRB and TRE. We also need to connect together pins 14, 2 and 11, to give a positive supply to all the inverters. And, finally, we have to join pins 7, 4 and 9 to provide the negative supply.

All these interconnections are illustrated in Fig. 2, with the interconnected pin numbers being shown in brackets. To use the first inverter we apply an input at pin 6 and obtain an output at either pin 13 or pin 8. The second inverter takes an input at pin 3 and gives an output at pin 1 or pin 5.

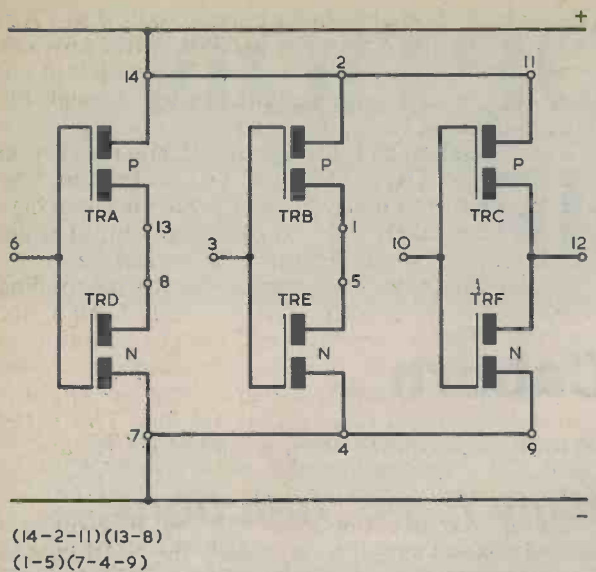


Fig. 2. Connecting the 4007 pins together in the manner shown here results in a triple inverter circuit.

The output impedance for each inverter, in either the high or low state, is 500Ω typical with a supply of 10 volts. So, if we draw from any output a current of 2mA (which is a reasonable current near the maximum for a digital CMOS output) the voltage dropped in the i.c. will be about 1 volt.

Connecting the 4007 as in Fig. 3 provides a single super-current inverter. All three inverter inputs are connected together, as are all three inverter outputs. An input at pin 6 produces an inverted output at pin 12. The output impedance is now in the order of one-third of 500Ω, and we can expect to draw output currents up to 6mA for a voltage drop in the i.c. of 1 volt. It is quite in order to connect the inverter outputs together in this manner, and the circuit of Fig. 3 has the blessing of the i.c. manufacturer.

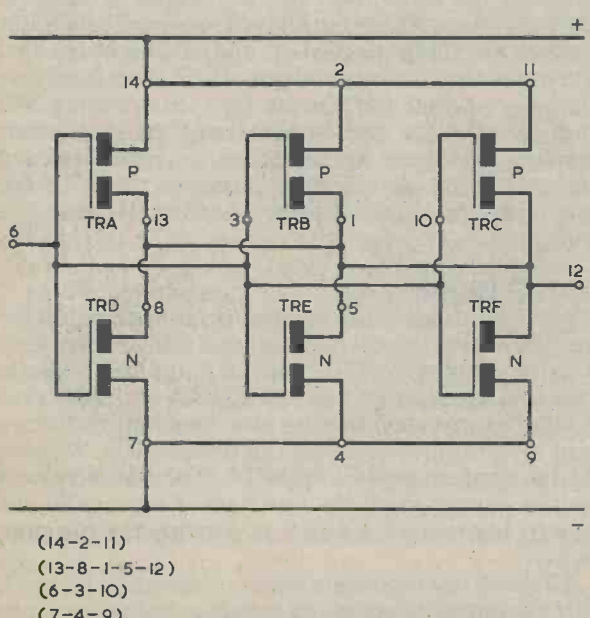


Fig. 3. With the three inverters in parallel, a single inverter with a high output current capability is produced.

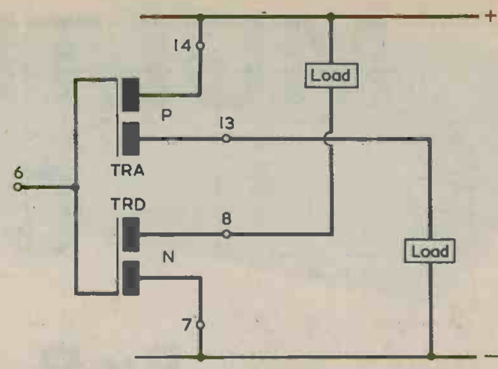


Fig. 4. The open-ended outputs of the 4007 can be used to drive separate loads in the manner shown here.

OPEN-ENDED OUTPUTS

Open-ended f.e.t. outputs are available at pins 13, 8, 1 and 15, and we can use these outputs in the manner illustrated in Fig. 4. If, in this example, pin 6 is taken high TRD is turned on, and it will drive a load connected between pin 8 and the positive rail. Taking pin 6 low causes TRD to turn off, and no current flows through the load.

At the same time, taking pin 6 low turns on TRA, and this can then cause current to pass through quite a separate load connected between pin 13 and the negative rail. The load current ceases when pin 6 is taken high.

NOR GATE

An application which may not be so obvious at first sight of the i.c. circuitry is shown in Fig. 5. Here, the 4007 is connected to function as a 3-input NOR gate. Examination of the diagram shows that the drains and sources of TRA, TRB and TRC are connected in

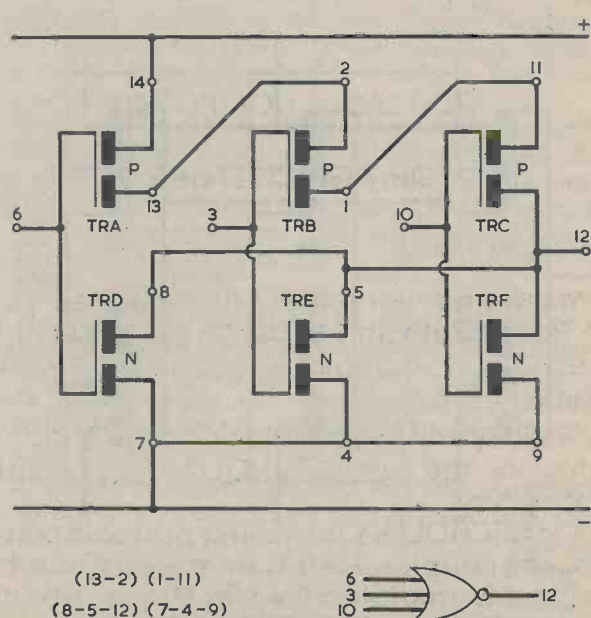


Fig. 5. The interconnections illustrated in this circuit allow the 4007 to function as a 3-input NOR gate.

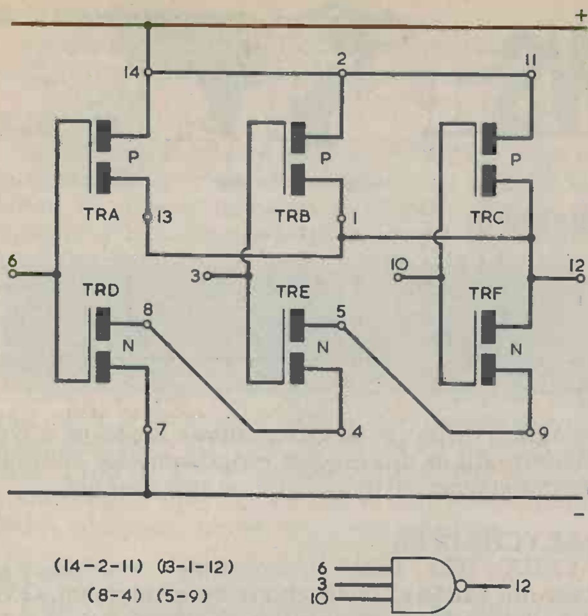


Fig. 6. Another configuration for the multi-option 4007. This time it operates as a 3-input NAND gate.

series between the positive supply input at pin 14 and the output at pin 12. At the same time the drains and sources of TRD, TRE and TRF are all connected in parallel. The three NOR gate inputs are at pins 6, 3 and 10.

Let's see what happens if we take all the input pins low. First, TRD, TRE and TRF are all turned off. TRA is turned on and allows current to flow to TRB, which is also turned on. In its turn, TRB provides current for TRC, again turned on. The output at pin 12 is high, with output current passing through the three P-channel f.e.t.'s in series.

If pin 6 is taken high TRA turns off, and the current chain through TRA, TRB and TRC is broken. The current chain is similarly broken if pin 3 is taken high or if pin 10 is taken high. To get a high output at pin 12, all three of the P-channel f.e.t.'s *must* be on.

Taking an input high causes the corresponding N-channel f.e.t. to turn on. With pin 6 high, for instance, TRD is turned on and the pin 12 output is low. So, the NOR gate output is low if any one or two, or all three of the inputs is high. The gate output is high only when all three inputs are low. This is the performance required from a 3-input NOR gate.

NAND GATE

The interconnections shown in Fig. 6 result in a 3-input NAND gate. Fig. 6 is really the NOR gate of Fig. 5 turned upside-down. This time it is TRD, TRE and TRF which are connected in series, with TRA, TRB and TRC is in parallel.

The output is low only when all three inputs are high, so that TRD, TRE and TRF are all turned on. The output at pin 12 is high for all the other input combinations, given by one input low, two inputs low or all inputs low. A fully serviceable NAND gate results.

