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ETI CIRCUITS No 4

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ETI CIRCUITS No 4

ideas and data for experimenters

Managing Editor: Collyn Rivers
Editor: Jan Vernon
Design: Bill Crump

The 'Ideas for Experimenters' and 'Idea of the Month' sections published in Electronics Today International have for many years been one of the most popular parts of the magazine. But by the very nature of being a monthly feature, it becomes impossible (without an elaborate cross-referenced filing system) to remember and locate particular circuits — or compare them with similar others.

Our answer to this problem is this series of Circuit Books. This is the fourth in the series and contains a substantial number of circuits not previously published in Electronics Today International.

As with previous editions we must stress that this series of books is intended as a source of ideas for people reasonably familiar with electronic circuitry. Whilst all reasonable care has been taken with presentation, in many instances circuits included have originated from readers and have not necessarily been assembled or tested by the publishers. For this reason this series of books is not intended for use by beginners. We regret that we cannot answer any queries concerning any circuits in these publications.

Electronics Today International will consider circuits or ideas submitted by readers for inclusion in ETI magazine and/or future editions of this book. All items used will be paid for. Drawings should be as clear as possible and text (preferably) typed. Each submission must be accompanied by a declaration that the ideas or circuits are original and not subject to copyright. Send entries to Electronics Today International, Federal Publishing Company, 140 Joynton Avenue, Waterloo NSW 2041.

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* Recommended and maximum price only.

eti

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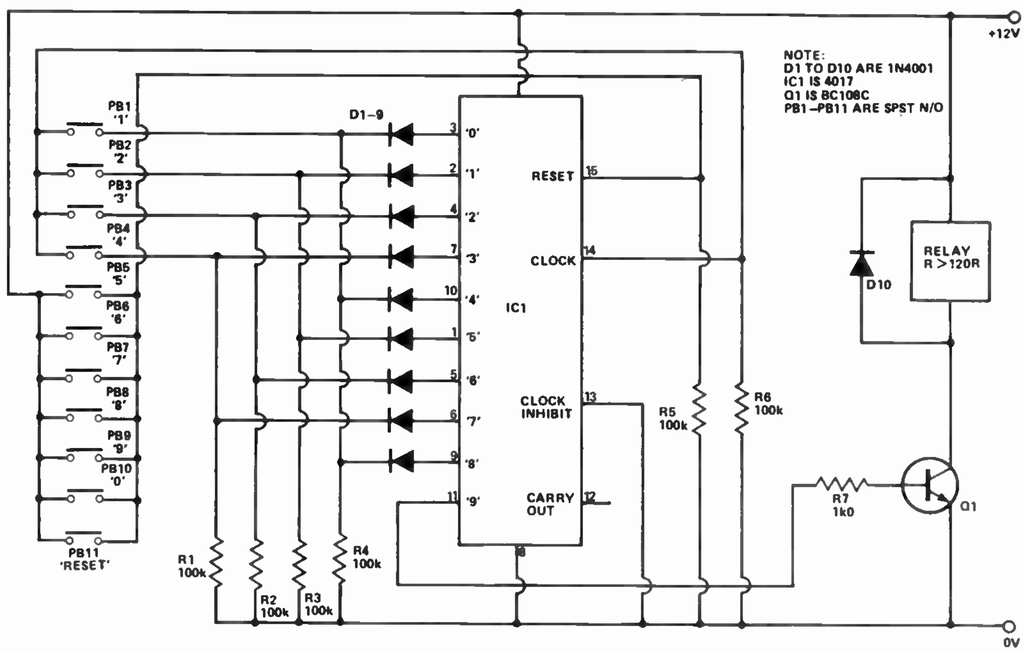
Simple Combination Lock

Although this circuit uses surprisingly few components, the unit provides up to nine code elements and a billion-to-one chance of random operation.

The first nine outputs of the decade counter (IC1) are fed via the diode OR gates (one for every different number used in the code) to the selected switches. As shown on the circuit diagram the combination sequence is 123412341. However, both the numbers and the sequence can be modified by rewiring the output diodes (D1-9) to different switches. To change the number of active code switches (ie. numbers 1234 in this case), you will have to either remove or add to the number of diode OR gates.

Operation is very simple. As the counter sequences through its outputs 0-9 it provides a logic 1 to one of the four diode OR gates, thereby making one of the active switches live. When this live switch is pressed it provides the clock pulse to increment the counter one step. This, then, provides a logic 1 to the next OR gate, making the next digit in the code live, which in turn, when pressed, provides the next clock pulse and so on until the counter reaches its tenth output. Once output nine goes high it turns on Q1, thereby switching the relay and desired load. Since only one of the outputs is high at any one time, only one of the keys will move the counter and, should any dud key (ie. keys 567890 in this case) be pressed, this will reset the counter to zero, making guesswork ineffectual.

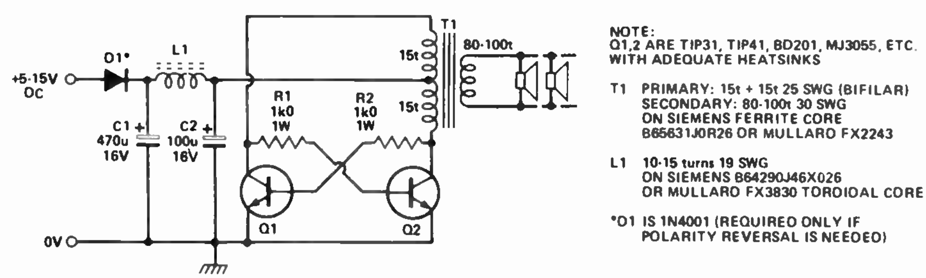
When selecting the code sequence, it is worth remembering that in order to maintain a nine element code the effect of switch bounce should be minimised by avoiding the use of any number consecutively, ie. codes such 123343222. However, if necessary, the clock input can be debounced to allow such a sequence.



High Efficiency Piezo Siren

The circuit shown is a self-starting inverter where Q1 and Q2 are connected as a multivibrator with the transformer primary forming the collector loads. The 1k0 resistors provide the base drive.

A square-wave of nearly 1 kHz is produced. This is stepped up by the transformer secondary winding which can drive one or more piezo-electric horn tweeters. The frequency of oscillation depends mainly on the number of primary turns and the type of ferrite core used. A slight adjustment to the frequency may be made by changing the value of the base drive resistors.



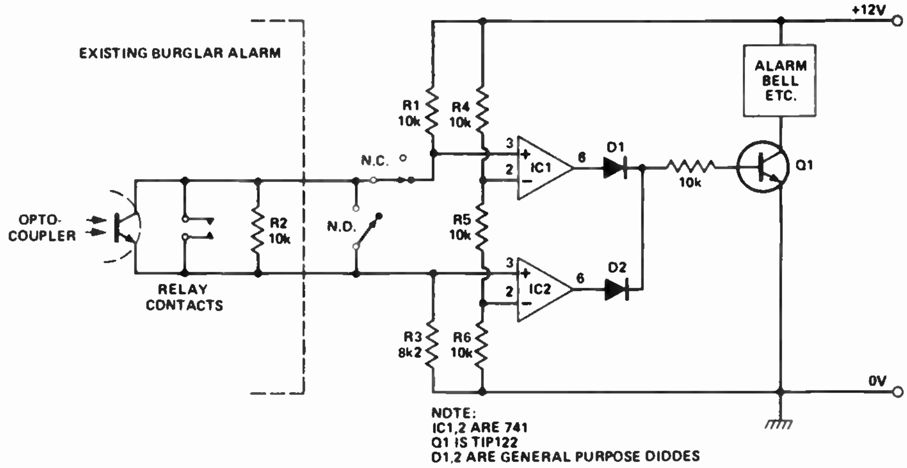
A very powerful sound is produced by the horn tweeter or tweeters due to the square-wave drive signal. This circuit was primarily designed to be used instead of the horn in a car alarm system, mainly to reduce the drain on the battery since the current consumption is less than 200 mA compared to more than an amp for the horn. However, this siren can also be used in place of any electromechanical warning devices such as bells, horns, motor-driven sirens, etc, especially those driven by a battery when it considerably reduces the current drain. Since piezo tweeters (such as the Motorola ones) are widely available and reasonably cheap, more than one tweeter can be used to distribute the sound over a larger area with the minimum of cost.

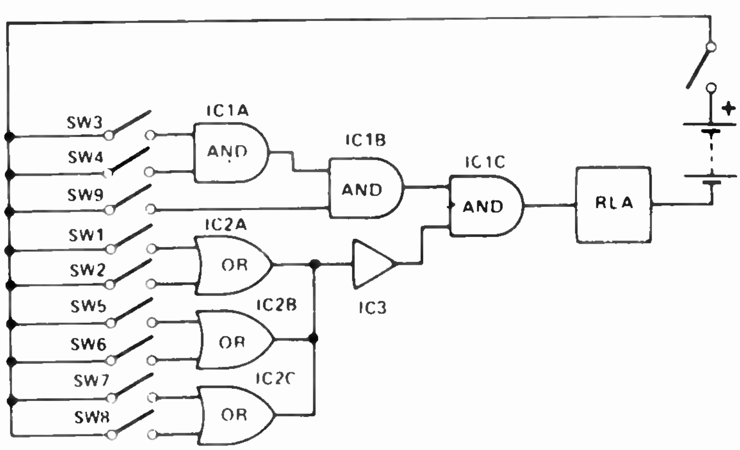
Tamper-proof Burglar Alarm

The circuit is a window comparator and works as follows. R4, R5 and R6 are voltage dividers with one-third of the supply voltage across each. R3 is chosen so that R1 > R3 > ½R1, noting that R1 = R2 (in practice, for R3 I used the next lowest standard value from R1, R2). Both non-inverting inputs of the comparators are thus kept lower than their respective inverting inputs.

If R2 is open-circuited, ie the leads to it are cut, the non-inverting input of IC1 is pulled high, thus taking the output high. If R2 is short-circuited the voltage across the non-inverting input of IC2 and ground is between one-half supply voltage and just over one-third of the supply (depending on the value of R3), thus taking the output of IC2 high. The two outputs may now be ORed using any general purpose diodes and the output used to drive a suitable load, in my case a TIP122 Darlington transistor and a 1½ amp bell.

I would recommend other users to put a monostable between the diodes and the load as well as employing a battery back-up, although these were not necessary in my case. A five minute monostable should be sufficient to keep the neighbours happy if the alarm is activated or tampered with. When installing this circuit, R2 should be situated inside the burglar alarm control unit across the existing relay contacts or an opto-coupler. When the alarm is activated, R2 is shorted. Tampering with the interconnecting cable can be detected and the bell enclosure may be protected with the appropriate normally-open or normally-closed microswitches.





Selective alarm controller

This circuit provides greater versatility than the simple "in-series" switches mode of alarm, but is still cheap and easy to build.

When SW3 and 4 are closed, the output of the AND gate goes high. This high is fed to the second AND gate only when SW9 is pressed. The output of this gate goes high and providing no other switches are pressed, it will operate the relay: if any other switches are pressed, the OR gives an output to the inverter and cuts off the power to the AND gate, preventing the coil being energised.

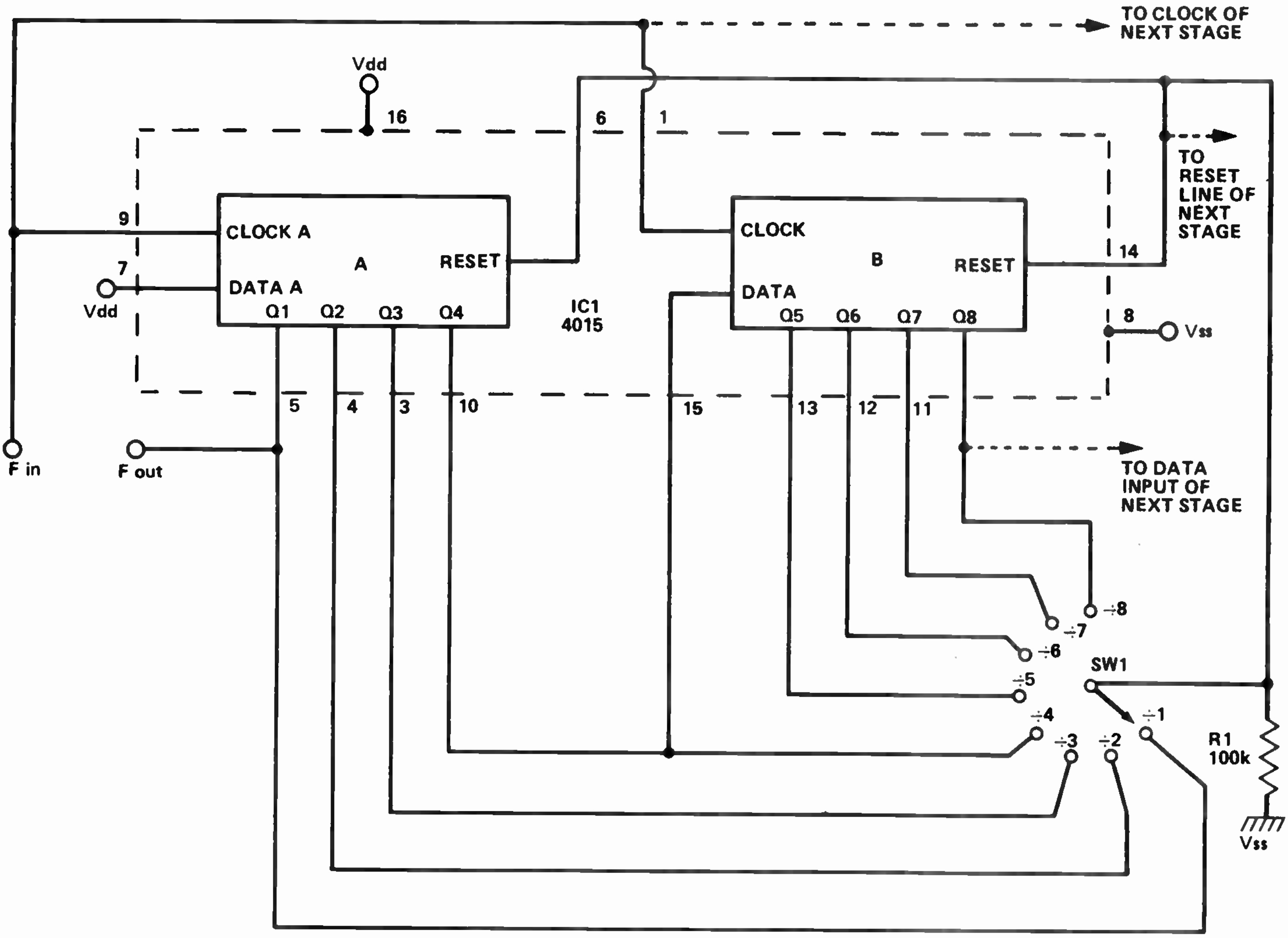
Increased range for I R systems

A simple method of increasing the range of published IR projects is to place the IR LED at the focal point of a magnifying glass, says **Spencer Featherstone of Toowoomba Qld.**

With a little experimentation a parallel beam of light can be produced. The diameter of the beam will depend on the diameter of the lens and, in some cases, its focal length.

In theory the beam will have a constant intensity with distance and will only be attenuated by its passage through the atmosphere. In practice it is difficult to focus the beam this accurately. However, ranges in excess of one hundred metres are possible and this means that the IR trip relay (ETI-570) can be used as a perimeter alarm, with the aid of a few mirrors.

This idea can also be applied to the IR remote control system (ETI-599). In this case it would be better to place the IR LEDs just inside the focal point of the lens to create a slightly divergent beam. While this will limit the maximum range, it will make the transmitter easier to aim over long distances.



Burglar alarm

The original circuit was developed as a car burglar alarm, but it could be used as a digital combination lock or, with slight modifications — removing counter 2 — a home burglar alarm.

A suitable 4 or 5 digit code is selected and, via a BCD switch wired to the appropriate latches of the 74118. Unused numbers commoned to the reset latch. Switch common is earthed through a push-button. Each is selected and entered by pressing the "enter" button. An incorrect number resets the latch. If the code is right then the unit is all reset and the relay is pulled in. The alarm is now disarmed.

If the code latch is reset a "0" appears at point A, counter 1 starts to count until it reaches eight, which sets the first RS latch, arming the detector latch.

A digital "0" from the detector switches resets the latch and starts counter 2, which allows a set time to elapse before RLA drops out and the alarm sounds.

Since originally designed for cars without external reset, the final delay was included to allow the owner to enter and reset before the alarm was activated. Therefore the oscillator is set to the fastest time the code can be set.

To arm the unit a noncode number is set in. This leaves enough time to leave the car before the unit is armed. I used an illuminated push-button and connected it to show when the counter had reached its reset point. This also has the advantage of showing the thief that your system is all go.

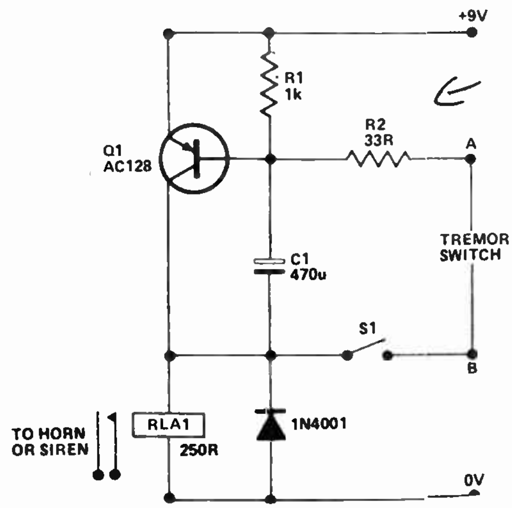
The power supply must be quite heavily smoothed as the unit was found to be quite sensitive to the noise found in car electrics. The coding switch was a thumbwheel type, since it fitted the holes already in the vehicle it was designed to be used in. A touch type keyboard could be substituted, but an enter button must also be fitted.

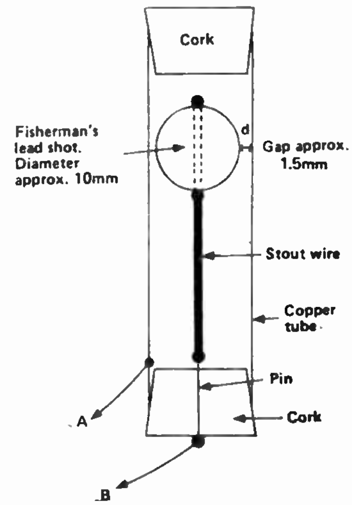
The whole unit can be built using CMOS, especially if it is required to run from a separate supply from the main battery. The relay is a reed type holding in a larger multicontact relay with its many enabling and disabling uses in a car. it will also operate many anti-theft devices in the home. A slow code input and 5 S clock acts as a reaction timer, which could be embarrassing after a "liquid lunch".

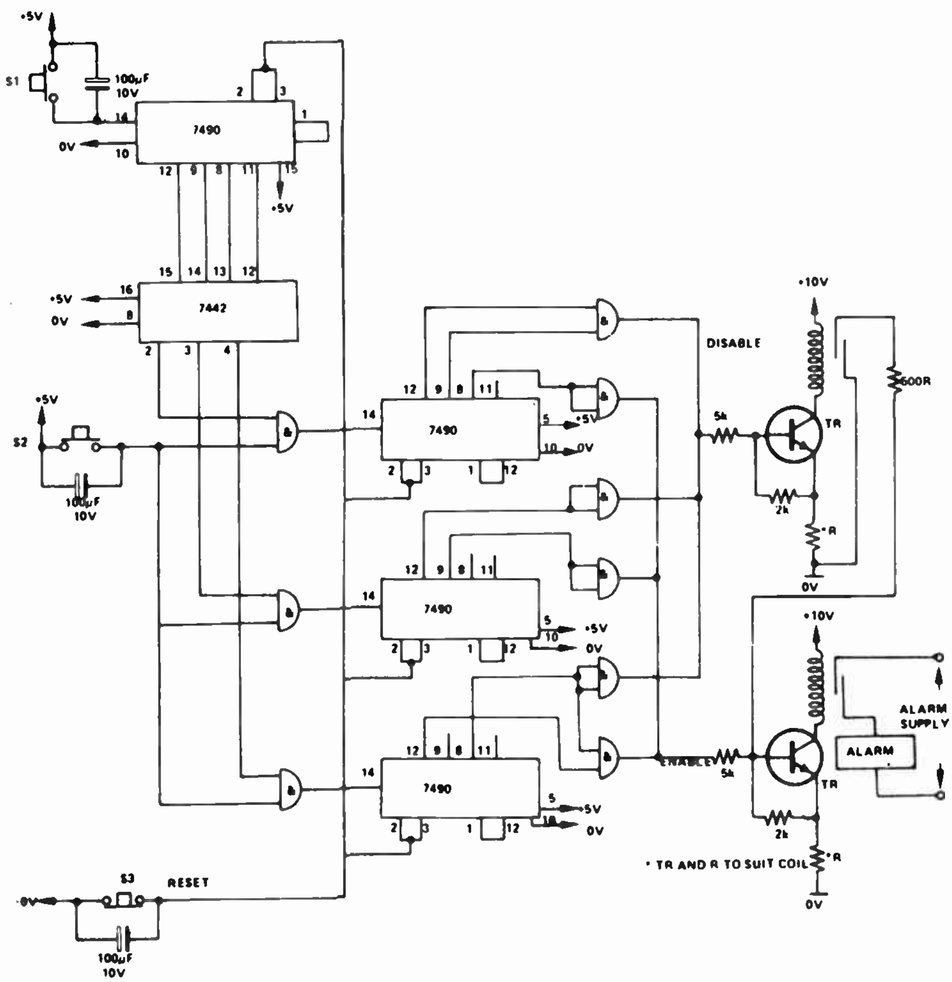
Motorbike alarm

When the motorcycle is tampered with its horn (better to have a siren independent of the motorcycle's battery) blares for ten seconds before the device is reset. Battery drain is approximately 20-30μA, so low that no on-off switch has been incorporated. SW1 isolates the tremor switch for riding. R2 prevents high current flowing on discharge of the capacitor which was found to weld the lead shot to the copper tube.

Tremor switch design is up to the constructor and the bits and pieces he or she has available. Sensitivity lies solely on the construction of this, (weight of shot, gap and length of wire).







Combination lock

The circuit and switching system is simplified by the use of a multiplex system. S1 inputs pulses to the decade counter 7490. The resulting BCD is decoded by the 7442. It is the decimal output of this which carries out the multiplexing via the AND-gates.

S2 inputs pulses which are transferred to the other 7490 decade counters by the AND-gate multiplex system. The BCD output from the 7490's is taken to the AND-gates whose outputs control the Alarm 'Disable' and 'Enable' switch system.

The 'Disable' function effectively prevents TR2 from being biased on and hence prevents the 'Enable' Reed relay from working.

This circuit has several advantages over conventional electronic combination locks as only two switches need be installed on the object to be guarded, regardless of the number of figures in the combination. The value of the example combination is 314. The alarm is triggered if any of these digits is exceeded in value. While the circuit is capable of directly driving an actuator it is recommended that it is only used to disable an alarm system — conventional locks doing the actual locking. (To operate the example the switch sequence would be: S1, S2, S2, S2, S1, S2, S1, S2, S2, S2, S2.)

Boost the output of your portable radio-cassette

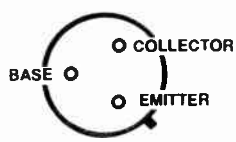
THIS AMPLIFIER was primarily designed for use as a booster to enable output powers of around 4 to 5 watts RMS to be obtained from a radio/cassette unit. Using a portable radio or cassette unit as a signal source will not provide hi-fi results, but using this set-up in conjunction with a speaker of reasonable quality and efficiency gives quite good results at low cost.

Of course, the amplifier is also suitable for other applications. It has an input sensitivity of approximately 350 mV rms into 10k for maximum output, and an output intended to feed an 8 ohm load.

The circuit uses a well-known configuration which has common emitter input stage (Q1) direct coupled to a common emitter drive stage (Q2), which is in turn direct coupled to the complementary emitter follower output stage (Q3-Q4). R7 provides virtually 100% negative feedback at dc, giving the circuit approximately unity voltage gain at dc. R1, R2 and R4 form a potential divider which biases the input of the amplifier to about half the supply potential. The output is also biased to about this level due to the dc unity gain. This bias level gives the optimum unclipped output voltage swing. R1 and C2 filter out any hum or noise which might otherwise be coupled from the supply lines to the input via the bias circuit. R6 and C5 are used to decouple some of the feedback at audio frequencies, and thus give the unit a useful voltage gain at these frequencies.

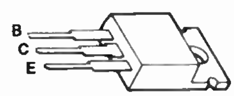
D1 is used to give a small standing bias to the output transistors, and together with the fairly substantial amount of negative feedback used, reduces crossover distortion to an unnoticeable level. The emitter follower output stage gives the circuit a low output impedance so that the low impedance load can be efficiently driven with the high output currents involved here. Q3 drives the speaker during positive-going output excursions while Q4 drives the speaker during the negative output excursions. C6 provides dc blocking at the output, and C3 provides the same function at the input. R1 and C4 aid the stability of the circuit. RV1 is a volume control, and in the amplifier's intended application, results will probably be best if the volume control on the cassette radio is set for a fairly high output (but not so high as to cause clipping), and the volume is adjusted using RV1.

The circuit requires a stabilised supply of about 18 to 22 volts that is capable of providing up to 400 mA. Q2 should be fitted with a clip-on TO5-size heatsink. Q3 and Q4 are both fitted with commercially made, finned, bolt-on heatsinks.

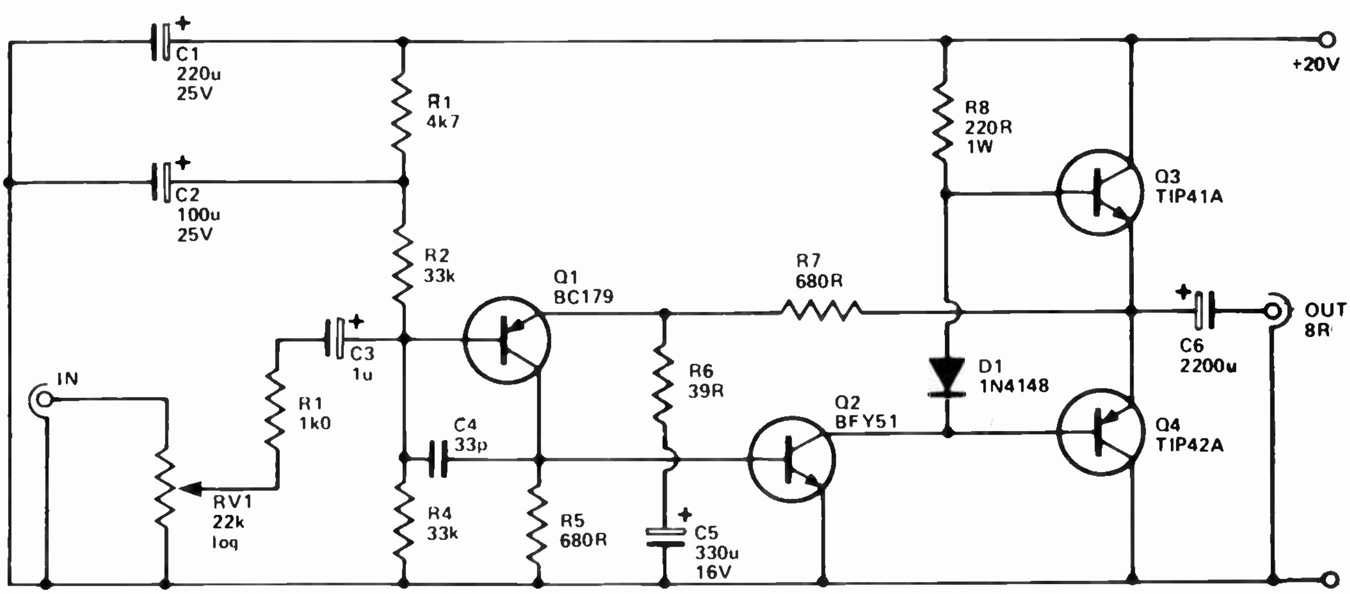


BOTTOM VIEW.

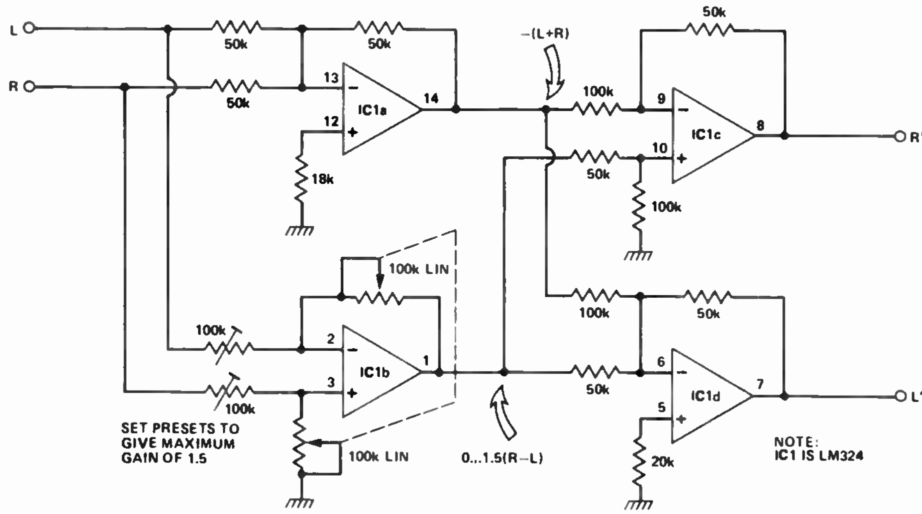
BFY51, BC179

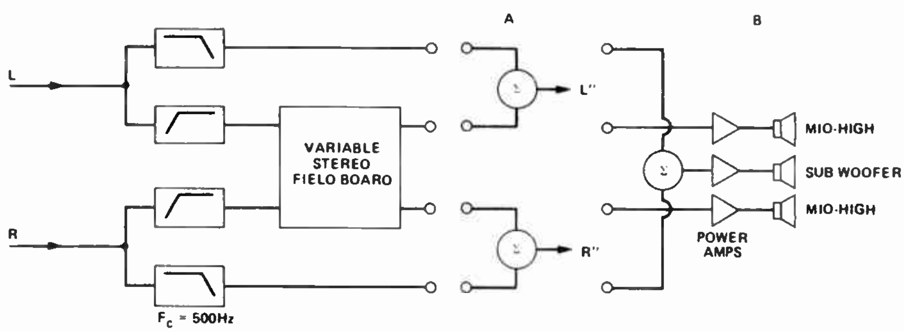


TIP41, TIP42



Variable Stereo Field

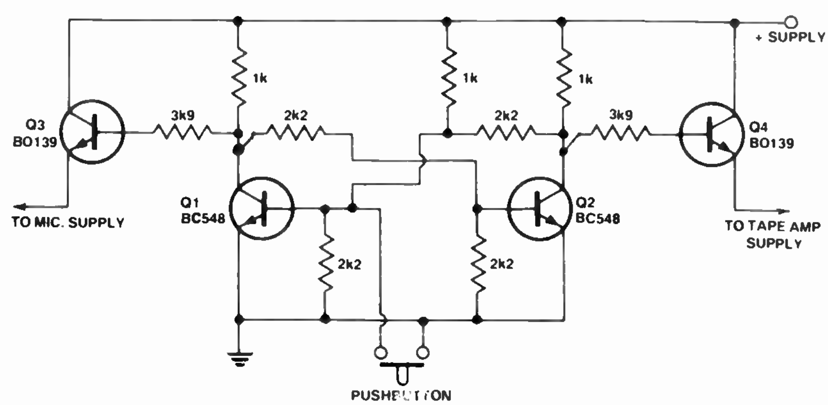




Here is a simple circuit, using only one IC, with which the usual stereo field can be varied from mono, over normal stereo, to 'superstereo'. The effect is controllable by only one (stereo) potentiometer: for the left channel from L' = (L + R)/2 (mono) to L' = 2L − R (superstereo), and for the right channel from R' = (R + L)/2 to R' = 2R − L. Unity gain is preserved through the entire control range. Pin numbers are given for the 324 quad op-amp, but this IC may be replaced by a lower noise type if desired. Resistors must have 1% tolerance because, if not, sounds in the centre of the normal stereo field may be attenuated in the superstereo position. The effect has to be connected between the preamp and power amp of a stereo system or, in the simplest case, one can use the tape output and monitoring input of a conventional amplifier or receiver.

The superstereo sensation may be increased by adding an active crossover filter as shown. In (a) the low bass part of the signal is bypassed; in the configuration (b), separate power amplifiers with individual gain contols are driven and low bass parts of both channels are summed, since sounds below 500 Hz have only poor directional characteristics.

Solid state audio switch



The purpose of this circuit is to switch off a music source (from a tape amp in this case) and turn on a microphone. **G.B. Wolfe of Bombala, NSW,** wanted to do it electronically, without messy, intervening cables, and this is how he did it.

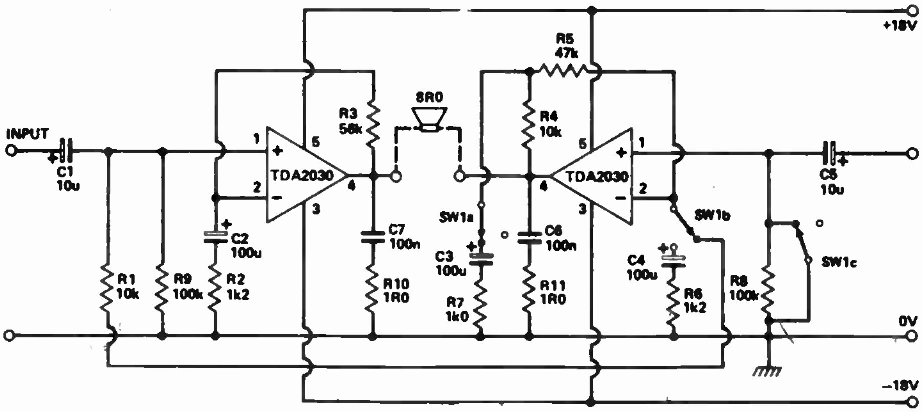
The pushbutton on the microphone stand is pressed into service to operate the solid-state switch. When operated (i.e: when you want to switch the music off and switch the mic in), the pushbutton shorts the base of Q1 to 0 V. Q1 turns off and Q2 turns on. This turns Q4 off, and as it is in series with the positive supply rail to the music source (tape amp), then the music source turns off. At the same time, Q3 turns on and provides positive supply to the mic preamp.

When the pushbutton is open, Q1 is biased on and Q2/Q3 biased off. Thus only Q4 will be biased on and the music source will be operating.

This way, there is no need to alter the signal circuits and the only change required is to the supply rails; control is by a single-pair lead.

Switchable Bridge Amplifier

By using the TDA2030 IC audio amplifier it is possible to realise a hi-fi quality amplifier which will deliver 35 W_{RMS} with less than 0.1% THD. This is done by using a pair of ICs in bridge and providing for use as a stereo amp by means of switching. The circuit is shown with the switching in the bridge mode. As can be seen, the amplifier requires a minimum of external components and these are only required to set the gain. The amps are housed in TO220 package and must, of course, be mounted on a heatsink, preferably one with a thermal resistance of 3°C/W or better.



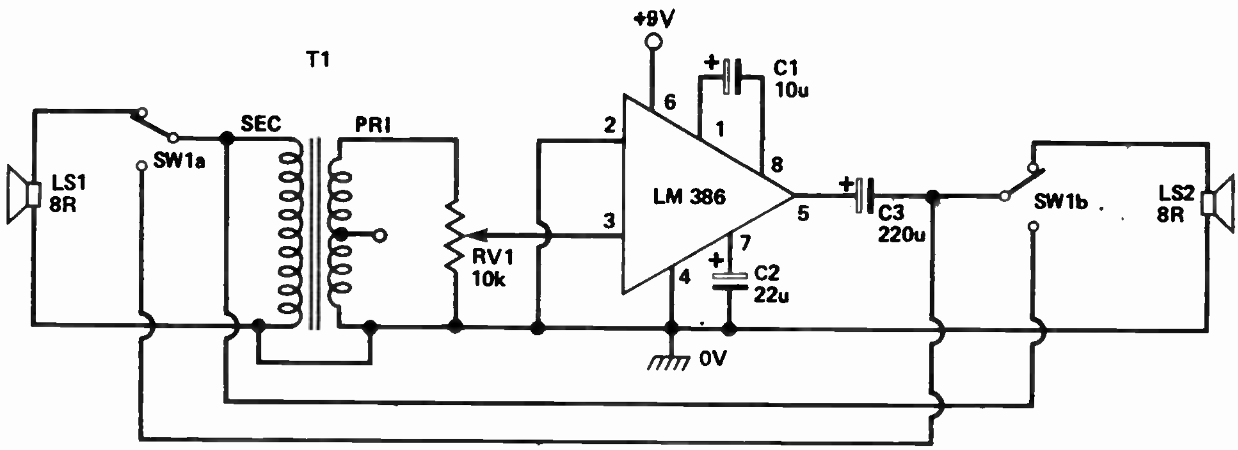
Simple Intercom

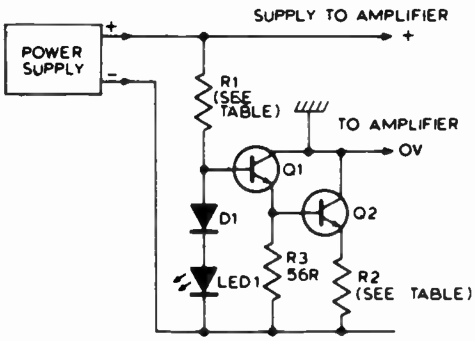
The heart of this simple intercom is the low power audio amp IC — the LM386. This usually has a gain of 20, but for this application the gain is increased to 200 by adding C1 between pins 1 and 8. The loudspeakers used are miniature transistor radio types and double as microphones, depending upon the position of SW1. The input signals from the speakers are fed into the transformer T1.

The output of the transformer feeds into the LM386 input via the 10 k volume pot. This is required because of the differences in output of small speakers when used as microphones, often a variation of 4 to 1.

One of the main reasons for using this particular IC is that its current consumption is only 3 mA and the battery used to power it can therefore be expected to last for almost its normal shelf life. Since the amp won't give up the ghost until the battery voltage falls below 4 V, this is several months.

The output power of the circuit is limited to some 250 mW, although in this application that is more than enough.





SUPPLY VOLTAGE	R1
10V to 22V	1k, ½W
22V to 40V	1.8k, 1W
40V to 70V	2.7k, 2W

AMPLIFIER POWER (RMS Watts)	R2
15W, 8R or 4W + 4W, 8R or 4W, 4R	0.5R
60W, 8R or 15W +15W, 8R or 15W, 4R	0.2R
30W +30W, 8R or 30W, 4R	0.15R

NOTE
Q1 is BD131 (up to 45V supply) or BD139 (up to 90V supply)
Q2 is 2N3055
D1 is 1N914
LED1 is a RED LED

Protection for power amplifiers

In many amplifiers, the only protection against overload is a single fuse. Experience has shown that output transistors can blow faster than fuses.

Normally, the current through R1 biases both the transistors fully on. The P.D. across the LED is less than 2V, and it will not light up. In the event of a fault or overload, the current consumption of the amplifier will increase. The forward bias on the transistors will decrease, and they will tend to turn off. This will cause the potential across R1 to decrease, which will increase the bias on the transistors, turning them on again. The overall effect is that current limiting takes place. Under these conditions, the LED will light up, indicating a fault condition. If the fault or overload persists, the main fuse in the amplifier will probably blow. The actual protection circuitry needs no resetting.

Under fault conditions, the dissipation in Q2 will be very high, and so it must be bolted onto the chassis or the heatsink.

Simple LED bar/dot level meter

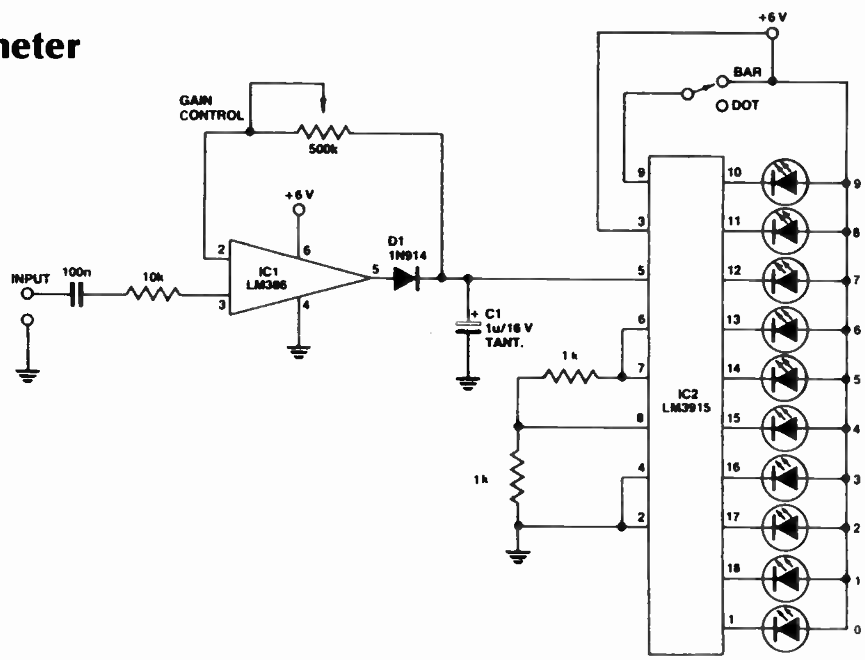
This simple level or 'power' meter can be arranged to give a bar or dot display for your hi-fi system, according to **D. Ellis of Glengowrie, SA.**

The LM386 op-amp plus D1 and associated components provide an 'absolute value' signal to charge C1. The voltage on C1 hangs on, enabling transients to be seen. The voltage on C1 is applied to the input of an LM3915 log LED display driver.

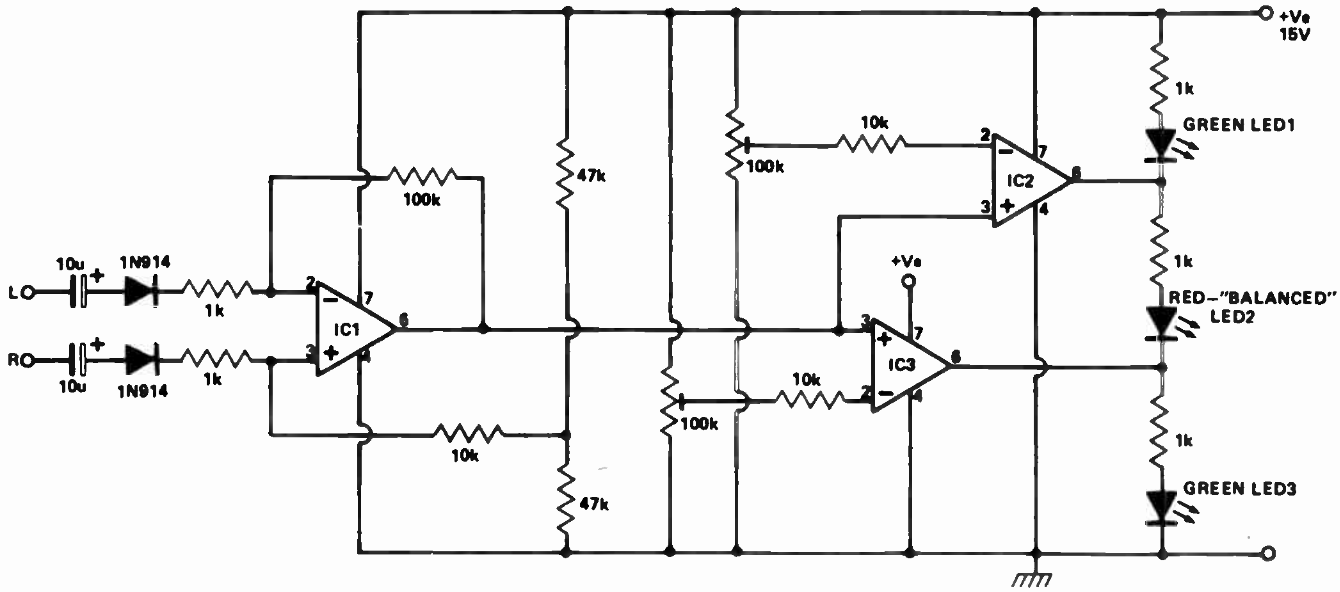
For LEDs 0 to 7, I used green LEDs, for no.8 I used a yellow one and for LED 9 a red one — the last to indicate peak power.

The gain control is provided to enable calibration on the equipment with which the unit is used.

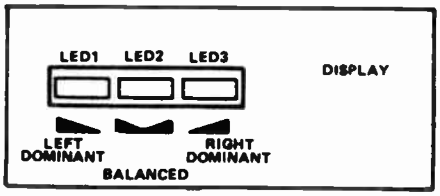
The unit draws some 200 mA, so a power supply is advisable, rather than running the unit from batteries.



