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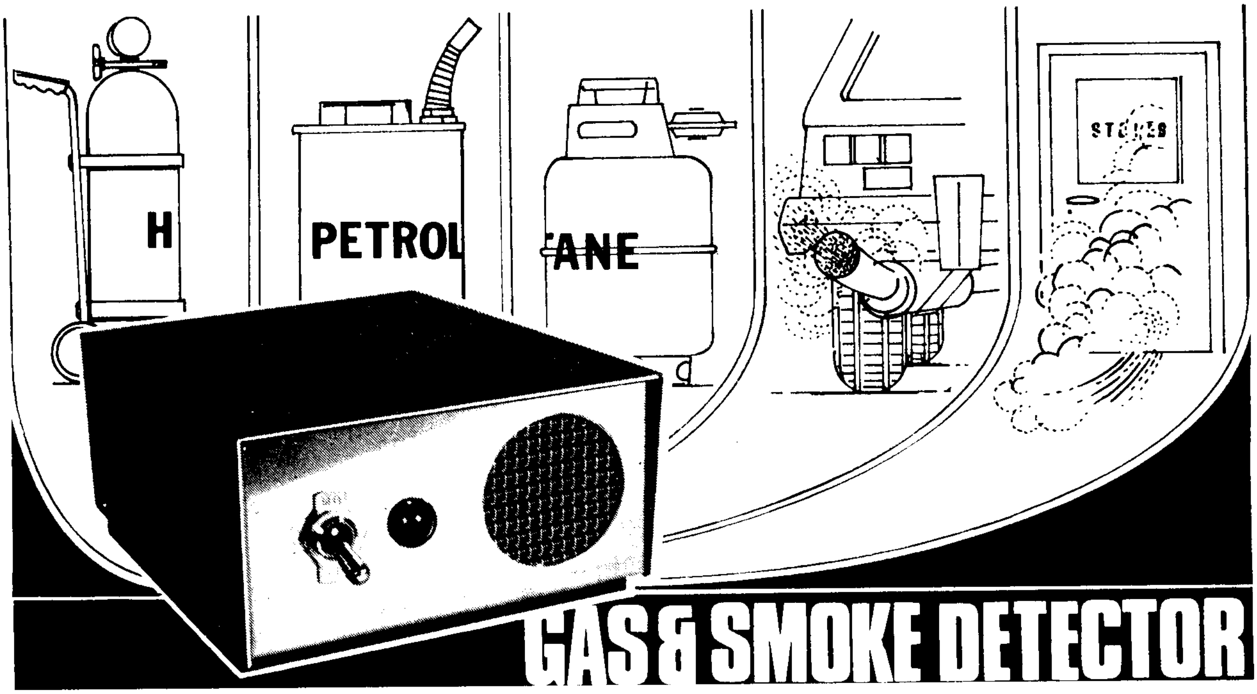


GAS & SMOKE DETECTOR

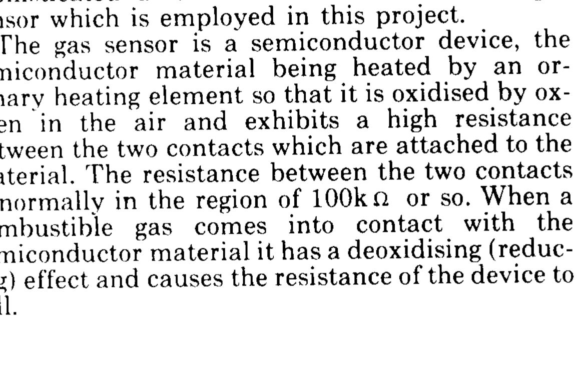
Part 1

By R. A. Penfold

★ Two-tone warble alarm
★ High sensitivity to combustible gases
★ Suitable for mains or 12 volt battery operation

It seems as though there is an electronic sensor for just about every conceivable application these days, ranging from simple devices such as thermistors and cadmium sulphide photocells to more sophisticated units such as the combustible gas sensor which is employed in this project.

The gas sensor is a semiconductor device, the semiconductor material being heated by an ordinary heating element so that it is oxidised by oxygen in the air and exhibits a high resistance between the two contacts which are attached to the material. The resistance between the two contacts is normally in the region of 100kΩ or so. When a combustible gas comes into contact with the semiconductor material it has a deoxidising (reducing) effect and causes the resistance of the device to fall.



Front panel layout of the gas and smoke detector. To the left is the alarm speaker, with the neon mains indicator central and the on-off switch on the right

The sensor is sensitive to virtually any gas or vapour, such as hydrogen, butane, carbon monoxide, methane, propane, most smoke, petroleum vapour and methylated spirit vapour. It will detect these at concentrations well below the lowest concentration needed to produce an explosion.

Power for the unit can either be obtained from the mains by means of a simple power supply unit, or a 12 volt d.c. battery supply can be used. The unit is therefore suitable for use in the home as well as in a boat or caravan. When gas is detected by the circuit a very noticeable two-tone audio alarm is sounded.

THE CIRCUIT

Fig. 1 shows the complete circuit of the gas and smoke detector, and this is based on three of the four comparators contained in the Motorola MC3302P quad comparator i.c. (or its equivalent, the LM3302P). One comparator couples to the gas detector circuit and its output controls the two-tone alarm oscillator. This is provided by two more of the comparators in the MC3302P. The fourth comparator is not used and no connections are made to it.

Before considering the operation of the complete circuit it will be helpful to refer to the skeleton circuits of Figs. 2(a) and (b). These show the basic gas detector and oscillator circuits respectively.

A comparator is rather like an operational amplifier, and has similar inverting (−) and non-inverting (+) inputs. However, a comparator has built-in trigger circuitry so that the output will

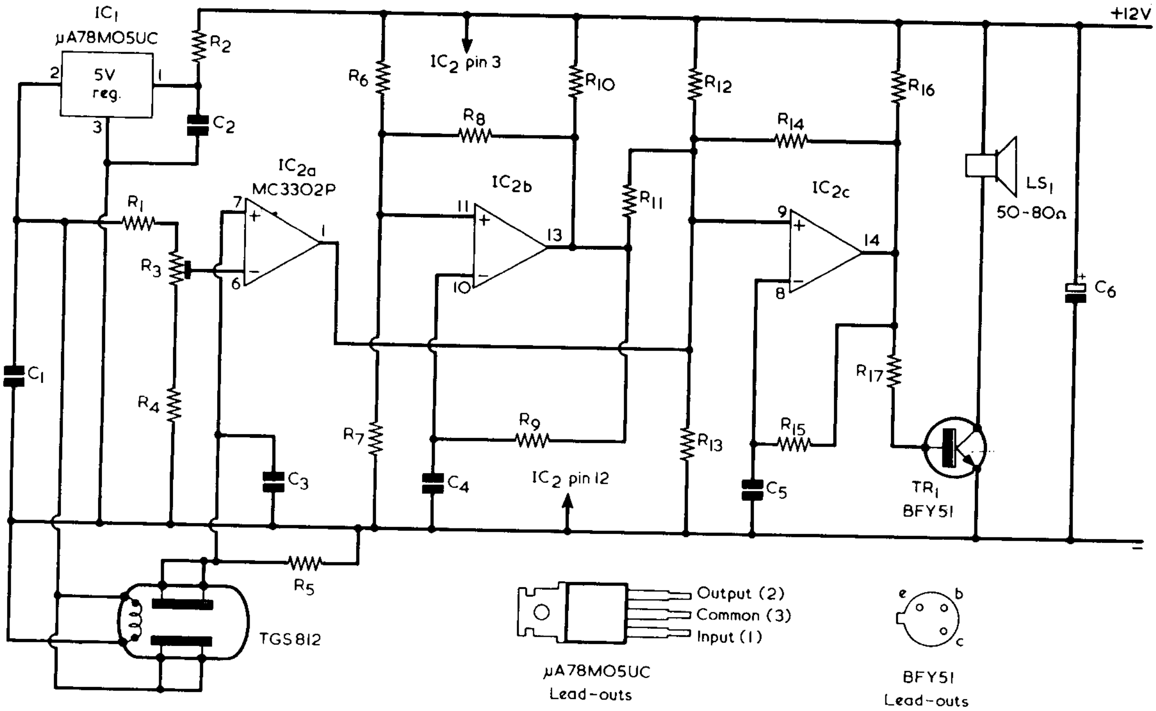


Fig. 1. The circuit of the gas and smoke detector. The sensor is a TGS 812 device

COMPONENTS

Resistors

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

R1 1.5kΩ
R2 33Ω ½ watt
R3 10kΩ pre-set potentiometer, 0.1 watt horizontal
R4 1.8kΩ
R5 47kΩ
R6 56kΩ
R7 56kΩ
R8 56kΩ
R9 1.2MΩ
R10 3.3kΩ
R11 150kΩ
R12 56kΩ
R13 56kΩ
R14 56kΩ
R15 560kΩ
R16 3.3kΩ
R17 5.6kΩ

Capacitors

C1 0.1μF type C280 (Mullard)
C2 0.1μF type C280 (Mullard)
C3 0.1μF type C280 (Mullard)
C4 0.1μF type C280 (Mullard)
C5 2,000pF or (2,200pF) polyester or polystyrene
C6 100μF electrolytic, 16 V. Wkg.

Semiconductors

IC1 μA78M05UC
IC2 MC3302P
TR1 BFY51

Gas Detector

Sensor type TGS 812 (Figaro)

Speaker

LS1 miniature speaker, 50-80Ω (see text)

Miscellaneous

Instrument case
Gas sensor holder
Veroboard, 0.1 in. matrix
Speaker fret or cloth
Bolts, nuts, wire, etc.

Additional components for mains power supply

Capacitor

C7 1,000μF electrolytic 16V Wkg.

Transformer

T1 mains transformer, secondary 9-0-9V at 250mA or more (see text)

Diodes

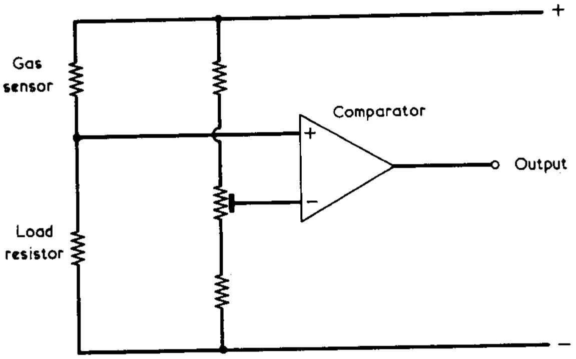
D1 1N4001
D2 1N4001

Indicator

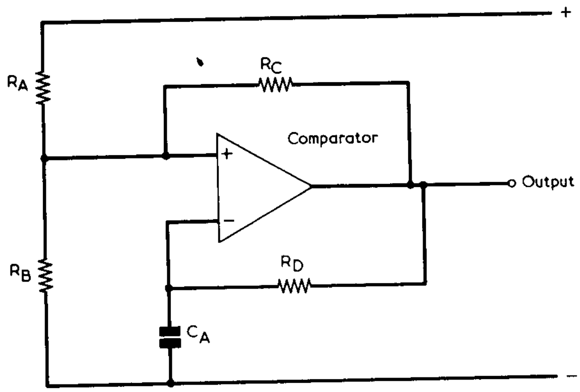
PL1 panel mounting neon indicator, 240V a.c.

Switch

S1 d.p.s.t. toggle



(a)



(b)

Fig. 2(a). The comparator circuit in which the gas sensor is connected

Fig. 2(b). Illustrating the basic manner in which a comparator may be employed as an oscillator

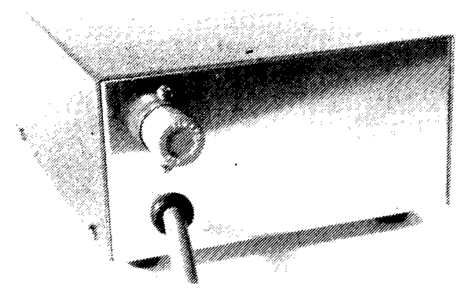
either be high (at virtually the positive supply rail potential) or low (at virtually the negative supply rail potential). Even with the input voltages accurately balanced the comparator output will not assume an intermediate level.

The output state of the device depends upon the comparative input voltages. If the non-inverting input is at a higher voltage than the inverting input, then the output will go high. If the comparative input states are reversed so that the inverting input is at a higher voltage than the non-inverting input, then the output will go low.

In Fig. 2(a) the inverting input is fed from a potential divider connected across the supply rails and the voltage at this input can be set to a predetermined level by adjustment of the pre-set potentiometer. The non-inverting input is also fed from a potential divider, and this consists of the semiconductor element of the gas detector and its load resistor.

In the absence of gas or smoke at the sensor the pre-set potentiometer is adjusted so that the voltage at the inverting input is very slightly in excess of that produced at the non-inverting input. This results in the output of the device being low. Actually, each comparator in the MC3302P has an open collector output (i.e. the output transistor has no integral load resistor to the positive rail) and so what happens is that the comparator output transistor is turned hard on. It then removes the biasing current from the tone generator oscillator and thus prevents the alarm from being activated.

If the gas sensor detects gas or smoke its resistance will fall significantly and the voltage at the non-inverting input will be taken above that at the inverting input. This will cause the output of the comparator to go high or, in other words, the comparator output transistor will switch off. The comparator then has no effect on the tone generator oscillator, which is allowed to operate normally and produce the alarm.



The gas sensor is positioned, in its holder, on the rear panel of the unit

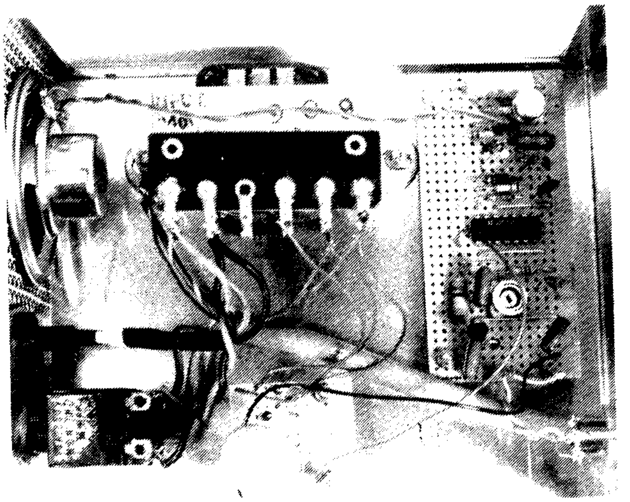
SCHMITT TRIGGER OSCILLATOR

The oscillator configuration of Fig. 2(b) will probably seem unusual to some readers, since the frequency determining components, RD and CA, are connected between the output and the inverting input of the comparator. They are therefore in a negative feedback loop rather than in the more usual positive feedback loop. This type of oscillator is not often encountered and is based on Schmitt trigger operation. For oscillation to occur there must be hysteresis at the input, and the output and input must be out of phase. When using a comparator in the circuit it is necessary to couple a resistor from the output to the non-inverting input, and in Fig. 2(b) this resistor is RC.

For the moment we will assume that the comparator output is not of the open collector type, and that it can go high in the same manner as an operational amplifier output. We will also assume that the three resistors RA, RB and RC all have the same value.

When the supply is applied CA is discharged, causing the voltage at the inverting input to be lower than that at the non-inverting input. The comparator output is therefore high and RC is effectively in parallel with RA. About two thirds of the supply rail voltage appears at the non-inverting input and CA commences to charge via RD. When the voltage across CA reaches and marginally passes that at the non-inverting input the comparator output will abruptly go low, causing RC to be effectively in parallel now with RB. The voltage at the non-inverting input will in consequence be about a third of the supply voltage. CA discharges via RD until the voltage at the inverting input falls to one third of the supply voltage, whereupon the comparator output goes high again.

CA once more commences to charge and the circuit continues to oscillate in this manner, with the frequency of oscillation being governed by the values of RD and CA. The output can be taken from the output of the comparator. Since, in prac-



The internal layout of the various sections of the gas and smoke detector

tice, the comparator output is of the open collector type it will be necessary to add an external resistor between the output and the positive rail. This resistor may have a value which is considerably lower than that of RA, RB or RC.

PRACTICAL CIRCUIT

Returning to the practical circuit of Fig. 1, in order to obtain reliable results it is necessary to power the input circuitry of the gas detection comparator from a stabilized supply. A stabilized 5 volt supply is derived from the main supply rail by means of a small monolithic voltage regulator, IC1. This also provides the 5 volt supply for the heating element of the gas sensor. C1 and C2 ensure stability in the regulator. The remainder of this section of the circuit is as outlined in Fig. 2(a).

The two oscillators both follow the principle illustrated in Fig. 2(b). The oscillator based on IC2(c) generates the audio output tone, and it drives a loudspeaker by way of common emitter amplifier TR1. R17 must be included between IC2(c) output and TR1 base as the base-emitter junction of TR1 would otherwise limit the output voltage of IC2(c) to about 0.65 volt, and would block oscillator operation.

When gas or smoke is not present at the sensor, IC2(c) is prevented from operating since the output of IC2(a) holds its non-inverting input at little more than zero volts. As a result, the output of IC2(c) becomes virtually equal to the negative supply voltage also, and TR1 is cut off. This is essential, as otherwise a high quiescent output current would flow through TR1 and the speaker. If gas or smoke is detected the resistance of the sensor falls and the output transistor in IC2(a) turns off. IC2(c) is then free to oscillate and produce an audible tone in the speaker.

An audio alarm can be made more noticeable by either pulsing or, as in the present case, frequency modulating the output tone. The modulation is provided by the low frequency oscillator based on IC2(b). This has its output connected to the bias network for the tone oscillator via R11, and it has the effect of switching the output tone between a frequency of a few hundred Hz and about 1kHz at a rate of a few Hz. The resultant alarm signal is very effective. It should be noted that IC2(b) oscillates all the time that the unit is switched on. It has no effect, of course, when IC2(c) is inhibited by the low output from IC2(a).

Before concluding on circuit details, a note should be made concerning the 5 volt regulator, IC1. The regulator orginally employed, and which is visible in the photographs, was the 100mA component type μA78LO5WC. This worked quite satisfactorily, but it was subsequently found that the manufacturer's figure for the heater resistance of the TGS 812 gas sensor is 38 Ω, which would cause a current in excess of 100mA to flow at 5 volts. In consequence it is recommended that a 5 volt 500mA regulator be employed, and a suitable type is the μA78MO5UC which is specified in the Components List. It does not require a heat sink. Both this regulator and the MC3302P i.c. are available from Maplin Electronic Supplies.

The gas sensor type TGS 812 and its holder can be obtained from Watford Electronics, 35 Cardiff Road, Watford, Herts, WD1 8ED.

MAINS POWER SUPPLY

A suitable mains power supply circuit for the unit is shown in Fig. 3. The mains supply is connected through on-off switch S1 to the primary of isolation and step-down transformer T1. PL1 is a panel mounting neon indicator, and it must be a component incorporating an integral series resistor for 240 volt mains operation. The centre-tapped secondary winding of T1 feeds a conventional full-

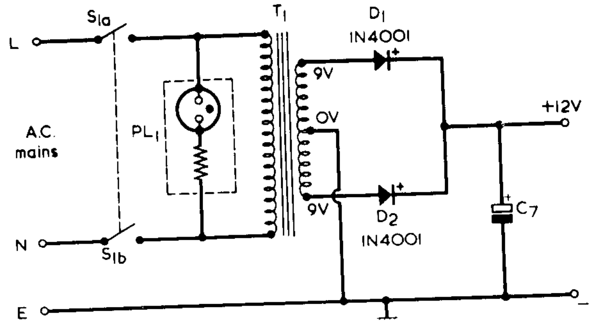
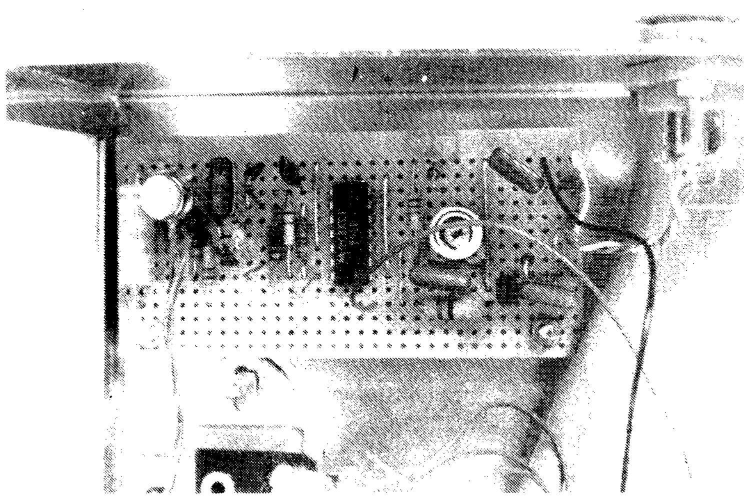


Fig. 3. The mains power supply incorporates a standard full-wave rectifier circuit



The main component panel. The sensitivity control potentiometer is mounted on this panel

wave rectifier and smoothing circuit. The loaded output voltage of the supply is approximately 12 volts.

The mains transformer can be any type having a 9-0-9 volt secondary rated at 250mA or more. That employed by the author is an Osmabet MT9V, the 9-0-9 volt secondary of which is rated at 1 amp. This transformer is available from Home Radio (Components) Ltd.

CONSTRUCTION

The prototype is housed in a metal instrument case having dimensions of 5 by 6 by 2½in. (127 by 152 by 63mm.), this being available from Harrison Bros., P.O. Box 55, Westcliff-on-Sea, Essex, SS0 7LQ. This case takes the components comfortably without crowding when the mains power supply is used, but it necessitates employing a speaker whose diameter is not greater than 63mm. Suitable speakers of this size are fairly readily available; the Maplin catalogue, for instance, lists a 50Ω speaker with a diameter of 57mm.