The 4007 doesn't seem to have received the attention in the constructional press which it fairly deserves. As you can see, it is an exceptionally versatile chip and is capable of carrying out many more different tasks in logic than can its fixed-purpose partners in the current CMOS listings. ■

TRADE NOTE

PORTABLE COMPUTER FOR AGRICULTURE

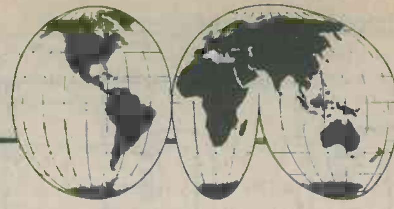
A marketing agreement was signed at the Royal Bath and West Show between Microdata Computers and Agriday Computers.

Agriday will have exclusive distribution rights for the new MICROLINK 1 portable computer system within the agricultural community.

The MICROLINK is the first portable computer to include a keyboard, plasma display, acoustic coupler, BASIC interpreter, bubble memory, real time clock and text processor, and is manufactured in Hayes, Middlesex.

In addition to the agricultural software to be supplied by Agriday, programme packages will be available to meet the needs of accountants, engineers, stocktakers, insurance brokers and salesmen.

SHORT WAVE NEWS



FOR DX LISTENERS

By Frank A. Baldwin

Times = GMT *Frequencies = kHz*

The items presented here are for the general guidance of readers who wish to tune over the short wave bands, some of the loggings will interest the short wave listener whilst others may catch the attention of the Dxer. All details are correct at the time of writing.

● **PAKISTAN**

Radio Pakistan on **17910** at 1548, local-style songs and music in the "World Service" programme in Urdu intended for the Middle East and the Persian Gulf areas, scheduled from 1330 to 1600. A newscast read at slow speed in English followed at 1600, this for the Middle East and East Africa.

● **VIETNAM**

Hanoi on a measured **15009.5** at 2120, a programme all about life in Hanoi now that peace reigns, in the English transmission directed to Europe, scheduled from 2030 to 2130.

● **JAPAN**

Tokyo on **21610** at 0800, station identification, time and frequency details followed by a newscast of local affairs – all in the English programme for Europe, scheduled from 0800 to 0830. Also logged in parallel on **17855**.

● **NORTH KOREA – 1**

Radio Pyongyang on **11350** at 1315, music and songs in the Korean Domestic Service, scheduled here from 2000 to 0300, 0400 to 0900 and from 1500 to 1800.

● **PORTUGAL**

Radio Renascenca on **9670** at 1504, station identification and announcements in Portuguese to Europe, scheduled from 1500 to 1530 – a relay from Radio Trans Europe, Sines, Portugal for Portuguese Catholics away from home.

● **CANADA**

RCI (Radio Canada International), Montreal, on **5995** at 2029, YL (Young Lady = female announcer) with station identification and programme details at the end of the English programme for Africa and Europe, scheduled from 2000 to 2030. Into the French programme at 2023. All this from the BBC relay station at Daventry.

● **PORTUGAL**

Lisbon on **6025** at 2040, YL with a newscast of both local and world events, followed by station identification. This was followed by OM (Old Man = male announcer) with the Dx programme for short wave listeners. All in the English programme for Europe scheduled from 2030 to 2100 on this channel.

● **SEYCHELLES**

FEBA (Far East Broadcasting Association), Mahe, on **11860** at 1638, chimes interval signal, OM with station identification as "Halkani wa FEBA Seychelles" – at least according to my tape recorder!

● **AUSTRALIA**

Melbourne on **6035** at 1700, OM with station identification and a newscast of world events in English.

Melbourne on **9570** at 0804, OM with both world and local newscast, this transmission in English to Asia.

Melbourne on **11865** at 1635, OM with local weather forecasts in an English programme directed to Asia.

Melbourne on **21570** at 0805, OM with news report in English, followed by a review of Australian business affairs.

● **FINLAND**

Helsinki on **6120** at 2135, OM with the English programmed "Northern Report" in a transmission to Europe, North West Africa and South America, scheduled from 2130 to 2200. "Compass North" commenced at 2140.

● **CLANDESTINE**

A Voz de Verdade on **4950** at 1820, OM with a tirade in Portuguese about Angola and UNITA. This is a pro-UNITA transmitter broadcasting to Angola.

● **NAMIBIA**

Windhoek on **4965** at 1721, OM in vernacular. This is a new transmitter which commenced operations in early October. The evening transmission on this channel is scheduled from 1515 to 2200.

● **EQUATORIAL GUINEA**

Radio Ecuatorial, Bata, on **4925** at 2020, a programme of local songs and music in typical style. This one seems to have abandoned **5005** for the time being.

Malabo on **6250** at 2022, YL with announcements in Spanish, short excerpts of classical music.

● **KENYA**

Nairobi on a measured **4934** at 0314, YL with announcements in vernacular, African drums. This is the North Eastern Service operating from 0250 to 0630 and from 1400 to 2015. The power is 100kW.

● **SIERRA LEONE**
Freetown on **5980** at 2225, local pops on records, OM in vernacular, just audible under QRM.

● **UGANDA**
Soroti on a measured **5027** at 1928, U.K. pops on records, OM with station identification at 1933 followed by a local newscast in English. This is the National Programme in English, French and Swahili, operating from (weekdays) 1300 to 2100; Saturdays and Sundays from 0300 to 0545 and from 1400 to 2100 (Sundays from 1430). The power is 250kW.

● **ZIMBABWE**
Gwelo on **3396** at 1735, OM in vernacular, songs and music in local style. This is the General Service, scheduled from 0350 (Sundays 0500) to 0545 and from 1500 to 2200 (Sundays 2105). The power is 100kW but it operates on 10kW only from 0545 to 0615, additional to the foregoing schedule.

● **CHINA**
CPBS Peking on **4905** at 2035, YL announcer, Chinese classical music in the Domestic Service 1 programme, operating from 2000 to 2300 and from 1100 to 1735. Also logged in parallel on **7504**.

Radio Peking on **7035** at 2050, Chinese music in the Standard Chinese programme intended for Europe and North Africa, scheduled here from 2000 to 2100.

Wuhan, Hypeh, on **3940** at 2150, OM and YL in Chinese, orchestral music local style. Schedule is from 2100 to 0100 and from 0300 to 1605.

Hohhot, Neimenggu, on **4000** at 2153, Chinese classical music. The schedule is from 2145 to 0555 and from 0900 to 1520.

Lanzhou, Gansu, on **4865** at 2211, OM with a talk in Chinese, The schedule is from 2145 to 0100 (Sundays to 0600), from 0320 to 0600 and from 1000 to 1600.

Nanning, Guangxi, on **5010** at 2215, YL announcer, Chinese music. This is Guangxi 2 operating from 2115 to 2200 and from 0950 to 1530.

Harbin, Heilongjiang, on **4840** at 2052, YL in Chinese with short periods of Chinese classical music. This one operates in Chinese from 2040 to 0630 and from 0830 to 1530, except in Korian from 0300 to 0400 and an English language lesson from 2130 to 2200.

● **MALAYSIA**
Kuala Lumpur on **4845** at 2257, OM and YL with songs, Indian-type music in the Tamil programme. The schedule is from 2130 to 0130 and from 1545 to 1530 Monday to Friday, from 2130 to 0330 and from 0545 to 1530 on Saturdays (2130 to 1530 on Sundays). The power is 50kW.

● **NORTH KOREA – 2**
Radio Pyongyang on **4770** at 2208, OM and YL in Korean in the Home Service 2, operating on this channel from 2200 to 2230 and from 1000 to 1045 irregularly. The power is 120kW but the channel suffers from QRM.

● **MONGOLIA**
Ulan Bator on **4830** at 2202, four-note tuning signal repeated several times, National Anthem, OM and YL in Mongolian. This is the Home Service, scheduled from 2200 to 0100 and from 1030 to 1500. The power is not known.

● **SRI LANKA**
Colombo on **4902** at 1829, religious chants on full moon day. This is the Home Service 1 in Sinhala, timed from 0000 to 0230 and from 1000 to 1745. On full moon days additionally from 1600 to 2400.

● **COLOMBIA**
La Voz del Cinaruco, Arauca, on **4865** at 0010, OM with newscast of local events in Spanish (the language not the events!). Many mentions of Colombian place-names. This one operates from 0900 to 0330 and the power is 1kW.

La Voz del Norte, Cucuta, on **4875** at 0505, OM with the local news. Still there at 0526 retune but this time with a political harangue, complete with cheers and jeers of the audience! The schedule is 0930 to 0500 but has been reported closing as late as 0630 on occasions. The power is 5kW.

● **ECUADOR**
Radio Popular Independients, Cuenca, on a measured **4801.5** at 0447, OM with announcements in Spanish, YL With folk songs. The schedule is from 1000 to 0530 but the frequency can vary from **4800** to **4802**. It also identifies sometimes as "Radio Amiga Popular de Cuenca". The power is 2kW and this one is heard only after Radio Lara, Barquisimeto, Venezuela closes at 0400.

La Voz de los Caras, Bahia de Caraques, on **4795** at 0420 the usual mix of local music and songs. OM with clear and full identification at 0434. The schedule is from 1100 to 0430 and the power is 3kW.