ALL LEDs TIL 220R



NOTE:
IC1,2 & 3 ARE 741
ALL LEDS ARE 0.2" OR SQUARE



Stereo balance meter

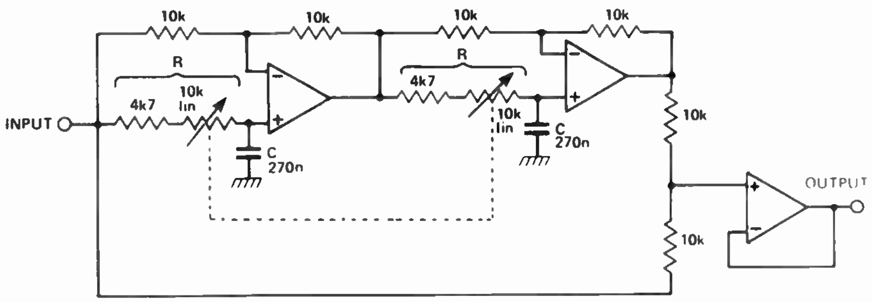
BALANCE on a stereo amplifier is usually set by ear, but this of course can be very difficult to judge. If an amplifier has a balance meter at all, it is usually of the centre-zero moving coil type — bulky, old-fashioned looking and expensive. This circuit is designed to overcome all of these problems.

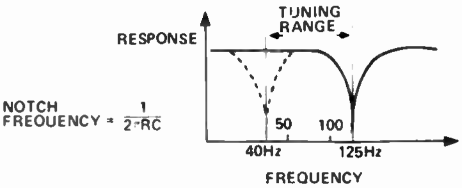
The outputs from each channel are fed to the two inputs of IC1, this being connected as a differential amplifier. If the left and right channels are of equal levels, the output of IC1 will have its output about halfway between the supply rails. If the left channel gets above the level of the right channel, the output of IC1 will approach the 0 V rail. If the right channel is loudest, the output becomes positive.

IC2 and IC3 are also differential amplifiers, but in this case they are driven by the output of IC1. LEDs form a display at the outputs of the two ICs. Pin 2 of ICs 2 and 3 each go to a preset across the supply. In practice the preset in conjunction with IC2 is set to hold pin 2 slightly above 0 V and the preset connected to IC3 is set to hold pin 2 just below supply voltage. These settings, however, must be set by trial and error so that the circuit works accurately.

The output of IC1 is connected to the non-inverting inputs of IC2 and IC3. If the output of IC1 approaches the supply rail, the outputs of ICs 2 and 3 would be low, thus illuminating LED1. If the two channels were equal in amplitude, the outputs of ICs 2 and 3 would be high and low respectively, lighting up LED2.

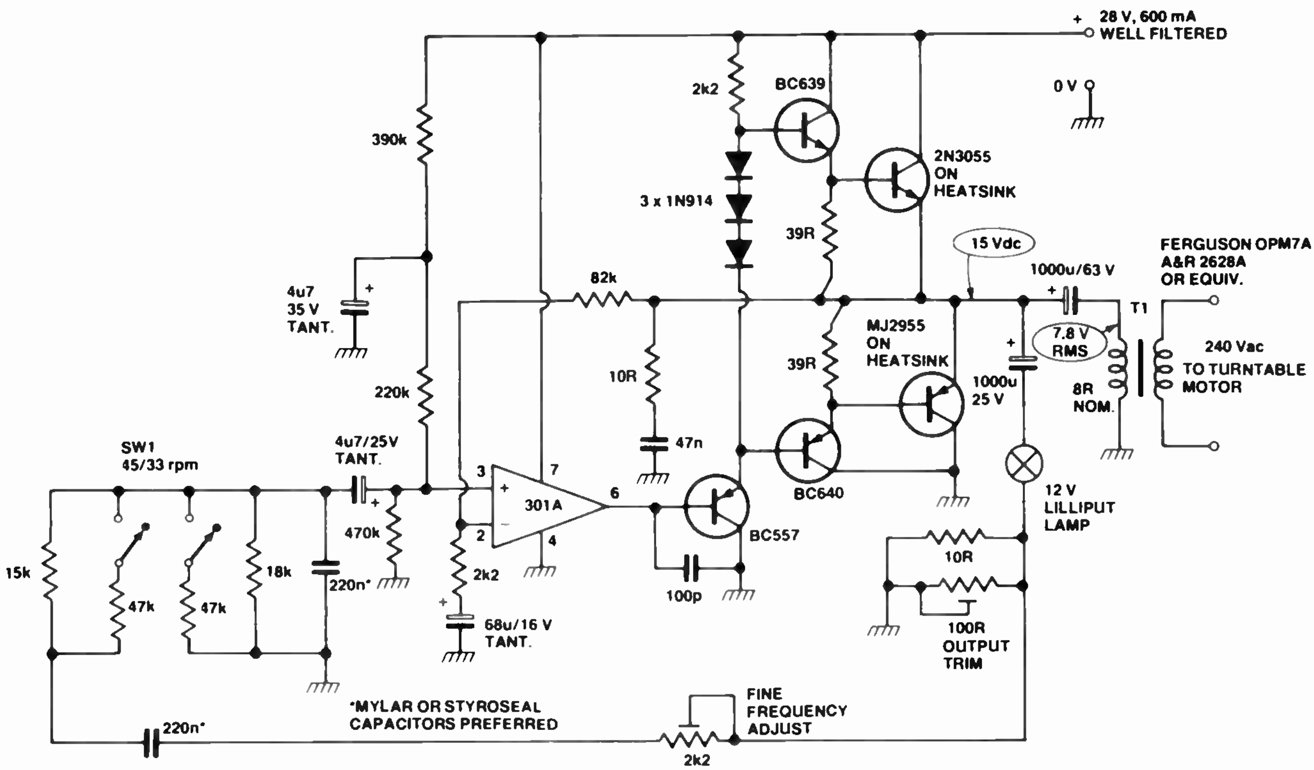
The circuit can easily be added on to a ready-constructed unit without using up large amounts of panel space, or used as an add-on unit for a hi-fi system. The unit draws about 20 mA, so battery operation is practical.





Notch filter

An audio notch filter has many and varied applications. This circuit will provide a very 'deep' (high attenuation) notch in the input-to-output response at a frequency set by the value of the ganged-pot sections. With the circuit values shown, it is tuneable over a range from about 40 Hz to 125 Hz. Varying the value of C will shift the range up or down the audio spectrum. If you use internally compensated op-amps then no extra frequency compensation will be required. Types such as the NE5534 (N or AN) or TL071 are suitable, or multi-op-amp packs such as the LM324 or TL074 may be employed. Note that C should be a good-quality film or polycarbonate capacitor.



Turntable speed controller

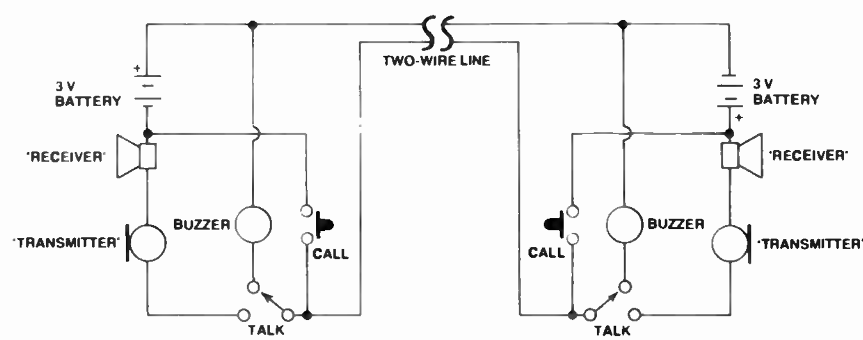
Philip Allison of Summer Hill NSW submitted this useful idea.

This device was designed to vary the supply frequency to the motor of a synchronous turntable, enabling correction of the 3-5% excess speed found with the unit. In addition, provision has been made for 45 rpm drive without the tedium of belt changing — a feature useful to owners of expensive single-speed turntables like the Linn Sondek. Other advantages of this circuit include a steady voltage output and low distortion compared to the mains. Note that one can also slow down those pop recordings that appear to be recorded at slightly high speed, producing a more 'natural' sound (maybe the apparent fast speed is deliberate? — Ed.)

The circuit is based around the ETI-452 Guitar Practice Amp power output stage (this appeared in the January 1980 edition but the ETI-453 General Purpose Amp Module, April '80, uses the same circuit — Ed.) I have made some modifications and additions, as shown in the circuit diagram, converting it to a power Wien Bridge oscillator using a 12 V lilliput bezel lamp as the stabilising element. I used a 2N3055 and MJ2955 combination for the output stage (though this is unnecessary — Ed.). The output transformer came from a discarded valve hi-fi amp, but others with a 30:1 ratio and at least a 12 W rating should be fine. A power transformer is not recommended here as I found they had poor efficiency.

The 100 ohm trimpot is adjusted to give 240 Vac with the turntable connected. A strobe disc allows setting the correct speed (using the 2k trimpot). Component tolerances may necessitate small adjustments to be made to the Wien Bridge capacitors or resistors to give the desired frequency range. Extra resistors are switched in circuit to increase the frequency for 45 rpm operation.

The simplest intercom



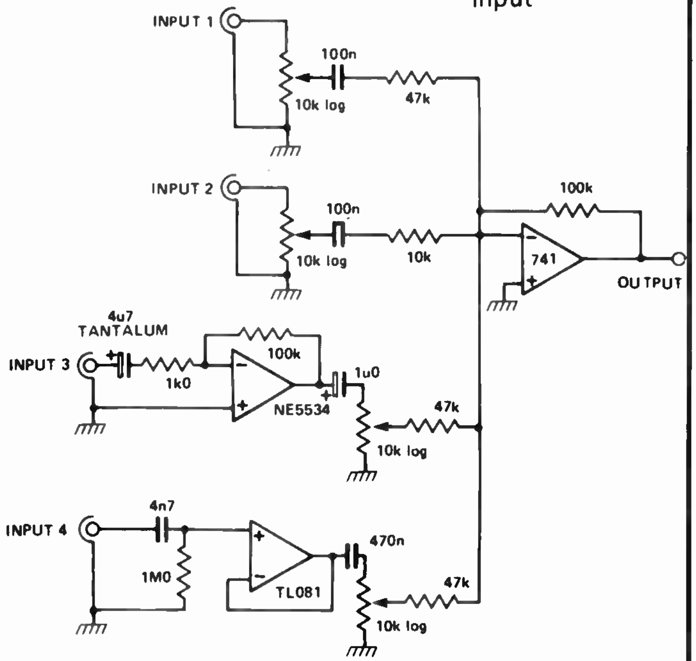
This is just about the simplest intercom one could devise, according to **David Timmins of Pullenvale in Queensland**. Its big advantage is that only a two-wire line is required.

The 'receiver' and 'transmitter' may be salvaged from 'surplus' telephone handsets. The transmitter unit is a carbon microphone and the receiver unit is a rocking armature earpiece. Any of the small electronic or electromechanical buzzers available may be pressed into service. Dick Smith stocks one, catalogue No. L-7009, while Tandy list several suitable types, such as catalogue Nos. 273-004 or 273-060. Pressing either 'call' button will sound both buzzers.

Each 'talk' switch should be a spring return-type. If you can arrange to hang the handset off them, so much the better.

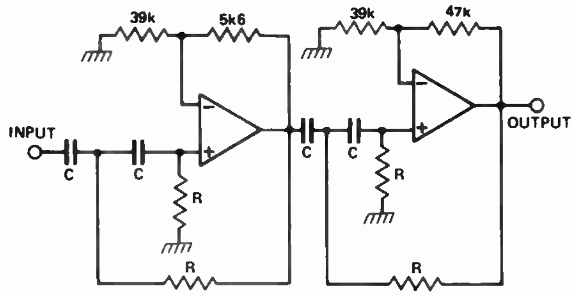
Simple Mixer

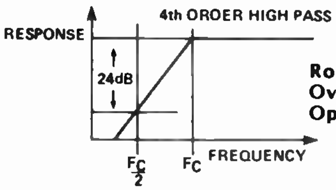
INPUT	MAX GAIN	INPUT IMPEDANCE	SOURCE
1	+6 dB	10k	line level
2	+20 dB	5 to 10k	line level
3	+46 dB	1k0	low impedance microphone
4	+6 dB	1M0	high impedance input



This simple mixer has been provided with four different types of input circuit. Any combination of these could however be used. Once again, the 741 limits the high frequency response and slew rate capabilities. To improve performance substitute the 741 for a faster device such as an NE5534N or TL071, etc.

Rumble Filter



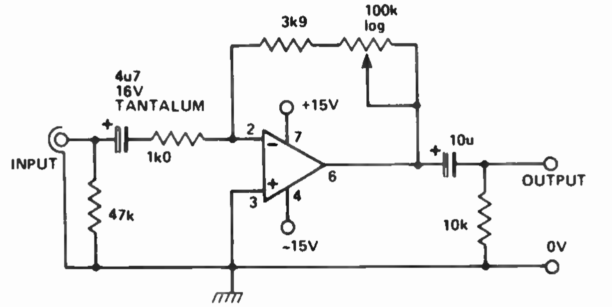


Roll-off slope = 24dB/octave
Overall voltage gain = x 2.6 (8.3 dB)
Op-amps are 741's or RC4558

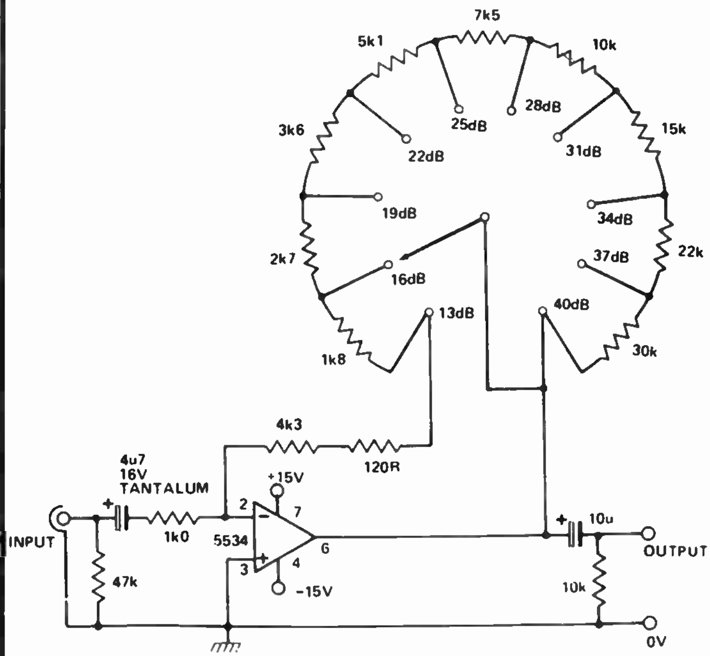
F_c	C	R
25 Hz	100n	62k
50 Hz	100n	30k
100 Hz	100n	15k
200 Hz	100n	7k5
	(5% tolerance)	

Low Impedance Source Preamp

Very low input noise
Input noise = 4 nV$\sqrt{Hz}$
Equivalent input noise voltage = 0.56 uV$_{RMS}$ (20 kHz bandwidth)
Input impedance = 1k0 (suitable for microphone)



Variable gain; x 3.9 to x 100 (12 dB to 40 dB)

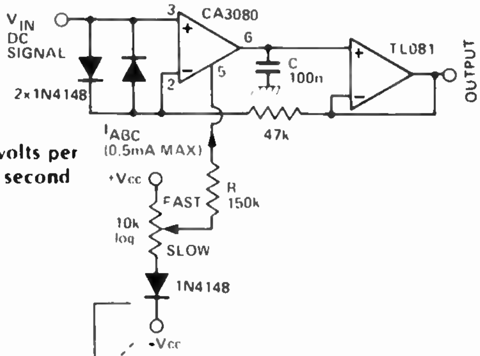


Switched gain; 3 dB steps

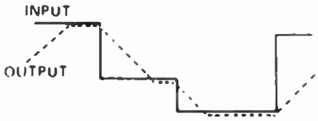
The NE5534N is a very low-noise op-amp specifically intended for audio applications. The device boasts one of the lowest noise figures of all op-amps combined with good slew rate and large signal bandwidth figures.

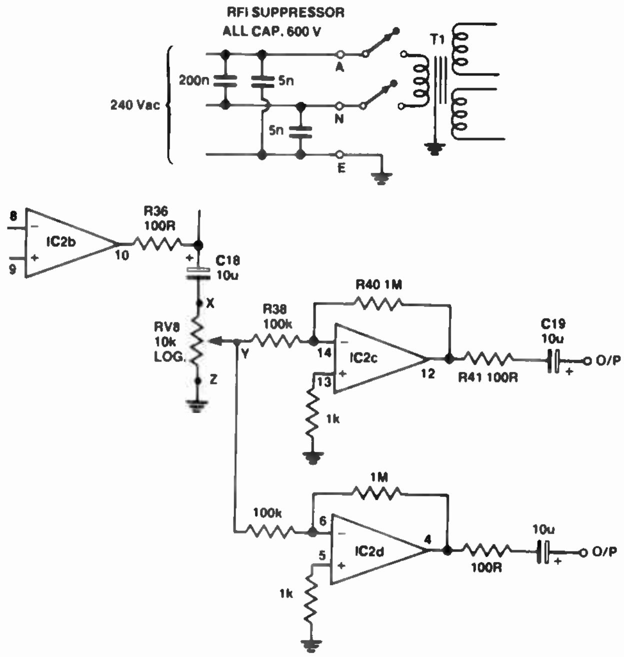
The lowest-noise devices have the designation NE5534AN. Suitable supply decoupling is essential if best results are to be obtained.

Slew Limiter



Slewrate = $\frac{I_{ABC}}{C}$ volts per second





Output splitter to feed stereo input

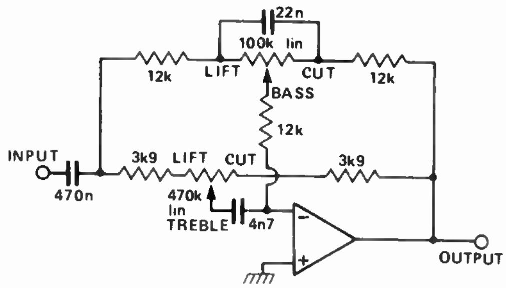
Having built up the ETI-467 Four Input Mixer/Preamp, Alec **Phillips of Myrtleford Vic.** discovered two interesting things.

I constructed a chipboard cabinet with a metal face panel and found it necessary to earth the front panel and also shield and earth the whole of the interior of the cabinet with tin foil. This was to stop hum from being picked up by the tone circuit. I also fitted the RFI filter as shown to remove additional mains hash.

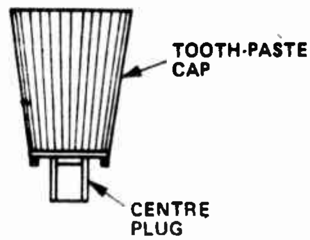
Wanting to use my mixer with a stereo amplifier I experimented with various splitting arrangements for the mixer O/P with varied but only moderate success. Then on close scrutiny of the circuit, it was discovered that IC2d wasn't being used. So with the addition of four resistors, one capacitor and paralleling off Y I had the perfect splitter to feed my left and right AUX I/P and not affect any other stereo I/P signals.

The end results were very noise-free and pleasing.

Bass And Treble Tone Control



The op-amp can be any type suitable for audio work, e.g: TL071, NE5534N, etc.



Cassette winder

This is a device for taking up the slack in cassettes. Take the centre "plug" from a Memorex cassette and glue it to the cap of a toothpaste tube.

It provides better grip than a pencil, and doesn't cost 75c.

The ETI-480 amp module — barefoot and bridged.

For many years now, constructors have built the ever-reliable ETI-480 power amp and many people in the industry have used this design in many different ways. Some other variations that have been tried from time to time are listed in the table here, compiled by **G.T. Dicker of Parkholme, S.A.**

ETI-480 TABLE OF OUTPUT POWER FOR VARIOUS CONFIGURATIONS

Supply Voltage	3055/2955	MJ802/4502	MJ15003/MJ15004
±30 Vdc single-ended	35 W - 8 ohm 65 W - 4 ohm	35 W - 8 ohm 65 W - 4 ohm	35 W - 8 ohm 65 W - 4 ohm 100 W - 2 ohm
±45 Vdc single-ended	65 W - 8 ohm	100 W - 8 ohm 150 W - 4 ohm*	100 W - 8 ohm 190 W - 4 ohm 300 W - 2 ohm*
±30 Vdc bridge	150 W - 8 ohm* 75 W - 16 ohm	150 W - 8 ohm 75 W - 4 ohm	150 W - 8 ohm 190 W - 4 ohm
±45 Vdc	100 W - 32 ohm	190 W - 16 ohm	195 W - 16 ohm 355 W - 8 ohm*

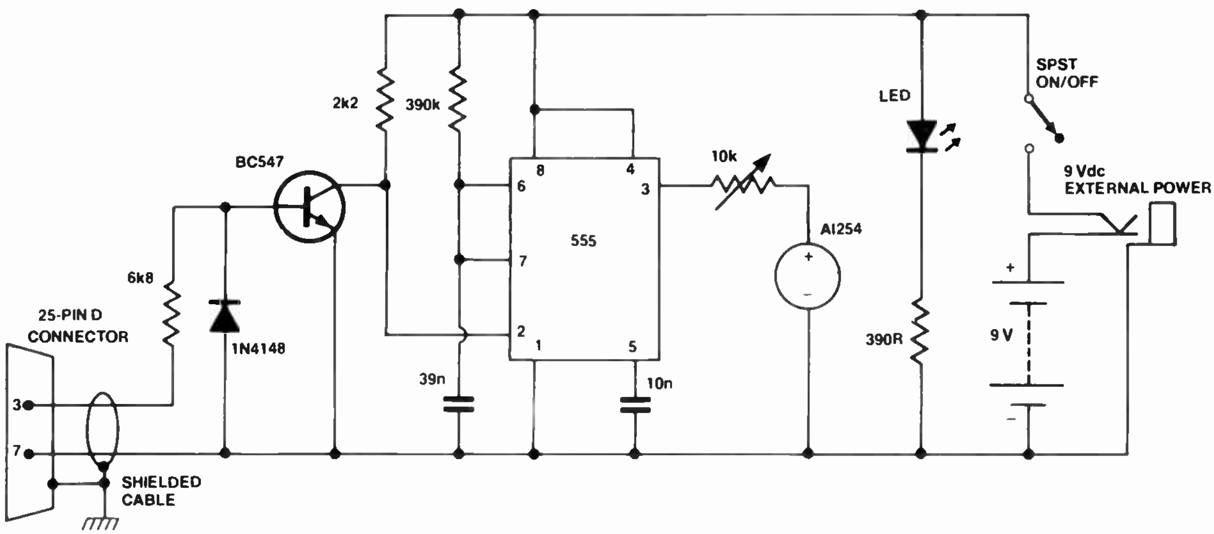
***NOTES:** Not recommended, unless for home hi-fi
At output powers above 100 W RMS extreme heatsinking and/or forced air cooling is recommended.
Not all configurations are necessarily safe for continuous output power operation
When MJ802/MJ4502 or MJ15003/MJ15004 are used supply fuses F1, F2 must be changed to 5 amps.

One of the most useful ways to utilise the ETI-480 is by bridging the output stage for increased power into higher load impedances.

This may be done with the 2N3055/2N2955 output stage combination or by utilising the MJ802/MJ4502 or MJ15004/MJ15003 type transistors in their place.

To bridge two modules, one must first get the modules working to specification, then add a 10k, ½W resistor from the junction of R8 and R9 on module 2 to the output stage, junction of R22 and R21 on module 1. Audio input is then provided to module 1 and output is taken from module 1 and 2 output stages. The input to module 2 may optionally be shorted but in practice makes little difference.

If you feel some of the options tabled look attractive wait and see what will be done with the ETI 466!



RS-232 beeper

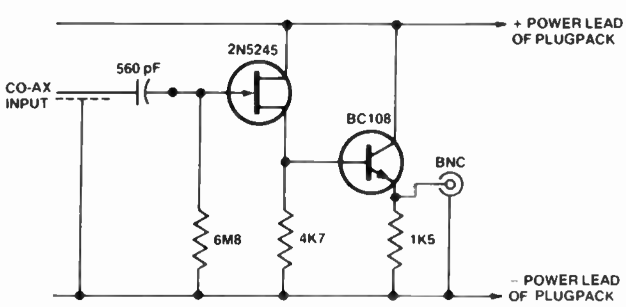
This circuit was devised to provide audio indication of data signals on an RS-232 interface, and was sent in by **Ian Hogan of St. Peters in South Australia.**

The device was built to provide audio feedback when using a digitiser table connected to a VDU. The time required to digitise a drawing is considerably increased if the operator has to continually refer to the VDU to ensure that a cursor key has registered correctly. Using this device, connected to the printer interface of the terminal, the operator can hear if the key has registered. Also, because the duration of the sound is related to the length of the data string received, it is even possible to hear when a new prompt or error message is sent to the terminal.

The circuit operation is as follows: the 6k8 and 2k2 resistors, 1N4148 diode and BC547 transistor act as the RS-232 interface for the circuit. The 555 timer, 390k resistor, 39n and 10n capacitors form a monostable multivibrator.

When no data signal is present, pin 3 of the D connector is between −5 and −25 volts with respect to pin 7 (signal ground), so pin 2 of the 555 is held high by the non-conduction of the BC547; hence the 555 is reset. When a positive-going pulse occurs in a data stream, the BC547 conducts, sending pin 2 of the 555 low, thus triggering a pulse in the 555 output, turning on the AI254 audio indicator. The duration of the pulse is given by 1.1xRC, where R and C are respectively 390k and 39n in this circuit.

The 10k potentiometer provides volume control of the audio indicator. The LED is simply for power-on indication. The external power socket allows a 9 Vac plug pack transformer to be used. The circuit was constructed on a small piece of Versa Strip board, and enclosed in a small zippy box.



Video buffer for the ZX80

When **J.L. Elkhorne of Chigwell, Tasmania,** became the proud possessor of a brand new ZX80, he didn't want to disturb the family's TV viewing by commandeering the TV set as the ZX80's VDU. Having a 230 mm (9") monochrome monitor on hand, the circuit here was developed to press it into service.

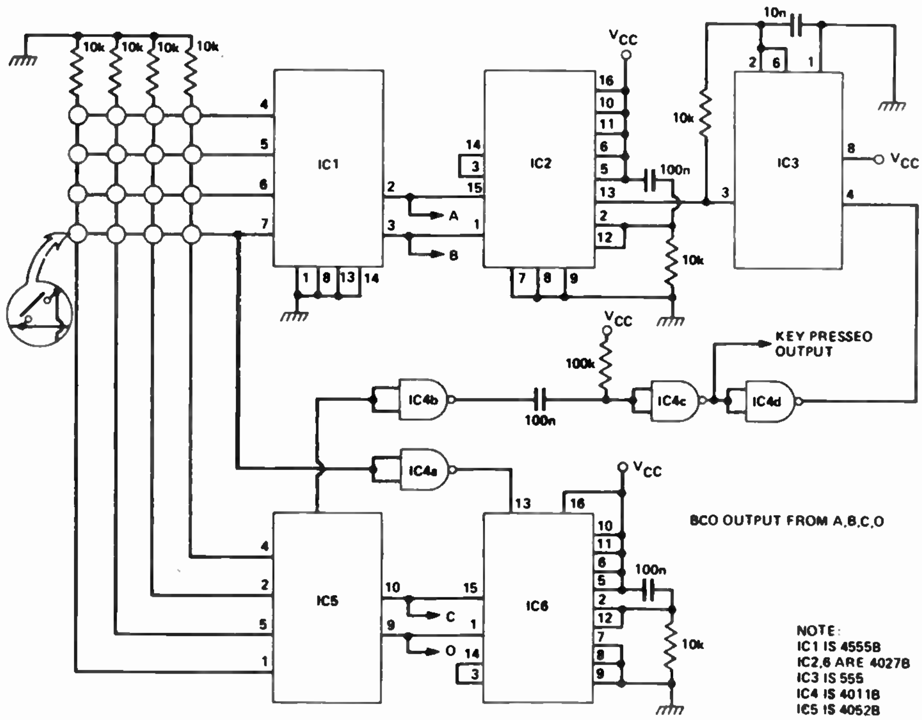
Nothing critical exists in the circuit; all values were determined empirically. Transistor type substitutions could probably be made without problems. The bias for the BC108 is provided by the dc coupling to the source of the 2N5245. In the prototype, the drop across the 4k7 resistor was about two volts.

The circuit was built on a tiny piece of Veroboard and put in a small plastic box on hand. The plugpack used with the ZX80 supplied the power. In keeping with a personal policy of minimal changes to commercial hardware, the only internal change to the ZX80 itself was tacking the 560 pF capacitor on the video lead into the on-board modulator. The free end was proteced with sleeving and protrudes out the back slot by the card edge connector.

The centre conductor of a length of miniature coax clips onto the capacitor. The flex of the plugpack was cut and the buffer board used to reconnect it, thus deriving power for nothing. A BNC connector mounted on the plastic box completed this small project.

Fully Debounced Keyboard

This circuit produces a debounced output whenever a key is pressed. Each matrix point is scanned in turn and the output of the 4052 data distributor goes high when a pressed key is detected. This stops the scanning oscillator (555) for about 10 mS and a 'key pressed' output is produced, thus enabling the BCD output to be stored in a latch or otherwise made use of. The use of CMOS ICs enables current consumption to be minimised, making the circuit suitable for operation in a car. The circuit is easily modified for a larger number of keys by using an eight-way data distributor (with relevent counter made from three J-K flip-flops rather than the two as used here).

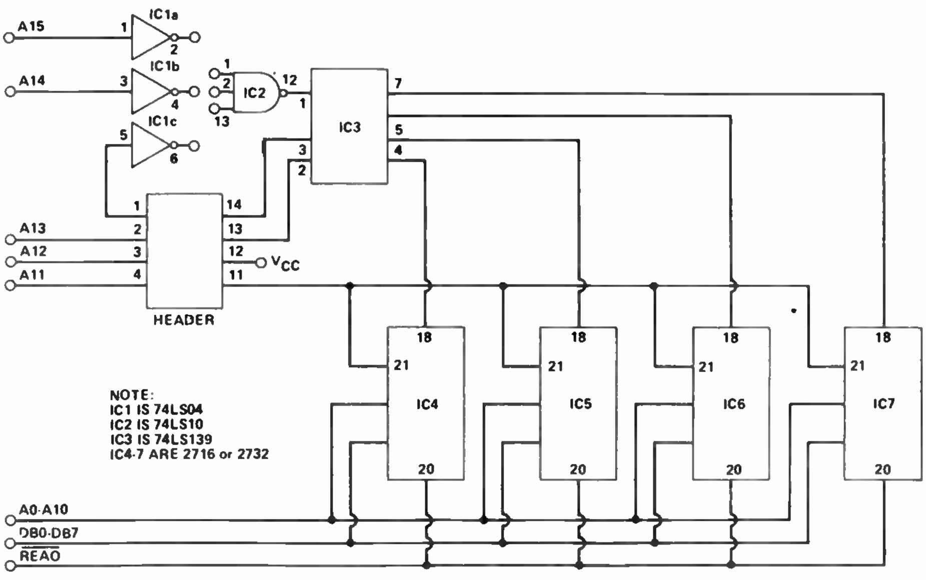


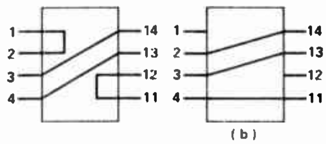
PROM Expansion Card

This circuit provides a very expandable expansion card for 16 bit address processors and single supply EPROMs. In all expansion cards I have seen they take either four 2K PROMs or two 4K PROMs leaving two empty sockets. Now, by very simple means, an expansion card can be made to give 8K or 16K of memory as shown in the diagram.

If an 8K set-up is first considered with the header wired as shown in Fig. 1a, then pin 21 (Vpp/A11) of IC4-IC7 is held high, A11 and A12 are used for chip select through the 2-to-4 line decoder (half a 74LS139) and IC1 and IC2 are hard-wired to decode address lines A13, 14 and 15 to select a particular 8K block of memory (see table).

Now, when your operator program outgrows this, a new card is not necessary, just a rewire of the header (Fig. 1b) and the larger EPROMs. In doing this, A11 is taken to IC4-IC7, A12 and A13 are used for chip select through IC3 and now with pins 1 and 2 joined together on IC2, hard wiring with IC1 gives a unique 16K block by decoding address lines A14 and A15.





8K BLOCK	a	b	c
1st	IN	IN	IN
2nd	IN	IN	OUT
3rd	IN	OUT	IN
4th	IN	OUT	OUT
5th	OUT	IN	IN
6th	OUT	IN	OUT
7th	OUT	OUT	IN
8th	OUT	OUT	OUT

IC1

16K BLOCK	a	b
1st	IN	IN
2nd	IN	OUT
3rd	OUT	IN
4th	OUT	OUT

IC1

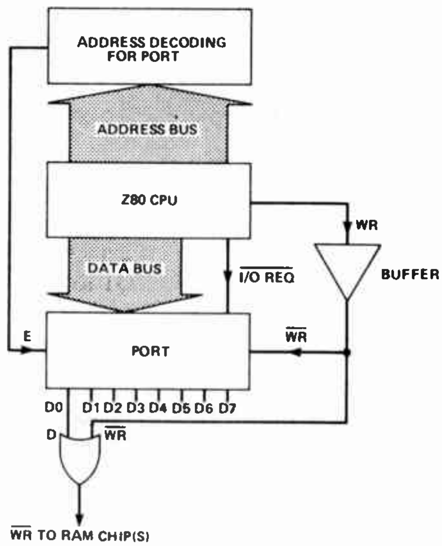
It must be noted, however, that this can only be used for 2716 and 2732 EPROMs as TEXAS 25XX EPROMs have different pin-outs.

By providing 28-pin sockets and additional wiring, the circuit could be reconfigured to take 2764 PROMs — how's that for versatility, as little as 2K to a mammoth 32K of ROM catered for by one card!

RAM To ROM Converter

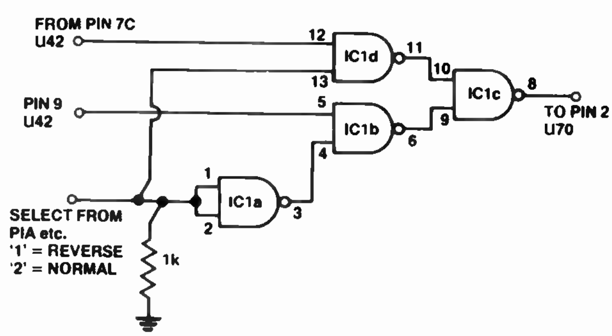
How many times have you experimented with machine-code on an MZ-80 computer or similar system where the monitor is loaded off tape into RAM, and crashed it by accidentally re-writing the monitor? Faced with the same problem on a Z80-based system I am planning to build, I devised a method of turning RAM into ROM under software control. The idea is really very simple — after the monitor or desired language has been loaded from tape into the computer, an OUT instruction is used to program the inputs of a bank of OR gates. Whether the OR gates are inside a chip or made from two diodes and a resistor, by considering one input as an enable, we see that if the enable goes high (logic 1) the output must also go high, irrespective of the data on the other input. This can be used to disable the WRITE line going to a RAM board. When the enable input is low (logic 0) the OR gate acts as a buffer and lets the data on the other input through, so the WRITE line is unaffected. By disabling the WRITE pin on a RAM chip, the RAM is turned into a Read Only Memory — obviously this will not stop your RAM from losing its contents as soon as the power is turned off, but can prevent loss of data due to the odd bug in a user's program.

Although the basic idea was just to protect the language loaded off tape, special areas of memory can be protected by using address decoding or simply interrupting the WRITE line going to individual RAM chips. Using one of these methods, OUT statements could be used before running a program to disable most of the RAM, leaving only workspace and/or the screen (video) RAM to be corrupted by the user's program.



Software selectable reverse video for the Superboard or UK101

Imagine being able to switch from white characters on a black screen to black characters on a white screen under program control, just when those alien invaders are about to demolish your last laser turret. **Neil Westgarth** of **Modbury Heights SA** could and came up with this modification.



All you need is a spare half hour, a 1k resistor, a 74LS00 and a means to POKE a '1' or '0' to switch the video. In my case I use one bit of a PIA port, however if you have a bare board with no other modifications you can use pin 5 of U14 (ACIA) which is set high by POKE 61440,81 and low by POKE 61440,17. These POKEs have no effect on other operations.

As the video information to be displayed is stored in binary form, i.e: '1' = white dot and '0' = black dot, it is a simple matter to switch an inverter in the appropriate port of the video circuitry and thereby reverse the video information.

All the modifications that I have seen to date use a DPST switch to do this and although it is effective it is a little awkward in use. I found it desirable to have it software switchable. The relevant circuit information can be found on OSI supplied circuits sheet 10 of 13.

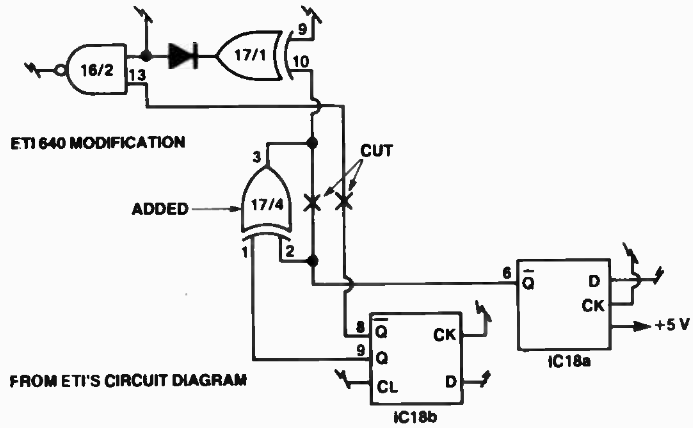
As shown U42 is a 74LS165 shift register whose Q output is used to shift the video information to pin 2 of U70. The modification involves cutting this connection and then selecting either pin 9 (Q op) or pin 7 (Q op, previously unused) through to pin 2 of U70 as before. The same modification is done to the UK101 except that U42 and U70 become IC42 and IC70 respectively.

The 74LS00 and resistor can be mounted on the prototyping area of the superboard. Remember to take care when cutting or soldering to the pc board traces.

Modifications to the S-100 VDU

A modification to the ETI-640 project has been sent in by **B.N. Coomer** of **Carlingford NSW.**

The modification changes the 'flashing' mode so that it flashes between normal and inverse, instead of between normal and blank. This requires a spare exclusive-OR, which is conveniently located in IC17 (pins 1, 2 & 3). The circuit diagram shows the changes.



On the component side of the board, between ICs 17 and 18:

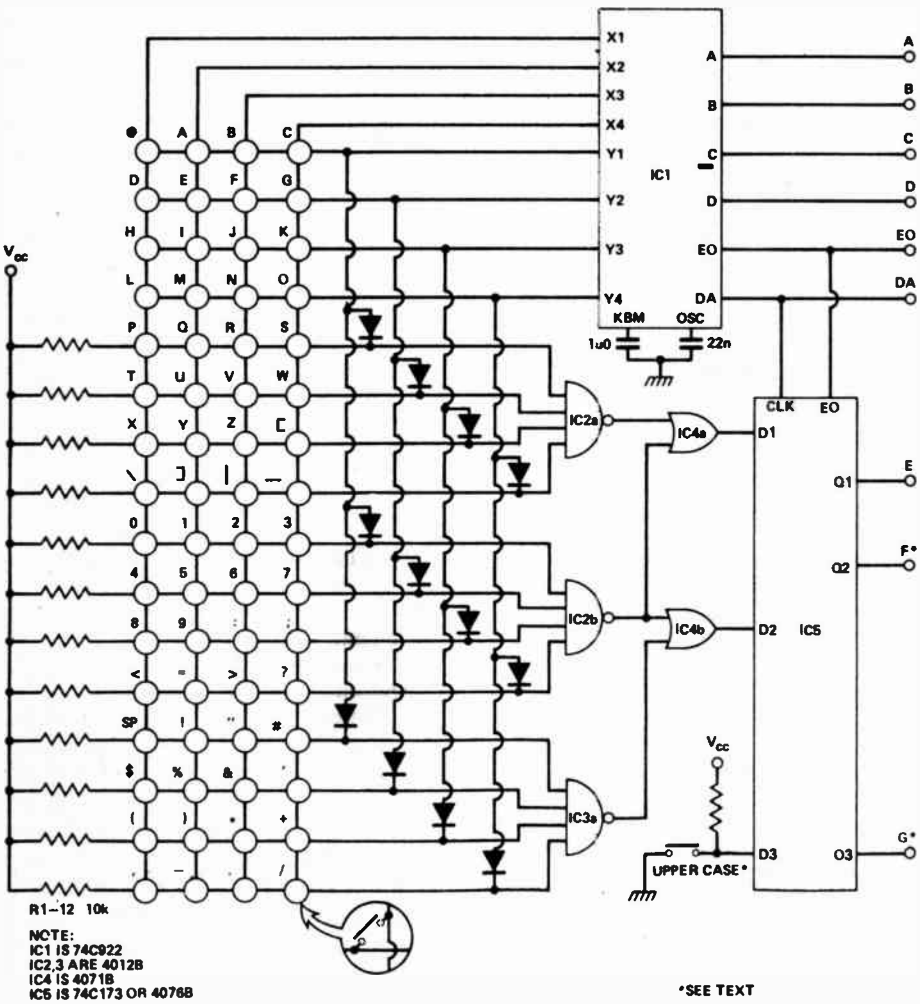
- cut track from IC18, pin 6
- cut track from IC18, pin 8

On the other side:

- IC17: connect pin 3 to pin 10
- connect IC17 pin 1 to IC18 pin 9
- connect IC17 pin 2 to IC18 pin 6

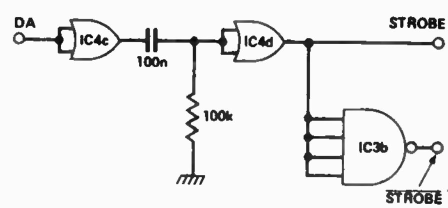
If you want to lengthen the inverse duration, substitute R16 (10k) for any value between 20k and 30k. (R16 is located under the flash rate trimpot.)

Low Cost ASCII Encoder



This encoder is based on the 74C922 16-key keypad encoder. This is a self-scanning encoder with debounce and latched outputs. In this case it has been expanded to four groups of 16, commoning the active-low X outputs and OR wiring the Y lines through the diodes. The NAND gates detect which group of 16 is being keyed; this is encoded through the OR gates, and latched into the flip-flops. Both the flip-flops and the 74C922 have tri-state outputs for bus operation. A data available output goes high when a key is pressed. A strobe is available, if required, using the remaining gates.

The circuit is shown with a six bit condensed code, ie with some upper and some lower case characters found on 64 character generators. A full upper case operation can be obtained by reversing outputs F and G. With a 64-key keyboard, it is possible to obtain all 128 ASCII instructions with only one shift key.

