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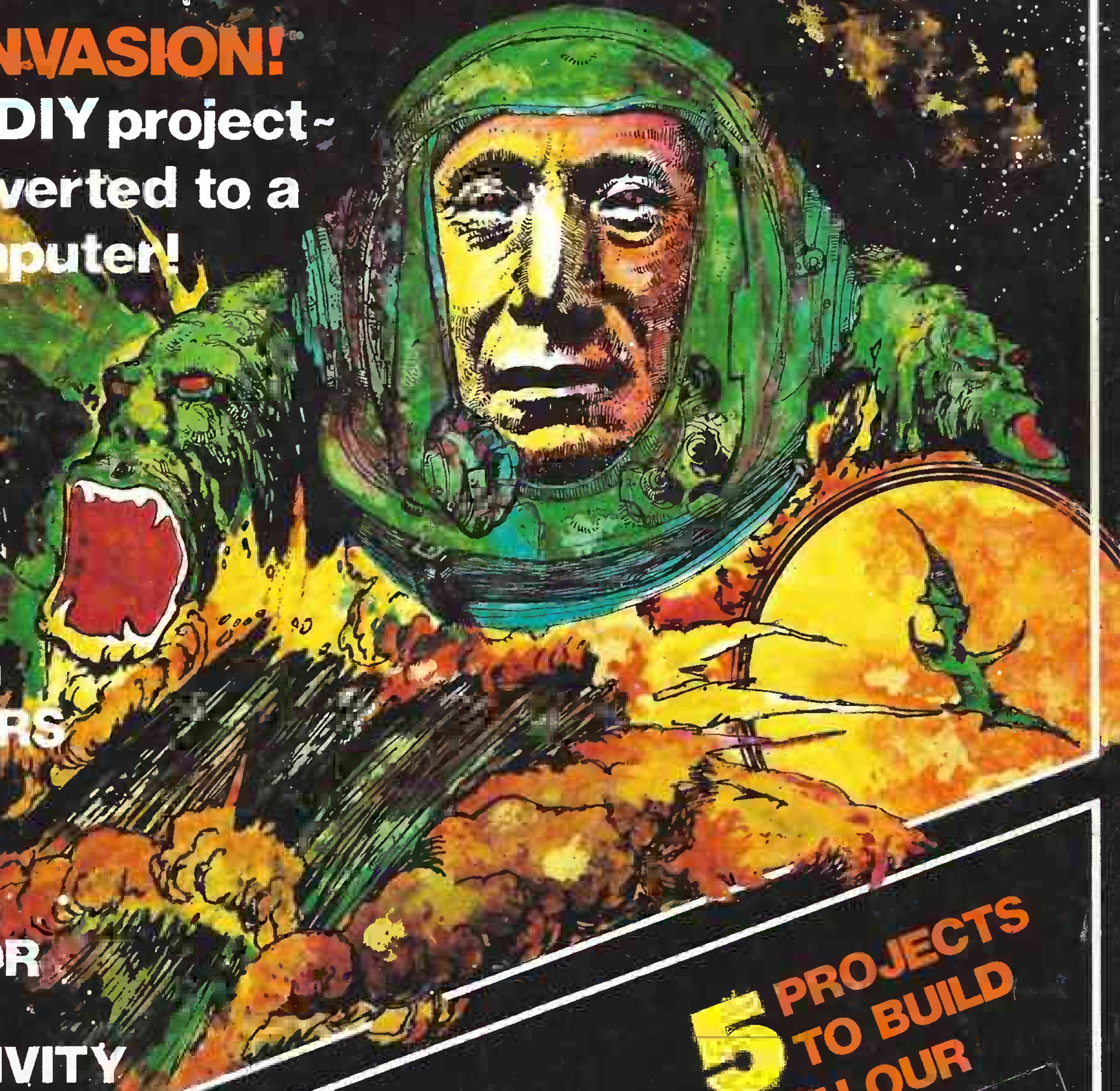

SPACE INVASION!
First ever DIY project – easily converted to a home computer!

DMMs AT HOME
A market survey

DESIGNING REGULATORS

VERSATILE TEST OSCILLATOR

RADIOACTIVITY EXPLAINED

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INSIDE:

WORTH £1!

. . .NEWS. . . .PROJECTS. . . .MICROPROCESSORS. . . .AUDIO. . .

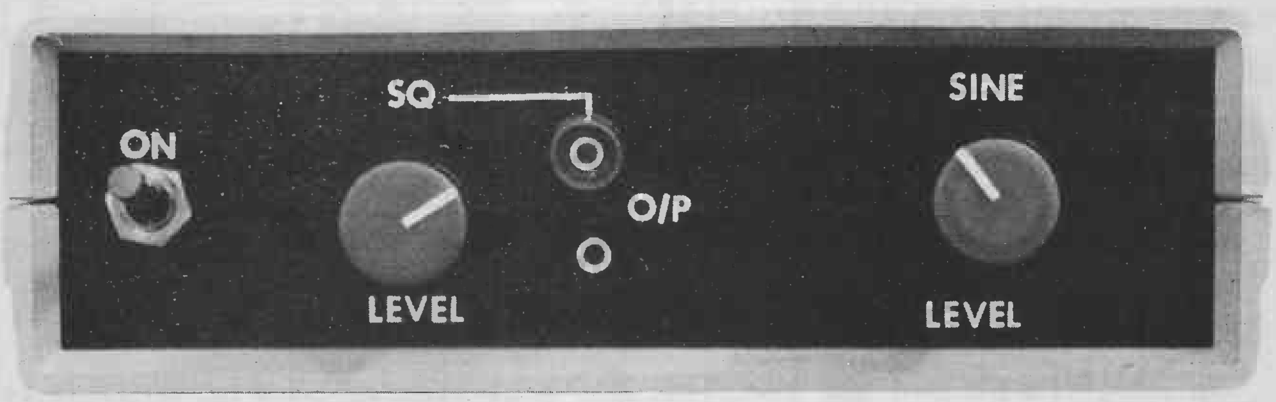
AUDIO OSCILLATOR

A testing time for ETI. This unit features sine and square outputs, from 30 Hz to 60 kHz, each with its own level control. Circuit design by Ray Marston. Project development by Steve Ramsahadeo.

Good quality sine/square generators, giving very low sine/wave distortion, are invaluable pieces of test gear but tend to be rather expensive. For the vast majority of practical applications, such as gain and frequency response testing, function checking and sound generation, etc, the expensive 'very low distortion' sine wave characteristic is, however, superfluous, since distortion factors up to several percent are quite acceptable in such applications.

With these points in mind, we've set out to design a really inexpensive and easily built, but genuinely useful, sine/square generator. Our generator covers the frequency range 30 Hz to 60 kHz in three switch-selected bands. Sine and square outputs are simultaneously available, each with their own independent level controls.

Automatic sine wave amplitude regulation is achieved in the circuit via a pair of back-to-back zeners in a control loop. This method of regulation is very inexpensive but has the great advantage of enabling range-sweeping to be achieved without amplitude bounce. Sine wave output distortion is typically less than 5% over most of the frequency range.



Construction

The circuit is very simple and construction should present few problems. We decided to construct our prototype unit as a miniature 'squirt box', with an uncalibrated frequency dial. If you decide to follow our method of construction, note that we have fitted the two frequency controls (RV1 and SW1) and the sine wave output terminals to the front panel of our unit and all remaining controls (RV3, RV4 and SW2) and the square wave output terminals to the instrument rear panel. Our unit is powered by two PP3 batteries.

Whatever form of construction you decide to use, note that timing capacitors C1-3 should all be 5% or better types and that RV1 should be a good quality stereo pot, with good tracking between its two halves. Failure to fit a good pot will result in a lousy sine wave output.

When construction is complete, switch the unit on, monitor the sine wave output on a 'scope and adjust RV2 to give the best possible output over the full operating range of the instrument. If you have any problems in obtaining top range oscillation, try altering the value of C4. When RV2 is correctly set, typical sine wave distortion will be less than 5% over most of the frequency range.

When using the generator, note that the '2 V' sine wave output terminal is intended for driving high impedance loads only. If this output is loaded by less than 10k or so the output will become severely distorted under maximum output conditions, due to the very limited drive capability of IC1. The '200 mV' and lower output ranges do not suffer from this loading restriction.

HOW IT WORKS

The heart of the unit is the Wien bridge oscillator designed around IC1. The Wien network comprises a series of C-R network (R1-RV1a and C1a/C2a/C3a) and a parallel C-R network (R2-RV1b and C1b/C2b/C3b) connected in series. Input signals are applied to the top of this network from the output of IC1 and the output of the network is applied to input pin 3 of IC1.

The main feature of the Wien network is that the phase relationship of its output to input signal varies from -90° to $+90^{\circ}$ and equals zero only at a certain 'centre' frequency ($f = 1/6.28CR$). At this centre frequency the network is precisely symmetrical. Thus, the Wien network can be used as the basis of an oscillator by connecting a non-inverting amplifier with a gain equal to the Wien loss factor between its input and output, as in our design.

In our circuit, automatic gain control is obtained by wiring the ZD1-ZD2-RV2-R3-C4 gain-setting potential divider between the op-amp output and pin 2. When RV2 is correctly adjusted, this network maintains the output amplitude of the IC1 signal virtually constant (at about 2 V RMS) over the entire frequency range of the unit (30 Hz to 60 kHz) and results in a typical distortion factor of less than 5% on its sine wave output. The amplitude of the final sine wave output signal is variable via RV3 and the simple R4-R5-R6 attenuator network.

The direct sine wave output of IC1 is fed, via R7, to the input of IC2. This IC is wired as a simple voltage comparator and converts the sine wave input signal to a square wave output. The amplitude of the final square wave output is variable via RV4.

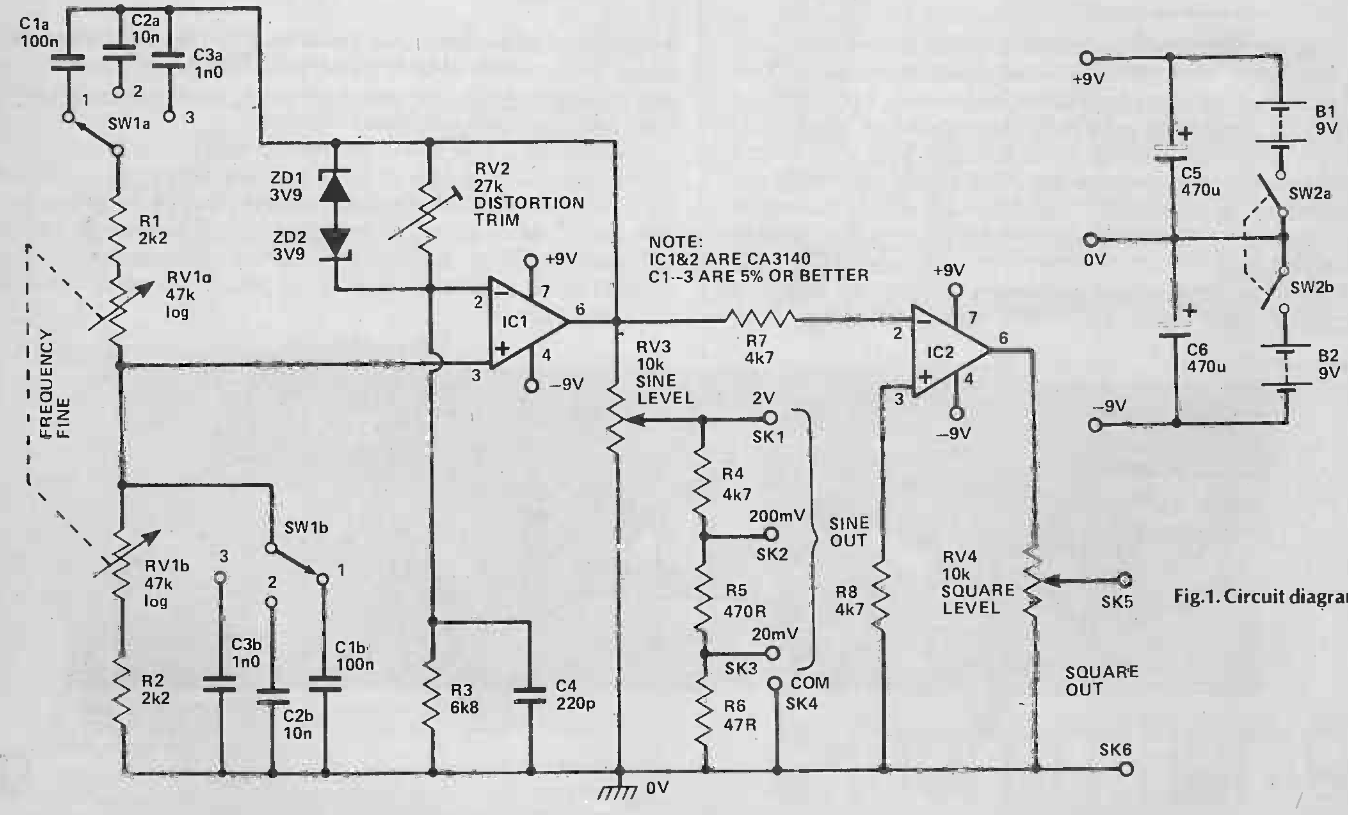
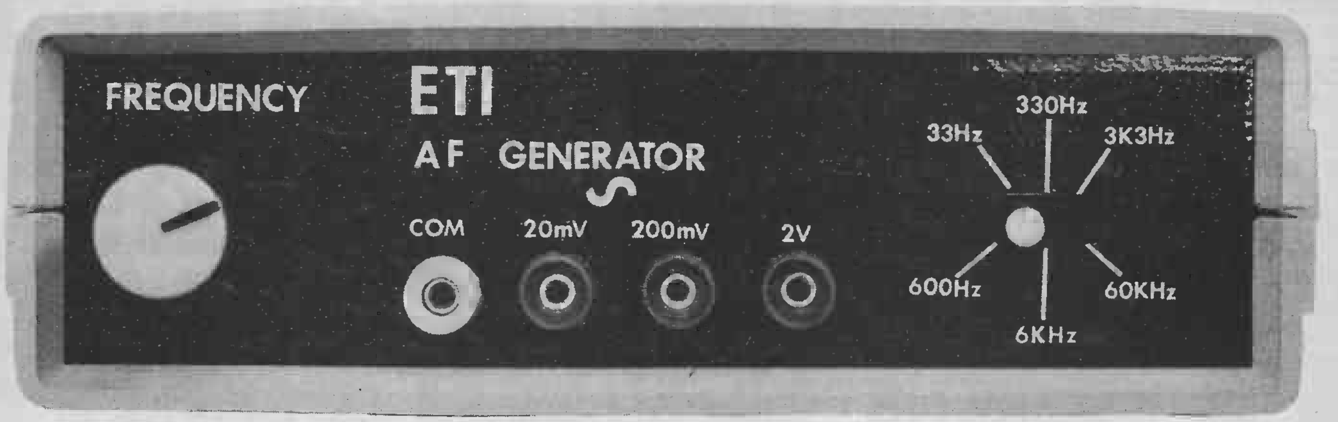


Fig.1. Circuit diagram.



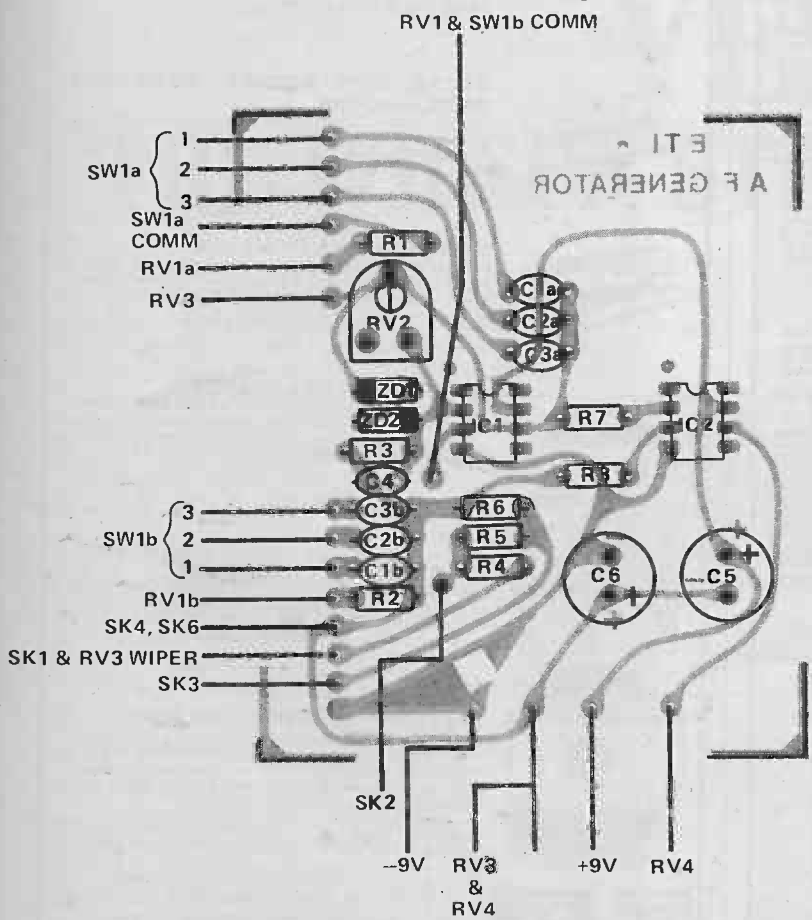
A simple front panel layout for ease of operation.

BUYLINES

There should be no problems in obtaining any of the components used in the AF generator as all are common types.

The case we used for the project is available from O.K. Machine & Tool Ltd. Order as CM5-125. Phone 0703-610944.

Fig.2. Component overlay.



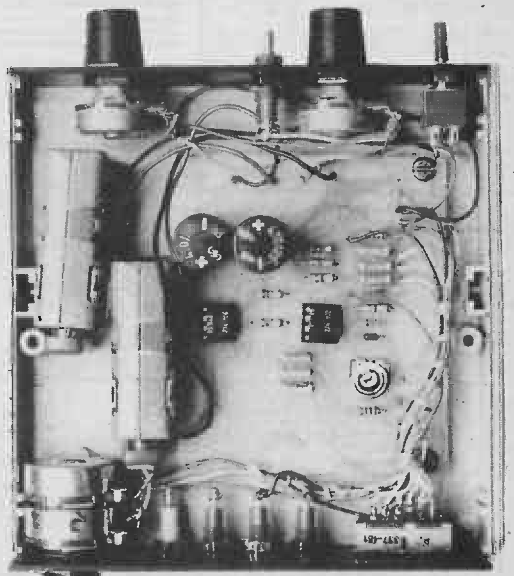
PARTS LIST

AF Generator

Resistors all ¼W 5%	
R1,2	2k2
R3	6k8
R4,7,8	4k7
R5	470R
R6	47R
Potentiometers	
RV1	47k logarithmic dual gang
RV2	22k horizontal miniature
RV3,4	10k linear
Capacitors	
C1a,b	100u 5% polycarbonate
C2a,b	10u 5% polycarbonate
C3a,b	1u0 5% polycarbonate
C4	220p ceramic
C5,6	470u 25V electrolytic PCB type
Semiconductors	
IC1,2	CA 3140

Miscellaneous

SW1 2 pole 3 position slide switch, SW2 DPDT miniature toggle, SK1-6 to suit, case (see Buylines), PCB.



Construction is straightforward as you can see. With the PCB installed, there's more than enough space left for batteries.

ETI

AUDIOPHILE

Disguised as Father Christmas, Ron Harris presides over our Sony competition Prize Day, finds a sticky mat to play with and casts a critical eye over a budget box of tricks.

Competition results time again. A few Audiophiles ago I ran that appalling, tasteless and thoroughly despicable Sony publicity photo for the 'Stowaway' portable tape player and asked for your captions . . . As usual you did not disappoint me. Six million pieces of paper later I think we have a winner. Well, almost. In fact, *two* winners, as I was unable to make up my mind between two very witty submissions.

Mr B. D. Barrett of Pickering, Yorkshire and C. R. Thorn of Gloucester (who did not bother to define gender more closely) are, therefore, declared joint 'Wit of the Month' and duly rewarded a year's subscription to ETI. Anyone who thinks second prize is two year's subscription to ETI had better leave now, lest he lose his vitals.

There were many more worthy attempts, but by far the most popular line was "O.K. Scotty, beam us up" which lost by sheer weight of numbers! I have given a few of the better efforts below, the winners first:-

Left: the great Sony picture show which started all this lunacy.

Joint Winners: "Are you *sure* this will stop me getting pregnant?" Mr R.D. Barrett, Pickering

"Darling — I know it's cheaper than a choir, but this *is* our wedding . . . " C. R. Thorn, Churchdown

Also worth an honourable mention or three:

"His equipment is so tiny . . . but I love the performance". Mr J Wakewell, Shirley, Surrey.

"Here — can *you* do this with your thumb?" Un-named of Maidstone. (Blew it, didn't you?)

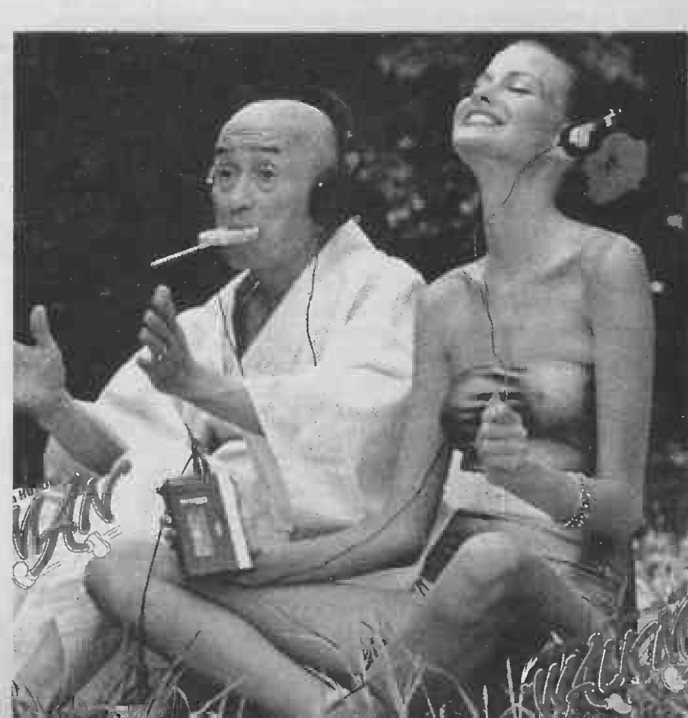
"So this is where you keep the spare batteries . . .". J. Clarke, Sutton Coldfield.

"Darling are you sure your pacemaker's working O.K.?" S. McKinty, Co. Down.

"Step two: place your right hand on your partner's left . . ." P. Skinner, Derby

A final chord in this symphony of corn and photographic pap. Just to prove that PR agencies are capable of exhibiting bad taste on a worldwide scale, I reproduce below the hand-out photos for the Stowaway from Japan and the USA . . .

No words of mine could do them justice, therefore — no comment.



On The Mat

Following on from last month's review of the Thorens TD160S turntable, I have more news of the 'conversion' kit to upgrade other models to a similar performance. Similar, but not equal. It seems that most

Thorens conversion kit includes self-adhesive damping material to improve the sub-chassis behaviour under resonant conditions. A new arm-board and turntable mat is also included.

of the changes to the standard 160 which were made to create the 160S are the brainchild of Cambrasound (a merged version of Metrosound and Cambra International) Thorens UK importer.

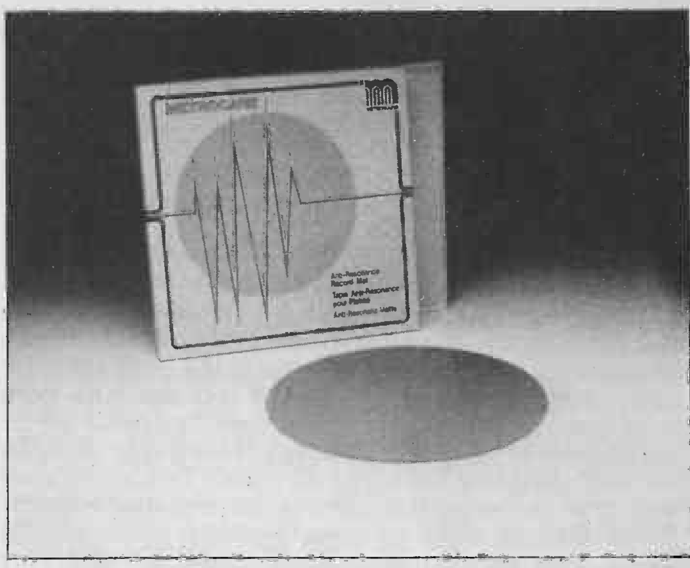
One point of difference exists, however, over the turntable mat. Thorens went their own way and produced a very heavy and sensible specimen which resides in the 160S production model. Metrocare have their own mat — and it is this that is included in the conversion kit. As this item is marketed separately, as a general application turntable mat, I thought it worth a closer look.

It is formed from a silicon elastomer, which is virtually 100% pure polymer. That description makes about as much sense to me as the Arabian Daily News. The material has a very high surface tension — higher on the face which will be in contact with the turntable.

Practically this means it is "sticky" to the touch and bonds very well to the metal surface. The record is effectively held across its entire surface, with no room for air gaps.

Resonant Peaks

Metrocare claim the biggest benefit lies in the reduction of those resonances which are inherent in all cast platters and cite an improved upper-bass and mid-range reproduction as the audible return for the £16.75 retail price.



Above: the very persistent Metrocare turntable mat, as fitted to the Thorens conversion kit, but not to the production 160S decks. A very high surface tension endows it with considerable LP holding qualities.

Because of the mat's amazing ability to hold dust, the Metrocare must be kept clean — and the deck covered at all times when not in use. Removing records from the mat has to be done carefully as the bonding is not just good, it is excellent. LPs are somewhat loathe to leave.

Having tried the Metrocare on a few decks, including the TD160S, I can confirm that is is indeed a worthy effort. Compared to Thorens' own creation it displays an improved mid-range and tighter control of the bass. Subtle changes, but clearly audible nonetheless. I cannot understand why Thorens would not accept the whole of the advice offered, and fit Metrocare to the TD160S production model. Swiss independence, I suppose. Ah well.

Trying the Metrocare on other decks, including some budget machines, suggested that it has much to offer most hi-fi users in that an audible improvement was obtained on all the decks we dropped it on. It is probably the only one of these "super-mats" that can claim such universal application. →

Above: the Trio KA300 budget amplifier. The appearance is certainly striking and bereft of superfluous controls. Loudness could have been disposed of, too, in my opinion without much weeping wailing and gnashing of teeth. Tape facilities are good for an amplifier in the under £300 class.

Budget Trio

In response to readers' calls for budget hi-fi reviews (and because someone told me Felicity Kendal had a Trio hi-fi) I have been taking a look at the new KA-300 from Trio, a 30 + 30 low price amplifier which will retail at somewhere in the region of £80-£90.

Facilities offered are not at all bad for this price area and dubbing between two tape decks is possible. One set of tape sockets (phono) is included in the front panel for ease of access. Not a bad idea if you can hide them somehow with one of those flaps the Japanese are so enamoured of, but a little ugly otherwise. In fact the KA-300 is anything but pretty all round! The controls are well sited and smooth to operate, but the appearance is downright ugly in my opinion. The black plastic ribbing which pops up all over the front panel gives a very strange look to the whole thing.

Individual is perhaps the kindest label to hang there!

On test the Trio acquitted itself well, exceeding the spec on every feature and giving a very competent electrical performance. Power available was somewhere around the 35 W a channel mark and this is well maintained across the audio spectrum. Noise ratios were commendably low for the price and distortion was at a level where it would not be a problem. The test results give you the details, if you're interested.

TABLE ONE

Output Power	; 40Hz - 20kHz	; 25W
Power Bandwidth	; at 0.01% THD	; 10Hz - 45kHz
S/N Ratio, unweighted	; phono	; 60dB
	aux, tuner, tape	; 65dB
Damping Factor	; 8R 40Hz - 20kHz	; 60
Input Sensitivity	; phono	; 2mV at 50K
	aux etc	; 130mV at 27K
Distortion	; THD 1kHz at 20W	; 0.1%
	intermodulation	; 0.05%

Test results for the Trio KA300 amplifier. Noise ratios are excellent. The impedance on the aux input is, however, somewhat less than excellent! A minimum of 50K is to be preferred.

Listen with Trio

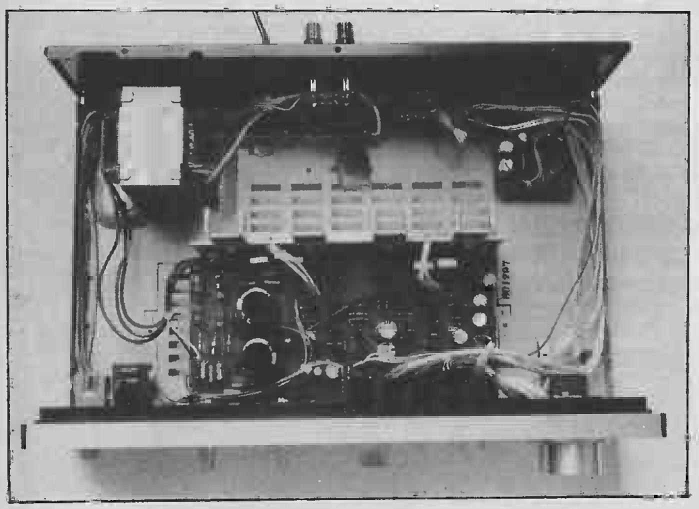
It is always difficult to decide exactly how to audition budget equipment. Do you hook it onto a top flight set-up, in order to exactly determine its strengths and weaknesses, or use the type of system it is designed to run with and accept that you are only able to judge it comparitively against a rival unit?