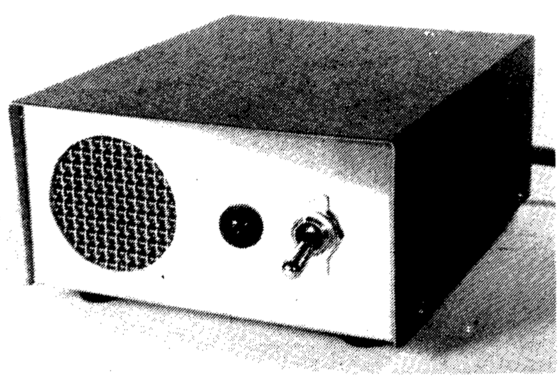
The speaker is mounted on the right hand side of the front panel, as viewed from the rear, and requires a circular cut-out about 50mm. in diameter. This can be made with a fretsaw or a needle file. A piece of speaker fret or cloth should be glued in place behind the cut-out and then the speaker is carefully glued in position over this. Use a high quality adhesive such as an epoxy type and be careful not to smear any adhesive on the speaker diaphragm.

PL1 and S1 are mounted side by side on the left hand side of the front panel, again as viewed from the rear. The gas detector is fitted in its special holder which is mounted in the top left hand corner of the rear panel. The holder requires a main 16mm. diameter cut-out, and the holder can then be used as a sort of template with which the positions of the two 6BA clearance mounting holes may be located.

Should it be necessary to have the gas sensor remotely located from the rest of the unit for some reason, it is perfectly acceptable to connect it to the main unit via a 3-way cable up to several metres long.

If the unit is to be mains powered, an entrance hole for the mains cable is required in the rear panel beneath the gas sensor. This hole must be fitted with a grommet, and the mains cable secured inside the case with a suitable clamp.

The ready made instrument case employed for the prototype gives the unit an impressive finish



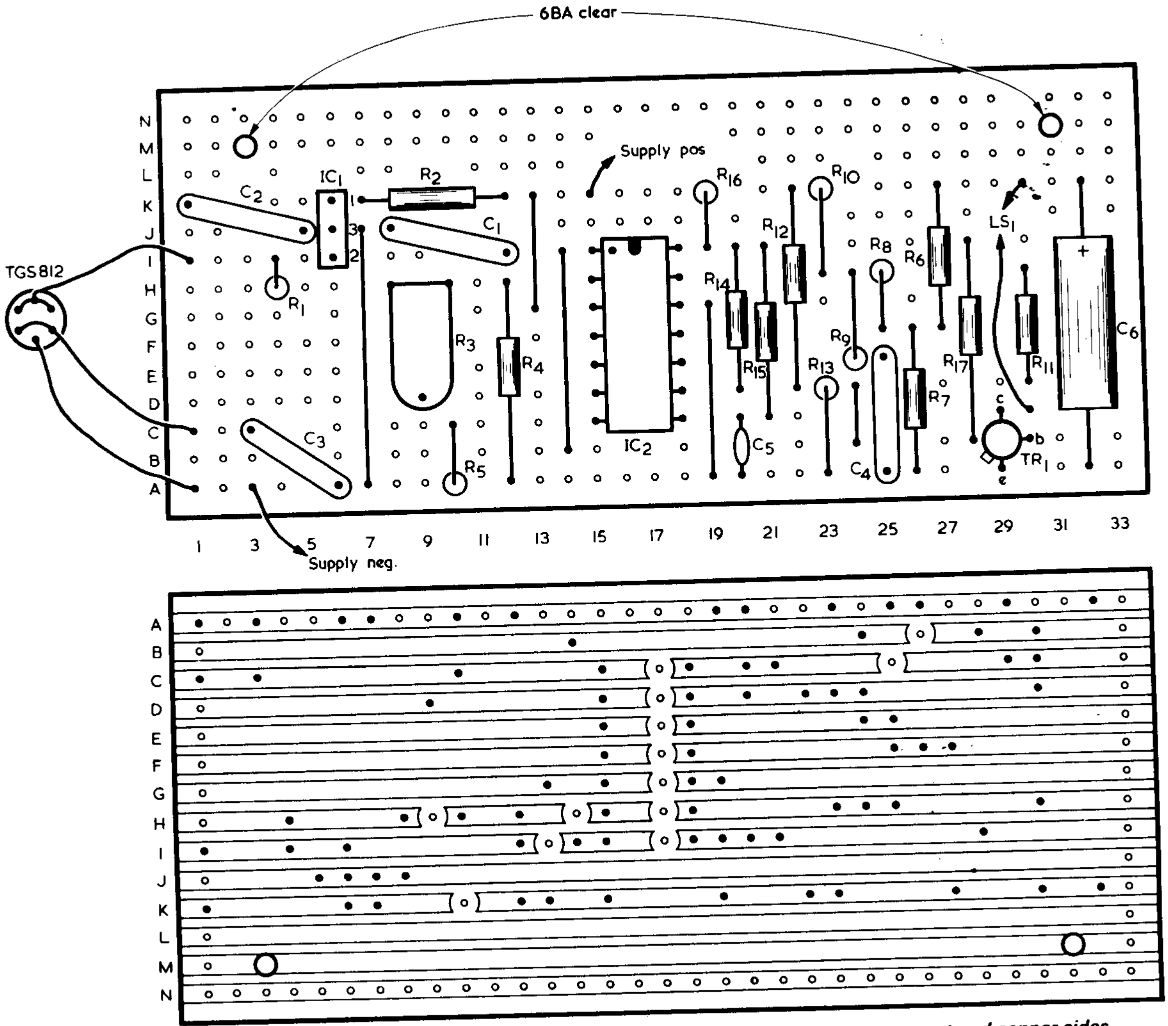


Fig. 4. The small components are assembled on a Veroboard panel. Shown here are the component and copper sides

COMPONENT PANEL

All the small components are assembled on a 0.1in. matrix Veroboard panel which has 14 copper strips by 33 holes. The component layout is illustrated in Fig. 4. After a panel of the required size has been cut out with a hacksaw, any rough edges are filed flat and the two 6BA clearance mounting holes are drilled. The 13 breaks in the copper strips are then made before soldering the components into position. The semiconductor devices are wired in last and care must be taken not to omit the 5 link wires.

The component panel is mounted towards the right rear of the case with C6 to the right, and two 6BA clearance holes are required in the bottom of the case for it. Spacing washers are fitted over the 6BA mounting screws to keep the underside of the panel clear of the inside metal surface of the case. Two flying leads for connection to the power supply are required, and the connections to the speaker and the gas sensor holder should be made before the panel is finally mounted in place.

If the unit is to be powered from a 12 volt external battery, which would normally be an accumulator, a 2-way non-reversible socket should be mounted on the rear panel and the supply lines from the component panel connected to this via a s.p.s.t. toggle switch inserted in the positive lead. The 12 volt battery is connected to the unit by a suitable lead and plug, and great care must be taken to ensure that the polarity is correct. The metal case can be made common with the negative rail; connection being made by way of a solder tag under one of the securing nuts for the socket. (If the unit is to be used in an environment with positive earth, the case may be connected to the positive rail and the on-off switch inserted in the negative lead.) The switch, socket and plug used for battery operation are not included in the accompanying Components List.

NEXT MONTH

The construction of the mains power supply will be described in next month's concluding article, after which details will be given for setting up and using the unit.

(To be concluded)

Remote 'Read-out' Thermometer

We regret that, during the course of printing, R6 was omitted from the list of components in the above article. The value is 220Ω.

NEWS . . . AND

STATIC DISCHARGE IN THE MODERN OFFICE

Static electricity in the modern world of electronics, particularly in the offices of industry, is a costly problem.

It can affect data entry terminals, central processors, word processing stations, mini computers, electronic cash registers, disc drives and computer printers of every type.

As many readers will know when static discharges to or near sensitive logic components, a wave of electromagnetic interference is set up. The static wave spreads out in all directions from the point of static discharge. When this wave reaches conductive objects, such as logic circuits, a small electrical current is generated. These small "eddy" currents cause circuit malfunctions and permanent damage, not always easy to correct.

Computer and other electronic equipment manufacturers try to shield sensitive circuits from static discharge, but no equipment is 100 per cent immune from this hazard. Metal housings for the equipment can help, but static can travel through cracks and seams in the equipment to cause malfunctions. The moulded plastic housings offer little protection and make the components inside particularly susceptible.

A quick and reliable method of improving computer system performance is to control static levels around the equipment. Where there is a risk of personnel electrostatic discharge (ESD) to cause malfunction of machines, the best answer to the problem is to eliminate the static discharge before it can cause damage.

The introduction from America by 3M United Kingdom Limited of a new "Velostat" electrically conductive floor mat means that any static discharge is harmlessly drained from personnel by stepping on the new mats when operating, or being in close proximity to, sensitive equipment.

3M United Kingdom Limited has introduced a range of 'Velostat' electrically conductive floor mats, designed to drain off any excessive static present in the modern office environment of data processing equipment and computerised business machinery. The photo shows a mat in use

FISH FINDING IN COLOUR

The Chromascope K range of echosounders from Marconi Marine, a GEC-Marconi Electronics company, is designed to display received echoes from fish shoals and the seabed in colour on a television-type screen. Received echoes, fed from a storage memory circuit, are displayed in colours and tints which directly relate to the intensities of the signals received from individual objects. The result is a coloured mosaic of signals which integrate to form a chart like presentation which shows fish shoals and the seabed in a manner which is easy to interpret. The integrated chart is constantly updated from the memory store. Bottom lock and range expansion are both available as well as the ability to "freeze" any particular sounding if required for closer examination.

Sixteen shades of colour are used for displaying echo intensities as compared with only four stages of graduation provided by a conventional black and white display. Colour changes according to echo intensity, strongest echo being dark red, weakest white and non-echoes blue, and the colours range through red, orange, yellow, green, blue green, white, greenish blue and blue, each with two tones from high to low level. Large fish, plankton zones or other images and shoals are clearly distinguishable from other echoes due to clear colour graduation, particularly fish shoals on the seabed.

Every 'Chromascope K' uses a dual transducer and the two frequencies can be selected from 14, 24, 28, 50, 75 and 200kHz. The colour display automatically indicates the range scale in use and the depth of the seabed. A tape recorder can be provided to store displayed information for later replay.

AMATEUR RADIO CLASSES R.A.E. 1979

A course will shortly commence for the R.A.E. at the Gosforth High School, Gosforth. Enquiries should be addressed to the Principal, Gosforth Adult Association, Gosforth High School, Knightsbridge, Gosforth, Newcastle upon Tyne. Tutor D. R. Loveday, G3FPE.

Another course preparing candidates for the R.A.E. will be held at the De Beauvoir I.L.E.A. Evening Institute, Tottenham Road, London N1. Tutor Fred Barns, G3AGP.

Both Courses are considered suitable for those wanting to gain an insight into radio Theory.

COMMENT

BBC WAVELENGTH CHANGES

SCOUTS TO HELP THE ELDERLY

Following the information we gave in our February issue on the BBC wavelength changes, it is very pleasant to record the help to be given to the elderly and infirm by scouts when the changes come into effect.

The Scout Association have agreed to co-operate with BBC Radio by offering to assist the elderly and the housebound to retune their sets in a "Tune-A-Radio-Week".

The BBC is concerned that many older people especially those with failing eyesight may need help to retune their radio sets. To meet this challenge, the BBC and the Scout Association are to mount Tune-A-Radio-Week in November. "We are delighted that the Scout Association is encouraging local groups to take part in this very important community service", says Stephen Hearst, Controller Radio 3 who is Chairman of the BBC group planning the public information campaign. He continues: "Many elderly people living alone are dependent on their radios, but many of them do not often change from one station to another. Retuning to find different wavelengths in November will be particularly difficult and confusing for them. Now that the Scout Association has agreed to help there is less need for elderly people to worry".

The changes that will take place are:

Radio 1 moves to 1089kHz/275m and 1053kHz/285m;

Radio 2, at present on long wave moves to medium: 693kHz/433m and 909kHz/330m;

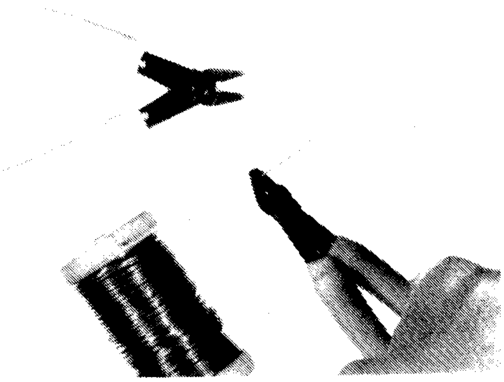
Radio 3 moves to 1215kHz/247m;

Radio 4, at present on several medium waves, moves to two long waves: 200kHz/1500m and in Central Scotland 227kHz/1322m.

The changes come into operation on 23rd November. Tuning positions for VHF services remain unchanged, as well as Radio Scotland, Radio Wales/Radio Cymru, Radio Ulster and most BBC local radio stations.

We are sure our readers will be among the first to assist anyone they may know who, through age or infirmity, finds it difficult to cope with the changes.

SAFER CUTTING



The OK Machine & Tool Co., of 48A The Avenue, Southampton, SO1 2SY, have introduced the new OK SAF 01 safety shears, which can handle hard or soft wires up to 1mm diameter, incorporate an adjustable clip to hold wire firmly after it has been cut. This prevents the hazard of clippings flying into the eyes or dropping into the workpiece.

A spring loaded scissors action ensures a clean cut, and the shears' handles have a bright orange padded covering which not only makes them comfortable during prolonged use but also ensures that they can be found easily on a cluttered workbench.

The shears, available from OK Machine & Tool (UK) Ltd at £2.11 each with discounts on quantities of 10 or more, are part of a large range of electronic and electrical technicians' hand tools.

We have been pleased to receive from readers a number of compliments on the contents and presentation of *R.&E.C.* during recent months.

We, naturally, wish to maintain the standards we have set particularly in regard to the reliability of our projects; a reputation which is second to none in our sphere of publishing. Unfortunately costs have continued to rise during the last 12 months and we regret that, commencing with the next issue, the cover price will be increased by 5p. The next issue will however contain more pages and, in fact, be even better value.

FRONT PANEL INDICATORS

Verospeed have introduced a range of front panel indicators to suit most electronic requirements. Filament types are available in three voltages with two body styles in five colours. 250V neons in both body styles can be supplied in a choice of three colours.

Prominent in the range is a 3.2mm diameter L.E.D. housed in an exceptionally attractive nickle-plated brass body, which is secured to the front panel by a fixing nut. It is available by return from Verospeed in either red, green or amber and is priced at £0.66.

Verospeed's address is: 10 Barton Park Industrial Estate, Eastleigh, Hampshire.

SUGGESTED CIRCUIT

CD4017 Musical Box

By G. A. French

Despite its limited repertoire, the musical box project which is described in this month's "Suggested Circuit" article is quite an amusing novelty. It is capable of continually repeating any well known melody of up to nine notes in sequence, provided that each note can be reproduced for the same length of time. If desired, one or more of the notes may be replaced by an equal period of silence.

CD4017 COUNTER

The heart of the musical box is provided by the CMOS Decade Counter-Divider type CD4017. This versatile device has appeared in a number of home-constructor projects in the past and it will be helpful here to briefly review the manner in which it operates.

The pinout diagram of the CD4017 appears in Fig. 1, with the pin functions indicated. Pin 8 connects to the negative supply and pin 16 to the positive supply. The clock input pulses are fed to pin 14, and the device advances one count on each positive-going pulse edge. The clock input is inhibited if the clock enable pin, pin 13, is "high," i.e. close to or at the potential of the positive supply rail, and is enabled if pin 13 is "low," i.e. at or near the potential of the negative rail. If the reset pin, pin 15, is taken high the counter is cleared to 0, and the 0 output at pin 3 goes high. All the other number outputs are then low.

When the reset pin is taken low, the 0 output goes low at the next positive-going clock input pulse edge, and the 1 output at pin 2 goes high. The following positive-going clock pulse edge takes the 1 output low, and the 2 output, at pin 4, high. The successive number outputs then go high in turn until the 9 output at pin 11 goes high. When the 9 output goes low the 0 output goes high again and another decade count commences.

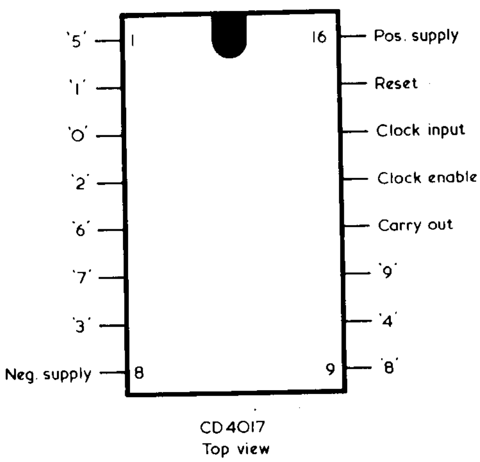


Fig. 1. Pin functions of the CD4017 integrated circuit

The carry out output at pin 12 triggers the succeeding counter in a multi-decade counting series, and is high while the 0 to 4 outputs are high and goes low when the 5 to 9 outputs are high. The carry out output is not used in the present project and no connection is made to it.

FULL CIRCUIT

The full circuit of the musical box appears in Fig. 2. At the left is a standard astable multivibrator circuit, incorporating a 555 timer i.c., which feeds a series of pulses to the clock input of the CD4017. The clock enable pin is directly connected to the negative rail and the reset pin is taken high via R3 when switch S1 is in the "Stop" position. Under this condition only the 0 output, to which no connection is made, is high.

Moving S1 to the "Start" position causes the reset pin to be connected to the negative rail, whereupon the number outputs from 1 to 9 go high in turn. In the diagram the 1 output pin is shown at the top and the 9 output pin at the bottom. When the 1 output goes high, diode D1 becomes forward biased and passes a current via VR1 and R4 to C2 in the emitter circuit of the unijunction transistor, TR1. All the other diodes in the circuit are reverse biased and the remaining potentiometers have no effect on circuit operation.

At the next count the 1 output goes low, causing D1 to become reverse biased, and the 2 output goes high. Current to C2 now passes via the forward biased diode D2, VR2 and R4. At the next count the current passes via VR3, then via VR4 and so on up to VR9. There follows a period during which the 0 output goes high, after which the 1 output goes high again and the whole cycle repeats. If at any time S1 is taken to the "Stop" position and then returned to "Start," a new cycle starts with the 1 output initially going high.

TR1 is in a conventional unijunction oscillator circuit, the frequency of oscillation depending upon the charging current available for capacitor C2. Thus, it is possible to adjust the potentiometers VR1 to VR9 such that the oscillator frequency follows the notes of a simple melody, with the provisos on performance which were mentioned earlier. The melody is reproduced by the 15Ω loudspeaker connected in the base 1 circuit of the unijunction transistor. The output is at a sufficiently high level to be comfor-

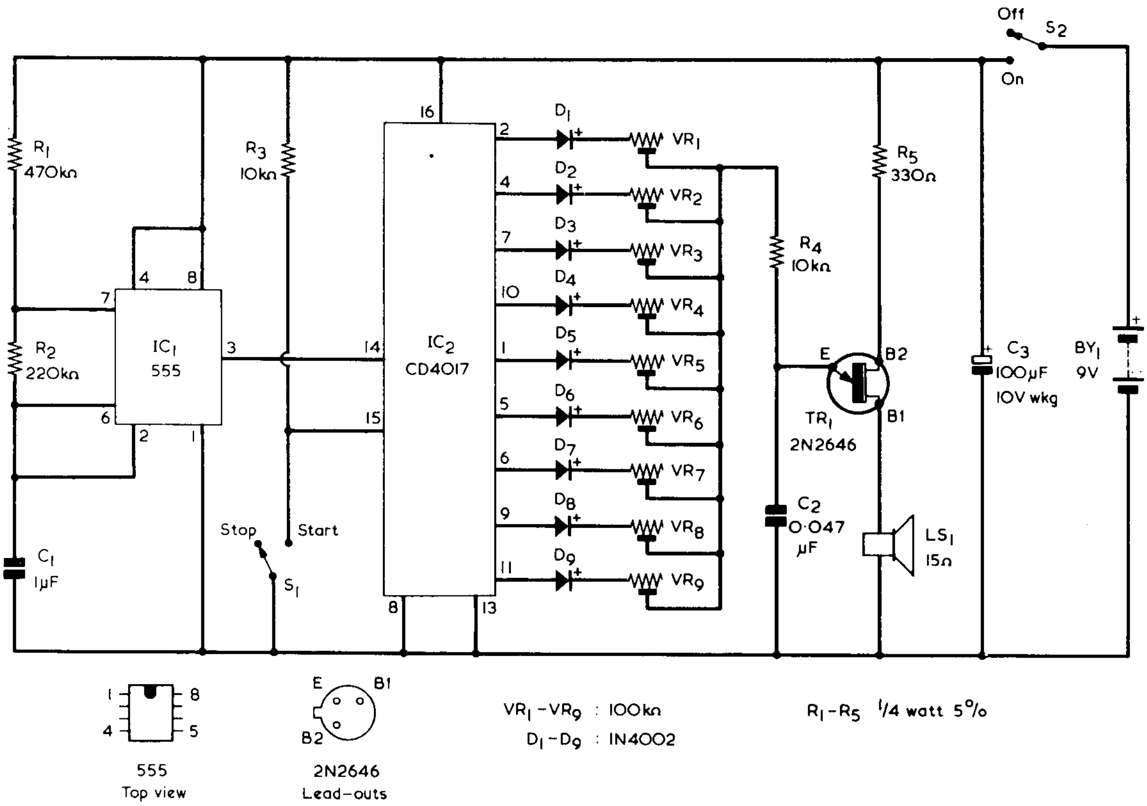


Fig. 2. The complete circuit of the CD4017 musical box

tably audible in quiet surroundings and the oscillator circuit around TR1 has the advantage of considerable simplicity.

TUNING UP

Before finally assembling the musical box circuit it is worthwhile having a reasonable idea of the tune it is to play, as it may be possible to omit one or more of the diodes and potentiometers. For instance the familiar passage "Should auld acquaintance be forgot" at the start of "Auld Lang Syne" has only eight notes and either D1 and VR1, or D9 and VR9 could be omitted. It is advisable to choose a tune in which successive notes have a different frequency; if two successive notes are at the same frequency it is just possible to detect the transition from one number output being high to the next, but in general the two notes tend to blend together. A solution to this difficulty consists of tuning the second note so that its frequency differs from that of the first by an extremely marginal amount.

A well recognisable melody can be taken from "Colonel Bogey," the passage in question being that which has been immortalised by the unofficial lyric "Dah-dah, and the same to you!" (Or, the writer hastens to add, words to that effect.) This reproduces very effectively if there is a gap following the initial "Dah-dah," whereupon the sequence consists of two notes, a space, and five more notes. D3 and VR3 may be omitted, as also may D9 and VR9, the resultant configuration being shown in Fig. 3. Here no connections are made to the 3 and 9 outputs of the CD4017.