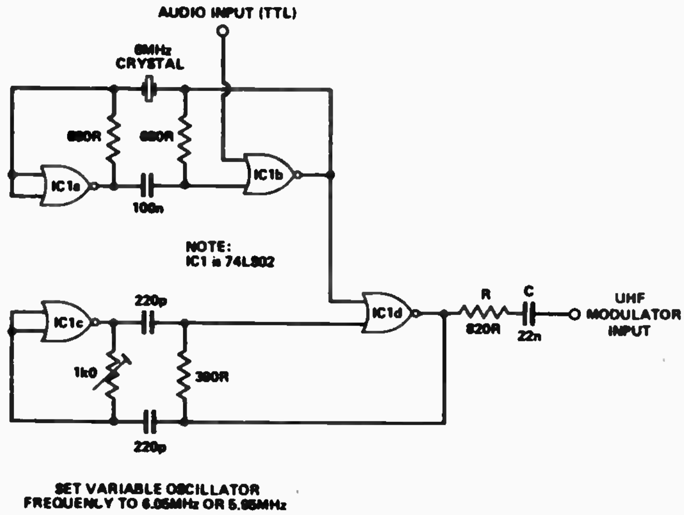


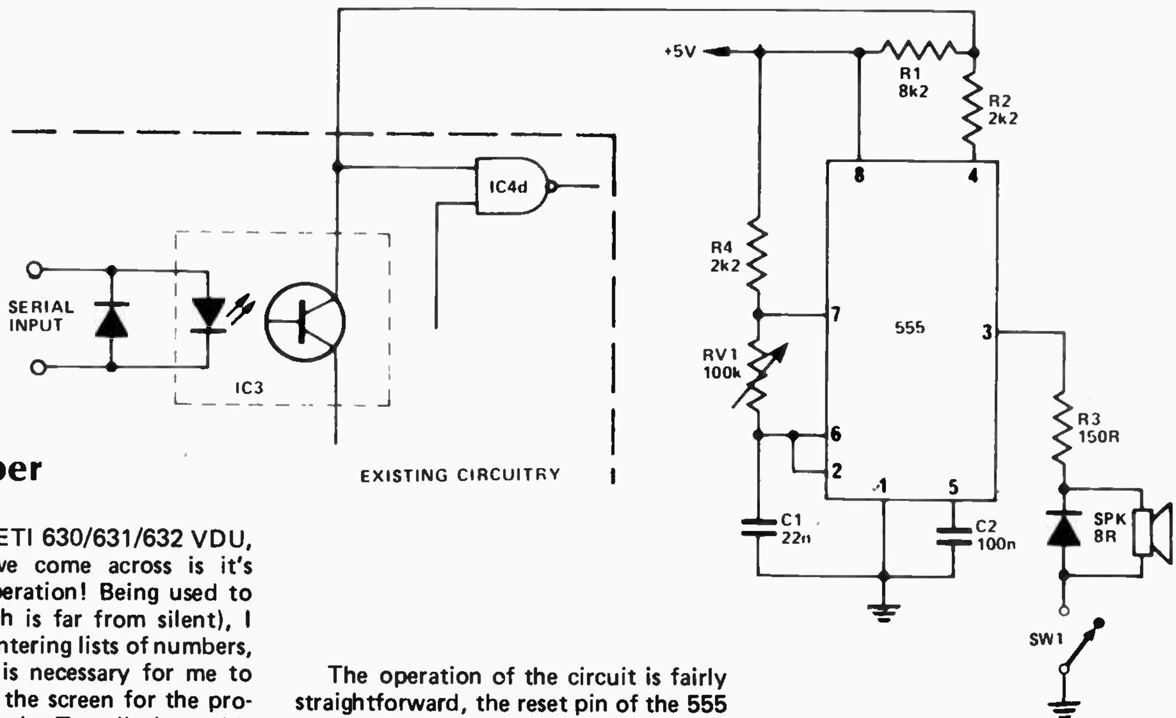
Computer TV Sound Modulator

When a computer that generates a square wave type audio signal is used with a domestic TV receiver, this simple circuit can be used to transfer the sound onto the TV. All 625 line transmissions in the UK use a frequency-modulated sound carrier spaced at 6 MHz from the vision carrier. In the receiver the two carriers are mixed to give a 6 MHz sound 'sub-carrier' superimposed on the vision signal. This is known as the inter-carrier system. It is possible to insert an external sound sub-carrier onto the video signal and this will be correctly detected by the receiver.

The circuit shown is a very simple frequency modulator which will switch between two frequencies depending on the level at the TTL input. The output is mixed into the video input to the computer's UHF modulator via the resistor-capacitor network. Quite a high level of sound carrier (approximately 500 mV pk-pk) has been found necessary to overcome video buzz on the audio output, but on the other hand too high a sound carrier produces interference on the picture. Some experimentation with the resistor value is therefore required to get the best compromise.

When the circuit is connected up the frequency of the variable oscillator should be adjusted to give the loudest undistorted output from the TV loudspeaker.





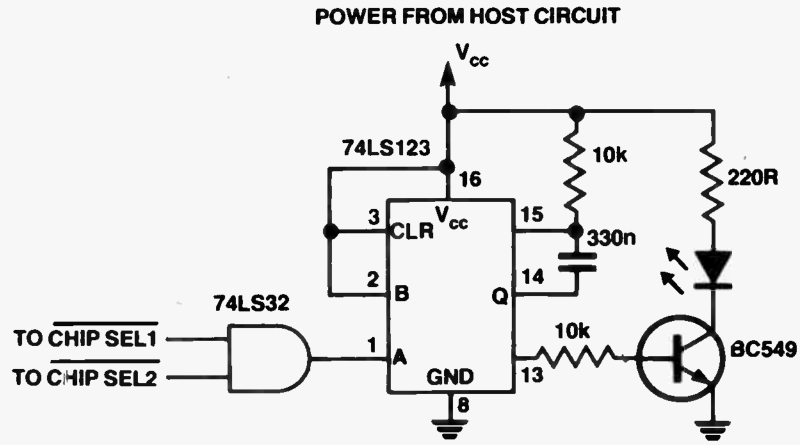
VDU bleeper

When using the ETI 630/631/632 VDU, one problem I've come across is it's totally silent operation! Being used to a teletype (which is far from silent), I find that when entering lists of numbers, for instance, it is necessary for me to keep looking at the screen for the processor's 'prompts'. To alleviate this problem, the following circuit modification will produce audible 'bleeps' whenever characters are received from the processor.

The operation of the circuit is fairly straightforward, the reset pin of the 555 being used to gate its oscillation. RV1 sets the frequency (which is largely a matter of personal preferrence) and the switch allows the bleeper to be switched off when dumping onto tape.

Resolving address contention in a microprocessor system

COINCIDENCE DETECTOR



Picture this scene. I have just added another whatever to my processor system — a new RAM, ROM or other address space consuming device. I turn it back on and the little blighter won't reset. I turn it off, remove my new whatever and it goes like a bought one.

One possible reason? — address contentions!

These can be a real pain to find — especially when the system can't even struggle out of reset. An answer is to cycle the address bus (note one s!) and see if more than one chip select goes down at a given location — hard yakka using conventional approaches such as counters or DIP switches. Since processor chips are now so cheap there is an alternative. The steps are:

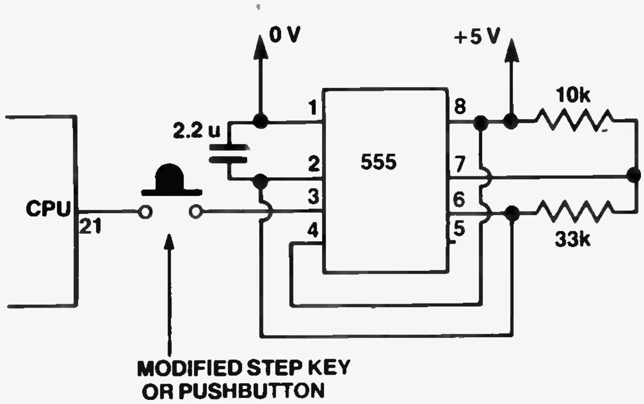
1. Obtain yourself a processor chip of your choice and resign yourself to stuffing (yes, I said stuffing) it.

2. Find out the processor's no-operation code. In the case of the 6800 it is hex 01, and 12 for the 6809. (No, I don't know what it is for the Z80 — why would I want to when my system is 6809-based?)

3. Put on your blue and white butcher's apron and bend all the data bus pins up! (Ouch.)

4. Now attach the data pins which should be high for a NO-OP to the V_{cc} rail and those that should be low to the ground rail. Wire-wrap wire works well for this.

Now when your system has an address contention or other problem, this device can be used to help locate it. The use is very simple. Just power up the system with the 'modified' processor installed. When the device resets it will read all NO-OP instructions and hence cycle the address bus through the whole address range. A logic probe or coincidence detector, like that in the accompanying circuit, can be used to detect the fault condition.



Rapid step through of '660 memory

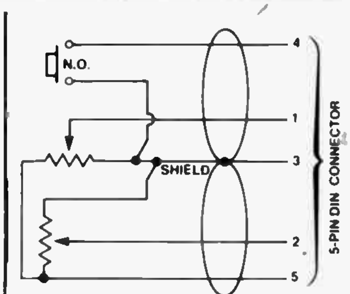
Operating the '660 by repeated pressing of the step key, or changing the contents of the address window, is a tedious way of stepping through memory.

So **Michael Samerski** of **Loftus NSW** devised a circuit which uses a 555 in the astable mode to pulse pin 21 of the CPU at a pre-determined frequency, when a modified step key is pressed. This causes the '660 to rapidly step through memory.

One of the step keys can be disconnected for normal use and made to operate as a 'step repeat' key. Or a separate pushbutton may be installed.

A piece of Vero board was used for the circuit and glued on to the main board between IC5 and IC24.

A word of warning — never hold down both 'step' and 'step repeat' keys simultaneously as a supply short results.



Colour computer joystick

L.W. Brown of Burwood Vic. built a pair of joysticks for his TRS80C.

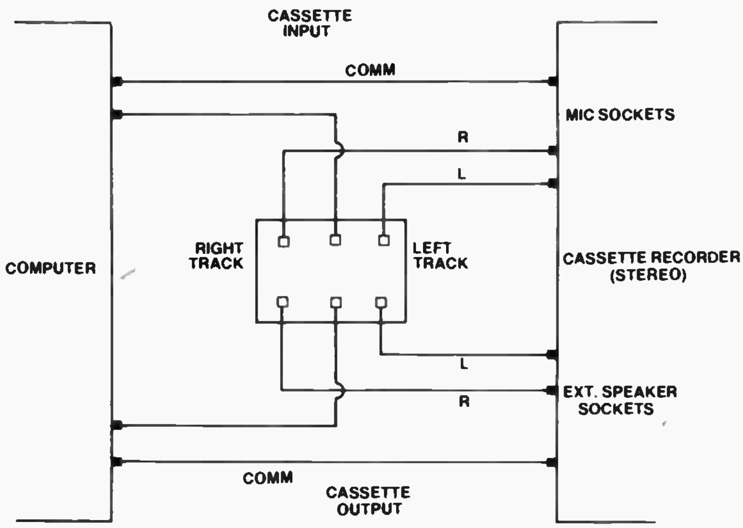
I used a Dick Smith 100k pot mounted inside a small plastic box. A small pushbutton of the normally open type was used for the 'kill' control. Four core shielded cable and a wide angle five pin DIN connector were used for connection to the computer.

The one difficulty with the project is that the cover of the DIN connector fouls on the TRS80C case. The solution to this problem is to solder the two metal shells of the connector together and then glue or solder the plastic cover only partially on to this.

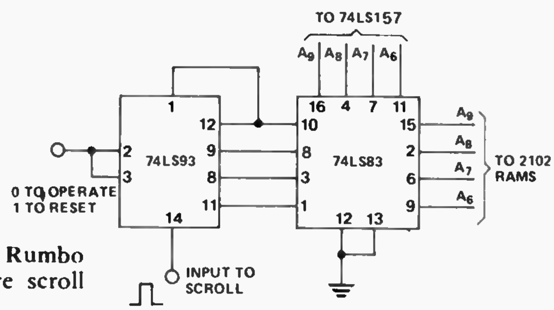
Double density computer cassette storage

This very smart idea came from **Murray Van Syn of Ardross in W.A.** By using a portable stereo cassette recorder for computer program storage, the program density can be conveniently doubled by employing all four tracks independently. A cheap DPDT switch, connected as shown, is used to select the appropriate track. Shielded wire is recommended for the interconnections.

Note: This idea will only work with decks that have a split erase head. Otherwise, when recording on one track, any recording on the other track will be erased.



Hardware Scroll For ETI640



A cunning circuit from E. R. Rumbo of Weetangera adds a hardware scroll facility to the ETI 640 VDU.

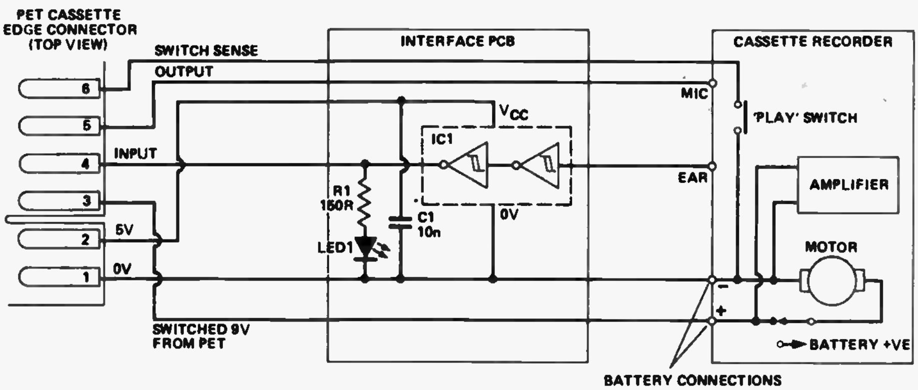
Scroll occurs when the cursor (the point on the screen at which the computer is writing) reaches the end of a line. All the lines on the screen then have to move up to make room for a new blank line at the bottom. Usually, this is done by the processor laboriously moving all the characters on the screen up one line. This is rather slow and an alternative is the circuit shown.

The 74LS83, a 4-bit adder, is used to offset the address of the memories whenever the rest of the circuit calls for a particular character. That character will then 'appear' a number of lines further up the screen. The position of the characters is controlled by the 74LS93 4-bit counter, which will scroll the entire screen contents up one line every time an input pulse is received from the processor.

This configuration will not produce a blank line at the bottom of the screen, however. This will still have to be done by software as, with this circuit, the top line of the display appears at the bottom when the screen is scrolled.

Cheap PET Cassette

In view of the price of the Commodore cassette unit, the following adaptation may be of interest. I have been using this arrangement for some time and have experienced very few problems. In order to signal the PET when the PLAY key has been pressed, a switch mus be incorporated into the cassette key assembly – a small microswitch is ideal. This is an improvement on the Commodore unit, in which any key activates the switch, leading to confusion and ambiguity. The 'signal present' LED is very useful in locating the start and end of the data tape. The cassette recorder is supplied with power from the PET, batteries only being required for fast forward and rewind functions — a switch should be fitted to facilitate this. When the PLAY key is depressed, the PET has control of the tape motor. It may be found necessary to disable any tone control circuitry or AGC which may be fitted in the cassette recorder. Any suitable TTL Schmitt gate may be used as IC1.



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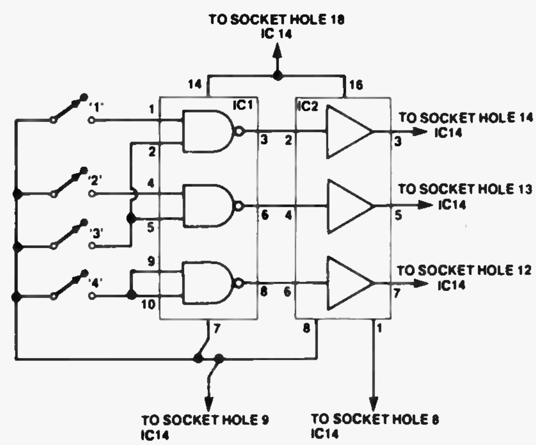


Second keypad for ETI-660

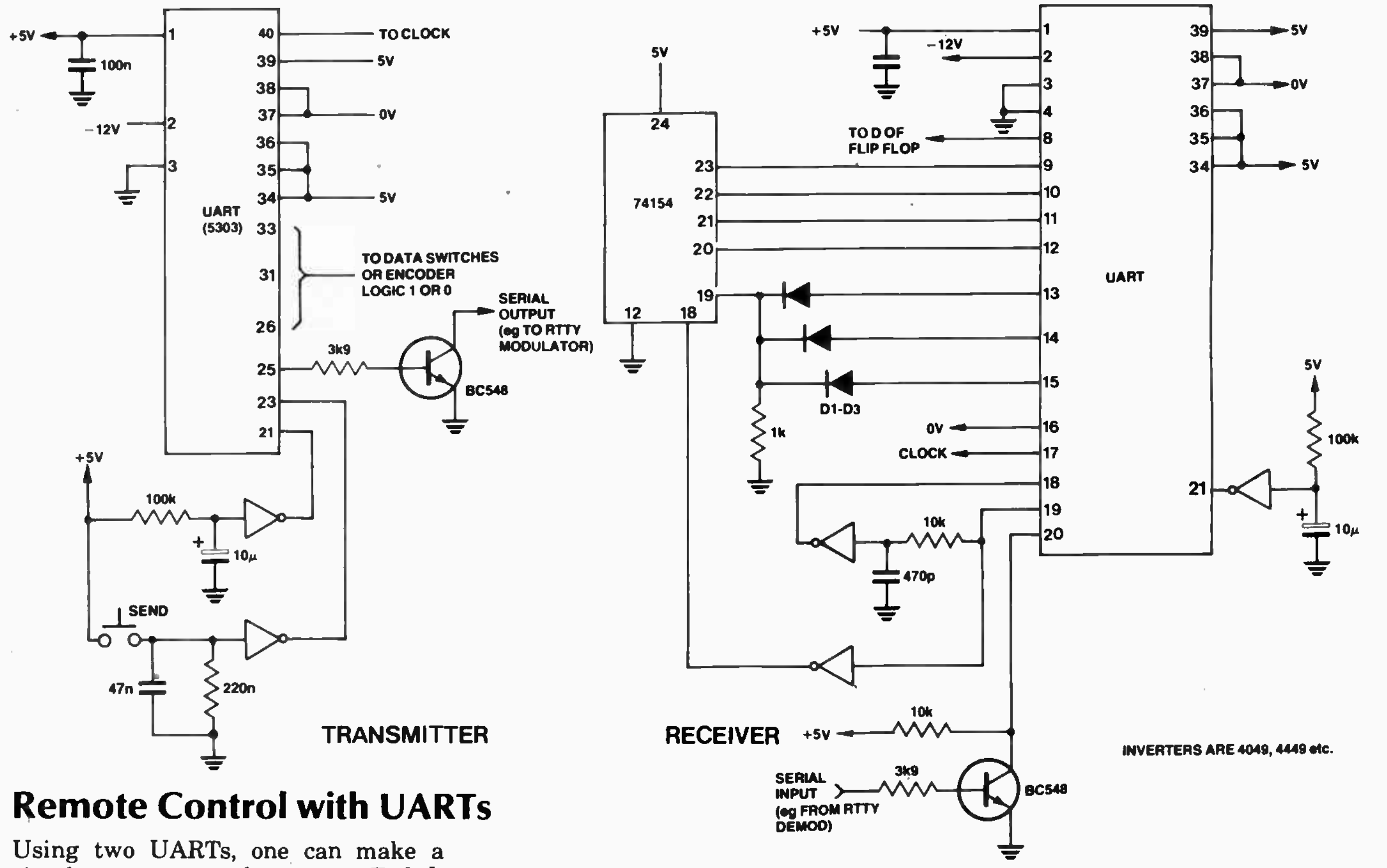
I.A. Curtis of Vale Park SA added a second keyboard to his ETI-660 computer so that he could enjoy two-player games.

This keyboard simply takes the place of RAM ICs 14 and 15, so take out ICs 14 and 15 (if they are in place) and store them in some conductive foam. Use thin solid core wire to plug in the keyboard to the socket IC14.

To read the value of the keyboard in a program use this program segment:

```
0600 AF00 I=0F00
0604 F165 V0:V1=MI
0604 rest of program
```

V0 and V1 now contain the value of the keyboard (lowest three bits). If no key is pressed then 0 will be returned.



TRANSMITTER

RECEIVER

Remote Control with UARTs

Using two UARTs, one can make a simple remote control system as **Ralph Youie of Oakleigh in Victoria** shows here. One UART is used as the transmitter and sends a binary word of, say, five bits. This word may be transmitted by radio, ultrasonics, infra-red etc. The receiver then converts the serial data into parallel data which can be decoded by logic devices, such as a 4-16 line decoder (74154). Each output of this decoder can be connected to the clock input of a 'D' type flip-flop, and the fifth bit can be connected to the 'D' input. Thus, a five-bit word programmed on the transmitter can control 16 flip-flops and hence 16 devices in two states. With a little more logic, one could control 16 devices in 16 states, 128 devices in two states, 64 devices in four states etc., using eight-bit words.

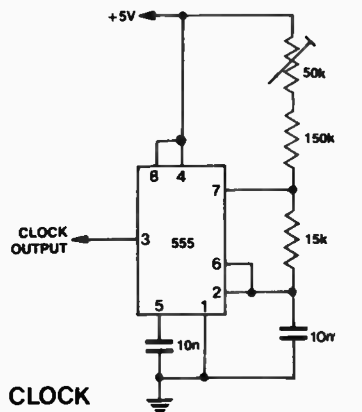
The circuit shown is just one possibility as many factors could be changed, such as clock rate, modulation system, word size, parity and transmission method to name a few. In the circuit, D1-D3 form an OR-gate which prevents the 74154 from operating if an error is found in the word received. Ralph used an RTTY system for the mod-demod and slide switches to program the code word on the transmitter. However, a refined system could use a keypad with encoder.

Possibilities include remote control of television, hi-fi, solenoid tape decks, lights, garage doors etc . . . limited only by imagination.

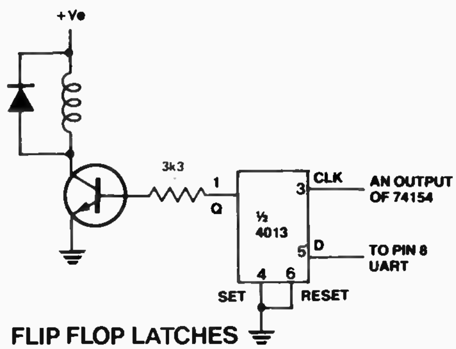
UART pin connections:

1: Vss	2: Vgg	3: Vdd	4: RDE	5: RD 7
6: RD 6	7: RD 5	8: RD 4	9: RD 3	10: RD 2
11: RD 1	12: RD 0	13: RPE	14: RFE	15: ROR
16: SWE	17: RCP	18: RDAR	19: RDA	20: RSI
21: MR	22: TBMI	23: TDS	24: TEOC	25: TSO
26: TD 0	27: TD 1	28: TD 2	29: TD 3	30: TD 4
31: TD 5	32: TD 6	33: TD 7	34: CS	35: NPB
36: NSB	37: NDB 2	38: NBD 1	39: POE	40: TCP

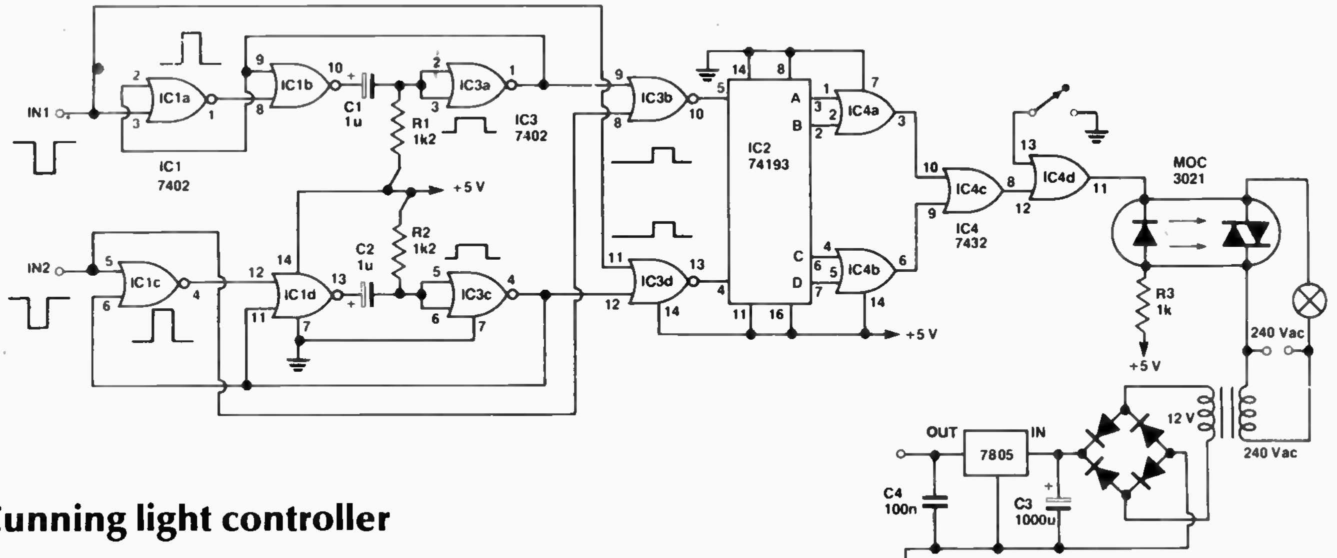
RDE Receive Data Enable (tri-states data line)
SWE Status Word Enable
RCP, TCP clock input
RPE, RFE, ROR parity, frame, and receive overrun errors.
MR master reset
NSB 1 or 2 stop bits
POE odd or even parity
RSI, TSO serial input, output
TDS send transmit data
NPB parity inhibit
NDB no of data bit 5,6,7 or 8
RDA, RDAR Received data, Received data reset



CLOCK



FLIP FLOP LATCHES



Cunning light controller

This circuit can be used to switch a light on or off as a person walks in or out of a room. If two sensors are arranged either side of a doorway (infrared trip switches, like the ETI-570 from Jan. '82, for example) they can drive the two inputs to this circuit, IN1 and IN2. You could also use pressure mats, like those used with burglar alarms.

When IN1 is activated as you start to walk through the doorway (low-going pulse), IN2 is disenabled. The IN1 pulse is stretched such that the output of IC3a is still high when IN2 receives a pulse as you pass through the doorway. The two pulses are fed into an up/down counter, IC2, IN1 driving the UP inputs, IN2 the DOWN input. The counter will count up if IN1 is activated first, down if IN2 is activated first.

When IC2's outputs are all low, IC4 decodes this and switches off the light via the optocoupled triac. A switch is added on the final output gate, IC4d, so that you can manually control the light. Alternatively, pin 13 of IC4 could be driven from some other logic-level source for additional control of the light (from a sound, source, etc).

To set the time allowable to pass the two sensors, 0.8 x R1 x C1 gives the period. Note that R1 = R2, C1 = C2.

There should be not more than 15 people in the room as the counter resets after this count and the lights will go off unexpectedly.

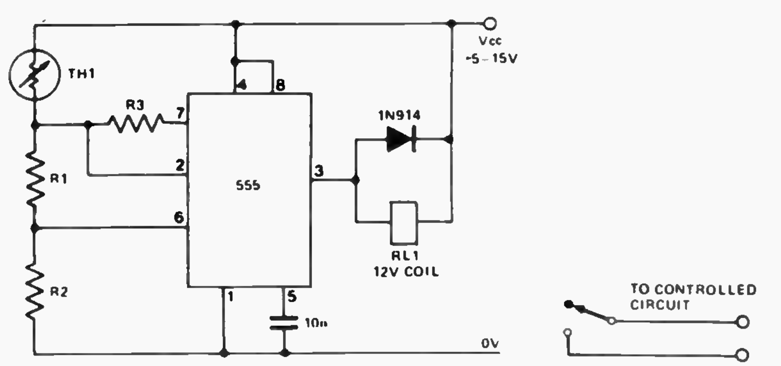
By decoding the outputs of the counter and displaying the result, you could externally monitor how many people are in the room. Next step is to put these switches all over the house, connecting the counter outputs to your computer, and have your computer keep track of you!

The same circuit could be used to control an electrically-operated 'pet door'. You could put the sensors at a suitable height or in a suitable place and regulate what animals are allowed in or out, e.g: let in the cat, keep out the dog, let in the wombat but keep the baby out. (Now *that* will require some ingenuity! — Ed.)

Electronic thermostat

Yet another idea for a 555. This circuit, **from Benjamin Simons of Beecroft, NSW,** uses a 555 timer IC to switch a relay when the temperature on a thermistor reaches a preset upper level and turn it off when the temperature reaches a preset lower level. The on and off states are determined by the values of R1, R2 and R3 and on the resistance of the thermistor. You'll have to experiment to find them.

Mr Simons suggests the circuit may be used to control a ventilator, fan or chemical bath.



Auto-reverse for split-phase motors

The idea with this circuit, from **Kris McLean of Granville Tech. College NSW**, is to provide automatic reversing under load for an ordinary split-phase motor of the type used on drill presses and some garage door openers.

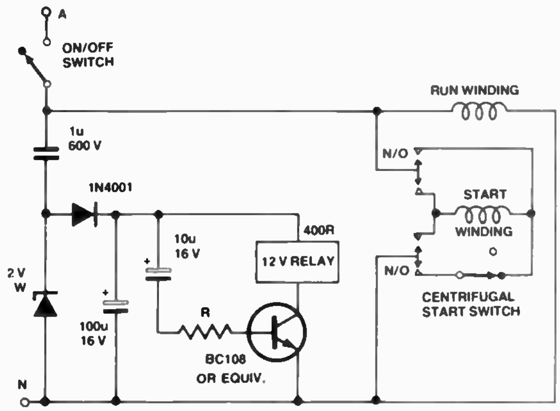
Resistor 'R' is chosen such that the relay is not energised so long that the start winding overheats, but is such a value that the relay contacts do not drop out before the starting switch has opened, causing the motor to spontaneously reverse. A period of around half a second for R between 10k and 1M seems best.

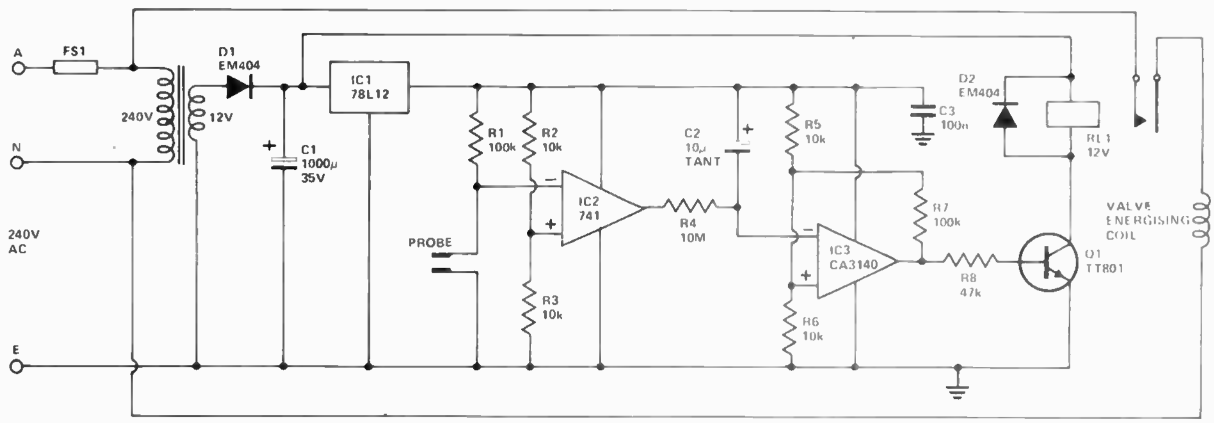
At switch-on the relay pulls in momentarily, the normally open contacts close briefly and give the motor a start in the right direction. Shortly before reaching full rpm, the motor's internal starting switch opens and the relay drops out.

Now, when the motor loads up, the loss of rpm causes the centrifugal switch to close and thus reverses the motor.

The circuit's one disadvantage is that synchronous single-phase motors maintain their rpm under quite drastic loads and as such a reverse can only be initiated just prior to a stall condition. To get a more sensitive response involves altering the springs on the centrifugal starting switch.

Note that the relay contacts should be rated at 15 or 20 A.





Electronic Ballcock

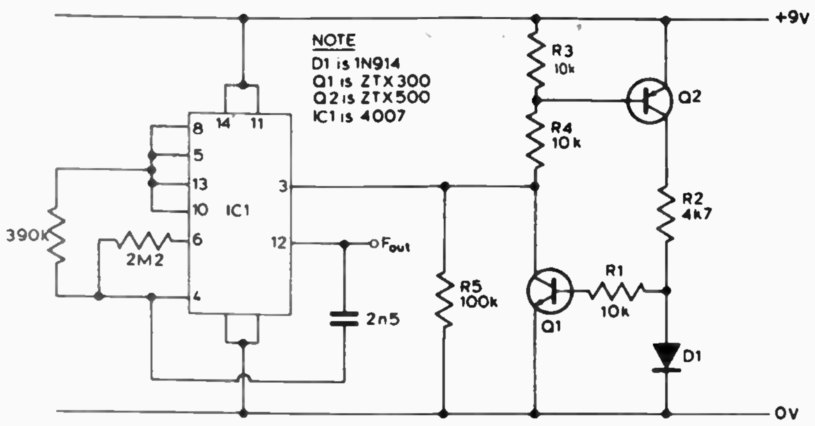
After fitting a filter system to his pool, Clifford Heath of Camberwell found that the pump had to be re-primed every time the water level dropped due to evaporation.

This circuit detects low water level in a swimming pool and switches the water supply on for about 20 seconds when it occurs.

The inverting input of IC2 is held low by a short across the probe (which can simply be a couple of bolts through the side of a fibreglass pool). When the water level is low the probe will go open circuit and the output of IC2 will go low. C2 will begin to charge and after about 2 minutes, the output of IC3 will change state. This 2 minute delay is to prevent waves from setting the device off prematurely.

Once triggered, IC3 (which is connected as a Schmidt trigger) will give a high output voltage for at least 20 seconds — this is the length of time needed for IC2 to change the inverting input voltage of IC3 past it hysteresis point.

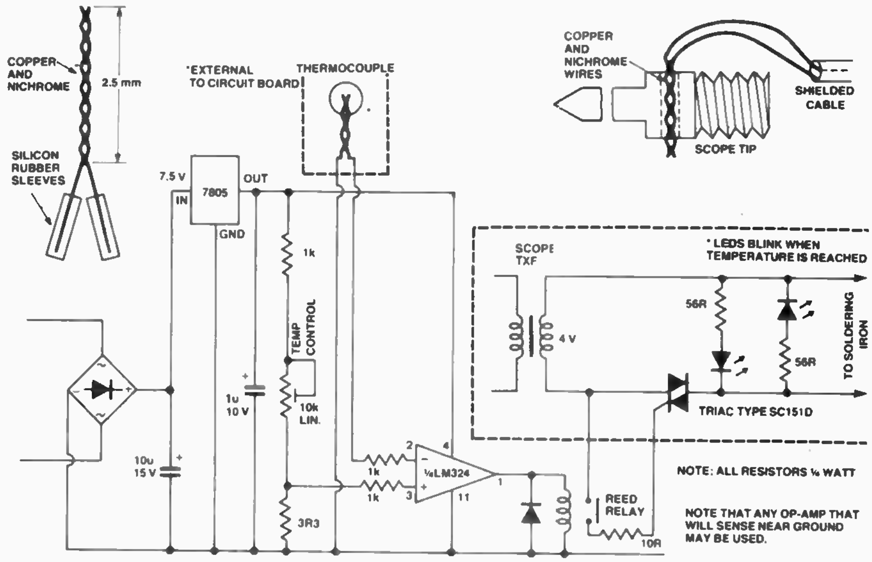
While the output of IC3 is high, Q1 will turn on and energise the water supply valve coil. Care should be taken with the valve mains supply — it's a good idea to put the end of the water supply hose into the pool. This will remove the possibility of mains-voltage water falling into the pool due to a short inside the valve.



Temperature to frequency converter

This circuit uses the fact that when fed from a constant current source, the forward voltage of a silicon diode varies with temperature, in a reasonable linear way.

Diode D1, and resistor R2 form a potential divider, fed from the constant current source. As the temperature rises the forward voltage of D1 falls tending to turn Q1 off. The output voltage from Q1 will thus rise, and this is used as the control voltage for the CMOS VCO. With the values shown, the device gave an increase of just under 3 HzC^{-1} (between 0 C and 60 C) giving a frequency of 470 Hz at 0 C.



Temperature control your Miniscope!

My Miniscope soldering iron had been a good friend for a number of years when I came to the conclusion that a temperature-controlled soldering iron was becoming more and more a necessity and not a luxury.

This necessity, plus my reluctance to part with the above-mentioned iron, led to the following circuit, which transformed it into a five-second, heat-variable, temperature-controlled soldering iron.

A simple, jury-rigged thermocouple provides a sensor. The LM324 op-amp senses the thermocouple voltage at pin 2 (with the wires used this voltage is about 11 mV at the solder melting point) and compares it to the reference level at pin 3. RV1 allows this voltage to vary between about three and 20 millivolts.

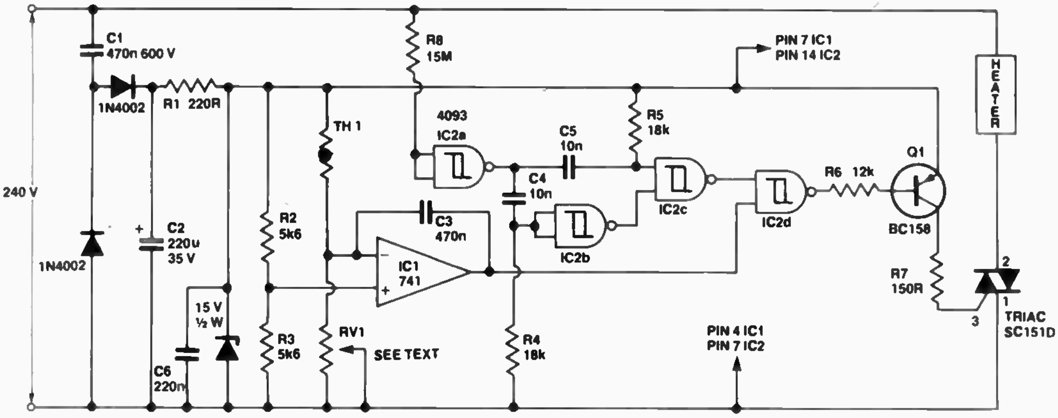
When the thermocouple voltage reaches the trip level, set at the comparator, the output goes low, de-energising the reed relay and thus turning the triac off. At this point the iron tip cools, the thermocouple voltage decreases and the comparator output goes high again, thus repeating the cycle.

The thermocouple was constructed by twisting together two short lengths of copper and nichrome wire (the nichrome wire was salvaged from a wirewound resistor).

A 1mm hole is drilled into the Miniscope tip, just before the thread begins, and the twisted pair is inserted into this hole. A firm squeeze with a pair of pliers will complete the job.

The circuit is not at all critical, save for the fact that shielded cable must be used to connect the thermocouple to the circuit board (the thinnest microphone cable will suffice). With a suitable change in divider resistors, the supply voltage may be anything from 4 to 15 V. The voltage regulator is used to stop the voltage from fluctuating as the iron is switched on and off (this happens in my case because I have used a transformer with two windings, one for the iron and one for the controller).

An improvement in temperature regulation would be obtained by using an optocoupler instead of the reed relay, as the former is a much faster device. Further, the thermocouple may be made up from different types of wire as long as a suitable output is obtained at the solder melting point.



Electronic thermostat

This circuit, designed by **Steve Gagen of North Balwyn Victoria,** has been used for several months to control the temperature in an incubation room. According to Steve it has performed well, achieving drift-free temperature regulation with an accuracy of ±0.5°C.

The low voltage supply to the ICs is taken directly from the mains, via capacitor C1. The thermistor (T) should be of the bead type and, if necessary, may be sited at some distance from the rest of the circuit. RV1 should be chosen so that its mid-range resistance is approximately equal to the resistance of the thermistor at the desired temperature.

The difference signal between the thermistor in the RV1 network and the voltage divider R2-R3 is amplified by IC1 and used to gate the output of the pulse generating circuit formed by IC2. Capacitor C3 prevents the amplification of any extraneous ac.

When the output from IC1 is high, 90 mA pulses of about 200 us length are applied to terminal 3 of the triac at the beginning of each mains half cycle, turning it on.

The circuit tends to cycle on and off every minute or so and the triac avoids the problem of burnt contacts which a relay would experience in these circumstances. Since the heat control is non-proportionating, the circuit is suitable for use with fan heaters.

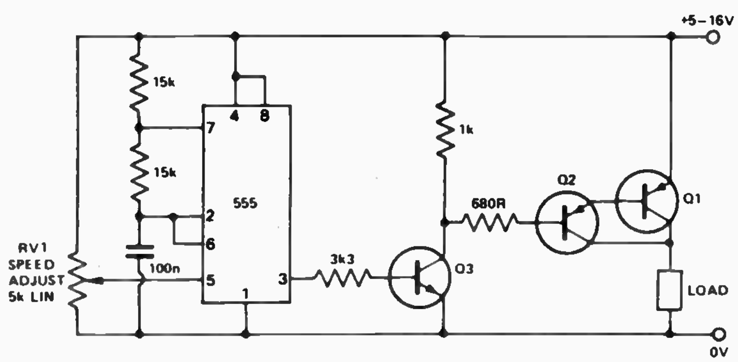
Care should be used as the entire circuit is at mains potential, and the triac should be mounted on its heatsink using a mica insulator. A heatsink is essential as when controlling a 2.4 kW heater the triac dissipates about 15 W.

Pulse width modulation controller

This novel idea, **from Donald Wallace of Bundaberg,** uses a 555 IC to generate a variable width pulse to run slot cars, model trains etc or the unit may be used as a light dimmer.

The pulse width is controlled by the voltage on pin 5, set by the potentiometer. The output transistor is switched on and off at several hundred hertz, the on to off ratio determining the speed of the motor, or brightness of the lamp.

The supply voltage may be 16 V maximum and the circuit can switch up to 10 A with an appropriate heatsink on the output transistor.



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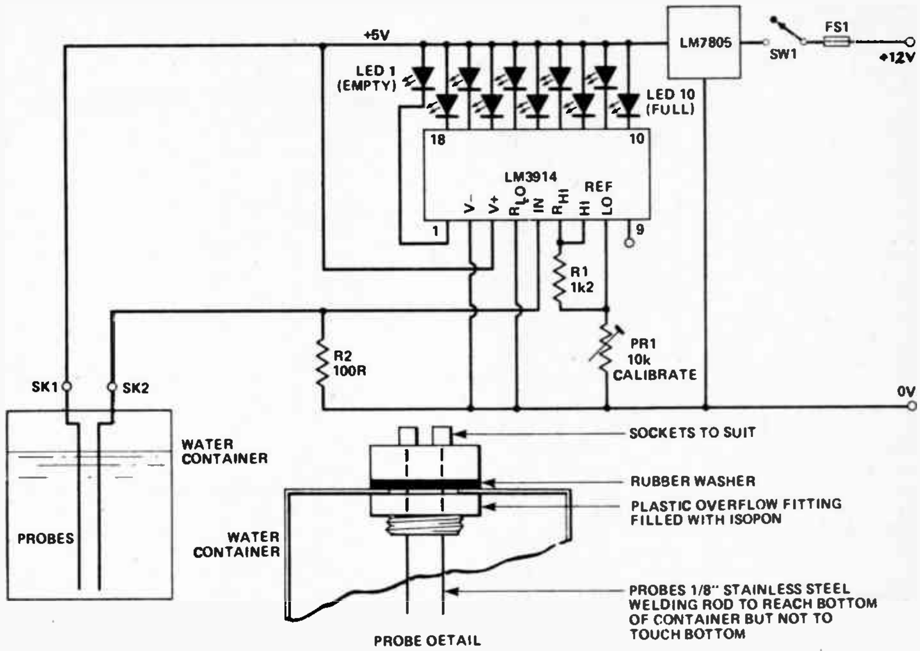
Water Supply Monitor

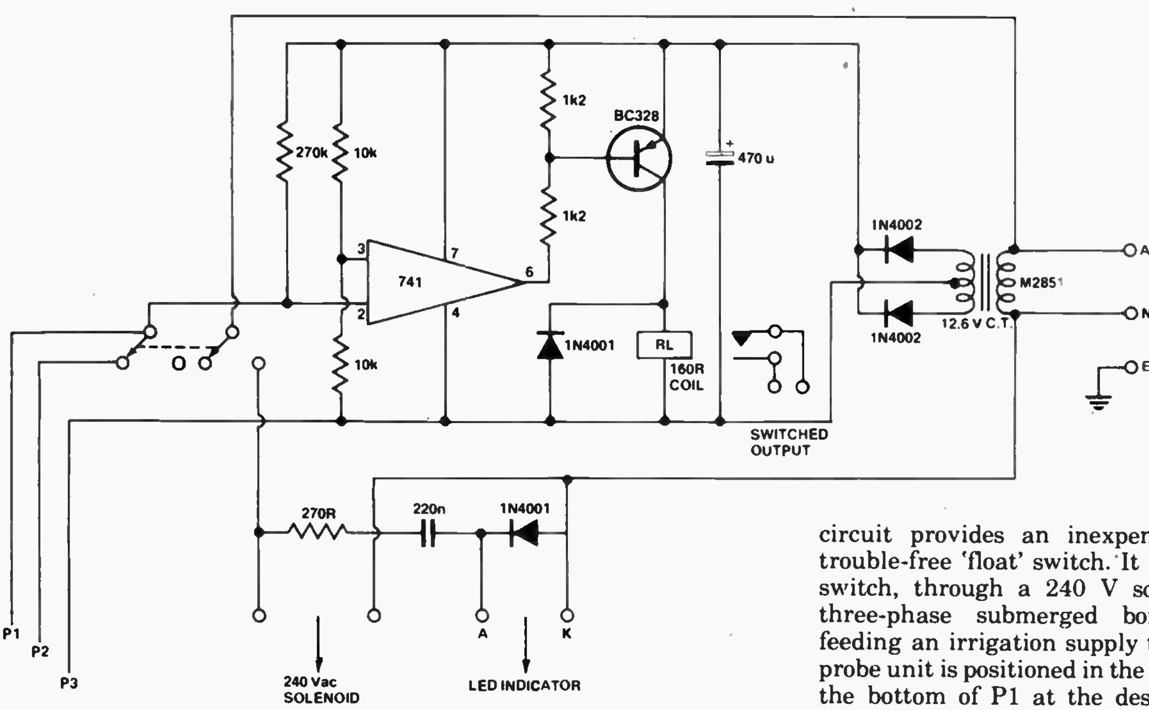


Being a keen caravanner I found that knowing how full the water containers were at any time was a problem, since they are opaque (being either plastic or aluminium). I designed the following circuit to give a visual display over the sink inside the caravan. The circuit is duplicated for drinking water and waste water levels, only the colour sequence of the LEDs being reversed. For drinking water, it is; full to half-full, green; half to one-quarter full, amber; quarter-full to empty, red.