My own approach is simply to do it both ways! Never one to makes things less complex, if at all possible. Hence the Trio was substituted into my reference system (driving Kef 105 IIs at one point!), first of all to try to get an absolute idea of performance before moving on. I might add that the Seoum amplifier on offer elsewere in this issue was also put to the test and used throughout as a comparison to the Trio. Final listening was carried out with reference to a friend's system using the NAD 3020, which is perhaps the best sounding unit in this price bracket.

Having now heard the KA-300, I think that NAD have little to worry about. On an absolute basis the Trio has poor bass control and a tendency to "harden" on complex material. The Seoum sounded a good deal clearer and coped with most material well, although the noise was higher than with the Trio.

On the 'plus' side, the KA-300 is possessed of a good signal-to-noise ratio on both phono and tape and is well engineered. Against that, it has a good sound quality that is bettered by competitors, such as the NAD 3020 and the Seoum, and a highly individual appearance that you will either love or hate.

Sorry Trio, I can't recommend this one at all.



Above: an internal view of the Trio KA300. Lots of space is there not? Surely a smaller cage could have been found without jeopardising the signal to noise ratios too much?

Will readers using the Audiophile hi-fi enquiries service please remember to quote full details of the hi-fi system they are using. It is of great value to me in trying to sort out problems to know what it is I'm trying to sort out!

Letters Pray

Dear Sir,

I am upgrading my system and have been told that what I ought to change next is the turntable. This is a Thorens TD150 and an SME 3009 and a Shure M75ED cartridge. Amplifier: Armstrong 621. Speakers KEF Cadenzas.

My friend told me to buy a Linn as this will improve my system more than anything else. But this will cost me over £300 and this is more than I paid for the whole system, I wanted to be sure. What would you suggest I do?

Yours sincerely
F. Kendal
London

Hang on whilst I recover from the heart-attack that that name and address induced . . . People with *that* name should make it clear at the start who they are *not* — not who they *are*! . . . Come on heart, don't fail me now . . . you can make it . . .

Anyway, Mr Kendal, the first thing I would advise you to do is take your 'friend' on a one way trip to the docks in brand new cement shoes. It is about all he deserves. If your TD150 is in good condition, a Linn will make little, if any, difference to your system. A better immediate upgrade would be to change the cartridge. If you like the Shure sound then the V15 IV is an excellent buy. If you fancy a change then give the Goldring G900 IGC or Empire 600 LAC a try. After that both the amp and speakers could well be replaced — in fact, the deck is the last thing to change!

ETI

RIAA PREAMP

Sounds amazing. Listen to your magnetic cartridge burst into life with our RIAA equalised preamp, designed for the ETI Multi-Option Board. Circuit design by Keith Brindley.

Magnetic cartridge pick-ups have very low output levels and consequently require low noise, high gain preamplifiers to boost their signals. Op amps for this application are relatively abundant nowadays. But, things aren't quite that simple — not only is the output level of a magnetic pick-up low, but it varies with frequency. At the top end of the audio spectrum (ie 15-20 kHz) the signal is about 40 dB up, (ie 100 times) that of the lowest end of the range.

The Record Industry Association of America (RIAA) laid down the rules for the frequency response curve, so that when designing such a preamp stage the engineer has only to calculate suitable values for the components in an op amp feedback loop. What is needed is an amplifier response which *diminishes* with increasing frequency over a range of 40 dB, to compensate for the response of the cartridge and give an overall flat output. Given a microcomputer, a sharp pencil and a bottle of vodka it should take him — ages. But why bother, it's all done nowadays (as it often is!) on one chip — the LM382.

Cue Cavalry

National Semiconductor came to the rescue with the introduction of this device, a wide-range supply voltage (9-40 V) preamp which, with only a handful of other components, gives an RIAA preamp featuring low noise, high gain and the required frequency response.

Construction

The only components which need correct polarisation are the four tantalum capacitors and the IC, so check the overlay carefully before soldering them into position on the ETI Multi-Option Board.

The input and output connections should be made with screened lead, the screen being taken to 0 V. The only thing to note here is that the input leads must be as short as possible, because the high gain involved in any preamp circuitry makes them very susceptible to hum and noise pickup. Short screened leads help to minimise this problem.

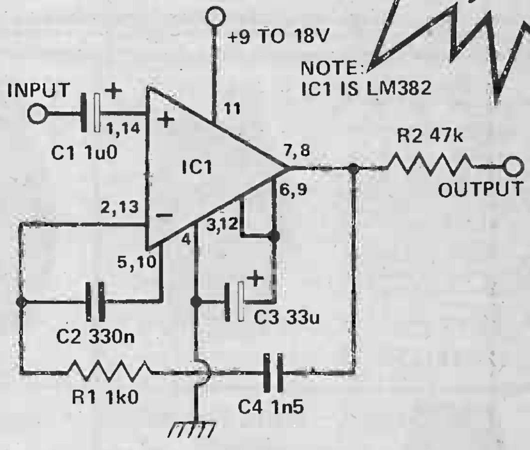


Fig. 1. Circuit diagram of one channel of the preamp.

HOW IT WORKS

The feedback loops in any RIAA amplifier are fairly conventional and apart from different component values, any one circuit is similar to another. What makes the LM382 novel is the internal resistor matrix available on the chip. This enables an exceptionally low number of external components.

For the technically minded the RIAA transfer function of such an amplifier can be stated as:

$$C = \frac{(1 - jf_2/f)}{(1 - jf_1/f)(1 + jf/f_3)}$$

where $f_1 = 50$ Hz, $f_2 = 500$ Hz and $f_3 = 2.12$ kHz.

This defines the corner frequency exactly and also the various slopes of the frequency response. It just so happens that capacitor/resistor feedback combinations can be used to achieve the required amounts of gain, corner frequencies and roll-offs. The internal resistor matrix of the LM382 simply allows us to use fewer external components in the circuit.

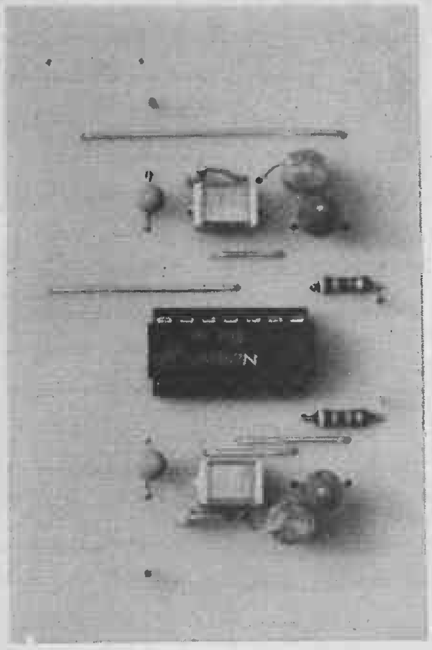
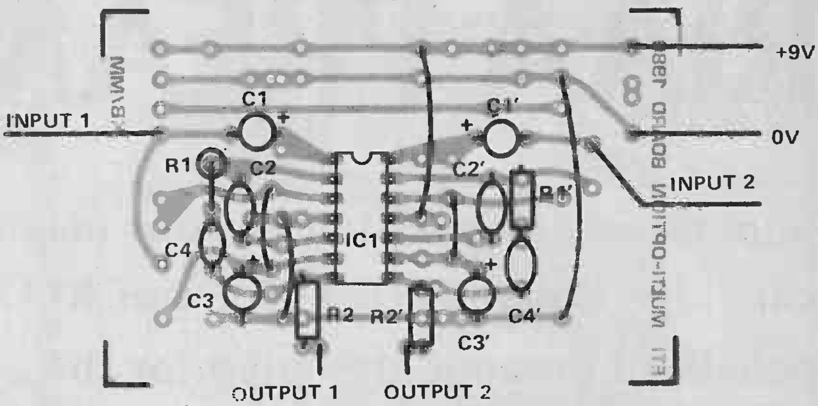


Fig. 2. (below) Component overlay of the stereo preamp fitted onto the Multi-Option PCB.



BUYLINES

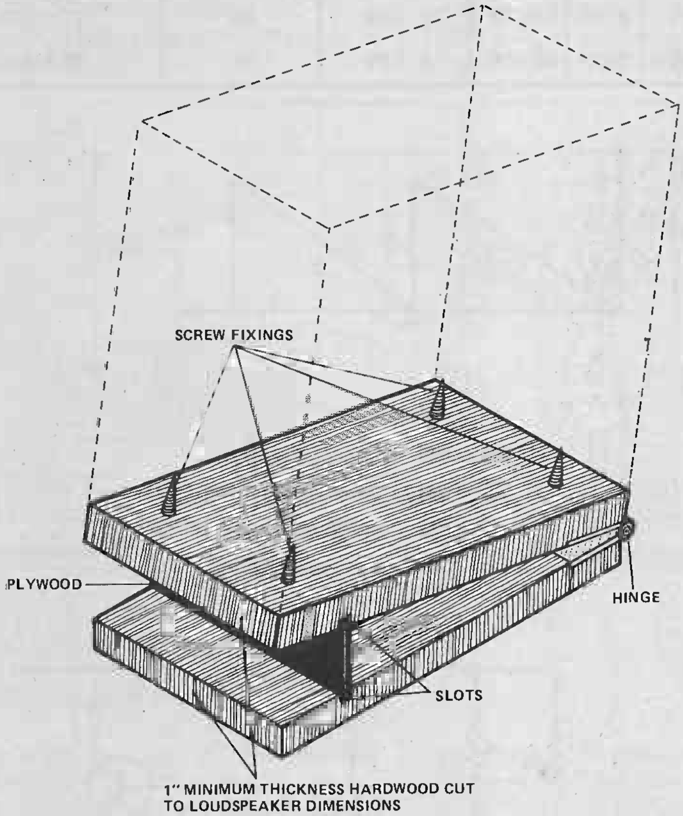
The one chip and handful of components used should not present any problems. They should be readily available from suppliers advertising in this issue.

PARTS LIST

Resistors all ¼ W 5%	
R1	1k0
R2	47k
Capacitors	
C1	1u0 35 V electrolytic
C2	330n polycarbonate
C3	33u 10 V electrolytic
C4	1n5 polystyrene
Semiconductors	
ICI	LM382
Miscellaneous	
ETI Multi-Option PCB	

ETI

TECH TIPS



Getting off the ground — cheaply

G. Adams, Poole.

The cost of loudspeaker stands prohibit many from buying them, although they are important to floor-standing arrangements for two reasons. They reduce possible colouration via floorboards etc. and, more importantly, they effectively heighten floor-standing loudspeakers so that the sound from each is directed where it should be, to one's ears, *not* to the upholstery and one's ankles!

With the latter problem particularly in mind, this design was finally decided upon. It is rather uniquely versatile, in that by using different sizes of plywood any degree of lift may be obtained. However, a lift of around 10° is considered a useful stone upon which to build.

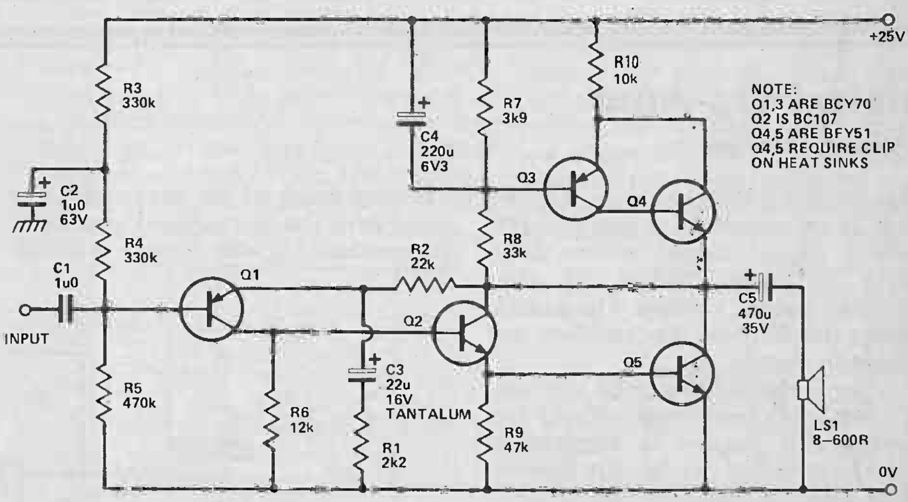
High Quality Headphone Amplifier

A. J. Jones, Cobridge

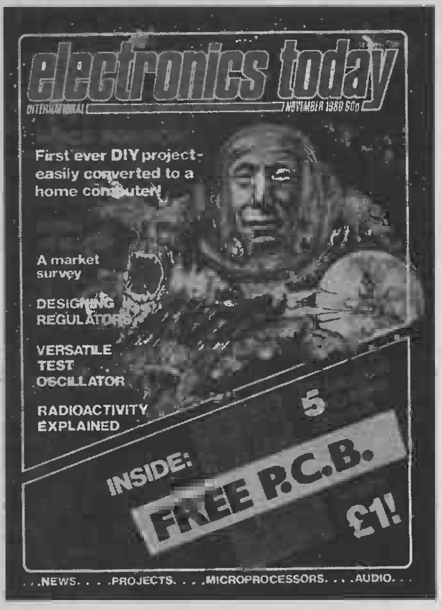
This circuit is capable of high performance using low cost, readily available components. The class A amplifier is designed to drive efficient, high impedance headphones of 150R and above, although it will drive 8R headphones with reduced performance.

Feedback is applied by R1,2 and gain with the specified components is 11. For maximum output the input sensitivity is 0 dB. Q3,4 and C4 form a gyrator circuit and present a high impedence to AC signals. This gives the circuit a high open-loop gain. Quiescent current is set by R9 (approximately 60 mA).

Performance is good with distortion and noise measured on Radford test kit at less than 0.01% for maximum output. Noise is less than −80 dB unweighted. Power bandwidth is less than 10 Hz to over 50 kHz. Slew rate is greater than 5 V/uS.



Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.
ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH—TIPS, Electronics Today International, 145 Charing Cross Road, London WC2H 0EE.



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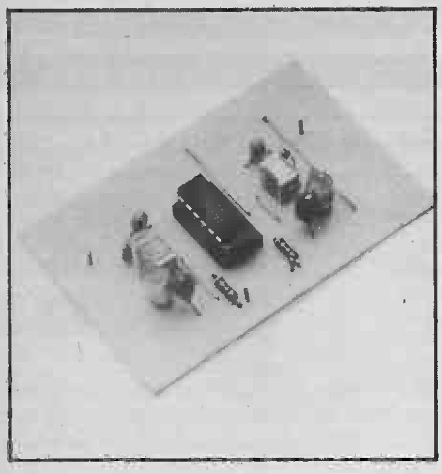
INFORMATION



one of the many p39

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Efficient P.A. Amplifier

N. D. Sheldon, High Wycombe

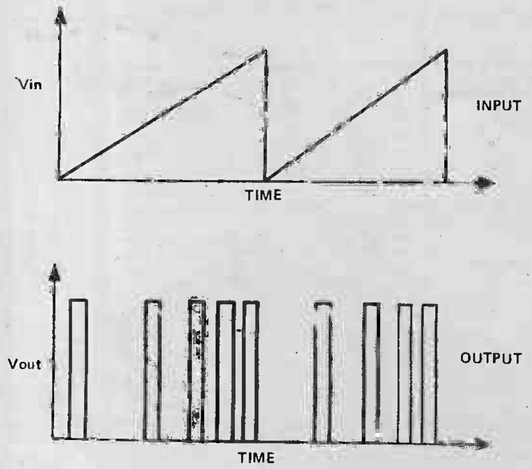
The efficiency of this amplifier is so high that an output of 3 W can be obtained with a BC107 used as the output transistor, even without a heatsink.

The amplifier consists of a voltage controlled pulse width oscillator working at about 6 kHz, driving a class D output stage. Since the output transistor is either hard on or completely off, the dissipation is minute — hence the high efficiency. The output waveform bears no resemblence to the input, but the integral of the output waveform is proportional to the integral of the input waveform, both with respect to time.

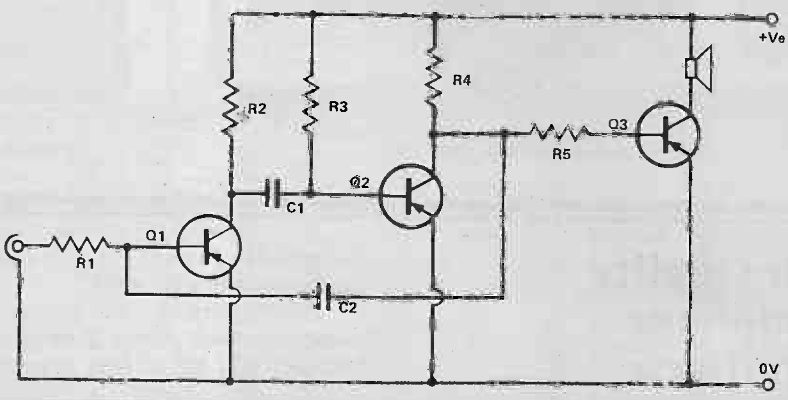
A table of component values has been given in order that any amplifier with an output of between 3 W and 100 W can be constructed. Still higher powers up to 1 kW can be obtained.

The drawback is that it produces about 30% distortion and can, therefore, be used for sound reinforcement only. It is especially suitable for public address systems, as speech is completely intelligible.

POWER (W)	R4	R5	Q3	HEATSINK	SUPPLY/V	O/P TRANSFORMER
3	1k5	390R	BC107	50 C/W	15	–
10	1k5	390R	BFY51	22 C/W	24	15R:8R0
30	1k0	270R	BD139	10 C/W	40	22R:8R0
100	820R	180R	BD139	5 C/W	60	35R:8R0



R1	27k	C1	1n8	Q1	BC107		
R2	1k5	C2	1n8	Q2	BC107		
R3	180k						



Digital Op-Amp

K. Wood, Leicester

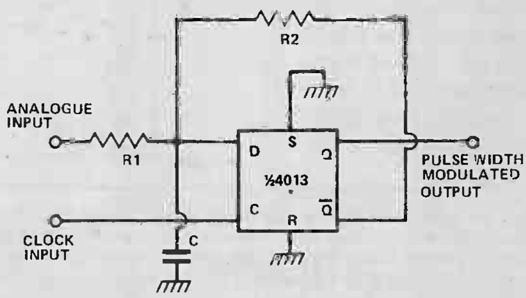
One half of a 4013 package may be used as an amplifier, if one doesn't mind a digital output whose duty cycle is proportional to the expected output voltage. This could always be filtered to recover an analogue output.

Clock pulses have to be applied as indicated and these should be considerably higher in frequency than the required bandwidth. Gain is R2/R1 and the time constant R1R2C/(R1 + R2) should be longer than the period of the clock pulses.

Uses of the circuit include the following:

1. Take pulses from the zero crossing point of the mains, drive a triac with the output and you have proportional power control without RFI.

2. Switch driver transistors with the output using a fast clock and you have a high efficiency PWM audio amplifier.



Interior Light Delay

S.A. Johnson, Newcastle

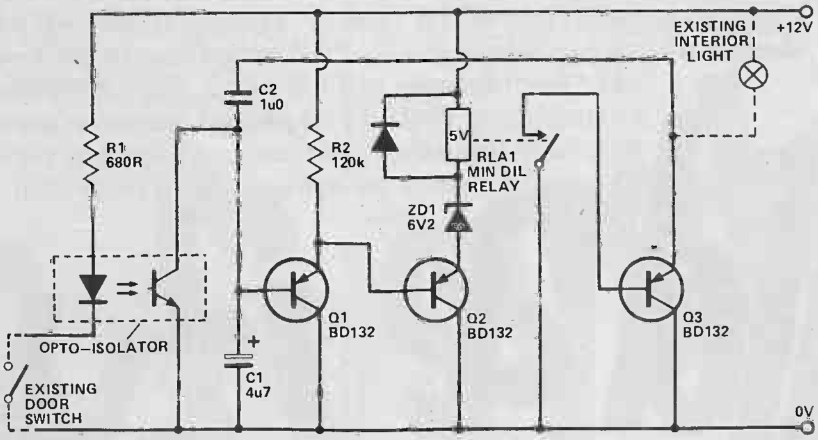
The circuit shown will delay the car interior light by about 10-15 S, depending upon the time constant of R2-C1.

One big fault with most delay units is that the delay is so long that the light is still on when you drive away, which can be very annoying at night. This unit, however, will extinguish the light either 10-15 S after the door is closed, or when the engine is started, whichever occurs first. The unit may be fitted without running any extra wires to it and may be fixed behind the interior light.

Capacitor C1 charges up through R2; thus turning Q1, Q2, RL1 and Q3 off after 10-15 S. When the door is opened C1 is discharged by the opto-isolator and begins to charge up after the door is closed.

If, however, the engine is started before 10-15 S the supply voltage will drop sufficiently to de-energise RL1, (approx 3V) and give C2 a positive pulse via Q3 which will charge C1 up sufficiently to switch Q1 off. **NOTE:** The value of C2 and ZD1 may need to be altered to get this effect.

The unit draws very little current when not in use and has only ten components.



Multivibrator

E. Vaughan, High Wycombe

The frequency of a conventional multivibrator is controlled by the R-C times constant of its feedback loops. This circuit has fairly good rise and fall time and will operate at repetition rates as high as 10-15 MHz. The disadvantage of this kind of circuit is poor frequency stability. Also, the frequency can by affected by temperature, voltage variations, and variation (within tolerance ranges) between capacitors and resistors in the feedback loops, the latter affecting not only frequencies, but waveform symmetry.

With the circuits shown, all these disadvantages can be eliminated and the advantages of a conventional multivibrator will not be lost. The same number of components are required as the crystal or crystals replace the capacitor in one or both feedback loops. The resistor value in the feedback is not critical. As it is used with a crystal it no longer controls the time constant.

Both CT cut or AT cut crystals are suitable. The circuit in Fig. 1 uses a crystal of 7 MHz with a low activity. Crystal activity was down to about one tenth of its 7MHz value when in the circuit, so it was not possible for it to operate below 750 kHz. To get below this a higher activity crystal would have to be used. Varying the feedback resistor in a conventional multivibrator changes the frequency. This had no effect on the frequency the crystal controlled circuit. Then the capacitance of the 7 MHz and 3.5 MHz crystals in Fig. 2 were measured and came out as 13pF and 12pF respectively.

These capacitors are not in the range that create an R-C time constant that permits the circuit to work at the above frequency, so there is no doubt the crystal was controlling the frequency. With a crystal the circuit operates only at its rated frequency. Frequency tolerances in the order of 0.001 to 0.0001 percent can be obtained with this circuit. The 2N2475 used is a very fast switch. If another transistor is used it need not be as fast, but should have a switching time that will permit operation at the desired frequency.

The circuit (Fig.1 modified) controls symmetry by employing different frequency crystals in the two feedback loops. R3 and R4 were changed to 10k and X2 to 3.5 MHz. The 7 MHz crystal remained in the second feedback loop. All other values are the same as shown in Fig. 1. This produces a symmetry of 2:1, but maintained a frequency stability of 0.007 percent with a 20 percent supply voltage variation. This modification has other advantages. It can be used to produce an extremely stable asymmetrical square wave. Crystals for this type of operation must have a harmonic relationship.

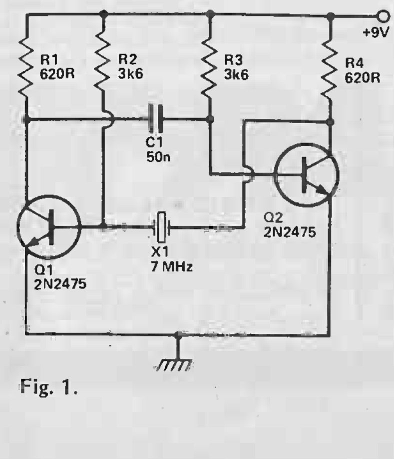


Fig. 1.

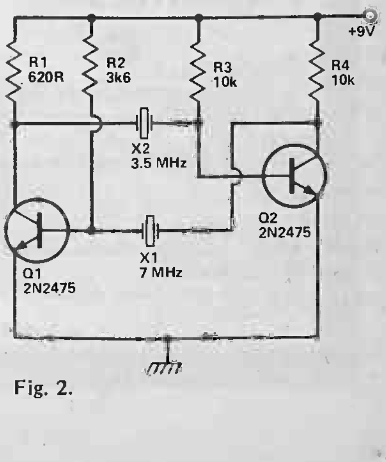


Fig. 2.

TOUCH BUZZER

Buzz off to your heart's content with our simple touch operated buzzer. Circuit design by Keith Brindley.

Versatility is the name of the game — modern day electronics is no exception. In the jungle of electronic components only the fittest and most adaptable survive — the rest fall by the wayside. You need only cast your mind back two or three years to the days of the dedicated TV games chips which played table tennis or perhaps squash if you were lucky. They have been forgotten now with the advent of programmable games units which have recently reached the stage of very realistic 3-D effects.

What About The Workers?

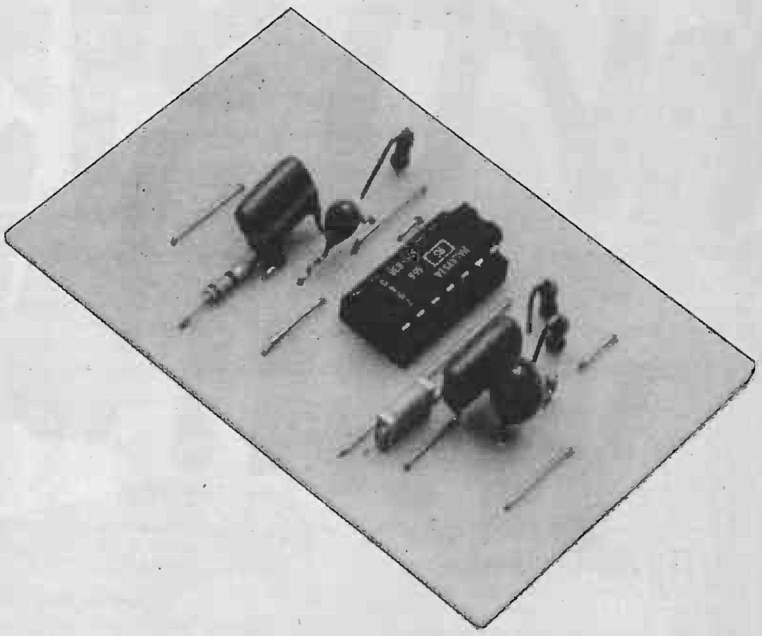
The 555 is a worker! It is adaptable to a wide variety of ideas and designs. It can operate on a power supply of 5 to 18 V. It can sink or source currents up to 200 mA.

The 555 has, therefore, been with us as a field leader for the ten years since Signetics first introduced it and you would be correct in assuming that it will be around for a while longer yet.

The ETI Touch Buzzer uses the dual version of the 555, which is designated the number 556. It is, of course, constructed on the ETI Multi-Option Board given away free with this issue and is extremely simple to build. You can utilise it as a rather clever VAS (Visitor Announcement System — otherwise known as a doorbell) or you can dream up your own uses for a very adaptable project. For instance, the output of the first half of the circuit from pin 5 of the 556 (see How It Works for circuit explanation), can be used to operate a low voltage relay to turn on and off other items of equipment and the circuit now operates as a touch switch.

Construction

No problems with this project — just be careful to get the two tantalum capacitors and the IC in the right way round and you can't go wrong. The overlay shows the position of all components and interconnections so study it carefully. The touch controls can be any suitable pieces of conductive plate which may be at hand.



HOW IT WORKS

The 556 is divided internally into two separate multivibrator circuits — a monostable followed by an astable. The monostable is triggered when the voltage at pin 6 of the IC is taken below one-third supply voltage. Normally pin 6 is held high by R2, a 2M7 resistor. However, when a finger is placed over the touch plates the skin resistance takes the voltage low.

The timing period of the monostable is given by the formula T = 1.1 x R1 x C1, which as all you budding mathematicians know (using the values of 100k and 10uF for R1 and C1 respectively) works out to be approximately 1 S. So every time the touch contacts are bridged the output (pin 5) of the monostable stays on (high) for about 1 S afterwards. The output is connected to the reset input (pin 10) of the second half of the chip, wired as an astable. The astable is prevented from oscillating when pin 10 is low and is allowed to oscillate when pin 10 is high. Thus, touching the contacts enables the astable to oscillate for about a second.

The timing components in the astable are set for a frequency of about 500 Hz.

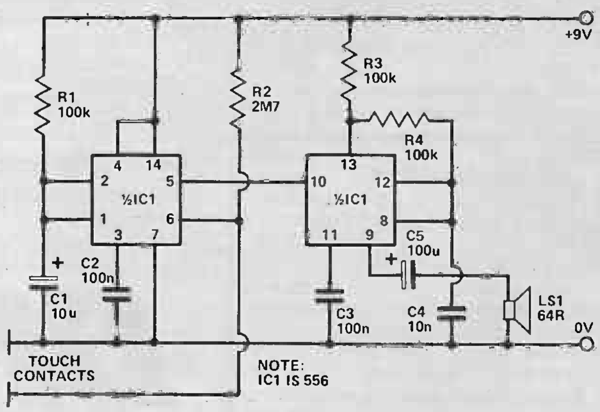


Fig 1. Circuit diagram.