Tuning up is fairly critical, but is not too difficult if a little patience is exercised. When skeleton pre-set potentiometers are used it will probably be found that the larger 0.25 watt types are easier to set up than the sub-miniature 0.1 watt components. Frequency increases as the resistance inserted by each potentiometer decreases, and the potentiometers should preferably be wired up such that decrease in resistance corresponds to clockwise rotation of the slider.

After deciding upon the tune to be played the assembled circuit should be turned on and started. The values of the timing components connected to the 555 i.c. allow one complete cycle to occur in about 6 seconds and this is slow enough to enable the potentiometers to be adjusted. If the first note is too low VR1 is experimentally set up, whilst the other notes are being sounded, for an increase in frequency, and is then experimentally readjusted again, if necessary, until the first note is correct. The same procedure is carried out with the second note, and so on. An alternative approach consists of slowing down the 555 by temporarily connecting a 4.7μF or 5μF capacitor across C1, whereupon each note can be adjusted during the period that it is sounded. Higher frequency notes have a more pleasing sound than

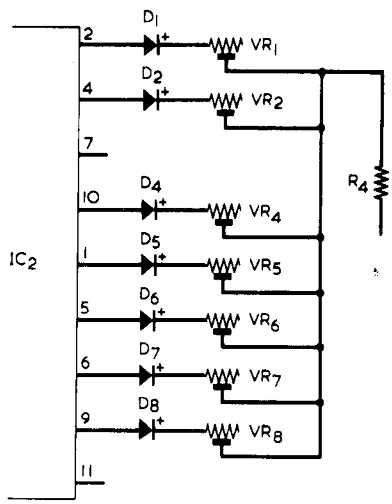


Fig. 3. For some tunes, such as the "Colonel Bogey" theme, some of the diodes and pre-set potentiometers may be omitted

lower frequency notes from the unijunction oscillator.

If, after tuning, it is considered that the reproduction rate of the notes is too slow, it may be speeded up by replacing R1 with a 100kΩ resistor. This will produce a complete note cycle in about 3 seconds.

FURTHER POINTS

A few further points remain to be dealt with.

The reset switch S1 employed with the prototype was a normal toggle component, and no precautions need to be taken against contact bounce. During any contact bounce that exists, pin 15 is merely taken high and keeps the counter reset with the 0 output high. The musical box should be switched on at S2 with S1 in the "Stop" position, after which S1 is set to "Start." No harm will result if S2 is closed with S1 at "Start", but it may be found that the note sequence commences at some point in the cycle. With the prototype circuit it was found that the sequence started correctly when S2 was closed with S1 set at "Start" on many occasions but not always.

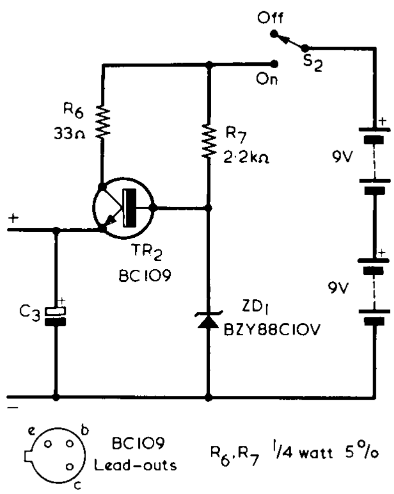


Fig. 4. If considered necessary, a voltage regulated supply, as shown here, can be employed. This causes S2 to be moved to a new circuit position

C1 is a polyester or polycarbonate capacitor. "Mylar" capacitors, incidentally, have a polyester dielectric. If a higher value capacitor is connected across C1 to slow down the 555 timer during tuning up, the added capacitor will almost certainly be electrolytic. Its negative lead should, of course, connect to the negative supply rail.

The current drawn from the 9 volt supply is approximately 6mA. The circuit is supply voltage sensitive and is liable to detune when the supply voltage falls below some 8.5 volts. If this is considered a disadvantage the circuit may be powered by an 18 volt supply feeding a 9 volt regulator circuit, as shown in Fig. 4. The current consumption at 18 volts is then of the order of 10mA, but the two 9 volt batteries providing the 18 volt supply will not need to be discarded until their combined voltage falls to about 12 volts. ■

ALTERNATING VOLTAGE MEASUREMENTS

By F. Bowden

A.C. VOLTS WITH A SINGLE DIODE

Ever since its inception, this magazine has presented circuits ranging from the very basic to more complex designs. The circuit to be discussed here will probably rate as one of the simplest of them all since, essentially, it consists of only one component: a diode! However, it is a diode which can be successfully used to ease the problems of measuring alternating voltages when only a direct voltage reading voltmeter is available.

In Fig. 1 the voltmeter is a moving-coil instrument, and will consist in practice of the meter movement itself in series with a resistor. It could, for instance, be a multimeter switched to a direct voltage range. The meter can be used to measure alternating voltage by inserting a rectifier diode in series with one of its terminals and applying it to the alternating voltage as shown. Provided the alternating voltage is sinusoidal (and assuming that the rectifier is a "perfect" component having zero forward voltage drop when it conducts) the voltage indicated by the meter, when multiplied by 2.22, will be equal to the r.m.s value of the alternating voltage.

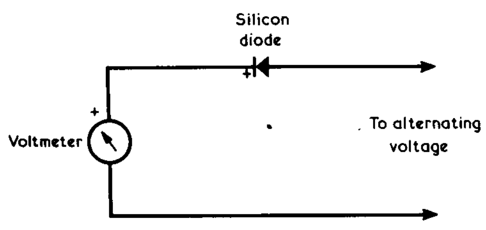


Fig. 1. Connecting a diode rectifier in series with a direct voltage voltmeter enables it to measure alternating voltage

AVERAGE VALUE

To see how the figure of 2.22 is arrived at it is necessary to look at some basic alternating voltage theory. Fig. 2(a) shows a series of sine wave half-cycles as would be given after full-wave rectification. All the half-cycles are positive-going. The waveform has a peak value, an r.m.s. value and an average value, and these are at the levels indicated. The r.m.s. value is equivalent to a direct voltage having the same effective heating power (when applied across a resistance) and is equal to 0.707 times the peak value. The average value is the mean value over a whole cycle and is 0.64 times the

TABLE

R.M.S. Voltage	Meter Reading
2	0.9
3	1.25
4	1.75
5	2.2
7.5	3.2
10	4.2
12.5	5.4
15	6.6
20	9.0
50	23
100	45
150	68
200	90
250	113

peak voltage. A moving-coil voltmeter indicates average voltage, but in most instances we want an indication of r.m.s. value. The r.m.s. value in Fig. 2(a) is 1.11 times the average value so that, if we measure the half-cycles with a moving-coil voltmeter and multiply the average reading it gives us by 1.11, we will obtain the r.m.s. value of the voltage.

The rectifier diode of Fig. 1 only allows alternate half-cycles to be applied to the voltmeter, as in Fig. 2(b). Since only half the half-cycles are now present the average voltage in Fig. 2(b) is 0.32 times the peak value instead of 0.64 times. The r.m.s. value of the waveform when all the half-cycles are present is now 2.22 times the average voltage indicated by the voltmeter.

Thus, to measure a sinusoidal alternating voltage with a moving-coil voltmeter we merely insert a rectifier diode in series and multiply the reading the meter gives by 2.22.

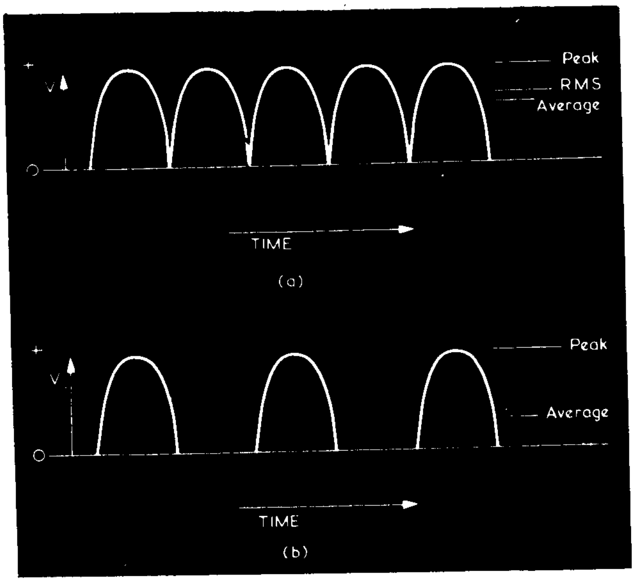


Fig. 2(a). In a series of half-cycles of the same polarity the peak, r.m.s. and average values are at the levels shown here
(b). When only alternate half-cycles are present the average voltage is halved

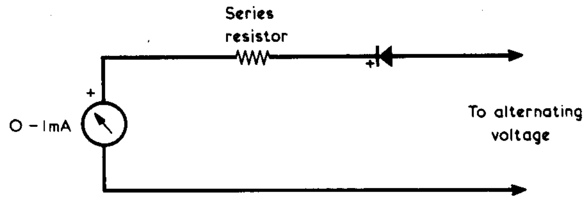


Fig. 3. A voltmeter circuit incorporating a milliammeter and a series resistor. The resistor value is calculated as described in the text

PRACTICAL DIODE

In practice the rectifier can be a silicon diode and, for alternating voltages above some 20 volts or so, the 0.6 volt forward voltage drop in the diode will not seriously affect the accuracy of the readings obtained. At lower voltages the forward voltage drop becomes more significant and causes the voltmeter to give readings that are lower than the r.m.s. voltage divided by 2.22. The Table lists r.m.s. voltages and corresponding voltmeter readings, these being calculated for r.m.s. values above 20. Those below 20 volts r.m.s. are as checked out by the author with practical measurements.

The diode can be any small silicon rectifier and it must have a peak inverse voltage rating which is higher than 1.414 times the highest r.m.s. alternating voltage to be measured. For measuring mains voltages the diode should have a p.i.v. rating in excess of 360 volts, and a good practical choice would be a diode with a p.i.v. of 400 or 600 volts. A silicon diode with a high p.i.v. will work quite satisfactorily for the measurement of low voltages.

The 2.22 factor can also be employed in the calculation of voltmeter series resistance. Assume that we want to monitor an alternating voltage of the order of 80 volts r.m.s. with a 0-1mA meter, a series resistor and a silicon rectifier. The arrangement is shown in Fig. 3. It would be reasonable to arrange matters so that the meter reads 100 volts r.m.s. at full-scale deflection. We start off by finding the series resistance required for f.s.d. at a *direct* voltage of 100. A little calculation soon shows that this is 100kΩ. We then divide 100kΩ by 2.22 to obtain the value required for alternating voltage measurement using the series rectifier. 100kΩ divided by 2.22 is 45kΩ, and this is the value of series resistance required. (To be precise, the value of 45kΩ should apply to the series resistance *plus* the internal resistance of the 0-1mA meter, but in this example the meter resistance will almost certainly be too small to be significant).

The maximum heat dissipated in the series resistance will be exactly half of that dissipated when a direct voltage of 100 is applied across it. Working from voltage squared divided by resistance, the dissipation calculates at 0.22 watt. In the a.c. circuit, with series diode, the dissipation will be 0.11 watt. A series resistor with a rating of 0.25 watt would be satisfactory although, seeing that this is a measuring circuit requiring long-term stability, it would be preferable to use a slightly larger 0.5 watt resistor. ■

DOUBLE DECCERS

PHOTO NIGHT LIGHT

By Ian Sinclair

The first of a series of ten projects designed for assembly on two S-DeCs or one Blob Board.

The circuits in this series have been designed in response to requests for projects suitable for constructors who have progressed beyond the stage of simple introductory circuits built on a single S-DeC. These new circuits have been arranged so that they can easily be built on a pair of S-DeCs positioned side by side. This has been done deliberately so that the large number of beginners who have assembled most of the circuits possible with a single S-DeC can now progress to 2-S-DeC circuits. Hence and name: Double Deccers.

At the same time, to keep faith with readers who followed the "Blob-a-Job" series, which appeared in the June 1977 to February 1978 issues of this journal, all the circuits to be described can be built also on the ZB-6-D Blob Board, which has the same layout and circuit position numbering as a pair of S-DeCs positioned side by side. The numbering in each circuit shows the positions of the lead-out wires on either the S-DeCs or the Blob Board. There is a vertical dashed line down the centre of each circuit which divides the two S-DeCs or marks the half-way point on the Blob Board. Link wires or components straddling the dividing line join together the two S-DeCs or the two halves of the Blob Board.

The first circuit is for a photo night light. This is a new twist to the familiar circuit in which a light is switched on and gradually fades as a capacitor charges or discharges. In this version switch-on is automatic and is triggered by the turning off of the main light in the room or the fading of daylight. When light falling on a photoconductive cell reduces below a certain level a low voltage lamp is turned on and its brightness then gradually fades until it can no longer be seen. Another cycle of operations can be started by closing and opening a reset switch.

CIRCUIT OPERATION

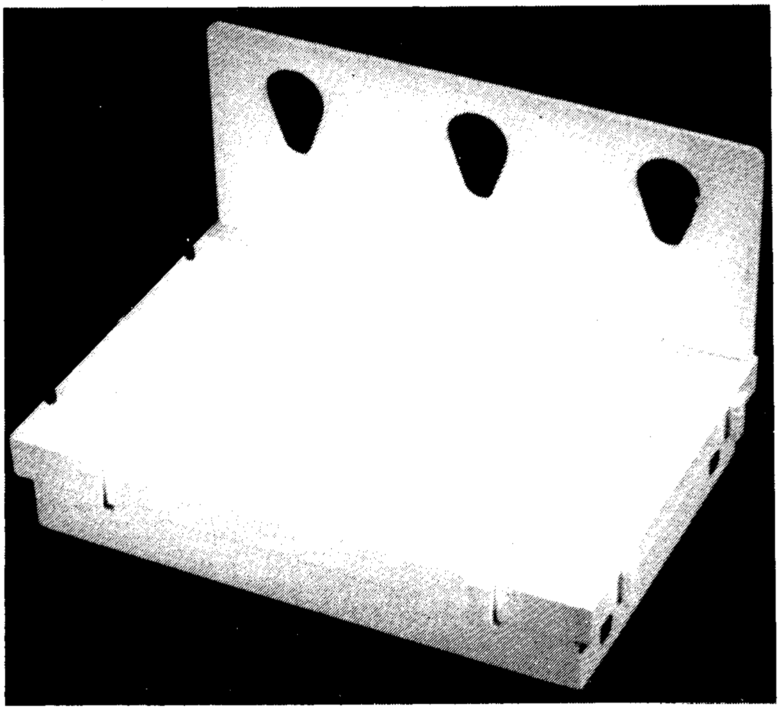
The photoconductive cell, or light-dependent resistor, is the familiar cadmium sulphide ORP12. This is wired in series with a 22kΩ resistor, R1, across the 6 volt supply, so that the voltage at point 12 in the diagram is low in daylight or normal room illumination but high when the light no longer reaches the photocell. In the stand-by condition, when the voltage at point 12 is low, TR1 is biased off. Like the remaining transistors in the circuit, TR1 is an easily obtained general purpose n.p.n. silicon transistor. Any one of three types may be used in any circuit position.

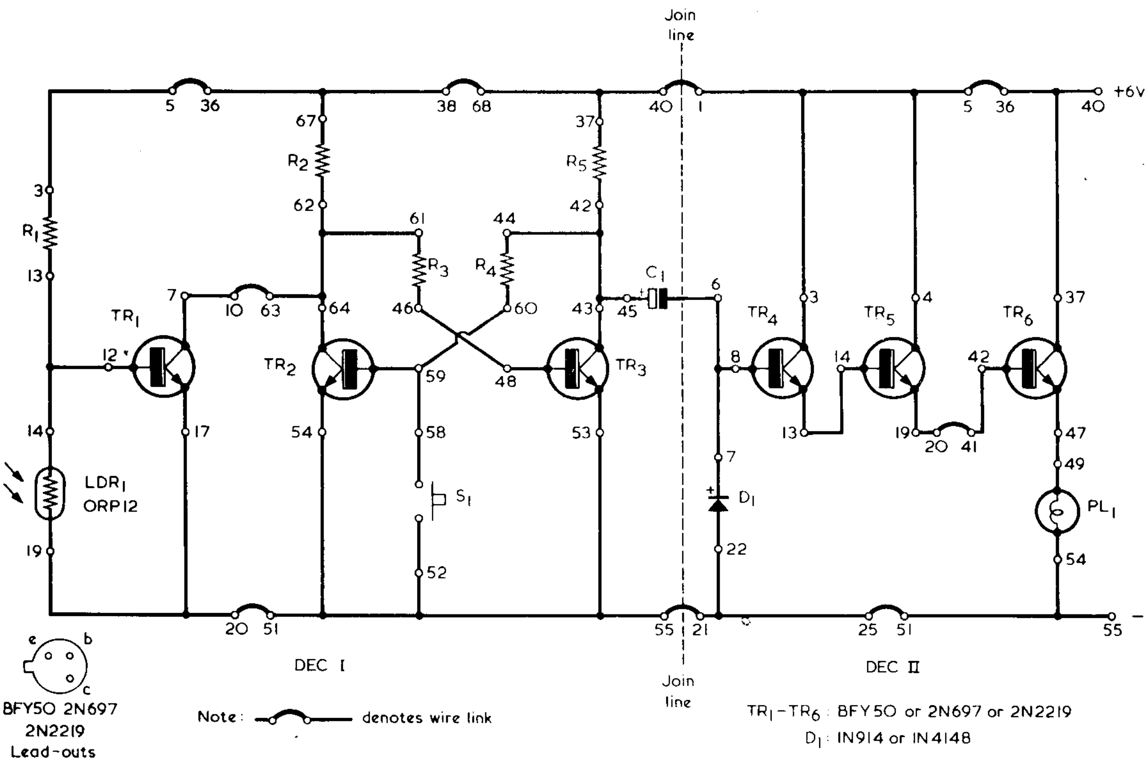
With TR1 off, the bistable formed by TR2 and TR3 remains as set by the action of the reset switch, S1. When closed, S1 connects the base of TR2 to the negative rail. This causes the collector current of TR2 to shut off and, in turn, allows base current to flow to TR3 via R2 and R3. TR3 is biased on and its collector takes up a very low potential above the negative rail. This then ensures that TR2 remains cut off when the reset switch is opened.

Still looking at the circuit in the stand-by condition, the low voltage at the collector of TR3 ensures that there is only a similarly low voltage across C1, which connects to the base of TR4. The only other connection to this base is through D1, which is a silicon diode such as the 1N914 or 1N4148 having a very low leakage current when reverse biased. The polarity of this diode is arranged so that the base of TR4, and the negative side of C1, cannot go more than about half a volt negative of the negative rail during reset.

With TR4 base at a low voltage, no current flows from its emitter to the base of TR5. TR6 is also cut off and the 6 volt lamp, PL1, in its emitter circuit is therefore unlit.

A single S-DeC. Two of these, mounted side by side to form a single long DeC, can be used for all the projects in this series





The circuit of the photo night light. Increasing darkness triggers off the circuit and causes PL1 to light up. Its brightness gradually diminishes as capacitor C1 slowly charges

COMPONENTS

Resistors
(All ¼ watt 5%)
R1 22kΩ
R2 1.8kΩ
R3 22kΩ
R4 22kΩ
R5 1.8kΩ

Capacitor
5μF or 100μF electrolytic, 16V. Wkg. (see text)

Semiconductors
TR1-TR6 BFY50 or 2N697 or 2N2219
D1 1N914 or 1N4148

Photoconductive Cell
LDR1 ORP12

Switch
S1 push-button, press to make

Lamp
PL1 6V, 60mA, m.e.s.

Miscellaneous
2-off S-DeC or Blob Board type ZB-6-D
6V battery
Lampholder, m.e.s.

TRIGGERING

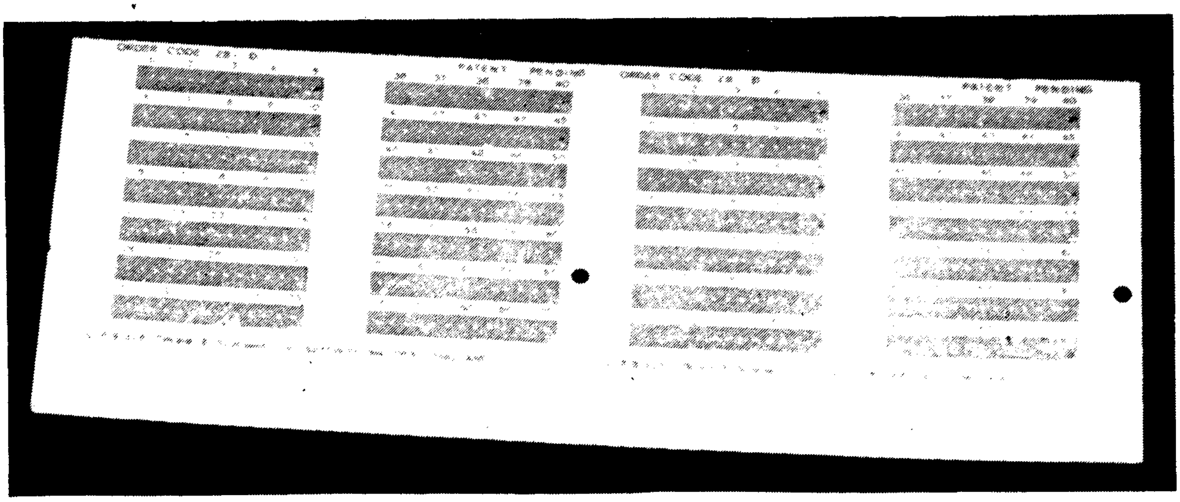
The circuit is triggered by a fall in the amount of light reaching LDR1. The precise level of light that will produce triggering is governed by the value of R1; increasing its value will make the circuit respond at a lower light level. At the reduced light level which causes triggering the voltage at point 12 rises, so that TR1 conducts. The collector current of TR1 however, must flow through R2, which is also the collector load of TR2, and the voltage at point 61 must drop. Now if the voltage at point 61 drops enough for the base current of TR3 to be significantly reduced, the bistable formed by TR2 and TR3 will switch over so that TR2 is fully conducting and TR3 is cut off. The changeover is quick, and the collector voltage of TR3 at point 45 rises rapidly.