The circuit is based on the LM3914 dot/bar driver using ⅛" stainless steel welding rods as probes. Electroplating is overcome by reversing the polarity through the probes each time the containers are filled (or emptied in the case of the waste container), by using a two pin plug and socket. The probes are spaced ½" apart but this isn't critical.

The probes are held in a plastic overflow joint connector, used for water tanks, and this is filled with Isopon; the surface nearest the water is smeared with Araldite to prevent the fibreglass tainting the drinking water.

The display, dot or bar mode, gives a linear display of the contents very accurately, thus preventing overflows of waste water or running out of drinking water.



Water level sensor and switch

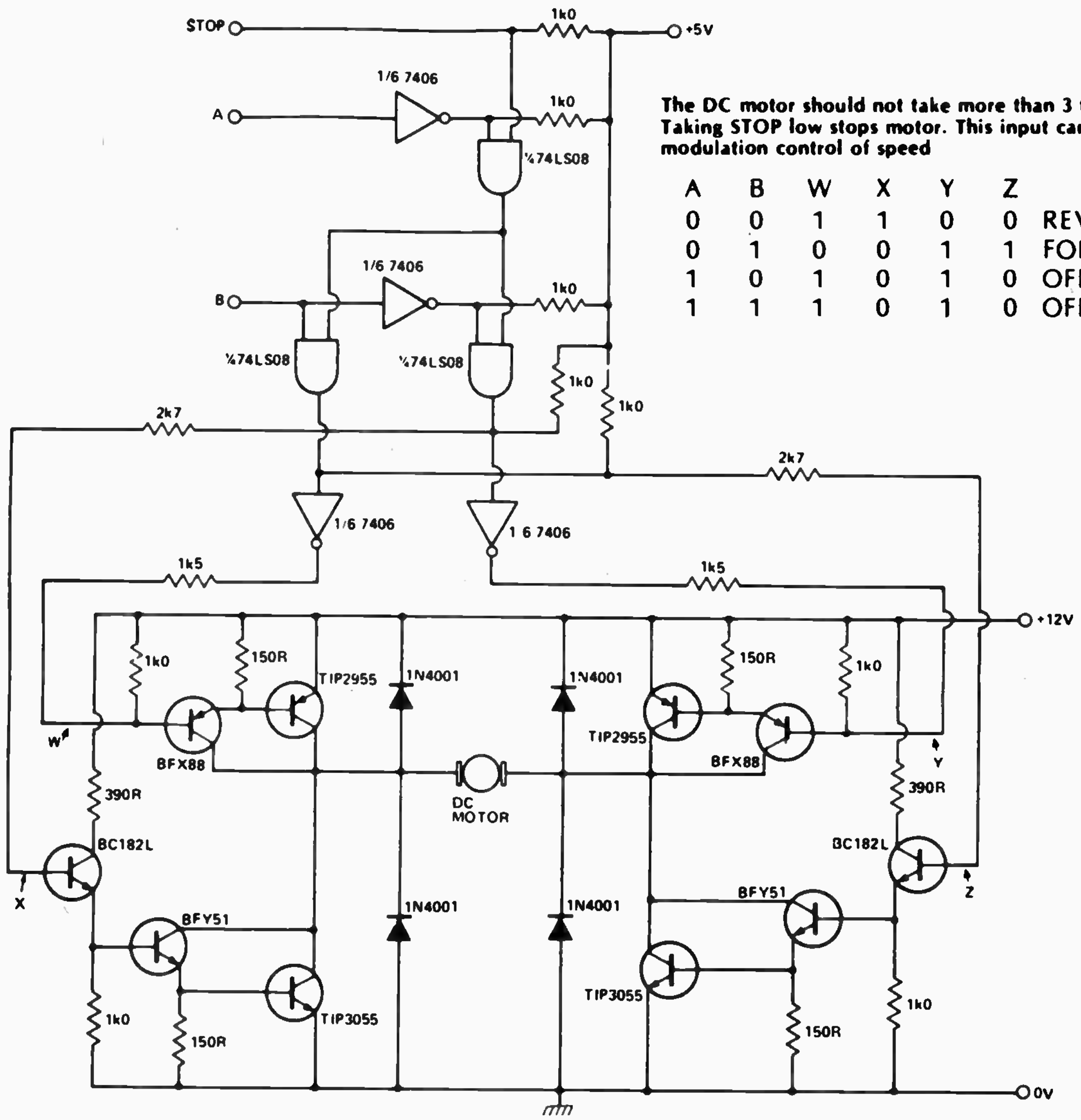
Here's a novel idea with a practical application, from **F.L. Harrison of Ardross in West Australia.**

It is a water level sensor that controls a pump which maintains the water level in a tank. Three 'sensor' wires are employed: one at the 'high' water level (P1), one at the 'low' water level (P2), and one well below the latter (P3) so that it's permanently in the water. Here's what it's all about.

Using an inexpensive 741 IC and a relay with two sets of contacts, the circuit provides an inexpensive and trouble-free 'float' switch. It is used to switch, through a 240 V solenoid, a three-phase submerged bore pump feeding an irrigation supply tank. The probe unit is positioned in the tank with the bottom of P1 at the desired 'full' level.

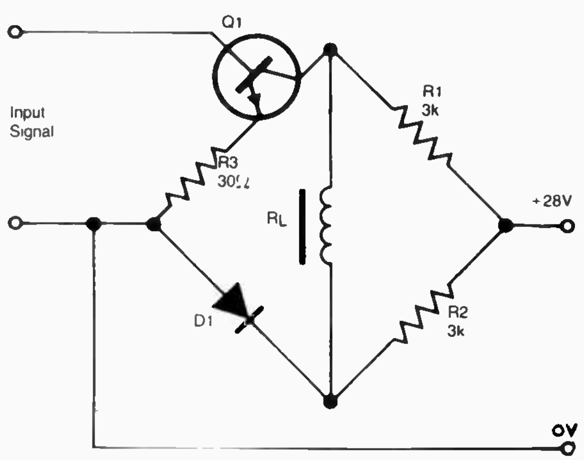
The bore pump does not start until the water level falls below P2 and is not switched off again until the water level reaches P1. This ensures that the supply tank always remains full. The LED, which is remotely mounted, gives a visual indication of when the pump is running.

Heavy Duty DC Motor Control



The DC motor should not take more than 3 to 4 A continuous current. Taking STOP low stops motor. This input can be used for mark/space modulation control of speed

A	B	W	X	Y	Z	
0	0	1	1	0	0	REVERSE
0	1	0	0	1	1	FORWARD
1	0	1	0	1	0	OFF
1	1	1	0	1	0	OFF



Temperature stabilized relay

Accurate relay trip-point operation can be obtained over an ambient temperature range from −50°C to +90°C using this simple circuit.

The temperature sensitivity of the silicon transistor Q1 is balanced out by the silicon diode D1. Gain/temperature stabilization may be obtained if required by using a positive temperature coefficient resistor for R3.

Fig. 1

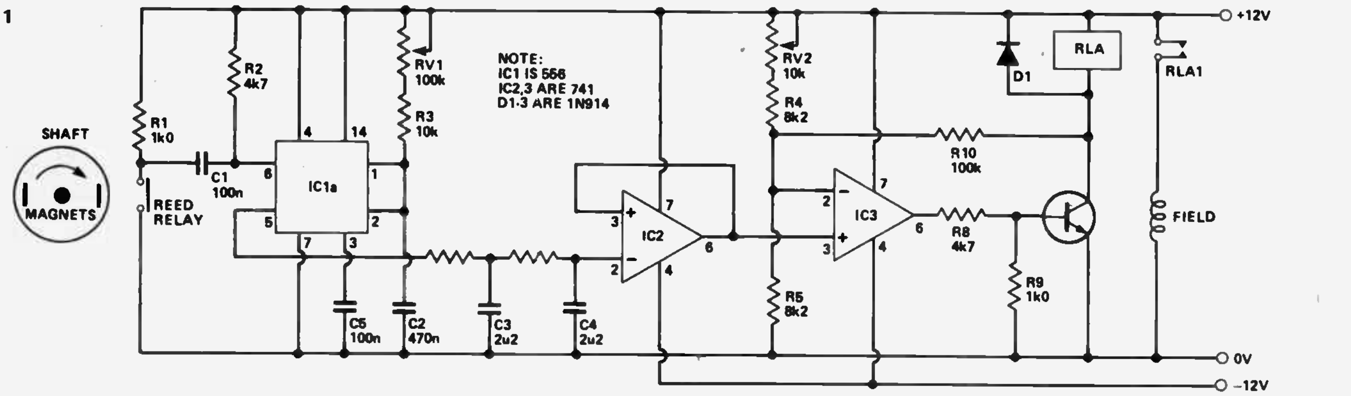
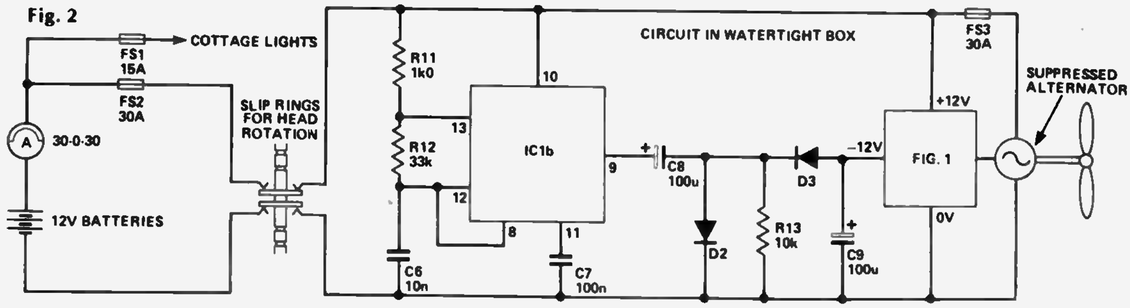


Fig. 2



Control Wind-power Circuit

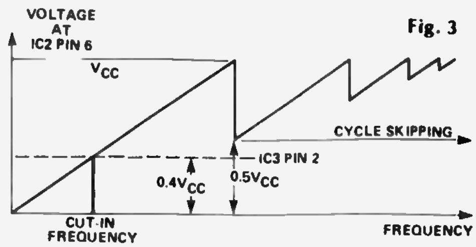


Fig. 3

This circuit was designed to control a windmill at a remote holiday cottage. The cottage's electrical supply is derived from 12 V batteries which are recharged by an alternator driven by the windmill. The field on an alternator draws about 1 A when the battery is not being charged, and the circuit was designed to cut out the field when the windmill speed is too low to permit charging.

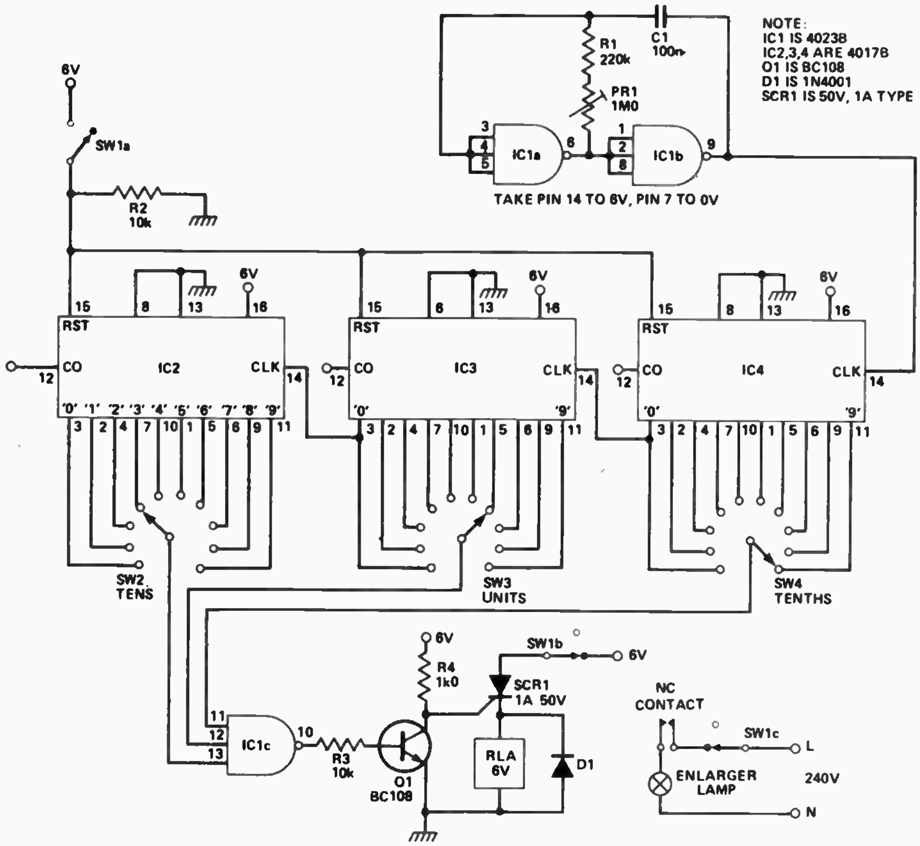
The windmill speed is measured by two magnets on the shaft which pulse a reed relay. This in turn fires the 556 monostable IC1 as shown in Fig. 1. The output from IC1 is thus a constant width pulse train whose frequency is determined by the windmill's rotational speed. This is smoothed by the two stage filter R6-C3-R7-C4 and buffered by IC2 to give a DC voltage at pin 6 of IC2 which is directly proportional to the windmill speed. This is compared with a preset voltage by IC3 and used to switch the field relay via Q1. R10 provides hysteresis, necessary because the windmill speed drops slightly as the alternator comes on load.

For IC2 and IC3 to work properly, a negative supply is needed. To provide this from the single 12 V battery supply, the simple DC-to-DC inverter shown in Fig. 2 was necessary. This utilises the other half of the 556 and gives a low current −12 V supply.

The voltage at pin 6 of IC2 is proportional to speed until the period of the monostable is equal to the rate at which the reed relay is pulsed. At frequencies above this, the voltage falls due to cycle skipping, giving the output voltage versus frequency graph of Fig. 3. As a windmill operates over a wide frequency range, it was expected that cycle skipping would occur at high speed. This is, however, of no importance if the trigger voltage is set at 40% of V_{cc} giving a single unambiguous cut-in point.

The coarse cut-in point is set by RV1, and the fine by RV2 (subject to the comments in the preceding paragraph). The circuit was designed for a cut-in speed of about 400 RPM which suited the windmill/alternator combination. The circuit draws minimal current from the battery therefore allowing the windmill to be left to its own devices while the cottage is unattended.

Enlarger Timer

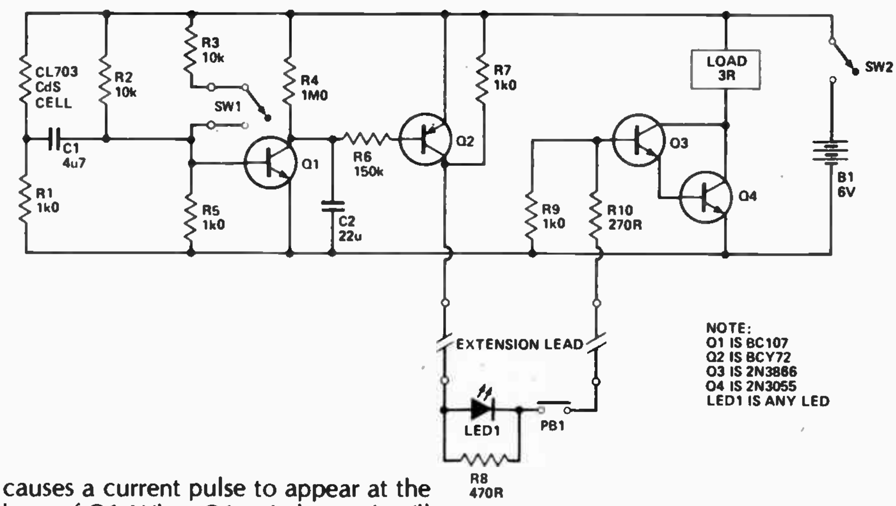


The circuit of the enlarger timer can time periods from 0 to 99.9 seconds in 0.1 second steps. PR1, C1, R1, IC1a,b form an oscillator that feeds a 10 Hz signal to the first 4017 counter stage. Either the 'carry out' or '0' outputs of IC2 and IC3 can be used to feed the next stage, as the frequencies are the same and the positive-going edges of the pulses appear at the same time. Outputs '0' to '9' go high in sequence as the pulses are received at the 'clock in'. The desired time is selected by SW2, SW3 and SW4.

Q1 is used as an inverter and with the NAND gate it performs the same function as an AND gate. As soon as the desired time is reached, all the inputs on the gate will be high and this will trigger SCR1. The relay will be turned on and switch off the enlarger lamp. The lamp will remain off until the circuit is reset.

The circuit can be resetted by closing SW1a and opening SW1b and SW1c. SW1a will reset the 4017s and keep them in the reset condition. SW1b will remove the current from SCR1 to reset it. SW1c prevents the light from going on when in the reset condition. When SW1 is switched back to normal, the light will go on and remain on for the desired time.

Remote Camera Release

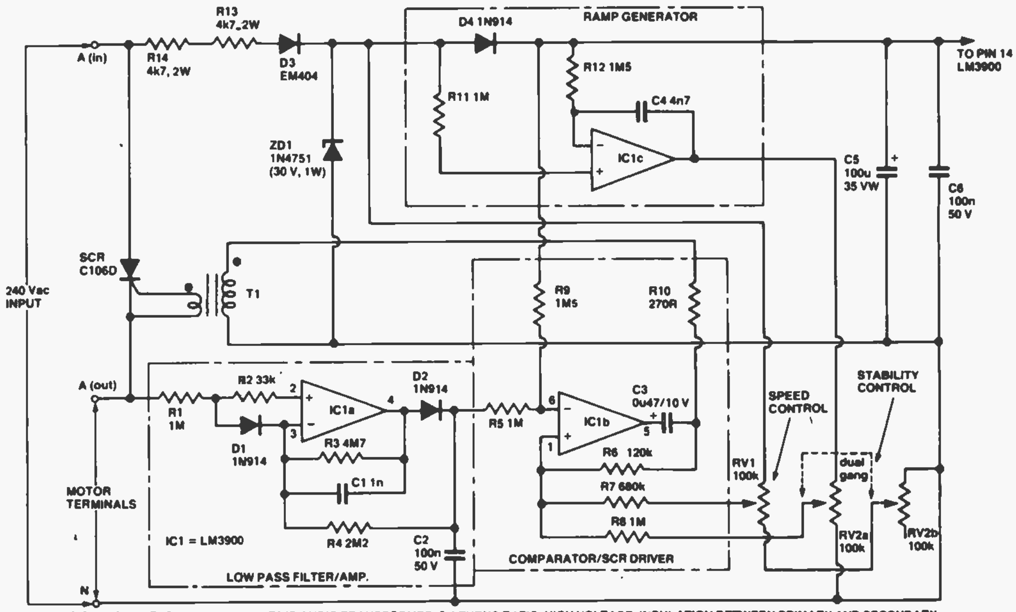


When taking photographs from a distance, a pneumatic remote release is normally used. These will only work over a limited distance and it is not always possible to tell if the camera has operated. This simple circuit uses a low current trigger circuit to operate the camera and provides a visible indication that the camera or flashgun has worked correctly.

The circuit operation is as follows. When the remote release push-button PB1 is operated, a current flows via the extension lead, which may be a 100 metres or more in length, to switch transistors Q3 and Q4. This combination provides the load current of up to 2 A for the camera release solenoid. When the flashgun fires, light falling on the CdS cell causes a current pulse to appear at the base of Q1. When Q1 switches on it will discharge C2, extending the pulse duration to about one second. While C2 is charging Q2 will be turned on, causing a large enough current to flow in the extension lead to operate LED1. If a flashgun is not used, the camera flash contacts (SW1) may be connected to bypass the CdS cell and remotely operate the indicator LED1.

SCR motor speed controller

Having tried a variety of SCR motor speed controllers, I could never find one to satisfy the requirements of adequate control, good speed regulation and freedom from hunting. The simple phase control circuits so often published utilise the back-emf of the motor as a feedback signal in a manner tending to maintain a constant speed characteristic. Unfortunately, the degree of feedback control obtainable with such a simple circuit is necessarily limited and the speed regulation, as a result, is relatively poor.



ALL RESISTORS ½W EXCEPT R13, R14. T1 IS AUDIO TRANSFORMER, 5:1 TURNS RATIO, HIGH VOLTAGE INSULATION BETWEEN PRIMARY AND SECONDARY.

The overall performance is a compromise between a combination of factors which determine, on the one hand, the degree of feedback control and on the other, stability (i.e: freedom from hunting, hysteresis etc). The two are inversely related. If you want maximum stability, you sacrifice feedback control, and vice versa.

Phase control over a full 0 to 180 degrees is impossible, in fact, it's considerably less. Component values are critical and dissipation in the control pot is fairly high.

The circuit I devised, after considerable investigation and many trials performs far better than any I have previously tried. It gives halfwave phase control virtually from 0° to 180° of the mains cycle, it has independently adjustable speed and stability controls, operation is independent of SCR characteristics and it provides stable operation even at low motor speeds with good speed/torque characteristics.

This circuit controls the speed of 240 V universal (ac/dc) motors. On no account must the circuit be used for appliances which are suitable only for ac operation, such as induction motors.

An SCR connected between input and output terminals of the circuit conducts on positive half-cycles of the ac supply. Triggering of the SCR is phase controlled. The triggering phase angle is variable over nearly a full 0° to 180° of each positive half-cycle. The back-emf generated by the motor during the intervals between conduction cycles of the SCR is used as a feedback signal to compensate for varying load conditions imposed upon the motor.

There are two variable control functions, one of which provides the 'speed' setting and the other of which is a 'stability' (or 'gain') control. The latter determines the feedback characteristics of the circuit and can be adjusted to obtain optimum performance from a motor with which the circuit is to be used.

This is an unusual and extremely useful feature as it can be used to programme the speed/torque characteristics of a given motor over a wide operating range and to adjust for an optimum balance between feedback control and motor stability under given operating conditions.

This is especially useful at low speed settings at which the back-emf of any motor is low and it is difficult otherwise to achieve both good torque characteristics and stable motor running.

The circuit uses ¾ of an LM3900 quad op-amp IC to control the phase triggering of the SCR. The voltage across the motor terminals is converted into a current signal which is applied to the non-inverting input of IC1a.

During the intervals between conducting cycles of the SCR this signal, which is proportional to the back-emf (and hence speed) of the motor, is amplified by IC1a.

The amplified signal is applied to capacitor C2 via diode D2. The capacitor C2 holds its charge sufficiently long each cycle to present a relatively clean dc signal to comparator IC1b. That is, a signal which is relatively free of spikes and other spurious noise components which could cause erratic phase triggering of the SCR. Capacitor C1 helps by filtering out most of these components before the signal is applied to C2.

Diode D1 ensures that the output of IC1a goes low when the SCR conducts as otherwise C2 would be charged up to a voltage proportional to the applied mains voltage rather than to the back-emf of the motor. In this regard, the ratio of resistors R1 and R2 is chosen so that diode D1 conducts when the input voltage exceeds the maximum (typical) back-emf of the motor (about 15 V).

An integrator, IC1c, provides a ramp signal which is synchronised to the phase of the supply. The amplitude of the ramp signal is varied by potentiometer RV2a and applied to an input of comparator IC1b. Potentiometer RV2a forms the 'stability' control.

An adjustable bias signal is obtained from potentiometer RV1 and applied to the same input as the ramp signal. Potentiometer RV1 forms the 'speed' control.

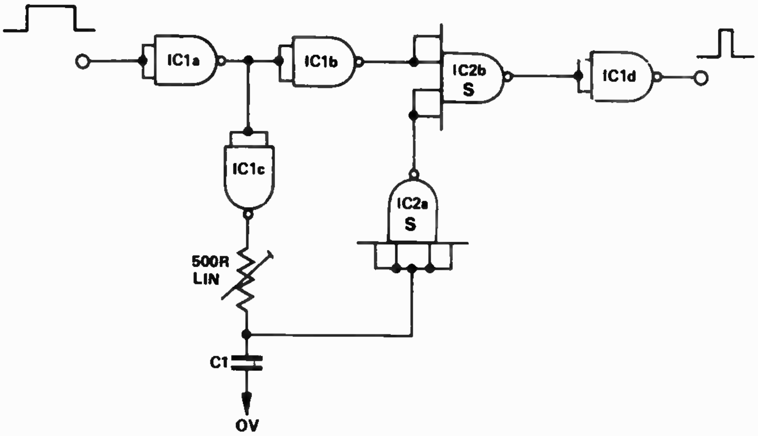
The feedback performance of the circuit is determined by the amplitude of the ramp signal applied to the comparator relative to the amplitude of the signal from IC1a. Adjustment of RV2, since it varies the signal applied to IC1b also affects the speed. To minimise this effect, a compensating variable resistor, potentiometer RV2b is connected in series with RV1 and ganged with RV2a.

The SCR is triggered by a pulse output produced by IC2, via a transformer. In this case an ordinary transistor output transformer taken out of the 'junk-box' was used. This transformer happened to have a turns ratio of about 5:1 and works well but other ratios may also be satisfactory.

Before it was used however, the pulse response of the transformer was checked with a signal generator and CRO. Most importantly, the insulation between primary and secondary windings was checked to make sure that it would withstand the peak mains voltage.

The power requirements for the IC are modest and thus a simple voltage dropping resistor arrangement was used in preference to a more expensive step-down transformer. The zener diode ensures a stable operating voltage which is virtually immune to mains voltage variations. The diode D3 is optional but has the advantage that it halves the power dissipated in resistors R12 and R13. Apart from these resistors, all resistors may be standard ½ watt, 5% types.

Pulse compressor



This circuit will prove useful in any application where it is required to reduce the width of a digital pulse by a pre-set amount.

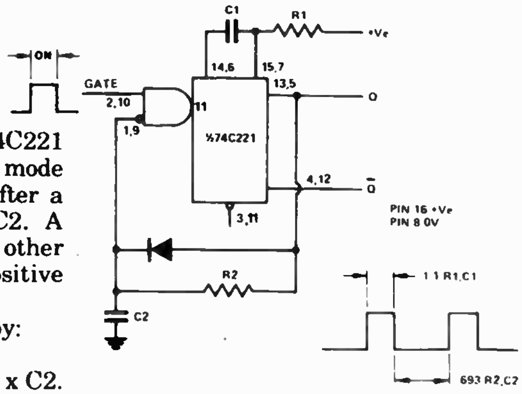
Using only two ICs, it can achieve pulse width reductions up to about 10 milliseconds. The following table gives some examples of the width reduction achieved by using different capacitor values:

Width reduction	C1
3 ms	8 u
5 ms	4 u
9 ms	1 u
9.5 ms	470 n
9.9 ms	100 n

Before the input pulse is applied, the output of IC1c is low and so IC2b's output is high. The circuit output is thus low.

When the input pulse is applied, the output of IC1c starts to rise, but the output of the circuit remains low because of the high on the output of IC2a. When C1 charges to the threshold voltage of IC2a, the output of IC2a will go low and the output of IC2b will go low while the input to the circuit is still high. Thus the start of the pulse is delayed by the amount of time taken for C1 to charge.

Astable mono



This circuit idea uses half a 74C221 operating in a normal monostable mode except that it retriggers itself after a delay determined by R2 and C2. A gating facility is provided by the other input, and should be tied to the positive rail for a free running mode.

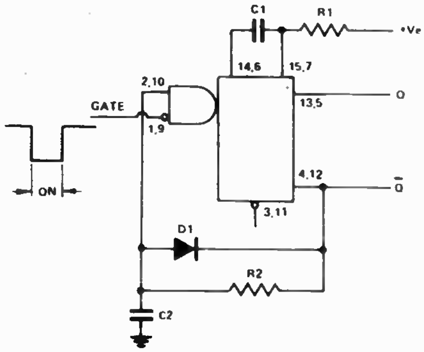
The 'on' time is determined by:

1.1 x R1 x C1

and the 'off' time by 0.693 x /r2 x C2.

The diode D1 ensures rapid charging of C2 when the duty cycle is less than 50%. This is not necessary for C1 since it is automatically discharged by the IC at the start of its timing cycle. Note that alternative pin numbers are shown on the circuit.

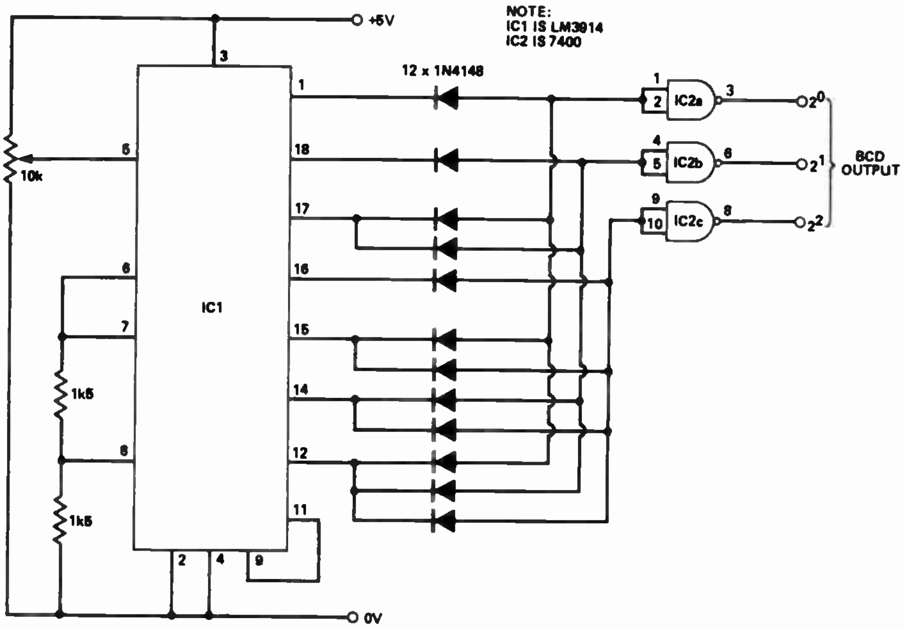
An alternative circuit, which will operate from a negative gate, is shown below the first. The circuits have been used to drive a LED at frequencies as low as two Hertz at a 30% duty cycle, says **Phillip Dennis of Berala NSW**, who sent them in.



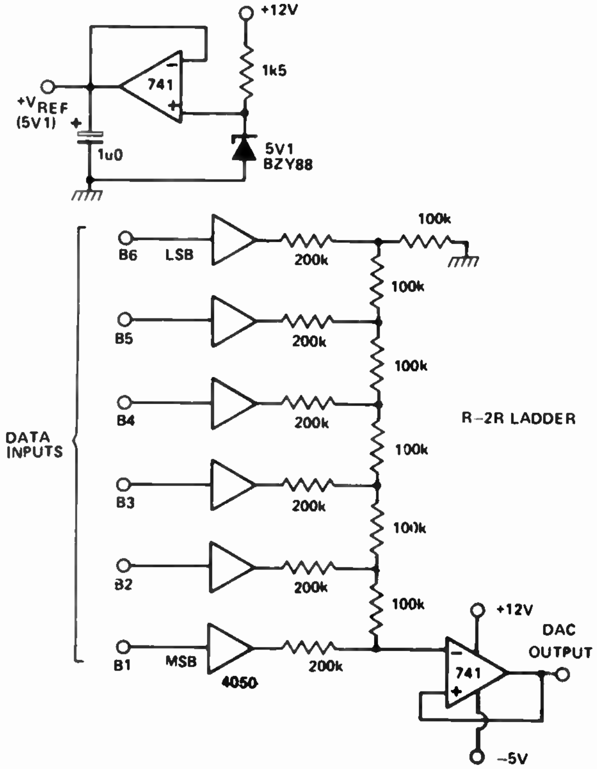
Low Resolution A-to-D Converter

A simple, low-resolution analogue-to-digital converter (three-bit output) can be built using the LED bargraph driver IC, the LM3914. This ADC can be used in applications where more usual (and more expensive) eight-bit or greater ADCs would give unnecessary accuracy.

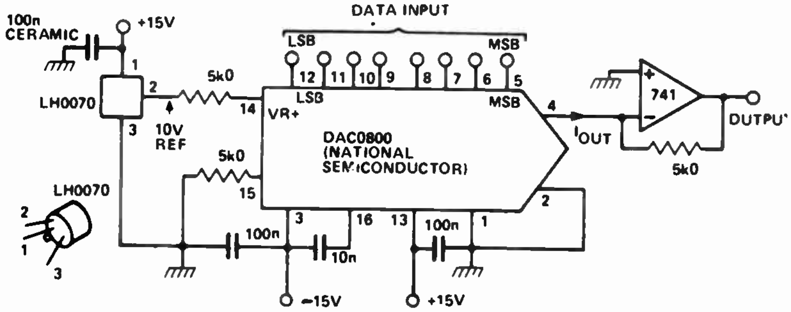
The bargraph IC converts the input voltage into a low signal on one of the 10 outputs, depending on its amplitude. The diodes code the outputs to binary-coded decimal, IC2 providing the ADC with TTL outputs.



Six-bit DAC — 10-bit Precision

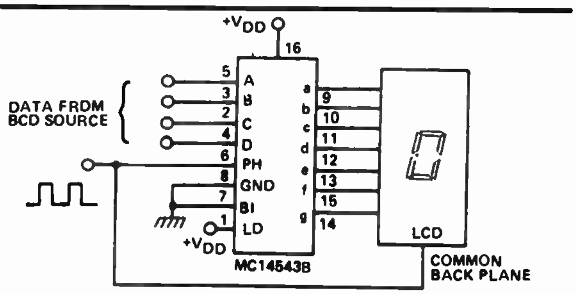


Buffers powered from 0 V and + V_{REF}
Resistors in ladder need 0.1% tolerance
DAC output has 64 steps



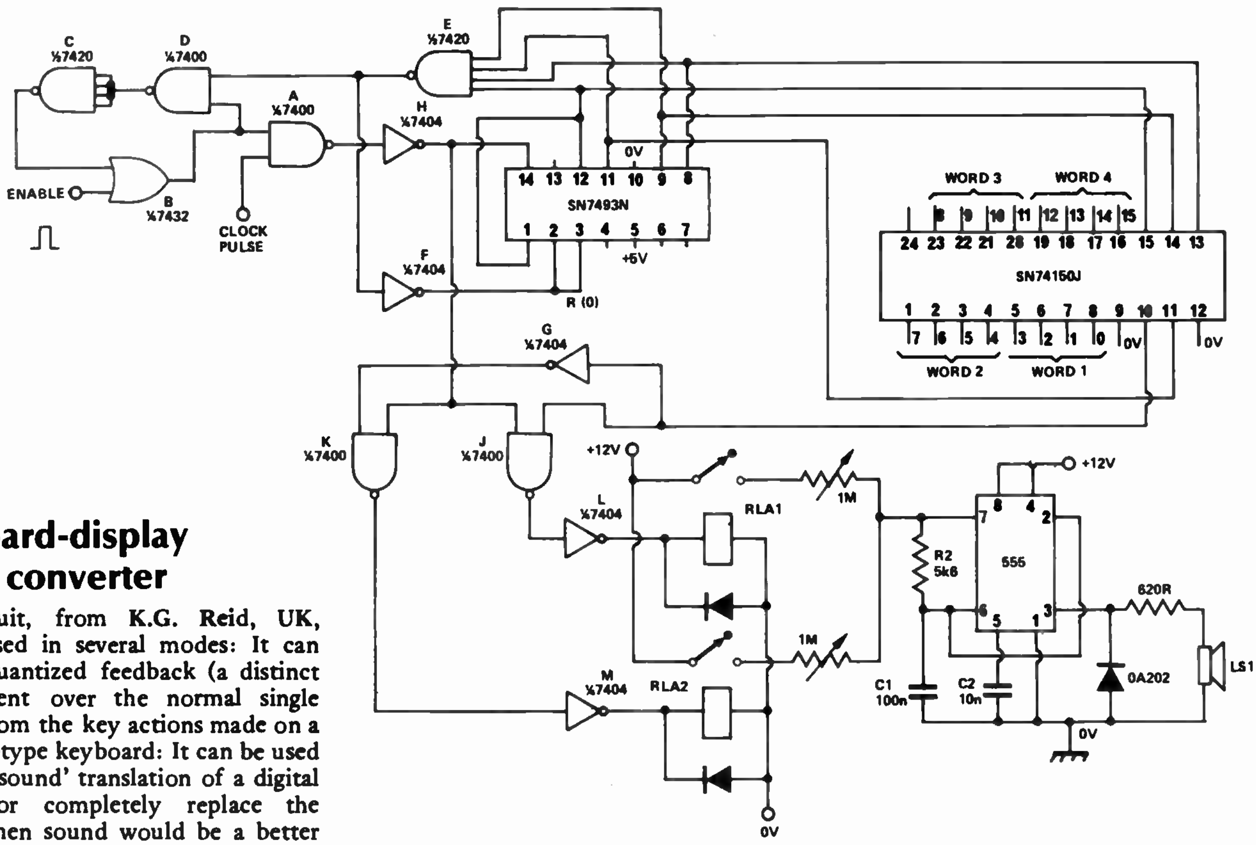
Standard Eight-bit DAC

The DAC08 is a multiplying digital-to-analogue converter (DAC). The data input selects a number that is multiplied by the input reference current to determine the output current. For accurate results it is therefore necessary to supply the DAC with a reference current. This role is filled by using the LH0070 precision voltage reference and generating a reference current by dropping this voltage across an accurate resistance, the 5k0. If this accuracy is not important or if the LH0070 is difficult to obtain a zener diode or three-terminal voltage regulator could be substituted.



BCD-to-seven-segment Driver for LCD

The use of liquid crystal seven-segment displays is becoming increasingly popular due to their low power consumption when compared with LED displays. A problem with LCD arises, however, due to its inability to cope with dc drive. The common or backplane must be supplied with a square wave to ensure that the display is not damaged. This circuit provides this function as well as the necessary BCD-to-seven-segment decoding.



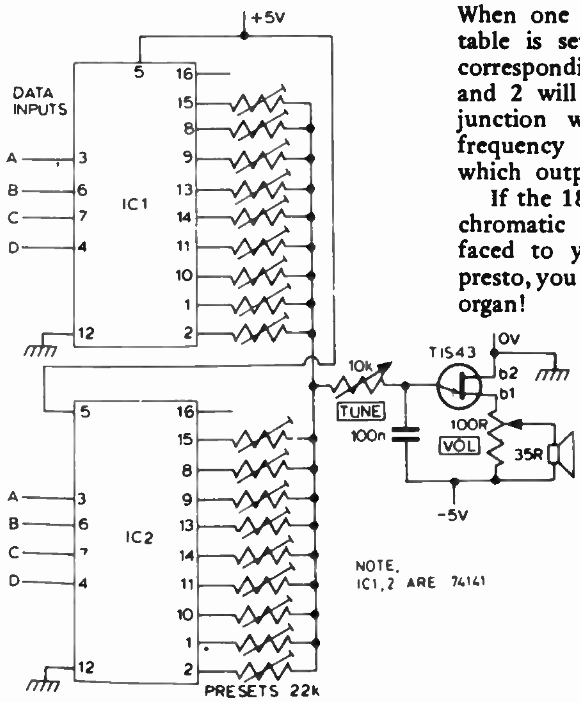
Keyboard-display sound converter

This circuit, from K.G. Reid, UK, can be used in several modes: It can provide quantized feedback (a distinct improvement over the normal single 'bleep') from the key actions made on a calculator-type keyboard: It can be used to give a 'sound' translation of a digital display, or completely replace the display when sound would be a better communication medium.

The keyboard or display information (a maximum of 16 bits with one 16-line 74150 multiplexer) is translated into a series of 16 high or low frequency tone pulses, corresponding to the 'high' or 'low' logic state of the 16 bits.

The circuit illustrated was used in conjunction with a digital multimeter, requiring three 4-bit words for the digits and three additional bits for over-range, negative and decimal point. Thus, 15 lines only were required, the 16th being used for resetting.

The 15 bits are latched on to the inputs of the 74150 multiplexer. Presentation of the enable pulse results in a logic '1' appearing at the output of gate B, allowing clock pulses to pass via gates A and H to the 7493 counter. Gates B, E, D and C form a latch which remains 'set' until all 15 bits have been sampled. As each bit is sampled, the inverse state appears at the multiplexer output, opening gate J or K and thus operating one of the two reed relays. As a count of 1111 appears from the counter, the output of F drops low, resetting the latch and counter. The operation of either relay results in a tone appearing at the loudspeaker (or earpiece), the tone frquencies being set (1.2 kHz maximum) by the 1 m pots. The tone pulse length is governed by the clock rate.

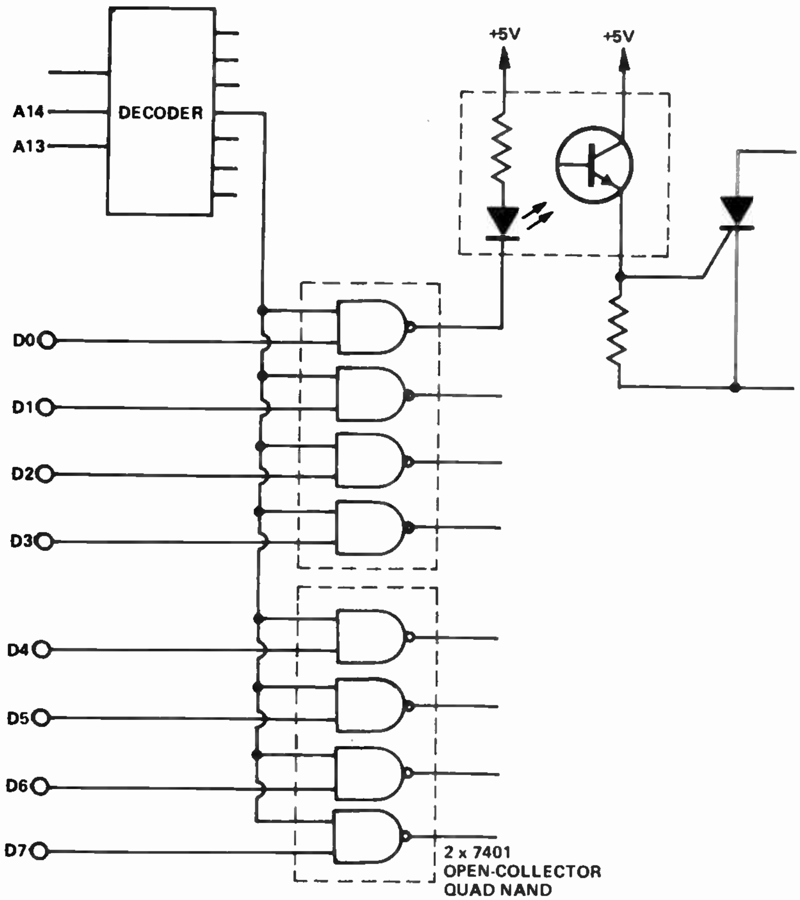


BCD tone generator

When one of the binary codes in the table is set up on the data inputs, a corresponding preset connected to IC1 and 2 will be grounded, and the unijunction will start to oscillate. The frequency of oscillation depends on which output of the ICs is grounded.

If the 18 presets are tuned to form a chromatic scale and the inputs interfaced to your MPU data bus – hey presto, you have a simple MPU controlled organ!

NOTE No	CODE (BINARY) HGFE	DCBA
1	0000	0001
2	0000	0010
3	0000	0011
4	0000	0100
5	0000	0101
6	0000	0110
7	0000	0111
8	0000	1000
9	0000	1001
10	0001	0000
11	0010	0000
12	0011	0000
13	0100	0000
14	0101	0000
15	0110	0000
16	0111	0000
17	1000	0000
18	1001	0000



Cheap micro output

In simple systems were little or no output bus buffering is needed, users may shy away from using standard TTL due to the drive requirements this places on the μP chip. Where unlatched outputs are acceptable, buffers are often used if standard TTL is to be driven. This is not always necessary.

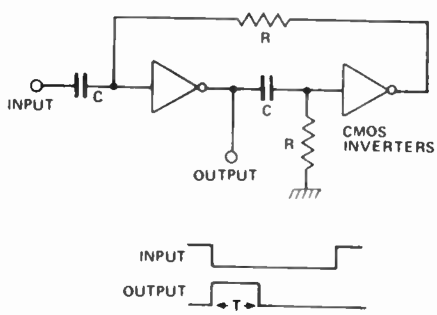
Looking at the diagram, it *appears* that the micro will have to pull down one TTL load per gate and so many TTL loads if several of these ports are used. This is not so, due to the nature of the input to the gate — once one input is low, only a few μA are required to drive the other and so the bus loading is negligible. Of course, the enable line still needs to be driven from a TTL output but as this is usually derived from a decoder, it should prove no problem.