A PROJECT FOR YOUR FREE PCB

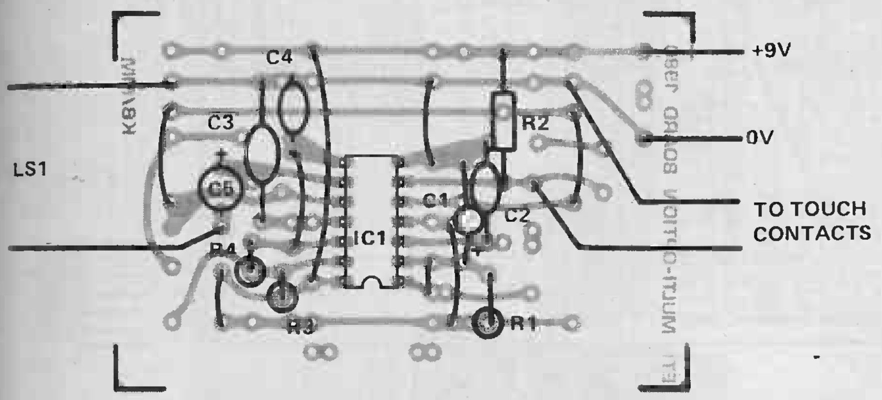


Fig 2. Component overlay. The touch contacts can be any available piece of conductor.

BUYLINES

All of the components used in this project should be available from the usual mail order companies who advertise in the magazine.

PARTS LIST

Resistors All ¼ W 5%	
R1, 3, 4,	100k
R2	2M7
Capacitors	
C1	10u 10 V tantalum
C2, 3	100n polyester
C4	10n polycarbonate
C5	100u 10 V tantalum
Semiconductors	
IC1	556
Miscellaneous	
LS1	64R miniature speaker
ETI	multi option board
9 V battery and connector	
Touch contacts	

ETI

ASTROLOGUE

The Farnborough Air Show opened its doors to the public again this year. Ian Graham reports on the Show with the latest news on the Space Shuttle.

The Space Shuttle was born in the heady days of the Apollo moon-landings, when America was the undisputed leader in the high-technology stakes. However, spaceflight gradually became 'ordinary', Press coverage waned, America's national pride took a couple of severe knocks and the world started downhill towards its worst post-war recession. These factors conspired to influence the Office of Management and Budget to cut the NASA Shuttle budget by thousands of dollars a year.

Going, Going, Wrong . . .

The earliest failures were in the main engine. Because of underfunding, NASA departed from its usual practice of proving each component separately before it was integrated into the complete system. The Shuttle main engine was tested as a whole. Consequently, some minor failures were accompanied by major engine damage. The first flight back-up engine was recently shut down automatically ten seconds into a 100 S burn. A defect in the operation of the high pressure liquid oxygen turbopump started a fire, damaging the turbopump, the main engine controller and some oxygen piping.

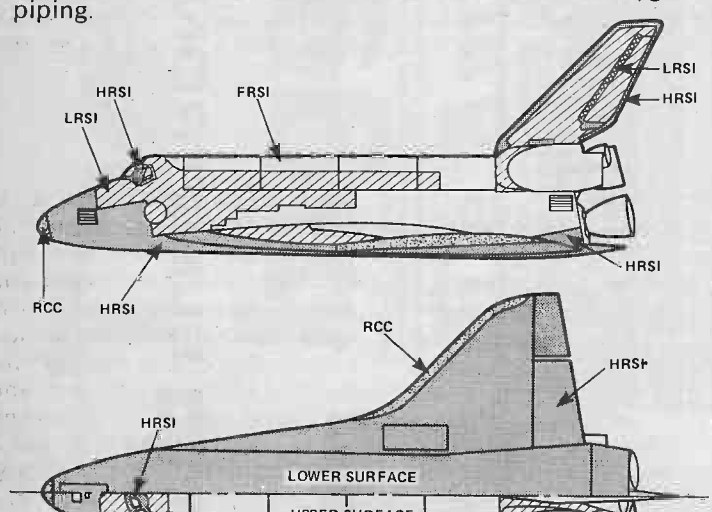


Fig. 1 The Space Shuttle's Thermal Protection System. RCC — reinforced carbon-carbon; HRSI — high temperature, reusable surface insulation; LRSI — low temperature, reusable surface insulation; FRSI coated Nomex felt, reusable surface insulation.

An artist's impression of Lockheed's new Alpha Jet during its three week tour of American military bases. The aircraft is competing for selection as a new advanced training aircraft for the US Navy.

Fact Or Fiction

The heat shield material used on Mercury, Gemini and Apollo was unsuitable for the Space Shuttle, because it could only be used once. On re-entry it slowly boiled off, dissipating the air friction heat. Heat conduction in the silicate developed for the Shuttle was almost zero. (You may remember the alarming photograph published at the time of a technician holding a tile at one corner while the centre glowed red hot).

The process of bonding the tiles to the Shuttle's aluminium skin was not researched as extensively as the tile thermal behaviour. Indeed, air friction alone was sufficient to strip some of the tiles off during a short flight on the back of its 747 carrier aircraft. Several thousand more may have to be removed, strengthened and replaced.

Unfortunately there wasn't a Space Shuttle at the Air Show, but there was a Press conference dealing with NASA's plans for the 1980s. Naturally, though, most interest was focused on the Space Shuttle.

The first launch is still expected by next March. Although we have become accustomed to taking revised launch dates with a pinch of salt, March 1981 *does* seem to be more definite than the others. Some of those involved in making preparation at the Cape are beginning to get 'launch fever'.

The Retile Trade

November 23rd should see the completion of tile replacement work. I was given a rather distressing demonstration of the mechanical properties of the thermal tiles. A piece of tile material was held up and snapped between two fingers like a piece of polystyrene foam. The endurance of the tiles in service will determine when the Shuttle finally goes operational.

At the Lockheed plant in Sunnyvale, California, a technician examines some of the silica tiles manufactured for the Space Shuttle. As each tile is shaped to fit only one spot on the spacecraft, no two tiles are the same.

That is planned for the fifth flight in September 1982. However, if large numbers of the tiles have to be removed and replaced between flights, the operational date will have to be put back.

Shuttle flights are all booked up until 1986. Therefore, conventional Delta and Atlas-Centaur launchers will continue to fly until at least 1985.

The Shuttle's thermal protection is far from satisfactory. However, the production of the current series of Orbiters is so far advanced that no major hardware changes can now be implemented.

For equatorial flights, the Shuttle will be launched from Cape Canaveral. For polar flights, it will be launched from Vandenberg Air Base. The work necessary to prepare Vandenberg for the Shuttle should be finished in 1984.

Outdoors

The highlight of the Show was the flying display. I was deafened and delighted by a cross-section of the world's civil and military aircraft. The Shorts Skyvan demonstrated its short (and I mean *short*) take-off and landing capability. Lulled into a false sense of security by the Canadair Challenger and Shorts displays, I was deafened by the Dassault military aircraft. An Alphajet, Mirages and a Falcon screamed around the airfield.

Five Westland helicopters approached the airfield from all angles. Each entertained the land-bound throng and 'parked' in the air in line with its predecessor. The line of aircraft hung in the air for a moment in silent salute and then made off. The British Army have ordered 100 Lynx helicopters. The Royal Navy have ordered 70 to replace Westland Wasps. Total Lynx orders are currently approaching 300.

Stars of the display were the American fighters — General Dynamics' F-16 and McDonnell Douglas' F-15A and F-18. The US Air Force plans to buy no less than 1400 F-16s. The 200th was delivered recently. More than 500 F-15A Eagles have also been delivered. Each has a maximum speed of more than Mach 2.5.

The US Navy needs 1377 F-18 Hornets. Each has a maximum speed in excess of Mach 1.8.

Optica

The Optica, designed by John Edgley was, perhaps, the oddest participant in the Show. The Bug-eyed EA7 Optica made its first flight from Cranfield Institute of Technology last Summer. It is designed to be used as a three seat observation aircraft. The cabin is mounted in front of the engine, a 180 HP Lycoming IO-360, which drives a ducted propulsor instead of a conventional propellor. The floor area can be modified to carry vertical mounting cameras. It is claimed to be a quiet machine both inside and outside. From the ground, it was certainly one of the quietest craft in the display.

Cosmic Traffic Jam

We've always thought of space as limitless. However, it is most useful to place a satellite in a geostationary (or geosynchronous) orbit about the equator. That is, the satellite appears to be stationary in the sky — it is orbiting as fast as the Earth is turning. That particular orbit is now becoming overcrowded. Looking towards the 1990s, NASA is carrying out research into new telecommunciations techniques to allow fewer satellites to carry greater workloads. In future, tracking and data relay satellites will also replace some ground stations.

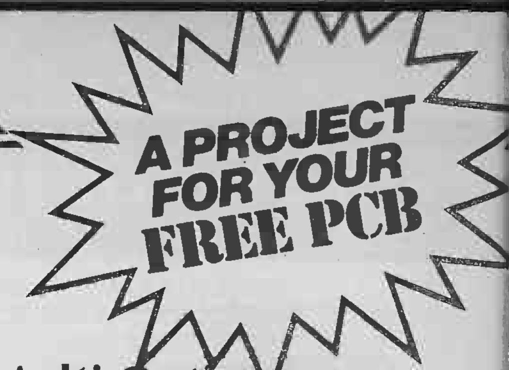
NASA may co-operate with the European Space Agency (ESA) to fly a satellite to Halley's comet. ESA is committed to sending the satellite and has offered NASA experimental space on-board. NASA may provide the launcher.

Indoors

NASA, ESA, satellites . . . in fact spaceflight in general constituted a very small part of the Show. The two spacious exhibition halls were packed with just about everything with anything to do with aviation and avionics. The main feature of Plessey's stand in the North Hall was a new, fully-equipped production version of a Transportable Air Defence Processing and Control Cabin. It houses the signal processing equipment and displays for the Plessey AR3D Long Range Radar system. The Radar and P & C Cabin provide ground forces with a mobile, autonomous radar command and control post capability. The post can automatically track 40 aircraft and carry out eight interceptions. The AR3D's electronic countermeasures can also be selected.

Ferranti announced the development of a miniature inertial navigation system (FIN2000) for use in military aircraft. Positional data is presented to the pilot on a control and display unit and is typically accurate to within 1 nm/hr of operation. The modular system features extensive built-in test and self-calibration facilities for easy maintenance and enhanced reliability. Pre-production models will shortly begin flight trials at the Royal Aircraft Establishment. **ETI**

METRONOME



We couldn't design five projects for our free Multi-Option Board without one based on the versatile 555. Circuit design by Keith Brindley

The 555 is such an adaptable integrated circuit that no home can afford to be without at least one. As a timer IC it does its job magnificently, working in a variety of monostable and astable multivibrator modes with just a handful of additional passive components, and its timing period is adjustable from literally just a *fraction of a fraction* of a second through to *hours*, simply by selection of one resistor and one capacitor.

Metro Gnome

Our chosen design using the 555 is a metronome. Before the advent of relatively cheap solid-state electronic components such devices were clockwork. Because of this they had a tendency to start off at a high speed and as the spring slowly wound down they got slower and slower. A completely electronic metronome does not suffer from this problem and yet can be far cheaper than a clockwork counterpart.

The circuit is simply an astable multivibrator. Increasing either the resistors or the capacitor values, or both, the timing period can be lengthened, decreasing the frequency and vice versa.

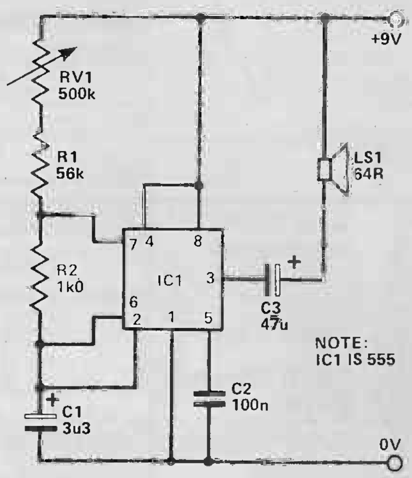


Fig.1. Full circuit diagram of the Multi-option Metronome.

Applications

At audio frequencies, ie 30 Hz to 16 kHz, the 64R loudspeaker is an adequate transducer, but outside this range other transducers can be utilised to suit. For instance, if the frequency of the astable is increased to 40 kHz by choosing suitable component values and the loudspeaker replaced by an ultrasonic transducer, then the circuit can be converted into an ultrasonic transmitter. It couldn't be simpler.

Combinations

You could use the astable as a clock generator for digital circuits, or you could combine this circuit with that of the 2 W Power Amplifier to make a loud siren. The choice is yours.

Construction

None of the components are at all critical and if you can't obtain exactly the right component value, don't worry. Anything remotely close to the specified values will get your device off the ground and operational.

If your capacitor value is too high, simply use a lower value resistor combination and vice versa. Six links are required to complete the circuit, then you can connect your battery and go.

HOW IT WORKS

The circuit is a standard 555 astable multivibrator which means that the device operates in a free run oscillating mode and the output from pin 3 is constantly switching between 0 V and 9 V at a rate determined by the components in the circuit. This switching output is coupled to the loudspeaker via C3.

The multivibrator mark/space ratio is deliberately kept uneven to provide short, sharp pulses to the loudspeaker, instead of the more usual square-wave normally associated with an astable. This, of course, produces a more pronounced click from the speaker to duplicate the tick of the metronome.

The mark/space ratio is adjusted by changing the values of RV1 and R1 along with R2. Capacitor C1 charges up toward supply voltage through RV1, R1 and R2 and the output of the 555 is low for this period. When the voltage at pin 6 (ie the voltage across this capacitor) reaches approximately two-thirds supply an internal switch operates, sending the output high. In going high, the output takes pin 7 to 0 V internally, which discharges the capacitor through R2 only. When the capacitor voltage falls to about one-third supply, the internal switch changes state again to take the output low. This action repeats itself ad infinitum.

From this you can see how different mark/space ratios are possible — the charge rate (off time) must be greater than the discharge rate (on time) by the ratio:—

$$\frac{RV1 + R1 + R2}{R2}$$

For example, with RV1 in minimum position the ratio is:

$$\frac{56k + 1k0}{1k0} = 57{:}1$$

In other words the off time is 57 times as long as the on time.

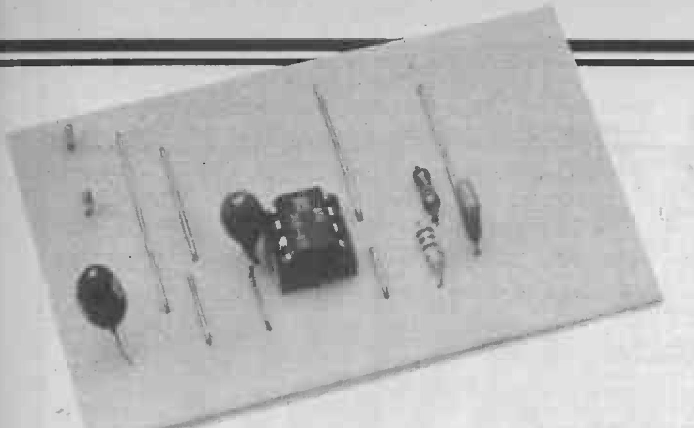
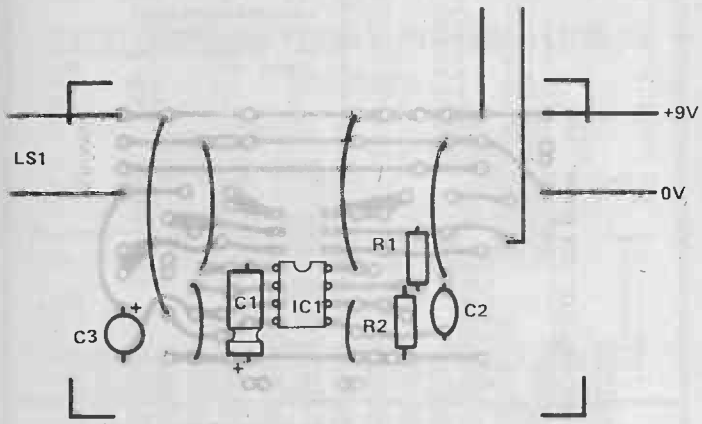


Fig.2. Component overlay for the Metronome. For once you'll have to ignore the unused locations on the PCB.



BUYLINES

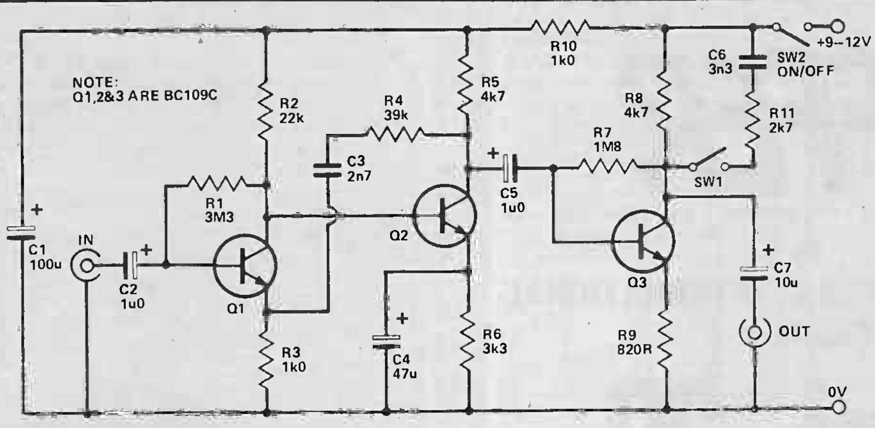
The ETI Multi-Option Board Metronome uses standard components, readily available from suppliers advertising in this issue.

PARTS LIST

Resistors All ¼ W, 5%	
R1	56k
R2	1k0
Potentiometers	
RV1	500k linear
Capacitors	
C1	3u3 10 V electrolytic
C2	100n ceramic
C3	47u 10 V tantalum
Semiconductors	
ICI	555
Miscellaneous	
ETI Multi-Option Board	
64R speaker	

ETI

SPOT DESIGNS



Cassette Preamplifier

Used in conjunction with one of the cassette mechanisms currently available on the surplus market (or a mechanism removed from an old recorder or player) this preamplifier circuit makes an inexpensive but useful cassette player for use with a hi-fi system. The circuit is for a mono player, but for a stereo unit it is, of course, merely necessary to make one preamplifier for each channel.

The output signal level from a cassette tape head is typically about 500 uV or so at middle audio frequencies for a mono head and only about half this level for a stereo type. The preamplifier must, therefore, provide a considerable amount of voltage gain in order to match this to a hi-fi amplifier, since these require a signal level of about 1,000 times higher than this. It is also necessary for the preamplifier to provide equalisation, because the output from a tape head rises with frequency at a rate of 6 dB per octave. However, at higher audio frequencies tape heads are not very efficient and require a much lesser degree of roll off.

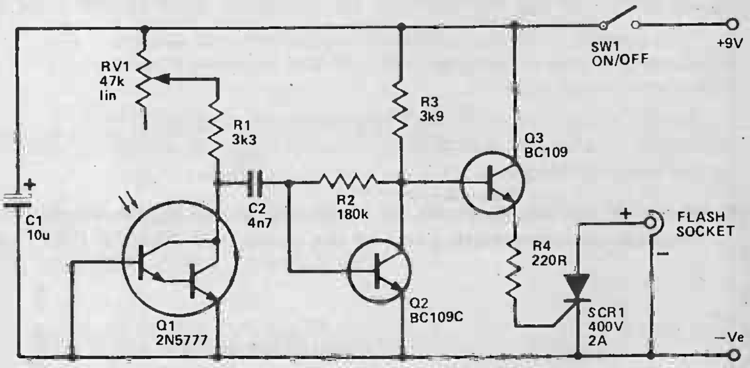
Q1 and Q2 are used in a conventional two stage, direct coupled, common emitter amplifier and the frequency-selective negative feedback through C3 and R4 provides the appropriate equalisation. These also set the midband voltage gain of the input stages at about 46 dB (200 times). With such a low input signal level it is obviously necessary to use low noise transistors (such as the BC109C) in order to obtain good results. Running Q1 at a low collector current of about 200 uA also helps to give a low noise level.

Q3 is used as a low gain common emitter stage, which provides the additional amplification needed to give a suitably high output level. R9 introduces negative feedback, which controls the voltage gain of Q1 and the specified value gives a gain of about 14 dB (five times). For a stereo unit R9 should be reduced to 390R in order to give increased gain to compensate for the lower output of a stereo tape head.

When playing a Dolby B encoded cassette SW1 can be closed. This gives a small degree of treble cut which provides a reasonably flat overall response, with a small excess of treble at low signal levels and a slight deficit at the highest levels. A useful level of noise reduction is obtained, although only about half that provided by a proper decoder.

The circuit is capable of excellent results and the output quality is largely dependent on the quality of the tape head, the tape used in the cassette and so on.

Flash Slave Unit



The photocell used in this circuit is a photo-Darlington transistor. This gives a fairly fast operating speed and high sensitivity. In fact the sensitivity is rather too high, making it likely that the cell would saturate in only moderately light conditions. Its base terminal is, therefore, connected to the negative supply rail to give a suitable reduction in sensitivity. R1 and RV1 form the collector load resistance for photocell Q1 and RV1 acts as a sensitivity control. With RV1 at a low resistance, the increase in the current passed by Q1 when it picks up the pulse of light from the primary flashgun will produce a fairly small voltage spike across the load resistance. With RV1 set at a high resistance, a similar current pulse would produce a much larger voltage spike across the load and high sensitivity is obtained.

One problem with equipment of this type is that under bright conditions the photocell can saturate, preventing the circuit from functioning. When used indoors, saturation is unlikely to occur even with RV1 set for maximum sensitivity. The sensitivity of the unit should be so high that it will trigger reliably even if the primary flashgun and Q1 are aimed in opposite directions. When used outside in bright conditions it would be advisable to back off RV1 and the aim of Q1 and the flashgun will inevitably be more critical (there will probably be less reflected light to trigger the unit in addition to the reduction in sensitivity).

C2 couples the output from Q1's collector to the input of a common emitter amplifier using Q2. This is biased by R2 so that there is a quiescent collector voltage of only about 1 V. Q3 is an emitter follower buffer stage which is used to drive the gate of SCR1 from Q2's collector. The quiescent voltage at Q3's emitter is insufficient to activate the thyristor, but when Q2 receives the negative voltage spike from Q1 it switches off and the emitter potential of Q3 rises to a high enough level to trigger SCR1 and fire the second flashgun. R4 is a current limiting resistor which prevents Q3 from passing an excessive current.

The current consumption of the circuit is about 2 mA. Note that the flash lead must be connected to SCR1 with the correct polarity or the unit will not operate.

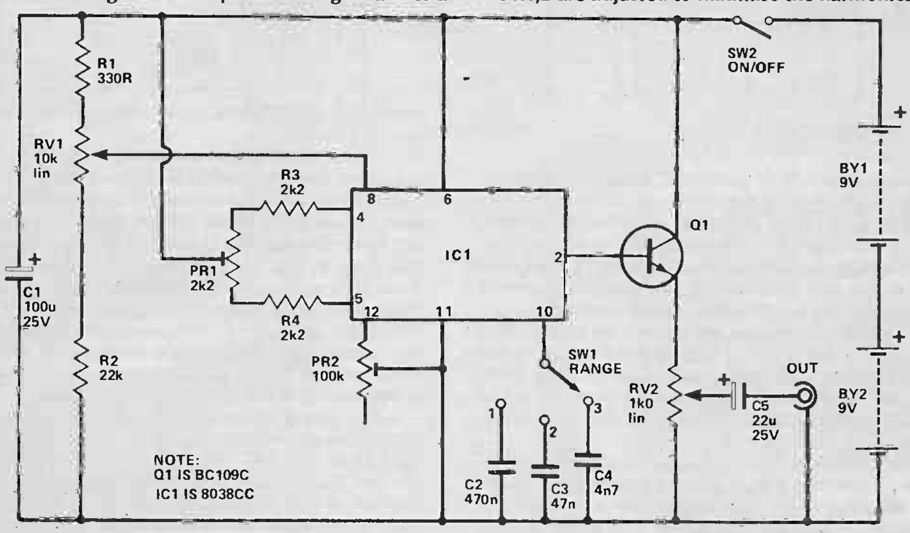
AF Signal Generator

Although the 8038CC is not capable of generating an extremely pure sinewave, it is capable of producing an output of high enough quality for general audio testing. The simple circuit shown here covers the audio frequency spectrum in three ranges — less than 20 Hz to more than 200 Hz; less than 200 Hz to more than 2 kHz; less than 2 kHz to more than 20 kHz. The output amplitude is continuously variable up to a maximum of about 550 mV RMS and is from a low impedance source.

The 8038CC oscillates by first charging a capacitor via a constant current source and then discharging it through another constant current generator. It thus generates a triangular waveform. This is then fed to a trigger circuit to generate a squarewave signal and to a non-linear amplifier which "rounds off" the signal to give a sinewave output of reasonable purity. C2 to C4 give the three ranges. R1, RV1 and R2 form a potential divider circuit, which is used to control the charge and discharge currents of the timing capacitor. RV1 thus acts as the fine frequency control. PR1,R3,R4 balance the charge and discharge currents, so that a symmetrical output is obtained. PR2 is part of the sinewave shaping circuitry and is adjusted for maximum purity.

The sinewave output at pin 2 of IC1 is at a high impedance and is, therefore, coupled to the output via an emitter follower buffer stage using Q1. RV2 is the output level control, and C2 provides DC blocking at the output. Current consumption is approximately 9 mA.

With the unit adjusted for a fairly low frequency output (about 50-200 Hz), it should be possible to hear the main fundamental frequency plus the higher frequency harmonic signals. The output can be monitored using a crystal earphone or amplifier/loudspeaker. PR1,2 are adjusted to minimise the harmonics.



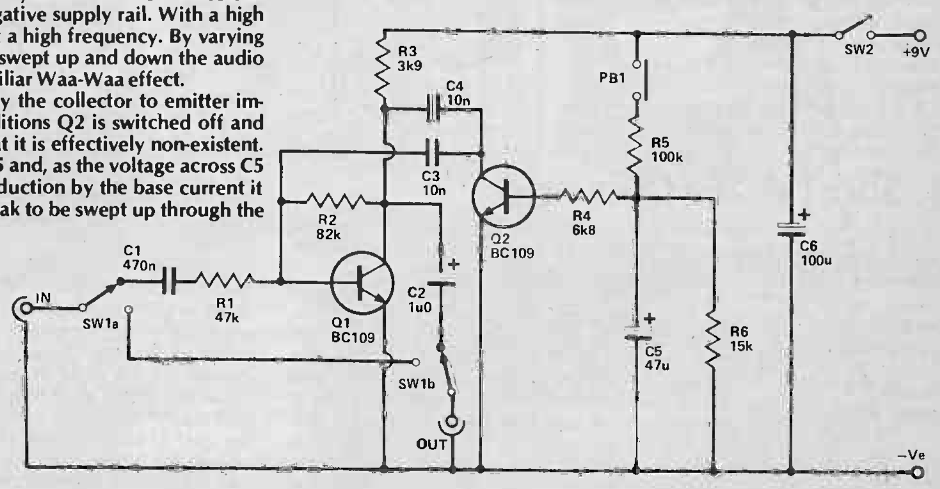
Waa-Waa Unit

An unusual feature of this circuit is that the Waa-Waa effect is obtained by operating a foot-switch, rather than the more usual method of operating a potentiometer via a pedal mechanism. This method is slightly less versatile than a proper Waa-Waa pedal, but is far simpler for the home constructor to build since it avoids the need for any pedal mechanics.

The basic Waa-Waa circuit uses a quite conventional arrangement based on common emitter amplifier, Q1. Frequency selective negative feedback is provided by C3, 4. These provide little feedback at a certain frequency. A peak in the response of the amplifier is produced at this frequency, as the lack of feedback enables virtually the full voltage gain of Q1 to be realised. The actual frequency at which the peak is produced can be controlled by means of a resistance between the junction of C3, 4 and the negative supply rail. With a high resistance here the peak is produced at a high frequency. By varying the control resistance the peak can be swept up and down the audio frequency spectrum, producing the familiar Waa-Waa effect.

The control resistance is formed by the collector to emitter impedance of Q2. Under quiescent conditions Q2 is switched off and the peak is at such a low frequency that it is effectively non-existent. If PB1 is operated, C5 charges up via R5 and, as the voltage across C5 increases, Q2 is biased harder into conduction by the base current it receives through R4. This causes the peak to be swept up through the audio band until C5 becomes fully charged. If PB1 is then released, C5 gradually discharges through R4, Q2 and R6, causing the bias on Q2 to decrease and the peak to be swept down the audio spectrum. Thus the required effect is produced by closing and opening PB1. The Waa-Waa frequency is partially controlled by the frequency at which PB1 is operated, but C5 restricts the range of frequencies that can be obtained in practice. However, the value of C5 can be altered to suit individual requirements, or several switched components of different values could be used.

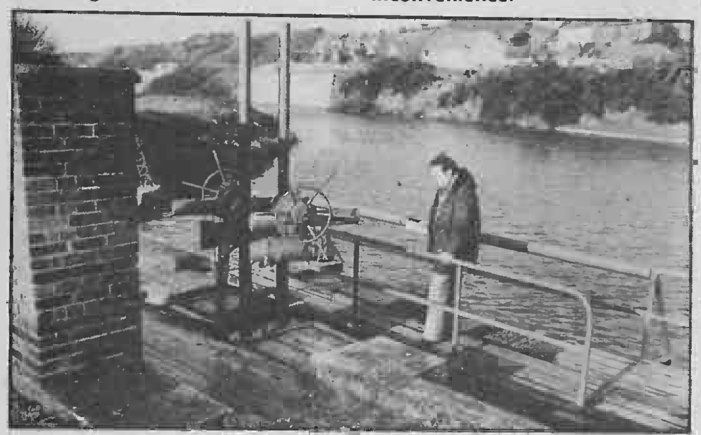
SW1 enables the Waa-Waa circuit to be quickly and easily bypassed. R1 is needed to reduce the gain of the unit which would otherwise be excessive. Current consumption is about 2 mA.