C1 now comes into action. If the voltage at one plate of a capacitor rises suddenly then the voltage at the other plate will also rise rapidly until the capacitor is able to charge up to the new voltage conditions. Because of this, when TR3 switches off the voltage at point 6 (on DeC II or the right hand half of the Blob Board) will also rise suddenly and, in the present case, to a level of about 6 volts. This turns on TR4, which turns on TR5 and in consequence TR6, so that PL1 lights up.

The connection of TR4, TR5 and TR6 as a triple emitter follower ensures that the amount of base current needed by TR4 to light the lamp is very small. For example, if PL1 takes 60mA at full brilliance and TR6 has a current gain of 60 times, then it only requires a base current of 1mA. If TR5 also has a current gain of 60, then only one-sixtieth of a milliamp (0.017mA) is needed at its base. Similarly, if the current gain of TR4 is also 60, then its base requires one-sixtieth of 0.017mA (0.00028mA) to keep PL1 turned on. It is a tribute to the success of the manufacturing process for silicon transistors (and for S-DeCs and Blob Boards) that such a tiny current is not provided by leakage. If it is found impossible to extinguish the lamp in this circuit the cause is nearly always a leaky transistor used for TR4.

The very small base current flowing in TR4 ensures that C1 will charge extremely slowly, so that the voltage at point 8 (DeC II) decreases equally slowly. As this voltage decreases so also does the voltage across the lamp so that its brightness gradually falls. The process will continue until the glow of the lamp can no longer be seen.

There is, incidentally, no need to shield LDR1 from the lamp, as the light from PL1 cannot make the circuit switch back again. Once triggered, the



The ZB-6-D Blob Board. This has strips and numbering corresponding to the connection points in the double-DeC assembly bistable remains switched over until the reset switch is operated.

When the reset switch is closed the bistable is changed over as described earlier. This has the effect of switching TR2 off and TR3 on again so that the voltage at TR3 collector and point 45 suddenly drops. Because of the action of the capacitor the voltage at point 6 (DeC II) also drops, but is held at about half a volt negative of the negative rail by the forward current flowing through D1, ensuring that C1 is correctly reset for the next cycle of operation. If the photoconductive cell is still in darkness when the reset switch is operated, the light-dimming part of the cycle will recommence when the switch is released.

The current drawn from the 6 volt supply is approximately 3.5mA when the photoconductive cell is illuminated, this rising to 60mA when the cell is in darkness and the circuit triggers. The current then gradually falls to 3.5mA again as the lamp brightness decreases.

CAPACITOR VALUE

Two suggested values are shown in the Components List for C1. This is not because the designer could not make up his mind, but to allow for testing. When checking this circuit it is rather irritating to have to wait for 30 minutes or more for the light to go out, so that the use of a 5μF (or 4.7μF) capacitor at C1 gives a fade-out which is fast enough to follow but is still slow enough to enable you to be sure that the circuit is working correctly as described. Do not use a multimeter to check the voltage at the base of TR4, incidentally, as it will cause C1 to charge very quickly so that PL1 extinguishes at once. When a 100μF capacitor is used for C1 the fade-out should be very slow. Some selection may be needed for the 100μF capacitor but, as was found with the prototype, a number of modern aluminium electrolytics checked were all up to the job. These had a working voltage of 16 volts, and the use of a working voltage higher than is needed can often ensure lower leakage currents with aluminium electrolytics. For the longest fade-out a tantalum electrolytic (rated at 10 volts or more) is needed.

S-DeC CONSTRUCTION

When the circuit is constructed on two S-DeCs, the DeCs should first be joined together at their narrower sides to form one long DeC. A single panel should be fitted to one of the DeCs to carry the reset switch and the lampholder. The nine link wires should then be plugged in between the points indicated before any components are inserted. The transistors can then be plugged in, followed by the resistors, C1 and then D1. Make sure that the transistor lead-out wires have been correctly identified. With the lead-out wires facing you the clockwise order of the leads is emitter-base-collector on all the transistor types specified.

Finish assembly by plugging in wires connected to LDR1, the reset switch and PL1. Incidentally, avoid using stranded wire in S-DeC circuits. Use single strand wire, or at least lightly and smoothly solder the strands of multi-strand wire together. Unsoldered strands of multi-strand wire become entangled in the spring contacts of the S-DeC, causing jamming and even short-circuits.

BLOB BOARD CONSTRUCTION

Construction with the Blob Board is similar to that with the two S-DeCs, except that wires are blob-soldered to the tinned strips instead of inserted in holes. Start with the link wires, then proceed to the transistors, the resistors, C1 and the diode. Lamp PL1 can be attached by long leads, if desired, as also can LDR1 and the reset switch. If the Blob Board circuit is to be mounted in a case, LDR1, PL1 and the reset switch will, of course, be fitted on the front panel.

FUTURE PROJECTS

Wherever possible, the following projects in this series will employ many of the same components which are used in preceding projects. Constructors who are using S-DeCs will therefore find that the number of new components needed for each succeeding project will be relatively low, as components from earlier projects can be used again in these. ■

INTEGRATED CIRC

By A.

Very sim modulated cillator for alignment.

A wobbulator is one of the less common items of test equipment and may be unfamiliar to some readers. It is a device which is used in conjunction with an oscilloscope to display the frequency response of a receiver. A wobbulator is really just a form of voltage controlled oscillator, the oscillator frequency being varied in synchronism with the horizontal deflection of the spot on the oscilloscope screen.

The wobbulator can be extremely useful when adjusting and experimenting with complex i.f. filters, as it enables the effect on the passband of any adjustment or alteration to be seen immediately without the need to make a set of measurements using such items as a signal generator and an r.f. voltmeter. It can also be very useful for aligning simple broadcast receivers when it is desired to stagger the i.f. tuning slightly in order to produce an increased i.f. bandwidth. This produces an improved audio signal as compared with straightforward peaking of the i.f. transformers, since the output has a flatter audio response and better treble. Without the aid of a wobbulator i.f. stagger alignment is rather a hit and miss affair, and can easily result in reduced performance rather than an improvement.

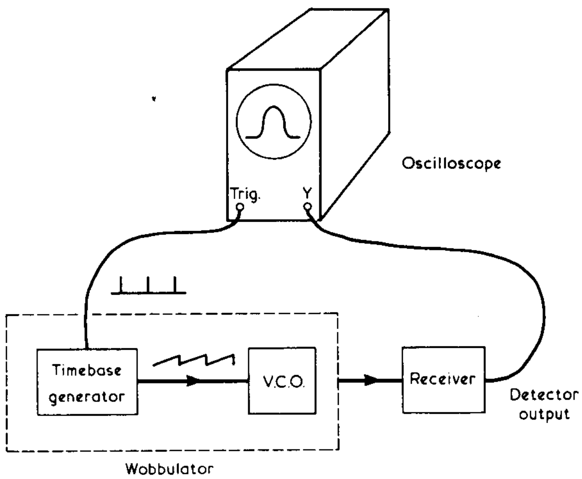
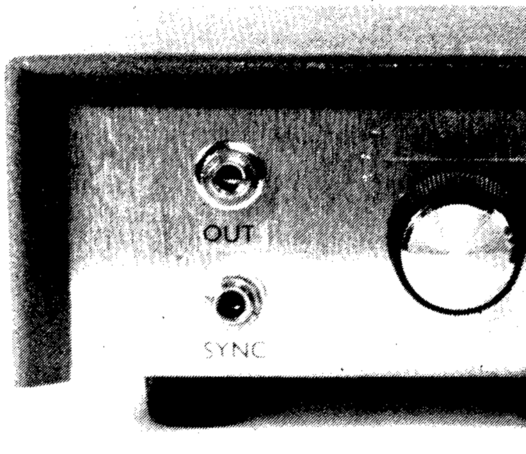


Fig. 1. Basic method of employing a wobbulator and oscilloscope to display the frequency response, or passband, of a receiver. Normally, this is the receiver intermediate frequency response

The very simple wobbulator to be described in this article contains its own timebase and voltage controlled oscillator, and is primarily intended for setting up the i.f. transformers in medium and long wave receivers. It can also be used for setting up the i.f. amplifier in any a.m. receiver in which the intermediate frequency is in the range of around 400 to 500kHz.

METHOD OF OPERATION

The basic set-up for using a wobbulator is shown in Fig. 1. A voltage controlled oscillator is adjusted so that its operating frequency is a little lower than



The three knobs at the front panel of the integr r.f. oscillator frequ

CUIT WOBBULATOR

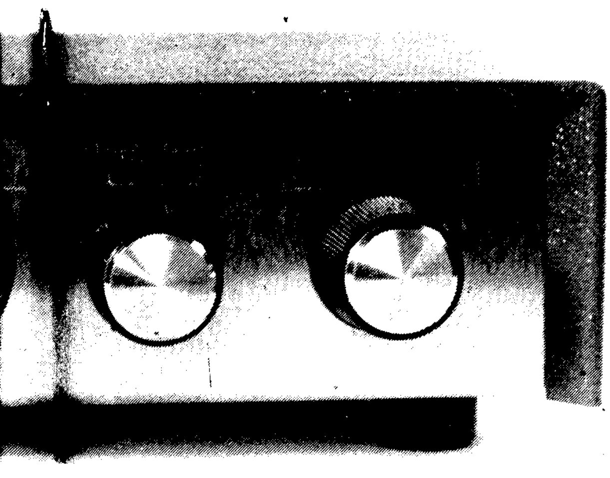
P. Roberts

ple frequency relaxation os- a.m. receiver

the frequency to which the receiver is tuned (or lower than the i.f. passband to be examined), and the v.c.o. signal should be just outside the receiver's passband. An internal timebase in the wobbulator then sweeps the v.c.o. frequency upwards across the passband of the receiver and beyond.

At the beginning of each sweep the timebase generates a brief pulse which is used to operate the sync or triggered sweep facility of the oscilloscope, so that the beam of the c.r.t. is swept across the screen at the same time as the v.c.o. frequency is swept across the receiver's passband.

The Y input of the oscilloscope is fed from the



grated circuit wobbulator control internal timebase speed, quency and sweep amplitude

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
- R1 27kΩ
- R2 470kΩ
- R3 390Ω
- R4 390Ω
- R5 220Ω
- R6 4.7kΩ
- R7 10kΩ
- R8 18kΩ
- R9 150kΩ
- R10 2.2kΩ
- R11 2.2kΩ
- VR1 50kΩ (or 47kΩ) potentiometer, linear
- VR2 5kΩ (or 4.7kΩ) potentiometer, linear, with switch S1
- VR3 10kΩ potentiometer, linear

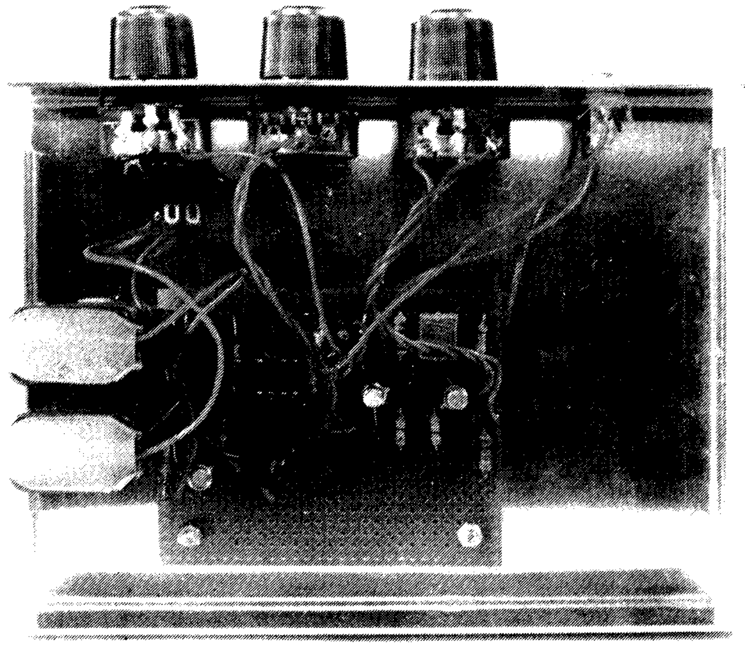
Capacitors
- C1 1μF polycarbonate
- C2 10μF electrolytic, 16V Wkg.
- C3 5μF (or 4.7μF) electrolytic, 16V Wkg.
- C4 0.001μF ceramic or polyester
- C5 82pF polystyrene
- C6 0.01μF ceramic plate
- C7 0.1μF type C280 (Mullard)

Semiconductors
- IC1 NE566
- TR1 BC177
- TR2 2N4871
- TR3 BC109
- TR4 BC109
- D1 BZY88C13V

Sockets
- SK1 3.5mm. jack socket (see text)
- SK2 3.5mm. jack socket (see text)

Switch
- S1 s.p.s.t. toggle (part of VR2)

Miscellaneous
- Instrument case type BV3 (see text)
- 3 control knobs
- 2 9-volt batteries type PP3 (see text)
- 2 battery connectors
- Plain s.r.b.p. panel, 0.1in. matrix
- 8-way i.c. holder (see text)
- Bolts, nuts, wire, etc.



The use of an integrated circuit relaxation r.f. oscillator removes the necessity for a coil and tuning capacitor

detector output of the receiver. The voltage here will be virtually zero at the beginning of each sweep, but will gradually rise as the v.c.o. is swept towards the centre of the receiver's passband, reaching a peak at the peak of the receiver's response. It then gradually falls back to zero as the v.c.o. is swept out of the passband on the high frequency side.

Thus the X axis of the oscilloscope display represents frequency, the Y axis represents the sensitivity of the receiver and the frequency response of the receiver is traced out graphically on the screen of the oscilloscope.

THE CIRCUIT

The wobbulator described here is based on an NE566 v.c.o. integrated circuit, which provides a high level of performance. The linearity between the timebase modulating signal and output frequency is typically 0.2% for 10% deviation. This level of distortion is negligible, and will probably be better than the linearity of the oscilloscope and wobbulator timebase generators. Thus, for all practical purposes the X axis of the trace can be regarded as having a linear relationship with frequency, and a distorted display of a passband will not be produced. The same is not true of some other methods of wobbulator frequency modulation such as occur with a varicap tuned LC oscillator.

Although the NE566 is not one of the less expensive i.c.'s currently available, it is still economically attractive as it uses a relaxation oscillator rather than an LC circuit. The output frequency is determined by a resistance and a capacitance, whereupon there is no need for an expensive tuning capacitor and coil.

Fig. 2 shows the complete circuit diagram of the wobbulator, C5 is the capacitive part of the frequency determining network and R10 plus VR3 the resistive part. VR3 is the tuning control and provides an output frequency range of, very approximately, 200kHz to 1MHz. A triangular output signal of 2.4 volts peak-to-peak with an output impedance of 50Ω is produced at pin 4 of the i.c., and this is fed to the output socket, SK2. Although this is obviously not a sine wave it gives the same results in practice when swept across a receiver i.f. passband. The NE566 also has a square wave output available at pin 3, but this is not used in the present application.

Pin 5 is the modulation input of the i.c., and this is biased by R8 and R9. C4 provides stability in device operation, as also does decoupling capacitor C6.

TIMEBASE GENERATOR

The timebase generator, incorporating TR1, TR2 and TR3, uses another relaxation oscillator, but of conventional unijunction transistor design. It is based on a circuit published in the April 1976 issue of this magazine ("Time Base Generator" by P. R. Arthur).

TR1 is a constant current generator which feeds timing capacitor C1, and it produces a linear increase in the voltage across C1 until the voltage reaches some 70 to 85% of the supply potential. The normally high emitter to base 1 resistance of TR2 then falls abruptly to a low level, causing C1 to discharge into R5. C1 then begins to charge once more, and the circuit continuously oscillates with a linear sawtooth being produced across C1.

VR1 controls the rate at which C1 is charged and therefore acts as the timebase frequency control. It provides a frequency range which extends from a few Hertz to several hundred Hertz.

The signal produced across C1 is at rather a high impedance and so an emitter follower buffer stage using TR3 is interposed between this and the modulation depth control, VR2. The output amplitude of the timebase generator is a little higher than is really necessary, and R7 is therefore included in circuit to provide a degree of attenua-

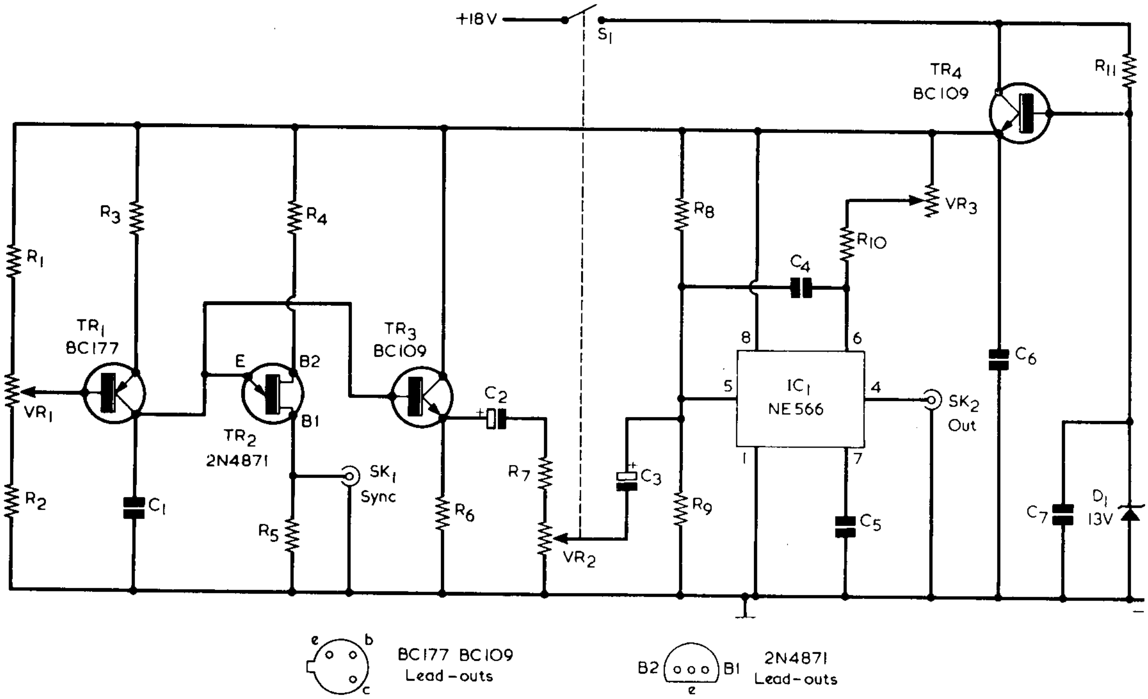


Fig. 2. The circuit of the wobbulator. This employs an 18 volt supply given by two 9 volt batteries in series

tion. The maximum sweep range is about ±10% of the nominal output frequency.

The sync pulses to trigger the sweep generator of the oscilloscope are obtained from the base 1 terminal of TR2. When C1 discharges, a positive pulse of several hundred millivolts appears at the upper end of R5, and this is ideal for use as an oscilloscope sync pulse.

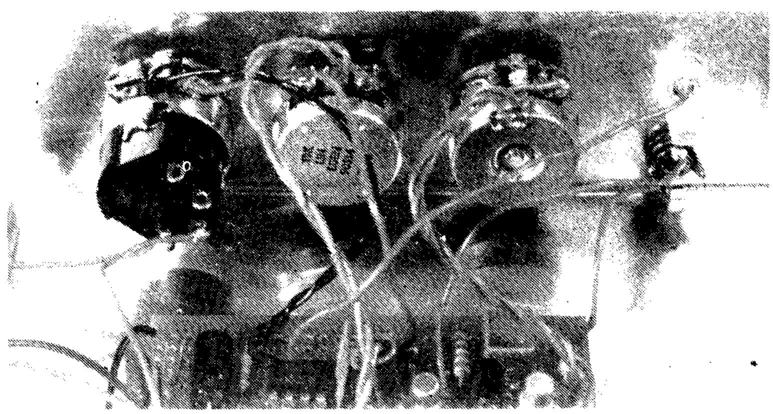
A battery supply is used for the circuit, but unfortunately the NE566 has a minimum power supply requirement of 10 volts. A single 9 volt battery is therefore inadequate in theory, and in practice the NE566 seems to cease functioning if the supply potential falls to marginally less than 10 volts. Two 9 volt batteries wired in series to provide an 18 volt supply are therefore employed to power the circuit.

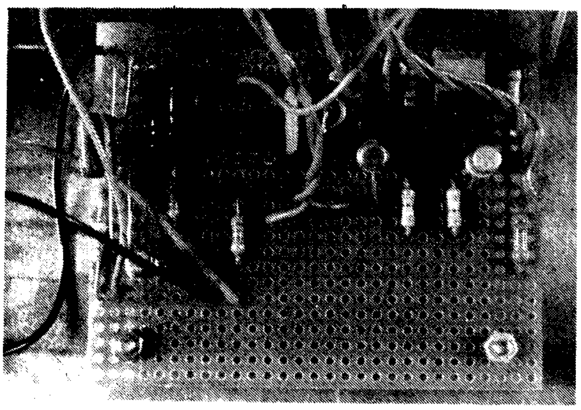
A simple and conventional series regulator incorporating TR4, R11, D1 and C7 provides a stabilized supply of approximately 12 volts to the main cuitry. A stabilized supply ensures good frequency stability from the NE566 and also gives a somewhat lower current consumption than would be obtained if the circuit was powered directly from the 18 volt rail. The actual current consumption of the unit is approximately 15mA. In the author's version the power is provided by two PP3 batteries in series, and these are adequate when the wobbulator is used for reasonably short periods of time. Larger 9 volt batteries may be employed if extended use of the unit is envisaged.