Radio Nacional Espejo, Quito, on a measured **4679.4** at 0438, OM with song in Spanish, local-style pops. The schedule is form 0800 to 0600 but sometimes around the clock and the power is 5kW.

● **BOLIVIA**
Radio Cobija, Cobija, on **4855** at 0406, OM with a political talk in Spanish. Local music and songs from 0430 after clear station identifications at 0415 and 0418. Gone at 0500 retune. This one operates irregularly from 1000 to 0300 and is seldom reported in the SWL press. The power is 1kW.

Radio Difusora Christal, La Paz, on a measured **5006** at 0024, choral folk song, OM with announcements in Spanish. Tentative logging – no identification heard despite several later observations.

"Let me introduce you to the twin speakers"

"K" TONE GENERATOR

By
Trevor P. Hopkins

The author's "K" tone generator. Screening is desirable, and all the components are housed in a metal case.

Automatic logic sends a morse "K" at each over

When working s.s.b. Dx, on both the h.f. and v.h.f. bands, it is often very difficult to determine exactly when the other station's over has been completed. This point is especially true when the signal is very weak or during contest operation.

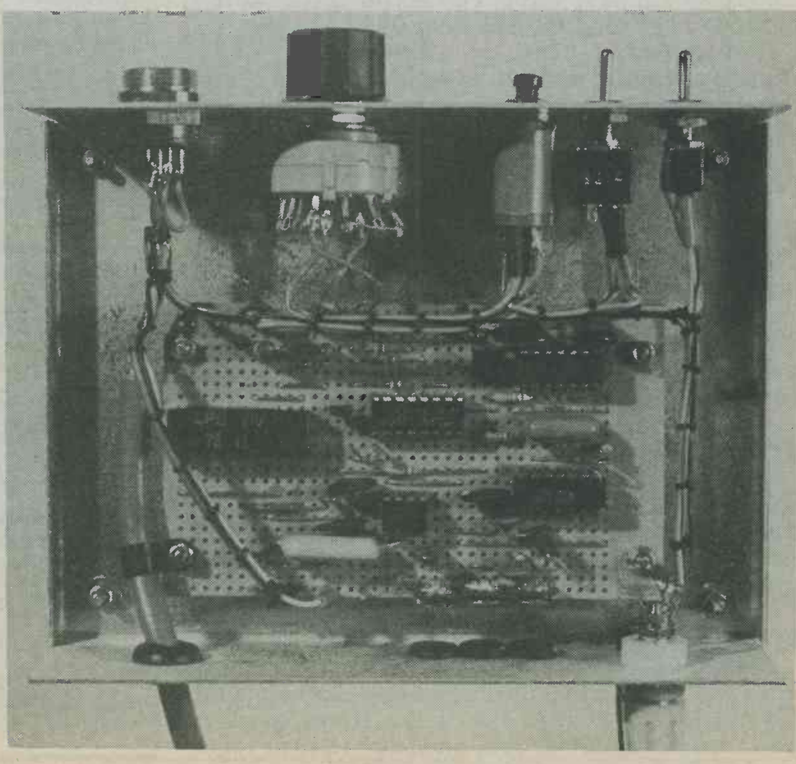
One technique to overcome this problem is to use a "pip"-tone generator which produces a short tone every time the Push-To-Talk (P.T.T.) switch is released. However, this can occasionally be confusing and a better method is to send a "K" in morse code (dah-di-dah) at the end of each over. The letter "K" is usually used during c.w. operation to mean "Invitation to transmit". The device to be described will provide this "K" function and is easily connected in the microphone lead of most transceivers.

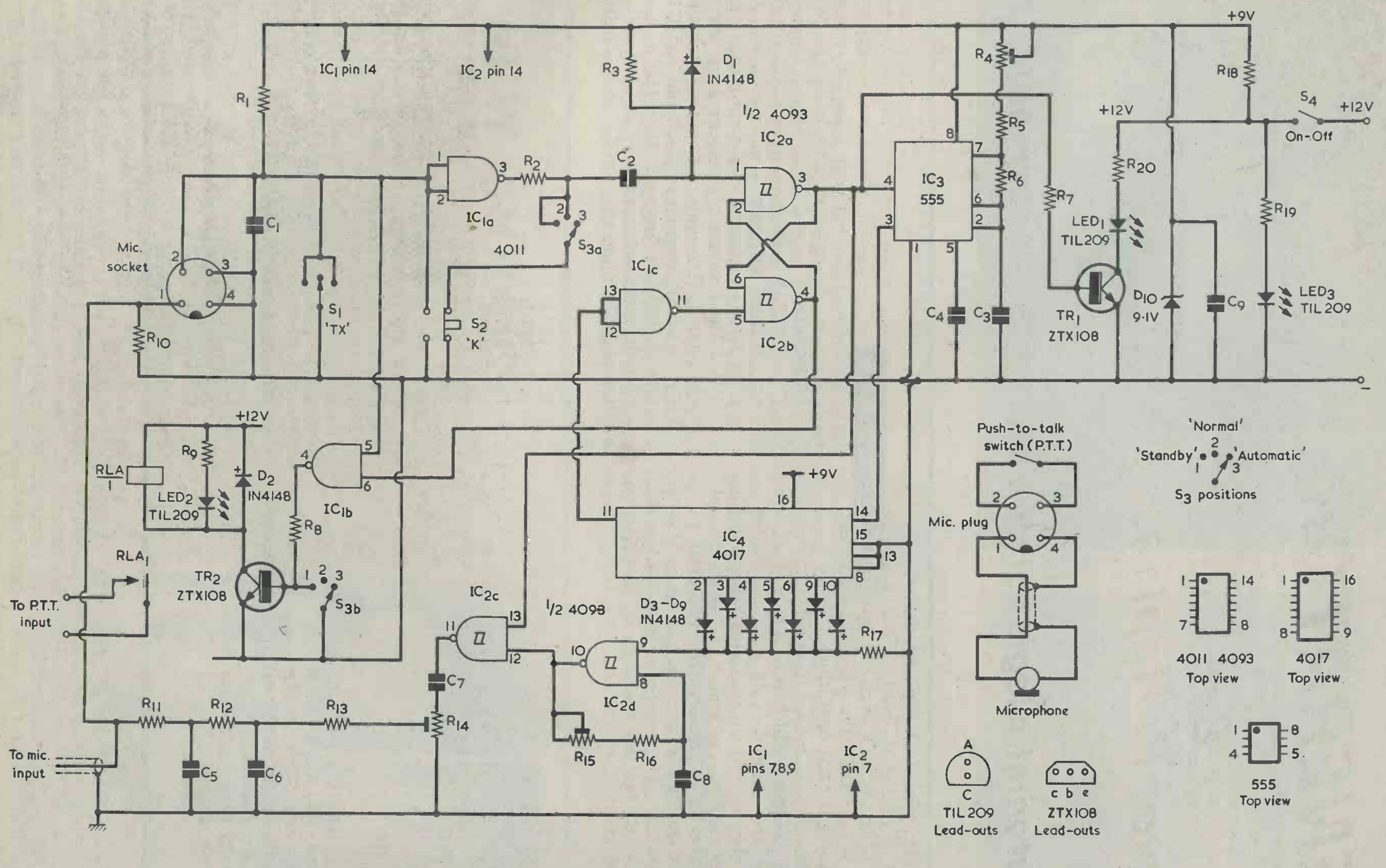
CIRCUIT OPERATION

The complete circuit of the "K" tone generator is given in the accompanying diagram. Assuming that the function switch, S3(a) (b), is in the "Automatic" position, the following sequence takes place. When the P.T.T. switch is closed, a logic "0" is applied to pins 1, 2 and 5 of IC1. The output of IC1(b) then turns on transistor TR2, which energises a miniature reed relay RLA. Contracts RLA1 close the original P.T.T. line, so that the transceiver goes into the transmit mode. LED2 lights up to indicate this state.

When the P.T.T. switch is released, pin 3 of IC1(a) reverts from logic "1" to logic *0*· The negative-going edge is differentiated by C2 and R3, and the resulting negative pulse triggers the latch consisting

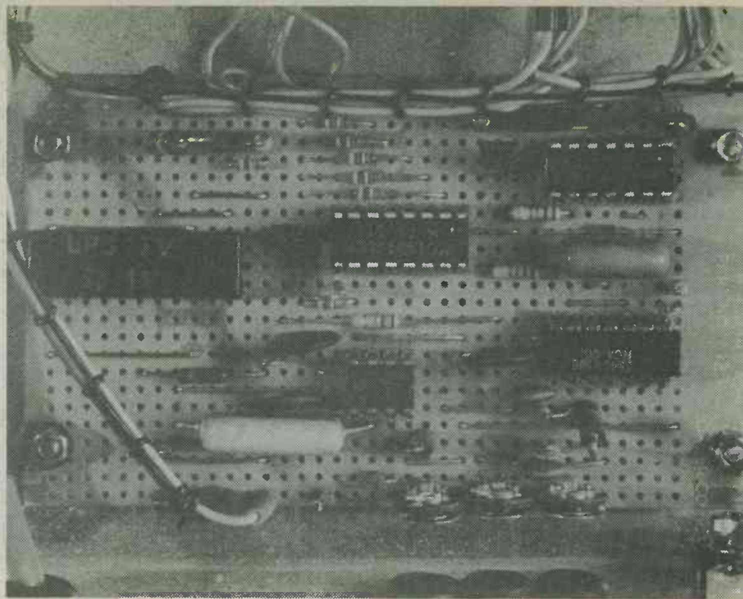
The method employed for assembly is left to the constructor. Most of the components in the prototype generator are wired up on a Veroboard panel.