DIGEST

High Level Control

A system for regulating the level of the Royal Military Canal in Kent has been installed by Shepway District Council. The fully automatic system was devised and commissioned by Rotork Retrofit of Bath and utilises a pressure transducer which senses a predetermined water level and intiates the raising of the water gates to allow water to flow beneath and so maintain a safe level. The electronic control system is housed in a weatherproof cabinet on the site and is programmed to provide four stages of control in winter and three in summer. In summer a high level is maintained to cater for the needs of pleasure boats and anglers. The automatic control ensures that this high level is maintained even in times of heavy rainfall to prevent fish being lost out at sea, which occurred before. During the winter the canal is tidelocked during high tide conditions and this has led in the past to incidents of flooding. Previously the gates had to be left in a partly open position and this necessitated having staff 'on call' day and night to adjust them manually whenever tide or weather caused problems. The new system saves time, money and staff inconvenience.



Cassette Interface PCB

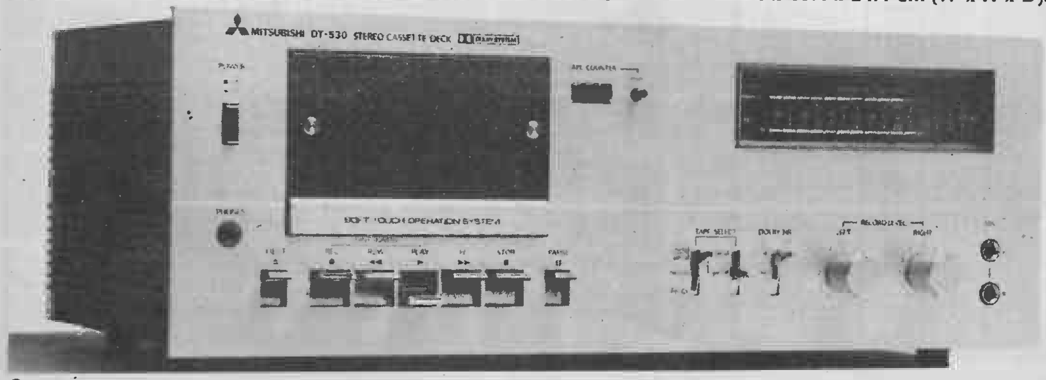
We omitted to include a Buy-lines section in the Cassette Interface project published last month. Jayman Electro Devices, 15 Ash Grove, Springhead, Oldham, Lancs OL4 4RP will supply a PCB for £4 all inclusive or a complete kit (including PCB) for £13.50 including post and VAT.

Copycat

Nashua have introduced what they consider to be the smallest plain paper copier in the world. Measuring only 18" x 18" ' 13", the Nashua 1205 will make its UK exhibition debut at the London Business Show on September 23-26. It is designed for the small business where inexpensive decentralised copying is required. The 1205 utilises fibre optics combined with a miniaturised development of Nashua's microprocessor controlled Liquid Toner Transfer system to achieve its small size. The first copy is ready in 7 S, subsequent copies at 12 per minute and the single paper tray can hold a range of paper from A5 to 8.5" x 14.0". There is an automatic shut-off 60 S after the last copy is produced and the toner/developer is held in self-contained cartridges. The machine also has improved copy (especially blue response), adjustable exposure control and a touch-tone keyboard with a digital readout to keep track of copy countdown. For further information contact Nashua Copycat Ltd, Cory House, Bracknell, Berkshire, RG12 1ET.

Getting It Taped

Mitsubishi Electric have launched their new metal tape cassette deck, the DT-530. For £122.00 you can enjoy such features as soft touch operation and one-touch recording, together with Dolby noise reduction and peak level indicators for accurate reading. Fifteen LEDs per channel provide an easy-to-read scale from −20 dB to +5 dB and at 0 dB the scale colour changes from green to red. The cassette housing on the front loading deck is air-damped and features background cassette illumination and a smoked glass front which detaches simply to facilitate head cleaning. Wow and flutter is 0.07% W RMS, S/N ratio (at 400 Hz) weighted, Dolby NR in, is 64 dB and frequency response (metal, special Fe-Cr) is 30 Hz to 16 kHz. Dimensions are 42.4 x 15.4 x 24.4 cm (W x H x D).

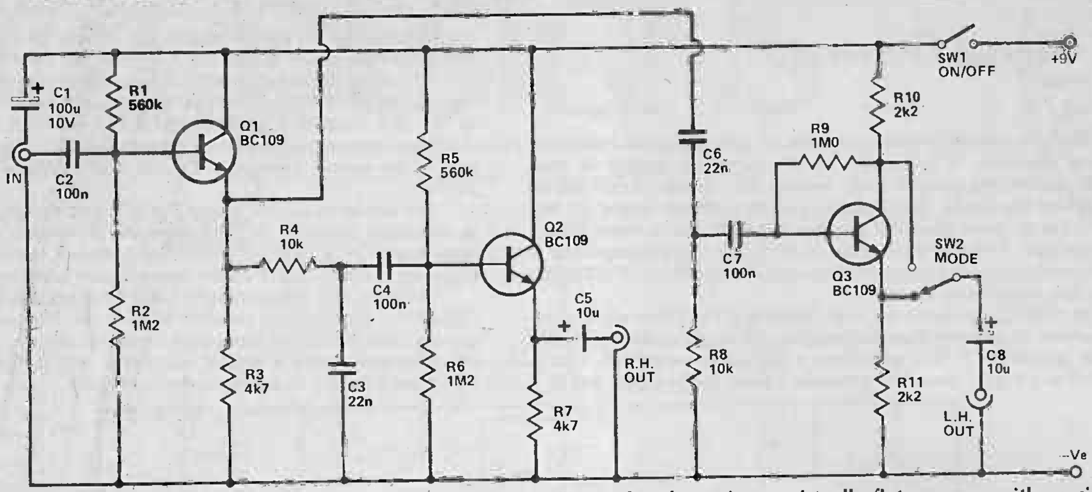


24 Hour Fone Machine

Most telephone answering machines lie redundant in the office all day, only bursting into action when everyone has gone home. The Ansafone 6A has been designed to be useful 24 hours a day.

In addition to providing telephone answering and simple announcement facilities, the 6A doubles as a simple-to-use dictation machine. It can also be used as a music cassette player for background music.

Ansafone 6A is available on rental from £2.35 per week from Ansafone, Lyon May, Frimley Road, Camberley, Surrey GU16 5EY.



Stereo Synthesiser

There are two common methods of producing a pseudo stereo effect from a mono signal; playing the mono signal from the two speakers in antiphase and the use of frequency selective techniques, which normally consists of directing lower frequency signals into one channel and higher frequency signals into the other. This circuit uses the second technique, but can additionally give antiphase signals which can give a better effect, especially when using headphones.

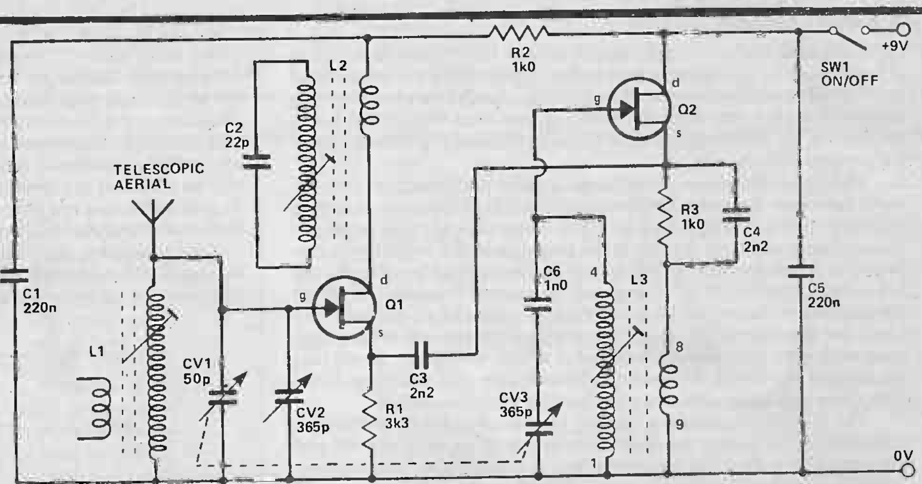
Q1 is used as an emitter follower buffer stage which ensures that the two filter networks fed from its output are driven from a low impedance source. If these were driven direct from the input, it is quite possible that they would be fed from a source impedance of a few kilohms or more, which would be quite sufficient to alter their effective characteristics.

The two filters are formed by R4 and C3 (low pass), and C6 plus R8 (high pass). A high roll off rate is by no means essential in this application and the 6 dB per octave attentuation rate of simple RC filters such as these is perfectly adequate. The −3 dB point of each filter is at approximately 800 Hz and the combined output of the filters, therefore, gives a virtually flat response with no significant peaks or troughs.

Q2 is connected as an emitter follower buffer stage and this ensures that there is minimal loading on the low pass filter. Q3 similarly ensures that there is minimal loading on the high pass filter, but this device is used as a phase splitter. With SW2 switched to take the output from Q3's emitter, Q3 effectively operates as an emitter follower and gives no phase inversion. With SW2 switched to take the output from Q3's collector, Q3 then effectively acts as a common emitter stage with 100% negative feedback (and unit voltage gain) due to R11. It also provides a 180° phase shift so that the two output signals are in anti-phase. An in-phase relationship is needed to give a good central stereo image and the use of anti-phase signals tends to give an impression of increased channel separation.

In a stereo orchestral recording it is normal for the violins to come from the left hand channel, with the cellos and basses from the right hand channel. Therefore, the high frequency signals are fed to the left channel and the low frequency signals are fed to the right channel so that the unit provides a similar effect (although it will obviously function properly with the outputs connected either way).

The current consumption of the circuit is about 3 mA.



NOTE:
Q1 & 2 ARE BF244B
T1 IS DENCO D.P. BLUE AERIAL COIL, RANGE4
T2 IS DENCO MW5FR FERRITE AERIAL
T3 IS DENCO WHITE OSC COIL, RANGE 4

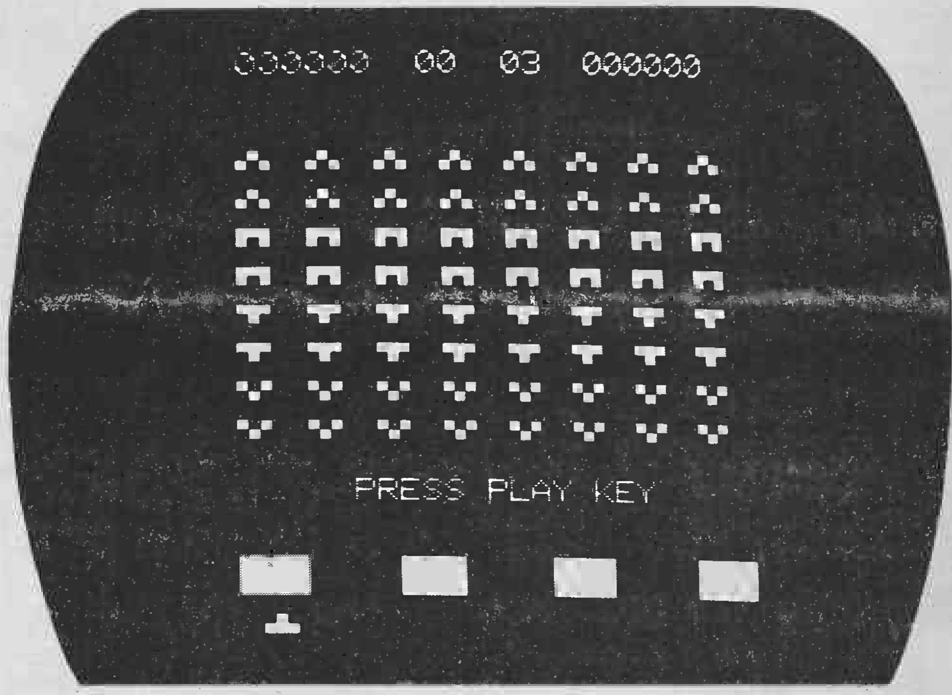
Short Wave Converter

This SW converter tunes over 5 to 15 MHz approximately and also enables an ordinary MW broadcast receiver to pick up stations operating on the 19, 25, 31, 41 and 49 m broadcast bands.

Signals picked up by the telescopic aerial are directly coupled into the aerial tuned circuit as these signals will be quite weak, necessitating a tight coupling. CV2 is the main tuning capacitor for the aerial tuned circuit and CV1 is the aerial trimmer control. The signals selected by the tuned circuit are coupled directly into the gate of mixer transistor Q1, no coupling winding being needed here due to the use of a JFET transistor with a very high input impedance. The drain load for Q1 is a MW ferrite aerial, but it is used in reverse in this application and is used to radiate the 1.6 MHz IF output of the converter. This is picked up by the MW radio, which is placed near the converter and tuned to a quiet spot on the band in the vicinity of 1.6 MHz. The position of the coil on the ferrite aerial is adjusted to resonate L2 at the appropriate frequency and effect optimum signal transfer.

The oscillator uses JFET device Q2 in the source follower mode, with positive feedback provided by L3. At the resonant frequency of L3 there is sufficient feedback to cause oscillation and CV3 tunes the oscillator over a frequency range which is 1.6 MHz higher than the range of the aerial tuned circuit so that the required difference frequency of 1.6 MHz is produced at the output. C6 is a padder capacitor which gives reasonably good tracking between the aerial and oscillator circuits. Perfect tracking is not required since CV1 can be used to keep the unit peaked for optimum results. C3 is used to couple the output from the oscillator to the input of the mixer stage. The circuit has a current consumption of only 4 mA.

SPACE INVASION GAME



You've heard of the beer you drink at home — now ETI is doing its bit to clear the pubs with the Space Invasion game you play at home. Will the social life of England ever be the same?

Hardware design by Paul Johnson. Software by Mike Rose.

One of the fastest growth industries of the last few years must be the production of video games. Only a couple of years ago we were pushing our five pence coins into the slot to play what was laughingly known as tennis (two oblong 'bats' and a blob that bounced all over the screen). Nowadays we can pilot starcruisers into the uncharted depths of space and zap the enemy with laser bolts, launch rescue missions to the Moon, and engage in dogfights with agile aliens who can fly rings round a cathode ray tube. Of course it costs more than fivepence too! Video games have probably led the field in showing the public that the microprocessor is capable of better things than frightening Clive Jenkins.

Life would be a lot better if you didn't have to keep feeding the coin slot to stay in practice, though, and as usual ETI comes to the rescue. Yes, for the first time anywhere we present a home-built version of the country's most popular pastime (all right, second most popular). Before you glance across to Buylines and decide we've got peculiar ideas about how to save you money, it should be pointed out that you get more than just a TV game. A TV game requires a microprocessor, some memory, a graphics generator, a keypad and a UHF output suitable for plugging into your television set. Amazingly enough these are also what you need for a home computer. Once you have the basic Space Invasion game, you can expand it at very little expense into just such a computer, designed by Tangerine Computer Systems.

Playing the Game

The game follows a fairly standard format. Eight columns of eight saucers fly backwards and forwards across the TV screen and slowly descend while you take potshots at them from your laser base at the bottom of the screen. The base may be moved to left and right to aim at the enemy and to dodge the bombs they are dropping on you. If they hit you, your base is destroyed, but there are defences for you to hide under — these are gradually whittled away by the alien barrage. (Your laser bolts can cancel bombs as they fall.) Everything gets faster as the number of aliens decreases, and when they've all been wiped out, lo! another fleet appears.

Scoring is as follows: Top two rows — 50; Next two — 40; Next two — 30; Bottom two — 20. Every time you blast a saucer, its score is added to your total. Occasionally a huge saucer flies across the top of the screen; it doesn't drop bombs and hitting it scores 100 points. There are four numbers displayed at the top of the screen, and from left to right they are: score this game, number of saucers left on screen, number of bases you have left and highest score during this session. You start off with three bases and are awarded an extra one for every two thousand points, but you can't have more than four at once.

The switches are provided to select one of four levels of difficulty — these are set to either 0 V or 5 V and provide a binary input, 00 for easiest level (slow) and 11 for expert (very fast). →

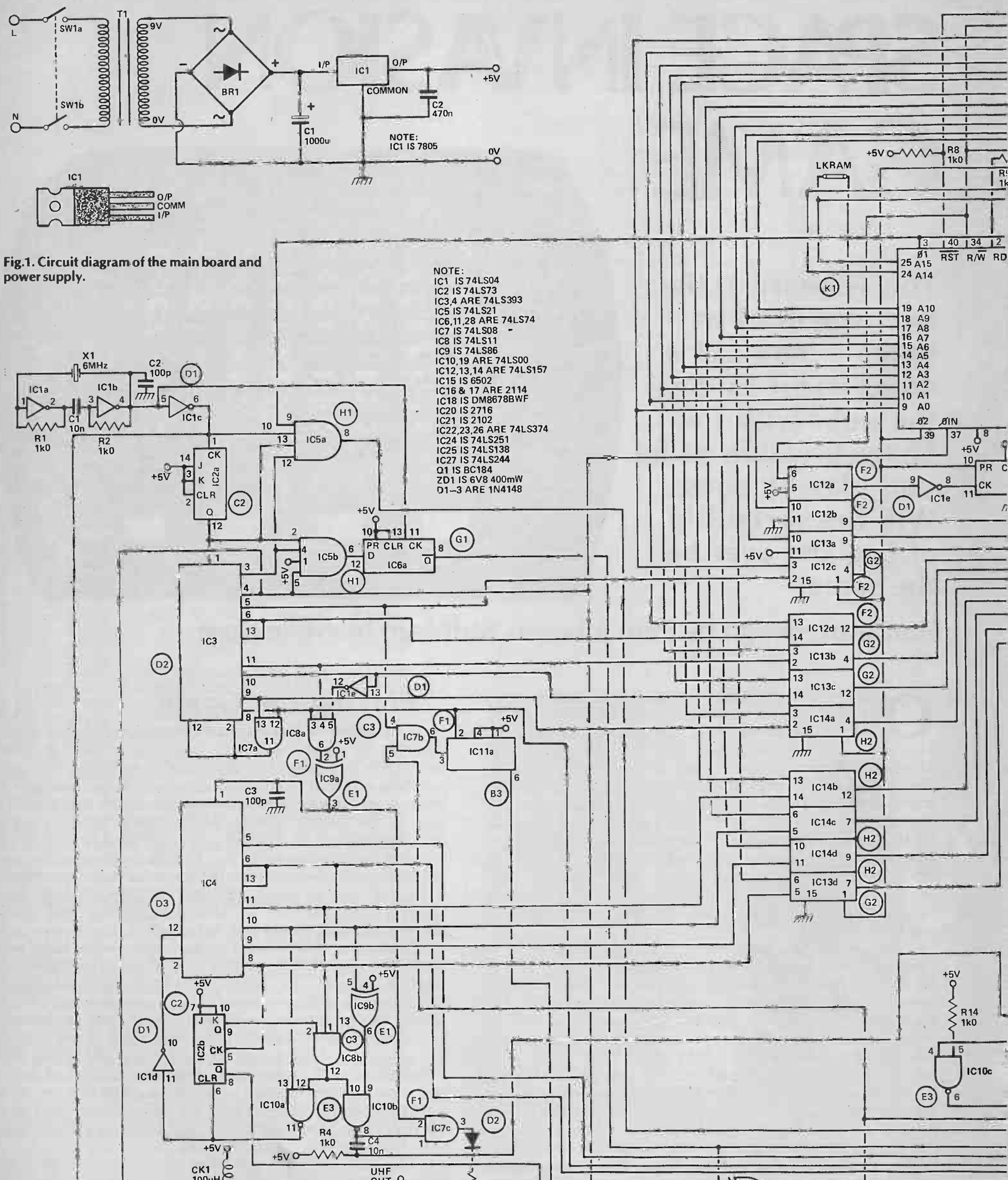
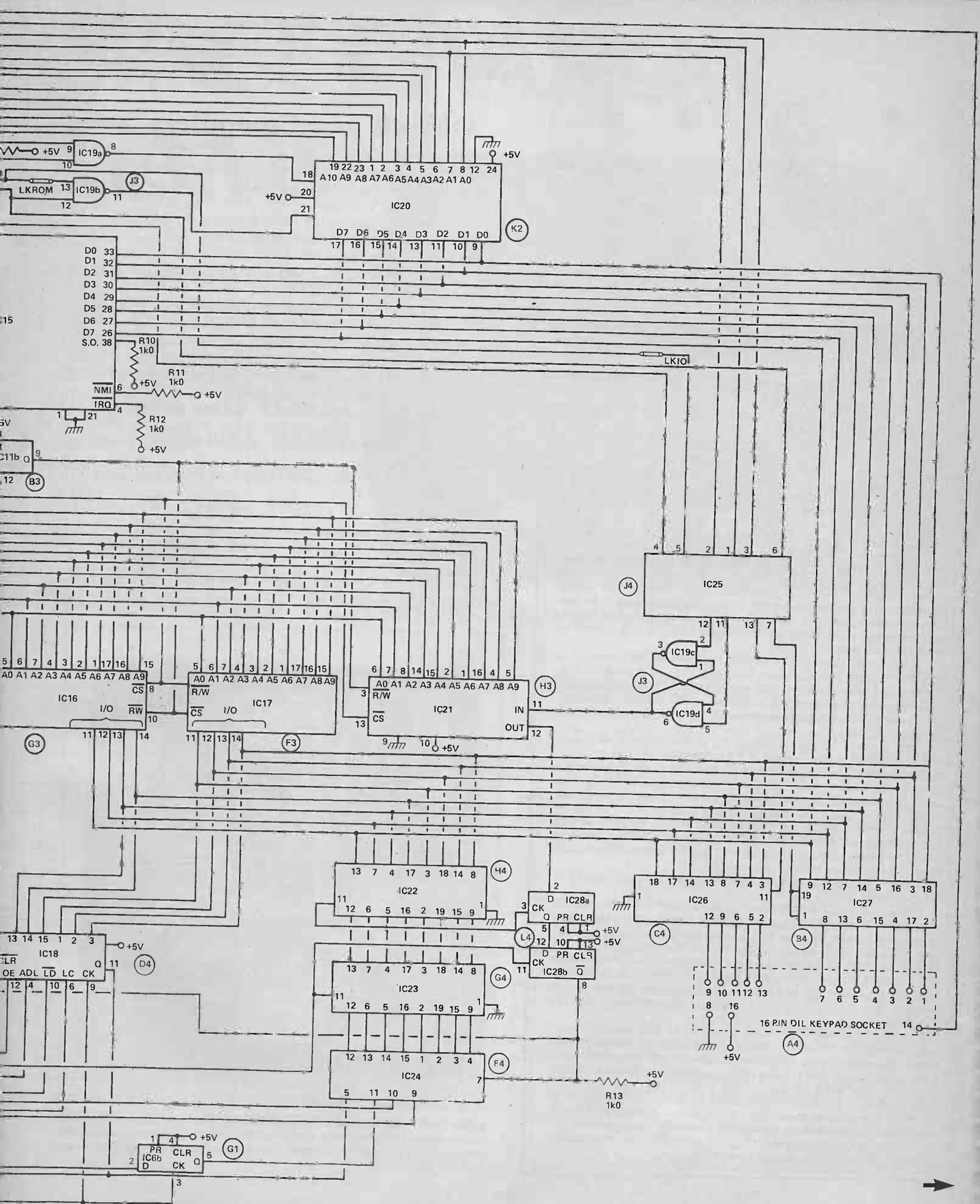
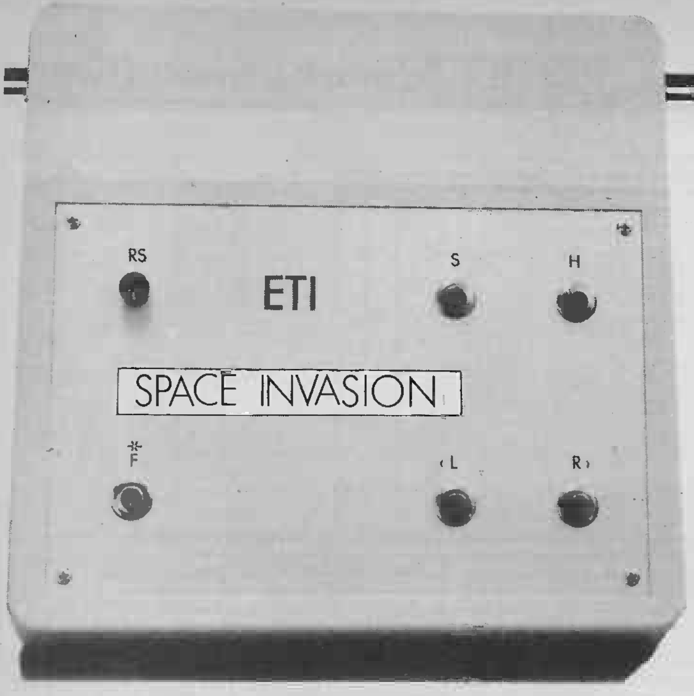


Fig.1. Circuit diagram of the main board and power supply.


IC19a
IC19b
LKROM
IC20
IC15
D0 D1 D2 D3 D4 D5 D6 D7
S.O.
NMI
IRQ
R10 1k0
R11 1k0
R12 1k0
IC11b
LKIO
IC25
IC19c
IC19d
IC16
IC17
IC21
IC22
IC23
IC24
IC26
IC27
IC28a
IC28b
IC18
IC6b
R13 1k0
16 PIN DIL KEYPAD SOCKET
+5V
K2
J3
J4
B3
G3
F3
H3
H4
G4
F4
L4
C4
B4
A4
D4
G1



The face of the Space Invasion. The simple controls are reset, start (play), hold, fire, left and right.

HOW IT WORKS

Although the circuit diagram looks hideously complex, it falls quite naturally into various basic blocks which can be examined separately. The heart of the system is IC15, a 6502 microprocessor. This can be seen at top centre of the circuit, surrounded by its memory and address decoding chips. Below these are the chips that generate the graphics for the display. The I/0 port for connecting the main board to the keyboard and sound generator circuitry is on the right. Finally, the entire section on the left produces the timing signals required by the microprocessor, as well as all the synchronising signals which must be mixed with the video information before it is passed to the UHF modulator.

The master oscillator is formed by three of the inverters in IC1; the frequency of operation is set at 6 MHz by crystal X1, IC2, IC3 and IC4 form the complete counter chain for generating all the timing signals and refresh addresses — the various additional gates and flip-flops decode the counter outputs to provide these signals as follows.

IC3 is reset by the output of IC7a; this controls its count length. Three of the outputs of IC3 are decoded by IC8a and IC9a to produce the line sync pulse, which also clocks the line counter IC4. The line blanking pulse is produced at pin 6 of IC11a. The count length for IC4 is controlled by the reset pulse derived from IC10a, and IC10b produces the frame sync pulse. The frame blanking pulse is produced at pin 8 of IC2b. The frame sync and line sync pulses are mixed in IC7c; the frame blanking and line blanking pulses are mixed in IC8c with the video information from the character generator circuitry.

The timing signals for loading the character generator IC18 are produced by IC5 and IC6.

The line blanked and frame blanked video is mixed with the sync pulses by diode 'OR' gate D2, D3. R5, R6 and R7 ensure that the various parts of the composite signal have the correct relative amplitudes before being fed to the input of the UHF modulator. The modulator requires a supply voltage higher than the 5 V that powers the other circuitry — this is derived from chopper transistor Q1 which is driven by one of the outputs of counter IC3. D1, ZD1 and C5 regulate the voltage from Q1 collector to 6V8.

IC12, IC13 and IC14 form the address and control signal selector for the memory. This switches over at the processor clock rate and allows both screen refresh and microprocessor access to occur at full speed without mutual interference. IC20 is the ROM chip; the RAM is provided by IC16, IC17, and IC21. The data output of the RAM is processed by IC22, IC23 and IC24 to produce the graphic pixel cells. IC28 selects either graphics or alphanumeric mode for a particular character cell position.

IC26 and IC27 provide the I/0 port to read the paddle switches and drive the sound generator.

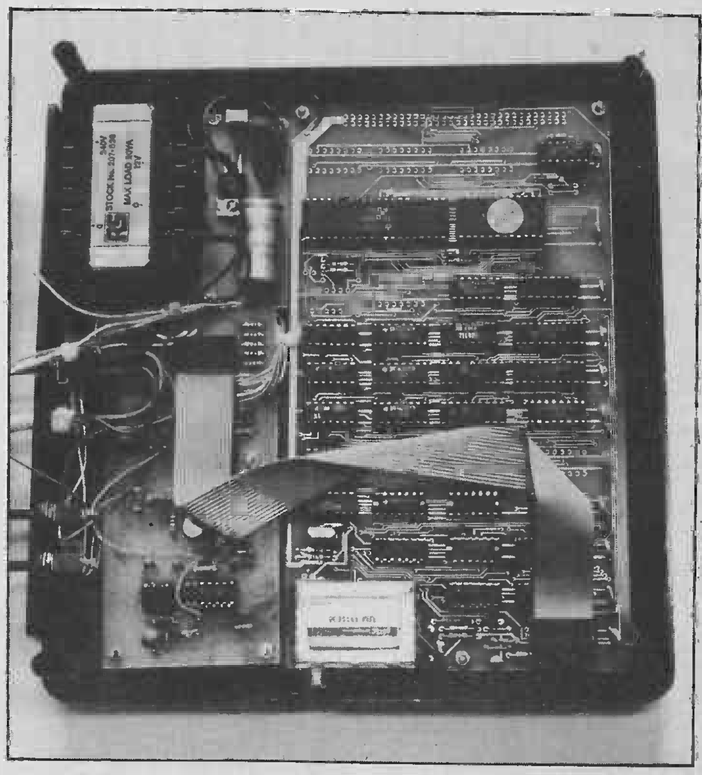
A unique feature of this game is the provision of a hold switch. If you want to go to the loo, or answer the phone, you can freeze the action in the middle of the game and carry on where you left off when you get back.