Monostables

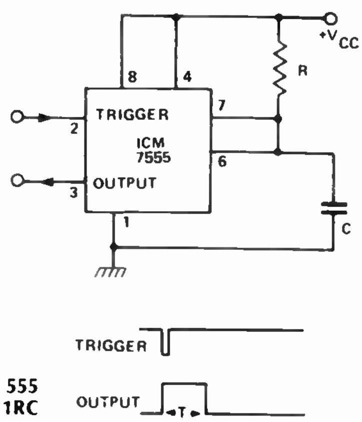
A commonly-used circuit block is the monostable. There are several convenient ways to realise one and these two general circuits show how. Suitable CMOS inverters for the upper circuit would be 74C04, 4009, 4049 and 4069. Inverters can be made by tying the inputs of NAND gates together, don't forget. 'Rule of thumb' timing equations are given.

The ICM7555 is a CMOS version of the ever-popular 555. In this application the input is pin 2, output is pin 3.

It couldn't be simpler, could it?



CMOS inverters
T = 1.38RC
Keep R greater than 47k



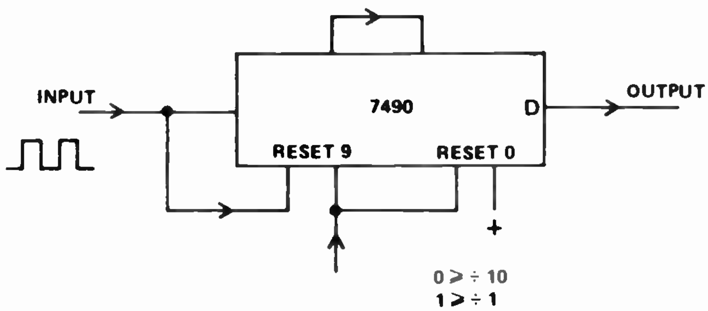
CMOS 555
T = 1.1RC

Simplest 'divide by 1 or 10' scaler

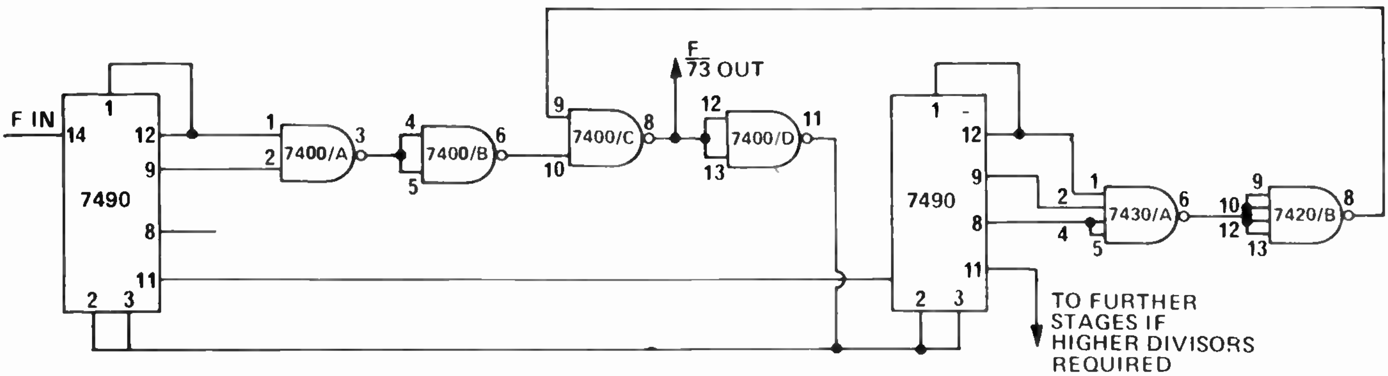
Variable division of clock signals is a nuisance to implement, because of the gating and switching it usually requires. Inspection of the internal circuitry of 7490 indicated an ultimately simple method of scaling.

Reset 9 overrides reset 0 in 7490. Thus if reset 0 is active and reset 9 is cycled, the D output will rise and fall in time with reset 9. When the common reset line is at 0 the counter divides by ten in the normal fashion.

The technique, from **D. Brown** of Lindfield NSW, can be extended to any number of cascaded 7490s.



Frequency division



Divisor	7490 PINS			
	11	8	9	12
0	–	–	–	–
1	–	–	–	X
2	–	–	X	–
3	–	–	X	X
4	–	X	–	–
5	–	X	–	X
6	–	X	X	–
7	–	X	X	X
8	X	–	–	–
9	X	–	–	X

This circuit is a means of frequency division by any prime number greater than ten (in this example 73). The need for this arose when I wished to experiment with a crystal controlled clock requiring a 50 Hz input. The only crystal I had available was a 1825 kHz which therefore required a divide by 10, divide by 10, divide by 5, and divide by 73.

The binary equivalent of decimal 3 on the first 7490 IC produces a logic 1 at the output of 7400B and the binary equivalent of decimal 70 produces a logic 1 at the output of 7420B. When both are present i.e. at every 73rd pulse IC 7400 D produces a reset pulse to the reset inputs of both 7490s. The pulse at the output of IC 7400C may be used to drive further stages.

The connections for other dividing factors are shown as X in the table (left). The first IC in line counts the units, the second the tens, the third, if used, the hundreds etc.

It is suggested that leads be kept as short as possible, appropriate bypassing used and that the above stage be used after any other dividing stages to reduce the frequency at which it operates. The prototype operated successfully at 7 MHz – no higher frequencies have been tried.

Note that the configuration for BCD output must be used for the 7490s and that each must be connected for decade counting.

Symmetrical divide-by-three

This circuit takes an input (symmetrical) square wave at CMOS levels and divides it by a factor of three, producing a symmetrical output. Figure 1 shows input and output waveforms.

At first glance, this may seem a simple task, but note that the output waveform first changes state on a negative-going transition of the input waveform, then on a positive-going transition, etc. The circuit of Figure 2 neatly overcomes the problem of non-symmetrical divided output by inverting the input waveform periodically, using an exclusive-OR gate.

The waveforms involved are shown in Figure 3. The prototype circuit used a 74C73 for flipflop 1 and 2, but almost any type of edge-triggered flipflop could be used. The same method could be used to obtain a divide-by-5, 7 or 9.

(Ed. note: this circuit may not work at high speeds owing to gate delays in flipflops 1 and 2, but is nonetheless a good idea, despite the limitations.)

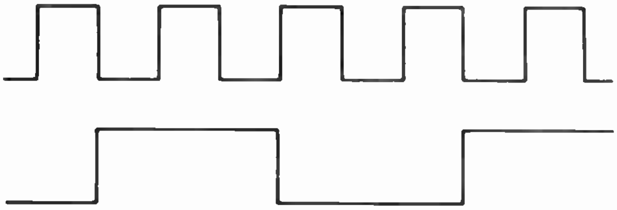


Figure 1

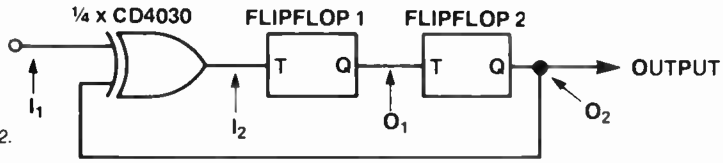


Figure 2.

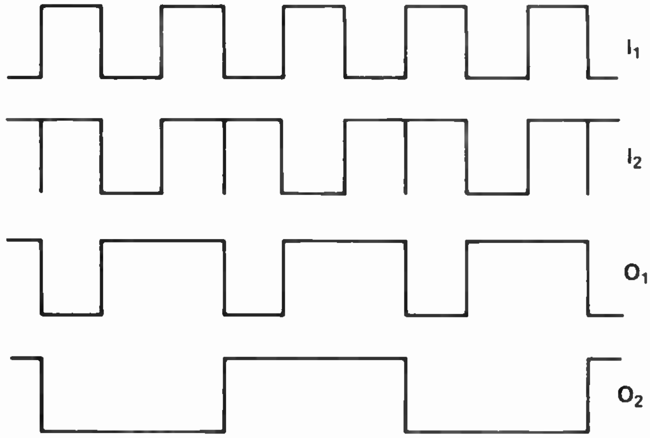


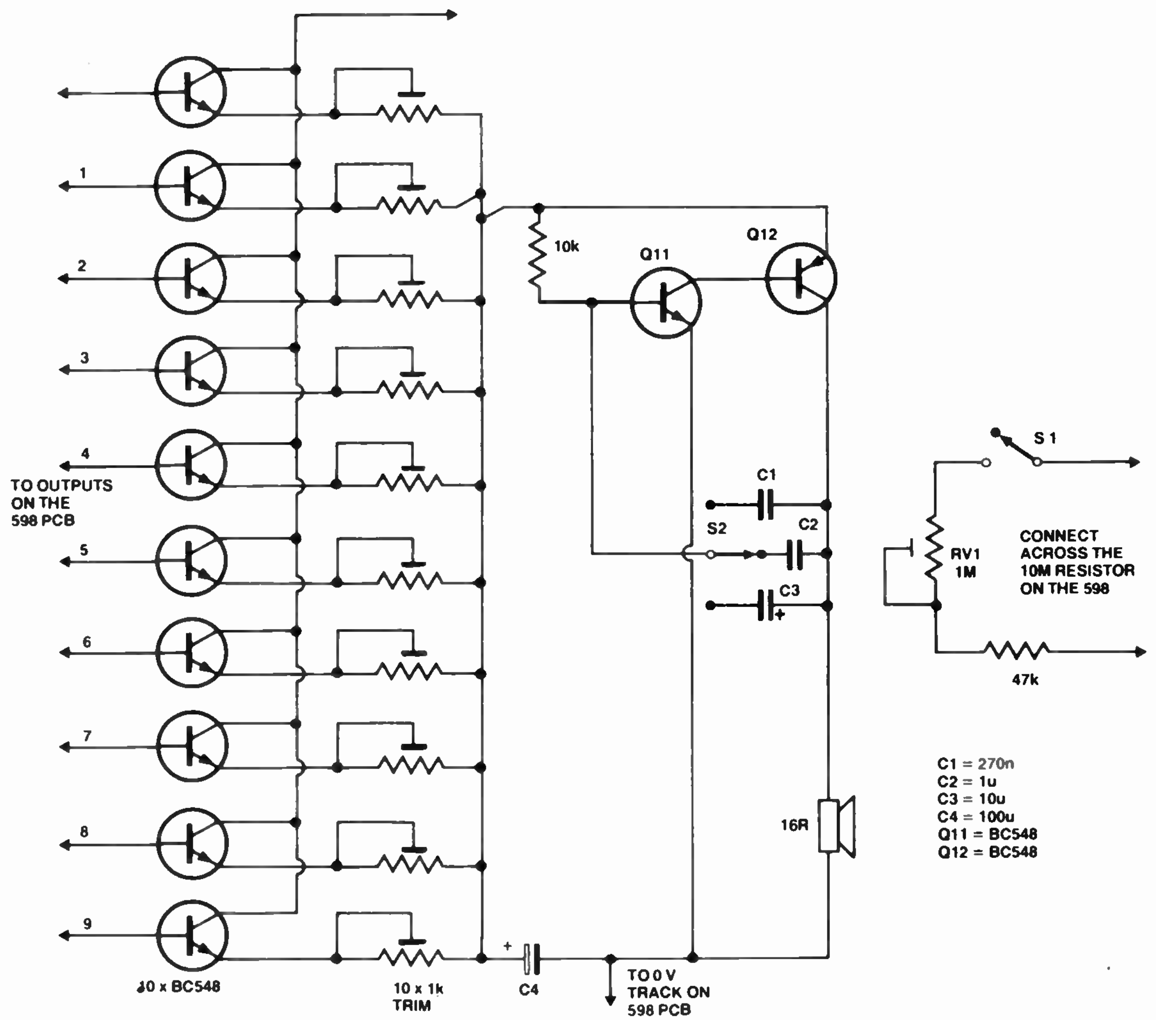
Figure 3.

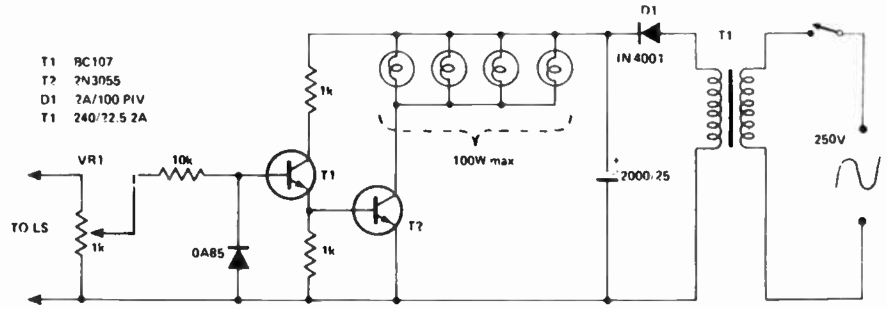
Sequential tone generator add-on for the ETI-598 touch switch

Fourteen-year-old **Jamie Rogers of Glenelg in South Australia** turned his ETI-598 sequential touch switch (ETI February '81) into a 10-tone sound generator with the addition of this simple circuit.

Transistors Q11 and Q12 are connected as a non-inverting amplifier with feedback directly from output to input, via a capacitor selected by S2, so that it forms an oscillator. The frequency of oscillation is determined by whichever capacitor is selected and the 10k resistor, plus one of the 1k trimpots at a time. Each trimpot is selected in sequence by a transistor, which is turned on by an output from the ETI-598. Each trimpot is adjusted to give the desired pitch note.

You can play a 10-note tune by having S1 open. You can make a 'Space Wars laser' sound by first setting S2 to C1 and adjusting each trimpot (commencing with the 'top' one driven from the '0' output) so that the first note is a high pitch and all the notes descend in pitch, with the lowest trimpot set to a suitable low note. Close S1 and adjust RV1 to give the 'right' sound.

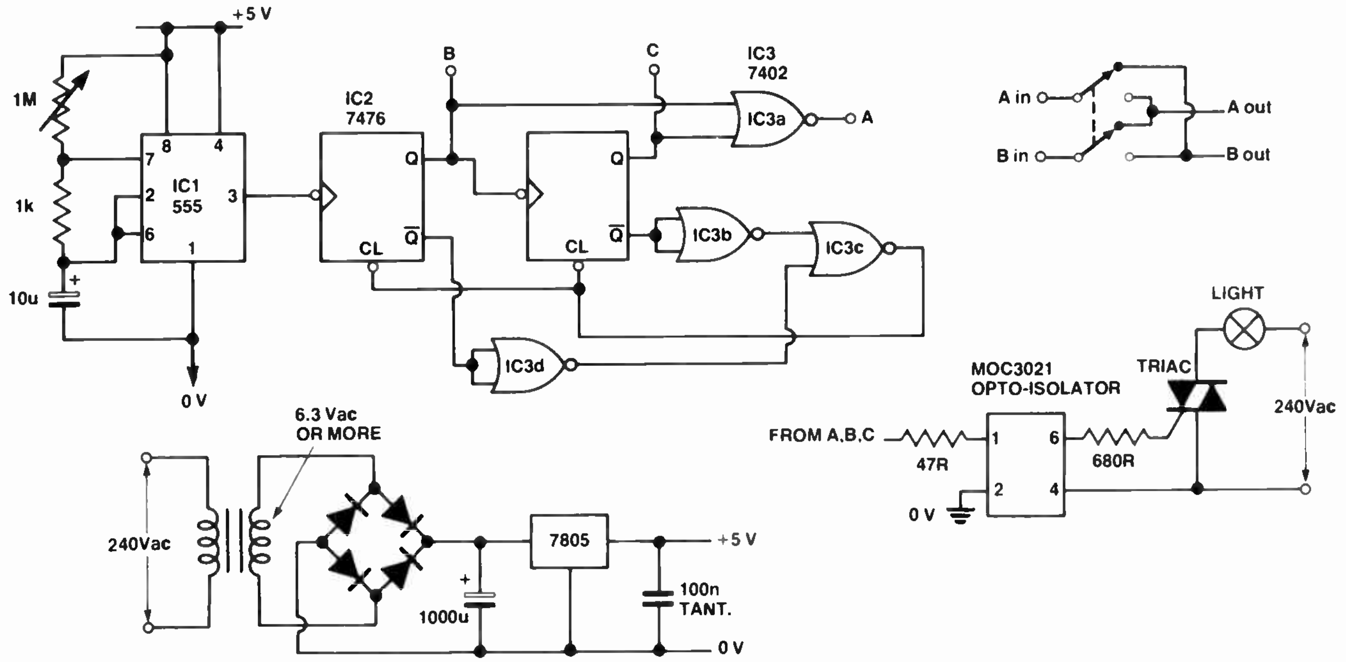




Dancing lights

This device will produce a shifting light display in time to the signal from a loudspeaker. Setting will vary according to the volume at which the music is played. When VR1 is at maximum the lights remain lit most of the time. At minimum the lights may not come on at all. A suitable position can be established in between these two extremes.

The bulbs used can be any number at 25V each and the total should not be more than 100W. A heatsink should be used for the power transistor.



Three-channel light chaser

This simple idea comprises a three-channel light chaser incorporating a 'reversing' switch so that you can change the direction of the 'chase'.

A 555 is arranged as a variable astable multivibrator (IC1). Its output drives one flip-flop from a dual JK flip-flop (IC2). The Q output of this flip-flop drives the second flip-flop and a group of NOR gates (IC3) such that three outputs are produced, going high successively. The three outputs then drive opto-isolators which trigger triacs which drive the lamps.

A simple power supply circuit provides supply to IC1, IC2 and IC3. The DPDT switch reverses the A and B drives to reverse the chase sequence. The 1M variable pot varies the speed of the chase.

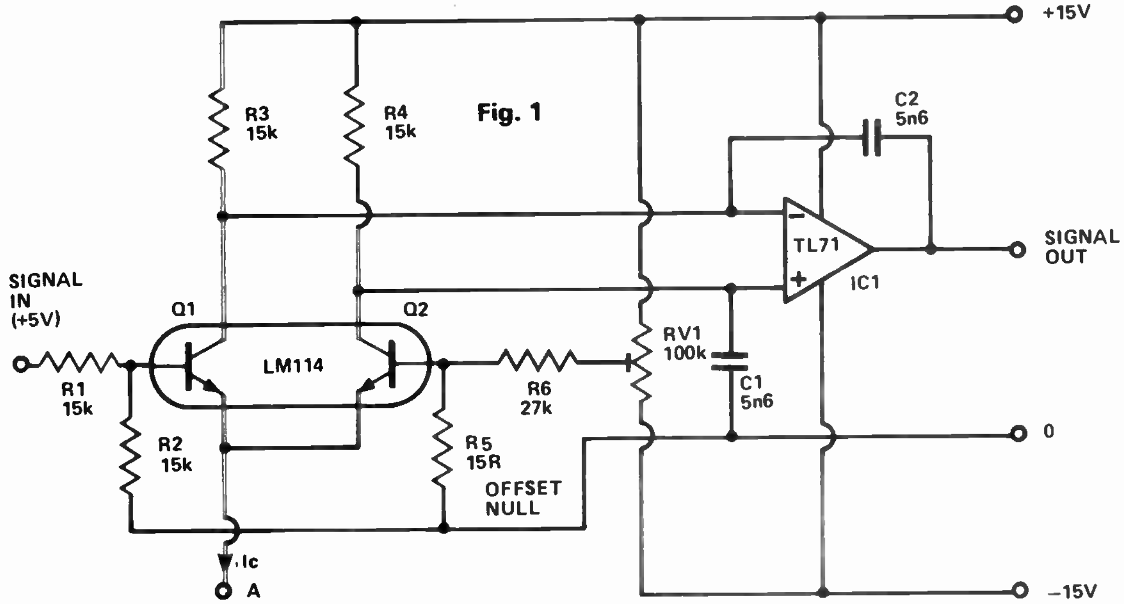


Fig. 1

Voltage Controlled Filter

T. W. Stride

The voltage controlled state variable filter has become almost standard in sound synthesizers, especially since the advent of the CA3080 transconductance amplifier. However, the CA3080 is a reasonably noisy device and this can be annoying when large passbands and/or high Q values are being used in the filter. This circuit is for a low noise, high performance transconductance multiplier, which though not cheap, will offer a truly Hi-Fi performance.

R1 and R2 attenuate the input signal to keep distortion low, and Q1, Q2 with R3, R4 form the transconductance multiplier. The differential output current is integrated by means of IC1, C1 and C2, a differential integrator. RV1 is provided to cancel out the offset of Q1, Q2; it is best adjusted by sweeping the filter and adjusting for minimum DC output shift.

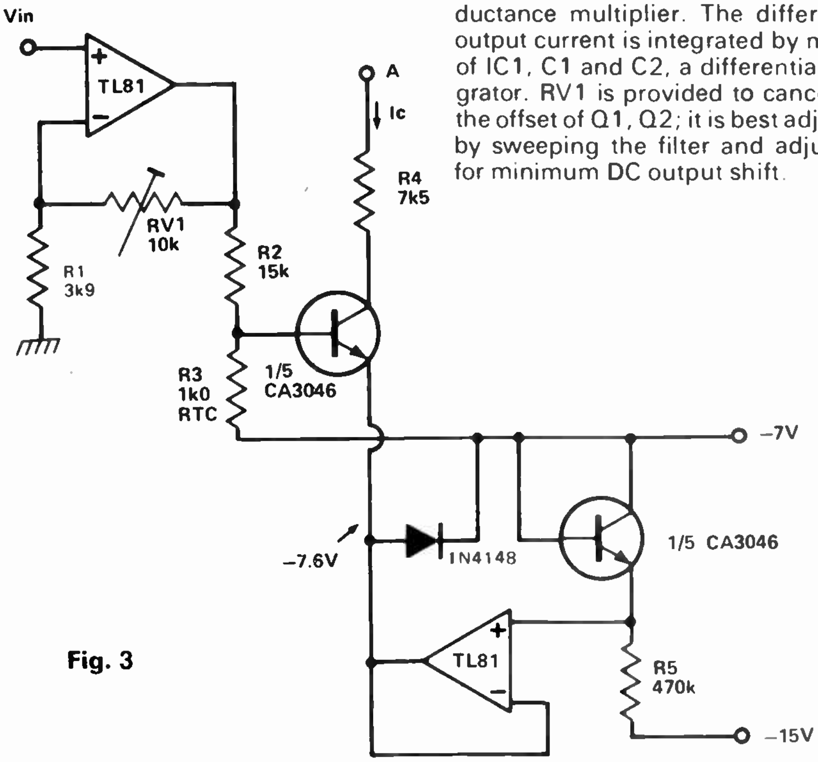


Fig. 3

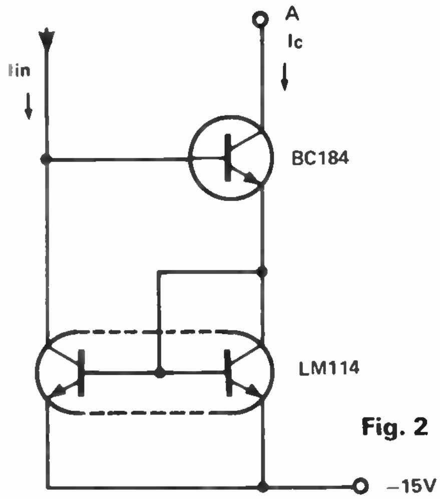


Fig. 2

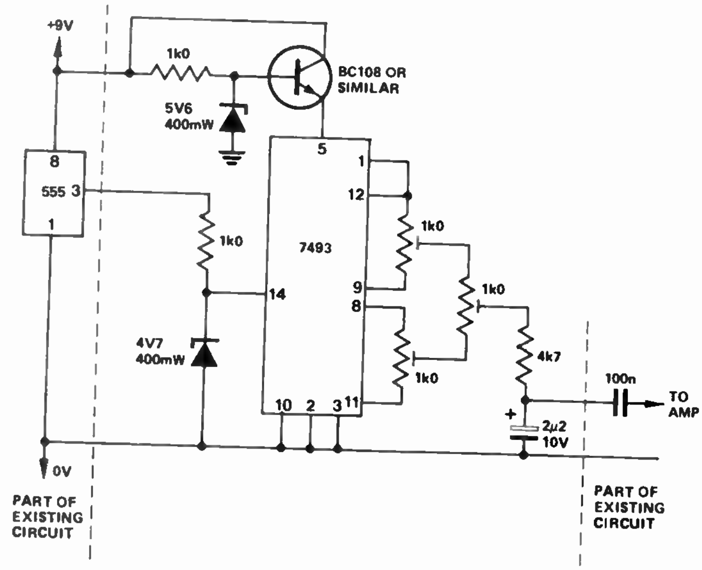
As can be seen from Fig. 1, the gain of the integrator is controlled by a constant current IC. This current can be provided in two ways, either from a current mirror (Fig. 2) which then makes the circuit an almost exact replacement for the CA3080, or for original equipment designs, from a current source. If it is desired to use this circuit as a replacement for a CA3080 in, for example, the Transcendent 2000 synthesizer, the following modifications are necessary. The integrating capacitor on the output of the 3080 must be replaced with a 10 k resistor and the input attenuator on the above circuit is discarded. The control current that would flow into pin 5 of the 3080 is input to the current mirror and the output current is drawn from the transconductance multiplier (point A).

Square Wave Smoother

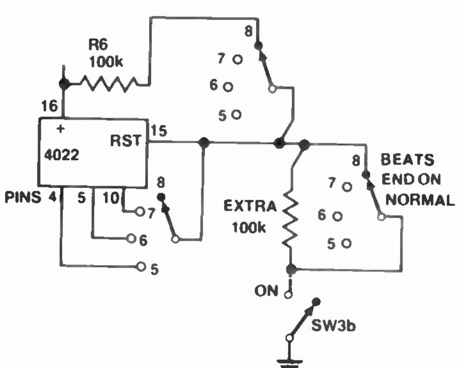
The output from the ETI 602 mini-organ can sound rather harsh, especially at the low end of the keyboard. **R. Dall** of Eight Mile Plains has used a Walsh function generator to overcome this problem (see 'Designing Oscillators', ETI December 78, p 15).

The 7493 is a four-bit counter which is clocked by the output of the organ's oscillator. The zenor diodes and transistor are necessary to interface the voltage levels from the existing circuit to the 7493. A 74C93 could have been used, but Mr Dall pointed out that the overall cost of this would actually be greater.

The outputs of the counter are 'mixed' by the trimpots to produce a sum waveform which can be made to sound less harsh than a square wave. The output waveform is then further smoothed by the RC filter.



Modifications to the sequencer for percussion synthesiser



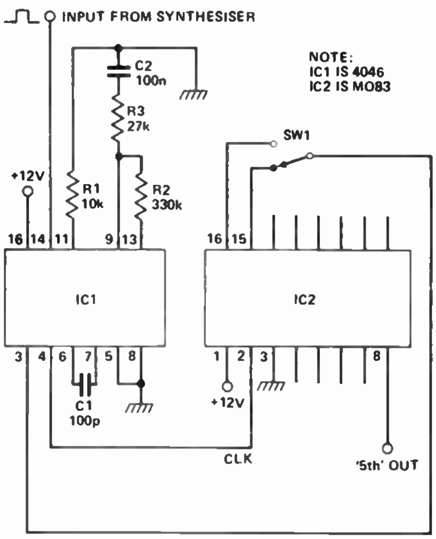
A sequencer which couldn't provide a true waltz rhythm just wasn't acceptable for **M. Dowson** of **Stanwell Tops NSW** so some modifications were worked out.

You can't get a true waltz rhythm with the sequencer since the fixed eight steps cannot be aborted, and a three step sequence will not divide exactly into eight steps. But by simply adding a three-pole four-position switch as shown, all steps from one through to eight are available.

A true waltz rhythm is obtained by setting the switch to reset the 4022 on the sixth count which is exactly divisable by the three step waltz rhythm. The emphasised first beats are turned on by SW2(1) and SW2(4). This extra switch can terminate the counts at 5, 6, 7 and the original 8. Counts of 1, 2, 4 and 8 divide exactly into 8 and can therefore be set up on the two DIP switches.

The pc board requires only one cut to isolate pin 15 of the 4022, and one extra 100k resistor.

When controlled by SW3b the sequence may recommence on any random count (a minor point) if pin 15 was not held high when SW3b opened.



Enriching Synthesiser Sounds

When working with synthesisers I have found that a much richer sound can be obtained if a second VCO is tuned to a fifth above the first. This can cause problems if quick patch changes are required since the second VCO will have to be retuned. The circuit given here overcomes this problem cheaply, leaves the second VCO free and also lends itself to other interesting applications.

IC1 is wired as a standard phase-locked loop, with R1, C1 setting the maximum operating frequency and R2, R3, C2 feeding the error voltage to the 4046 VCO. The output of the 4046 is used to clock IC2, a top octave divider, which divides the input by a series of integers to produce semitones. One of the two 'C' outputs is sent back to the PLL via SW1.

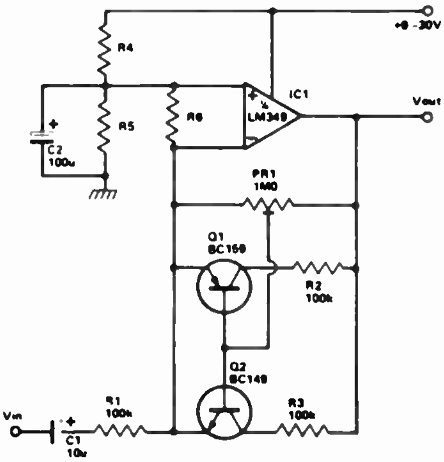
The circuit will now track accurately any square pulse of suitable level, for example from a CEM3340, and produce any semitone in an octave starting from the input frequency or the one above. The output is, of course, only a square wave, but by suitable shaping any waveform may be derived. Clearly the circuit is open to many modifications; for example, if the top octave divider is replaced by a 4024 divider, with suitable decoding and filtering harmonics could be obtained, making any sound possible!

'Soft' limiter

One of the fundamental differences between valve and transistor amplifiers is their behaviour when driven into clipping. The valve amps go into so-called 'soft' clipping whilst their transistorised counterparts generate large quantities of harmonic distortion. The circuit shown simulates the soft clipping of valve amplifiers and is intended to be used between the power amplifier's input and the preamplifier's output.

Resistors R4 and R5, decoupled by C2, set a half supply reference for the non-inverting input of the op amp. Input signals are fed into the inverting input via the dc blocking capacitor and R1, the latter defining small signal gain and input impedance.

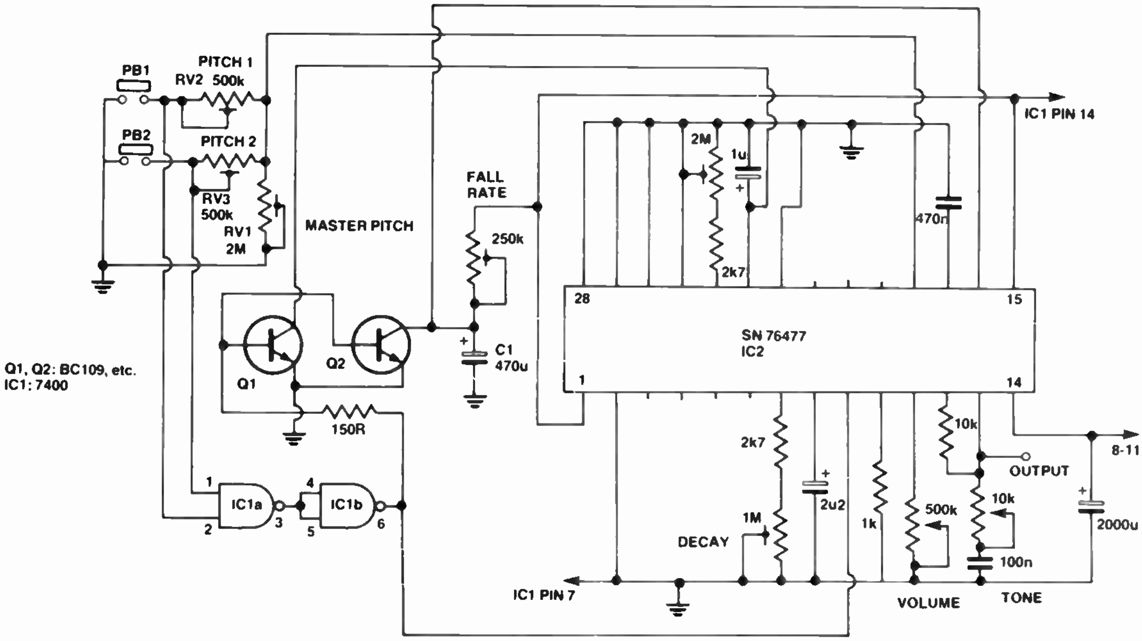
For small signals, the amplifier's output is an exact unity gain copy of the input. As the signal level increases however, the time will come when the voltage across the output and slider of PR1 will be sufficient to bias Q1 or Q2 on. When this occurs the feedback increases due to the shunting effect of R2 and R3.



R4, R5 = 4k7 R6 = 22k

The net effect is that musical peaks above a certain threshold are reduced in amplitude to prevent the power amplifier going into hard clipping. As a result, distortion is noticably decreased whilst the subjective loudness appears unaffected.

The circuit is adjustable in operation between 130 mV and 10 V rms input sensitivity by means of PR1. To set the circuit up, simply set the slider so that it is shorted to the output of the amp. Play some music at high volume through the system and adjust until the harshness just disappears



Simple drum synth.

'Electronic drums' are used by a number of pop groups, and this circuit will simulate the sounds produced by a drum synthesiser — but cheaply.

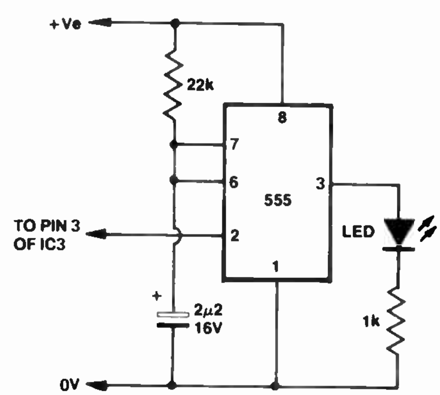
Commercial drum synthesisers use some sort of pressure-sensitive transducer for input — but they're next to impossible to make so I used pushbuttons instead. Keyswitches are another possibility.

The unit is built around the SN76477 Complex Sound Generator IC from Texas Instruments (IC2). Capacitor C1 causes IC2 to produce a falling pitch as it charges, the rate being controlled by RV1. Q1 and Q2 ensure that the pitch will trigger at the same place when either button is pressed. IC2 contains a voltage-controlled oscillator which provides a square wave output at pin 13. As this can sound harsh, a tone control was added to give a similar sound to the commercial units.

Almost any transistors can be used for Q1 and Q2, and a single AND gate from a 7408 could replace the two NAND gates from the 7400 (IC1).

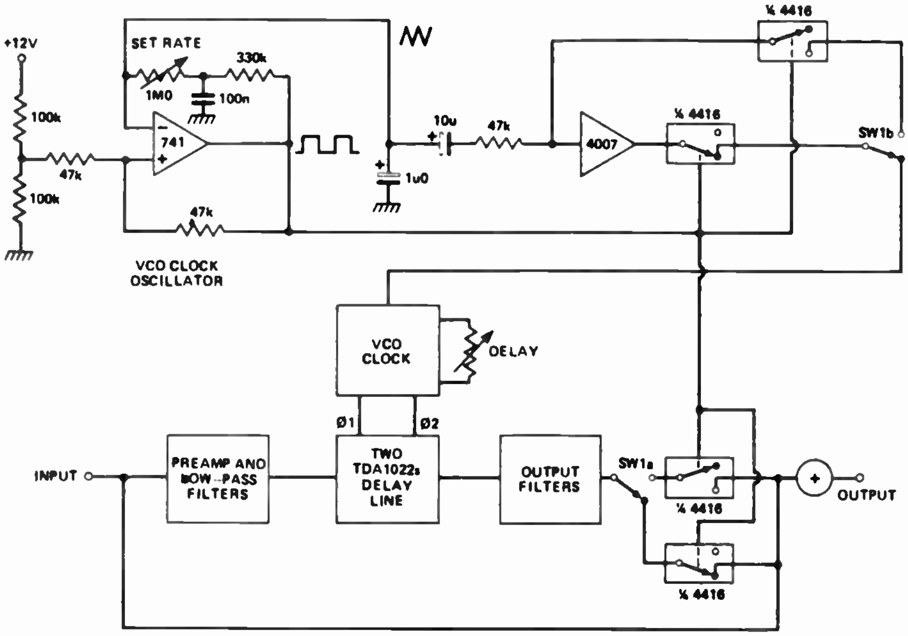
Construction proved non-critical and any power supply from 8 to 11 volts (**but no higher — Ed.**) may be used as IC2 contains a 5 V regulator. The output is connected to an amplifier and RV1, RV2 and RV3 are adjusted to provide the pitches desired. The remaining potentiometers may be varied to achieve the desired sound.

Visual beat for ETI-604 metronome



Mr A. Partridge of Launceston, Tasmania, constructed our Accentuated Beat Metronome (ETI-604, September '77) and found it very useful. However, he felt the lack of visual indication of the beat was a drawback. Connecting a LED and limiting resistor from pin 3 of IC3 and 0 V in the project was unsuccessful as the flashes were too brief to be of use.

The solution he found was to add another 555, wired as a monostable as shown in the circuit here. This 'stretches' the beat pulse and has the additional advantage that, with the 555's 200 mA sourcing capability, it can drive a small incandescent lamp directly, although a LED is shown here. Any suitable LED may be used, such as the common TIL220 — either red, green or yellow, to suit your taste.

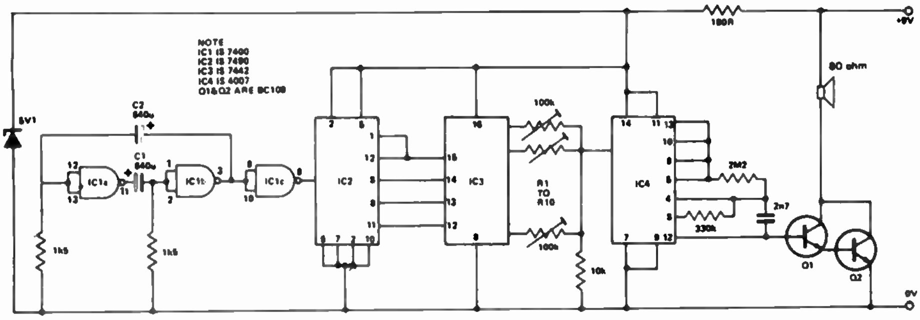


Guitar Harmoniser

This is one for guitarists who cannot afford commercial units which cost at least £1000 at the moment. Constructors who have built the CCD phaser will be familiar with the pitch-changing effect when it is set up in the vibrato mode, and must have noticed that the longer the delay, the greater the pitch change above and below the frequency of the input.

All that this circuit does is to silence the output for one half of the clock modulation oscillator's cycle. This is achieved using a 4416 quad CMOS switch, which is controlled by the square wave output of the clock modulation oscillator. This IC differs from the 4016 in that two switches will be on and two will be off even when the same control signal is applied to each switch. Depending on which way SW1 is connected, either the raised or the lowered frequency of the input will appear at the output, which can be adjusted by the rate control or by altering the delay of the TDA1022s.

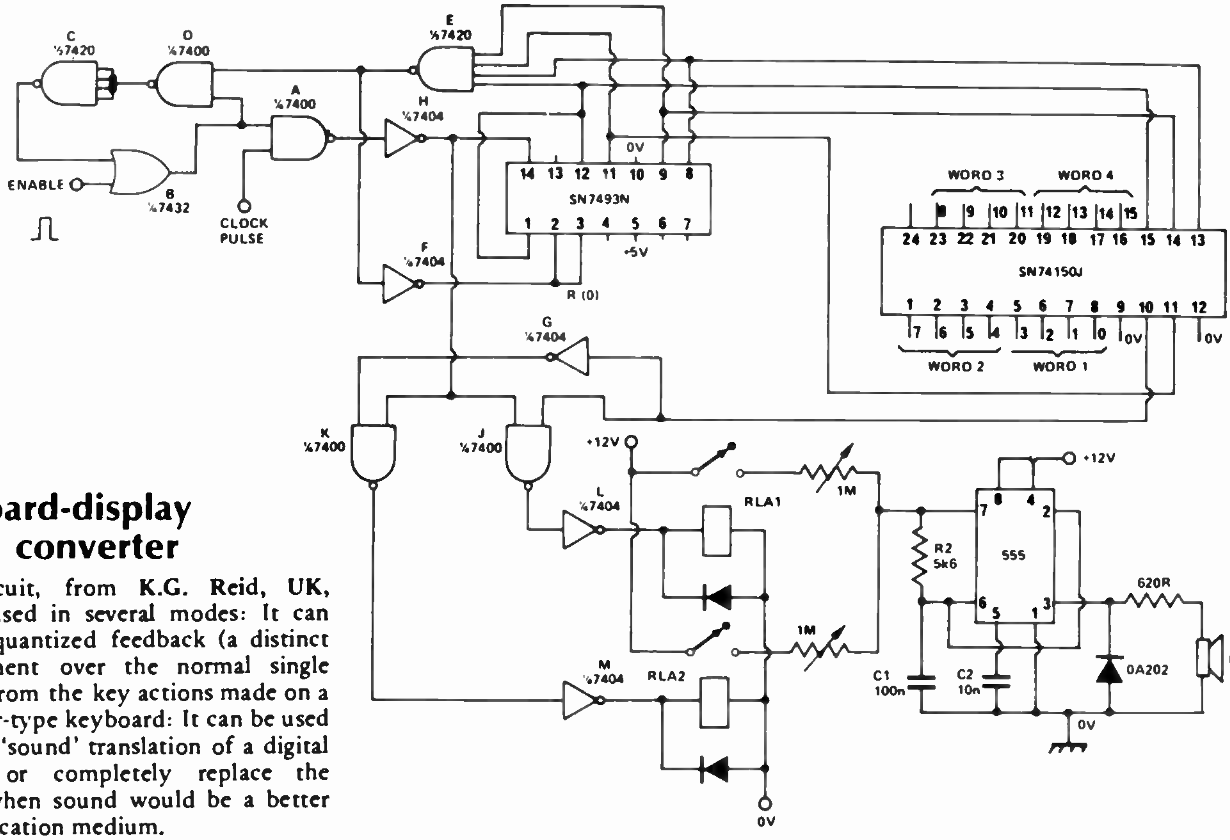
There are many circuits available for TDA1022 clocks and filters so I have not bothered to include them here. Constructors must remember that there will be a slight tremulant effect as the signal in harmony with the input will only be present for the time that the clock modulation oscillator is high or low.



Musical tone generator

This circuit provides a means of generating a series of up to ten musical notes.

The 7400 oscillator produces pulses at about 1 second intervals. These pulses, after being buffered are fed to a decade counter which produces a BCD output. The output is fed to the 7442 which produces a decimal output. Each output is taken to a preset forming a potential divider. The VCO senses the voltage at point 'a' and changes the frequency of the output tone. Careful adjustment of the presets can give a reasonable range of notes. The length of each note as well as the time between notes can be varied by changing the timing components in the 7400 oscillator.



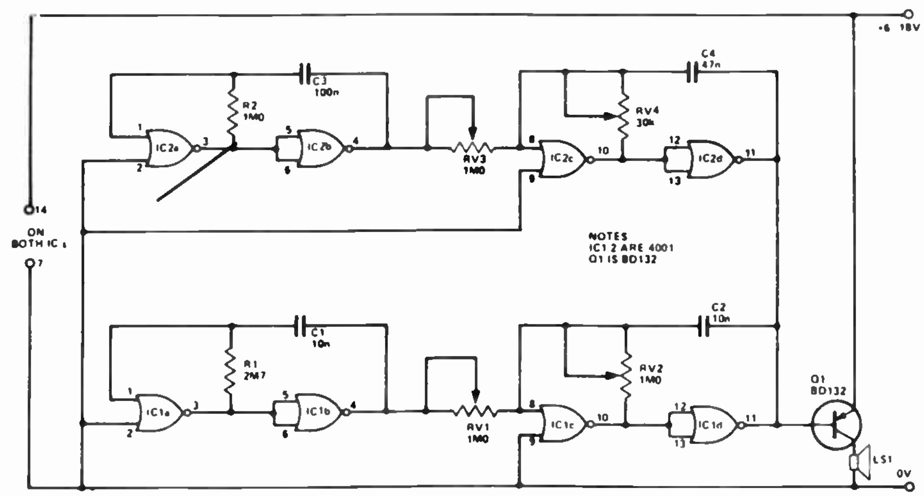
Keyboard-display sound converter

This circuit, from **K.G. Reid, UK,** can be used in several modes: It can provide quantized feedback (a distinct improvement over the normal single 'bleep') from the key actions made on a calculator-type keyboard: It can be used to give a 'sound' translation of a digital display, or completely replace the display when sound would be a better communication medium.