CONSTRUCTION

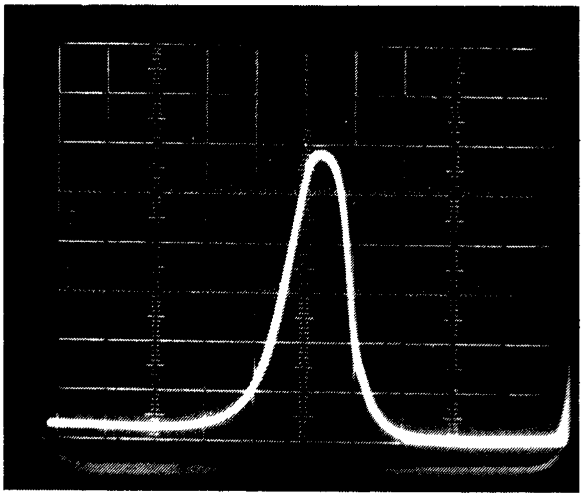
The prototype wobbulator is housed in a metal instrument case type BV3. This has dimensions of approximately 6 by 4$\frac{3}{4}$ by 1$\frac{3}{4}$in. and can be obtained from Bi-Pak Semiconductors, but any similar metal instrument case capable of taking the

The wiring to the three potentiometers and the sockets on the front panel

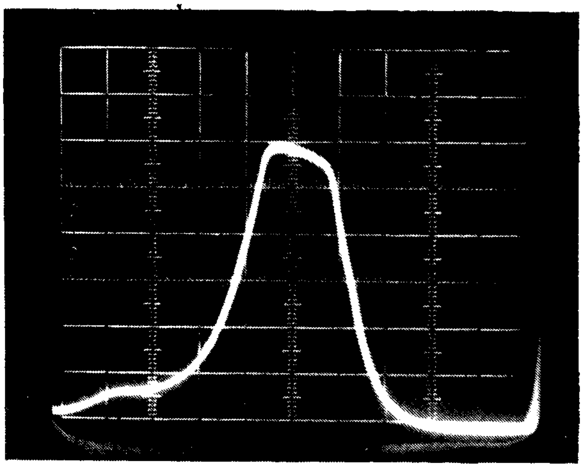




The components assembled on the perforated s.r.b.p. board



The i.f. response of a typical medium and long wave receiver



An excessively high wobbulator input causes the receiver a.g.c. circuit to effectively flatten and broaden the response

components and batteries should be equally suitable. The front panel layout of the unit can be seen from the accompanying photographs, and is not at all critical. SK1 and SK2 are on the left, with VR1 next, then VR3, and finally VR2 on the right. The author used 3.5mm. jack sockets for both SK1 and SK2 and these are perfectly adequate, but coaxial or some similar alternative types of socket can be employed here if preferred. When jack sockets are used these should be of an open non-insulated construction, as the chassis connection is made via its mounting bush and nut.

All the small components are wired up on a plain 0.1in. matrix s.r.b.p. panel which has 22 by 29 holes. This must be carefully cut down from a larger panel with a hacksaw and then the two mounting holes are drilled 6BA or M3 clearance. The components are next mounted on the panel and wired together. The component layout and underside wiring of the panel are illustrated in Fig. 3. If desired, an i.c. holder can be wired up at the IC1 position, the NE566 being inserted in this when wiring is complete. The wiring to the panel components is shown in Fig. 4.

The completed component panel is fitted to the base of the cabinet to the rear of the three controls, being positioned to allow adequate space for the batteries. It is mounted with two 6BA or M3 screws, using spacing washers to hold the panel underside clear of the inside metal surface of the case so that there are no short-circuits to the panel wiring. Before it is finally bolted in position, the panel must be wired up to the components mounted on the front panel. For neatness, the wires to each potentiometer may be lightly twisted together.

USING THE UNIT

The sync pulses from SK1 are coupled to the trigger input of the oscilloscope via a 2-core lead terminated in plugs of the appropriate type. As this signal is at quite a low impedance there is no necessity to use a screened connecting cable here. The output from the wobbulator is quite strong and it should not be necessary to make a direct connection between SK2 and the aerial circuit of the receiver. When using the unit with an ordinary medium or long wave broadcast receiver it will simply be necessary to connect a short lead to SK2 and then position it near the ferrite aerial of the receiver.

The Y input of the oscilloscope must be connected to the output of the receiver's detector, and this is usually quite easy to achieve since, in conventional superhet circuits, the detector output is developed across the volume control.

The oscilloscope must be adjusted for a timebase frequency of about 25 to 50Hz, the exact frequency being unimportant. Slower speeds are not really suitable since the display will noticeably flicker. Higher timebase frequencies may be satisfactory but it is likely that the trace will tend to break up, whereupon it will become useless.

VR1 is adjusted to match the wobbulator timebase frequency to that of the oscilloscope, and this adjustment is not as critical as might be expected. If the wobbulator timebase is running slightly too fast this will simply result in slightly more than one v.c.o. trace being displayed by the oscilloscope. Too low a frequency will only result in

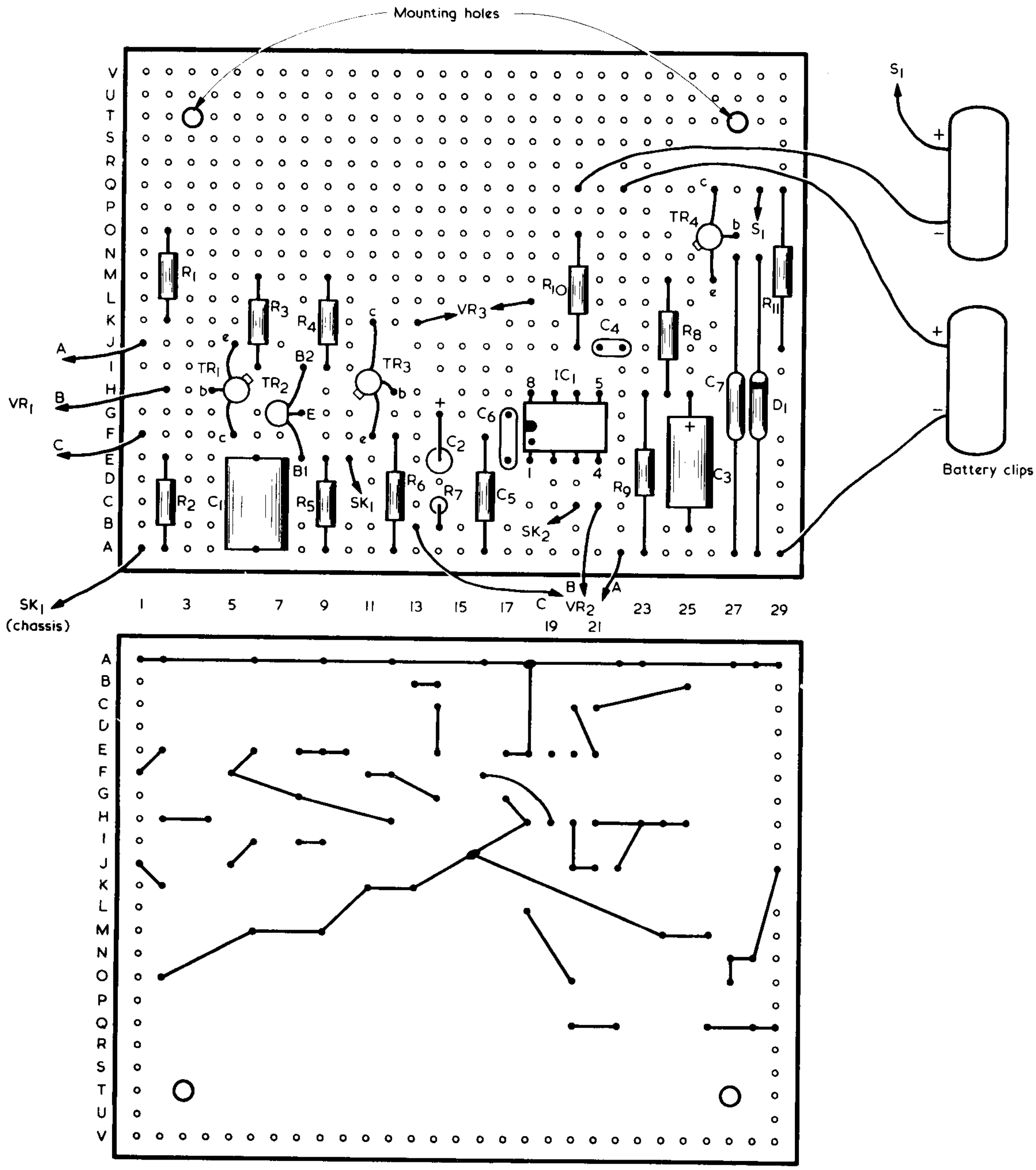


Fig. 3. The component and wiring sides of the perforated s.r.b.p. panel

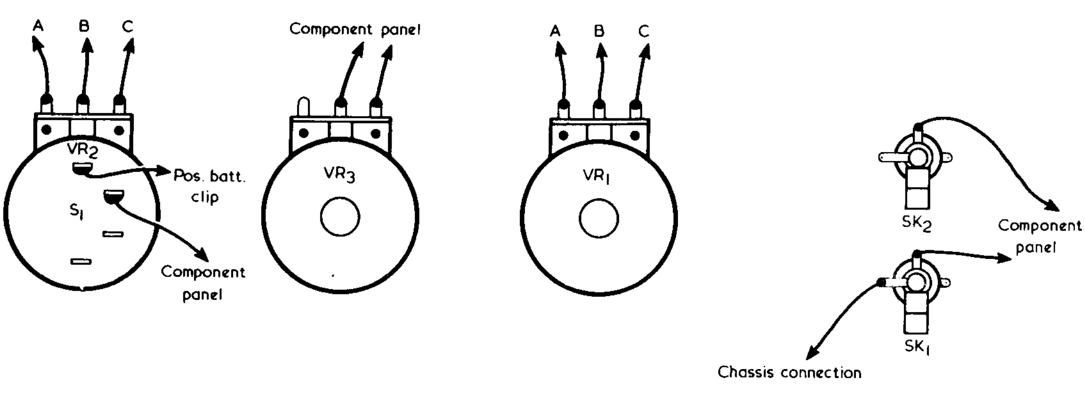
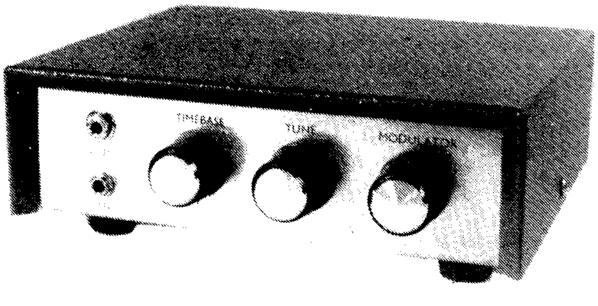


Fig. 4. The wiring behind the front panel. The two leads to VR3 may be connected either way round



Another view of the integrated circuit wobbulator in its instrument case

a little less than a full v.c.o. sweep being displayed.

The receiver must be tuned to a frequency which is covered by the wobbulator, and then VR3 is used to tune the v.c.o. to a frequency that enables it to be swept across the passband of the receiver. The receiver mixer circuit converts the central wobbulator signal to the intermediate frequency, whereupon the i.f. transformers can be aligned to give the desired frequency response. On medium waves the response of the aerial input tuned circuit will normally be considerably broader than the i.f. response and will not affect the appearance of the latter to any great extent.

The popular intermediate frequencies around 455 to 470kHz are included in the frequency coverage of the unit and so it can be used for testing and aligning this type of i.f. strip. A very loose capacitive coupling to the input of the i.f. strip will usually be sufficient for injecting the wobbulator signal. Harmonics of the output signal can also be used to provide an input signal for a short wave receiver.

VR2 controls the v.c.o. sweep width. When it is adjusted towards maximum the passband of the receiver will amost certainly occupy only a very narrow section of the oscilloscope display. This can be useful for showing any spurious responses, but normally VR2 should be adjusted well back so that the passband occupies a substantial part of the display. The part of the display showing the passband can be moved from side to side on the screen by means of VR3. Under normal circumstances VR3 will be adjusted to centralise the display of the passband.

Standard receivers incorporate a.g.c. circuits. Either the a.g.c. circuit must be disabled or the signal transfer from the wobbulator to the receiver must be kept low enough to prevent the a.g.c. from being effective. The latter is probably the more practical approach. If the a.g.c. circuit does operate it will have the effect of apparently broadening and and flattening the response of the receiver.

Finally, it is important that the receiver does not pick up any significant signal apart from that from the wobbulator, otherwise the two signals will produce a beat pattern which will modulate the trace. ■

SOLID STATE TELEPHONE EXCHANGES ONE STEP NEARER

General Instrument Microelectronics Ltd. have announced the introduction of a TTL-compatible 5 channel Relay Driver in MOS microcircuit form. The new device designated AY-5-9050 will provide a further essential step in the continuing conversion of electro-mechanical telephone exchanges to solid state control.

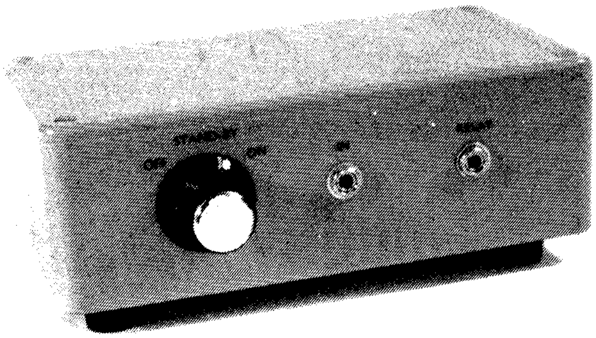
Designed to provide an interface between the latest solid-state circuits and standard Post Office relays, the high reliability, low cost device contains five individual channels, each comprising a logic section which switches a high current output driver. Each output driver is capable of supplying 50mA to a relay, connected directly to a nominal-48V exchange supply. Because of the extremely hostile electrical environment of telephone exchanges, delay circuitry is incorporated to improve rejection of noise interference on the inputs. The input logic levels are compatible with standard TTL and since only a very small input current is required, a resistor may be connected in series with the device to protect the preceding logic under fault conditions.

When higher currents and/or lower output voltages are required, channels may be paralleled externally to provide up to 250mA. Each driver operates as a buffer with a high impedance input and a high current output able to withstand large negative voltages in the off condition. In the 'on' condition, each output may be considered as a resistor of 40 Ohms maximum with a current rating of 50mA.

The new 14-lead interface circuit is fabricated using G.I.M.'s P-channel MTNS process, which is approved to British Post Office Specification D.4000. All necessary voltages are generated on-chip, and isolation is provided between the logic circuitry and the exchange (noisy) earth. Although the exchange earth may fluctuate by +4V, malfunction of the logic circuitry will not occur.

This new circuit is the latest in a wide range of G.I. standard microcircuits devoted exclusively to the needs of the telecommunications industry. These include pushbutton dialler circuits, coinbox circuits, multi-frequency tone and clock generators, filters, multiplexers and others. G.I. circuits are now being used in telephone and other approved telecommunications equipment throughout Europe and the rest of the world. ■

RADIO & ELECTRONICS CONSTRUCTOR



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Before undertaking any constructional project described in a back issue, it must be borne in mind that components readily available at the time of publication may no longer be so.

3 BAND SHORT WAVE SUPERHET Part 3

By R. A. Penfold

Assembling the b.f.o., product detector and Q multiplier stages.

In the last article, construction proceeded as far as the assembly of the a.f. amplifier. We proceed next to the product detector and the Q multiplier.

PRODUCT DETECTOR

The circuit of the product detector and b.f.o. section of the receiver is given in Fig. 9. The b.f.o. employs a simple and very stable Hartley circuit. Coil L3 is the primary of an i.f. transformer which would normally feed an a.m. receiver detector. The secondary winding is ignored here.

When S2 in Fig. 9 is in the "A.M." position the detected output from C10 of Fig. 3 (published in Part 1) is fed direct to VR2 of Fig. 7. At the same time, no power is applied to the b.f.o. and product detector. It is necessary to disable the b.f.o. during a.m. reception as its output could otherwise break through to the i.f. stages, even if only at a very low level.

Setting S2 to "U.S.B." or "L.S.B." disconnects VR2 from C10 and couples it to the product detector output via C31. The product detector has an input from C9, which is also in Fig. 3. Also, power is applied to the b.f.o. and product detector stages. R25 and zener diode D4 stabilize the b.f.o. supply voltage.

The core of L1 is adjusted so that the b.f.o. frequency is just slightly above the central i.f. when S2 is in the "U.S.B." position. When S2 is put into the "L.S.B." position, C27 is switched into circuit and this additional tuning capacitance reduces the b.f.o. frequency to slightly below the central i.f.

It may seem to some readers that the two sideband switch positions have been marked incorrectly, and that the legends should be transposed. However, the markings are correct and the reason for the apparent anomaly is that the mixer and oscillator stages invert the input signal in terms of

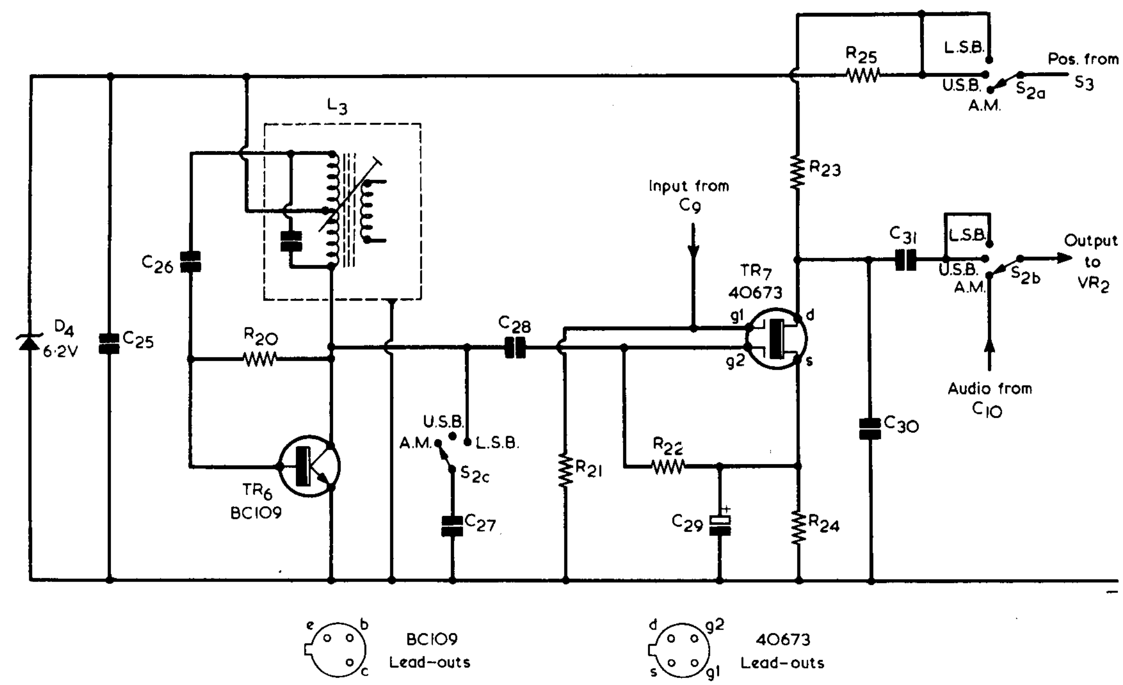


Fig. 9. The b.f.o. and product detector stages. The latter has switching to cater for upper and lower sidebands

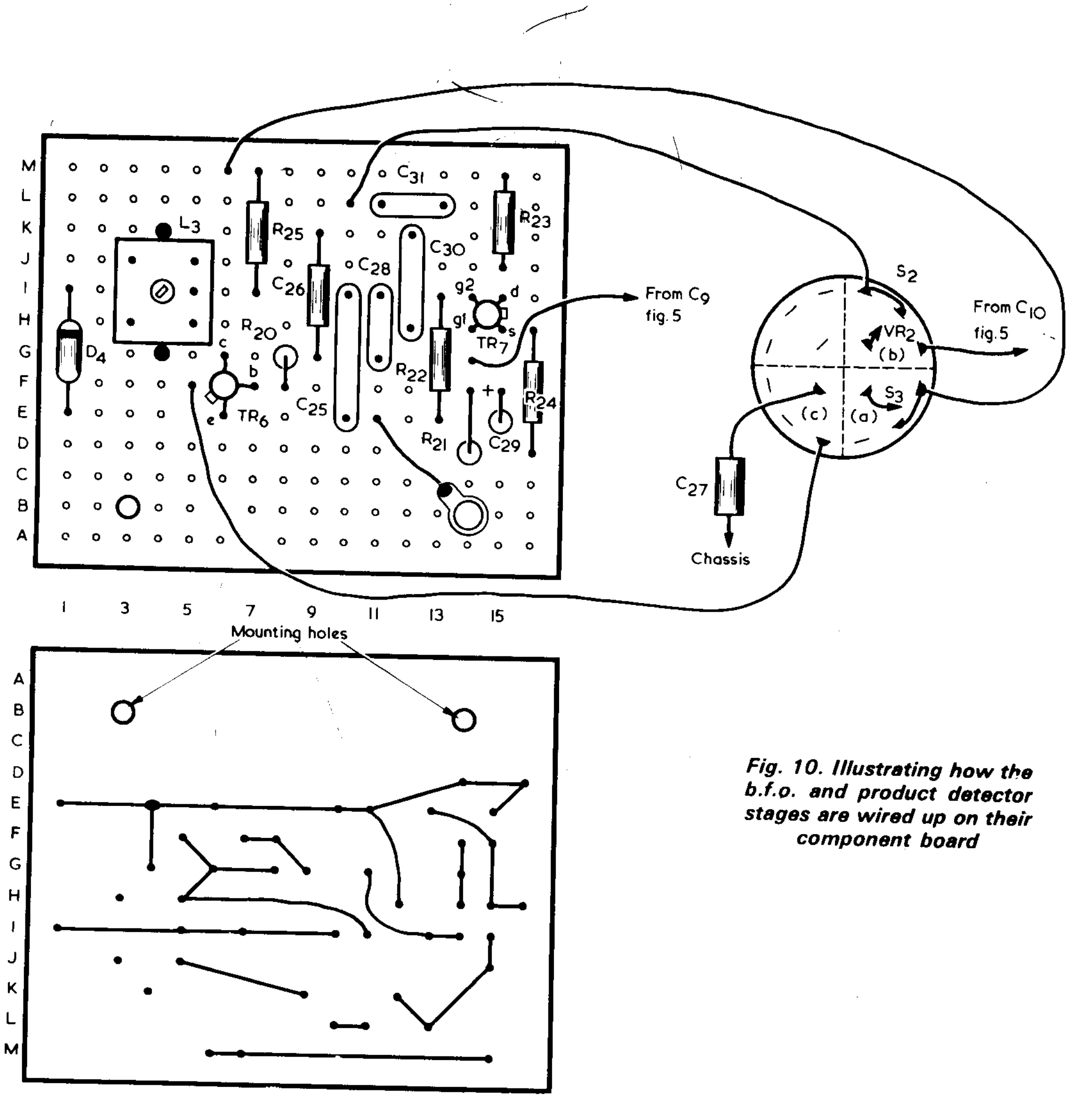


Fig. 10. Illustrating how the b.f.o. and product detector stages are wired up on their component board

relative frequency. For instance, with an aerial input signal at 10MHz, the corresponding oscillator frequency will be 10.455MHz to produce an i.f. of 455kHz. The same oscillator frequency will convert a signal at 10.001MHz to an i.f. of 454kHz (10.455 minus 10.001 equals 0.454). Thus an upper sideband signal at the aerial becomes a lower sideband signal in the i.f. stages, and vice versa.