Objects and Computers

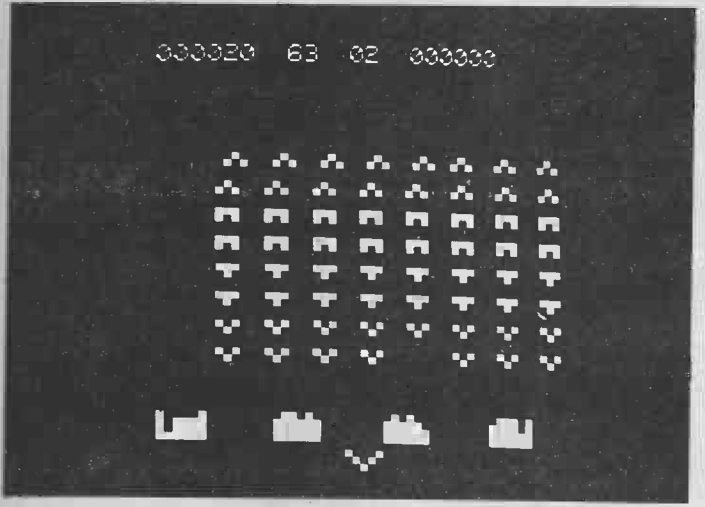
The object of the game is to score 999,999 points! If you manage it a suitable message appears on the screen but we're not going to tell you what it is — play the game and find out for yourself, if you can. You lose if:
1) You lose all your bases before reaching 999,999;
2) An invader touches your laser base;
3) An invader lands on the baseline.

If you already own a Microtan 65 computer than it isn't necessary to build all the hardware for this project — you simply run the Space Invasion software on your existing machine. Sound effects are optional and require the additional circuitry shown in the diagram. The special hardware may be added by connection to the cable socket. All the possible configurations for getting Invasion onto your TV screen are given below.
1) Invasion PCB + Hex keypad + Invasion PROM
2) Invasion PCB + special Key Unit + Invasion PROM
3) Microtan 65 + Tanex + Invasion PROM (in position E2) + Hex keypad
4) Microtan 65 + Tanex + Invasion PROM + special Key Unit
5) Microtan 65 + Tanex + 2K RAM + keyed-in software + Hex keypad
6) Microtan 65 + Tanex + 2K RAM + keyed-in software + Key Unit.

Note the use of a Hex keypad — this project will *not* run with an ASCII keyboard.



Inside the box, the main board is fitted into the right hand side, connected to the sound effects board on the left by ribbon cable. The power supply board is squeezed in next to the transformer. The two switches on the rear panel select the level of difficulty.



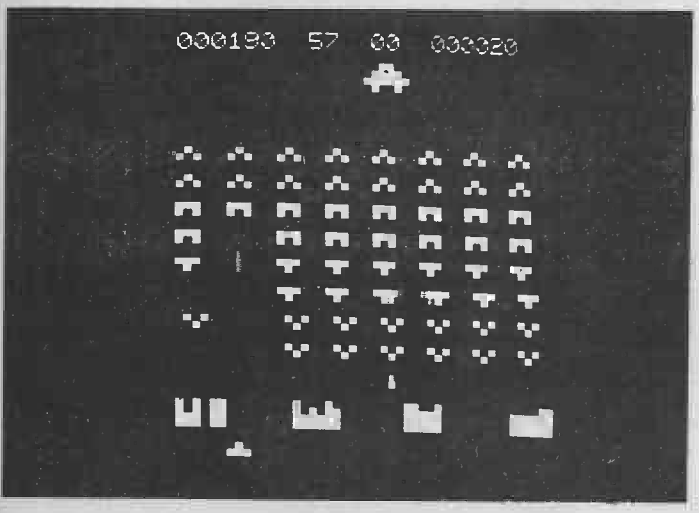
The screen display. This unfortunate space traveller has just been zapped by an alien.

Construction

Tricky bit first. The main board is double-sided but it isn't necessary to solder components on both sides because the holes are plated through (sighs of relief). Fit the links and the discrete components first, being careful with the polarity where necessary, then solder all the IC sockets in the positions shown in the overlay diagram. You'll find there are more spaces for sockets than there are sockets but don't panic — this is to allow for later expansion into a computer as mentioned earlier. The UHF modulator is fixed to the PCB by soldering the case tags to the large pads provided — make sure it's the right way round. Now, double-checking both device type and orientation very carefully, plug the ICs into their sockets. Fit two lengths of wire for the power supply connections (these solder directly to the copper track) and the main board is complete. Check it again.

Well, there's still a long way to go. We have a score of 480 with 49 aliens still coming and no bases left. But we did better than the last astrogamester. He only scored 20.

With a flying saucer zooming across the top of the screen, one alien has just launched a missile. Hit your left or right button quick! Or try to blow his (its) missile off the screen.



Operating Differences

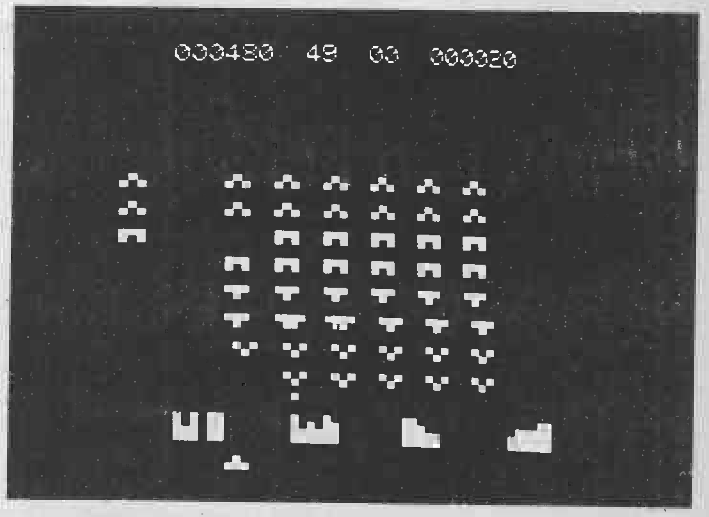
The UHF modulator for either version of the game is pre-tuned to Channel 36. Plug into the aerial socket, select a channel and adjust the tuning until the picture appears. If the game has been switched on without 'Reset' being operated, the screen will contain garbage.

If you are using the basic Invasion PCB, then operating the Reset switch brings the system into the 'ready-to-play' condition. If you are running the software on the Microtan 65, use Reset to gain access to TANBUG. The PROM is assembled to live at E800 (Hex), and the listing for the RAM version is assembled to live at 400 (Hex). So for the PROM version, typing GE800 brings the game to readiness by moving to the start address. With the software keyed into RAM, type G400.

If you are using the Hex keypad, the following keys are equivalent:

0 = PLAY
4 = BASE RIGHT
8 = BASE LEFT
C = FIRE
SHIFT = HOLD

Hitting any of the keys except HOLD removes hold.



Now you can sit in front of your telly and make your living room a safe haven for the human race. For details of the modifications to produce a home computer, watch this space!

BUYLINES

Tangerine Computers Ltd can supply the ETI Space Invasion project built for £99.85 all inclusive (or £80.85 in kit form). The sound generator and keypad section is available built for £20.55 all inclusive (or £15.38 in kit form).

If you want to shop around for your own components you can get the main Space Invasion PCB only for £21.15 all inclusive and the sound generator board for £5.60. The ROM is available for £17.75 all inclusive.

A case with internal PSU will be available from Tangerine soon. Contact them for the latest information on availability and price. Tangerine Computers Ltd, Forehill, Ely, Cambridgeshire.

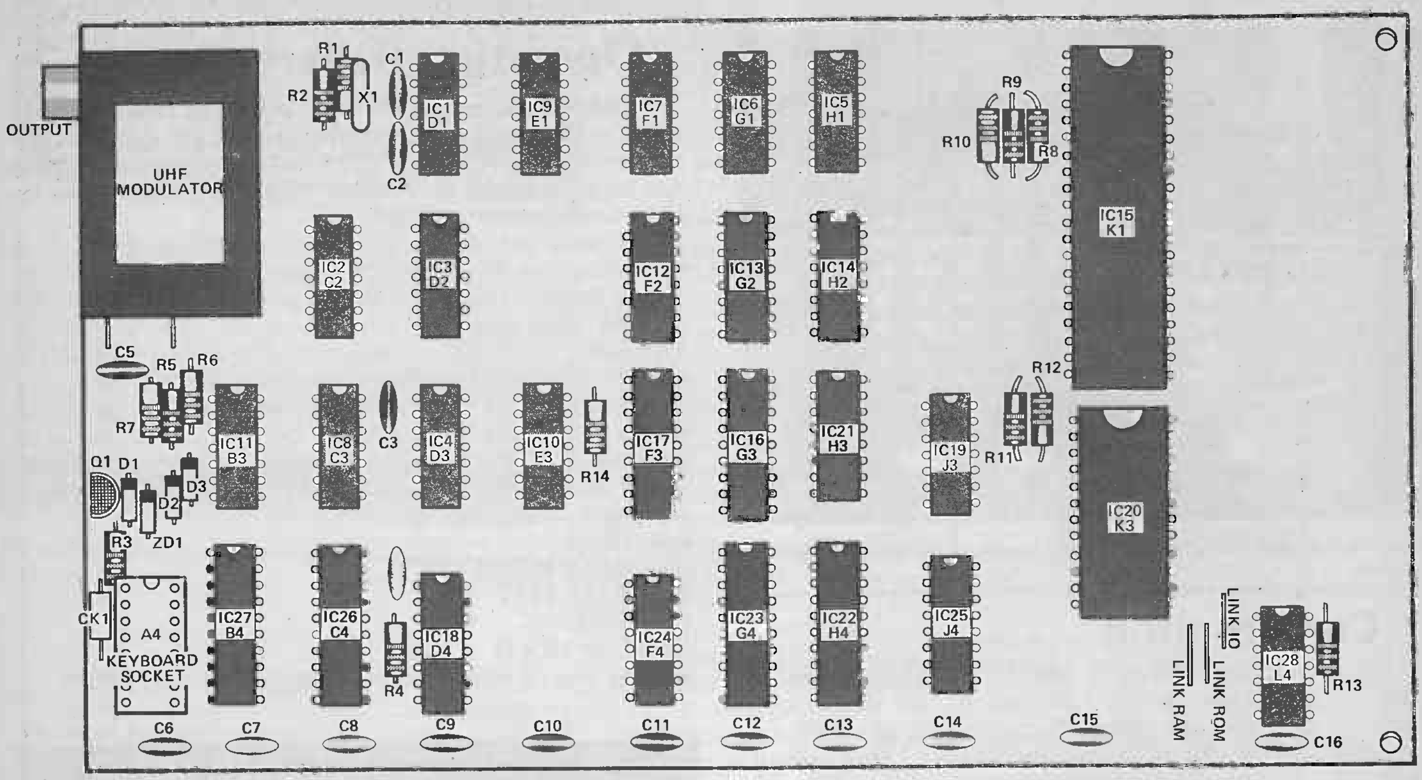


Fig.2. (above) Component overlay for the main board. All the chips face the same way.

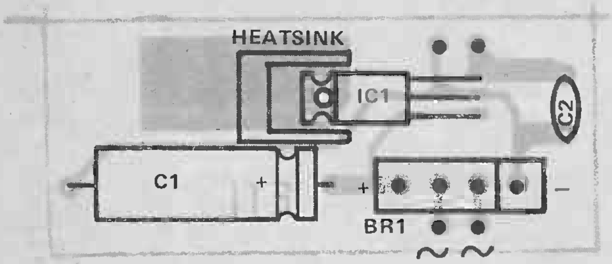


Fig.3. Component overlay of the power supply circuit. The heatsink is a type TV4, available from Watford Electronics.

PARTS LIST

Capacitors	
C1	1000u 25 V electrolytic
C2	470n polycarbonate
Semiconductors	
IC1	7805
BR1	1.6 A 'In-Line' package
Miscellaneous	
T1	0-9 V @ 1 A
SW1	DPDT miniature toggle
heatsink	

Next month, we conclude the ETI Space Invasion Game with constructional details of the sound effects board.

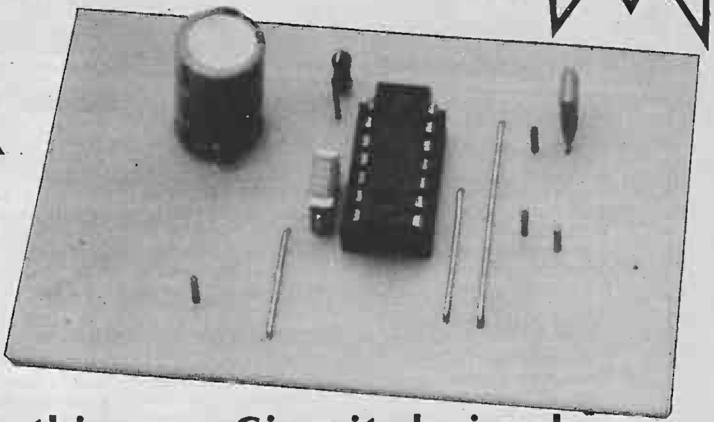
ETI

PARTS LIST

Resistors all ¼ W 5%	
R1,2,4,8,9,10,11,12,13,14	1k0
R3	10k
R5	470R
R6	220R
R7	75R
Capacitors	
C1,4	10n ceramic
C2,3	100p ceramic
C5,6-16	47n disc ceramic
C6-16 are decoupling components, one for each column of ICs.	
Semiconductors	
IC1	74LS04
IC2	74LS73
IC3,4	74LS393
IC5	74LS21
IC6,11,28	74LS74
IC7	74LS08
IC8	74LS11
IC9	74LS86
IC10,19	74LS00
IC12,13,14	74LS157
IC15	6502
IC16,17	2114
IC18	DM8678BWF
IC20	2716
IC21	2102
IC22,23,26	74LS374
IC24	74LS251
IC25	74LS138
IC27	74LS244
Q1	BC184
ZD1	6V8 400 mW
D1-3	1N4148
Miscellaneous	
CH1	100 uH choke
X1	6 MHz crystal
UHF modulator	UM1111E36
PCB, case, 14-pin DIL socket (x13), 16-pin DIL socket (x8), 18 pin DIL socket (x2), 20 pin DIL socket (x4), 24 pin DIL socket, 40 pin DIL socket.	

A PROJECT FOR YOUR FREE PCB

2W POWER AMPLIFIER



This must be just about the simplest power amplifier that you're likely to come across — a few components and a free PCB. No excuses for not building this one. Circuit design by Keith Brindley.

If you need a simple-to-build, inexpensive power amplifier and you've got 15 minutes to spare, unpack your soldering iron and ETI Multi-Option Board. That's all it'll take to get your ETI 2 W Power Amplifer up and running.

We aren't claiming total originality for this circuit. The donkey work, of course, is all done by the well known and loved LM380 power amplifier IC. This chip eliminates the need for preset adjustments of any kind, and distortion and output noise are so low as to render the circuit virtually in the "High Fidelity" category.

Only four other components are needed to complete the amplifier, which will provide the builder with a fine device, needing only a power supply of between about 9-18 V DC (ideal for battery operation) to get things going.

For those interested in technical specifications, you'll want to know that the IC features an internally fixed gain of 50 (34 dB) and an output which automatically centres at half supply voltage. The output stage is short-circuit current-limited and thermal shutdown in the chip prevents overheating-to-damage point — it turns itself off if it runs a temperature, takes two aspirins and calls you when it cools off again. So, it's safe to assume that the amplifier is just about idiot-proof!

Construction

Nothing much to comment on here. It's all straightforward. Just make sure the chip is the right way round, as should be the power connections (shown on the overlay).

HOW IT WORKS

The whole IC can be regarded as a simple op amp with a power output stage tagged on at the end. Pin 2 is the inverting input and pin 6 the non-inverting input. To these can be added the usual feedback connections to tailor gain and frequency response as required, but internal resistors tie what would be the open loop gain to a flat ratio of 50. So with no feedback resistance, a fixed gain of 34 dB occurs whatever the input.

The output stage is a class AB, quasi-complementary pair, emitter-follower. This keeps crossover distortion to a minimum whilst also maintaining quiescent current at less than 15 mA. This latter fact allows satisfactory battery operation, with low distortion.

R1 and C2 form a Zobel network, which effectively suppresses a possible 5 to 10 MHz small amplitude oscillation which can occur during the negative swing into the load. Obviously the oscillations are not in the audio range nor will they pass through the speaker (due to coil reactance), but nevertheless they can cause power loss and other problems in an RF sensitive environment.

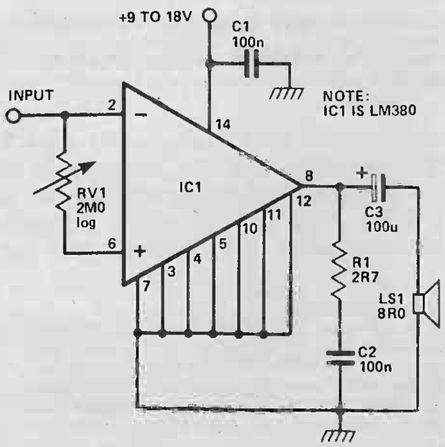


Fig.1 Circuit diagram. Pins 3,4,5,10,11 and 12 are joined internally.

PARTS LIST

Resistor ¼ W 5%	
R1	2R7
Potentiometer	
RV1	2M0 logarithmic
Capacitors	
C1,2	100n polycarbonate
C3	100u 16 V electrolytic
Semiconductor	
IC1	LM380
Miscellaneous	
LS1	8R0 Loudspeaker
ETI Multi-Option PCB	

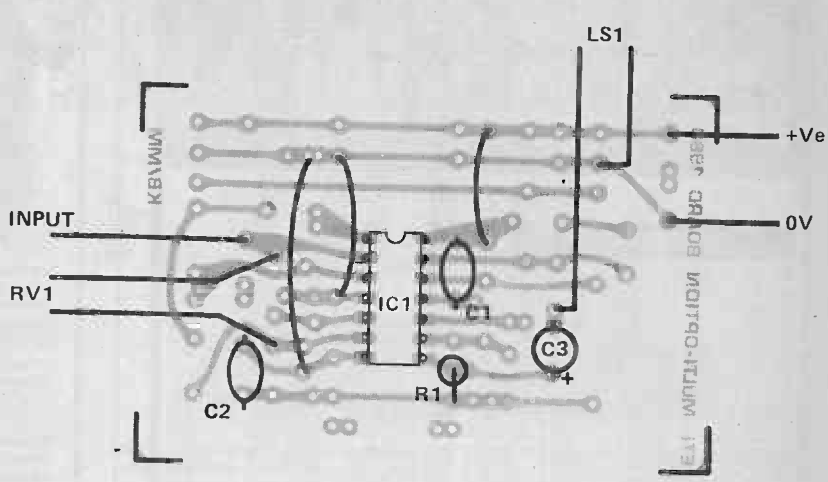


Fig.2 Component overlay.

BUYLINES

A simple project with few components. You shouldn't meet with any difficulty in obtaining the components. Have a look at the major suppliers advertising in this issue.

ETI

DESIGNER'S NOTEBOOK

In this month's 'Notebook' Ray Marston explores the mysterious depths of 'zero-voltage switching' of mains power and looks at some practical applications of the CA3059 'zero-voltage' IC.

There are two basic ways of switching mains power to a load — either via a mechanical switch or via a solid state switch such as a triac. Mechanical switches are fairly slow acting devices: they suffer from severe arcing at the moment of switching and generate a great deal of RFI (radio-frequency interference) at switch-on and switch-off. This RFI can often be heard on domestic radio and TV sets and can cause malfunctioning of delicate electronic equipment.

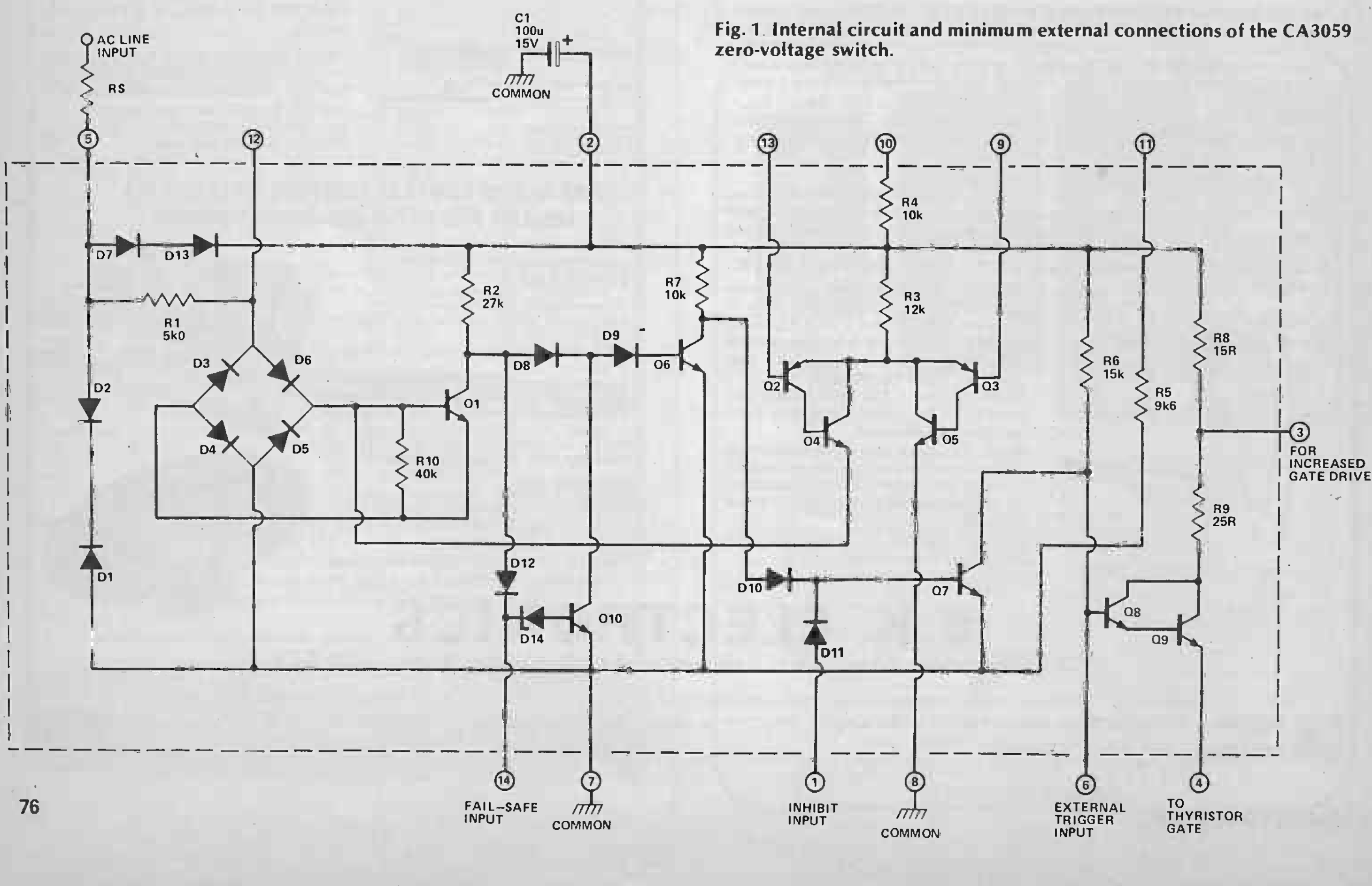
Triac switches are fast acting devices and do not suffer from arcing problems. Nevertheless, they are still capable of generating considerable RFI at switch on. Why? As the triac turns on, the load current may rise from zero to several amps in a mere couple of microseconds: since this current flows through the mains wiring, the wiring may radiate a great 'splurge' of RFI in response to this heavy surge current. The magnitude of the RFI is proportional to dI/dt and can be reduced by either reducing the surge current amplitude or increasing the surge current rise time, or possibly both: once the triac has turned on, the subsequent large 'rise time' of the 50 Hz mains signal causes virtually zero RFI even when load currents of tens of amps are being drawn.

Zero-Voltage Switching

Thus, the degree of triac switch-on RFI is proportional to the value of instantaneous mains voltage at the moment of triac turn-on. If a 100R load is being driven from 230 V AC mains, the surge current will be 3A25 if switch-on occurs at a 'crest' value of 325 V, or mere 32.5 mA if switch-on occurs at a 'near zero-crossover' value of 3V25.

Triacs are self-latching devices. If they are turned on by a brief gate signal, they remain on until their main-terminal currents fall below a minimum 'holding' value

Fig. 1. Internal circuit and minimum external connections of the CA3059 zero-voltage switch.



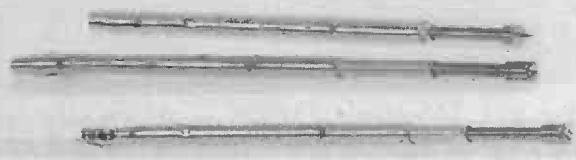
Keep Your Pecker Up

Chiptech have just introduced a new portable EPROM programmer based on the Z80 microprocessor. The PKW5000 is capable of programming devices up to 32K bits, including the 2708, 2716, 2732, 2516 and 2532 EPROMs. Keyboard function commands such as load, write, erase, check, compare and buffer clear as well as data entry and various editing functions through the RAM buffer are available.

A 16 digit hex display shows address and data information and also the EPROM type selected. An audible warning confirms the key-in operation, programming completion and error occurrence.

In addition to its programming capability, the PKW5000 may be used to run and debug Z80 programs with readout of all registers and insertion of up to two breakpoints. An optional I/0 card will allow the unit to be interfaced with a 150 CPS tape reader, a 20 mA current loop or RS232C serial interface. The option also contains sockets which can accept preprogrammed EPROMs containing an assembler, debug program or BASIC.

For further information on the PKW5000 get in touch with Chiptech Ltd, Unit One, Tewin Court, Welwyn Garden City, Hertfordshire AL7 1AU.



Test Points

Vero Electronics can now supply a range of high quality, low cost probe pins for testing bare or component-loaded boards, wire-wrap boards or backplanes.

The pins come in two parts — the receptacle, which is available in either minwrap or solder termination, and the spring contact, which can have any one of three tips. The serrated tip will cut into flat pads to enable readings to be taken; the conetip can be used to probe plated-through holes; the cup can be used for wire wrap boards or backplanes.

The pin constituents are a veritable tour of the periodic table. The spring contact probes have heat treated beryllium copper plungers plated with rhodium over nickel and the phosphor bronze receptacles and nickel silver contact shells are plated with gold over nickel.

For further details of these low cost probe pins contact Vero Electronics Ltd, Industrial Estate, Chandlers Ford, Eastleigh, Hampshire SO5 3ZR.

APOLOGY

On page 84 of the September issue of Electronics Today International we published an advertisement placed by Tempus which stated that Zeon had gone into voluntary liquidation. This statement referred to Zeon Products Limited and was not intended to reflect in any way on Zeon Limited.

The advertisement was phrased in such a way that it may have been detrimental to Zeon watches. No criticism of the watches sold by Zeon Limited under the "Zeon" trade mark was intended. Furthermore, we are informed that Zeon Limited have taken over the service obligations entered into by Zeon Products Limited, thereby providing continuing service.

We wish to apologise to Zeon Limited for any embarrassment which the advertisement may have caused.

Microbasics

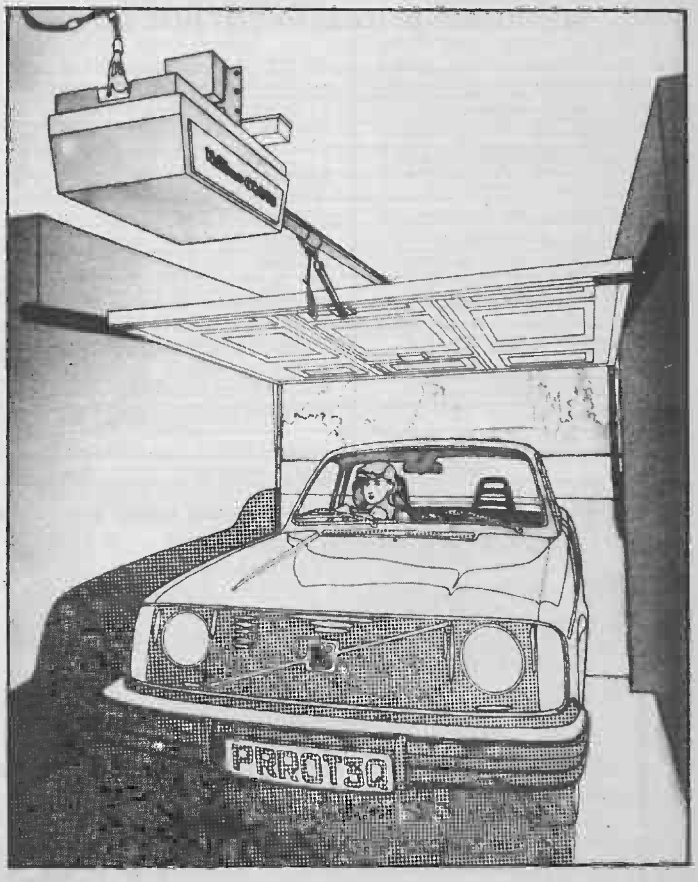
We've had a few inquiries about the subject of the photo we used to start off Microbasics in September. It was one of the first all-transistor computers, built at Harwell between 1952 and 1954. In the 1950s, CADET (the reversed initials of Transistor Electronic Digital Automatic Computer) was thought of as a mini compared to the vast valve complexes of the day.