The keyboard or display information (a maximum of 16 bits with one 16-line 74150 multiplexer) is translated into a series of 16 high or low frequency tone pulses, corresponding to the 'high' or 'low' logic state of the 16 bits.

The circuit illustrated was used in conjunction with a digital multimeter, requiring three 4-bit words for the digits and three additional bits for over-range, negative and decimal point. Thus, 15 lines only were required, the 16th being used for resetting.

The 15 bits are latched on to the inputs of the 74150 multiplexer. Presentation of the enable pulse results in a logic '1' appearing at the output of gate B, allowing clock pulses to pass via gates A and H to the 7493 counter. Gates B, E, D and C form a latch which remains 'set' until all 15 bits have been sampled. As each bit is sampled, the inverse state appears at the multiplexer output, opening gate J or K and thus operating one of the two reed relays. As a count of 1111 appears from the counter, the output of F drops low, resetting the latch and counter. The operation of either relay results in a tone appearing at the loudspeaker (or earpiece), the tone frquencies being set (1.2 kHz maximum) by the 1 m pots. The tone pulse length is governed by the clock rate.



Sound Effects Unit

This circuit consists of four CMOS oscillators gated together in a configuration that will produce a multitude of effects from white noise to a multi-banked Trimphone.

Each IC is connected as a warble tone generator and mixed together at the base of Q1. LS1 can be from 8 – 100 R, but the transistor tends to get a bit hot below 30 R, so a small heatsink may be needed.

None of the component values are critical and if desired, RV1,3 can be replaced by ordinary resistors without affecting the variety of sound effects too much.

Memory-mapped sound generator

HERE IS A CIRCUIT idea for using AY-3-8910 Programmable Sound Generator (PSG) chips on an Apple buss.

The usual way of interfacing these chips to microprocessors is by using PIAs. However, I wanted to remove the additional burden and wastefulness of programming PIAs by memory-mapping the PSG. This is done as follows: from the data sheet, pins BC1, BC2 and BDIR control the chip operation (see Table 1).

It can be seen that if BC2 is taken to +5 V then only BC1 and BDIR control the chip. I tried various gate layouts but these failed. Finally I used a dual 4-line to 1-line data selector (74LS153), each side controlling BC1 and BDIR respectively.

To control the 74LS153 I used the R/$\overline{W}$ and A0 lines of the Apple on the A and B inputs. The inhibit input was selected by a signal from the 7442 so that the 153 was only selected if the '0' output of the 7442 was low (see Table 2).

The selection of the 7442 is an easy matter on an Apple buss because each slot has a line $\overline{DEV}$ which selects one of 16 addresses. To make programming easier the reset pin of the PSG is also memory-mapped. The OR gate on output '1' of the 7442 makes sure the reset is only selected by one address.

A simple program to test the chip is given. Since the PSG requires a register address first, then the data for the register, the register address (latch address) is mapped C0X0 (where X is the slot number +8). The data is then read or written to C0X1 with the reset on C0X2. Resetting the PSG clears all registers. In the program the data is held at 2000 hex, with the number of registers used in 2000, followed by the data and then the registers (hi ▶ lo). To reset the PSG a dummy store is used.

Since the load requirements of the Apple buss are fixed, the R/$\overline{W}$ line is buffered to enable two PSGs to be used. The I/O ports of the PSG can either be used as extra PIAs or to address PROMs. The signal outputs of the three channels of the PSG drive a conventional audio amplifier. I used an LM380.

The AY-3-8910 can be obtained from Watford Electronics, 33/35 Cardiff Rd, Watford, Herts, UK, or Technomatic, 17 Burnley Rd, London NW10, UK. Cost: around £9 mail order.

NOTE:
IC1 IS AY-3-8910
IC2 IS 74LS153
IC3 IS 74LS42
IC4 IS 74LS32
IC5 IS 74LS04
IC6 IS LM380

Program for frequency 440 Hz

```
1000  8D C2 C0   STA $ C0C2
      AC 00 20   LDY $ 2000
      BE 04 20   LDX $ 2004, Y
      B9 00 20   LDA $ 2000, Y
      8E C0 C0   STA $ C0C0
      8D C1 C0   STA $ C0C1
      88         DEY
      D0 F1      BNE $ 1006
      60         RTS
2000  04 0F 3E 00 FE 08 07 01 00
```

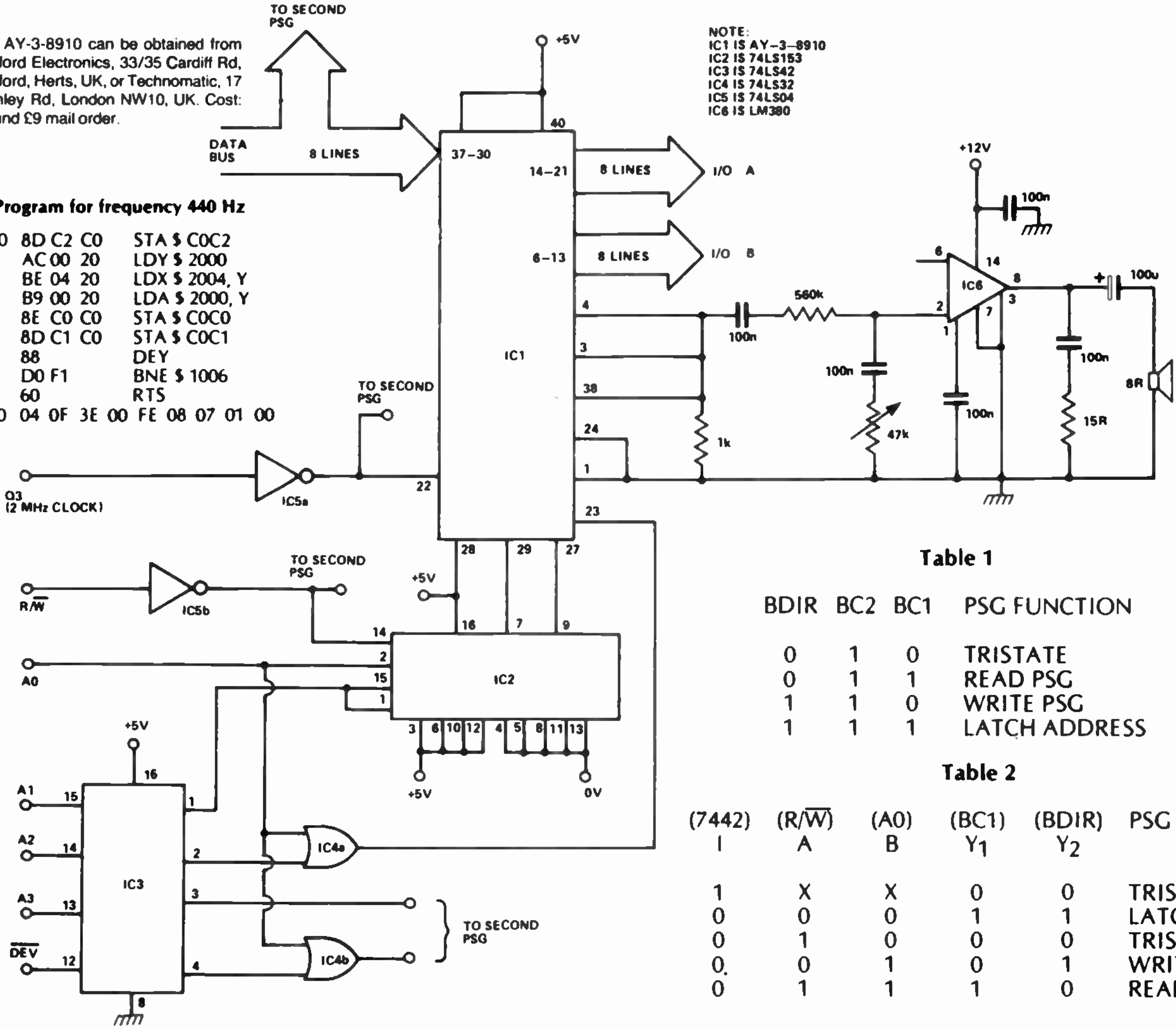
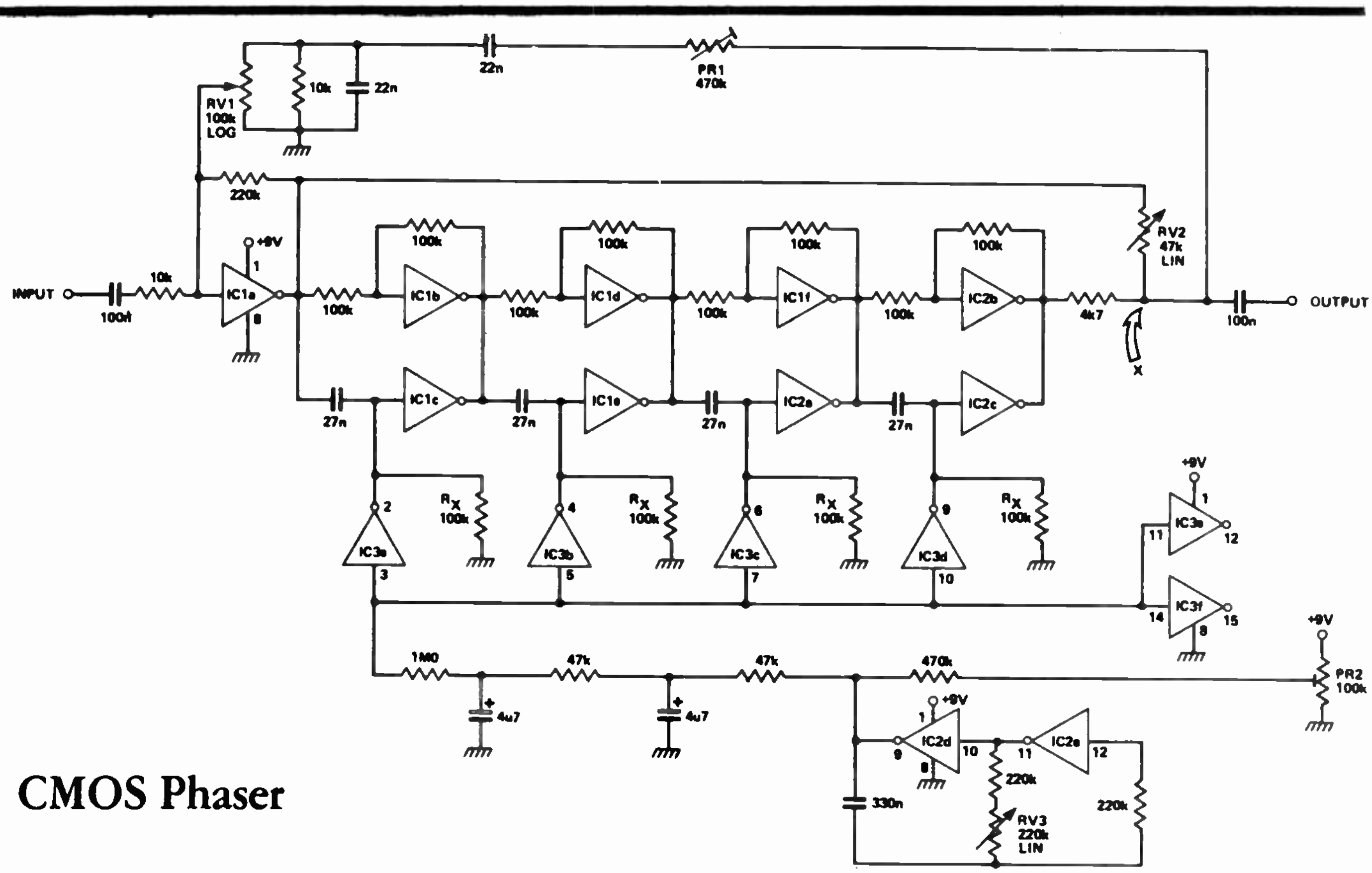


Table 1

BDIR	BC2	BC1	PSG FUNCTION
0	1	0	TRISTATE
0	1	1	READ PSG
1	1	0	WRITE PSG
1	1	1	LATCH ADDRESS

Table 2

(7442) I	(R/$\overline{W}$) A	(A0) B	(BC1) Y_1	(BDIR) Y_2	PSG
1	X	X	0	0	TRISTATE
0	0	0	1	1	LATCH ADD
0	1	0	0	0	TRISTATE
0	0	1	0	1	WRITE PSG
0	1	1	1	0	READ PSG



CMOS Phaser

This is an extension of the usual op-amp phaser, which uses CMOS inverters instead. IC1a amplifies the input signal to compensate for some of the loss in gain through the four-stage allpass network formed by IC1b-1f and IC2a-2c. The resistance of the four resistors marked R_X is altered by the enhancement FETs in IC3 and the changing voltage applied to their gates by slow oscillator IC2d,e as in the ETI audio phaser.

To set up, adjust RV2 for approximately the same level as at X, then adjust PR2 until the familiar phasing sound is heard with a smooth sweep. RV2 can then be adjusted for the best effect. These adjustments should be made with RV1 at a minimum; this is a feedback control which gives a deeper phasing effect. PR1 should be adjusted so that with RV1 full on, the feedback whistle just disappears.

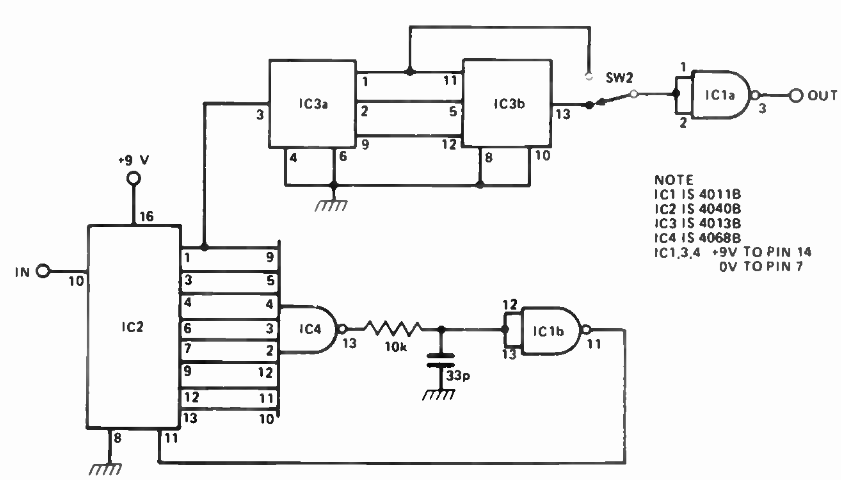
ETI-606 tuning fork mods

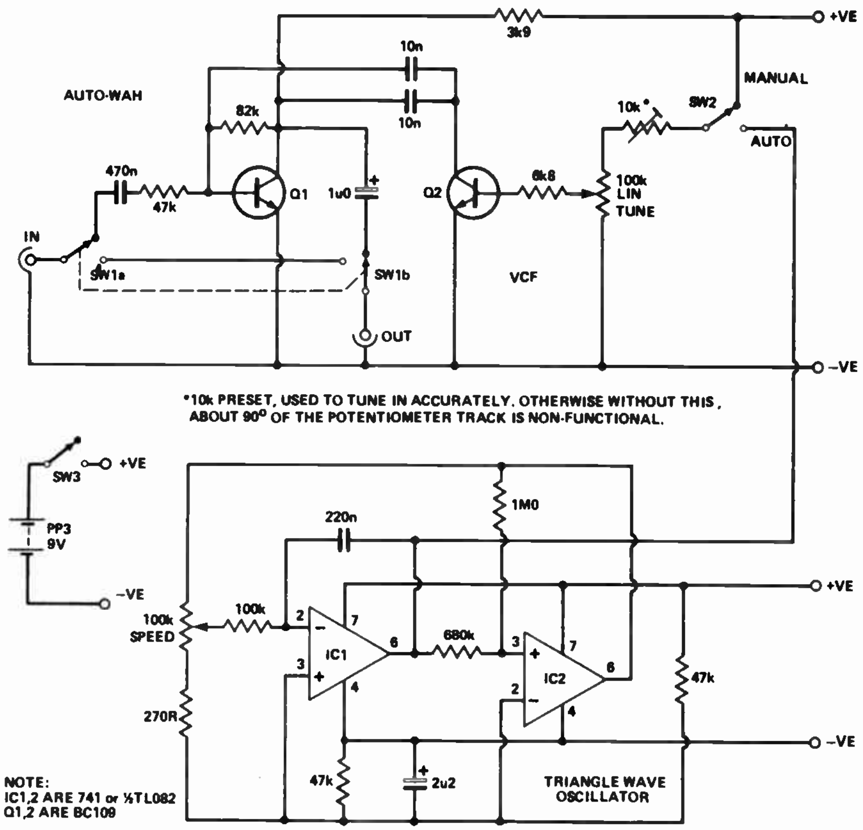
With a few slight modifications to the ETI-606 Tuning Fork (Nov. 1979) it is possible to use the very cheap and plentiful TV colour crystal tuned to 4.43361875 MHz.

The oscillator circuit output is divided by 2519, giving a frequency of 1760 accurate to one part in 250 000. The division is done by a 4040 in place of the 4020 and the switching giving an alternate 'A' at 445 Hz is eliminated.

A 4013 dual flip-flop is added before the output buffer to give further division by two and four. These outputs are switched before the buffer to give a choice of 'A's at 880 and 440 Hz respectively. The extra cost of the 4013 is offset by eliminating one of the 4011s.

The diagram shows the altered parts of the circuit. The oscillator is retained, using the changed crystal, as is the output circuit from R4 onwards.



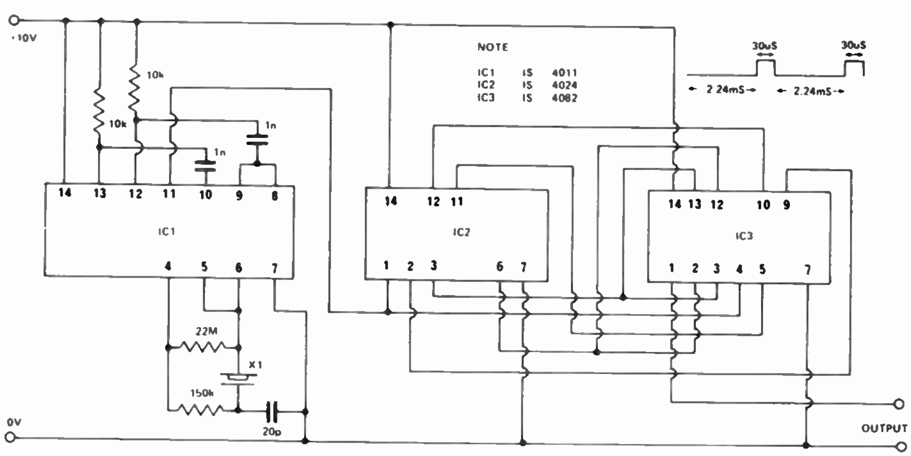


Cheap Auto-Waa

Although this unit is not capable of fulfilling the specifications of an expensive auto-waa, it has an advantage of being cheap and relatively simple.

Q2 is used as a voltage controlled resistor connected to a simple filter network based around Q1. The controlling voltage is applied to the base of Q2 and can be varied manually or automatically through the use of a triangle wave generator consisting of a standard integrator and comparator oscillator. The frequency of the sweeps is determined by the 'speed' potentiometer and can be altered from 0.5 Hz to about 10 Hz.

A 9 V supply was used so the unit can be fully portable if a PP3 battery is used.



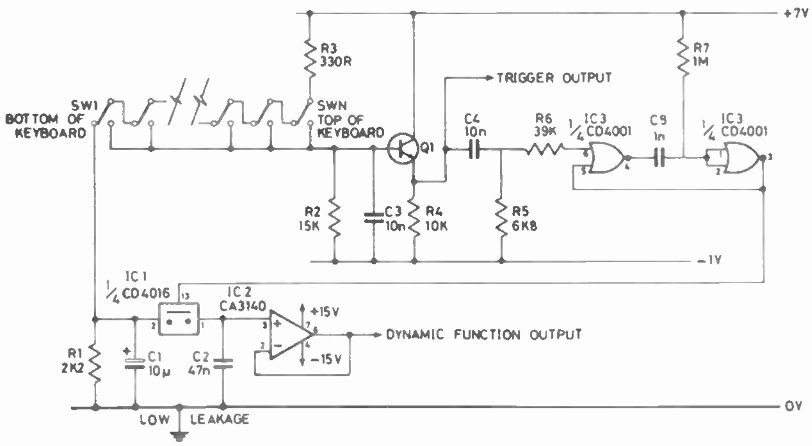
440 Hz pitch generator

As any orchestral player knows, a source of 440 Hz, perfect or standard A is essential if he is to be in tune. On many occasions a piano will not be available — hence this circuit.

In the following a standard crystal at 32.768 kHz is used to stabilise an oscillator. This frequency is then divided by 149 and doubled to give 439.8 Hz, an error of only 0.05%!!!

To enable a division of 149 to be obtained, a dual AND gate is used. The first gate detects the 149th pulse, and the second resets the binary counter on the 150th pulse.

The resulting 30us pulse may be fed to a suitable amplifier.



Touch keying

A dynamic function (touch sensitivity) greatly increases the flexibility of expression available to the player of a music synthesiser. This circuit achieves the dynamic function by measuring the change over time of the keyboard switches and hence the velocity of the keys.

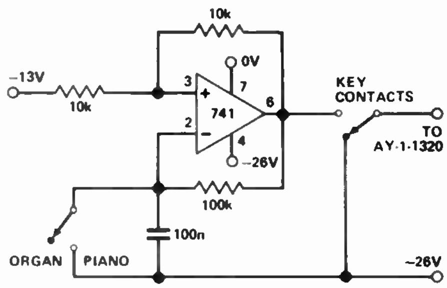
The circuit is basically composed of three parts: firstly an RC time constant network (R1, C1) controlled by the keyboard switches, a buffer amplifier and monostable (Q1, IC3) and a sample and hold circuit (IC1, C2, IC2).

Normally, C1 is kept charged up to +7V through the chain of closed keyboard switches. When a key is pressed, the chain is broken and C1 discharges through R1. As the key is further depressed, contact is made with the trigger busbar, Q1 is turned on and the monostable triggers. The monostable gives out a 1 millisecond pulse which allows the analogue switch, IC1, to close allowing C2 to charge up to the voltage on C1 at the time. After this, the voltage is stored on C2. Since the input impedance of IC1 is about 1.5 x 10^{12} ohms the delay time of C2 is very long. An output is available from the emitter of Q1 to trigger envelope shapers, etc. To ensure that the response is the same all over the keyboard, the contact wires of the keys should be adjusted to the same spacing.

W Stride

Organ Conversion For IC Piano

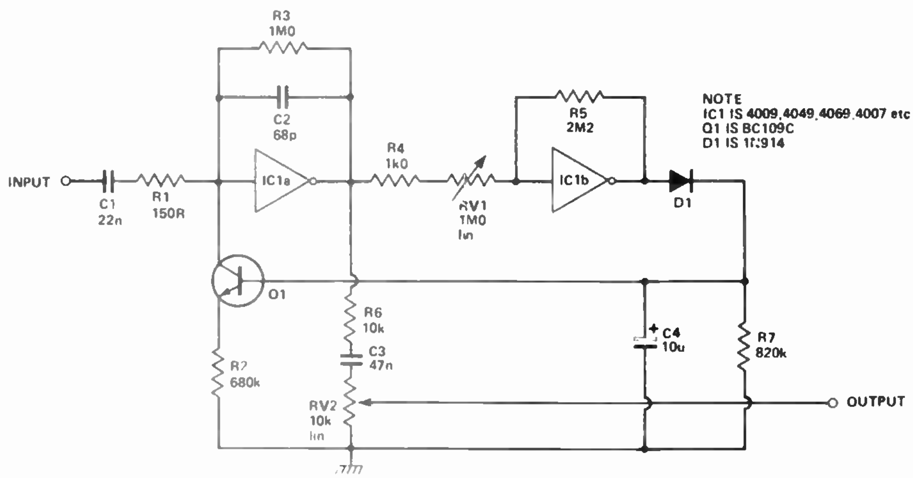
This simple oscillator circuit overrides the decay characteristics of the AY-1-1320 touch-sensitive piano IC to provide the infinite sustain of an electronic organ. In effect, it simulates hitting the piano key with great rapidity, such that the repeated note merges into a continuous sound. The circuit is short-circuit-proof, and can be switched to revert to the original piano sound. If the frequency of oscillation is lowered, a vibrato effect occurs. Conversely, raising the frequency might cause breakthrough into the sound circuits, causing an unpleasant background noise. The values shown have been found to work quite satisfactorily.

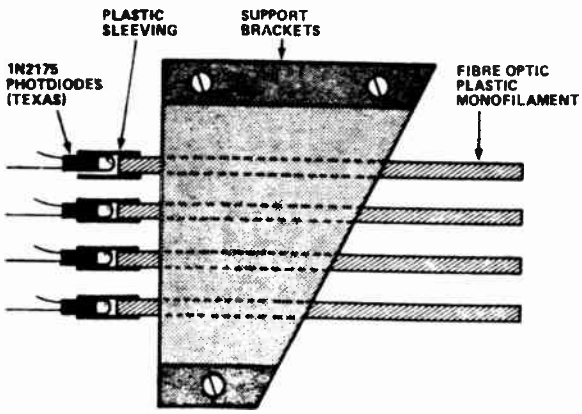


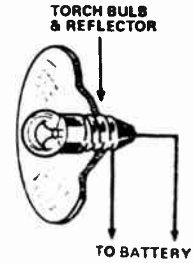
CMOS Sustainer for Electric Guitar

I believe this must be one of the simplest and cheapest sustainers for electric guitars around. IC1a and IC1b are both CMOS inverters, wired to act as op-amps. Any inverter will do the trick, such as 4009, 4049, 4069 or 4007.

The gain of IC1a is determined by the collector-emitter resistance of Q1 plus R2. If the output level is to remain constant while the guitar note decays away, the gain of IC1a must be increased by a corresponding amount. This is achieved by rectifying the output of IC1a through IC1b and D1 and passing the resultant DC voltage, which is smoothed by C4 and R7, to the base of Q1. This forces the collector-emitter resistance of Q1 to increase in proportion to the input level from the guitar. RV2 can be set to any desired level and when set high can easily overdrive the input stage of the guitar amplifier giving a valve-type of distortion.

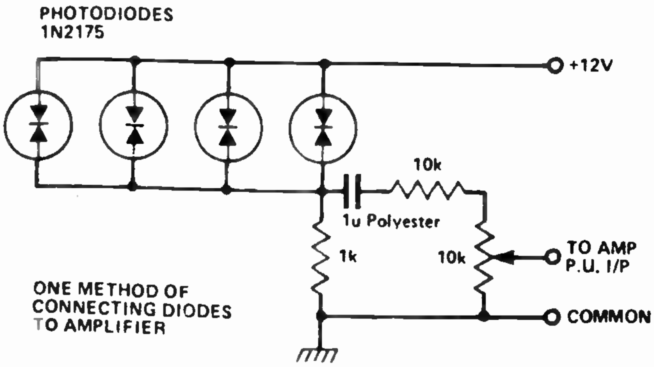




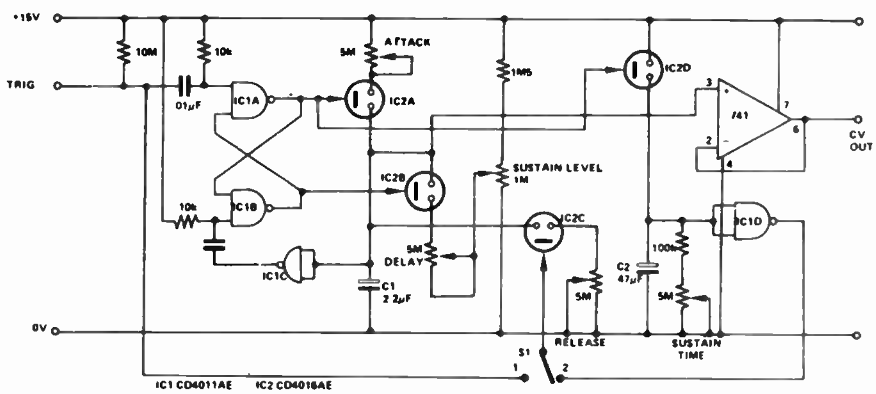


Fibre optic bass guitar

This item is in effect a simple musical instrument. It consists of a number of short lengths of plastic monofilament fibre optic material arranged in such a way that when a fibre is touched then released it vibrates at its own natural resonant frequency (like a ruler twanged on the edge of a desk). When in a light beam supplied from a torch battery the vibrating end sends sine wave impulsed along the fibre, at the fixed end there is a photodiode which with suitable circuitry feeds a signal to a normal audio amplifier. The sound produced is similar to that obtained using a tea chest, piece of string and broom handle, remember those days? Thickness of the fibres and length are not critical and it is best to experiment to obtain the sound that pleases the constructor. The fibres need be no longer than about 60 m/m. Remember the shorter they are the higher the note produced.



ONE METHOD OF CONNECTING DIODES TO AMPLIFIER



ADSR envelope shaper

When a negative going trigger pulse is applied to the input, IC2(c) disconnects the 'release' pot, the bistable is set and the 'attack' pot connected to C1. C1 charges up to the threshold voltage of IC1(c) where the bistable is reset. IC2(b) causes C1 to discharge to the level set on the 'sustain level' pot. If S1 is in position '1', when the trigger pulse goes high again IC2(c) causes C1 to discharge via the 'release' pot.

During the time IC1(a) is high C2 is charged up forcing the output of IC1(d) low. Once IC1(a) has gone low C2 begins to discharge and after a while IC1(d)'s output will go high sustain is controlled by the monostable thus formed. It is retriggerable so that should a second trigger arrive before the cycle has completed the cycle will restart. The 741 buffers the output.

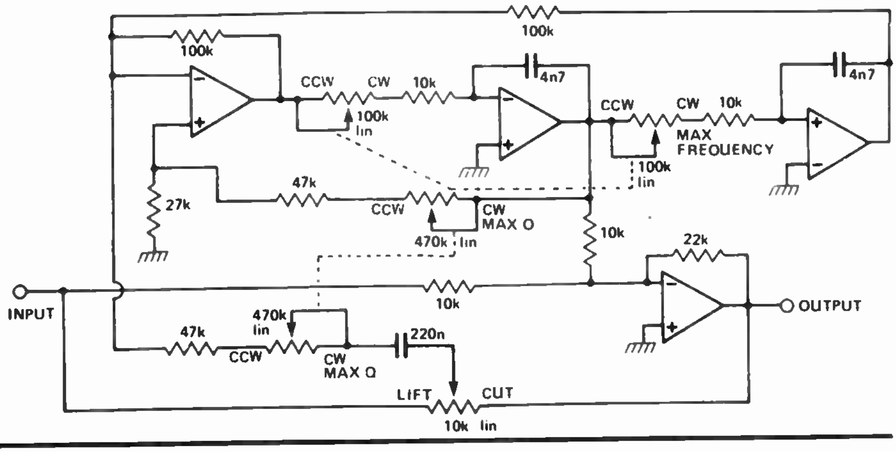
Any ideas?

Have you had a bright idea lately, or discovered an interesting circuit modification? We are always looking for items for these pages so naturally, we'd like to hear from you.

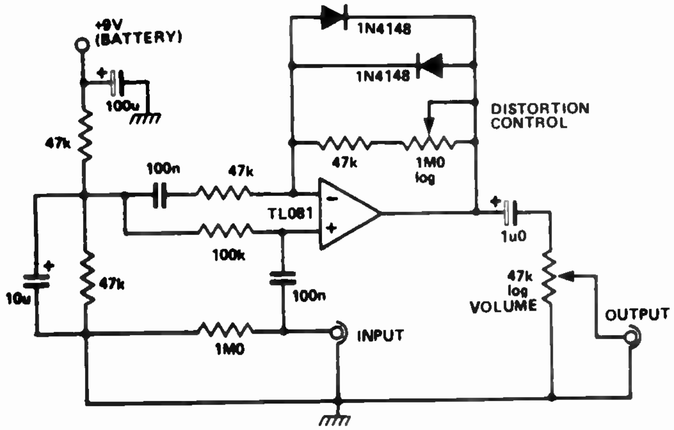
We pay between $5 and $10 per item — depending on how much work we have to do on it before we publish it.

The sort of items we are seeking, and the ones which other readers would like to see, are novel applications of existing devices, new ways of tackling old problems, hints and tips.

Parametric Equaliser

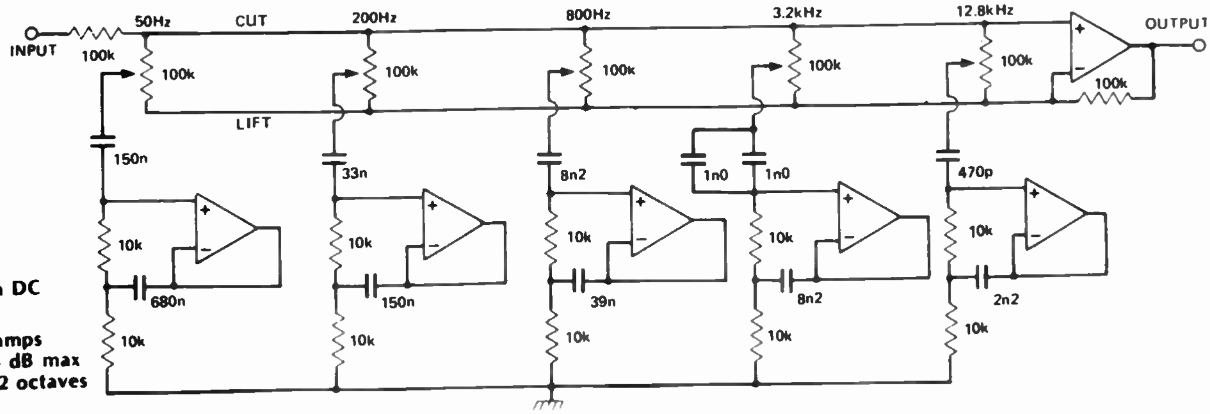


Fuzz Unit For Guitar



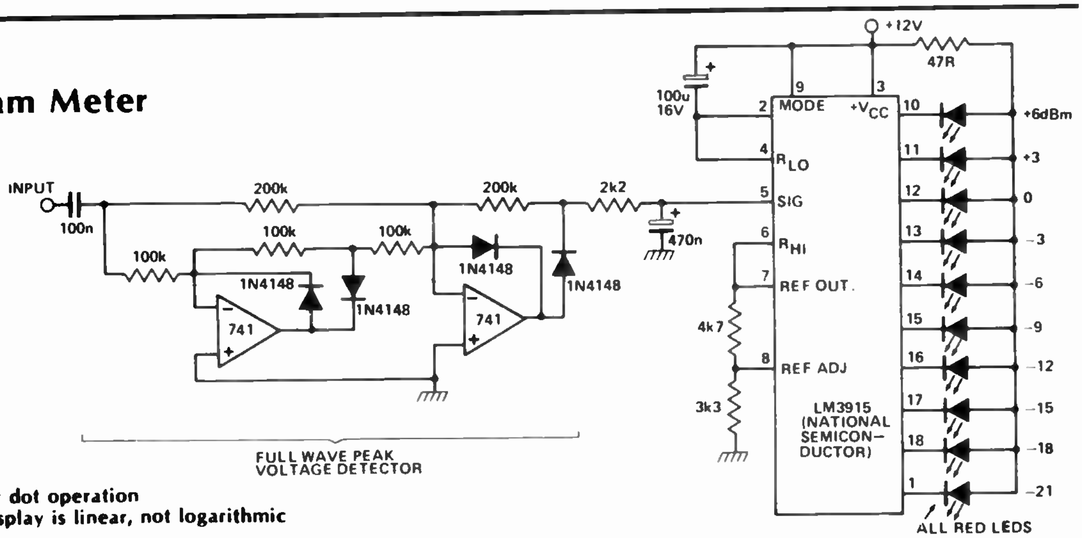
The battery can be switched on via the jack socket (a stereo jack can be used).

Graphic Equaliser

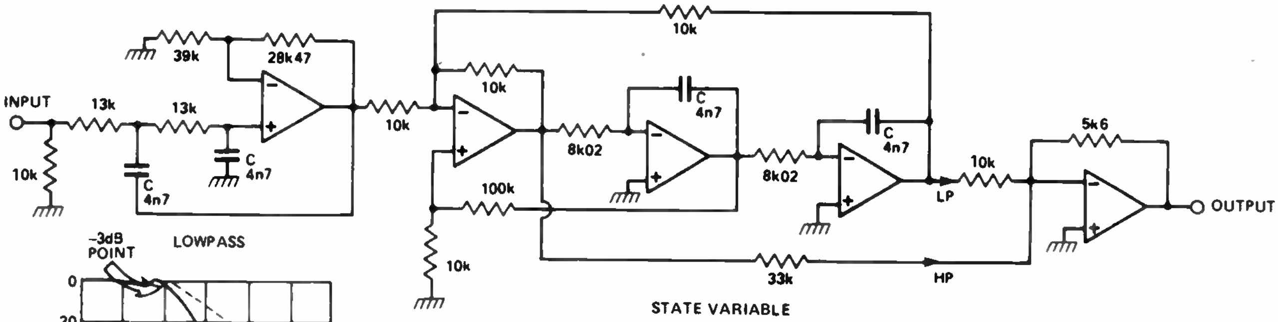


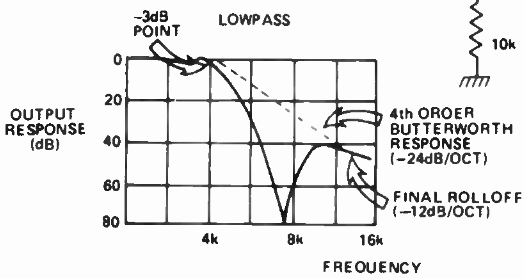
Input must have a DC path to ground
Use 741's for op-amps
Cut and lift = 13 dB max
Filter spacing = 2 octaves

LED Peak Program Meter



Leave pin 9 open circuit for dot operation
If an LM3914 is used the display is linear, not logarithmic





4th Order Elliptic lowpass

Cutoff frequency is 4 kHz. To change cutoff frequency, scale capacitor C (four off)

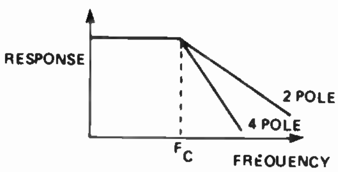
Lowpass Active Filters

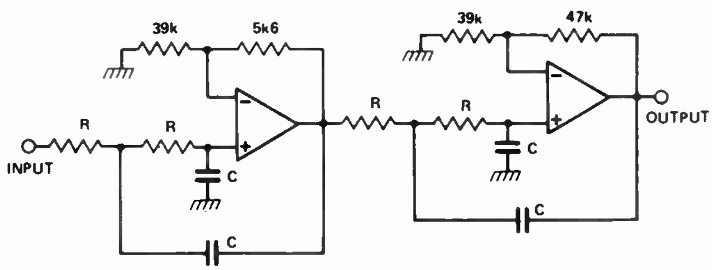
Inputs must have a DC path to ground

$$F_c = \frac{1}{2\pi RC}$$

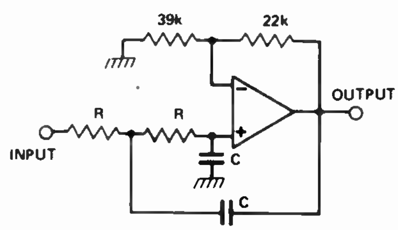
2 pole roll-off = −12 dB/octave
4 pole roll-off = −24 dB/octave

R	C	F_c
107k	15n	100 Hz
10k7	15n	1 kHz
10k7	1n5	10 kHz





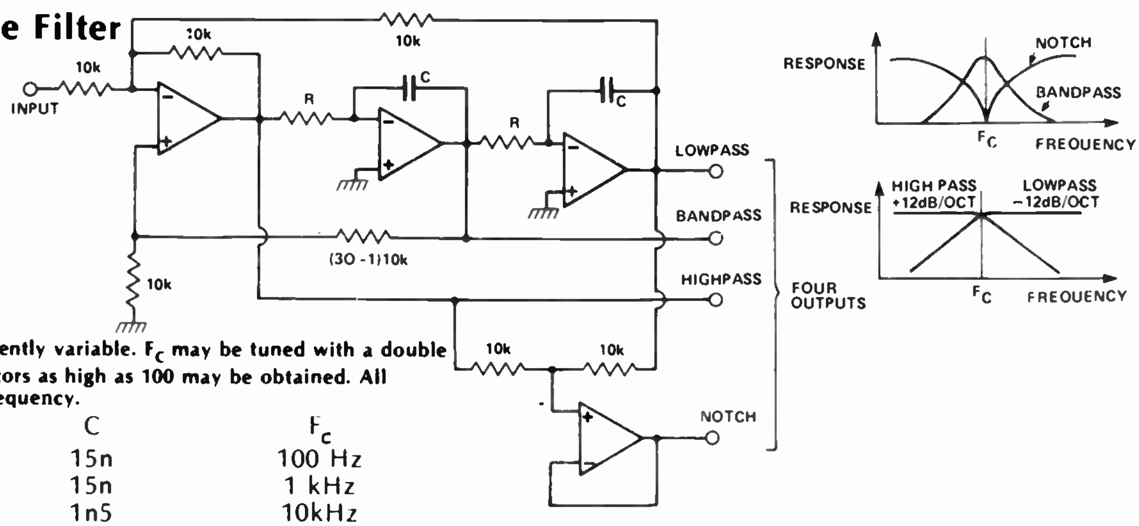
4 pole Butterworth



2 pole Butterworth

State Variable Filter

$$F_c = \frac{1}{2\pi RC} \text{ Hz}$$

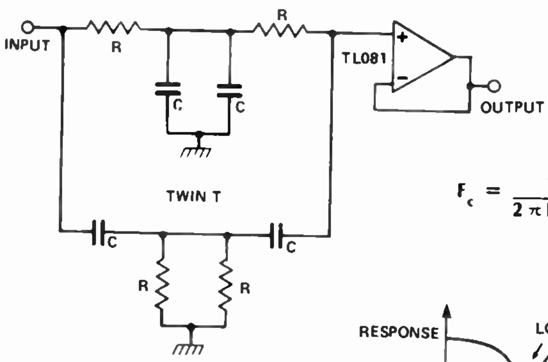


Gain = Q
Q and F_C are independently variable. F_C may be tuned with a double gang pot (for R). Q factors as high as 100 may be obtained. All responses track with frequency.

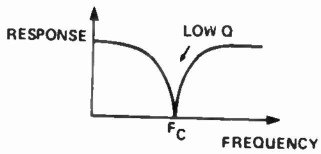
R	C	F_c
107k	15n	100 Hz
10k7	15n	1 kHz
10k7	1n5	10kHz

Active Notch Filter

The two R's in parallel represent R/2
The two C's in parallel represent 2C
For 50 Hz, R = 680k, C = 4n7 (a hum remover)

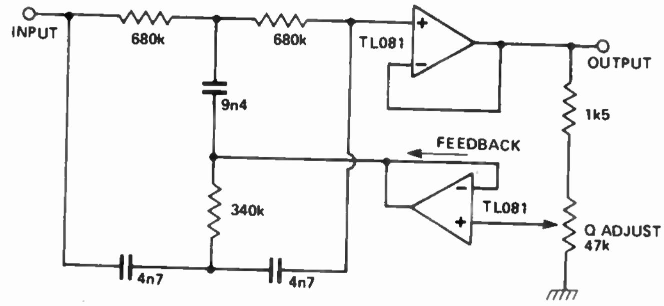


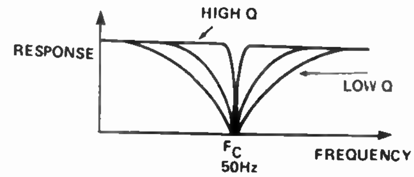
$$F_c = \frac{1}{2\pi RC}$$



A basic Twin-Tee notch. Rejection depends on component matching, so for best results use high-stability components.

50 Hz Notch, Variable Q

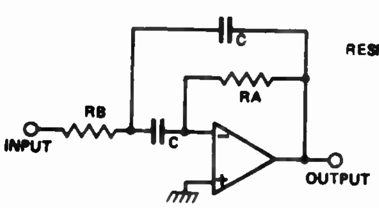


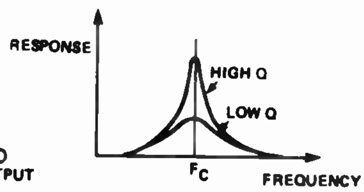


This is a modified version of the basic Twin-Tee notch filter. The Q can be adjusted by controlling the amount of feedback with the 47k potentiometer. The rejection offered by the circuit is determined by the matching of the passive components, but even with ordinary components a figure of 30 dB to 40 dB should be obtained.