The circuit of the "K" tone generator. When S3 is set to "Automatic" this produces a morse "K" at the end of each over. Note that no connections are made to the pins of IC4 which do not appear in the diagram.

A closer look at the Veroboard panel. The miniature reed relay is at centre left, and the three preset variable resistors are mounted at the right near the bottom edge.



COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
R1 10kΩ
R2 15kΩ
R3 680kΩ
R4 22kΩ preset potentiometer, 0.1 watt.
R5 82kΩ
R6 10kΩ
R7 15kΩ
R8 15kΩ
R9 1kΩ
R10 1.2kΩ
R11 1.2kΩ
R12 15kΩ
R13 15kΩ
R14 10kΩ preset potentiometer, 0.1 watt
R15 22kΩ preset potentiometer, 0.1 watt
R16 82kΩ
R17 15kΩ
R18 390Ω
R19 1kΩ
R20 1kΩ

Switches
S1 s.p.d.t. toggle, centre off, biased one way
S2 s.p.d.t. push-button
S3 2-pole 3-way, miniature rotary
S4 s.p.s.t. toggle

Capacitors
C1 0.047μF ceramic
C2 0.22μF polyester
C3 0.47μF polyester
C4 0.01μF ceramic
C5 0.047μF ceramic
C6 0.047μF ceramic
C7 2,200pF ceramic
C8 2,200pF polystyrene
C9 0.047μF ceramic

Semiconductors
IC1 4011
IC2 4093
IC3 555
IC4 4017
TR1 ZTX108
TR2 ZTX108
D1 – D9 1N4148
D10 BZY88C9V1
LED1 – LED3 TIL209

Relay
RLA miniature reed relay, 12 volt coil.

Miscellaneous
Metal case
Control knob
Microphone socket, etc.

of IC2(a) and IC2(b). Pin 3 of IC2 goes to "1" and pin 4 to "0", and there are four results. First, the output of IC1(b) stays at "1", so that the relay remains energised and the transceiver stays in the transmit mode. Second, transistor TR1 turns on and illuminates LED1 to indicate that a "K" is being produced. Third, the reset pin of the 555, IC3, is taken to "1", allowing pulses to appear at its output pin 3. Finally, pin 13 of IC2(c) is taken to "1".

The pulses from the 555 are fed to the clock input of the 4017 decade counter/divider, IC4. Diodes D3 to D9 form a logic OR gate and take pin 9 of IC2(d) to logic "1" on the counts 012 – 4 – 678. IC2(d), which is a Schmitt trigger hysteresis a.f. oscillator, is thus enabled to produce a tone having the correct dash – dot – dash pattern for the letter "K". IC2(c) gates the oscillator output when the latch is set and feeds the "K" audio tone to the passive filter R13, C6, R12, C5, and thence to the transmitter microphone input.

After the last "K" forming pulse from IC4, its pin 11 goes to logic "1" and IC1(c) resets the latch to its previous state. The 555 is inhibited, TR2 is turned off and relay RLA releases, thereby opening the transceiver P.T.T. line. Preset resistor R4 sets the speed at which the "K" is transmitted, R15 adjusts the tone frequency and R14 allows its audio level to be set.

Switch S1 is the transmit switch and allows the transceiver to transmit continuously. In the prototype, S1 was a single pole changeover toggle type with a centre-off position and biased one way only. This enables the same switch to be used for both momentary or continuous operation.

S3 is the mode switch. In the "Standby" position, transmission is disabled; and in the "Normal" position no "K" tone is generated. Putting S3 to "Automatic" causes the "K" tone to be generated at the end of each over. Pressing S2 allows a morse "K" to be transmitted in the "Normal" mode. S4 is the on-off switch, and LED3 lights up to indicate that the 12 volt supply is switched on.

OPTIONS

As just described, the "K" tone generator can be constructed as a self-contained unit. However, the maximum current consumption is approximately 50mA, mainly due to the l.e.d.'s, and the prototype was powered by the transceiver power supply. If desired, the l.e.d.'s can be omitted along with TR1, D10, R7, R9, R18, R19 and R20, and RLA replaced by a 6 volt type. The generator will then operate from a 9 volt dry battery and will have a very low standby current consumption. The circuit may be further simplified by removing all the switches, and in this form could be incorporated inside many transceivers.

CONSTRUCTION

The layout of the circuit is not critical and any convenient method of construction may be used. The prototype components were assembled on a piece of 0.1in. Veroboard measuring 4 by 2½in., and were housed in a proprietary metal case measuring 6 by 4½ by 1¾in. (152 by 114 by 44mm.). The preset resistors were vertical types mounted at one edge of the board, and holes were drilled in the rear of the case, and fitted with grommets, to allow adjustment. The microphone plug and socket were chosen to suit the author's transceiver. Other arrangements can be made to suit other transceivers.

SETTING UP AND TESTING

It is suggested that the output of the generator be connected to a suitable audio amplifier for initial testing. All three preset resistors should be set to their centre positions and a microphone connected to the input. Connect a suitable 12 volt supply and switch on. With S3 in the "Normal" position, operating the microphone P.T.T. switch or the transmit switch S1 should actuate relay RLA and light LED2. Set S3 to "Automatic" and press and release the P.T.T. switch. Both LED1 and LED2 should light and a morse "K" should be heard. Adjust R4 and R15 respectively for suitable speed and tone. Speak normally into the microphone and adjust R14 until the audio levels are the same. Final adjustments should be carried out "on-air", using a monitor receiver or by requesting a critical report. Ensure that the audio level does not overdrive the transmitter as this will cause severe distortion and interference.

No r.f. interference problems with the control logic were experienced with the prototype, although the use of a metal box is to be recommended. If r.f.i. problems do arise, 1,000pF decoupling capacitors and ferrite beads should be used on inputs and outputs. ■

NEW PRODUCT

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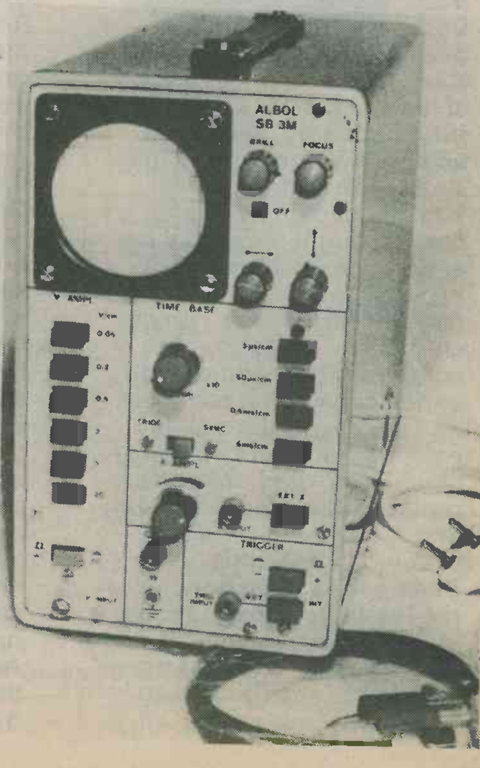

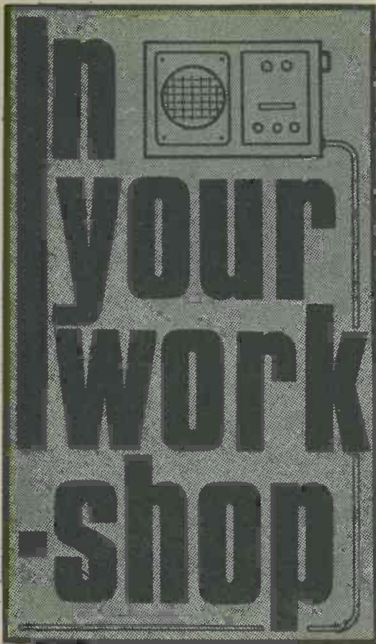

The "Haunted" Radio

The set which always worked for Smithy, but never for Dick.

Had you chanced to enter the Workshop on the morning when our story commences you might well have thought yourself taken back through time by at least several decades when, first, you caught sight of Smithy the Serviceman delving into the interior of a mains valve radio with a cabinet styling dating from the early 50s. But this is the Age of the Antique, when almost anything which has survived at least a quarter of a century suddenly seems to acquire a value grossly in excess of its true worth. The owner of the old radio had sought Smithy's assistance in bringing it back to working order, and Smithy was now checking through the components, removing paper capacitors and fitting more modern polyester components in their place. He had already replaced the electrolytics and, indeed, there seemed very little else that needed to be done to the radio, whose aged valves gave evidence of a cathode emission which was so prolific as to be almost unseemly.

VINTAGE YEARS

Had you then carried on to observe Smithy's assistant, Dick, your reaction might well have been that the tapestry of the years had been drawn back even further, and you could in fact have wondered whether you were in an electronic servicing establishment at all. For Dick was carrying over from the "For Repair" rack a small shiny model of a truly vintage car which, since you are undoubtedly up on these things, you would at once have identified as a Rolls-Royce "Silver Ghost".