CADET was used for several years at Harwell. The UK nuclear programme and Harwell's involvement generally in electronics and instrumentation benefitted from the experience gained from the design, construction and use of CADET. You may have seen some of its original circuit panels at the 'Challenge of the Chip' exhibition at the Science Museum in London.

Home Computing

A new computerised garage door which has achieved great success in the States, is now being sold in the UK. It is being introduced to builders' merchants, hardware, electrical DIY and car accessory retailers. The NuTone garage door operates from the greater than normal distance of 400 yards, has a computer that makes its own adjustments and is simple to instal. Whilst it is a convenience to the ordinary motorist it is also useful for elderly or handicapped drivers. The hand-held radio control unit is fitted with British-made electronics and is Home Office approved. Additional units can be purchased as well as an alternative key-operated opening device which can be fitted to the gatepost or a site convenient to the garage entrance. Inside the home a push button switch (this is included) can be installed to operate the NuTone door.

A built-in light is also included to switch on once the door is opened. Should the door be obstructed as it tries to close, the motor will automatically reverse until the door is fully open. In the event of an obstruction as it opens, the motor will stop. The garage door operator costs £229 including VAT. The radio receiver, transmitter and aerial costs £75; the key switch system £9.25; a manual release button £14.85; additional transmitters £28.25 and pushbuttons 85p. A Haos service agent will confirm whether or not a garage door can accommodate the unit. The Haos Company Ltd are at The Built-In Centre, 32 Letchworth Drive, Bromley, Kent.



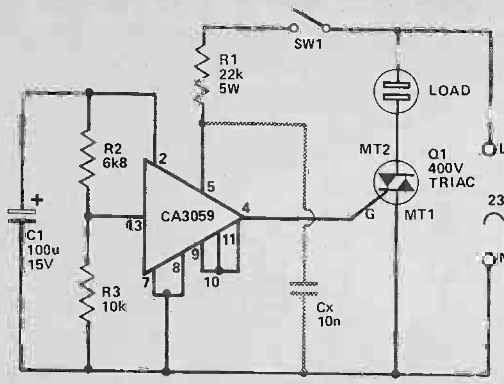


Fig.2 A simple mains-switched zero-voltage switch. Cx may be used to overcome latching deficiencies of some triacs.

of a few milliamps. They automatically turn off at the end of each mains half cycle as their main-terminal currents fall to near-zero. They can be turned on near the start of each half cycle as soon as their main-terminal currents are capable of exceeding the minimum holding value.

Thus, a triac can be persuaded to generate virtually zero switch-on RFI by feeding it with gate current *only* when the instantaneous mains voltage is close to the zero or cross-over value at the start of each half cycle. This technique is known as 'zero-voltage switching'. Special zero-voltage triac-driving ICs are available from a number of manufacturers. One such device is the CA3059, manufactured by RCA.

The CA3059 Zero-Voltage Switch

The internal circuit and minimal external connections of the CA3059 zero-voltage switching IC are shown in Fig.1. The device is housed in a 14-pin DIL package and incorporated DC power supply circuitry, a zero-crossing detector, triac gate drive circuitry and a high-gain differential amplifier/gating network. Circuit operation is as follows.

Mains power is connected between pins 5 and 7 of the device via limiting resistor Rs (22k, 5 W when 230 V mains is used). D1 and D2 act as back-to-back zeners and limit the pin 5 voltage to ± 8 V. On positive half cycles D7 and D13 rectify this pin 5 voltage and generate approximately 6V5 across the 100uF capacitor connected to pin 2. This capacitor supplies sufficient energy storage to drive all internal circuitry and provide adequate triac gate drive, with a few milliamps or so spare drive available for powering auxiliary (external) circuits.

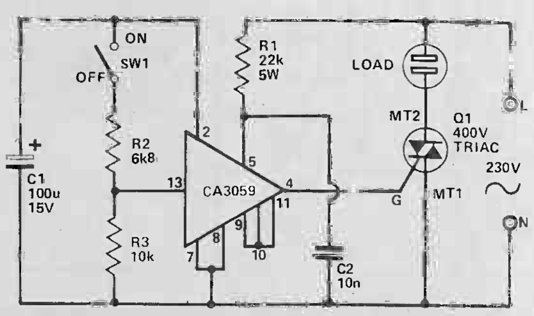


Fig.3 Direct-switched zero-voltage switch.

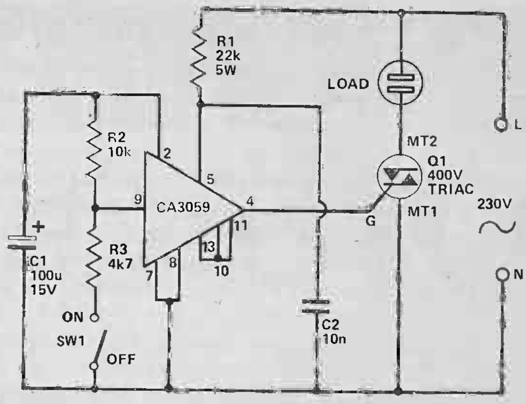


Fig.4 An alternative and very useful method of direct-switching the CA3059 IC.

Bridge rectifier D3-D6 and transistor Q1 act as a zero-voltage detector, their action being such that Q1 is turned on (driven to saturation) whenever the pin 5 voltage exceeds ± 3 V. Gate drive to an external triac can be made via the emitter (pin 4) of the Q8-Q9 Darlington pair of transistors, but is available only when Q7 is turned off. When Q1 is turned on (pin 5 greater than ± 3 V) Q6 is turned off through lack of base drive, so Q7 is driven to saturation via R7 and no triac gate drive is available from pin 4. Triac gate drive is thus available only when pin 5 is close to the 'zero-voltage' or cross-over mains value. When gate drive is available, it is delivered in the form of a narrow pulse centred on the cross-over point with pulse power supplied by C1.

Vive La Differential

The CA3059 incorporates a differential amplifier or voltage comparator, built around Q2 to Q5, for general purpose use. Resistors R4 and R5 are externally available for biasing one side to the amplifier. The emitter current of Q4 flows via the base of Q1 and can be used to disable the thyristor (pin 4) gate drive by turning Q1 on. The configuration is such that the gate drive can be disabled by making pin 9 positive relative to pin 13. The drive can also be disabled by connecting external signals to pin 1 and/or pin 14.

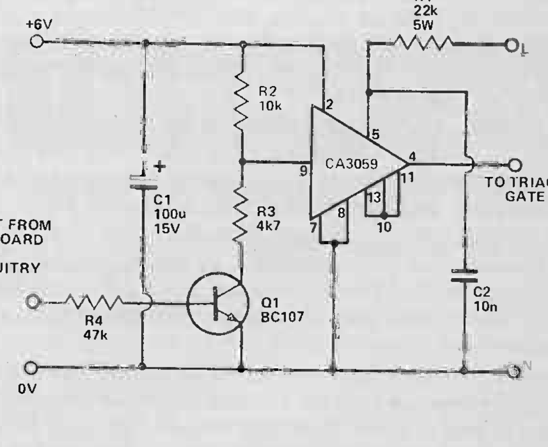


Fig.5 One method of transistor-switching the CA3059 via on-board CMOS circuitry such as one-shots, astables, etc.

CA3059 Switching circuits

Figure 2 shows the simplest possible way of using the CA3059 as a 'noiseless' switch with the zero-voltage switching provided via the IC and the triac and with on/off switching controlled by SW1. The circuit action is quite simple. The IC is connected to the mains via SW1 and limiting resistor R1. DC energy is stored by C1. The IC is wired in the 'enabled' mode by biasing the pin 9 side of the internal differential amplifier at half-supply (DC) volts via the pin 10 and 11 connections and by biasing the pin 13 side above half-supply via the R2-R3 divider network. Switch SW1 passes only a few milliamps of current and thus generates negligible RFI. The circuit can power mains loads such as lamps and heaters via a suitable rated triac.

The 'zero-voltage' triac-gate-drive pulse of the CA3059 is very narrow. In some applications, the pulse may terminate before the triac main-terminal currents have reached their minimum holding levels and self-latching may fail to occur. This problem can be overcome by wiring Cx as shown in Fig. 2. This capacitor, in conjunction with R1, gives a slight phase shift to the pin 5 signal and extends the 'zero-voltage' pulse further into the start of each mains half-cycle. A value of 10nF is adequate in most applications.

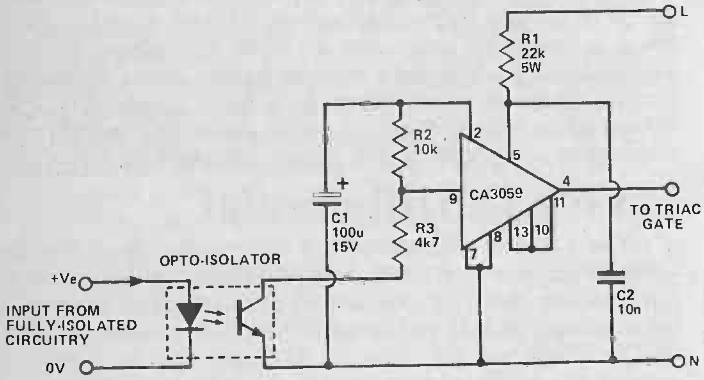


Fig.6 A method of remote-switching the CA3059 via an opto-isolator.

The Fig. 2 circuit consumes virtually zero mains power under the 'off' (SW1 open) condition. The only defect of the circuit is that SW1 operates at full mains voltage. This defect can be overcome by using the switch to directly enable or disable the CA3059 logic circuitry, as shown in Figs. 3 and 4, but in this case the circuit consumes a few watts of power (via R1) when the circuit is in the off mode.

The Figs. 3 and 4 circuits work by using the switch to enable or disable the triac gate drive via the internal differential amplifier of the IC. Remember, the drive is enabled only when pin 13 is biased above pin 9. In the Fig. 3 circuit, pin 9 is biased at half-supply volts and pin 13 is biased via R2-R3 and SW1. In Fig. 4, pin 13 is biased at half-supply and pin 9 is biased via R2-R3 and SW1. In both circuits, SW1 handles maximum potentials of 6 V and maximum currents of 1 mA or so.

Note in Fig. 4 that the circuit can be turned on by pulling R3 low or can be turned off by letting R3 float. Figures 5 and 6 show how this simple fact can be put to use to extend the versatility of the circuit. In Fig. 5, the circuit can be turned on and off by transistor Q1, which in turn can be activated by on-board CMOS circuitry (such as one-shots, astables, etc) that are powered from the 6 V pin 2 supply.

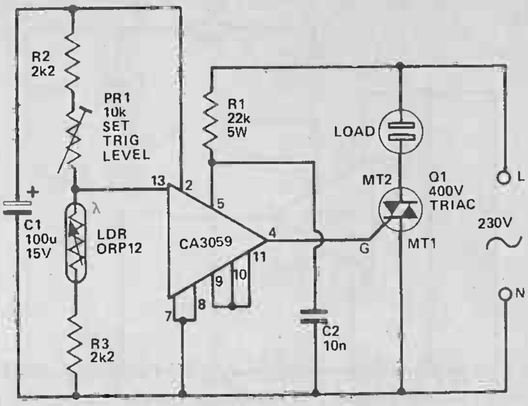


Fig.7 A basic dark-activated zero-voltage switch.

In Fig. 6, the circuit can be turned on and off by fully-isolated external circuitry via an inexpensive opto-isolator: the isolator needs an input current of only a milliamp or so to give the 'on' action.

CA3059 Comparator Circuits

The built-in differential amplifier of the CA3059 can readily be used as a precision voltage comparator that turns the triac on or off when one of the comparator input voltages goes above or below the other. If these input voltages are derived from transducers such as LDRs or thermistors, the on/off power control action can be controlled by ambient light levels or temperatures. Figures 7 to 10 show some practical circuits of these types.

Figure 7 shows the circuit of a simple dark-activated zero-voltage power switch. Here, pin 9 is tied to half-supply volts and pin 13 is controlled via the R2-PR1-LDR-R3 potential divider. Under bright conditions the LDR has a low resistance, so pin 13 is above pin 9, the triac is enabled and power is fed to the load. The precise threshold level of the circuit can be preset by PR1.

Figure 8 shows how a degree of hysteresis or 'backlash' can be added to the above circuit, so that the triac does not switch annoyingly in response to small changes (passing shadows, etc) in the ambient light level. The hysteresis level is controlled via R3, which can be selected to suit particular applications.

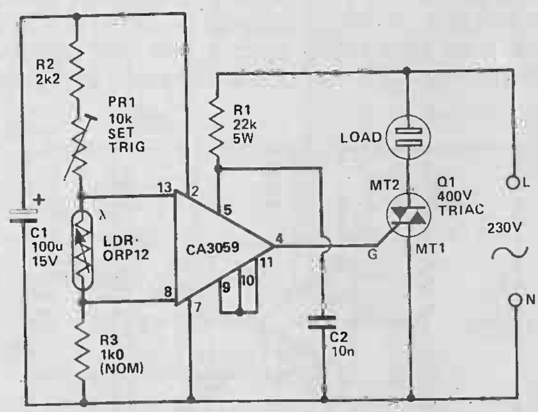


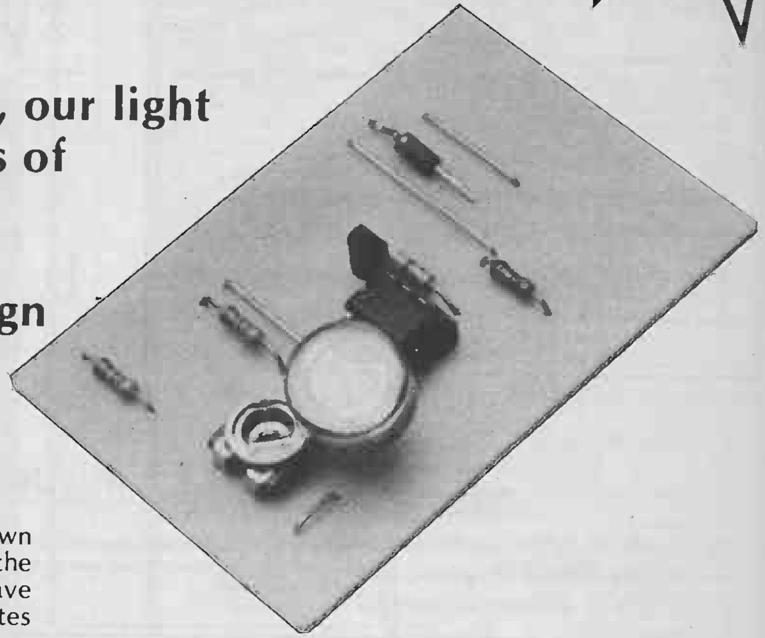
Fig.8 A dark-activated zero-voltage switch with hysteresis provided by R3.

ETI

A PROJECT FOR YOUR FREE PCB

LIGHT SWITCH

An interesting device in itself, our light switch can also form the basis of more ambitious projects — porchlight, burglar alarm . . . the list is endless. Circuit design by Keith Brindley.



Got a light switch? No, but I've got a dark brown multiplexer. Seriously though, this project using the ETI multi-option board is a must if you have need of a sensitive light operated switch which operates (turning either on or off) when the light exceeds a predetermined level. Such a device can be the heart of an automatic porch light, which turns on at dusk as the ambient light level falls below a certain amount. It could be used as part of a burglar alarm system — the switch operating when light from, say, a burglar's torch activates it.

The circuit diagram of the ETI Light Switch shows the device in its low-light operating mode. When the amount of light on the photocell, LDR1, is lower than the preset amount, the relay is energised. Alternatively, swapping LDR1 and R1 causes the relay to be energised when the light exceeds the preset level.

A single operational amplifier is the active component of the circuit and we have specified this as a type 301. However, don't rush out specially to buy one if you don't have one of these at hand, the only reason we used this particular type was because we had one handy at the design stage. Virtually any 8-pin DIL op amp will function in the circuit eg. 741, 748, 308, 3130, 351, etc can be used as substitutes.

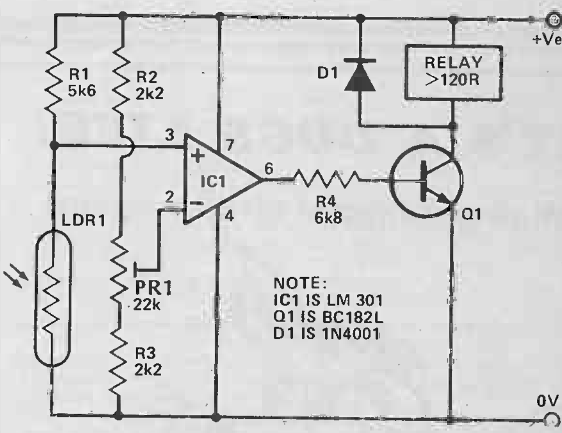


Fig.1. Circuit diagram. The switching threshold is controlled by PR1.

Construction

Construction, to use a well-worn phrase, is easy if you follow our PCB layout. It is easier still if you have the Multi-Option Board given free with this issue.

There are four links to make and these are best inserted before the components. Next, insert the resistors, the preset pot and the diode. Transistor Q1 is inserted next to IC1, using three of the remaining holes included in the board for a 14 pin DIL IC. Make sure you insert Q1 and the IC the right way round. Finally, make all the off-board connections to the battery, relay and photocell and then switch on and try your completed project. The light level at which the switching action occurs can by adjusted by PR1.

HOW IT WORKS

LDR1 is a light dependent resistor. The resistance between its terminals varies in inverse proportion to the amount of light which falls on its face — the greater the light intensity the less its resistance. So when it is connected across a power supply with another resistor in series, (R1 in this circuit), the *voltage* across it decreases with light intensity.

IC1 is a comparator which compares the voltage across the LDR with a predetermined voltage, obtained via resistor chain R2,3 and PR1. As the light level falls, the voltage across the LDR rises until it exceeds the preset level at PR1. At this point the output of IC1 goes high, turning on Q1, which in turn, operates the relay. D1 prevents damage to Q1 from any back EMF when the relay is switched off.

Swapping the positions of LDR1 and R1 means that the voltage at pin 3 of the comparator now rises with *increasing* light, so circuit operation is reversed.

→

PARTS LIST

Resistors All ¼W 5%	
R1	5k6
R2,3	2k2
R4	6k8
Potentiometer	
PR1	22k miniature horizontal
Semiconductors	
IC1	LM301
Q1	BC182L
D1	1N4001
Miscellaneous	
ETI Multi-Option Board	
Relay (coil 120R)	
LDR1 ORP 12	
9 V battery and connector.	

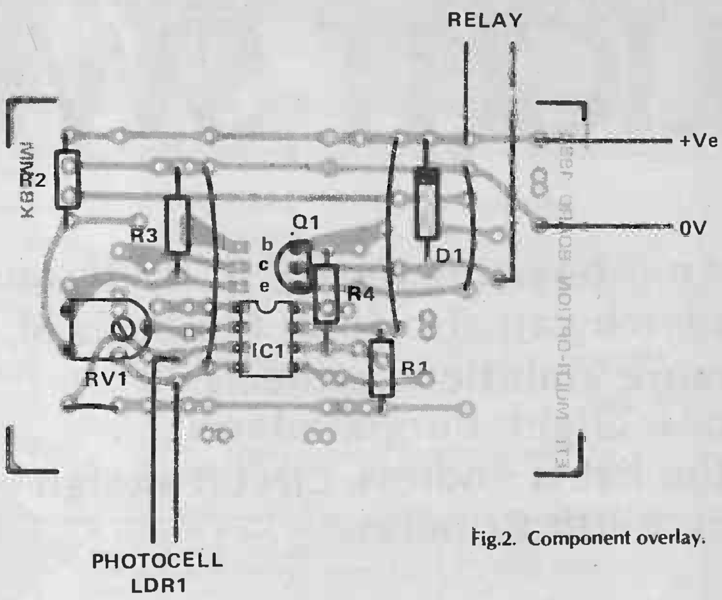


Fig.2. Component overlay.

BUYLINES

Nothing here that should cause any problems, all of the components are easily obtainable items. Make sure you get a BC182L; the pin-out for the BC182 is different.

ETI

RADIOACTIVITY

Spend the last three minutes before the bomb drops reading A.S. Lipson's excursion into that frazzling phenomenon of modern physics — radioactivity

In the last few years of the nineteenth century, a French scientist by the name of Henri Becquerel was fiddling about with some uranium compounds, trying to investigate their fluorescent properties. During the course of his work, however, and almost completely by chance, he discovered something quite different. These compounds could fog photographic plates, even if the plates were wrapped in black paper to keep out light! Henri Becquerel had discovered radioactivity.

One Into Three

As more and more work was done on the new phenomenon, it was eventually found that there are three main types of radiation. These are known, respectively, as alpha, beta and gamma rays, after the first three letters of the Greek alphabet (scientists and mathematicians long ago ran out of English letters to use as symbols. In fact, they're running short of Greek now, as well. Hebrew letters — Oy Vey! — are beginning to come into use for some things).

What makes the three types of radiation different from each other, though? Suppose we have a lump of some radioactive material. We know it's giving off rays of some sort, but how do we find out which type they are?

Eeny Meeny....

Well, actually it isn't all that bad. The three radiation types have quite different properties from each other and it's quite easy to tell the difference between them. One of the simplest ways is based on their different penetrating powers. Alpha rays, you see, don't take an awful lot of stopping. Even a moderately thick piece of paper in the way is enough to cut out most of them. Beta and gamma radiation, however, are not stopped so easily. It takes several millimetres of aluminium or lead to block off beta radiation effectively and as for gamma — nothing short of several centimetres of lead will stop that.

Shields Up, Scotty

Suppose, then, that we have a radioactive source and some means of detecting radiation, such as a Geiger counter (Fig.1). If we find that the radiation from the source is cut off when a piece of card is placed in front of the detector, then it is very likely that the radiation is alpha type. If the radiation is virtually unaffected by card, but is effectively stopped by 5 mm or so of lead, then it is probably beta radiation, whereas if it is only reduced by placing several centimetres of lead in the way, it is most likely to be gamma radiation.

Some radioactive materials give off more than one type of radiation, but, by finding the amount by which the radiation is reduced with different thicknesses of shielding, the amounts of each type present can be discovered. (Easy, Innit?).

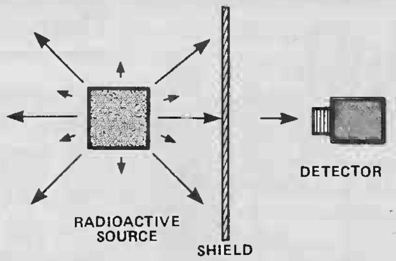


Fig.1. Alpha particles are stopped by thick paper. Beta particles are stopped by several millimetres of aluminium or lead. Gamma rays can only be stopped by several centimetres of lead.

There are other ways of detecting the difference between the three types of radiation. For instance, in an electric or magnetic field, alpha particles will be deflected one way and beta particles the other way, while gamma radiation remains unaffected. This is because alpha radiation carries positive electric charge, beta radiation carries negative charge and gamma radiation is neutral. By finding which way the radiation is bent in an electric or magnetic field, then, it is possible to work out what type of radiation it is (Fig.2). It is this method of detection, in fact, which is used by physicists to detect many other less common types of radiation and subatomic particles encountered in nuclear physics.

But What Are They?

So far, we have only looked at the different ways in which alpha, beta and gamma radiation behave without really saying much about what they are. What is it that makes a beta ray different from an alpha or a gamma ray? Why should alpha and beta radiation carry electrical charge — alpha positive and beta negative — while gamma radiation is neutral?

The Gamma Story

Light can be thought of as a wave of electromagnetic radiation travelling through space with a speed of nearly 300,000 kilometres per second with a wavelength of between 4×10^{-7} and 7×10^{-7} metres. In fact, the wavelength determines the colour of the light. There is, however, other electromagnetic radiation, travelling with exactly the same velocity as light and identical to it in every way except that of wavelength. Radio waves, for instance, are this type of radiation, but with much longer wavelengths (up to thousands of metres). Gamma radiation is also this sort of electromagnetic radiation, but with a much *shorter* wavelength than light (anything under 10^{-16} or 10^{-17} metres).

Gamma radiation, then, is very short wavelength electromagnetic radiation and as such it carries no electric charge, any more than light or radio waves do (Fig.3).

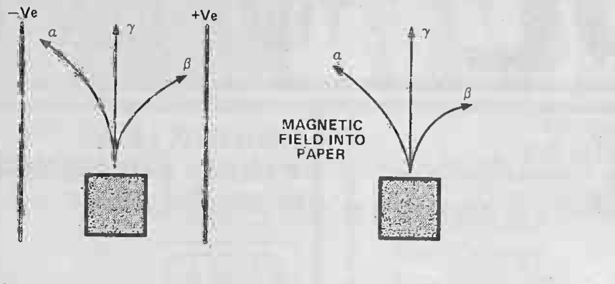


Fig.2. Alpha or beta particles carrying electrical charge can be deflected by electric or magnetic fields. Gamma rays, which are neutral, are not deflected.

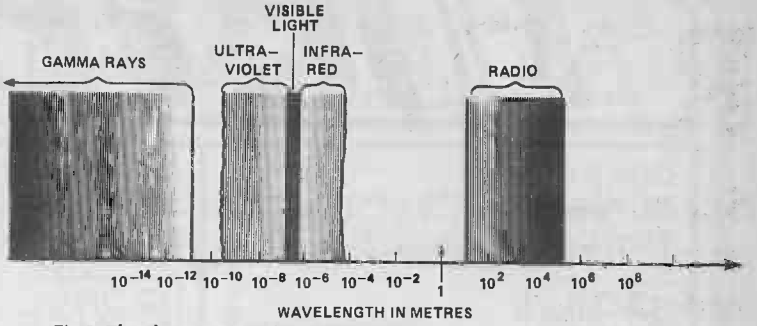


Fig.3. The electromagnetic spectrum.

A,B,. . .

Alpha and beta radiation are a little harder to explain. The atom consists of a very small, central region — the nucleus — which carries a positive charge. Surrounding the nucleus, and taking up the bulk of the atom, are electrons, which, being negatively charged, counteract the positive charge of the nucleus and make the atom as a whole neutral. The nucleus consists of two types of particles — protons and neutrons. Protons are positively charged and neutrons, as the name indicates, are neutral. The number of protons in the nucleus decides which element the atom belongs to. The number of neutrons present doesn't matter so much, but in most atoms there are at least as many neutrons as protons. (One notable exception is hydrogen, which has a nucleus consisting of just one proton). The protons, you see, being positively charged, all repel one another. The neutrons, by some mechanism still not properly understood, seem to hold the whole kaboodle together in a relatively stable lump. In some atoms, however, — particularly the larger ones, with more than 90 or so protons — the nuclei are not quite stable enough. In fact, they are liable literally to fall apart! This, as you probably guessed, is where the alpha and beta radiation comes in . . .

Let There Be Helium

It turns out that there are two ways in particular in which atoms 'like' to fall apart. One of them is by giving off two protons and two neutrons together, in a lump. In fact, this 'lump' is exactly the same as a normal helium nucleus, carrying the positive charge of two protons. It is this positively charged helium nucleus, which unstable atoms tend to release, that we call the alpha particle.

And what of the beta particle? Well, it was found by experiment that beta particles are actually free electrons. Because of this, you might be tempted to think that it was one of the electrons from around the atom, which has been released. This is not, however, the case. (It's such an obvious explanation that it can't possibly be right — Murphy's Law). Occasionally, within the nucleus, a neutron will turn into a proton, giving off an electron — and, at the same time, another particle called an anti-neutrino. The anti-neutrino really belongs in an article by itself, so we'll pass it by, except to say that it has no charge, little or no mass, and is virtually impossible to detect; although it is undoubtedly one of the most intriguing particles discovered yet. The electron given off when this happens is (you guessed it!) the beta particle.

We can see, then, that, although we say alpha, beta and gamma 'rays', only the gamma type is a ray. The other two types are really particles. However, when they occur in streams with large numbers of the particles, it is just as convenient to call them rays.