Bandpass Active Filter

$F_C = 1/2\pi C\sqrt{RA+RB}$
$Q = 1/2\sqrt{RA/RB}$
Gain $= 2Q^2$





F_C = 1kHz, C = 15n

RA	RB	Q	GAIN
10k6	10k6	0.5	x 0.5
21k2	5k3	1.0	x 2.0
42k4	2k65	2.0	x 8.0
84k8	1k32	4.0	x 32.0

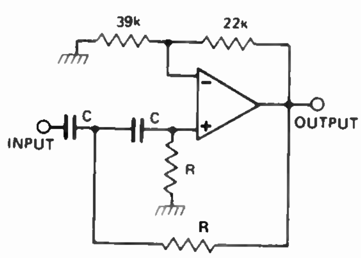
This is probably the most common bandpass filter. The circuit is really only useful for the relatively low Q shown. For a higher Q one of the more complex bandpass circuits should be used, such as the state variable filter.

Highpass Active Filters

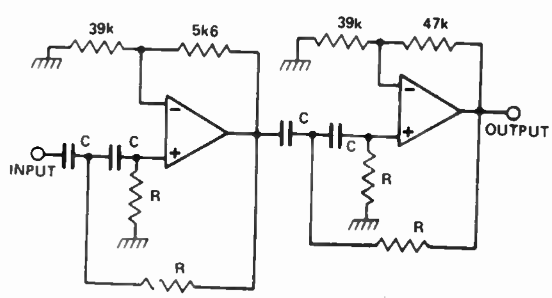
$$F_c = \frac{1}{2\pi RC}\ \text{Hz}$$

2 pole roll-off = +12 dB/octave
4 pole roll-off = +24 dB/octave

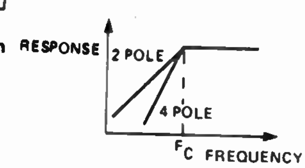
R	C	F_c
107k	15n	100 Hz
10k7	15n	1 kHz
10k7	1n5	10 kHz



2 pole Butterworth



4 pole Butterworth



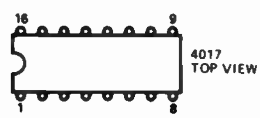
"Heads or tails" — electronic decision maker!

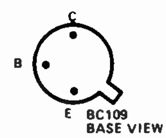
THIS SIMPLE novelty circuit is designed to electronically simulate the tossing of a coin; randomly producing a 'heads' or 'tails' output. The output of the unit is displayed on two LEDs, one being marked 'heads', and the other being given a 'tails' legend. The unit has a pushbutton switch which is briefly pressed in order to 'toss the coin', and only one of the LEDs will be switched on when this switch is released, indicating the 'decision' of the unit.

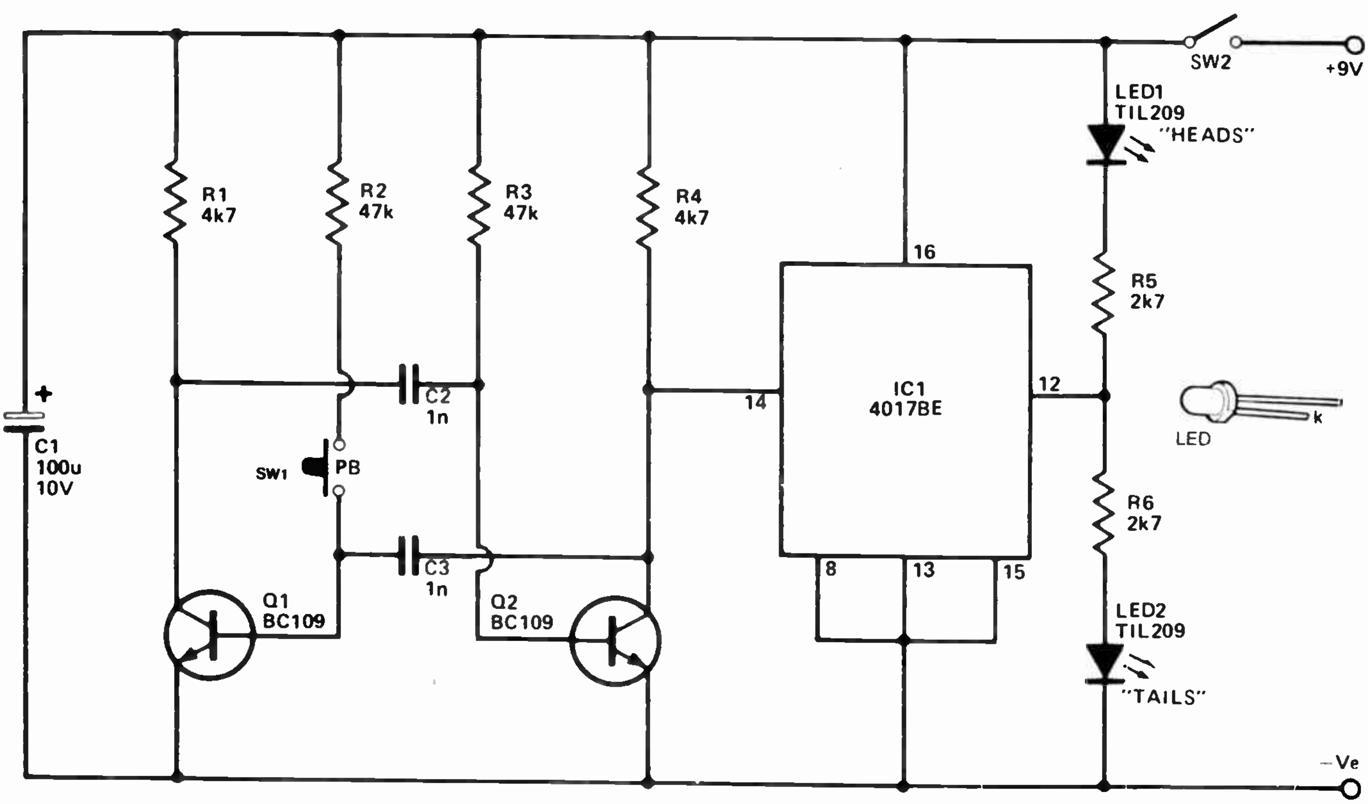
The circuit uses Q1 and Q2 in what is virtually a standard astable multivibrator circuit. The only deviation from the standard configuration is the inclusion of pushbutton switch SW1 in the bias circuit for Q1. As the circuit stands there is no bias to Q1, and the circuit therefore fails to oscillate. However, if SW1 is operated the circuit can function normally. A roughly square wave output is then produced at the collector of Q2, and the specified values give an operating frequency of many kilohertz.

This square wave output is fed to a 4017 divide-by-ten circuit, which is used here effectively as a form of bistable circuit. After each five input cycles, the output of IC1 (pin 12) changes state, and while the clock oscillator is functioning, this output therefore changes state a few thousand times per second. LED1 and LED2 are the two indicators, and are driven from the output of IC1 via current-limiting resistors R5 and R6. When IC1's output is low, R6 and D2 are effectively short circuited by the output stage, but D1 will be switched on. Conversely, when the output is high D1 and R5 are short circuited, and it is D2 that is switched on. While the oscillator is running, both LEDs appear to be switched on since the switching action is far too rapid for a human observer to perceive. When SW1 is released and the oscillator stops, IC1 will stay in whatever output state it happened to have at the instant the oscillator stopped. There is, of course, no way of predicting which state this will be, and which of the LEDs will be switched on. It is purely a matter of chance whether the unit indicates 'heads' or 'tails'.

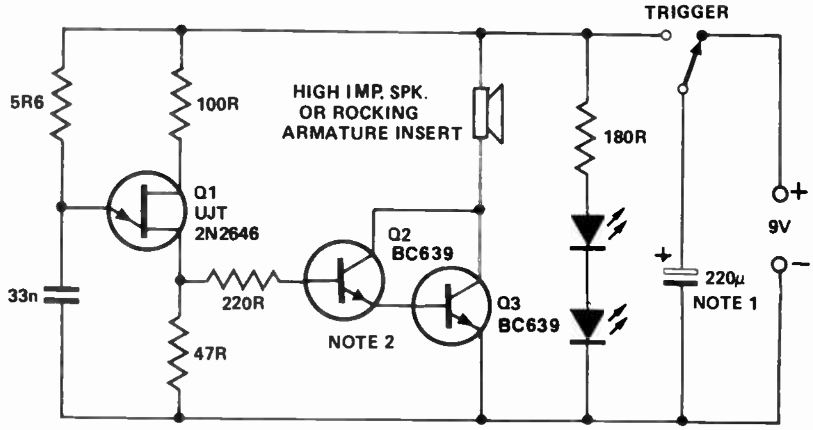
SW2 is the on/off switch. The current consumption of the circuit is only about 5 mA.







Zap! Pow! Zeep, zeep! — vaporise those Cylons!



NOTE 1
VALUE MAY BE REDUCED IF LEDS ARE NOT USED
DURATION OF SOUND PULSE DEPENDS ON VALUE USED

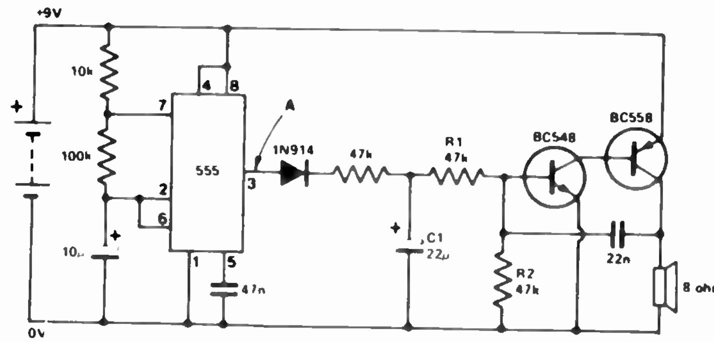
NOTE 2
AMPLIFIER ARRANGEMENT TO SUIT SPEAKER (ROCKING ARMATURE TELEPHONE RECEIVER IMPEDANCE APPROX. 100R)

Star Wars, Star Trek and Battlestar Galactica have brought a new dimension to electronic technology — as any eight or nine-year-old child will tell you (and at length).

This circuit, from **W.H. Spriggins of South Melbourne,** can be assembled into a suitable plastic toy 'space gun' and will keep the junior space warriors happy for ages (until they save up for a really-truly laser, that is).

A simple high-pitched oscillator, having plenty of harmonic output, is made from a UJT oscillator. This drives a straightforward Darlington audio output stage. Sound is produced by a rocking armature insert (telephone type) or a high impedance speaker (75 or 100 ohms, for example). The circuit is 'triggered' by a spring-return push-button (SPDT). An electrolytic capacitor is charged by the battery when the trigger is not pressed. When the trigger is operated, the 220 uF capacitor discharges via the circuit. Discharge is rather rapid and a short 'zeep' (rising tone) is emitted and the two LEDs light up.

Go get them Cylons!



Siren circuit

This circuit simulates the sound of an American police car. Just the thing to stimulate a child's ebbing enthusiasm for an expensive Christmas present!

The 555 timer is used as a very low frequency oscillator giving regular charges to the 22u capacitor, C1. The capacitor discharges through R1 and R2 until the next pulse comes from the 555. The changing voltage on the base of the first transistor changes the frequency of the oscillator, rising quickly in frequency and falling slowly.

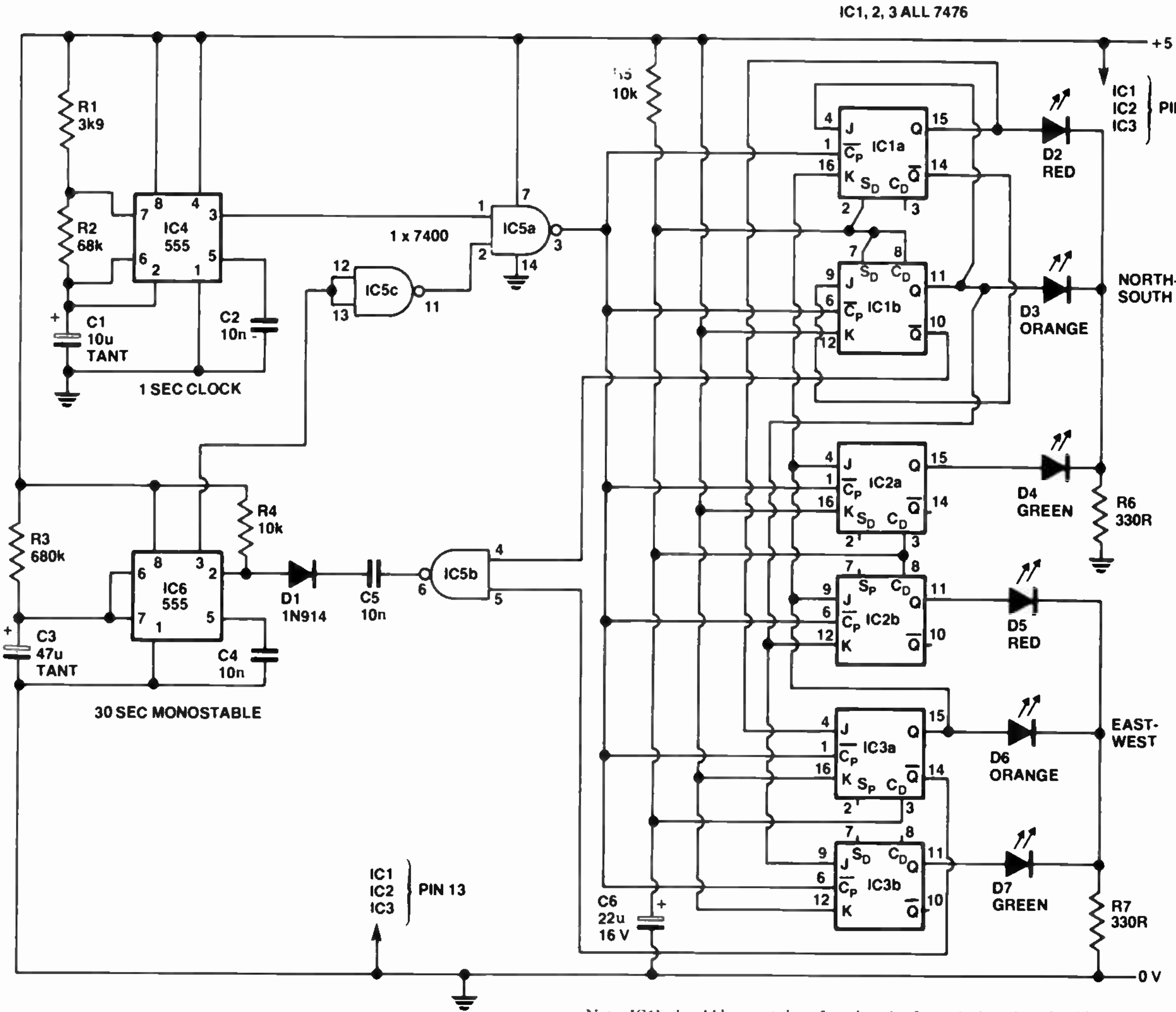
Flashing LEDs can be added with a current limiting resistor at the point marked 'A'. Submitted by **David Brighton of Huonville, Tasmania.**

Any ideas?

Have you had a bright idea lately, or discovered an interesting circuit modification? We are always looking for items for these pages so naturally, we'd like to hear from you.

We pay between $5 and $10 per item — depending on how much work we have to do on it before we publish it.

The sort of items we are seeking, and the ones which other readers would like to see, are novel applications of existing devices, new ways of tackling old problems, hints and tips.



Note: IC1b should be reset therefore the wire from pin 8 to pin 7 should be removed.

IC3b should be set (i.e: Q high). The reset line from R5C6 to pin 3 of IC3a should be connected to pin 7 of IC3b.

In order to drive more than one LED off each flip flop will require a transistor driver stage for each output.

Traffic lights

This circuit for a traffic light system that can be used in model town applications or for a child's toy has been designed by **C.A. Symes of Flynn ACT.**

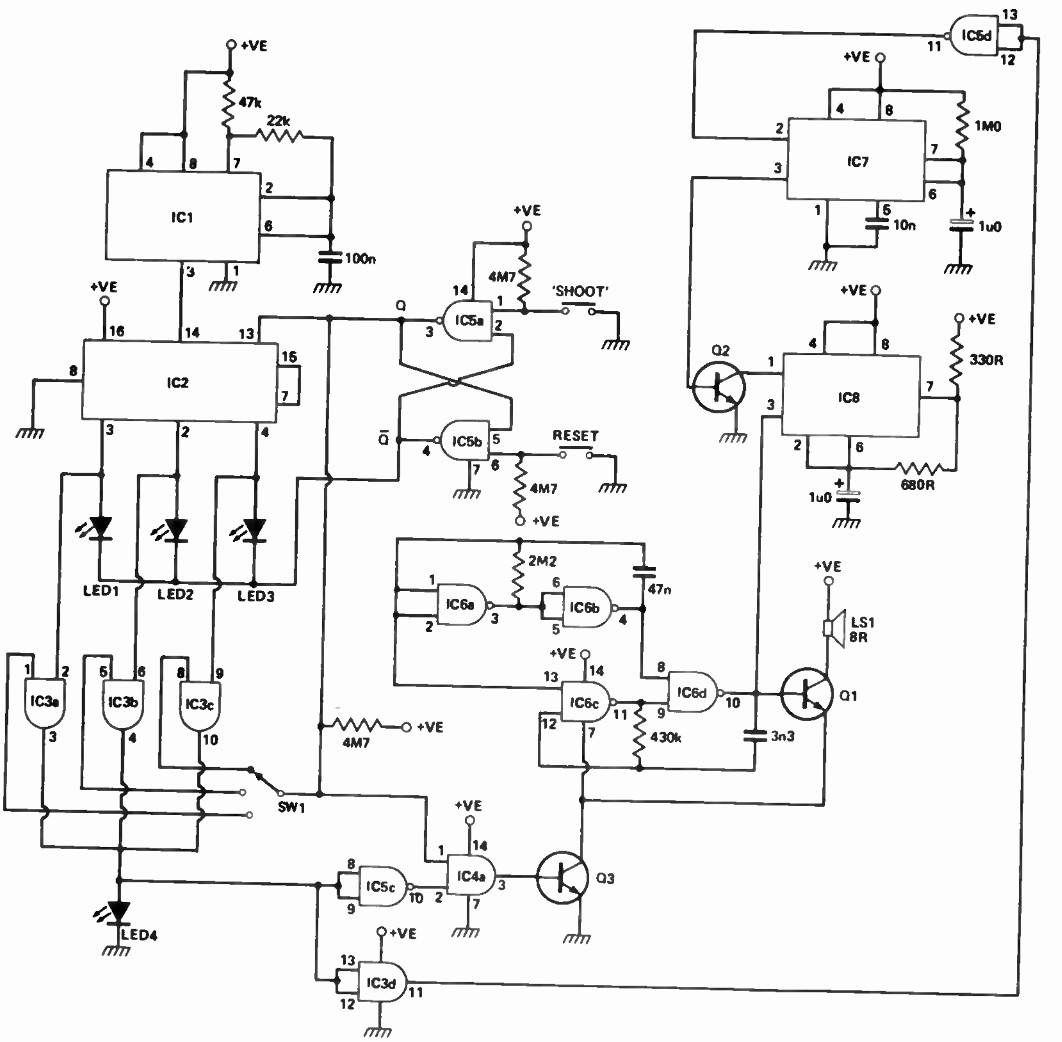
The six JK flip-flops form a sequence counter to achieve the same sequence of operation as traffic lights using red, green and orange LEDs.

When the circuit is switched on, R5 and C6 set the flip-flops ICa and IC3b and the other four flip-flops are reset. This turns the lights on in the correct sequence.

A one second clock is formed by IC4 and its associated circuitry, but the clocking of the flip-flops is inhibited by the NAND gate IC5a. IC6 forms a 30 s monostable flip-flop. Pin 3 is usually high for 30 s, then it goes low and the gate IC5a goes high and the clock then pulses the flip-flops.

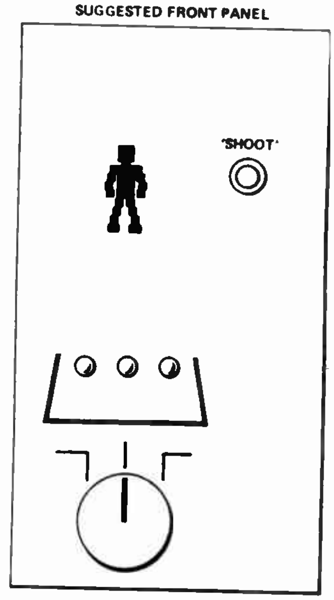
The traffic lights then change from orange to red (green in the other direction) at a 1 s step rate. IC5b output changes from low to high as either orange light switches on. When the orange light switches off and the red goes on the output of IC5b goes low. This sends a pulse through the diode D1 which causes the monostable output to go high again and disables gate IC5a again for a further 30 s.

Resistor R4 holds the trigger line of IC6 high to prevent false triggering of IC6.



NOTE:
IC1,7,8 ARE 555
IC2 IS 4017
IC3,4 ARE 4081
IC5,6 ARE 4011
Q1-3 ARE BC108
ALL LEDs ARE 0.2"; COLOURS TO CHOICE

SUGGESTED FRONT PANEL



Penalty Kicks

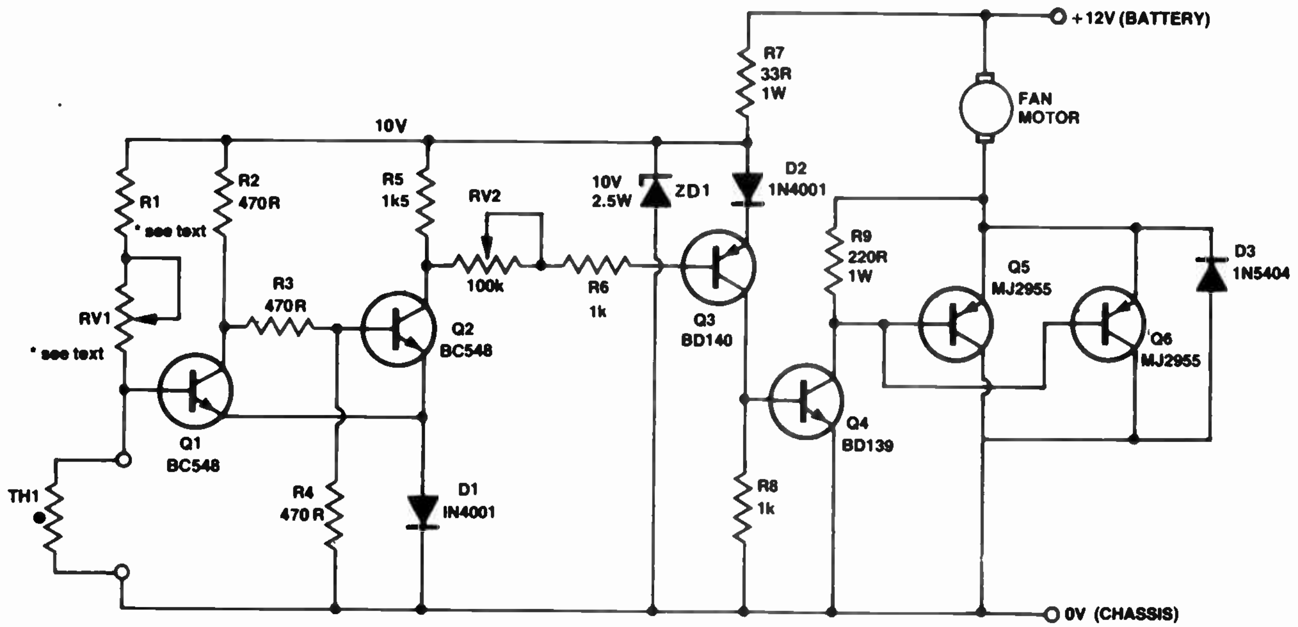
We designed this following hand held game to be simple for construction, cheap and most of all fun for the operator. The idea of the game is to put yourself in the position of the goal keeper and to guess which way the striker is going to kick the ball, by turning the rotary switch to the marked positions. The shoot button is then pressed; a noise will indicate whether the operator has guessed right.

IC1, a 555, is wired up as a astable multivibrator running at about 100 Hz feeding the clock input of the 4017. If the 'shoot' button is not operated, the Q output of the latch formed by IC5a,b is low, allowing the 4017 to count. Three LEDs are driven by the 4017; in the reset state these are blanked by the latch.

Switch SW1 is turned into the position the 'goalie' thinks the ball will come towards the goal. The 'shoot' button is pressed. IC2 stops counting and one of the LEDs lights.

If you guessed correctly the 'saved' LED is lit via IC3a,b or c and a 1 kHz sound generator built around IC8 is sounded for just over a second, being controlled by IC7, a one-shot monostable.

If you 'let the ball into the goal' a buzzer is triggered, formed by IC6.



Thermatic fan controller for a vehicle

Engine temperature is sensed by a thermistor, TH1, mounted at a convenient point on the engine block. This thermistor controls a Schmitt trigger (Q1 and Q2) which drives several power transistors (Q5 and Q6), connected in series with the fan motor, via two intermediate stages (Q3 and Q4).

So that the operating points of the Schmitt trigger remain stable despite supply voltage variations (as much as 30% in 12 V systems) the collector supply to Q1 and Q2 is stabilised at 10 V by zener diode ZD1. This also ensures supply line spikes do not cause spurious operation of the fan.

Potentiometer RV1 sets the switch-on temperature while RV2 sets the switch-off temperature.

When the engine is below the required temperature the voltage drop across TH1 should be above 1.2 V. Thus, Q1 will be on and Q2 will be off. As no collector current flows in Q2, Q3 and Q4 will be off and no base drive will be applied to Q5/Q6. Thus, the latter transistors do not conduct and the fan will be idle.

When the engine reaches the required temperature, the voltage drop across TH1 will fall below 1.2 V (preset using RV1) and Q1 will turn off. Q2 then turns on and base current will be supplied to Q3 via D1, Q2, RV2 and R6, turning Q3 on. This turns Q4 on which applies base drive to Q5 and Q6, turning them hard on, operating the fan.

Diode D3 prevents back-emf spikes from destroying the two MJ2955s when the unit turns them off.

There will be a certain amount of hysteresis in the operation of the Schmitt trigger. However, the collector current in Q2 will vary as Q1 will turn on gradually when the temperature drops below the preset switch-on temperature. Thus the base current to Q4 will vary. The point at which insufficient current is supplied to Q3 can be set by varying RV2.

Construction

The whole unit was constructed in a die-cast aluminium box which was bolted to the vehicle chassis inside the engine compartment. The MJ2955s were mounted directly on the case, no insulation is required as the collectors are connected to 0V in any case. General construction is non-critical. However, I used a pc board and supported it by soldering the common connection copper area to the backs of the pots which were mounted on the box.

The thermistor I used had a resistance of 34 ohms at 77°C (170°F). In general, R1 and RV1 are selected such that the voltage across the thermistor TH1 is 1.2 V when the engine is at its recommended operating temperature (or in the middle of its operating temperature range). Whatever thermistor you use, you will need to know its resistance at that temperature. Knowing this, you can calculate R1 and RV1 as follows:

$R1 = 4 \times R_{TH1}$ (at operating temp.)

$RV1 = 6 \times R_{TH1}$ (at operating temp.)

Having calculated these values, use the component nearest in value above that calculated. The correct setting of switch-on temperature should be within the range of RV1. Values used in my unit were, R1 = 150R, RV1 = 250R.

You will need an engine temperature meter of some sort to set the on and off points correctly.

All resistors should be of the rating specified. Those used around Q1 and Q2 (R1 to R5) may be ¼-watt types, but ½-watt or higher rated types may be more reliable. I did not find it necessary to use low value emitter resistors on the MJ2955s to assist current sharing (though it may be a good idea to match a pair for Vbe ... Ed.). The current through the fan motor when connected directly across the battery was 8.6 amps. In this circuit it draws 7.7 amps but the loss did not noticeably affect the cooling.

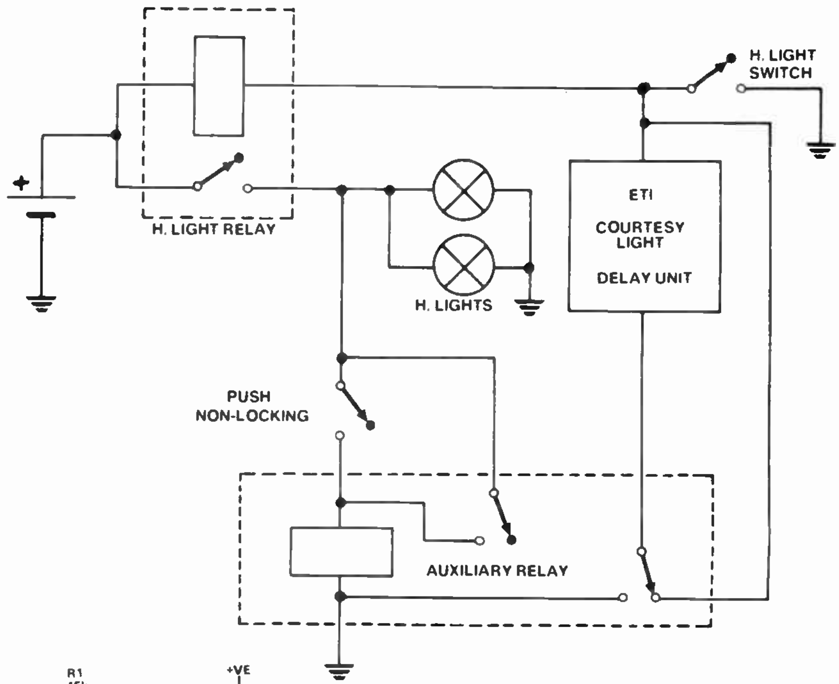
Headlight delay

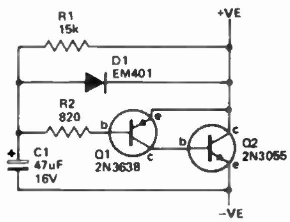
Ever driven home late at night and had to risk life and limb walking in the dark from the car to the house? Well, the problem is easily and cheaply solved by adding this circuit to your car, says **Stephen Mann of Forrestfield, W.A.**

The system is built around the ETI-232 courtesy light delay unit (or extender) from the October 1974 issue and Simple Projects Vol. 2.

Coupling this to the headlight relay as shown provides a particularly good turn-off delay for the headlights. Operation is simple. Whilst the headlights are still on, operate the pushswitch. The headlight switch may now be turned off and the delay unit and auxiliary relay will keep the headlights on. The length of time the headlights remain on is dependent on the value of C1 and the headlight relay dropout voltage.

The unit was installed on a Toyota Corolla and a value for C1 of about 300 uF gives a delay of about 60 seconds. The auxiliary relay is simply a 12 V type with double changeover contacts.



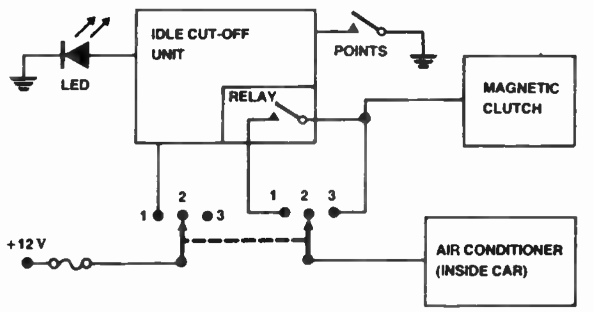


Idle cutout for car air conditioning

Mr R. Lee of Beverly Hills, NSW, found a simple and effective solution to the problem of car air conditioning loading the motor when idling.

Being the owner of a small-engined car fitted with air conditioning, I found that in city traffic, owing to the frequent stops, the extra load of the air conditioner's compressor was causing the engine to overheat and idle roughly, sometimes stalling.

Commercial units to disengage the compressor at idle are available, but expensive and none too effective. By modifying the ETI Over-rev Alarm (Project 322, Mar. '80) I have constructed an automatic idle cutout switch which disengages the air conditioner compressor's magnetic clutch during the time the vehicle is stopped, with the engine idling.



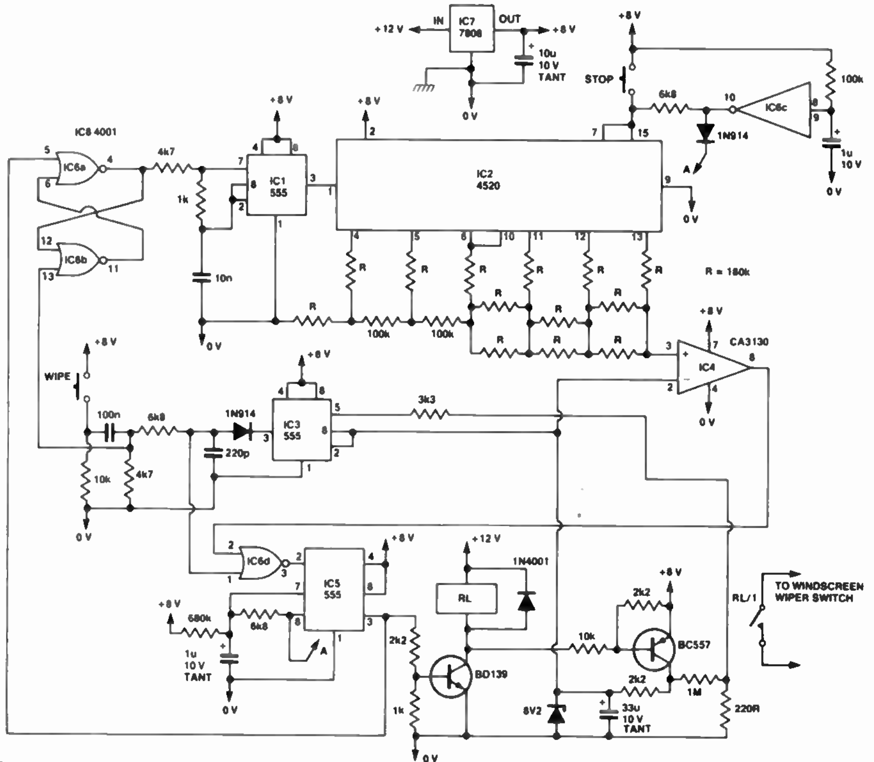
SWITCH IS 3-POSITION, 2-POLE.
POSITION 1: IDLE CUT-OFF (AT IDLE COMPRESSOR DISENGAGED).
POSITION 2: MAGNETIC CLUTCH OFF (FAN MAY BE ON IF REQUIRED).
POSITION 3: NORMAL OPERATION.
N.B. MAGNETIC CLUTCH IS ALWAYS UNDER THE CONTROL OF THE THERMOSTAT.

The changes necessary to the Over-rev Alarm's circuit are:

1) Increase C2 from 100n to 220n (four-cylinder car)
2) Only one adjustment is necessary, therefore only RV1 is required.
3) A Bosch automotive relay is used in lieu of the Sonalert (its contacts being wired to the compressor magnetic clutch).
4) A diode is placed around the relay to protect Q1 from voltage spikes.
5) A LED is mounted inside the car for visual indication of the unit's operation.
6) A three-position switch is used to allow:
 (a) air conditioner to operate normally
 (b) idle cutout switch in-circuit
 (c) magnetic clutch circuit disconnected but with fan operating (to reduce load for steep hills, etc)

The block diagram shows how the unit is connected to the car air conditioner's and car's electrical systems.

Programmable wiper controller



This simple circuit uses cheap, readily-available components.

The relay contact is wired in parallel with the standard windscreen wiper switch. A single push of the WIPE button activates the relay for about one second, giving one wipe of the screen. Another push of the WIPE button within 40 seconds of the first will operate the wiper again, which then continues at the interval set by the time between the first and second presses of the WIPE button. The interval is therefore easily programmed by pressing the WIPE button twice, when the screen needs wiping at intervals. If the rainfall increases, the WIPE button is pressed again to set a shorter interval between wipes.

The STOP button may be pressed at any time to stop the wiping. However, if the WIPE button is again pressed within 40 seconds after the last wipe, an interval is again programmed. The last wipe is always remembered as long as it was less than 40 seconds ago. Programming becomes second nature once you've done it once or twice and requires no fiddling.

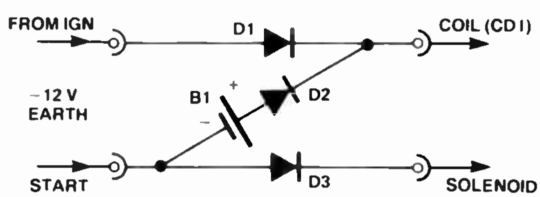
The circuit operation is as follows: If a wipe has not occurred within the last 40 seconds, pins 6 and 2 of IC3 are below their threshold level, so pin 3 of IC3 is high. When the WIPE button is pressed, pin 2 of IC5 momentarily goes low, allowing the one-second monostable, IC5, to work, activating the relay and the wiper. At the same time, the 33u capacitor is charged up. This discharges slowly after the relay has again turned off. When the WIPE button is again pressed, within 40 seconds of the first press, pin 3 of IC3 is now low (pins 2 and 6 are above the threshold) so IC6d cannot operate. The flip-flop formed by IC6a/IC6b is switched so that the oscillator formed by IC1 is enabled, thereby causing IC2 to count up, ramping up pin 3 of IC4 until the voltage on it rises to that on pin 2, thereby operating the monostable, IC5, via IC6d. IC6a is also switched, stopping the counter. A count is thus stored in IC2, corresponding to the interval time.

The STOP button resets the counter. IC6 forms a power-on reset circuit.

The circuit was built on a 60 x 67 mm pc board and mounted in a cigarette box-sized case under the dashboard, with the two buttons on the front. The relay was mounted in the engine compartment so it could not be heard.

The cold start booster

If you're a skiing enthusiast and you've been caught in sub-zero temperatures with a reluctant ignition then you'll appreciate this little circuit. Originally designed to cure cold starting problems encountered with a CDI kit, it adds an extra six volts to the ignition circuit potential just at the time when the battery voltage is likely to be at its lowest. The circuit uses a diode switching network to provide an alternative starting circuit to the ballast resistance and low resistance coil circuit found in various makes of cars.



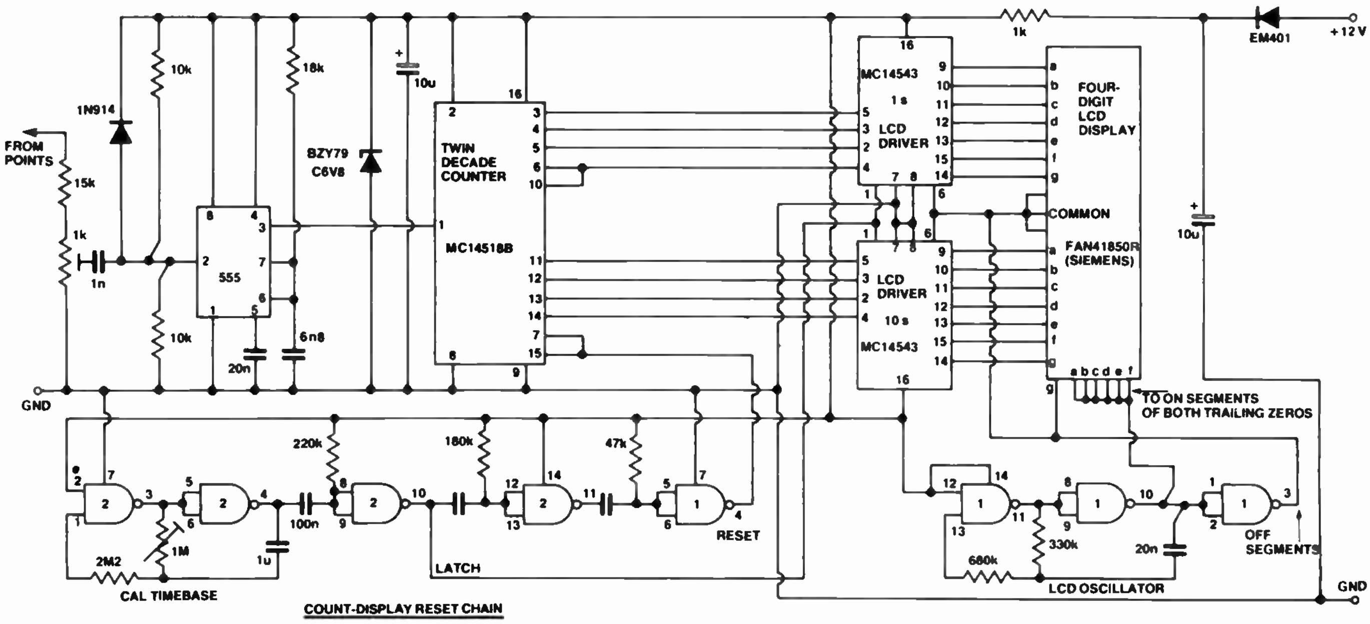
D1, D2, D3 400 V, 5A 1N5625 or sim.
B1 6 V lantern battery type 509 or 609
Reverse all polarities for +ve earth

It works as follows. The battery voltage, B1, is switched in series with the car battery when the starter solenoid is energised, providing the extra boost. Diode D1, being reverse biased, isolates the boosted voltage from the rest of the car's 12 V circuitry. Diode D3 prevents B1 discharging via the coil (or CDI) and the starter solenoid. Diode D2 prevents B1 being charged via the starter solenoid.

Fail-safe operation is assured because if B1 fails the ignition circuit is energised the normal way via D1. In my circumstances I had a lantern battery on hand which fitted snugly under the dash and was connected via alligator clips for easy replacement. I used automotive terminals for the connections to the car's electrics, enabling the booster circuit to be inserted between the ignition switch terminals and the normal leads.

A possible modification for those who wish to use a rechargeable battery would be to add a bleeder resistor in parallel with D2 to trickle-charge B1 while the car was running.

The circuit has been running reliably since last winter with sure-fire starts every time.



LCD tacho

This rev counter circuit, sent to us by **L.W. Brown** of **Burwood, Victoria,** was built as an automotive tacho and has functioned for several years.

The tacho consumes very little power because of the use of CMOS ICs and a liquid crystal display. At night a dash lamp is necessary for viewing, and the type of display I used does not function in extreme heat, nor did it work completely on frosty mornings, so it may be preferred to use a display with a wider temperature specification.

I used a display featuring a single edge connector, and the pc board was built the same size as this display-plus-edge connector. A very compact module of approximately 77 x 44 x 24 mm was constructed by mounting the pc board behind the display.

The circuit uses a conventional 555-type tacho stage, driving two decade counters. Each decade counter drives a latch decoder driver and then the display. A 60 Hz square wave oscillator supplies the ac drive to the LCD and to the drivers. As this is a four-digit display reading directly in rpm, the two trailing digits are fixed at zero. These 'on' segments of the display are driven with an out-of-phase signal, while the 'off' segments are driven with the same signal as the common terminal.

The timebase provides the necessary gating for counting by generating the display latch followed by the counter reset signal. The gate times required for a four-stroke engine are:

0.3 s for four cylinders
0.2 s for six cylinders
0.15 s for eight cylinders.

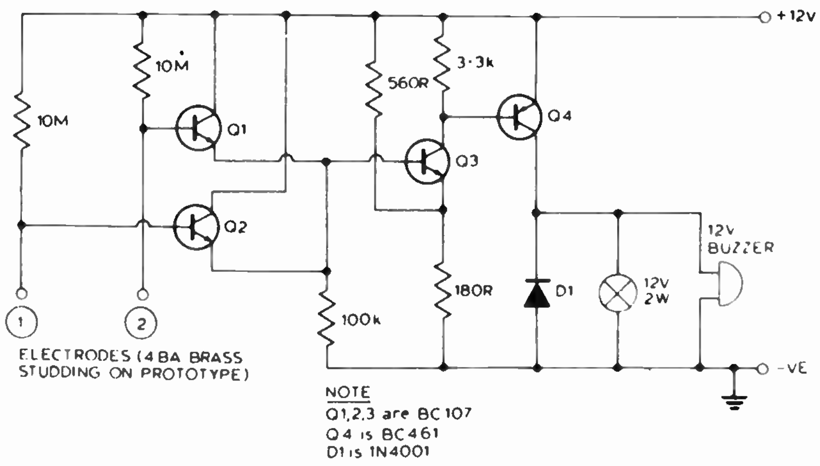
For a single cylinder two stroke engine the gate time is 0.6 s.

If a dc supply is not available, try connecting a 10k resistor from the points to the 12 V input. I have not tried this 'self power' modification, however.

Brake fluid indicator

This circuit indicates by means of a warning light and a buzzer when the fluid in the tank of a braking system is getting low.

Normally both electrodes are immersed in the brake fluid, and the bases of Q1 and Q2 are at ground potential (the fluid makes a connection between the electrodes and the brake cylinder which is connected to the car chassis). If the fluid level should fall, and either of the electrodes becomes dry, Q1 and Q2 will turn on which will turn on Q3 and Q4 and the alarm will be energised.



Square wave and pulse generator

This hobbyists' square wave and pulse generator can be built in a jiffy box and powered with a 9 V battery. It is meant as a clock, to power IC experiments.

With S1 to the right, square waves are generated in five overlapping ranges, each variable 10:1, via RV2. Total range is about 1 Hz to 100 kHz.

With S1 to the left, five fixed frequencies are generated: 10 Hz to 100 kHz, as selected by S2. The pulse width is variable in this mode. RV1 alters the duty cycle 1% through 99%, on the time-base of the frequency selected.