But things these days are rarely what they seem. The model of that prestigious car, which Dick was now placing on his bench, had two adjuncts which could never have existed on the original. Just visible above the running board on the right projected the milled edge of a flat circular knob, whilst a similarly positioned knob rim could be seen on the left hand side of the model. And, of course, you would have realised that the model was not just a model of a vintage motor car, attractive in its own right as it might be. It was also a radio, with one of the knobs being the tuning control and the other the combined volume control and on-off switch.

Dick sat down on his stool and turned the model over. A leaflet slipped out from the driving seat and fluttered onto the bench surface. Dick put down the car and examined the leaflet. Some unknown and helpful hands in far-off sunny Hong Kong had not only printed an illustration showing the positions of the battery cover, speaker and controls, but had also appended the circuit diagram of the radio as well. (Fig. 1.)

Dick picked up the model and again turned it over. A grille on the underside was obviously the aperture for the speaker. Dick turned one of the knobs, and there was a mechanical click as the radio became turned on. He then experimentally turned the tuning control, but there was no sound from the speaker. He held the model close to his ear. He could detect

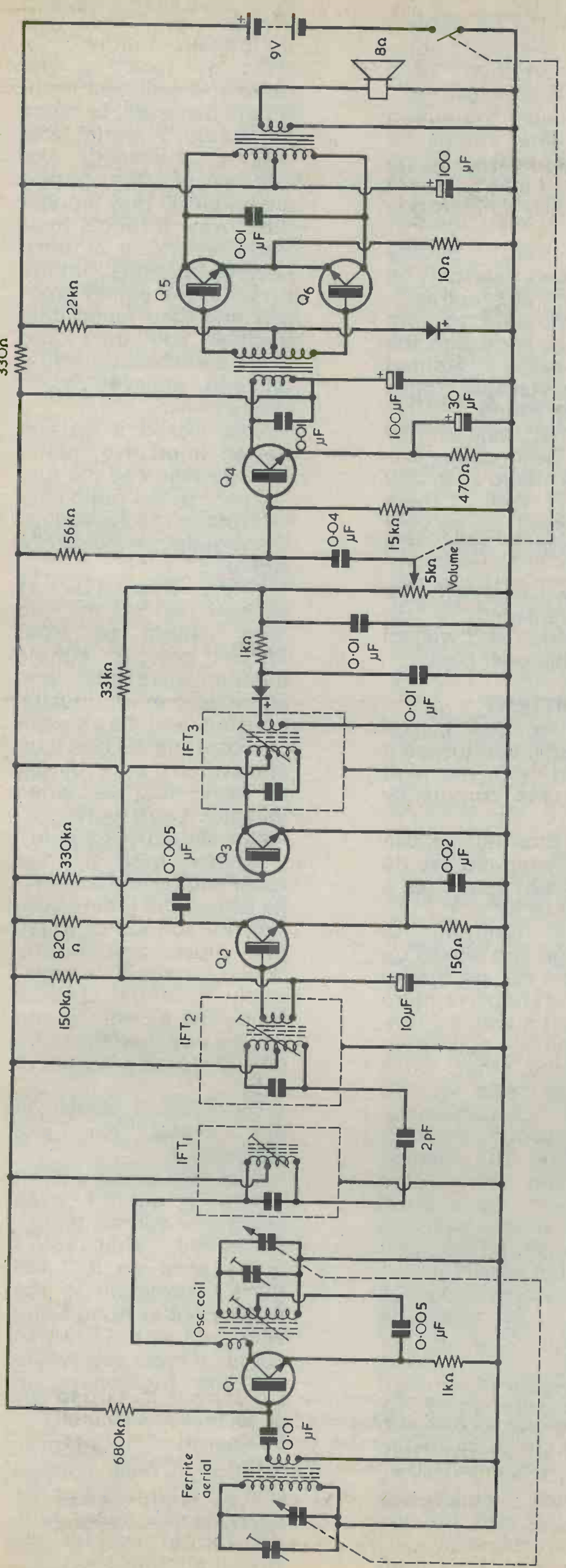

Fig. 1. Typical circuit for a novelty medium wave radio. As is common practice outside the U.K., transistors are identified by the letter "Q". Q1 is the mixer-oscillator, Q2 and Q3 the i.f. amplifiers, Q4 the a.f. driver, and Q5 and Q6 the a.f. output transistors.

a faint hiss but nothing else.

He next opened the batter cover, to reveal a PP3 battery. With the radio still switched on, he checked the battery voltage with his testmeter. The meter indicated 7 volts, whereupon Dick walked over to the spares cupboard to obtain a fresh battery. After fitting this, he checked its voltage with the radio still on. The meter gave a satisfactory reading of about 9.2 volts. Once more he tried the tuning control, but the set still refused to reproduce any signals. Irritably, Dick switched the radio off and glared at it.

"What the devil have you got there?"

Startled, Dick turned round to find the Serviceman leaning over him.

"Blimey, Smithy, I wish you wouldn't sneak up on me like that. You're **always** creeping up on me and scaring the wits out of me!"

"Perhaps," said Smithy sternly, "it's a good thing I do. I should remind you that you're supposed to be servicing radios and TV's in here, not playing around with model cars."

"This," retorted Dick with dignity, "is not just a model car."

"Oh, then what is it?"

"It's also a medium wave radio."

Smithy looked down suspiciously at the shiny little model.

"Humph," he grunted. "Radios ought to **look** like radios."

He reached out and turned one of the two controls.

"That one's for tuning," said Dick. "You switch it on and control the volume with the other one."

Smithy turned the remaining control, whereupon the model car at once reproduced, quite clearly and with reasonable volume, a string ensemble working away vigorously at one of the works of Bach.

"That must be Radio 3 on 247 metres," commented Smithy. "Let's see what else we can get."

He adjusted the tuning control. The strains of Bach disappeared, to be replaced after some moments by strident pop music.

"And that," Smithy pronounced, "can only be Radio 1 on 285 metres."

He continued to turn the tuning knob and the car-cum-radio emitted the unmistakable tones of Jimmy Young.

"And that," said Smithy finally, "will quite certainly be Radio 2 on 330 metres. Well there doesn't seem to be very much wrong with this set."

He switched off the radio, replaced it on Dick's bench and walked back to his own bench.

IMTERMITTENT

Scowling, Dick picked up the radio and turned it on. Apart from the faint hiss, it was completely dead.

"Hey, Smithy," he called out, "what did you do with this set? I can't get a peep out of it!"

Smithy returned to Dick's side and picked up the model car. He turned one of the knobs, remembered that it was the tuning control, and then rotated the other. Once again the radio worked quite satisfactorily. Smithy tuned through Radio 3 on 247 metres, Radio 1 on 285 metres and, finally, Radio 2 on 330 metres. He switched the radio off and handed it back to his assistant.

"It's working all right as far as I can see," he remarked. "Try it for yourself."

Bemusedly, Dick turned on the radio again. As before, it was completely dead. He adjusted the tuning control but to no avail. The set stubbornly refused to pick up any signals whatsoever.

"This is crazy," muttered Dick as he switched the radio off. "Here, you try it again, Smithy."

Smithy took up the radio and switched it on. A little distorted, because the Radio 3 signal was slightly mistuned, the efforts of the string ensemble as they worked their way through their Bach repertoire at once became audible. Smithy tuned in the signal properly and then tuned, respectively, to Radios 1 and 2. He switched the radio off and replaced it on Dick's bench.

Dick picked it up and turned it on. No matter how he adjusted the tuning control the radio simply refused to reproduce the vaguest suspicion of a signal.

"This," moaned Dick as he switched off the set, "just cannot be true! We've got a simple medium wave radio here, admittedly in an unusual housing, and it's only got two controls. If I pick it up and switch it on it refuses to work. And yet when you pick it up it works perfectly. Here, do it again!"

Smithy took up the radio and turned it on. As he turned the tuning control the sounds of Bach, pop music and Jimmy Young issued successively from the speaker inside the model vintage car. He switched the radio off and placed it in front of Dick.

Dick looked bleakly at the model car and shuddered.

"I'm getting to the point where I daren't even touch the darned thing," he wailed. "That radio's got a spell on it. I bet there's someone in the factory out at Hong Kong who puts an old Chinese curse on these sets just to put the frighteners on young foreign devils like me!"

"Well," admitted Smithy, "I must confess that it's a bit odd that the radio works every time with me but never for you. Give it another try."

Dick reached out a faltering hand to switch on the radio and then adjusted the tuning.

As before, the set stayed completely dead.

"What did I tell you?" he stuttered. "The flaming thing's bewitched!"

"Nonsense," snorted Smithy. "It must have an intermittent fault of some sort which will show up after a bit of straightforward fault finding. Can you get the printed board out, Dick?"

Dick examined the bottom of the model car closely.

"There are four screws holding the bottom plate on," he said. "Let's take these out."

Dick removed the screws, to find that the whole radio section came out neatly as one module.

"Obviously," remarked Smithy, "we haven't got a service manual for this job."

"We've got a circuit," said Dick. "I forgot to tell you that there was a leaflet with the model car which showed the circuit of the radio."

Dick picked up the leaflet and passed it over to Smithy, who examined it carefully.

CIRCUIT DIAGRAM

"You know, Dick," he remarked after some moments, "you've got to take off your hat to the people who design and manufacture these novelty medium wave radios. Everything is tidy and functional and yet the circuit uses the bare minimum of components."