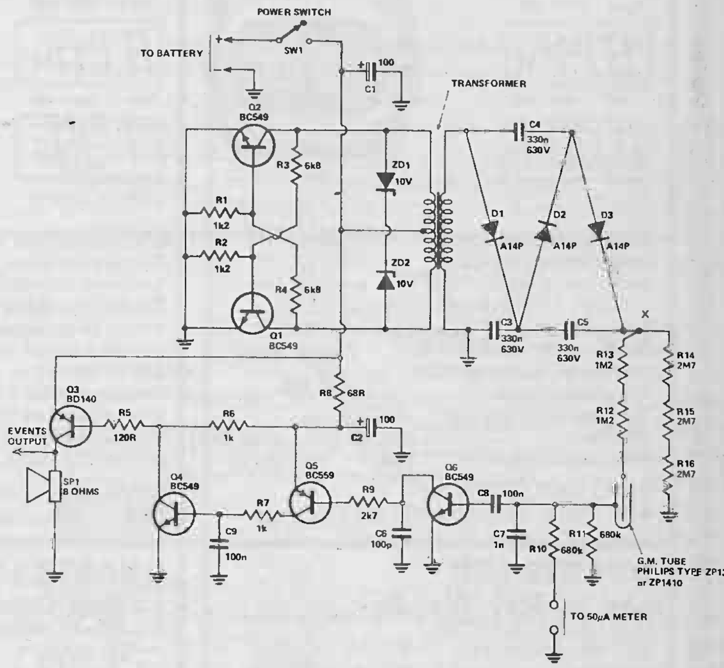


Fig.4. Circuit diagram of a Geiger-Muller tube radiation detector.

Lead Into Gold

A while back, we stated that the number of protons in the nucleus determined which element the atom belongs to. However, when alpha or beta radiation is given off, the number of protons changes (with alpha radiation, it decreases by two, and with beta radiation, it increases by one). Hence, when atoms 'decay' radioactively, by giving off alpha or beta radiation, they actually turn into other elements! Interestingly enough, the particular elements they turn into, when possessing the numbers of neutrons actually available, are not always themselves stable and so they may decay further. For instance, if you take an atom of astatine with 85 protons and 132 neutrons in the nucleus and allow it to decay radioactively, then it would decay into a bismuth atom by giving off an alpha particle. Now, although a bismuth atom with the right number of neutrons (126) is stable, the bismuth atom produced from astatine has 130 neutrons. Because of this, it is unstable, and will itself decay (usually giving off a beta particle, but occasionally an alpha). It is possible, in fact, to find whole chains of elements, which decay radioactively into one another!

Age Before Theory

One of the most exciting applications of all this (yes, it isn't just theory; there actually is a use for it) is in radio-carbon dating, in which it is possible to tell the age of an object from measurements of the amount of radioactive carbon in it. That, however, is another story altogether . . . . .

ETI

DMM SURVEY

The DMM is an invaluable aid to both the handyman and the professional. Tina Boylan explores the low cost end of the digital multimeter market.

The seventies saw the emergence of the digital multimeter onto the test equipment market and since Fluke produced the 800A in 1972 an explosive growth in production and design has been witnessed. A short life-span (three to five years) and the continuing introduction of new models from America and the Far East, as well as from Great Britain, has ensured lower prices and improved performance. The original LED display has been forsaken for the LCD display, despite early teething problems like poor refractory angle, slow response and blackening after two or three years. The LCD display now boasts a life of ten years.

Analogue to Digital

The analogue meter has been with us for as long as 80 years and, despite its low cost, it contains some unwelcome characteristics which have caused problems in testing and for many of these problems the digital multimeter provides a more reliable service. Primarily the analogue meter contains moving parts which are prone to damage, overload, reverse polarity and wear. On the other hand the digital multimeter contains only electronic components, up to 20% of which may be used solely for protection purposes, and these, as well as being more rugged, mean that the meter itself can be made smaller and lighter than its analogue counterpart — by virtue of the latest integration methods.

As far as hand-held DMMs are concerned, those with standard features, (voltage, current, resistance) are sure to continually drop in price, thus serving the end of the market traditionally held by the low cost hand-held analogue meter, while it maintains enough room to expand the capabilities of the same size meter for including complicated features.

For the professional, analogue meters can still appear to provide better testing facilities, particularly where bench-top models are concerned, but this is a myth which is fast being disproved by the technical advances being made in the DMM field. Until recently digital versions gave difficulty in reading transients or peaks because of the rapidly changing display, due in part to the fast analogue/digital conversion times of the DMM. The latest models now incorporate a peak reading memory, and these even take the guesswork out of watching a moving needle and making approximate readings.

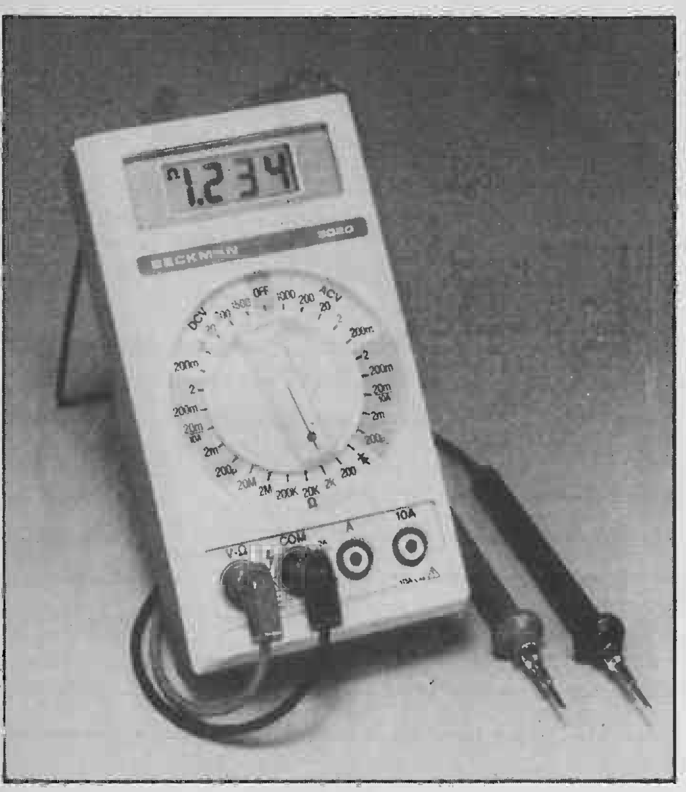
Microprocessors

Present trends in DMM development are focusing on the use of microprocessors in their design which will make the instrument easier and faster to use, as well as making it more powerful in terms of computational and mathematical facilities. This coupled with lowering price trends will mean that the man in the street will soon have a sophisticated DMM for his handyman activities while it remains an essential to the engineer and technician.

ETI has compiled a list of some of the low priced DMMs, both of the hand-held and bench varieties, to give some indication of the diverse types which are currently available.

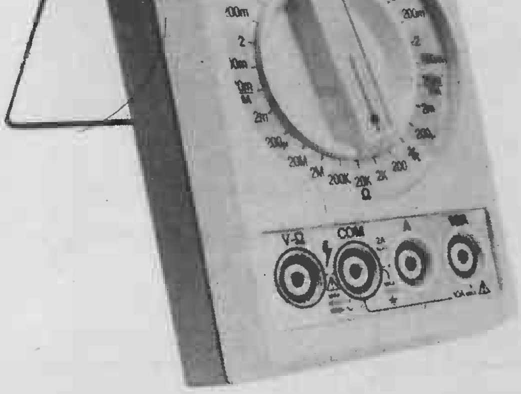
AVOMETER DA211
PRICE: £45.00 ex. VAT
BATTERY: Single 9 V dry cell
BATTERY LIFE: 200 hours approx.
DIMENSIONS: 90 x 171 x 31 cm
WEIGHT: 280 g
SELECTION OF RANGE OR FUNCTION: 8 in-line push buttons.
FUNCTIONS: Voltage, current, resistance
DC VOLTAGE RANGE: 5 ranges, 200 mV to 1000 V
AC VOLTAGE RANGE: 5 ranges, 200 V to 1000 V
DC AND AC CURRENT: 4 ranges, 200 uA to 200 mA plus 5th range measuring up to 10 A DC.
RESISTANCE RANGE: 4 ranges, 0 and 2M0 plus low voltage diode test facility.
DISPLAY: 3½ digit LCD
HEIGHT OF DISPLAY CHARACTERS: 13 mm
READING RATE: 2.5/S
OVERLOAD PROTECTION: 500 mA fuse
OTHER FEATURES: Auto-polarity, auto-zero.

AVOMETER DA212
PRICE: £65.00 ex VAT
BATTERY: Two R6 (HP7)
BATTERY LIFE: Approx. 200 hours
DIMENSIONS: 160 x 96 x 47 mm
WEIGHT: 340 g
SELECTION OF RANGE OR FUNCTION: Rotation of two selector switches.
FUNCTIONS: Voltage, current, resistance
DC VOLTAGE RANGE: 5 ranges, 200 mV to 1000 V
AC VOLTAGE RANGE: 5 ranges, 200 mV to 750 V
DC AND AC CURRENT: 200 uA to 1000 mA
RESISTANCE RANGE: Two voltage levels, Hi or Lo, by push button.
DISPLAY: 3½ digit LCD
HEIGHT OF DISPLAY CHARACTERS: 13 mm
READING RATE: 2.5/S
OVERLOAD PROTECTION: to 1000 V on voltage ranges and 250 V on all other functions.
OTHER FEATURES: Controlled by on/off switch, auto-polarity, auto-zero, battery low indicator.



BECKMAN 3020
PRICE: £115.00
BATTERY: 9 V transistor type
BATTERY LIFE: 2,000 hours
DIMENSIONS: 17.4 x 9.3 x 4.6 cm
WEIGHT: 453 g
SELECTION OF RANGE OR FUNCTION: Single central dial
FUNCTIONS: Voltage, current, resistance
DC VOLTAGE RANGE: 5 ranges, 200 mV to 1500 V
AC VOLTAGE RANGE: 5 ranges, 200 mV to 1000 V
DC AND AC CURRENT: 5 ranges, 200 uA to 2 A. Separate input extends this to 10 A.
RESISTANCE RANGE: 6 ranges from 200R to 2M0
DISPLAY: 3½ digit LCD
OVERLOAD PROTECTION: Voltage input protected to 1500 RMS AC. Resistance protected to 300V DC or RMS AC. Current inputs with 2 A fuse.
OTHER FEATURES: Insta-Ohms™ instant continuity test indicator; semiconductor test function provides 5 mA of test current, accuracy within 0.1% ± 1 digit on all DC voltage ranges, battery low indicator.

BECKMAN RMS 3030
PRICE: £176.00
BATTERY: 9 V transistor type
BATTERY LIFE: 2,000 hours
SELECTION OF RANGE OR FUNCTION: Rotary switch
FUNCTIONS: Voltage, current, resistance, AC voltage and current in true RMS.
DC VOLTAGE RANGE: 5 ranges, 200 mV to 1500 V
AC VOLTAGE RANGE: 200 mV to 1000 V in true RMS
DC AND AC CURRENT: 200 uA to 2 A
RESISTANCE RANGE: 6 ranges from 200R to 2M0
DISPLAY: 3½ digit LCD
OVERLOAD PROTECTION: Input up to 1500 V DC or 1000 V RMS, resistance up to 300 V DC or RMS. Current inputs with 2 A fuse, 10 A range up to 20 A for 30 S.
OTHER FEATURES: Instant continuity test, RMS input accuracy is 0.5%, battery low indicator, calibration guaranteed for one year.



FLUKE 8022A
PRICE: £75.00
BATTERY: 9 V
BATTERY LIFE: Alkaline 200 hours, zinc-carbon 150 hours.
DIMENSIONS: 18.0 x 8.6 x 4.5 cm
WEIGHT: 37 g
SELECTION OF RANGE OR FUNCTION: 8 in-line push buttons.
FUNCTIONS: 6 functions, 24 ranges
DC VOLTAGE RANGE: 5 ranges, 200 mV to 1000 V
AC VOLTAGE RANGE: 5 ranges, 200 mV to 750 V
DC AND AC CURRENT: 4 ranges, 2 mA to 2000 mA
RESISTANCE RANGE: 200R to 20M
DISPLAY: 3½ digit LCD
OVERLOAD PROTECTION: Withstands 500 V on resistance, 1000 V on voltage, 2 A on current and 6 kV voltage transients.
OTHER FEATURES: Auto-polarity, auto-zero, battery low indicator, Tilt Stand.

FLUKE 8024A
PRICE: £135.00
BATTERY: 9 V
BATTERY LIFE: Alkaline 200 hours, zinc-carbon 150 hours.
DIMENSIONS: 18.0 x 8.6 x 4.5 cm
WEIGHT: 480 g
SELECTION OF RANGE OR FUNCTION: 8 in-line push buttons.
FUNCTIONS: Voltage, current, resistance, conductance, temperature, continuity, level detection.
DC VOLTAGE RANGE: 5 ranges, 200 mV to 1000 V
AC VOLTAGE RANGE: 5 ranges, 200 mV to 750 V
DC AND AC CURRENT: 4 ranges, 2 mA to 2000 mA
RESISTANCE RANGE: 200R to 20M
DISPLAY: 3½ digit LCD
OTHER FEATURES: Audible continuity test, fully compensated direct temperature readings from 0°C for any K-type thermocouple, peak hold feature for transient signals, auto-zero, auto-polarity.

FLUKE 8010A/8012A (Bench Top)
PRICE: 8010A: £159.00
8012A: £199.00
BATTERY: Option of rechargeable NiCad batteries (-01) series)
BATTERY LIFE: 40 hours for DC voltage, 10 hours on other measurements.
DIMENSIONS: 6 x 22 x 25 cm
WEIGHT: 1.08 kg
FUNCTIONS: Current, voltage, resistance, conductance, high current
DC VOLTAGE RANGE: 5 ranges, 200 mV to 1000 V
AC VOLTAGE RANGE: 5 ranges, true RMS, 200 mV to 750 V
DC AND AC CURRENT: AC: 5 ranges, 200 uA to 2000 mA
DC: 4 ranges, 200 uA to 2 A
RESISTANCE RANGE: 6 ranges, 200R to 20M, 8021A low resistance 2R to 20R
DISPLAY: 3½ digit LCD
OTHER FEATURES: Battery low indicator, one year guarantee, auto-zero, auto-polarity, touch and hold, 8012A has two additional low resistance ranges.

FLUKE 8050A (Bench Top)
PRICE: £199.00
BATTERY: Rechargeable battery option (-01 series)
FUNCTIONS: Voltage (including AC voltage in true RMS, AC coupled) current, resistance, conductance, relative reference, direct readings in decibels. 39 measurement ranges.
DC VOLTAGE RANGE: 5 ranges, 200 mV to 1000 V
AC VOLTAGE RANGE: 5 ranges, 200 mV to 750 V
DC AND AC CURRENT: 5 ranges, 200 uA to 2000 mA
RESISTANCE RANGE: 200R to 20M
DISPLAY: 4½ digit LCD
OVERLOAD PROTECTION: Voltage: 750 V AC or 1000 V DC. Resistance: 300 V DC, short transients to 6 kV. 2 A fuse for current input plus heavy duty fuse.
OTHER FEATURES: Microprocessor control, DC accuracy of 0.3% for one year, safety indicator for input above 40 V.

HEWLETT PACKARD 3476A/3476B (Bench Top)
PRICE: 3476A: £126.00
3476B: £155
BATTERY: Rechargeable NiCad batteries with 3476B.
BATTERY LIFE: 8 hours with 3476B
DIMENSIONS: 5.8 x 16.8 x 20.6 cm
WEIGHT: A: 0.77 kg, B: 0.97 kg
FUNCTIONS: Voltage, current, resistance
DC VOLTAGE RANGE: 100 uV to 1000 V
AC VOLTAGE RANGE: 3.3 mV to 700 V (RMS)
DC AND AC CURRENT: AC: 3.3 mA to 1.1 A
DC: 100 uA to 1.1 A
RESISTANCE RANGE: 1R0 to 11M
DISPLAY: LED
READING RATE: 3/S
OTHER FEATURES: Autorange, auto-polarity, auto-zero.

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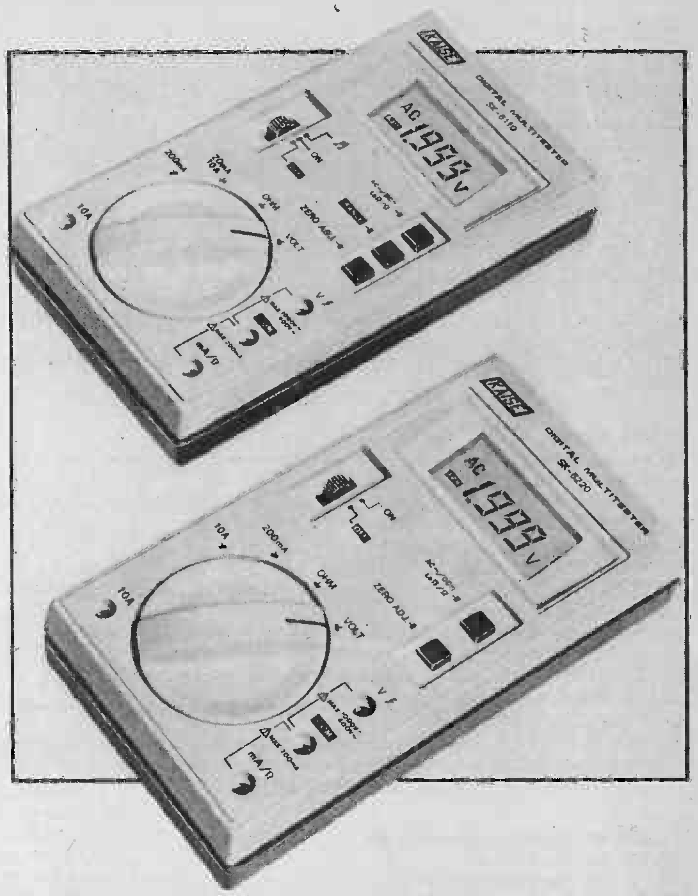
KAISE MODEL SK-6100, SK-6110
PRICE: SK-6110: £56.48, SK-6110: £65.17 ex VAT
BATTERY: Two 1.5 V, UM-3 or AA
BATTERY LIFE: 200 hours continuous operation.
DIMENSIONS: 155 x 85 x 28 mm
WEIGHT: 250 g
SELECTION OF RANGE OR FUNCTION: Rotary switch
FUNCTIONS: Voltage, current, resistance, low-power resistance.
DC VOLTAGE RANGE: 5 ranges, 200 mV to 1000 V auto ranging
AC VOLTAGE RANGE: 4 ranges, 2 V to 600 V
DC AND AC CURRENT: 20 mA to 200 mA
RESISTANCE RANGE: 200R to 2M0 and low power resistance 2k0 to 2M0.
DISPLAY: 3½ digit LCD
HEIGHT OF DISPLAY CHARACTERS: 10 mm
READING RATE: 2/S
OTHER FEATURES: Auto display, auto ranging, range hold function, overrange indication, battery low indicator, 0.5% accuracy, SK-6100 has continuity check with buzzer, SK-6110 has 10 A AC/DC range.

KAISE SK-6200, SK-6220
PRICE: SK-6200: £34.74, SK-6220: £43.43 ex VAT
BATTERY: Two 1V5 type UM-3 or AA
BATTERY LIFE: 200 hours continuous operation.
DIMENSIONS: 155 x 85 x 28 mm
WEIGHT: 250 g
SELECTION OF RANGE OR FUNCTION: Rotary switch
FUNCTIONS: Voltage, current, resistance and low power resistance.
DC VOLTAGE RANGE: 200 mV to 1000 V auto ranging
AC VOLTAGE RANGE: 2 V to 600 V auto ranging
DC AND AC CURRENT: 200 mA, SK-6220 only 10 A
RESISTANCE RANGE: 200R to 2M0
DISPLAY: 3½ digit LCD
HEIGHT OF DISPLAY CHARACTERS: 10 mm
READING RATE: 2/S
OTHER FEATURES: Full auto ranging, auto display, range hold function, overrange indication, 0.8% accuracy, battery low indicator. SK-6220 has 10 A AC/DC range.



KEITHLEY 169 (Bench Top)
PRICE: £110.00 plus VAT
BATTERY: Six 1V5 "C" cells
BATTERY LIFE: 1,000 hours carbon-zinc, 2000 hours alkaline.
DIMENSIONS: 85 x 235 x 275 mm
WEIGHT: 1.4 kg
SELECTION OF RANGE OR FUNCTION: Colour-coded push button switches.
FUNCTIONS: Voltage, current, resistance
DC VOLTAGE RANGE: 5 ranges, 200 mV to 1000 V
AC VOLTAGE RANGE: 5 ranges, 200 mV to 1000 V
DC AND AC CURRENT: 5 ranges, 200 uA to 2000 mA
RESISTANCE RANGE: 6 ranges, 200R to 20M
DISPLAY: 3½ digit LCD
HEIGHT OF DISPLAY CHARACTERS: 0.6"
OVERLOAD PROTECTION: Voltage to 1400 V peak, resistance to 300 V RMS, current by 2 A fuse.
OTHER FEATURES: Auto-zero, out of range indication.

New Records

Digital recording techniques are taking off in a big way at EMI's Abbey Road studios in London. The result of a four year R&D programme is EMI's first digitally recorded classical album — Debussy's 'Images' played by the London Symphony Orchestra conducted by André Previn. This has won three major awards since its release in December 1979.

EMI has been using five SE7000M units for its experimental recordings, which were primarily designed for laboratory standard scientific and engineering instrumentation and data recording applications. They were selected for use by EMI for their high quality performance and ability to withstand rigorous use. The advantages of digital recording are that it provides audio engineers with the ability to eliminate all extraneous background noise and distortion problems associated with conventional recording techniques.

Analogue recording is susceptible to equipment noise and non-linear recording characteristics as well as many other factors. Digital recording gives the ability to store and subsequently edit signals so that the sound remains distortion-free throughout the various production processes. The resultant sound has far greater clarity and freshness.

Each of the recording systems being used at Abbey Road comprises a single encoder and decoding unit interfaced to an SE7000M recorder. The complete system is trolley mounted to facilitate movement around the studios and for location work. At Abbey Road they can be moved to various locations within the building,although they will mainly be used in the larger Studio One for orchestral productions. However,they are also required for location work in Europe and America and have been shipped for recording sessions as far apart as Berlin, Philadelphia, Vienna and Amsterdam.

All material is recorded on standard 10½" reels of 1" magnetic tape running at 30 inches per second. Currently only two channels of sound can be processed digitally, using two tracks per channel to store data at the very high density level of 25 k/bits per inch. The outstanding quality of recordings is achieved due to this and an extremely sophisticated error-correction system to counteract drop-out or blemishes on the tape. For recording sessions, two digital systems are normally used together to provide a back-up facility. At Abbey Road they can interface with the mixing consoles in any of the three studios.

At present, editing of the digital material is carried out on the computer-controlled prototype equipment at the Central Research Laboratories. This function will soon be undertaken at Abbey Road itself.

By the end of 1980 virtually every classical record produced at Abbey Road will be digitally recorded. 'Middle of the road' and 'pop' discs generally rely on multi-track facilities, but even these can be produced using a mixture of analogue and digital recording processes. The final product will still offer improved reproduction quality.

Sound and Vision

Thorn Television Rentals and Magnetic Video, a subsidiary of 20th Century Fox, have reached an agreement in which Thorn will market through its TV rental outlets VHS video cassettes of 43 film titles. The range includes 'Butch Cassidy and the Sundance Kid', 'The Poseidon Adventure', 'Cleopatra', 'M.A.S.H', 'Patton', 'The Sound of Music', 'The French Connection', 'Hello Dolly', 'Gentlemen Prefer Blondes', 'Soldier Blue' and 'Von Ryan's Express'. Initially they will be available on a test market basis through rental showrooms and later in the year through all 1,200 outlets of the Thorn Rental Group. This will be the first time that major film titles will be available on a rental basis to the general public. Rates will be £5 for hire over three days.

EMPerative

If you wish to protect your telecommunications equipment or other information transmission system from the effects of EMP, the M-O Valve Co. has something for you. They have introduced a fast acting gas-filled surge arrestor, type E3465. Conventional gas-filled surge arrestors designed for lightning protection do not give adequate protection against EMP. The E3465 is a sub-miniature metal ceramic device which, when used in conjunction with a suitable holder can provide protection on a nanosecond time scale. It has a maximum surge strike voltage of 1 kV at 1 kV/nS rate of rise and a maximum capacitance of 4 pF, whilst retaining the normal advantages of gas-filled arrestors of high current capability and low discharge voltage. For further information contact the M-O Valve Co, Brook Green Works, London W6.

For further news of ETI's pursuit of the EMP phenomenon turn to page 15!

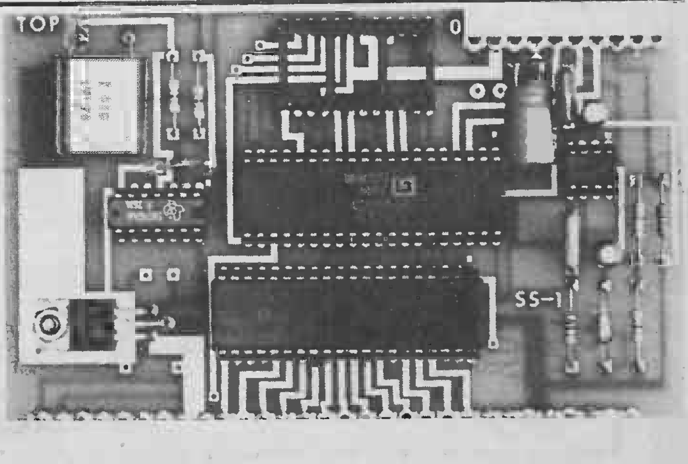
Sounding Board

Sirius Cybernetics can now supply a programmable sound synthesiser board for the SWTPC S50 bus 6800 and 6809 computers. For £60 (including post, but excluding VAT) you get an assembled and tested slot printed circuit board and driving software.

The package enables the 16 internal registers of the sound synthesiser chip to be programmed either from assembly language or BASIC. Three independently controlled sound channels producing a tone and white noise can generate a variety of sound effects or music.

Two bi-directional 8-bit ports are also provided on the board for, amongst other things, the connection of keyboard or games paddles to the host computer. The board even has its own on-board power amplifier. Just connect a loudspeaker.

The 6800/6809 S50 bus Sound Synthesiser board is available from Sirius Cybernetics Ltd, 7 Euston Place, Leamington Spa, Warwickshire CV32 4LN.



KEITHLEY MODEL 130
PRICE: £79.00 ex VAT
BATTERY: 9 V alkaline or carbon-zinc
BATTERY LIFE: Alkaline 200 hours, carbon-zinc 100 hours
DIMENSIONS: 178 x 78 x 38 mm
WEIGHT: 400 g
SELECTION OF RANGE OR FUNCTION: Rotation of two selector switches.
FUNCTIONS: Voltage, current, resistance
DC VOLTAGE RANGE: 5 ranges, 200 mV to 1000 V
AC VOLTAGE RANGE: 5 ranges, 200 mV to 750 V
DC AND AC CURRENT: 5 ranges, 2 mA to 10 A
RESISTANCE RANGE: 200R to 20M
DISPLAY: LCD
HEIGHT OF DISPLAY CHARACTERS: 0.6"
OVERLOAD PROTECTION: mA input: 2 A fuse (250 V) externally accessible; 10 A input: 20 A for 15 S unfused.
OTHER FEATURES: Auto-zero, auto-polarity, stand mounted, overrange indication.

LASCAR LM100 (Bench Top)
PRICE: £88.61
BATTERY: PP7
BATTERY LIFE: 2,000 hours
DIMENSIONS: 60 x 210 x 255 mm
WEIGHT: 1.2 kg
FUNCTIONS: 5 functions, 25 ranges
DC VOLTAGE RANGE: 6 ranges, 200 mV to 1000 V
AC VOLTAGE RANGE: 6 ranges, 200 mV to 1000 V
DC AND AC CURRENT: 6 ranges, 200 uA to 20 A
RESISTANCE RANGE: 200R to 20M
DISPLAY: 3½ digit LCD
HEIGHT OF DISPLAY CHARACTERS: 12.5 mm
READING RATE: 3/S
OTHER FEATURES: Auto-zero, auto-polarity, digital hold facility.

SOLARTRON 7045 (Bench Top)
PRICE: £360.00
BATTERY: 4 type D NiCad rechargeable (Optional)
DIMENSIONS: 200 x 70 x 260 mm
WEIGHT: 2.1 kg with batteries
FUNCTIONS: Voltage, current, resistance, temperature
DC VOLTAGE RANGE: 6 ranges, 19.999 V to 1000 V
AC VOLTAGE RANGE: 5 ranges, 199.99 V to 750 V
DC AND AC CURRENT: AC 6 ranges, 19.99 uA to 1999 mA
DC 6 ranges, 19.999 uA to 1999.9 mA
RESISTANCE RANGE: 6 ranges, 199.99R to 19.999M
DISPLAY: 4½ digit LED
READING RATE: 4/S
OTHER FEATURES: Battery low indicator, freeze display button, automatic ranging.

VOLTAGE REGULATOR DESIGN

If you've got the DC DTs, Karl Wright comes to the rescue with this simple design to stabilise your supply

The function of a DC voltage regulator is to supply a constant DC voltage to a load from a specified range of input voltages. The basic circuit of the DC regulator is shown in Fig.1. This circuit is usable over a wide range of input and output voltages. The actual function of regulation is performed by sampling the DC output of the regulator by a potential divider, formed by R5, R6 and RV1 and comparing it, via Q2, with a reference voltage provided by ZD2 and R3, the potential difference being passed to the DC amplifier, also formed by Q2. The DC signal then passes to the control section, formed by Q3 and Q4, which makes the necessary adjustment to maintain the output voltage at the specified value. The remaining components, R1, R2, ZD1 and Q1, form a constant current source, which supplies the collector of the DC amplifier, Q2, and the base of the control section, Q3. C1 is included to prevent high frequency instability and R4 is included to provide a leakage current path and to allow low load current operation.