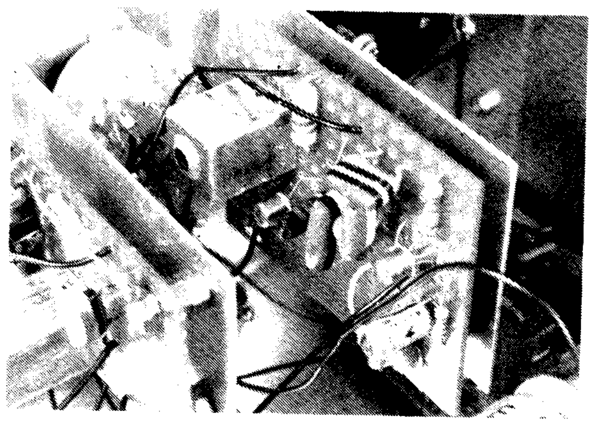
It is worth mentioning that many short wave receivers have a variable b.f.o., the precise b.f.o. frequency being not too important because of a wife i.f. bandwidth. The present receiver, with its mechanical filter and Q multiplier, has a narrow i.f. bandwidth and there is therefore little latitude with regard to the b.f.o. frequency.

C.W. signals can, of course, be demodulated with S2 in either the "U.S.B." or the "L.S.B." position.

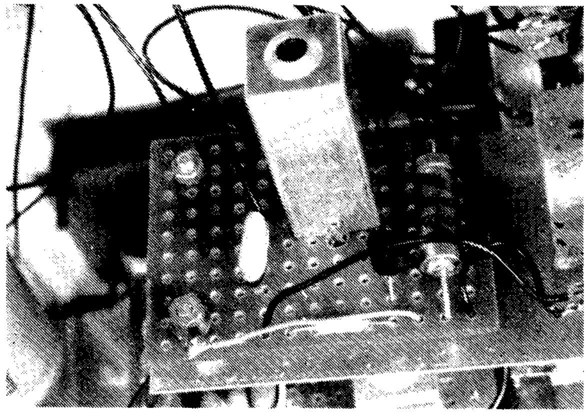
A product detector is a mixer of the same type used in the input stages of the receiver, but instead of converting an r.f. signal to the intermediate frequency, a product detector converts the i.f. signal to an audio frequency. TR7 is a dual gate MOSFET mixer which is used as the product detector. C30 filters out the r.f. signals which are generated at the output and leaves the desired audio signal.

The b.f.o. and product detector are constructed on a plain perforated 0.15 in. matrix s.r.b.p. panel having 16 by 13 holes. The components and the panel are prepared and wired up in the same way as was the i.f. panel. Details are given in Fig. 10.

The panel is not mounted on the chassis but is, instead, secured to an L-shaped bracket held in place behind the front panel by the mounting bush of S2. First cut out a rectangle measuring 150 by 50 mm. from 18 s.w.g. aluminium sheet, then make a 90 degree bend in it 40 mm. from one of the 50 mm.



The product detector and b.f.o. module



Close-up view of the Q multiplier board

edges. Drill a hole of 10 mm. diameter in the centre of the 50 by 40 mm. section of the bracket. The bush of S2 will pass through this hole. The component panel is mounted on the remaining section of the bracket, on the same side as the switch, with the panel rear edge flush with the rear edge of the bracket. It is oriented so that L3 is nearer the switch. The board is secured to the bracket with 6BA or M3 bolts and nuts, spacers about 6 mm. long being passed over the bolts to keep the panel underside clear of the metal bracket. When mounted in the receiver the 110 by 50 mm. section of the bracket is vertical, and is on the "S" meter side of S2.

Q MULTIPLIER

The i.f. bandwidth provided by the mechanical filter is just about ideal for communications quality a.m. reception, but is wider than is really necessary for s.s.b. and c.w. reception. The short wave bands are so crowded these days that this can be a severe drawback, and some means of enabling a narrow bandwidth to be provided when necessary is very desirable.

A Q multiplier is a device which enables the selectivity of a receiver to be varied from a little less than its normal level to a very narrow peaked response which is only suitable for c.w. reception.

An ordinary i.f. transformer provides only a limited degree of selectivity because losses in the resistance of the wire from which the coil is wound tend to produce a rather low Q value (usually in the region of 100). A Q multiplier increases the effective Q of a coil by extracting some of the signal in it, amplifying this signal and then feeding it back into the coil. The signal that is fed back compensates for the losses in the coil and so boosts its effective Q value. The more signal that is fed back the higher the effective Q of the coil, until a point is reached where the level of feedback is sufficient to cause the circuit to break into oscillation.

If the Q multiplier coil is connected across the input of the receiver i.f. amplifier it can be used to reduce the i.f. bandwidth. When the Q multiplier has a variable feedback control that control can then vary the receiver selectivity.

The circuit of the Q multiplier stage appears in Fig. 11. As may be seen, few components are required. The secondary of i.f. transformer IFT3 is

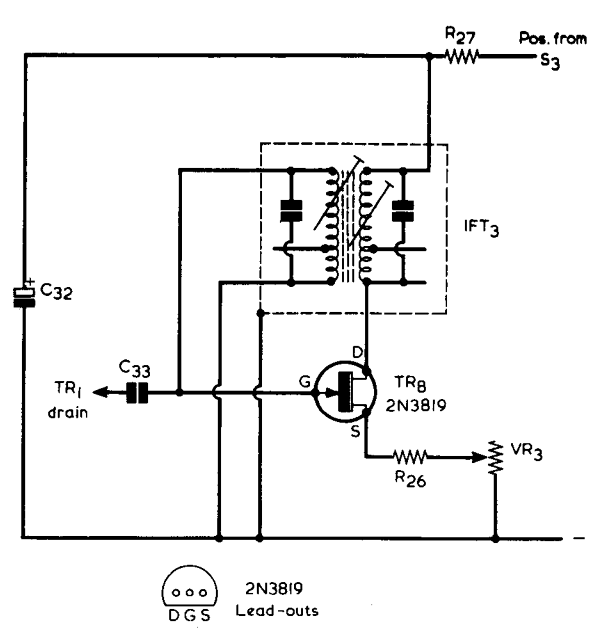


Fig. 11. The Q multiplier has the simple regenerative circuit shown here

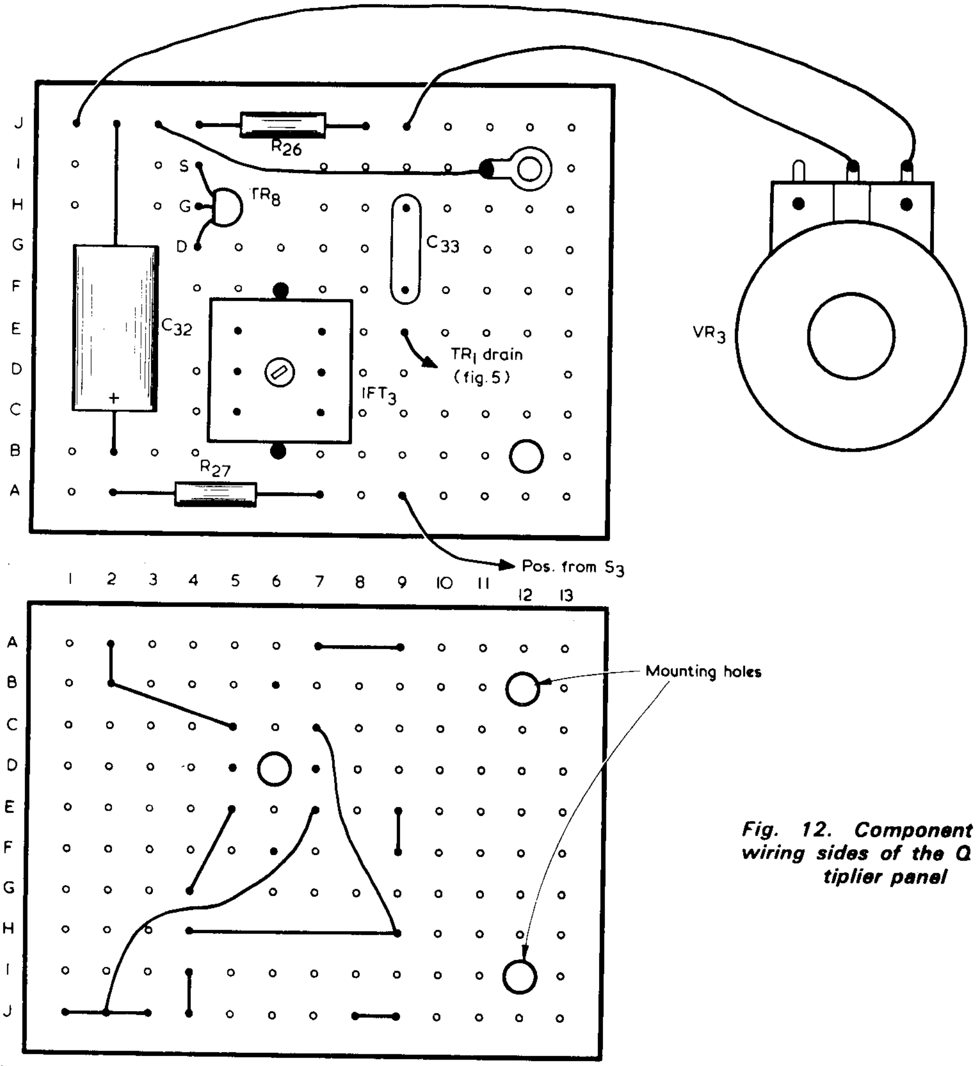


Fig. 12. Component and wiring sides of the Q multiplier panel

the coil which is shunted across the input of the i.f. amplifier, and it couples to the drain of TR1 of Fig. 3 via d.c. blocking capacitor C33. The regeneration required for Q multiplier operation is provided by TR8, the gate of which connects to the primary of IFT3 and is thence coupled to the secondary.

VR3 varies the gain of TR8, and so it controls the level of feeback and thus functions as the receiver selectivity control, C32 and R27 provide supply decoupling.

All the Q multiplier components except VR3 are wired up a plain perforated s.r.b.p. panel of 0.15in. matrix having 13 by 10 holes. The layout is illustrated in Fig. 12, and the panel is constructed and wired in the same manner as the i.f. amplifier and the product detector and b.f.o. panels. In this cae, IFT3 has two cores and a hole has to be drilled in the panel to provide access to the lower core.

Like the product detector and b.f.o. panel the Q multiplier panel is mounted on an L-shaped bracket made of 18 s.w.g. aluminium sheet. This is secured under the mounting bush of VR3. First cut out a rectangle of the aluminium sheet measuring 120 x 40 mm., then make a 90 degree bend 40 mm. in from one of the 40 mm. edges. A 10 mm. diameter hole is then drilled in the centre of the 40 by 40 mm. section. This will take the mounting bush of VR3.

The component panel is secured to the 80 by 40 mm. section of the bracket with its rear flush with the rear edge of the bracket. C32 is towards VR3. A hole is required in the bracket to provide access to the lower core of IFT3. When mounted in the receiver the 80 by 40 mm. bracket section is vertical and is on the product detector and b.f.o. side of VR3, and it thus provides a screen between the Q multiplier and the b.f.o. stage. This prevents pick-up of the b.f.o. signal in the Q multiplier wiring.

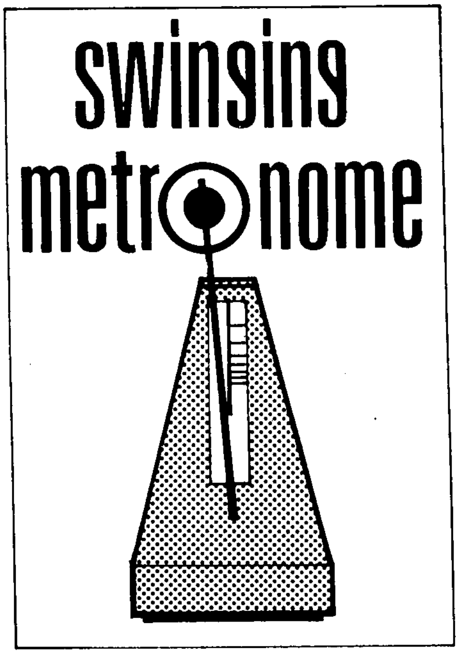
The only remaining wiring consists of connecting the negative battery clip and SK2 to convenient chassis points, and of connecting the positive battery clip to the appropriate tag of S3.

The receiver may be connected to headphones or to an 8Ω speaker. A large capacity 9 volt battery type PP9 is used to power the receiver since it has a quiescent current consumption of about 16mA, this approaching, at high volume levels with an 8Ω speaker, some 100mA. There is plenty of space on the receiver chassis for the battery.

NEXT MONTH

In next month's concluding article, details will be given of alignment and the operation of the receiver.

(To be concluded)



by
R. J. Caborn

Sloping l.e.d. columns add realism in this CMOS design.

Electronic metronomes are not new to the pages of constructional magazines and designs which have appeared in the past have included units which produce loud regularly spaced clicks, or a.f. tone bursts, at a repetition frequency which is governed by a simple speed control knob. In some instances a light-emitting diode is included, this flashing at the same time as the clicks or a.f. tones are reproduced.

Such designs do not have the visual impact of the conventional clockwork metronome which they replace. The latter, with its widely swinging vertical arm, gives an almost hypnotic impression of the beat it is presenting, and the oscillating arm is often subconsciously observed by the musician who is using the metronome. The circuit to be described here employs a CMOS logic i.c. to produce accurately spaced audio "bleeps" in conjunction with a light-emitting diode display which simulates the swing of the moving arm of a mechanical metronome.

BLOCK DIAGRAM

A block diagram illustrating the basic operation of the electronic metronome appears in Fig. 1. Here, a standard 555 astable pulse generator produces positive-going pulses at a frequency which is five times that at which the final a.f. tone bursts are required. These pulses are fed into a divide-by-ten CMOS i.c. having ten digit outputs. Each output gives a positive pulse in turn from "0" to "9" then commences at "0" again for a further count. The "0" output is fed to a BC107 l.e.d. driver which, in the presence of the positive "0" pulse, causes a sloping column of six l.e.d.'s to be brightly illuminated.

The "5" output of the divide-by-ten i.c. couples to another BC107 l.e.d. driver, and this causes a second sloping column of six l.e.d.'s to be illuminated.

Fig. 2 shows the manner in which the two l.e.d. columns light up in terms of pulses from the 555 timer. As can be seen, each column is illuminated

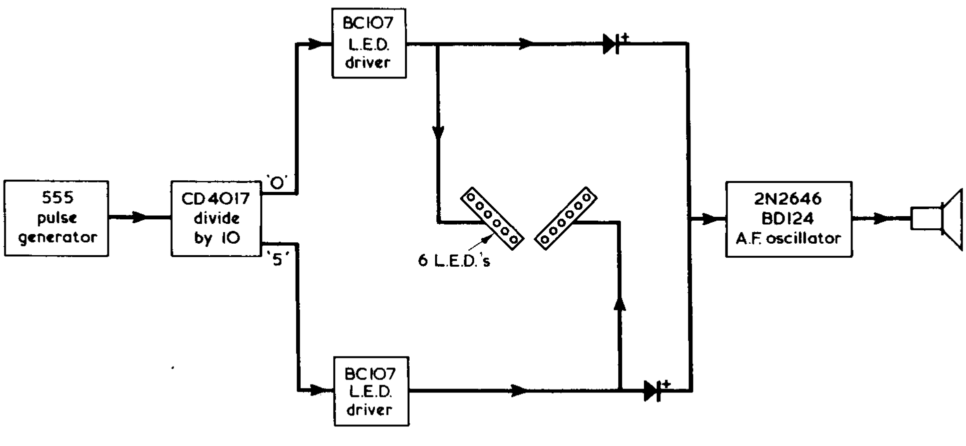


Fig. 1. Block diagram illustrating the manner in which the metronome operates. The a.f. oscillator is turned on when either of the l.e.d. columns is illuminated

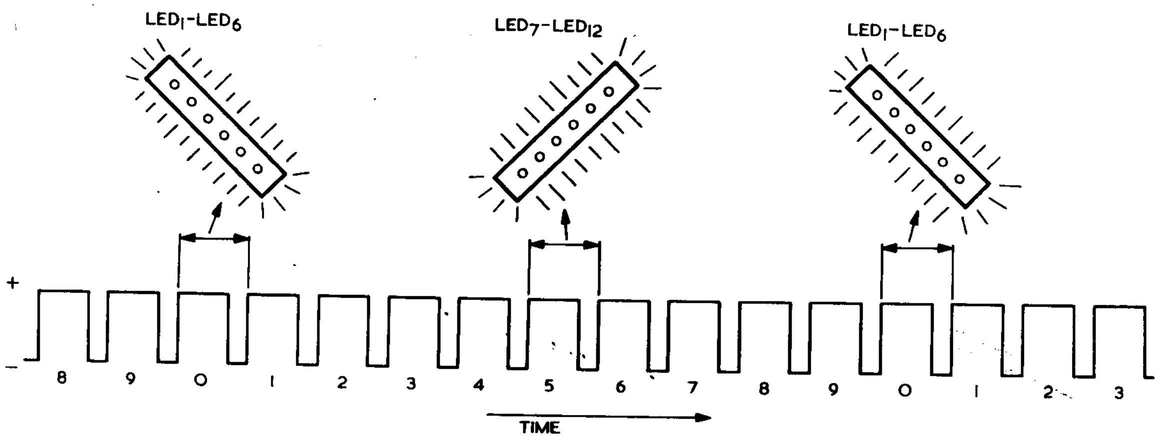


Fig. 2. Timing of the l.e.d. column illumination. The pulses are those from IC1 and the figures below them indicate the corresponding digit outputs of IC2

for one-tenth of a complete cycle, with equal intervals between the lighting of one column and the lighting of the other.

The outputs of the two l.e.d. drivers also couple, via steering diodes, to an a.f. oscillator circuit incorporating 2N2646 and BD124 transistors, this oscillator being enabled at the same time that either l.e.d. column is illuminated. Thus, an a.f. tone burst is produced in synchronism with the lighting of the columns. The overall effect is a simulation of a clockwork metronome, the left hand l.e.d. column representing the metronome arm at its furthermost swing to the left, and the right hand column representing the furthermost swing of the arm to the right.

It is of interest to note in passing that similar l.e.d. presentations are employed in some American digital clocks, the l.e.d. displays in these giving the effect of the swing of a pendulum.

FULL CIRCUIT

The full working circuit of the metronome is given in Fig. 3. IC1 is the 555 i.c., and it appears in a standard multivibrator circuit, the frequency of which is controllable by VR1.

The output of the 555 is fed to the clock input at pin 14 of the CD4017, IC2. Pins 13 and 15 of this i.c. are the clock enable and reset pins respectively, and both are taken to the negative rail. Pin 16 takes

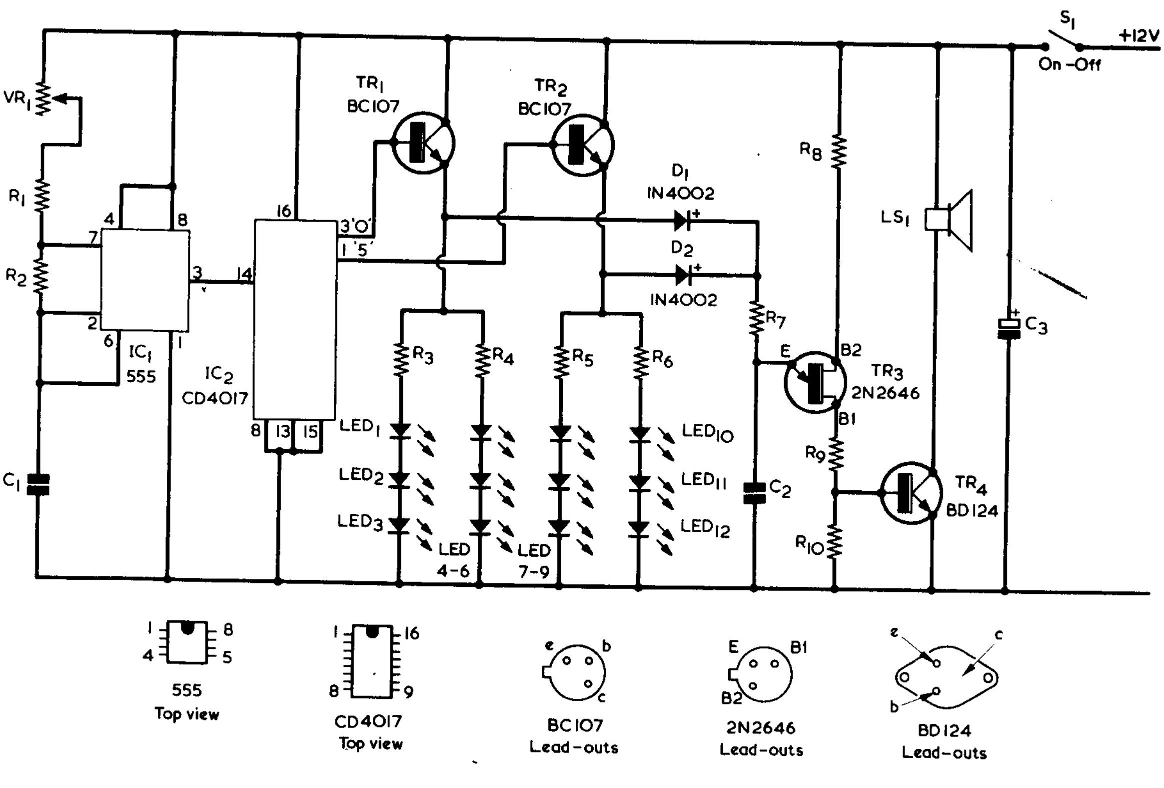


Fig. 3. The working circuit of the metronome

COMPONENTS

Resistors
(all fixed values $\frac{1}{4}$ watt 10%)
R1 22kΩ
R2 10kΩ
R3 470Ω
R4 470Ω
R5 470Ω
R6 470Ω
R7 22kΩ
R8 470Ω
R9 47Ω
R10 100Ω
VR1 250kΩ potentiometer, linear

Capacitors
C1 1μF polyester
C2 0.047μF polyester
C3 1,000μF electrolytic, 16 V. Wkg.