"That circuit may be tidy and functional with you," complained Dick, "but it certainly isn't functional so far as I'm concerned!"

"Well, let's just take a butcher's at it," pronounced Smithy. "If we work back from the speaker it's very easy to follow. There's the usual Class B output stage preceded by the driver transistor. As almost always with these little radios, a.f. transformers are used instead of the more modern a.f. amplifier arrangements which don't require transformers."

"Before the driver transistor," put in Dick, "there's the third i.f. transformer and the diode detector which feeds into the volume control."

"That's right," agreed Smithy. "The volume control is also the diode load, and you'll notice that the diode is connected so that the top end of the volume control track goes more negative as signal strength increases. The voltage at the top of the volume control track is fed back via a 33kΩ resistor to the base of the first i.f. transistor to give automatic gain control."

"There isn't an i.f. transformer between the two i.f. transistors," put in Dick, "they're coupled together by a 0.005μF capacitor."

"True," confirmed Smithy. "So the coupling between these two transistors is untuned. But there are two i.f. transformers between the mixer-oscillator transistor and the first i.f. transistor. These are coupled together by a 2pF capacitor to form a bandpass pair. So there are still three tuned circuits in the i.f. amplifier." (Fig. 2.)

"All that seems fair enough," commented Dick. "What about the mixer part?"

"That uses a very simple circuit arrangement," stated Smithy. "Since the set only tunes over the medium wave band very few components are needed here. A coupling winding on the ferrite rod aerial couples inot the base of the mixer transistor. The mixer collector connects through a coupling winding on the oscillator coil to the first i.f. transformer, and the

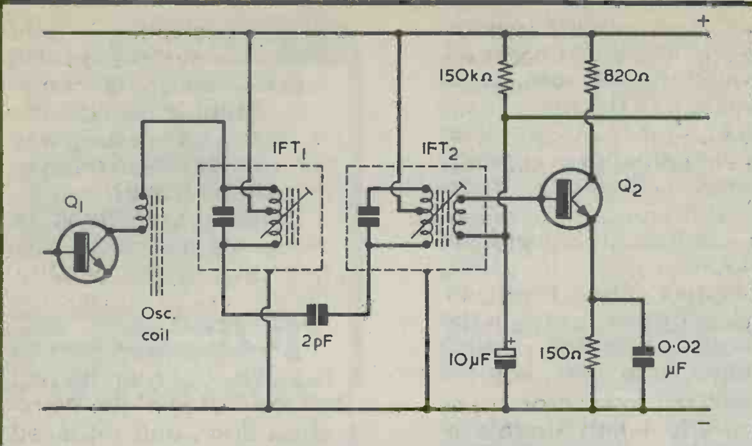

Fig. 2 Two i.f. transformers, coupled to form a bandpass pair, appear between Q1 and Q2.

oscillator tuned coil has a tap which connects to the mixer emitter. So the oscillator feedback is from the mixer collector back to its emitter." (Fig. 3.)

Smithy put the leaflet with the circuit diagram back on Dick's bench.

"Right," he said briskly, "to business! Did you notice anything about the set when you switched it on and it didn't pick up signals?"

Dick thought for a moment.

"Well, there was a quiet hiss."

"Was there? Can you switch on the set now you've got the board out?"

"Oh yes."

Dick rotated the volume control knob to turn on the set, then rotated the tuning control. As on all the previous occasions, the radio doggedly refused to function for him.

"Signal genny next!" said Smithy. "Bring it over and set it up for around 465kHz."

Dick pulled his battered signal generator over and switched it on. As he set up its frequency, Smithy searched through a cardboard box of spares on his assistant's bench and found a 0.01μF capacitor. He next coupled the earthy output lead of the signal generator to the negative battery clip and clipped the 0.01μF capacitor to the non-earthy output lead. He next examined the little printed board and traced the printed wiring from the ferrite aerial coupling coil through its coupling capacitor to the base of the mixer transistor, then applied the free end of the 0.01μF capacitor to that base. (Fig. 4.)

SIGNAL INJECTION

The 400Hz modulation of the signal generator was at once audible from the speaker of the radio. Smithy increased the signal generator attenuation until the modulation could just be heard and then adjusted the generator frequency for maximum output. After that he removed the 0.01μF capacitor and the signal generator earthy lead from the radio, then glanced at the generator frequency scale.

"The i.f. amplifier," he remarked in a satisfied tone, "is peaking nicely at 470kHz, and the i.f. stages seem to be giving plenty of amplification. I thought I'd start off by checking the i.f. amplifier as a whole rather than inject a signal at each stage and work back to the mixer. I had a hunch, inspired by your remark about the hiss, that the whole i.f. amplifier would be all right, and so it has turned out to be."

"So," said Dick slowly, "let's see what we've got up to now. I've switched on the set and, as always, it refuses to pick up any signals for me. And yet the i.f. amplifier is all right. There must be a fault in the ferrite aerial circuit, then."

"There could be," agreed Smithy, frowning. "Or it could be that the mixer isn't oscillating."

"Not oscillating?"

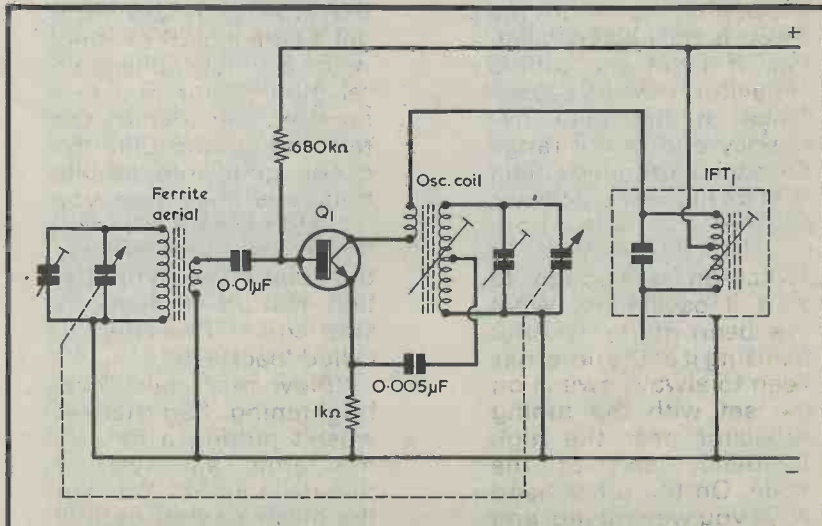

Fig. 3 Since the mixer-oscillator has only to cover the medium wave band it has a very simple circuit.

repeated Dick. "Well, why won't it oscillate for me and yet oscillate for you?"

"I don't know," replied Smithy slowly. "Hang on a jiffy though, I've got a glimmering of an idea! When I switched the set on, didn't I always tune in the Radio 3 signal first?"

"I can't remember," said Dick dolefully.

Smithy leaned forward, switched off the radio, set the tuning capacitor to the high frequency end of its range and switched on again. He then slowly adjusted the tuning capacitor, and a signal almost immediately became audible. It was a talk on social proclivities in Outer Mongolia. Johann Sebastian Bach must have won and Radio 3 was now continuing with its next programme, cutting its own narrow swathe through the airwaves of England.

"Ye gods," said an aghast Dick. "Even when its out of its case that darned radio will still only work for you!"

Smithy proceeded to turn the tuning control, passing yet again through Radio 1 and Radio 2. After tuning in this last station he switched off the radio and turned it on again. And the radio remained silent.

"It's the oscillator that's wrong," stated Smithy triumphantly. "What's happening is that the mixer is only just oscillating. If I set the tuning capacitor to a low capacitance at the high frequency end of the range the oscillator tuned circuit is at its highest efficiency, so that the little shock given to the oscillator at switch-on is enough to start it oscillating. What I've been doing, without realising it at the time, has been to always switch on the set with the tuning capacitor near the high frequency end of the scale. On the other hand what you were doing, and also without knowing it, was to switch on the radio with the tuning capacitor set to a greater capacitance. With the reduced tuned circuit efficiency which resulted, the switch-on shock just wasn't enough to start the oscillator."

"But you got the mixer to oscillate at those lower freqencies."

"Only after I'd initially got it to start at the high frequency. This quite often happens with a reluctant oscillator, particularly when there's a coupling capacitor somewhere in the feedback circuit. As you can see, there's a 0.005μF coupling capacitor in the emitter circuit. When the oscillator is caused to start at the high frequency it settles down to proper working and it will then continue to oscillate even when you take it down to frequencies lower than that at which it starts. You get a similar sort of effect with a badly designed reaction circuit in a t.r.f. receiver. You advance the reaction control until the circuit goes into oscillation, and then find you have to back off the reaction control well beyond the point at which oscillation started to make it stop again. The effect is called 'backlash".'

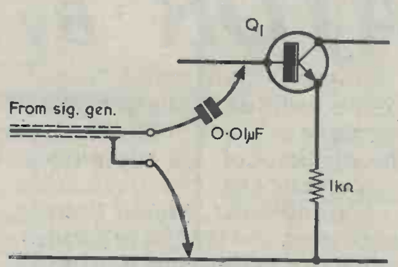

Fig. 4 Checking the i.f. and a.f. stages by injecting a modulated i.f. signal into the base of Q1.