Design Procedure

In order to design the DC regulator to suit the individual requirement of a piece of equipment, the initial specifications must be defined as follows: — the output voltage required, $V_o = 40$ V DC, the maximum output current required, $I_o = 1A5$, the range of input voltages to be used, $V_{in}(min) = 45$ V DC, $V_{in}(max) = 60$ V DC, the operating temperature range, $T_{min} = 50°C$, $T_{max} = 125°C$ and the output resistance, $R_o \leq 0R25$.

The values shown for each of the parameters will be used in the calculations as an example. The first step is to determine the parameters of the transistors in the control section, Q3 and Q4.

$V_{ce4}(min) = V_{in}(min) - V_o = 45 - 40 = 5\,V$
$V_{ce4}(max) = V_{in}(max) - V_o = 60 - 40 = 20\,V$
$I_{e4}(max) = I_o = 1A5$
$P_{tot} = V_{ce4}(max) \times I_{e4}(max) = 20 \times 1.5 = 30\,W$

By reference to a semiconductor index the TIP29 is found to be adequate for this purpose. It also has a minimum value of $H_{fe} = 40$, which is used to determine the base current of Q4.

$$I_{b4} \leq \frac{I_{e4}}{H_{fe4}(min)+1} = \frac{1.5}{40+1} = 36.66 \text{ mA}$$

Q3 is selected by the following parameters;

$V_{ce3}(max) = V_{ce4}(max) - V_{be4} = 20 - 0.7 = 19.3\,V$
$I_{e3} = I_{b4} = 36.66$ mA
$P_{tot3} \leq V_{ce3}(max) \times I_{e3} = 19.3 \times 0.03666 = 0.7075\,W$

By reference to a semiconductor index the BFY50 is found to be suitable for Q3. It also has a minimum value of $H_{fe} = 30$.

$$\text{So, } I_{b3} \leq \frac{I_{e4}}{(H_{fe4}+1)(H_{fe3}+1)} = \frac{1.5}{(40+1)(30+1)}$$

$$= \frac{1.5}{1271} = 1.18 \text{ mA}$$

I_{c1} is at least $= 2 \times I_{b3}$, thus $I_{c1} = 3$ mA and $I_{c2} \geq I_{b3}$. Using a silicon transistor for Q1 will allow the regulator to operate over the maximum temperature range, i.e. $-50°C$ to $+125°C$. As Q1 is an PNP type, a BFX29 is chosen, with an $H_{fe(min)} = 50$ and $V_{be} = 1V0$. Therefore, if $I_{c1} = 3$ mA, $I_{e1} = I_{c1} + I_{b1} = 3 + 3/50 = 3.06$ mA.

V_{ZD1} is chosen as 2V7.

$$R2 = \frac{V_{ZD1} - V_{eb1}}{I_{e1}} = \frac{2.7 - 1}{3.06 \times 10^{-3}} = 555.56R \sim 560R$$

$$R1 = \frac{V_{in}(min) - V_{ZD1}}{I_{ZD1} + I_{b1}} = \frac{45 - 2.7}{(148 + 0.06) \times 10^{-3}}$$

$$= 285.69R \sim 300R$$

V_{ZD2} is not critical, so a value of 6V2 is chosen.

Current through ZD2 must be sufficient to maintain breakdown, thus a value of I_{ZD2} which is larger than I_{c2} is chosen, in this case 5 mA.

$$R3 = \frac{V_o - V_{ZD2}}{I_{ZD2}} = \frac{40 - 6.2}{5 \times 10^{-3}} = 6760R \sim 6k8$$

The collector current of Q2 will be approximately 3 mA, so a BFY50 is chosen for Q2.

RV1 is chosen as 250R and is a wire wound type. I_{R5} is chosen as 5 mA.

$$R5 = \frac{V_o - V_{be} - V_{ZD2}}{I_{R5}} = \frac{40 - 0.7 - 6.2}{5 \times 10^{-3}} = 6620R \sim 6k8$$

$$R6 + RV1 = \frac{V_{be} + V_{ZD2}}{I_{R5}} = \frac{0.7 + 6.2}{5 \times 10^{-3}} = 1380R$$

So, R6 = 1380 − RV1 = 1130R ∼ 1k2
C1 = 100nF
R4 = 33k

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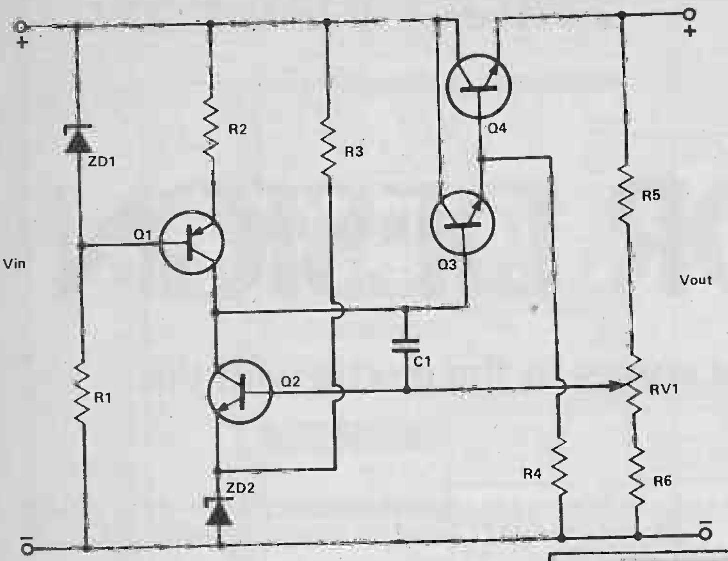

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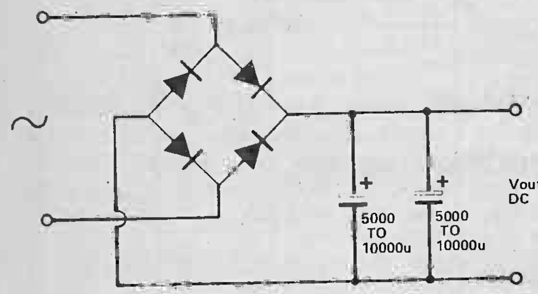


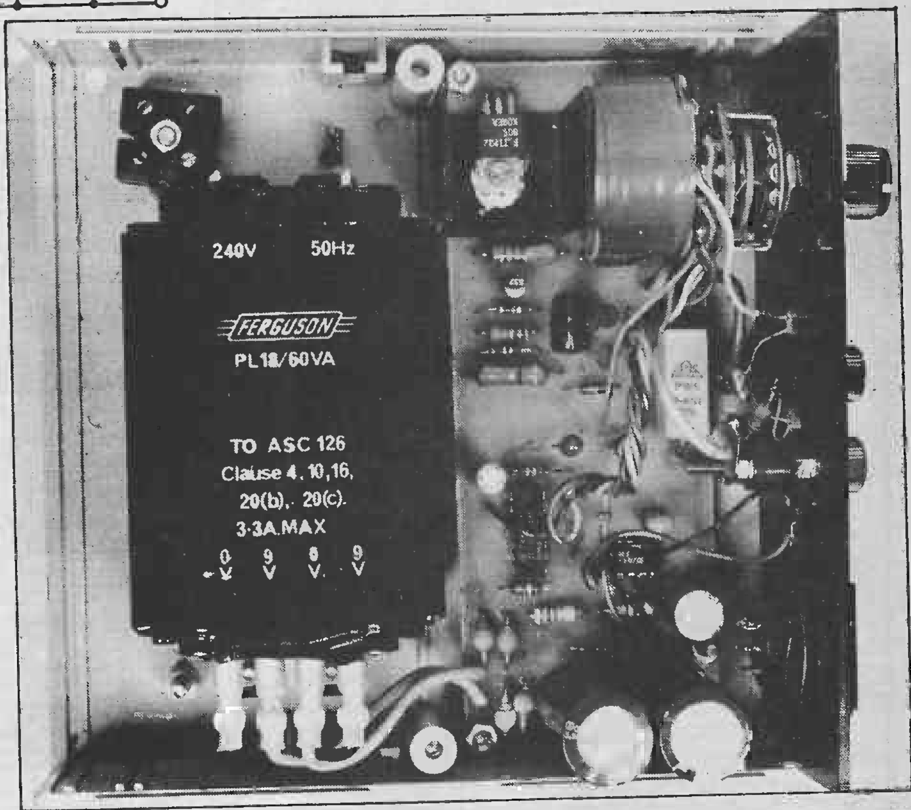


Fig. 1. (top) The basic circuit of the DC regulator.

Fig. 2. (above) This simple circuit will feed the regulator with a smoothed, but unregulated supply.

This is how professionals do it (right). This commercial power supply unit produces a regulated output voltage by the same principles as those on which the above simple design is based.

It should be noted that with the TIP29 operating at 30 W it should be mounted on an adequately sized heatsink. Alternatively a higher power transistor could be used.

The regulator needs a relatively smooth input voltage. This can be supplied by the circuit shown in Fig.2. This is simply a standard full wave bridge rectifier circuit with a large reservoir capacitance.

The DC output from the circuit can be calculated by; V DC = 1.414 V AC.

The ripple output from the regulator is negligible as long as the ripple from the basic rectifier is relatively small, this being achieved by using a large reservoir capacitance.

If a high output voltage from the regulator is necessitated, then the positions of ZD2 and R3 should be interchanged, this being done to allow the transistor Q2 to operate at low levels irrespective of output voltage. **ETI**

EMP

Following ETI's article on EMP, Tina Boylan has been finding out what's going on in the country to protect us in a nuclear war.

In the event of war our protection will depend mainly on local councils and this is the area that we have explored to find out exactly what is going on. Local councils will be in charge of re-organising the survivors in their area in the aftermath of a nuclear strike. This will basically mean local groups providing food, medical help and checking damage. As far as their radio communications are concerned, equipment at this local level has no special, built-in protection against EMP other than those in the Home Office's standard specification. How effective this will be is something no-one really seems to know.

The only other protection this equipment will have is either that at the 'four minute warning' the radios will be switched off at the mains and have their aerials removed, or that a back-up system will remain 'frozen' until the danger of EMP has passed. Standard procedure will then be followed. After 24 hours the equipment will be switched on again and broadcasts will be tried on frequencies 1-10 (is there anybody out there?); after 36 hours frequencies 10-20 will be tried, etc, until either something is located or until someone realises that the equipment is useless. In the meantime, according to one man "there'll be a lot of telephoning around". Perhaps someone forgot to tell him that EMP will almost certainly destroy *all* telephone communications!

This method of 'protection' of equipment relies heavily on the assumption that 1) there *will be* a four minute warning and, 2) that the enemy hasn't made a nuclear detonation over somewhere like the North Sea, which will knock out these communications anyway.

Us and Them

Strangely enough, local as well as national Government has known about the EMP effect for between four and six years, since its discovery during nuclear tests in the Pacific, but they have not considered it to be of interest to the general public. With this long-standing knowledge perhaps something more tangible should have been done, but again, it's the same old story; finance — or rather lack of it — has prevented much action being taken.

Until recently, civil defence in general has not appeared on the local council list of priorities. But since the Afghanistan crisis reared its ugly head, a more careful study of the country's state of readiness for war has been made. The results of this investigation prompted Mr. Whitelaw, the Home Secretary to make a statement in the House of Commons on August 7th this year. There is a firm belief that any war is likely to start conventionally and escalate into nuclear exchange.

The main points of Mr Whitelaw's speech were that the UK monitoring and warning organisations would modernise their equipment and that the associated communications network responsible for wartime broadcasting would be improved, so that it can continue public broadcasting even after a large scale attack.

As far as local defence plans are concerned he had this to say:

"A great deal of civil defence work must be done at local level, and the Government propose to double the money available for this purpose. We shall consult the local authority associations about the allocation of additional resources for planning and training, and the adaptation of premises by district councils to complete the pattern of local authority wartime administrative headquarters and communications. Effective civil defence arrangements depend upon co-operation between central Government and local government. I know that concern has been expressed about variations in civil defence arrangements in different parts of the country. I am satisfied that the Government have adequate powers to ensure that proper standards of protection are provided throughout the country, and it will naturally be our aim, with the local authorities, to see that this is done."

Cut-Backs

It is understood that by 1984 civil defence spending will have risen by 60%. This additional cost will be covered by "re-allocation of resources within existing programmes without adding to the total of public expenditure". This means that local government will have to find the money out of their existing budgets, already tightly squeezed by cut-backs. In one county at least, civil defence was described 'second to bottom on the list of priorities'. So even if there is extra cash allocated to it, there are no plans at present for further expenditure on communications in particular. The main priorities are to improve training of volunteers and if possible choose various leading members of the community to help with reorganisation after the holocaust. The concensus of opinion is that if nuclear war, as opposed to conventional war, breaks out, there is little that can be done to prevent huge numbers of casualties. The only course of action therefore, that local government can (reasonably) take is to provide a well trained reorganisation force to help the survivors. However, as one spokesman said, and this must be ETI's quote of the month, "after all, life goes on, you know". I somehow think *he* won't be standing at ground zero!

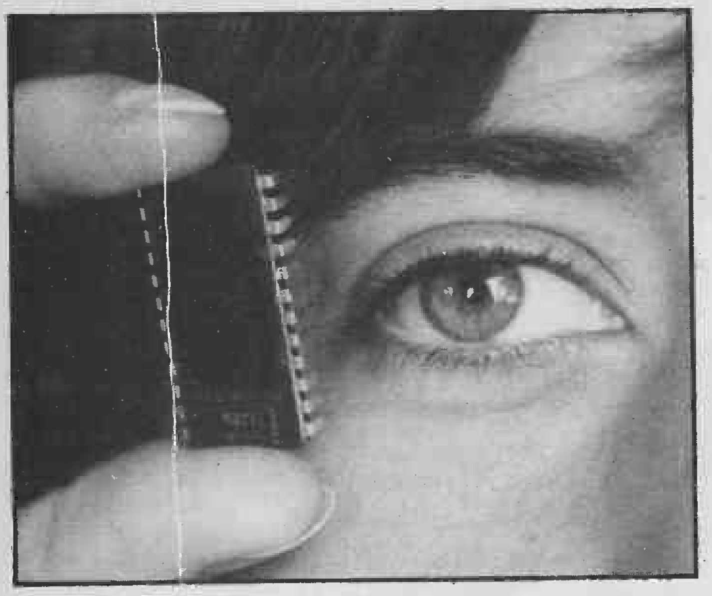
So it seems to be largely up to the public themselves to find out what should be going on, then try to do something about it. The 'men from the ministry' whom I contacted, seemed rather upset that the great British malaise is apathy. It generally takes two forms. Firstly, that we believe we will be looked after completely by the Government, something similar to what happened during the Second World War with plenty of shelters and ARP/Home Guard types. Secondly, there is the pacifist attitude that "honour will prevail" and common sense and negotiation will prevent war.

After the Afghanistan crisis the local authorities were bombarded with telephone calls from people either willing to offer their services or simply wanting to find out how to protect themselves. If you want to find out who is in charge of your local defence plans, simply telephone the Home Office in London on 01-213 3000. They were able to supply us with the names, addresses and telephone numbers of all civil defence organisations, or you can contact your local council. For 50 pence you can also obtain the government leaflet 'Protect and Survive' which certainly prompted us to ask a few questions! Keep sending the letters.

ETI

MICROBASICS

Remember, remember ETI November. Henry Budgett explains how microprocessors ROaM round the RAM chips. It's all a question of memory.



It is doubtful if even the legendary skills of the elephant could cope with the vast and bewildering array of memory devices that are currently offered with each and every microprocessor. Would you choose dynamic or static; is there any difference between on-line and off-line storage; do bubbles really bubble and many other similar questions often crop up in reader's enquiries and only go to show that the fundamental topic of computer storage is in dire need of a bit of explanation. To that end let's go right back to the fundamentals and take it from there.

The Elemental Store

Computers of digital type work on the binary system — they process information that occupies one of two states. The commonest logical element that can occupy one of two states is the bistable and, in simple terms, all computer memory can be regarded as constructed of simple bistable elements. We need not concern ourselves with the history of memory devices (it will only serve to confuse the issue), so let's start off with semiconductor devices such as Random Access Memory and Read Only Memory, RAM and ROM to use the common acronyms.

In virtually all computer designs RAM is the fundamental storage system for the user to put his instructions into. Within this family of circuits there are two sub-groups, static and dynamic, but the simplest element is the common bistable. Static RAM is really a vast number of bistables arranged in a special fashion. Some popular arrangements are 1024 by 1, 2048 by 1, 1024 by 4 and many, many others. The numbers specify the way the device is used, for example if you wish to construct a memory card that could hold 1K bytes of program you would need eight of the first kind of chip or two of the third kind.

Amnesia

Because these static elements are based on simple logic gates, they will lose their contents when turned off, just as any logic will, but they do have a number of advantages. Once the desired information has been loaded into the memory (more on that later) it will stay there until either it is altered or someone turns the computer off. The disadvantage of this is that it requires the power to be constantly maintained within the chip and thus the current consumption of these devices is high. You do get a good, high-speed response in exchange, though. It is common to find that within the structure of a single microcomputer both static and dynamic RAM devices are used, with the static providing the workspace or 'scratchpad' area for the CPU and the dynamic providing the bulk user RAM and hence saving power.

The fundamental difference between dynamic and static devices is that dynamic devices will lose the stored information if they are not 'refreshed' every so often. The reason for this is that they are based on MOS technology and store the information on tiny capacitors as a charge. This charge will leak away after a finite time and thus has to be constantly topped up. This process

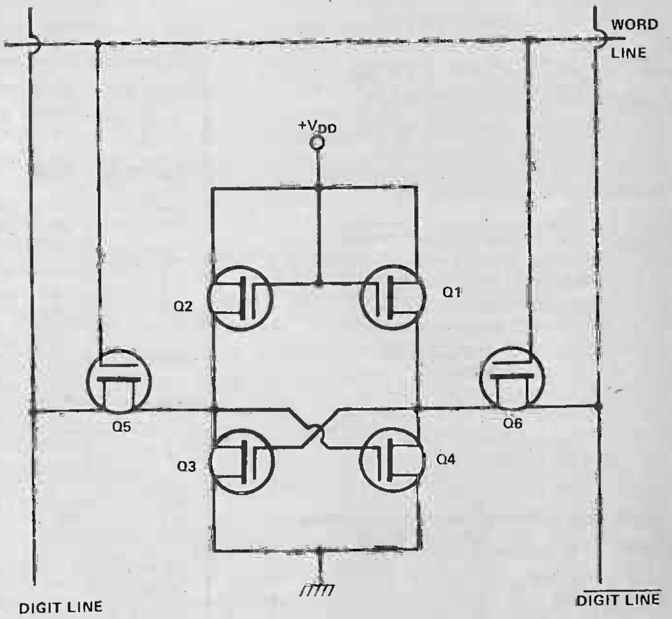


Fig.1 MOS static memory cell.

can either be performed within the chip or by some special circuitry on the memory board or, in the case of the Z80 CPU, by the micro itself. Typical refresh times are between 1 and 2 mS and woe betide the designer who tries to cut it fine because increases in temperature have very undesirable effects that compound the problem.

In summary, therefore, RAM is used by the micro as its immediate store and is based around the humble bistable type of logic element. In strong contrast we have the ROM memories which as their name implies, can only be read and hence are used as permanent stores.

Memories Are Made Of This

It is worth taking a few minutes to inspect the internal architecture of both static and dynamic devices at the storage element level. Figure 1 shows the equivalent circuit for a static MOS memory cell. Transistors within the chip are all made as MOSFETs which, although slower than bipolar transistors, consume less power and hence allow greater packing densities. Q1 and Q2 are actually being used in this circuit as resistors to bias the bistable element made from Q3 and Q4. The transistors Q5 and 6 act as switching gates to allow information to be read or written to the cell. To read a cell the word line is set to logic one which will turn on either Q5 or Q6 depending on the contents of the cell. To write the word line is again set to logic one but the appropriate digit line is set so that the cell contents are toggled to the correct value.

The dynamic MOS element shown in Fig. 2 uses the technique of stored charge to represent information. To write new information to the cell the row line is set to logic one and the appropriate data is set onto the data line. Reading the cell is performed by setting the row select high and inspecting the state of the data line.

A Family Affair

If you thought that having two types of RAM was quite enough to cope with then ROM will try your mental processes even more. The original ROMs are truly Read Only in that the user buys them pre-programmed to a specification and there is no way that he can alter the contents. Computer monitor programs are commonly based in ROM, but with the high cost of producing the original 'mask', (that's the pattern to which they are made), several companies are turning to other devices such as the EPROM. The internal arrangement of a ROM chip is not dissimilar to that of a RAM chip except that each and every element is 'hard wired' to either logic '1' or logic '0'. It would obviously be nice if the user could program in his own pattern and try it out and to this end the PROM device emerged. This is a ROM with each element uncommitted, but with a tiny piece of 'fuse wire' called a fusible link fitted to each element. If you wish to select that as a logic '0' you leave it as it is, if you want it to be a logic '1' then you have to 'blow' the fuse, usually with a high voltage pulse.

All very well but once you've cooked it you're stuck with it, or are you? The designers found that if you didn't burn the link away thoroughly enough it started to grow back, embarrassing! This gave rise to the EAROM or Electrically Alterable ROM which allows you to erase the content of the device and later re-program it. It also gave birth to the most common type of device, the EPROM or Erasable Programmable ROM, which uses a

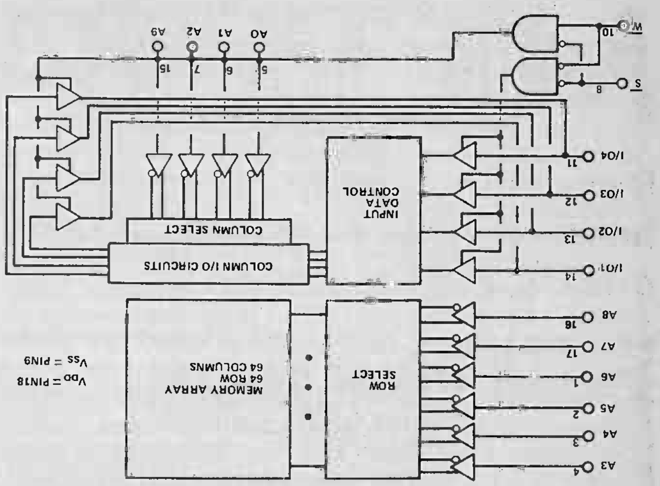


Fig.2 Dynamic memory cell.

slightly different internal structure and can be 'wiped' with ultraviolet light of a certain frequency — the contents of an EPROM will naturally self-erase after about one hundred years anyway!

The programming of these devices requires a special piece of equipment called, not surprisingly, a Programmer. These vary from the very crude to the amazingly sophisticated professional models that allow full program editing and verification and can handle many of the different types.

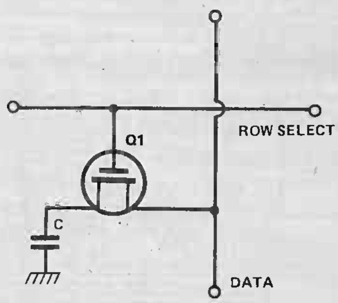


Fig.3 The internal layout of a 4096 bit static RAM device. Compare the architecture of this 1024 by 4 layout to that in Fig.4 of a dynamic 4096 bit device organised by 4096 by 1.

We can now introduce a new term which nicely classifies the two types of computer memory. RAM is called volatile memory; the contents 'evaporate' when the power is removed; ROM is non-volatile because it retains the information. Interestingly, the much-vaunted successor to RAM, the bubble memory device, is a non-volatile store, because it works on magnetism (much like the old-fashioned core memory).

Reads And Writes

Getting information into and out of memory devices is, generally, a straightforward process. With an eight bit microprocessor which has a 16 bit address bus the maximum amount of memory that you can directly address is 2^{16} or 65536 locations. Because we are working in binary and cannot have nice 'round' numbers this is referred to as 64K where one 'K' is 1024 locations. Each location contains eight bits of data, one byte, and can be uniquely addressed by the 16 address lines. The CPU determines whether the required access is a READ, taking information out of memory, or a WRITE, which puts information into memory by setting a control line to either a logic one or a logic zero. This line is taken to all the memory devices and, appropriately gated, enables the required area of memory. Figures 3 and 4 show the internal structure of two typical devices.

Once the specified location has been opened, the data stored there is either transferred onto the data bus, in the READ situation, or is overwritten by the information on the data bus, the WRITE situation. It is important to note that the information is overwritten, so saving you the job of clearing out the previous contents.

There is a further control pin on many memory devices called Chip Select. This is set to either logic one or zero (depending on the device) when that memory area is required for use and this prevents possible accidents such as overwriting data in another part of the memory to that which you actually wanted. How can this happen if you have a unique addressing system? In most small computers you only have a small area of memory on the actual CPU card, the actual memory cards hold the bulk of RAM and ROM. Because of this the address bus is not decoded into specific areas; the Microtan 65 is a good example. Now, when you are using

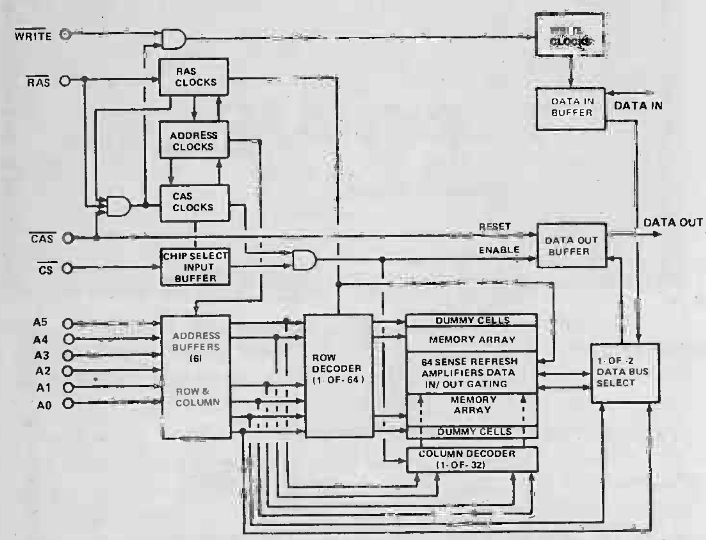


Fig.4 A 4096 bit dynamic RAM device. Compare with Fig.3.

only a small amount of memory you don't bother to decode all the addresses, you merely use, say, A15 to operate the Select on the monitor ROM, A14 to control the I/0 area and A13 to enable the RAM. This leads to repeating address inside the memory space, but this doesn't matter, because there are no devices physically occupying those actual locations. The trouble starts when you expand and forget to eliminate all these 'reflected' areas. The diagrams in Fig.5 and 6 show the case on the Microtan before and after memory mapping has been done and illustrates the problem admirably.

Dynamic Stuff

Because of the different technology used in the consideration of dynamic memory devices, allowing many more locations to be put onto one chip, one finds that, given a sixteen pin package, you don't have enough pins to supply all the necessary signals. This is solved by multiplexing the address bus and supplying the row address first and then the column address. The row address is stored internally, hence giving a complete matrix address and allowing the information to be accessed. The row address is also used to carry the refresh information during the correct cycle time.

The latest versions of dynamic RAM are being equipped with the capability of on-chip refresh. This means that to the outside world they look just like a static device, indeed they are sometimes called 'pseudo-static', and thus save all the problems of timing that are associated with the procedure.

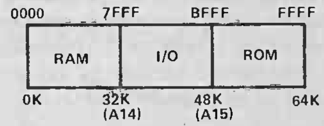


Fig.5 A simple memory map created by allowing the address lines A_{14} and A_{15} to select the appropriate memory areas. This causes the contents of the selected chip to be 'reflected' through the entire section of memory, but this does not matter provided that you only access the addresses which are connected to a device.

Banking On A Solution

In some situations 64K of memory is not enough, believe it or not. It is possible to access more by using a technique known as bank selecting. The required extra memory is treated as a peripheral device and accessed through the data bus, each extra board of memory occupying the same address area but having a unique code that selects it. The NASCOM 2 system is set up to allow up to four 48K RAM cards, that's nearly two hundred thousand bytes of memory to be plugged in. The technique does have another use in the field of Teletext and Prestel information. Here each page must be loaded into memory as it is received, with only 64K you'd soon run out. The technique is to allocate pages of memory to the received information and then to access that information from the paged memory as though it were a peripheral device.

One other technique that is very important, especially when you move into the realms of discs is that of Direct Memory Access (DMA). Because the time taken for the processor to read information from a fast peripheral such as a disc is slow, the disc controller takes command of the processor bus by asserting a control signal. The CPU goes into a high impedance stage, effectively it is disconnected, and the information is passed directly to the memory area specified.

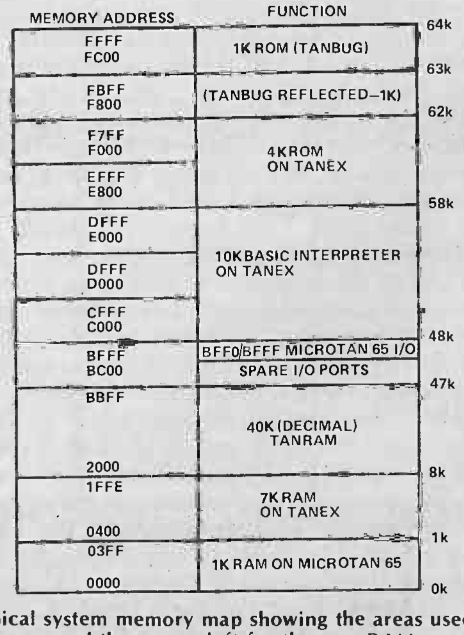


Fig.6 A typical system memory map showing the areas used by the system firmware and the spaces left for the user RAM.

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