Semiconductors
IC1 555
IC2 CD4017
TR1 BC107
TR2 BC107
TR3 2N2646
TR4 BD124
D1 1N4002
D2 1N4002
LED1-LED12 red l.e.d.'s

Switch
S1 s.p.s.t. toggle

Speaker
LS1 3Ω, 4in. round or larger

Miscellaneous
12 volt battery (see text)
16-way i.c. holder
Control knob.

the positive supply and pin 8 the negative supply. In addition to a carry out pin, the CD4017 has ten digit output pins, and the only further connections to the i.c. are at its "0" output at pin 3, and its "5" output at pin 1.

The output current capability at these last two pins is low and, to obtain a bright l.e.d. display, each connects to the base of a BC107 emitter follower. When the "0" output is positive, TR1 causes LED1 to LED6 to light up via current limiting resistors R3 and R4. In a similar fashion, TR2 turns on LED7 to LED12 via R5 and R6 when the "5" output is positive. LED1 to LED6 form the left-hand sloping l.e.d. column, whilst LED7 to LED12 make up the right-hand column.

The a.f. oscillator section employs the unijunction transistor TR3 and the output transistor TR4. When TR1 turns on the l.e.d.'s in its emitter circuit it also causes the upper end of R7 to go positive by way of D1. TR3 then oscillates in normal unijunction manner, and a series of current spikes flows in its base 1 circuit at a repetition frequency of around 600 to 700Hz. As soon as TR1 base goes negative, at the end of the "0" pulse from the CD4017, no positive voltage is available for R7 and the unijunction transistor is inhibited. The unijunction transistor is also enabled, and allowed to oscillate, when TR2 turns on the right-hand column of l.e.d.'s. This time the positive voltage for the upper end of R7 is supplied via D2.

The current spikes in the base 1 circuit of the unijunction transistor cause TR4 to be conductive when they are present. As a result a series of amplified current spikes appears in the collector circuit of TR4, and these are reproduced as an audible tone by the speaker, LS1. Although the spikes have very short duration their amplitude can theoretically be in excess of an amp, and for this reason a small power transistor is employed in the TR4 position. Its average dissipation is considerably below that at which it is rated, and it does not need to be mounted on a heat sink.

The supply bypass capacitor is C3, and this has the rather large value of 1,000μF. A high value is desirable here to ensure that the l.e.d. currents and the output current spikes are adequately decoupled and do not effect the operation of the remainder of the circuit. Despite the fact that the current in each l.e.d. is around 15mA, the average current drawn from the supply is approximately 12mA only. It has to be remembered here that the l.e.d.'s only light up for one-fifth of the total time. Similarly, the output current spikes in the speaker are only present for a small fraction of the period during which TR3 is enabled.

The metronome will function for falling battery voltages down to 9 volts or less, although such lower voltages naturally cause reduced brilliance in the l.e.d. columns. The frequency of the metronome is not significantly altered by changing battery voltage, as the 555 multivibrator circuit operates against fixed fractions of its supply voltage.

CONSTRUCTION

The construction of the metronome unit can follow any conventional method, and a suggested front panel display is shown in Fig. 4. A circular speaker aperture appears at the upper centre, and it is recommended that the speaker, if a round type, should have a diameter of 4in. or more. Smaller speakers should not be used. Below the speaker are the two l.e.d. columns. The l.e.d.'s in each column should be regularly spaced at $\frac{1}{2}$in. to $\frac{3}{4}$in. intervals. To the left is on-off switch S1, with the frequency control, VR1, to the right.

The frequency range obtained with the prototype is from around eight audio "bleeps" per second when VR1 inserts minimum resistance to slightly more than one "bleep" per second when maximum resistance is inserted. The range can be varied, if desired, by altering the values of R1 and VR1.

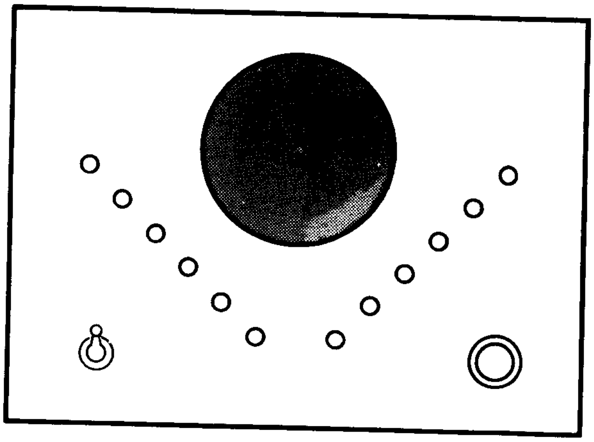


Fig. 4. A suggested front panel layout for the metronome unit. The sloping column of six l.e.d.'s on the left consists of LED1 to LED6, whilst that on the right consists of LED7 to LED12

The 12 volt supply can consist of any series combination of batteries or cells which add up to this voltage. It could, for instance, consist of eight HP7 cells in two 4-cell holders. An economical but somewhat bulky supply will be given by four twin-cell cycle lamp batteries of the Ever Ready No. 800 type.

The visual effect of the display is quite good, and is most noticeable at the slower metronome frequencies. If desired, all the l.e.d.'s in one column could be of one colour and all those in the other column of another colour, although the writer had the subjective impression that best results were given by using red l.e.d.'s throughout.

As a final point, the CD4017 i.c. is a CMOS device and must be protected against high static voltages at its input pins. The best approach here is to wire up the metronome employing a 16-way i.c. holder in the IC2 position. The CD4017 can then be fitted in this holder after all wiring has been completed and checked. ■

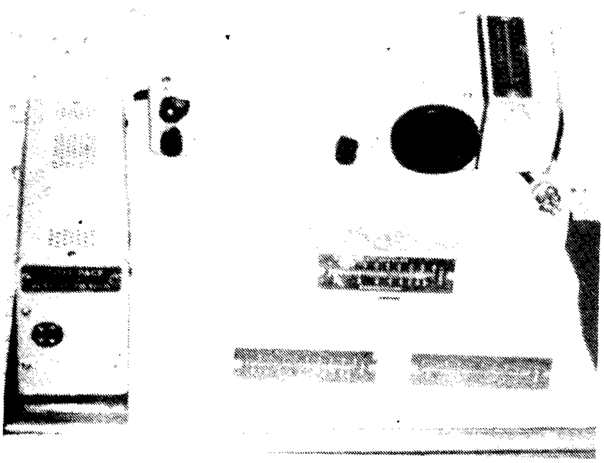
THE MCR1 RECEIVER

by
Ron Ham

Another World War II spy set

Among the host of surplus radio equipment available after World War II was the Miniature Communication Receiver type MCR1. This was sold in 1947, complete with mains power pack, four coil-sets and headphones, for £10. 10s.

This clandestine 5 valve superhet, using one 1R5 and four 1T4 valves, has four plug-in coil-sets covering the ranges 150-1,600kHz, 2.5-4.5MHz, 4.5-8.0MHz and 8.0-15.0MHz.



The MCR1 receiver, at top, with one coil-set plugged in. The three remaining coil-sets are in front of the receiver. The MCR1 operates from a dry battery or from the multi-input mains power supply shown on the left

EASY CONCEALMENT

The top unit in the photograph is the receiver with one coil-set plugged in. The set measures 8½ by 3¼ by 2¼in., about the size of a house building brick for easy concealment, weighs 3½lb. and was designed for both r.t. and c.w. reception. A large knob is provided for slow motion tuning and the three pear-shaped knobs, clearly marked, control reaction, sensitivity and aerial trimming. The dial aperture is a tiny square on top of the case above the tuning control and its calibration, from 0 to 180, has to be checked against the frequency scale marked on each coil-set. The three remaining coil-sets for the receiver are shown in front of it.

The MCR1 works from a special combined dry battery giving 90 volts h.t. and 7.5 volts for the valve filaments, or from a mains unit which can be seen at the left of the picture. The mains unit input is adjustable for operation from 107 to 235 volts a.c. or d.c., the a.c. power consumption being about 10 watts.

Throughout its useful range, which includes three amateur bands, this 35 year old receiver is very sensitive and the author was surprised by its low background noise and performance with s.s.b. signals. There are four terminals at the left of the set, two for low resistance headphones of about 170Ω, one for aerial, about 30ft. is recommended, and one for earth. The power is supplied through a fly lead terminated in a 4-pin plug, and the corresponding socket, identical to that provided on the battery, can be seen on the front of the mains unit.

SHORT WAVE NEWS
FOR DX LISTENERS

By Frank A. Baldwin

Times = GMT *Frequencies* = kHz

NOW HEAR THESE

From time to time it befalls our lot to walk into the shack at the most odd hours, switch on — and find that conditions for reception of this or that part of the world are at their best for many a long day — or night! From several such sessions recently the following loggings have emerged.

● LIBYA

"Radio of the Holy Qur'an" on **6206** at 1720, OM reading from the Holy Qur'an, such readings interspersed with classical music in the Arabic style. This is a transmission from the former pirate radio ship "Mebo II" moored off the Libyan coast. The schedule is from 0600 to 1800.

● JAPAN

Radio Japan on **9685** at 0700, musical chimes interval signal, identification in English followed by a newscast. This was a test relay from Sines, Portugal, the times of operation being from 0700 to 0715 in English and from 0715 to 0730 in Japanese.

● TAHITI

Radio Papeete on **15170** at 0415, OM in French, drums, marimba music, drums with YL chorus singing some lovely Polynesian melodies. A surprisingly strong signal for 20kW, heard and taped from 0415 through to 0435.

The parallel channel is **11825** where, at 0640, was logged the interval signal of flute and drum and OM in French. The former channel is however the better.

● BRAZIL

Radio Clube de Conquista, Vitoria de Conquista, on **3335** at 0143, local songs in Portuguese, local pops, identification at 0146 followed by more pops. A return to this channel at 0250 ascertained that they sign-off at 0255 without the National Anthem. The schedule is from 0900 to 0300 and the power is 2.5kW.

● BOLIVIA

Radio Alfonso Padilla Vega, Padilla, on a measured **3482** at 0150, OM with announcements in Spanish followed by local pops. The schedule is from 2215 to 0245 (Sundays 0200) and the power is 0.3kW. The frequency however can vary (nominal is **3490**) as can the schedule. In receiving this one the low power is only half the problem, the other half is the surrounding utility QRM.

AROUND THE DIAL

● CHILE

Radio Nacional de Chile, Santiago, on **15150** at 2154, songs and announcements in Spanish, guitar music, YL with local songs.

● CUBA

Havana on **15230** at 0847, YL and OM alternate with the French programme for the Mediterranean area, scheduled from 0830 to 0930.

● CZECHOSLOVAKIA

Radio Prague on **21660** at 1745, OM with the English programme (all about the Ethiopian Revolution) to Africa, scheduled from 1730 to 1830.

● HUNGARY

Radio Budapest on **17710** at 0410, OM with the DX programme in English to North America, scheduled from 0400 to 0415 in English on Wednesdays and Saturdays. Also to be heard in parallel on **6000, 6080, 6105, 9585, 9833, 11910** and on **15225.**

● ISRAEL

Jersualem on **15105** at 0500, OM with the world news in English and the local weather forecast (very hot in the Jordanian desert). This is the English programme for Europe, the Middle East, South and East Asia, North America, Australia and New Zealand, scheduled here from 0500 to 0515 and in parallel on **9835, 11655, 11960** and on **17710.**

Jersualem on **12077** (measured) at 1850, OM with a talk in Hebrew in the Domestic Service B Network to Europe, the Middle East, North Africa and Central America from 1815 to 2000 on this channel.

Jerusalem on **17630** at 1813, OM in Hebrew in a relay of the Domestic Service B Network in Hebrew to listeners abroad, scheduled from 0400 to 1740 and from 1815 to 2300 on this frequency.

Readers should note that frequency-usage is subject to change.

● IRAQ

Baghdad on **9745** at 1900, chimes, time-check and identification in Arabic followed by a newscast in the "Voice of the Masses" programme for expatriates.

ECUADOR

HCJB Quito on **15300** at 1903, choir with hymns in an English programme for Europe, scheduled here from 1900 to 2030 and in parallel on **11955**.

● ALBANIA

Tirana on **7065** at 1908, OM with a programme in Arabic for the Near East, scheduled here from 1900 to 1930 and in parallel on **9500**.

Tirana on **11985** at 0714, local music in the English programme intended for Australia scheduled here from 0700 to 0730.

Tirana on **11935** at 1205, YL with the Indonesian programme to South East Asia, scheduled here from 1200 to 1230.

● CLANDESTINE

"Voice of the Patriots" on **9650** at 1639, OM in Persian with a political talk. The daily schedule is from 1615 to 1645 but has been heard signing-off as late as 1650. Also heard on **11700** under R. Moscow. The transmitter is thought to be located in Libya.

● TURKEY

Ankara on **9665** at 1200, YL with news of Turkish affairs in the English programme intended for South West Asia, scheduled here from 1200 to 1300.

Ankara on **11800** at 0720, local music in the Turkish programme for Turks abroad, scheduled here from 0600 to 1700 daily.

● EGYPT

Radio Cairo on **17785** at 1625, OM with a talk about "Freedom-Fighters in Africa" in the programme intended for Zulus. This is daily programme, now in English, from 1600 to 1645 directed to Central and South Africa.

● ROMANIA

Bucharest on **11940** at 0710, OM alternate with YL in a talk on tourism in Romania in the English programme to the Pacific area, scheduled here from 0645 to 0715.

Bucharest on **17825** at 1210, OM with a newscast in English in the transmission scheduled here from 1200 to 1230 directed to Asia.

● MALAYSIA

Kuala Lumpur on **15295** at 0730, OM with announcements and identification followed by classical music (Mars from The Planets Suite etc.) in the English programme to South East Asia scheduled here from 0625 to 0855. Reader J. D. Court of Cannon Hill, Birmingham, Warks., brought this transmission to our notice, logging them at 0830, also notifying us of the following two stations which he has heard.

● NEW ZEALAND

Wellington on **15130** at 0500, time pips, OM with identification "This is Radio New Zealand" after a programme of light music. This is the Pacific Service scheduled here from 1800 to 0730. J. D. C. logged this one at 0520.

● AUSTRALIA

Melbourne on **15355** at 0516, YL announcer with programme of pops on records after station identification. The schedule is from 0001 to 0530 on this channel and the power is 10kW. J. D. C. heard this one at 0330.

● VIETNAM

Hanoi on **11750** at 1508, YL with the programme for Japan, scheduled from 1430 to 1530. Also logged in parallel on a measured **15009**, although this had changed some days later to **15008** when at 1740 they were in Vietnamese to Europe, scheduled from 1700 to 1800, and into the English transmission to Europe at 1800.

● U.S.S.R.

Radio Moscow on **11790** at 1800, OM in Russian in a relay of the Moscow 2nd programme "Mayak" ("Lighthouse"), scheduled here from 1800 to 1830.

Radio Moscow on **11630** at 1807, OM with the French programme to Africa, scheduled from 1800 to 1830.

Radio Moscow on **12000** at 2046, YL and OM alternate in English to Africa, scheduled here from 2000 to 2100.

Radio Moscow on **15455** at 2029, programme of jazz music in the Russian 5th programme "Voice of the Soviet Homeland" to Europe, scheduled here from 2000 to 2100.

● CHINA

Radio Peking on **6345** at 2240, OM in Chinese with the Domestic Service 2, scheduled here from 1243 to 1700 and from 2100 to 2400.

Radio Peking on **6665** at 2035, YL with the Domestic Service 1 programme, scheduled from 2000 to 1735 (not from 0500 to 0800 on Fridays).

● NETHERLANDS ANTILLES

Bonaire on **21640** at 1730, OM with identification, newscast in the Arabic programme to the Middle East and North Africa, scheduled from 1730 to 1820. A relay of Radio Nederlands.

● MADAGASCAR

Madagascar on **11730** at 1840, OM with the English programme to Africa, scheduled here from 1830 to 1920. Also a relay of Radio Nederlands.

In your work-shop

EXCLUSIVE—OR GATE

Looking inside CMOS

"Gosh," said Dick, "some of these CMOS digital i.c.'s haven't half got involved internal circuitry."

He leafed through a pile of CMOS manufacturers' technical data sheets which were lying on Smithy's bench, and gazed uncomprehendingly at their i.c. circuit diagrams.

"The more complicated i.c.'s," chuckled Smithy, seated alongside him, "do tend to get rather difficult. When the circuit gets too complex for individual f.e.t.'s to be shown, the manufacturers fall back on block diagrams using boxes. But you can still find individual f.e.t.'s shown in the simpler i.c. circuits."

He drank deeply from his disreputable tin mug.

"Even the ones which don't use boxes still baffle me," sighed Dick. "The diagrams have got field-effect transistors crawling all over them."

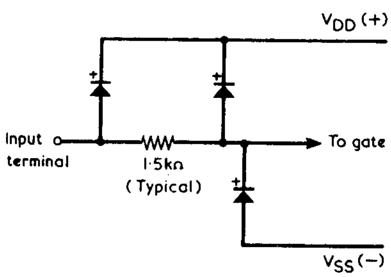


Fig. 1. CMOS digital integrated circuits have a protection circuit between each insulated gate and its input terminal. The protection circuit is omitted in diagrams showing internal CMOS circuitry

"Most of them are quite simple once you start analysing them," said Smithy. "Indeed, to my mind CMOS i.c. internal circuits are a whole lot easier than the old t.t.l. ones. Apart from the input protection circuits, which normally use three diodes and a resistor to prevent excessive voltages reaching each f.e.t. insulated gate, the working circuits of these i.c.'s consist of nothing else but the f.e.t.'s themselves. No resistors or diodes or anything else like that, just f.e.t.'s all interconnected together." (Fig. 1.)

SINGLE F.E.T.

"They still baffle me," stated Dick gloomily. "To begin with, some of the f.e.t.'s are shown with the letter 'N' alongside them, whilst others have the letter 'P'. What do these letters mean?"

"They indicate the type of channel the f.e.t. has," replied Smithy. "Look, I'll show you the set-up for an n-channel f.e.t."

Smithy put down his mug, reached over for his note-pad and took a ball point pen from his overall jacket pocket. Quickly, he sketched out a basic diagram for an n-channel f.e.t. (Fig. 2.)

"This is all elementary stuff," he went on, "and so I don't want to spend too much time on it. What I've drawn here is an insulated gate n-channel f.e.t. with its source going to the negative supply rail and its drain going to the positive rail. There's a thin channel of n-type silicon material between the source and the drain, and this is physically supported on a backing substrate of p-type silicon. When the gate is at the same negative potential as the source it repels the flow of electrons along the channel, with the result that no current can pass between the source and the drain, and the channel acts as though it is an extremely high resistance. If, on the other hand, the gate is taken positive, electrons are encouraged to flow along the channel and a current passes between the source and the drain. This time the channel behaves like a low value resistor."

"That seems fair enough," conceded Dick. "But what about the p-type substrate? Doesn't that have any effect on the electrical working of the f.e.t.?"

"It won't have if the substrate is connected to the negative rail," replied Smithy. "You then get what is effectively a reverse-connected p.n. diode between the substrate and the source, and current can

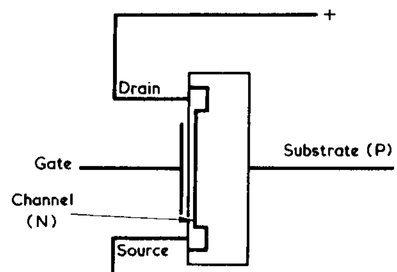


Fig. 2. Diagrammatic presentation of an insulated gate n-channel f.e.t. The drain and source areas are highly doped n-type regions

only flow in that diode if, as in any other silicon p.n. diode, the p. part is 0.6 volt or more positive of the n. part. When the substrate is connected to the negative rail that just can't happen. Okay?"

"I think so," said Dick dubiously, "but the f.e.t. symbols in these CMOS circuit diagrams still confuse me. For instance, they don't mark the source or the drain in any recognisable way, and there is a third gubbins in between the two, with an arrow on it."

Smithy drew a circuit symbol on the pad. (Fig. 3(a).)

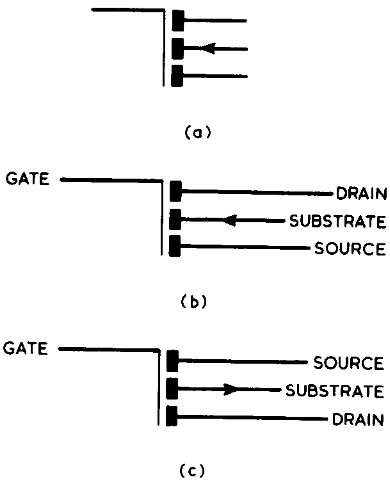


Fig. 3(a). Typical f.e.t. symbol, as encountered in CMOS i.c. diagrams
(b). The symbol is for an n-channel f.e.t.
(c). In a p-channel f.e.t. symbol the substrate arrow points outwards

"Is this the sort of thing you mean?"

"That's right."

"Well," said Smithy, "what I've drawn is the symbol for an n-channel f.e.t. as used in a CMOS integrated circuit. I'll mark up the parts for you."

Quickly he added the names of the symbol electrodes. (Fig. 3(b).)