"Blow me," said Dick, brightening. "So that set wasn't putting a hex on me after all. Wait a minute, though. You got the mixer to start oscillating by tuning around the Radio 3 wavelength of 247 metres, and it then kept oscillating right down to Radio 2 on 330 metres, which is nearly 100 metres down the scale. Isn't that a long way for your backlash thing to remain effective?"

"Not if you think in terms of oscillator frequency," stated Smithy. "Now, let me consult my newspaper."

Smithy walked over to his coat, hung on its peg on the inside of the Workshop door, and retrieved his daily newspaper from a pocket. He selected the page with the radio programmes.

"We're more than a bit old-fashioned in this country," he remarked, "because we still tend to keep talking about station wavelengths on medium and long waves. Now my very superior newspaper not only gives station wavelengths but it also gives frequencies, and it tells me that the Radio 3 frequency is 1,215kHz whilst the Radio 2 frequency is 909kHz."

"That's still," objected Dick, "a ratio of something like 3 to 2."

"Ah yes," agreed Smithy, "but don't forget that oscillator frequency is higher than signal frequency by the intermediate frequency. which, with this set, is 470kHz."

Smithy took out a pen and proceeded to jot some figures in the margin of the circuit diagram leaflet. (Fig. 5.)

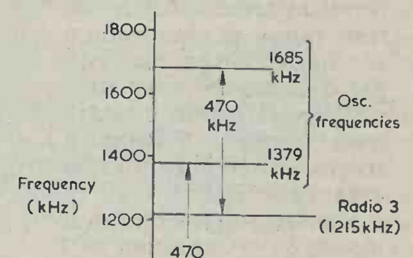

Fig. 5 The oscillator frequencies corresponding to the signal frequencies of Radio 3 and Radio 2.

"The oscillator frequency for Radio 3 is 1,215 plus 470kHz," he went on, "which comes to 1,685kHz. And the oscillator frequency for Radio 2 is 909 plus 470kHz, which works out as 1,379kHz. The ratio between these two frequencies is not 3 to 2 but is less than 5 to 4, which is quite low enough for a backlash effect to take place."

NEW TRANSISTOR

Smithy was right, of course.

A few quick checks showed that the resistors and capacitors around the mixer transistor were as they should be, whereupon the fault could lie in the oscillator coil or in the mixer transistor itself. Smithy plumped hopefully for the latter which, the little leaflet told him, was a 9011G. Even Maplin don't list this one so Smithy consulted the Workshop copy of the invaluable **Towers' International Transistor Selector – Up Date 2** to find that this was a silicon transistor with a quoted hFE of 72 to 108. A BC107A seemed a reasonable substitute and this, with due attention to its different lead layout, was ceremoniously installed by Dick.

And, with its new transistor, the little radio worked perfectly regardless of whether Smithy or Dick switched it on. It would probably even have worked for Jimmy Carter. Every cloud has its silver lining, and the silver lining in this case was that the radio was not after all haunted despite its silver ghostly housing. ■

NEGLECTED OSCILLATOR

By R. S. Burns

When the ICM7555 (the "CMOS 555") came on the scene we looked upon it as the latest thing in low supply current operation. Having all the attributes of the 555, apart from output current capability, the ICM7555 could run as an oscillator requiring only about 40 to 50μA from a 9 volt supply.

But a CMOS digital device which can function as an oscillator with even lower current consumption was already sitting in the lists before the appearance of the ICM7555. This digital device is the 4047 Low-Power Monostable/Astable Multivibrator.

4047 PINOUT

The 4047 has the pinout shown in Fig. 1, and a simplified block diagram representing its internal logic is given in Fig. 2. As can be seen, it includes a low power astable multivibrator whose output passes to pin 13. The multivibrator output is also fed into a frequency divider which divides it by 2, with a Q output at pin 10, and a not-Q output at pin 11. There are a number of inputs, most of which are concerned with monostable functioning. The astable and not-astable inputs at pins 5 and 4 respectively do, however, control the i.c. in astable operation.

Fig. 3 shows the 4047 connected for free-running astable operation. You can take an output at multivibrator frequency from pin 13, or an output at half multivibrator frequency either from pin 10 or from pin 11. The two divided outputs are guaranteed square waves. Frequency is controlled by the values of R and C.

Fig. 4 shows the output waveforms at pin 13 and pin 10 relative to each other. The pin 13 output is not a guaranteed square wave because its duty cycle depends upon the transfer characteristic of the f.e.t. inside the i.c. which follows pin 3. The pin 10 output changes state on every positive-going pulse edge of the pin 13 waveform. Since each half-cycle of the pin 10 output has the same length as a whole pin 13 cycle, the pin 10 output has to be a true square wave.

The cycle length of the pin 10 waveform is specified as being typically:

$$T = 4.40\ RC$$

where T is in seconds, R is in ohms (or megohms) and C is in farads (or microfarads). Interestingly enough, this equation for typical cycle length represents the minimum time within tolerance. If the transfer characteristic of the multivibrator input f.e.t. shifts in either direction to its specification limits the maximum cycle length is given by:

$$T = 4.62\ RC$$

4.62 is 4.40 plus 5%. So you can calculate cycle length by using the 4.40 figure, and this will give you the actual cycle length within –0% and + 5% To take an example, let's say that R in Fig. 3 is 470kΩ and that C is 0.0022μF. The typical cycle length at the pin 10 output is then:

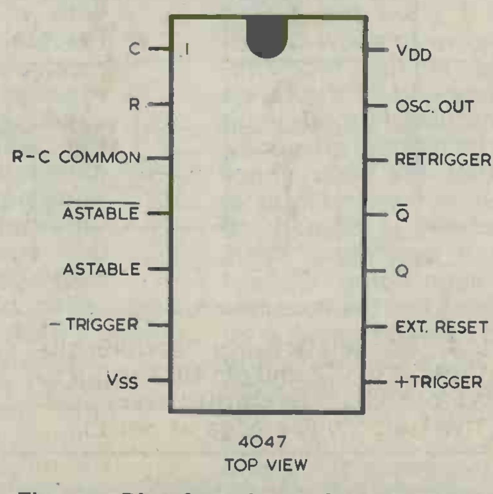

Fig. 1. Pin functions for the 4047 monostable/astable multivibrator.

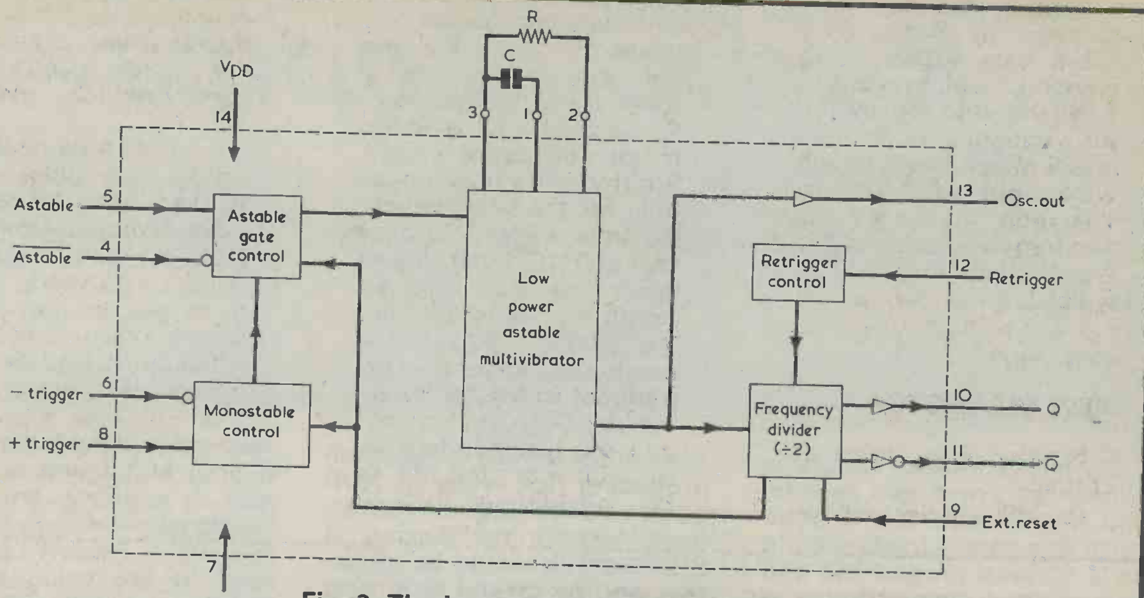

Fig. 2. The internal logic of the 4047.

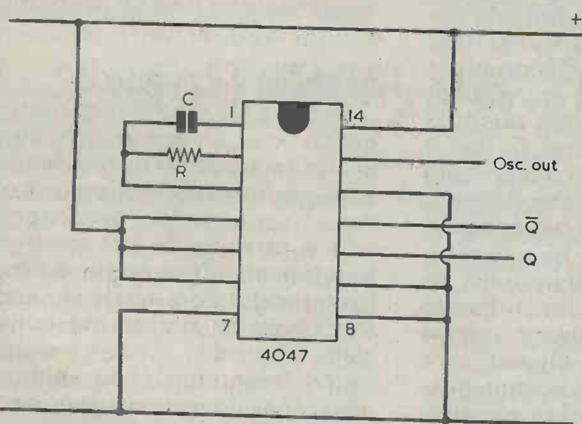

Fig. 3. Connecting up the 4047 as a free-running multivibrator. There are three outputs, one at multivibrator frequency, and two at half multivibrator frequency.