"As you can see," he went on, "the long thin line represents the gate, and the two outside bars facing up to it are the source and the drain. The device is actually symmetrical, but it's usual to assume that the bar which connects to the f.e.t. output is the drain. The middle bar represents the substrate and, with n-channel f.e.t.'s, this has an arrow pointing inwards, just like the emitter arrow of a p.n.p. transistor. All we have to remember with an n-channel f.e.t. is that the channel acts like an extremely high resistance when the gate is at the same potential as the source, and that it acts like a low value resistance when the gate is taken positive. With CMOS digital f.e.t.'s the gate is taken positive right up to, or very close to, the positive supply rail."

"There's another type of f.e.t. in these circuits," said Dick. "But this time it's got the substrate arrow pointing outwards."

Smithy drew a further f.e.t. symbol (Fig. 3(c).)

"Here's what you're talking about," he remarked. "This one is a p-channel f.e.t., and it works in exactly the opposite manner to the n-channel f.e.t. The source normally goes to supply positive. The p-type channel exhibits an extremely high resistance when the gate is at the same potential as the source and a low resistance when the gate is taken negative. The substrate arrow points outward, like the emitter arrow of an n.p.n. transistor. The channel is p-type this time, of course, whereupon the substrate is n-type."

Smithy picked up his mug, drank appreciatively and beamed at his assistant benignly.

INVERTER

"Don't tell me," snorted Dick aggrievedly, "that you're just going to leave things at this point?"

"Why not? It's my lunch break and I've already spent part of it explaining the two types of f.e.t. to you. What more do you want?"

"How about showing me how some of these CMOS digital i.c. circuits work?"

"Very well then," said Smithy resignedly. "I'll start off with an easy CMOS circuit, which is that for a CMOS inverter. But before I begin I'd better introduce a few terms. CMOS logic is positive logic, in which the figure 1 is represented by a high voltage and the figure 0 is represented by a low voltage. With CMOS the high voltage is at or very near the positive supply rail and the low voltage is at or very near the negative supply rail. When talking about these voltages it is a good idea to simply refer to them as 'high' or 'low' respectively. It also helps to refer to the individual f.e.t.'s as 'transistors', which is how they're usually described in the manufacturers' data sheets. Let's draw that inverter now."

Smithy picked up his pen and rapidly sketched out the circuit of the inverter. (Fig. 4.)

"There doesn't seem to be much in that circuit," stated Dick, staring critically at Smithy's notepad. "Just a p-channel f.e.t. — sorry, transistor — at the top, and an n-channel transistor at the bottom."

"Exactly," confirmed Smithy. "In fact, that's the beauty of CMOS i.c. circuitry. Everything is so clean and uncluttered with one transistor connecting directly to another. As

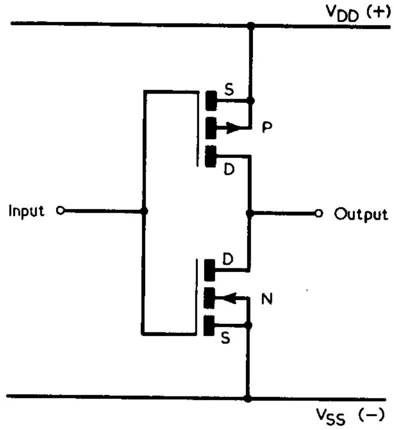


Fig. 4. A CMOS inverter. Its output is low when the input is high, and vice-versa

you can see, the input terminal goes to the two gates. What happens if that input is high?"

"Well," said Dick slowly, "the gate of the p-channel transistor will be at the same voltage as its source, and there'll then be a very high resistance between its source and its drain. The gate of the n-channel transistor will be positive of its source and so the n-channel will show a low resistance."

"Putting it another way," stated Smithy, "we can say that the p-channel transistor is turned off and the n-channel transistor is turned on. What will the output be? Remember that the output is only intended to connect to the gates of other CMOS transistors, which draw virtually zero current."

"Then," said Dick, "the output will be low, right down at the negative rail. Let's next see what happens if we take the input low. This will turn off the n-channel transistor and turn on the p-channel transistor. So the output will be high?"

"It will be," confirmed Smithy. "To sum up, the inverter gives a low output when its input is high, and a high output when its input is low. Which is precisely what it's supposed to do. Now, if you'll just be so good as to fill my mug again, I'll sort out a more man-sized CMOS circuit for us to look at."

Obligingly, Dick took Smithy's mug and carried it over to the battered tea-pot at the Workshop sink. Smithy picked up the data sheets and looked through them carefully. He stopped at one of the sheets, examined it more closely, then drew it out and placed it on his bench as Dick returned with the replenished mug.

"Is that the circuit you're going to talk about?"

"It is," responded Smithy. "What I've got here is the data sheet for the quad exclusive-OR gate type CD4030. It's quite an interesting and unusual device, and it takes us fairly close to the level of complexity at which manufacturers start showing the internal circuits of CMOS i.c.'s with blocks instead of individual transistors. It also introduces another manner in which individual CMOS transistors may be turned off."

"Exclusive-OR," repeated Dick musingly. "How does that differ from an ordinary OR gate?"

"With an ordinary OR gate," said Smithy, "the output is high, or is at 1, when any one or more of the inputs is high. With an exclusive-OR gate, the output goes high only when one of the inputs goes high. The CD4030 gate has two inputs and if both of these go high the output goes low." (Figs. 5 and 6.)

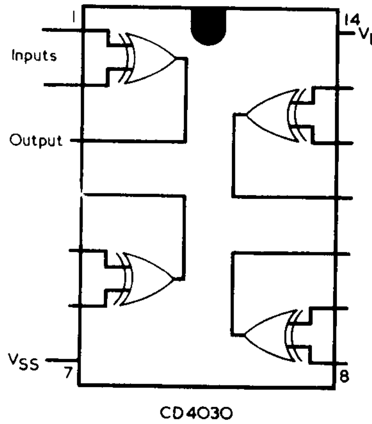


Fig. 5. The CD4030 has four 2-input exclusive-OR gates

"I see," said Dick reflectively. "You talked just now about another method of turning off CMOS transistors. What's that, Smithy?"

"It's a very simple and obvious point," responded Smithy, "but it's one you have to keep in mind if we're going to discuss this exclusive-OR gate. Now, we already know that an n-channel transistor turns off when its source is low and its gate is low. The n-channel transistor will be even more turned off, as it were, if its source is high and its gate is low." (Fig. 7(a).)

INPUT A	INPUT B	OUTPUT
0	0	0
1	0	1
0	1	1
1	1	0

Fig. 6. Truth table for one of the CD4030 gates

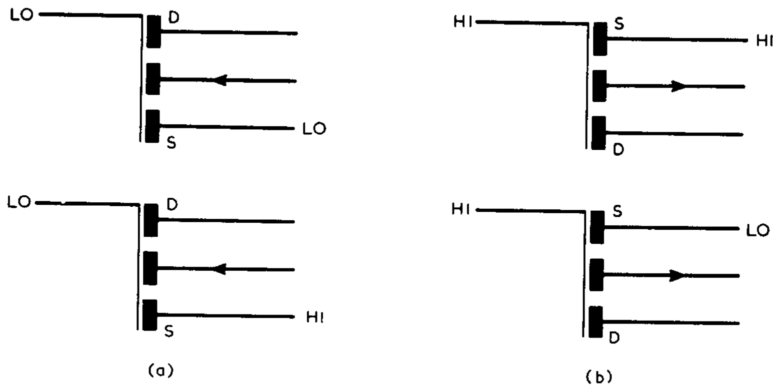


Fig. 7(a). An n-channel transistor is turned off when its source and gate are low. It is also turned off when its source is high and its gate is low
(b). A high voltage on the gate and source of a p-channel transistor turns it off, as also do a low source voltage and a high gate voltage

"What you mean," said Dick, "is that the gate is then negative of the source, whereupon it will offer even more repulsion to electrons in the channel."

"That's right," confirmed Smithy. "And a p-channel transistor gives the opposite effect. It is turned off if its source is high and its gate is high, and it is turned off also if its source is low and its gate is high." (Fig. 7(b).)

"That seems to make sense to me," commented Dick. "Now lead me to that CMOS circuit!"

"I'll do that in just a moment. But first I want to stay with these transistors when they're turned off in the second manner. There's no proper technical term for the condition but the benefit of our present little natter I'll refer to them as being 'reverse-biased'."

"Okay," said Dick impatiently. "Now, what about that circuit?"

EXCLUSIVE-OR GATE

Smithy passed the data sheet over to Dick, then proceeded to sip his tea as his assistant gazed at the gate circuit. (Fig. 8.)

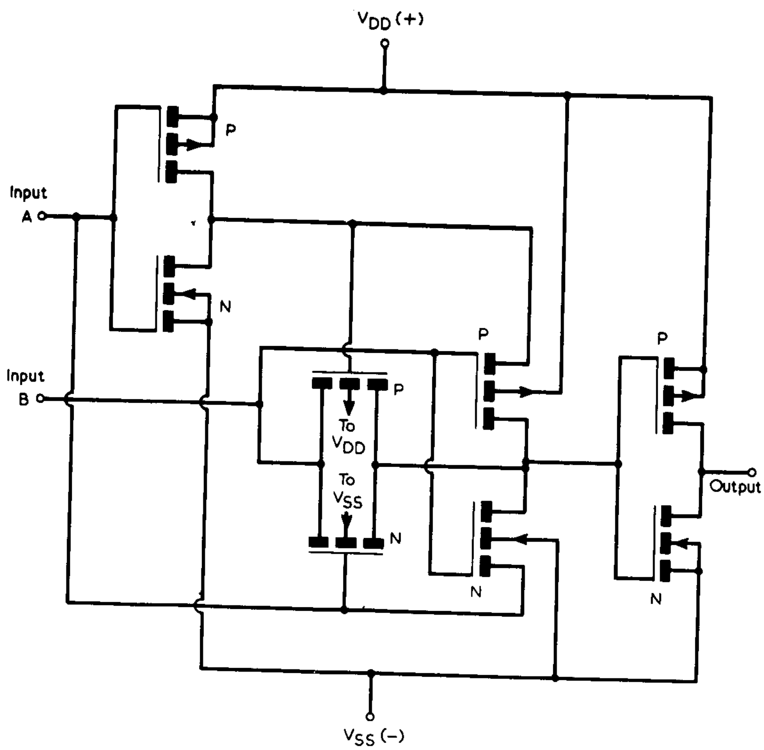


Fig. 8. The internal circuitry of one of the gates in the CD4030

"Ye gods," moaned Dick eventually. "I'll never get to grips with this. It doesn't make sense to me anywhere."

"Come on," snorted Smithy irritably, "you can't be as myopic as all that. There are two sections in the circuit which we've already talked about during this lunch break."

"Blimey, are there? Why, stap me, so there are!" said Dick excitedly. "There's one two-transistor inverter at the top left, immediately after the upper input terminal, and there's another two-transistor inverter at the bottom right, just before the gate output. Well, that makes things a bit easier, doesn't it?"

"It certainly does," agreed Smithy, "because it enables us to draw a simplified circuit straightaway using two inverter symbols. Things will also become easier if we draw the transistors without the substrates, since they play no part in circuit operation. That leaves us with just two inverters and four transistors, and these can be numbered TR1 to TR4."

Smithy tore off the top sheet of his note-pad and carefully sketched the simplified circuit. He then entered the voltage states which existed with both inputs A and B low. (Fig. 9(a).)

"That circuit looks a lot more digestible now," commented Dick. "What are you going to do next?"

"I'm going to go through circuit operation when both the inputs are low," replied Smithy. "With the upper input low, the output from the inverter at the top left will then be high. Let's look first at TR2. Its source is low and its gate is low, so this transistor is turned off. Similarly, the source of TR4 is low and its gate is low, and this transistor is turned off, too. The source of TR1 is low and its gate is high so this transistor is not only turned off but it's reverse-biased as well."

"That leaves only TR3," put in Dick. "Its source is high and its gate is low and so it must be turned fully on. Since all the other transistors are off, the drain of TR3 must be high. The drain connects to the second inverter at the right, whereupon the output of that inverter will be low."

"That's it," agreed Smithy, crossing out the voltage indications in his circuit, and inserting new ones. "Let's try out the system with both inputs high." (Fig. 9(b).)

"Righty-ho," said Dick eagerly. "Well now, the source of TR3 is low and its gate is high, so this transistor is reverse-biased. The source of TR1 is high and its gate is low, so TR1 is turned on and its drain will be high."

"Correct," said Smithy. "Which means that, if the circuit is to work, TR2 and TR4 must be off. And they are, too. Both the source and gate of TR2 are high, and both the source and gate of TR4 are high. In fact, all *three* electrodes of both these transistors are high so that not only are they cut off but there's no source-to-drain voltage to cause current to pass through them anyway."

"Let's see what happens," said Dick keenly, "when the top input is high and the bottom input is low." (Fig. 9(c).)

"All right," agreed Smithy equably. "We'll first find the transistor that's turned on. Ah yes, it's TR2 this time. Its source is low and its gate is high, so its drain must be low as well. This makes all three electrodes of TR1 low. The same happens with TR3. The source of TR4 is high and its gate is low and so TR4 is the reverse-biased transistor. The low output from TR2 goes into the second inverter, which makes the gate output high. Right, there's only one other combination left, and that's where the top input is low and the bottom input is high." (Fig. 9(d).)

"Well," said Dick, looking at Smithy's diagram. "If the top input is low and the bottom input is high, the fully turned on transistor must be TR4, because its source is low and its gate is high."

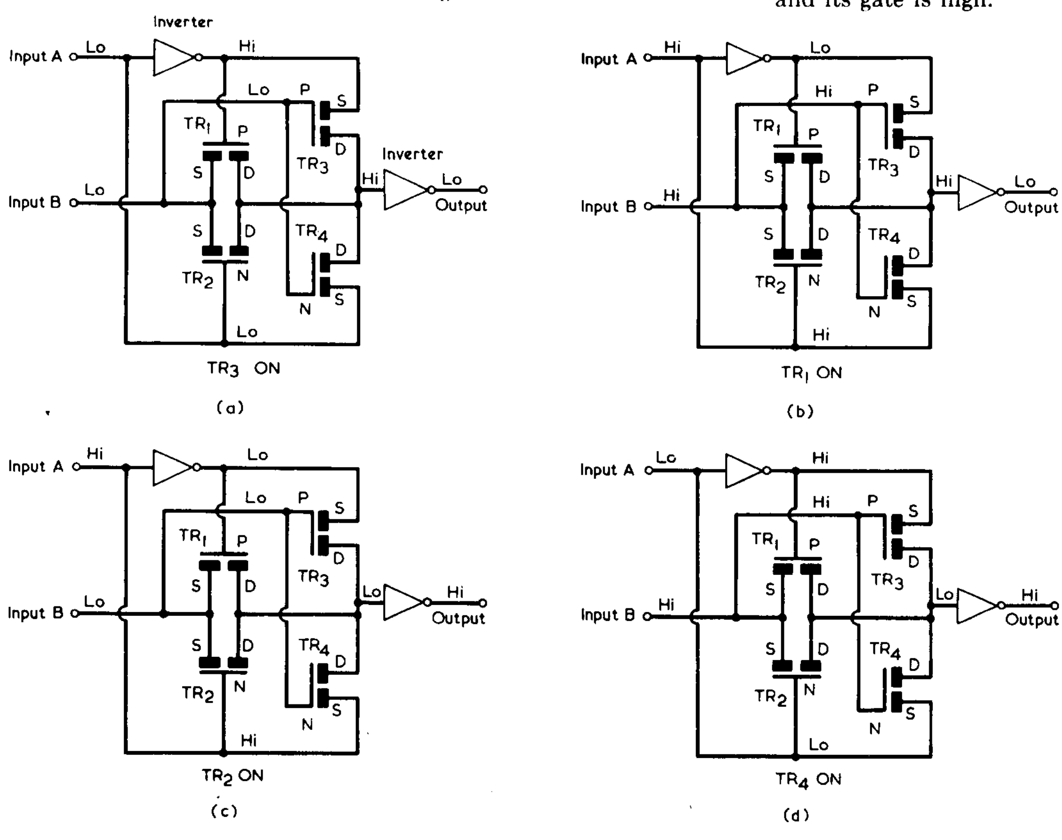


Fig. 9(a). Simplified version of the CD4030 gate circuit with substrates omitted. Here, the two inputs are low
(b). Circuit conditions with both inputs high
(c). When input A is high and input B is low the output is high
(d). The final possible combination of input voltages also causes the output to go high

"Right," chimed in Smithy. "Now, the source and gate of TR3 are both high, and so TR3 is turned off in normal fashion. So also is TR1, which has both its gate and source high. All that's left is TR2, and this is reverse-biased with its source high and its gate low. The low output from TR4 drain is then converted to a high by the second inverter. And that's the lot! This exclusive-OR circuit functions just as it's supposed to do. Its output is low when both inputs are low and when both inputs are high. The output only goes high when one of the inputs is high and the other one is low."

FINAL POINTS

Smithy reached for his mug and took a prodigious draught of tea.

"You were certainly right," remarked Dick, "when you said that this was an interesting CMOS circuit."

The Serviceman put down his mug and wiped his mouth with the back of his hand.

"It's an unusual circuit, too," he commented, "because it has to deal with four input combinations. However, the main point of today's exercise has been to demonstrate that it's possible to look *inside* a CMOS i.c. and see what's happening there. Far too often we look upon these integrated circuits as little magic boxes with pins neatly spaced at 0.1 inch intervals, and we don't realise that what goes on inside them can be explained in terms of ordinary discrete component circuitry. CMOS digital circuitry is particularly easy because you just have to think in terms of voltages which are high or low."

"In other words," stated Dick quickly, "you can get the low-down on CMOS without high-blown and high-faluting hypotheses about hybrid voltage and current operation."

Smithy turned and looked at his assistant gravely.

"That," he remarked, "is pretty well the high and low of it." ■

BREADBOARD '78

Breadboard '78, described as the kits and bits show for the home electronics enthusiast, is to be held at the Seymour Hall, Seymour Place, London W1, from 21st to 25th November, 1978.

This first show solely for the home electronics enthusiast has certainly fired the interest of exhibitors and the exhibition is sold out.

A lively programme of demonstrations will accompany the show and in various rooms around the main exhibition, visitors will be able to build and play electronic organs, assemble microprocessors and personal computers and try their hand at all manner of d.i.y. electronic projects ranging from computerised musical doorbells to t.v. games.

Visitors also stand a chance of winning valuable prizes in competitions being run by exhibitors. A major competition offers a grand prize of a SCAMP microprocessor kit and daily prizes in other competitions will bring the total value to more than £1,000.

The organisers, Trident Conferences and Exhibitions Ltd, are already receiving enquiries on visiting the show from both the UK and the Continent. Many are planning coach trips to the exhibition and there is considerable interest in the fact that this is an electronics market place where the enthusiast who sees just the component or kit he needs, will be able to hand over his money and take it home.

The Seymour Hall is situated approximately half way between Marble Arch and Baker Street, and is near the Edgware Road. For further stations see advertisement on page 134.

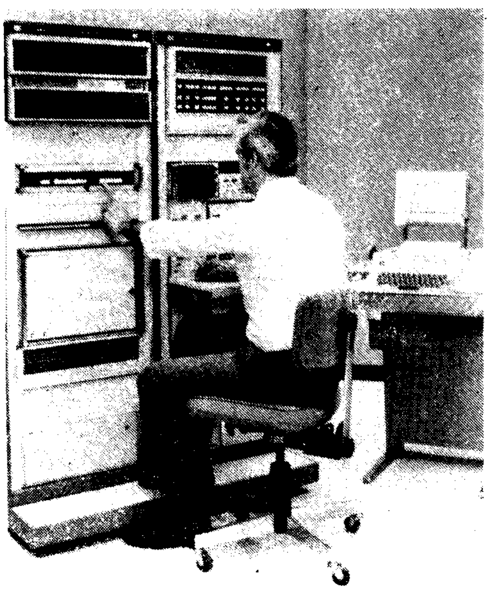
FOURIER SIGNAL ANALYZER

By

Michael Lorant

New, highly complex machine handles numerous random signal studies.

Hewlett Packard in the United States has developed a new and improved Fourier Signal Analyzer, the Model 5451B. Compared with previous models this has a transform speed which is eight times faster, a greater real-time bandwidth and accommodation for more inputs. A new software system exploits the microprogramming capability of the analyzer's minicomputer and eliminates hardwired processors in almost all situations.



An overall view of the new Hewlett Packard Fourier Signal Analyzer. This has an exceptionally wide range of applications, including the investigation of random machine vibration

Fourier analyzers are widely used to solve problems in mechanical vibration, in signature analysis, modal analysis, impact testing, noise source detection, underwater acoustics, servo testing, communications and filter design. They can also digitally implement a unique algorithm, the Fourier Transform, to convert time-domain signals into the frequency domain where they can be more readily analyzed.

Real-time power spectrum analysis is possible with the new Analyzer up to 3,000Hz. It includes a two-channel analogue-to-digital converter pre-wired for the addition of two more channels. With full analogue-to-digital capability, four channels of data can be simultaneously digitized, each to a bandwidth of 100kHz.

0.1% accuracy and 80dB dynamic range are maintained by using double-precision arithmetic. Auto and cross power spectral density, together with transfer and coherence function analyses are easily obtained. Other time and frequency domain techniques and statistical procedures are incorporated, these including convolution, auto and cross correlation, amplitude histogramming and windowing. The system acquires data, stores, analyses and displays it, having a 2100S Microprogrammable Systems Computer with 16K of core memory, direct memory access, extended arithmetic unit, floating point hardware and power-fail auto restart.

An array of computational functions and system operations can be called forth by a push-button keyboard with function related keys. Frequently used sequences can be stored and automatically executed any number of times. No software programming knowledge is required to operate the system.

A display control unit provides a flexible means of viewing signals, both during acquisition and after processing. Signals or measurement results can be viewed either in the time or frequency domain with linear or log coordinates, or in rectangular or polar modes. The display is always calibrated, and vertical calibration information is displayed visually.

Over fifty standard peripherals can be added to the base system to expand its capabilities. These include additional core memory, magnetic tape subsystems, disc subsystems, analogue output subsystems and analogue or digital plotter subsystems. ■