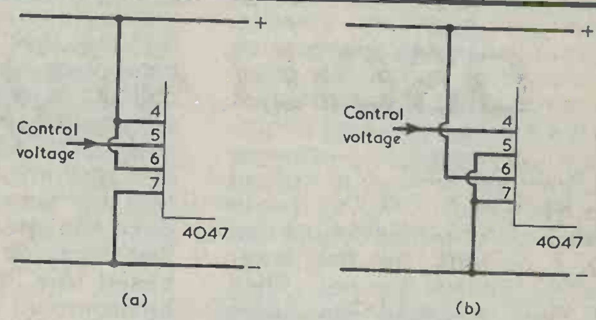

Fig. 5(a). When pins 4, 5 and 6 are connected as shown here, the multivibrator runs when pin 5 is high and stops when it is low.
(b). With this alternative method of connection, the multivibrator runs with pin 4 low and stops when pin 4 is taken high.

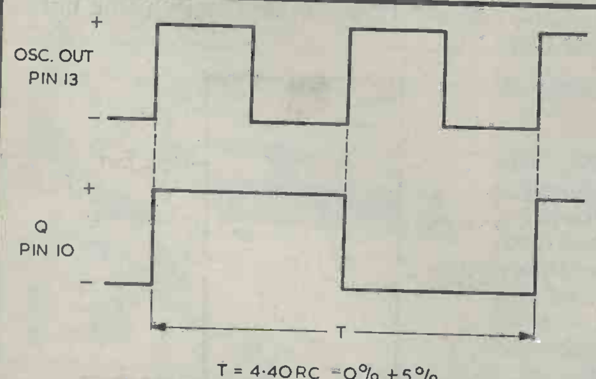

Fig. 4. The relationship between the outputs at pin 13 and pin 10. The pin 10 waveform changes state at every positive-going pulse edge at pin 13.

$$4.40 \times 0.47 \times 0.0022$$

which calculates as 0.00455 second. The reciprocal, which gives the frequency, is 220Hz.

LIMITING VALUES

The manufacturer's limiting values for the timing components, R and C, state that the resistance must lie between 10kΩ and 1MΩ, whilst the capacitance must have a minimum value of 100pF with no limit on maximum value.

Current consumption, when employed as a free-running multivibrator, depends almost entirely upon the value of the timing resistor. When this is 1MΩ the current drawn from a 9 volt supply is less than 25μA, and when it is 100kΩ the current is less than 45μA. With a 10kΩ timing resistor the current at 9 volts is much higher, being in the region of 600 to 800μA. So, provided the timing resistance is 100kΩ or more, a 4047 oscillator draws less current from its supply than does an ICM7555 oscillator.

The 4047, when free-running, can be controlled by voltages at the astable and not-astable inputs. If pins 4, 5 and 6 are connected as shown in Fig. 5(a), the multivibrator runs when pin 5 is high and stops when pin 5 is low. With the pins connected as in Fig. 5(b), the multivibrator runs when pin 4 is low and stops when it is taken high. ■

Radio Topics

* * * * *

By Recorder

So far as Mother Nature is concerned I'm a real townie, and my concept of the good earth is a nice shiny brass pin on a 13 amp plug at the end opposite to where the wire goes in. But I recently had to assume responsibility for a small plot of ground measuring some 6 feet by 4 feet which had become completely overgrown. I could either donate it to the nation as an area of outstanding natural free-growing flora or get to work in pulling up the weeds. I like to live in peace with my neighbours and so I decided on the latter course. Believe it or not, I filled at least a dozen bin liners before I had the area reasonably well cleared.

THE TREE

Normal weeds were easy enough but the ground also supports a little tree of such abundant fecundity that it's beginning to dog my dreams. The roots go under some concrete and so I just contented myself with cutting it down. But I only have to turn my back on it for a couple of days to find that it has pushed out a whole new system of branches all covered with bright chlorophyll laden leaves. And, of course, the branches and leaves exactly reflect the basic make-up of the tree, which I assume to be a member of the *genus Quatermass.*

Now, it occurs to me that this abundantly productive tree is carbon based, and that it should not be beyond the capabilities of our experimental biologists to create a silicon based form of plant life. Just imagine the benefits to modern technology which would accrue. We could, for instance, raise 4001 or 4011 trees, each producing rich crops of NOR gates and NAND gates respectively just for the picking. A BC109 shrub would be attractive, and by careful grooming and selection it should be possible to cultivate three individual plants which fell into the BC109A, BC109B and BC109C categories. As our silicon plant cultivators became more adept we could have a 555 bush or even an MC6800 tree. In fact it is in the microprocessor field that my scheme should produce the greatest awards. In just the same way as a carbon based tree interfaces with its environment the silicon based microprocessor plant could interface with its own source of nutrient, with each branch providing its own data bus coupling it with the main trunk.

I think I'll take another look at that prolific tree of mine. Ordinary sand is a good source of silicon, and I see no reason why I couldn't try copper nitrate as a fertilizer. So watch this space. Even if I only succeed in producing a 1N914 plant, it will still be quite a major step forward. But with my gardening luck I'll probably end up with an OA70 bush.

ASSEMBLY STATION

In the accompanying photograph you can see an operator at the factory of Oxford Medical Systems assembling one of the firm's tape recorders, which are used to monitor heart beats. This is not a flow line production system, and the operator builds the complete assembly. She is helped by a "Trescomp" independent assembly station designed and produced by Link-Hampson Ltd., 5 Bone Lane, Newbury, Berkshire, RG14 5TD.

In this assembly station at Oxford Medical Systems the operator builds the complete product. Components are brought forward as required by a Link-Hampson "Trescomp" motorised conveyor.

The Link-Hampson "Trescomp" independent assembly station is part of an integrated parts handling system which can provide increased levels of production over more conventional factory flow lines. Oxford Medical Systems were one of the first firms to install these stations, and they report an increase of 40% over the previous flow line system. At their Abingdon based factory, where tape recorders for monitoring heart beats and associated analysis equipment are produced, "Trescomp" stations are used to complete the different assemblies. The products are constructed from a mix of electro-mechanical and electronic components and individual operators are responsible for complete assemblies.

Each assembly station has a motorised conveyor which supports rows of trays with sufficient capacity to carry 153 different components. Before the assembly work commences the trays are loaded with all the required components in a pre-planned sequence. The operators then follow a pre-determined order of assembly. When a new component is needed, the conveyor is activated by a foot switch and the appropriate component moves into position.

By employing independent stations it is found that not only does production output increase but improved reliability also results from greater operator responsibility. This is because each operator builds up a complete assembly and any defect that occurs can then be rectified by the person concerned. As can be readily visualised, there is less personal association with a completed product when it is assembled using the flow line system, with defects being rectified by a special repair section employing different staff.

The Klippon cable insulation stripper. This deals with all types of insulation having an outer sheath diameter of 4.5 to 28.5mm.

CABLE STRIPPER

The second photograph shows the Type AMI insulation stripper which has been introduced by Klippon Electricals Ltd., Terminal Works, Power Station Road, Sheerness, Kent, ME12 3AB. This is suitable for use with round cables having an outer sheath diameter of 4.5 to 28.5mm. The AMI is a compact and easily held hand-tool, yet it is very robust and will give many years of trouble-free use.

The insulation cutting blade can be adjusted with a simple thumbscrew to obtain the correct cutting depth, and the tool firmly grips the cable during the rotary cutting action. To complete the cutting operation, the blade is rotated by means of a push-button to enable an axial cut to be made.

In cases where the insulation is extra thick or difficult to remove, the tool features an integral hook-blade cutter which can be pulled along the initial axial cut to ensure easy removal of the insulation. The AMI is made of steel and high strength thermoplastic and measures a mere $5\frac{1}{4}$ by $\frac{3}{4}$in. ■

We regret that owing to pressure on space, the article entitled Experimental Electronics has been held over to our next issue.

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(Continued on page 253)

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VOLTAGE REGULATORS

A voltage regulator is intended to provide a nearly constant supply voltage for a load despite varying load current and varying regulator input voltage. In (a) the zener diode is a reverse biased silicon diode which is designed to break down at a specific voltage. The voltage-current characteristic is shown in (b). As the reverse voltage approaches the breakdown zener voltage reverse current starts to flow and, after some curvature, produces nearly a straight line graph. Vs divided by Is is the zener "slope resistance". The value of R in (a) is chosen to ensure that, within its permitted dissipation figure, the zener diode functions on the straight part of its characteristic at all load currents and unstabilized input voltages.

In (c) the added emitter follower carries nearly all the load current, so that variations in the latter have only a small effect on zener diode current.

The forward biased light-emitting diode of (d) drops a voltage of typically 1.6 volts which increases only slightly with increasing forward current. It may in consequence be used as a voltage regulator. So also, as in (e), may a series chain of forward biased silicon diodes, each of which drops around 0.6 volt, again with a zener-type voltage-current characteristic.

An amplified voltage regulator is illustrated in (f). A reference voltage from the zener diode is applied to the non-inverting input of the amplifier whilst a fraction of the regulated output voltage is applied to the inverting input, giving the relationship shown. Any very small change in regulated voltage at once produces an amplified correcting voltage in the opposite direction at the amplifier output, and a very high level of voltage regulation results.