Table 1 shows the value of capacitors required, whilst table 2 shows the pulse widths available.

To test, connect an 8 ohm speaker in series with a 100R resistor and a 100 uF capacitor between the output and 0 V. Through the audio range it will squeal; when in the LF/short-pulse mode, it will click.

Quite a neat idea, from **Ron Mellor of Peakhurst, NSW.**

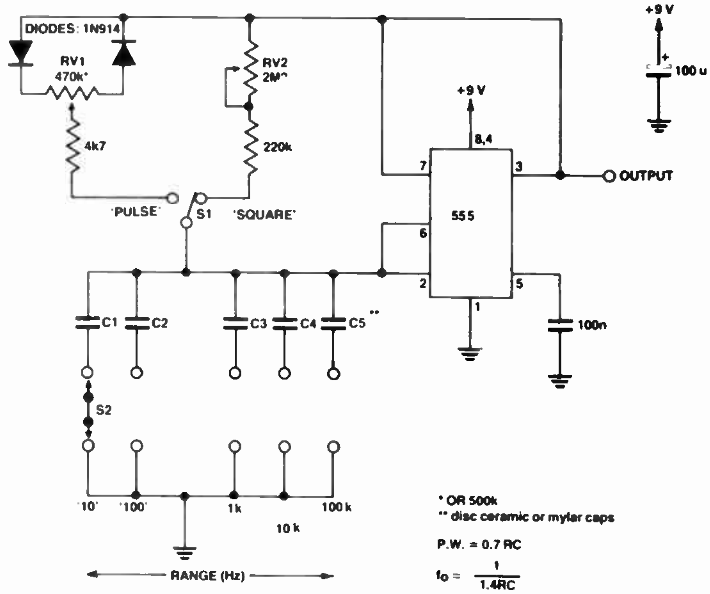


TABLE 1

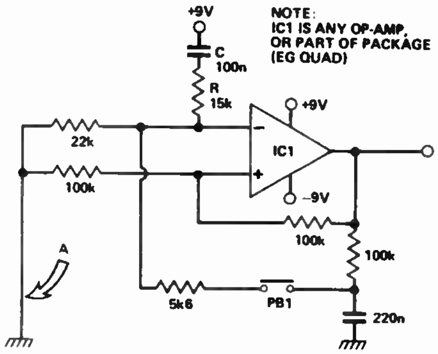
C1	330n
C2	33n
C3	3n3
C4	330p
C5	33p

TABLE 2

RANGE (Hz)	PULSE WIDTH RANGE (RV1)
'10'	1 ms - 100 ms
'100'	100 us - 10 ms
'1k'	10 us - 1 ms
'10k'	1 us - 100 us
'100k'	100 ns * - 10 us

* may not achieve

Single Push-button Op-amp Flip-flop



This circuit will be of use to constructors who find that while designing a circuit with quad op-amps, they have only one spare op-amp in their packages.

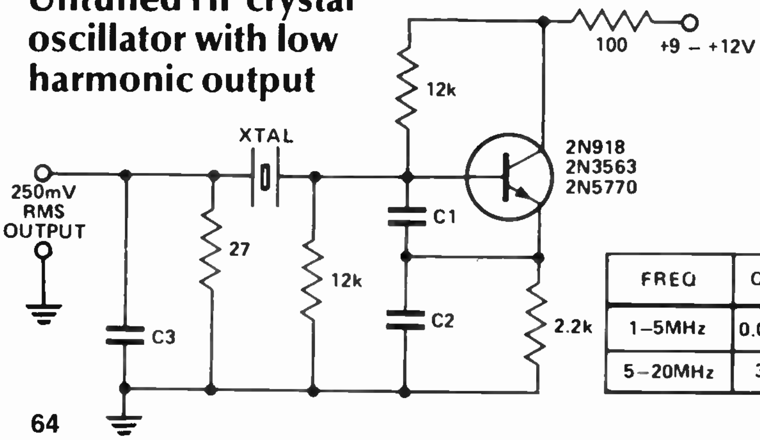
Upon switch-on, the CR combination at the inverting input takes the output to −9 V. The non-inverting input causing the output to switch to 9 V.

Even if the push-button is kept depressed, the circuit will not oscillate because the non-inverting input will now become 4V5, and the inverting input (22k/127k6) x 9 = 1V55. When the push-button is released the 220n capacitor can then charge fully to the op-amp output of 9 V and the non-inverting input falls to 0 V.

The circuit will maintain this new state until the push-button is pressed once again, when the reverse will occur taking the op-amp output back to −9 V.

There are two further points; the CR combination may be taken to the −9 V terminal to allow the op-amp output to become 9 V upon circuit switch-on. This circuit may also be powered from a single rail power supply if point A is connected to a voltage divider comprising two resistors of 4k7 between the battery positive and ground, giving approximately positive and ground alternating states.

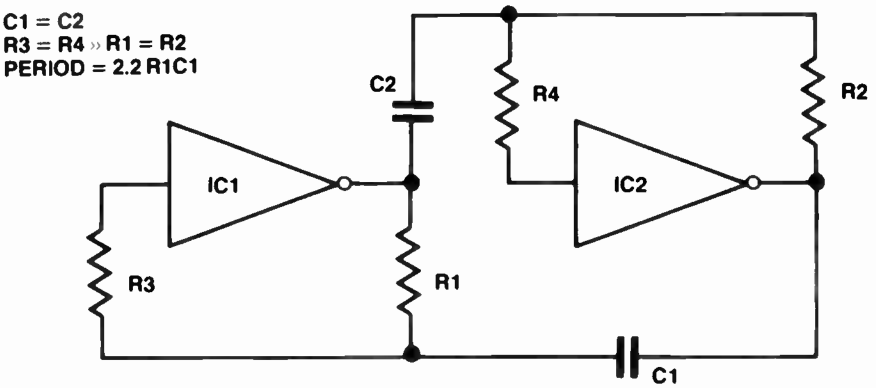
Untuned HF crystal oscillator with low harmonic output



FREQ	C1, C3	C2
1–5MHz	0.0022μF	560pF
5–20MHz	390pF	10pF

This untuned version of the familiar Colpitts crystal oscillator will accept crystals in the range 1 to 20 MHz and provide an output with the second harmonic content (usually the highest amplitude) attenuated by 60 dB, or sometimes more. The crystal oscillates in the series resonant mode on the fundamental frequency. (Note that this frequency will differ from its parallel mode frequency). Parallel mode operation is achieved by placing a 5-6 pF trimmer in series with the crystal and trimming to frequency.

Symmetric multivibrator using two inverting gates



THIS CIRCUIT provides a frequency fairly independent of supply voltage, the output having a near-perfect 1:1 duty cycle. It is based on the improved astable multivibrator circuit described in *ETI Circuit Techniques Volume 1*, p.68, and is useful when low power consumption and simplicity are the main considerations.

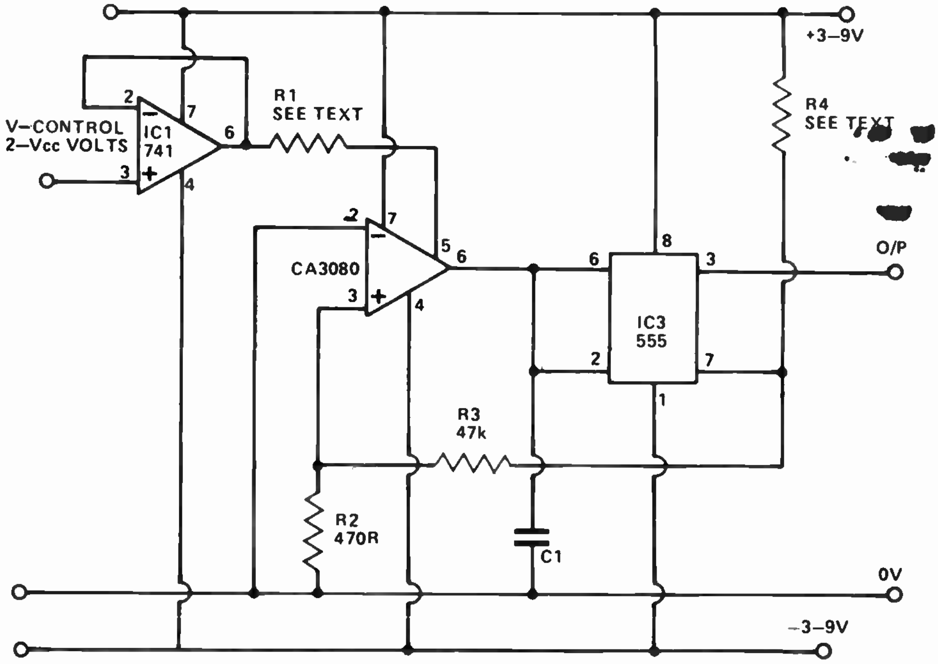
The circuit uses the dual RC relaxation circuits formed by R1C1 and R2C2, and is self-starting as it has no stable steady-state. While astable multivibrators using a single RC relaxation circuit suffer non-unity space-to-mark ratio due to the transfer voltage not being exactly halfway between the supply voltages, this circuit avoids the problem by using a dual relaxation circuit based on *two inverter sections on the same IC chip.*

The voltages applied to the gates of both inverters relax exponentially until one of them reaches its gate's transfer voltage. Hence the states of the inverters change instantaneously and the cycle repeats with the two inverters swapping their roles.

Resistors R3 and R4 should have a value of more than three times that of R1 and R2 for the RC relaxation circuits to behave as if R3 and R4 were infinite. However, too high values of R3 and R4 may affect the operation of the circuit as the voltages at the inputs of the inverters may then fail to follow the relaxation voltages. The only requirements for proper operation are that IC1 and IC2 must be sections of the same physical integrated circuit chip, and that corresponding components of the dual circuits must have the same nominal values.

In my particular application, I used a 4009 CMOS hex-inverter chip with R1 = R2 = 300k (20% tolerance), R3 = R4 = 1M (20% tolerance), C1 = C2 = 680p (10% tolerance) of the same production batches. The frequency obtained is fairly stable (with only 33% variation when the supply voltage varies between 3.3 V and 15 V) and its duty cycle is almost a perfect 1:1 over the whole permissible range of supply voltage. When the ratio R3/R1 = R4/R2 is high, the period of the circuit should have the value of 2.2R1C1; in my application it is about 400 ns.

555 Voltage Control



This circuit was developed to provide a cheap, reliable and accurate voltage controlled oscillator. It uses readily available components and the control over mark-space ratio common to other 555 circuits is retained. Frequency-voltage response is linear over approximately one decade making the circuit useful in timing applications. Operation is as follows:

IC1 buffers the input voltage and produces the control current for IC2. IC2 is an operational transconductance amplifier and produces an output current proportional to the control current multiplied by the differential input voltage. This output current is used to charge and discharge the capacitor C1 in the normal way. The equation for output high and output low times are given below:

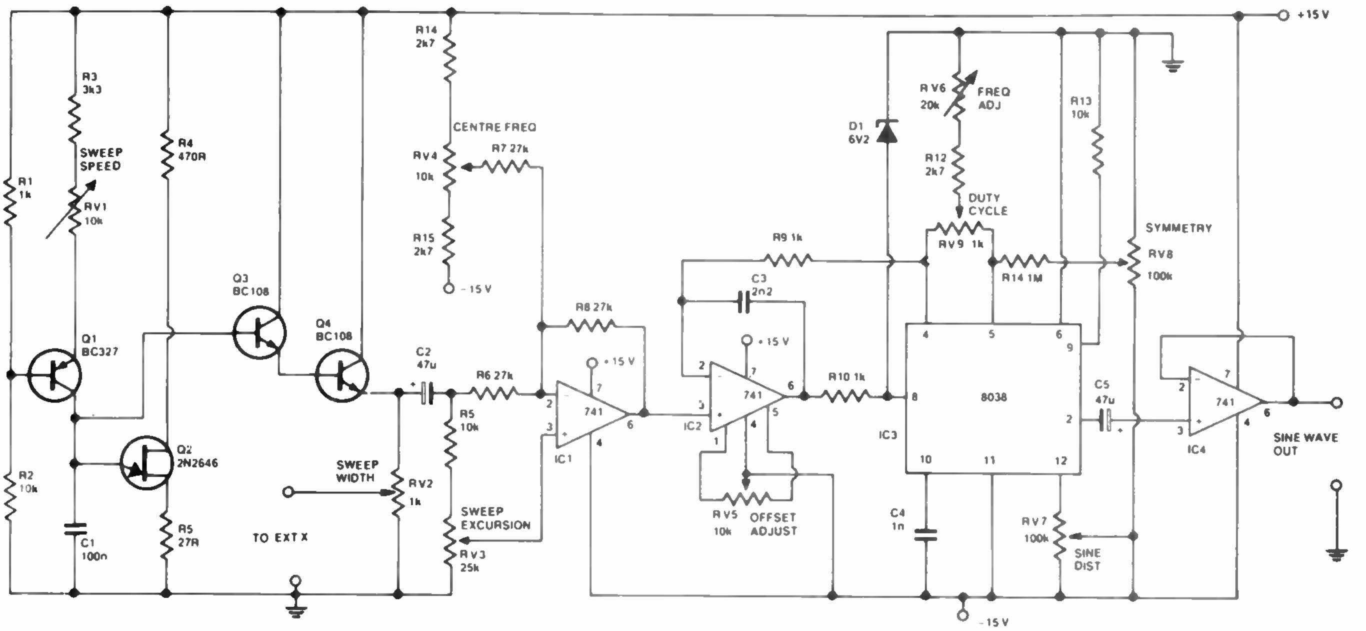
$$\text{Output high time} = \frac{R1C1(47.5+R4)}{9024\,V_{control}}$$

$$\text{Output low time} = \frac{R1C1}{192V_{control}}$$

where all resistances are in kilohms and all capacitances are in microfarads.

Current consumption is a miserly 10 mA from a 12 V supply making the unit suitable for battery power.

N.B. – R1 should not be less than 18 k.



Sweep generator

AN INTERSIL 8038 voltage-controlled oscillator can form the basis for a highly accurate sweep frequency generator when driven by a sawtooth waveform.

In the circuit, Q1 and Q2 form a linear sawtooth generator, with Q1 providing a constant current source charging capacitor C1 until the unijunction transistor Q2 conducts, discharging C1 through R5. Potentiometer RV1 adjusts the period of the waveform, normally about 20 ms, and hence the sweep speed.

Q3 and Q4 are a Darlington pair which reduce the non-linearity of the sawtooth due to loading. RV2 is a sweep width adjustment for the external X-input of an oscilloscope. IC1 enables the amplitude and average dc level of the sawtooth to be varied independently, thus varying the sweep excursion (RV3) and the centre frequency (RV4).

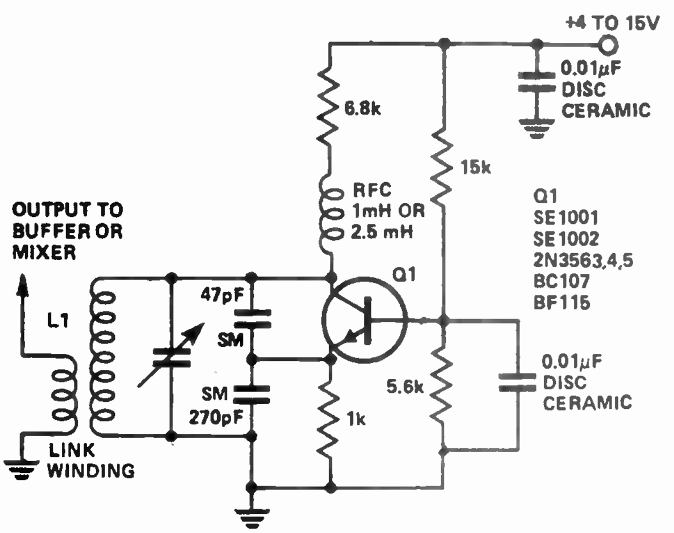
IC2 provides a buffered input to the function generator and also compensates for the non-linear voltage-to-frequency characteristics of the 8038 by applying feedback through R9 from one of the two current sources on the 8038. IC4 provides a buffered sinewave output.

With zero volts applied to pin 8, i.e: RV4 set to mid-range and RV3 at ground, the frequency of oscillation is given by:

$$f = 0.15/((RV6 + R12) \times C4)$$

For the component values shown this ranges from approximately 6 kHz to 55 kHz. RV6, R12 and C4 may be chosen to provide a centre frequency from 1/1000 Hz to 1 MHz. However, for optimum performance the charging current through RV6 and R12 should be in the range 20 uA to 2 mA. Once RV6 is set, further variation of the centre frequency is obtained with RV4.

The duty cycle may be varied over a range of 50% by RV9, and a sweep excursion of up to 1000: 1 is obtained by adjusting RV3. RV8 adjusts the symmetry and RV9 adjusts the distortion of the sinewave output. The output distortion was found to be less than 1% with a linearity of better than 0.1%.



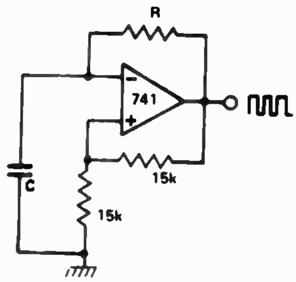
High performance RF oscillator

This high performance RF oscillator will produce an output that is level to within ± 10 mV over approximately a 2:1 frequency range. Stability is quite good following warm-up provided the usual precautions are taken. Single point earthing is an advantage.

With the component shown the oscillator will work from 2 MHz to about 25 MHz. L1/C1 should be selected according to the desired range.

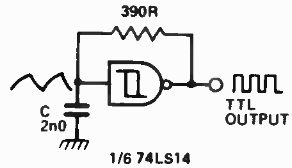
Actual output depends on the link winding. The turns ratio of the link winding to L1 should be about 10:1. Couple the link winding to the 'earthy' end of L1. Tight coupling degrades stability. About 300 mV to 500 mV is readily obtained with only loose coupling.

Op-amp Oscillator



F ∼ 1/RC (rule of thumb)

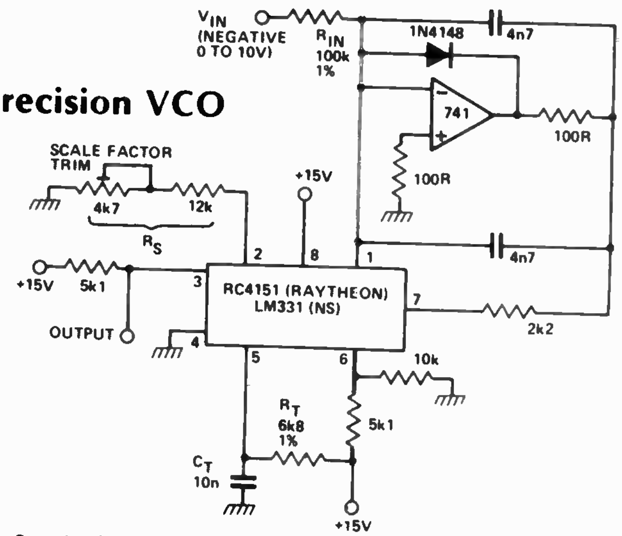
TTL Oscillator



Vary C to change frequency
Do not increase the size of the 390R resistor

Frequency range = 1 Hz to 1 MHz

Precision VCO



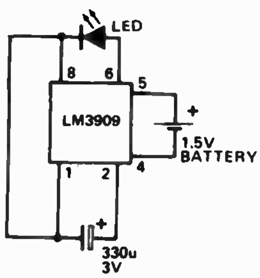
$F = (-V_{IN})/2.09 \times (R_S/R_{IN}) \times 1/(R_T C_T)$ Hz

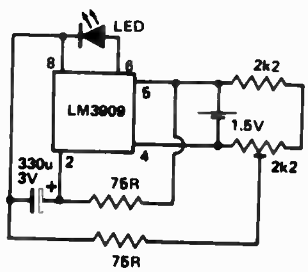
Maximum frequency = 10 kHz
Linearity = 0.05%
Response time = 10 us
Op-amp powered from ± 15 V

The LM331 is a precision voltage-to-frequency converter. In this application an additional op-amp is used to facilitate immediate response to changes of the input control voltage. The other advantage of the use of an additional op-amp is an increase in the sensitivity of the circuit to low control voltages. The limit here is the offset voltage and current for the particular op-amp used. The 741 specified is satisfactory although an improvement would be obtained if alternative devices were used, e.g: LM108, LM308A or LF351B.

Note that the 4n7 capacitor in the integrator should be a mylar capacitor to ensure accurate operation.

LED Flasher

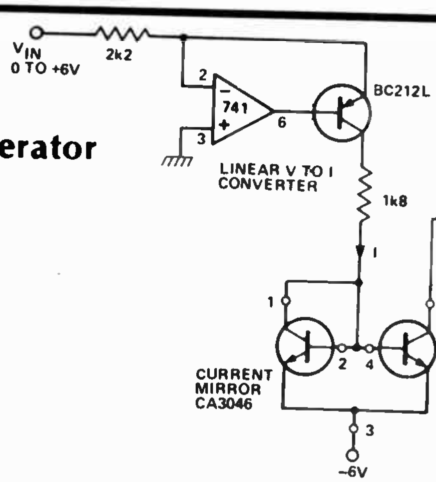


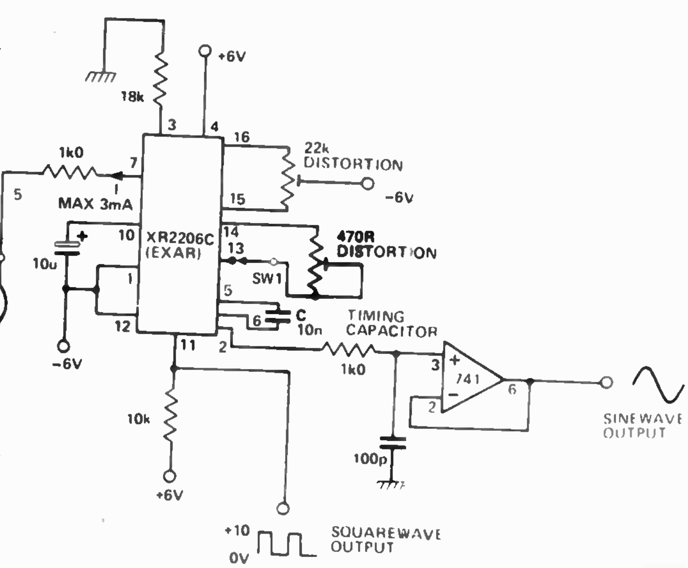


1 Hz flash rate
Average current drain = 0.32 mA
Circuit uses the timing capacitor to boost the output voltage

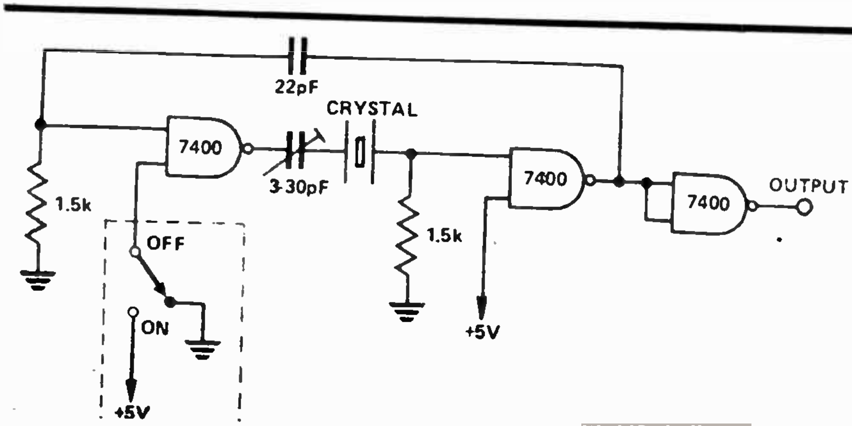
Variable flash rate 0 to 20 Hz

Function Generator





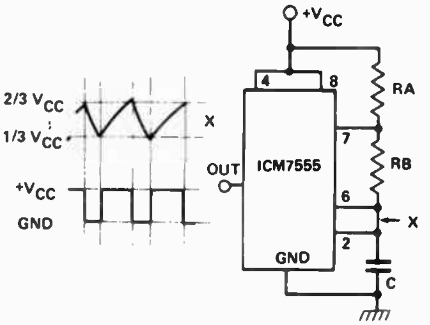
Oscillation frequency F = 320I/C Hz, where I is in mA and C is in uF
Maximum frequency = 1 MHz
Best THD of sinewave = 0.5%
When SW1 is open-circuit, the sinewave becomes a triangle
Typical supply current for the XR2206 is 14 mA



Gated TTL crystal oscillator

Gating a TTL crystal oscillator on and off with a digital signal is easily accomplished with the above circuit. The bracketed portion shows a switch that connects the spare input of one gate to LO to turn the oscillator off and H1 to turn it ON.

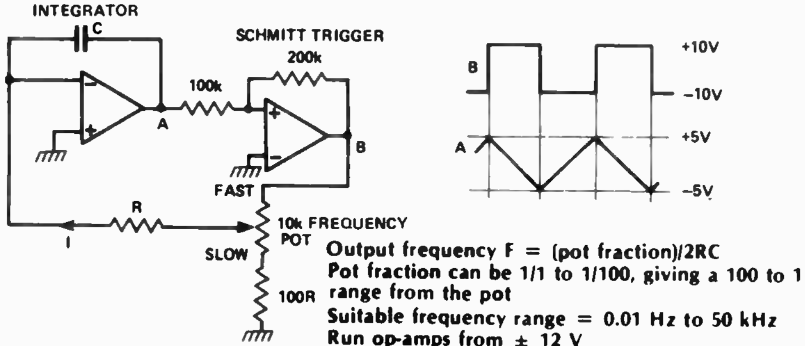
CMOS 555 Oscillator



Output frequency F = 1.46/C(RA + RB)
C in farads, R in ohms
Quiescent current ∿ 120 uA
Input current ∿ 50 pA (this allows the use of resistors up to 10M in value)
Frequency range 0.001 Hz to 500 kHz
Supply range 2 to 18 V
Rise and fall time (pin 3) = 40 ns

RA,RB	C	F
10M	10u TANT	7.3 mHz
1M0	1u0	0.73 Hz
100k	100n	73 Hz
10k	10n	7.3 kHz
10k	1n0	73 kHz

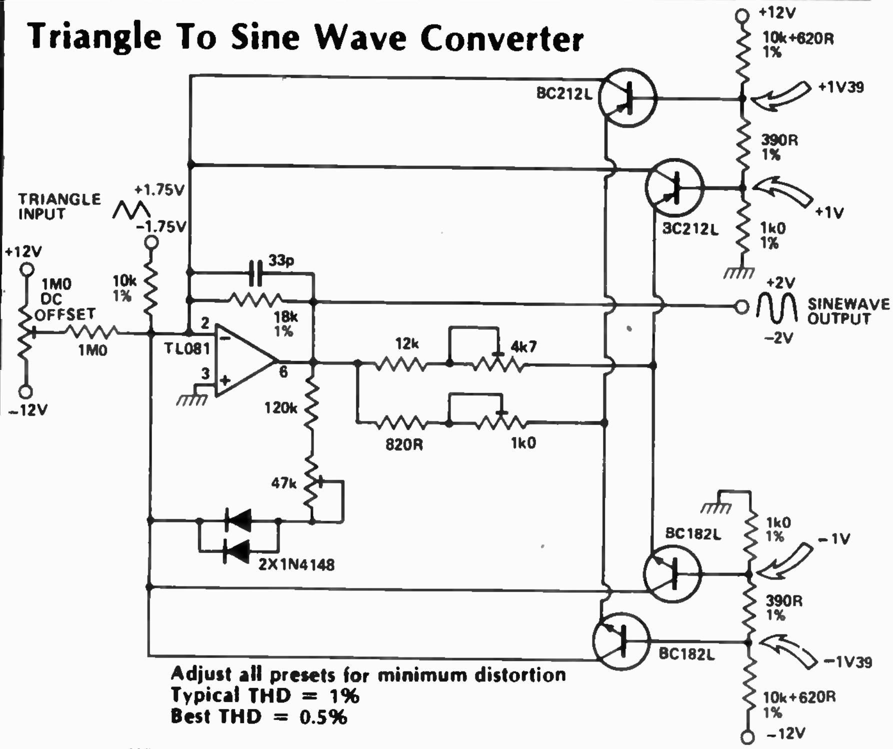
Triangle/Square Wave Oscillator



Output frequency F = (pot fraction)/2RC
Pot fraction can be 1/1 to 1/100, giving a 100 to 1 range from the pot
Suitable frequency range = 0.01 Hz to 50 kHz
Run op-amps from ± 12 V

This oscillator provides both triangle and square wave outputs at a frequency that can be varied over a range set by the 10k pot. A dual op-amp such as the TL072 is suitable and would provide frequencies to beyond 50 kHz.

Triangle To Sine Wave Converter

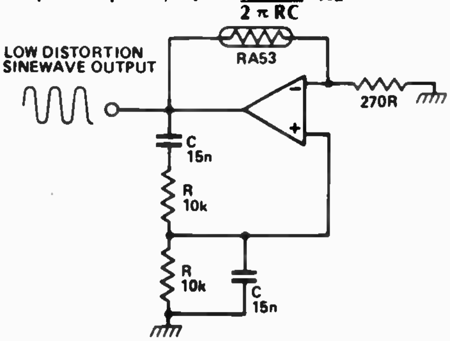


Adjust all presets for minimum distortion
Typical THD = 1%
Best THD = 0.5%

When designing a complete function generator it is often convenient to start with one of the triangle/square wave oscillators given earlier and convert the triangle wave into a sinewave. This is a particularly good method if a sweep oscillator is required, since sinewave sweep oscillators are extremely difficult to design. Some experimenting with the preset pots is necessary to obtain minimum distortion, although this is not particularly difficult.

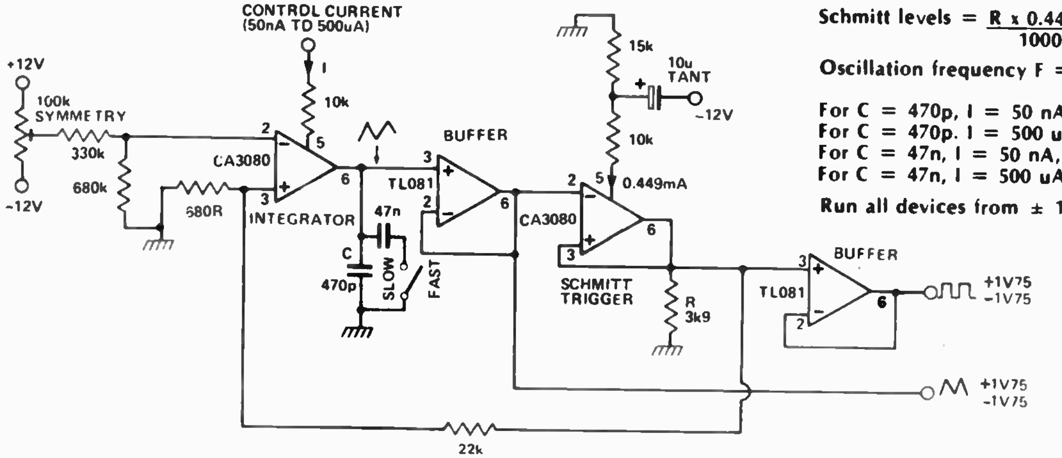
Wien Bridge Oscillator

Output frequency $F = \frac{1}{2\pi RC}$ Hz



The RA53 is a negative temperature coefficient thermistor; it sets A_v to 3 for stable oscillation.

Linear VCO/Function Generator

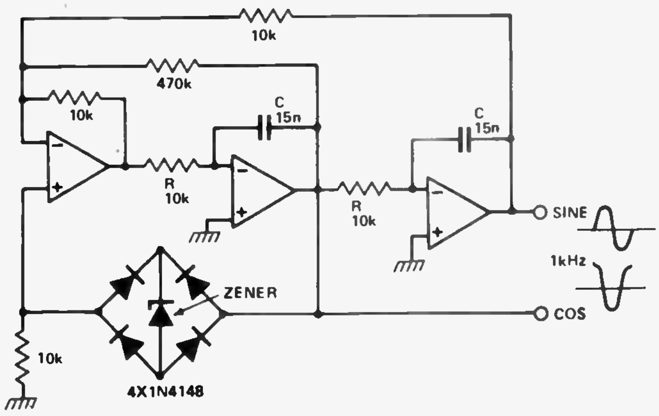


Schmitt levels = $\frac{R \times 0.449}{1000}$ = 3.9 x 0.449 = ± 1V75

Oscillation frequency F = I/(C x 4 x 1.75) = I/7C Hz

For C = 470p, I = 50 nA, F = 15 Hz
For C = 470p, I = 500 uA, F = 150 kHz
For C = 47n, I = 50 nA, F = 0.015 Hz
For C = 47n, I = 500 uA, F = 150 Hz

Run all devices from ± 12 V



Dual Integrator Oscillator

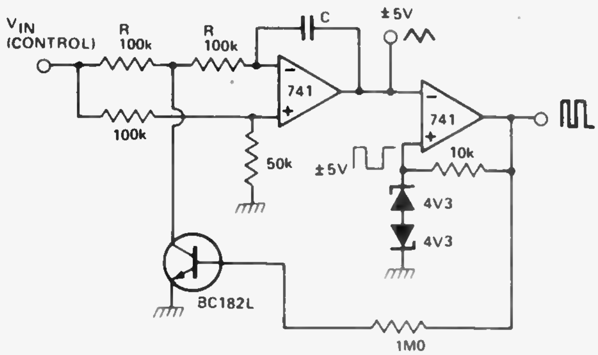
Quadrature outputs (ie sine and cosine)

Output frequency $F = \dfrac{1}{2\pi RC}$ **Hz**

To change frequency, change both R's or both C's.
Maximum frequency ∿ 20 kHz
Minimum frequency ∿ 0.016 Hz using C = 1u0, R = 10M, and TL081 op-amps
Oscillation amplitude = 2x(zener voltage + 1V2) V_{pp}

This oscillator provides two sinewave outputs with a phase shift of 90° with respect to each other, i.e: sine and cosine waveforms. The output frequency is relatively stable provided good components are used, and distortion figures below 0.1% are easily obtained.

Linear VCO



Triangle and square wave outputs

Output frequency $F = (1.667 \times 10^{-7} \times V_{IN})/C$ **Hz**

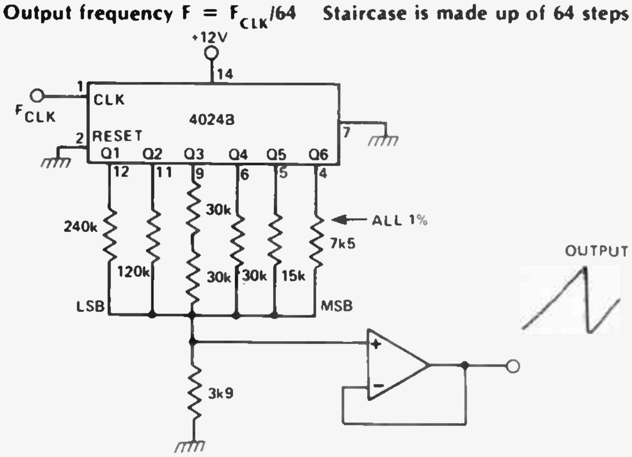
If C = 1n0 and V_{IN} **= 10V, then F = 1.66 kHz**

Changing both R's from 100k to 10k will increase F by x 10

For low frequencies use TL081 op-amps
Frequency range 0.1 Hz to 10 kHz

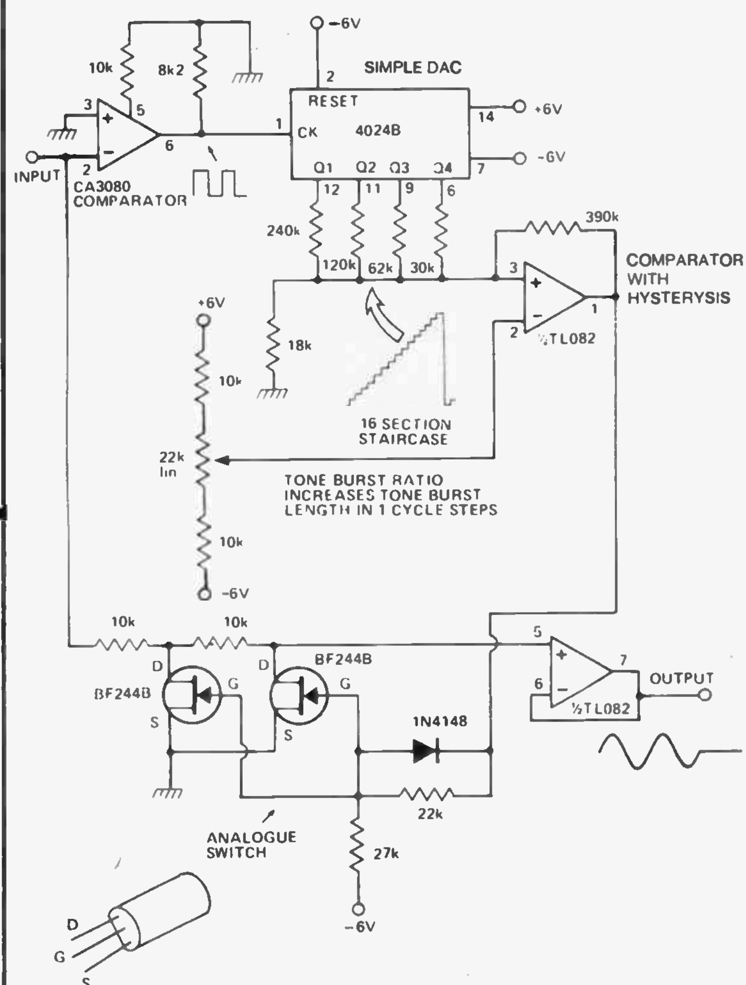
Staircase Generator

Output frequency $F = F_{CLK}/64$ **Staircase is made up of 64 steps**



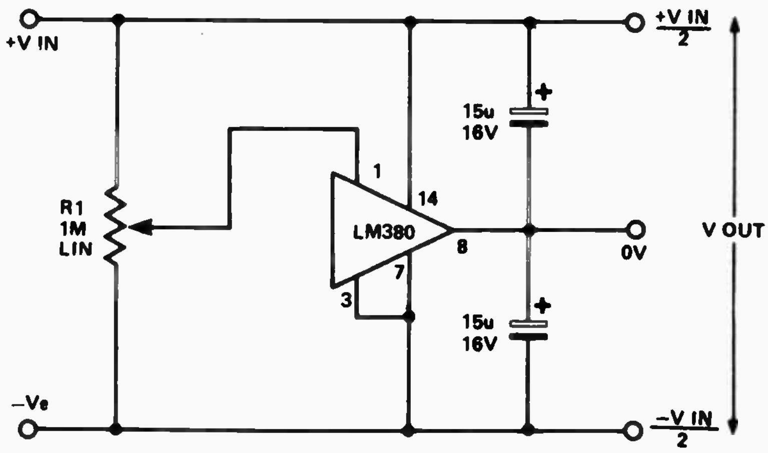
The 4024B is a CMOS seven-stage binary ripple counter. Upon receipt of a clock pulse the counter selects a combination of the resistors and increases the voltage at the output of the op-amp buffer. As with all edge-triggered devices the clock should be conditioned to have a single clean edge with a rise and fall time faster than 5 uS. The device clocks on the falling edge of the clock waveform.

Variable Length Tone Burst Generator



Input is a sinewave or any other periodic waveform, maximum level ± 2 V, maximum frequency 100 kHz
Output is a tone burst variable from one cycle on, 15 cycles off to 15 cycles on, one cycle off
All devices powered from ± 6 V

Simple dual power supply



This circuit offers a cheap and simple way of obtaining a split power supply (for Op-amps etc.), utilising the quasi-complementary output stage of the popular LM380 audio power IC.

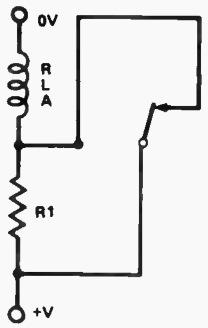
The device is internally biased so that with no input the output is held mid-way between the supply rails.

R1, which should be initially set to mid-travel, is used to nullify any inbalance in the output. Regulation of V_{OUT} depends upon the circuit feeding the LM380, but the positive and negative outputs will track accurately irrespective of input regulation and unbalanced loads.

The free-air dissipation is a little over 1 watt, and so extra cooling may be required. The device is fully protected and will go into thermal shutdown if its rated dissipation is exceeded, current limiting occurs if the output current exceeds 1A3.

The input voltage should not exceed 20 V.

Relay power saver



When power is at a premium (usually in battery circuits), this circuit can be used to save 20% or more of the power used by a relay.

Since the pull-in voltage of a relay is several volts more than its drop-out voltage, there will be no noticeable effect if a resistor is switched into circuit when the relay pulls in. This is very simple to achieve. Any contact which carries the coil voltage of the relay can be used to bypass current limit resistor R1 until the relay is energised. When power is applied to the relay, all the necessary current flows through this contact, but when the relay pulls in, the current has to flow through R1, which reduces the power drain.

The value of R1 must be determined by experimentation; try about a quarter to a fifth of the relay's coil resistance. Bear in mind that the on-load voltage of a battery decreases with use, so while a resistor may seem to be suitable with a new battery, the relay may start to drop out when the battery ages.

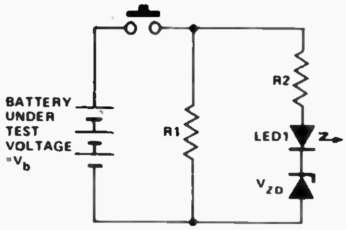
Battery condition indicator

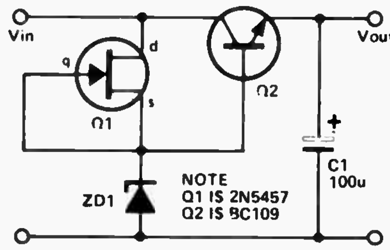
This simple circuit loads the battery under test and then checks to see if the output voltage is above 80% of its specified value. The resistor, R1, draws a steady load current (I_{load}) and the total current drawn from the battery is thus I_{load} plus I_{LED}. The zener voltage is selected so that the LED will not light when the battery voltage drops below the required value.

$R_1 = 0.8 \times V_b/I_{load}$; $V_{zd} = 0.8 \times V_b - V_{led}$; $R_2 = (V_b - V_{zd} - V_{LED})/I_{LED\ (max)}$

V_b	R_1	R_2	V_{zd}
3	270	68	0.7*
4.5	390	100	2.1*
6	470	120	3.3
9	820	180	5.6
12	1k	220	8.2
18	1k5	390	13.0

* For these low zener voltages, use one or more silicon diodes in series, forward biassed.



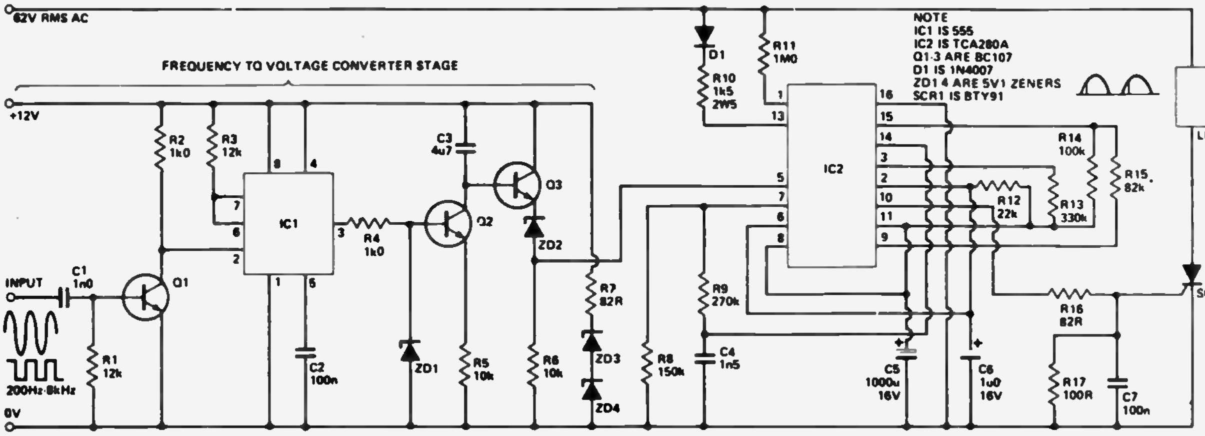


Voltage stabiliser

Here is a voltage stabiliser with good performance and low component count which will operate well, even when $V_{in} - V_{out}$ drops to 2 V. Only a few milliamps are dissipated through the zener, making it suitable for battery operated equipment.

Most circuits of this type (but with the FET replaced by a resistor) suffer from zener saturation when V_{in} is getting low, or in excessive zener current when V_{in} is high.

Actual component values can be varied to suit individual applications.



Frequency-To-Phase Controlled Power Supply

The circuit shown in the diagram was initially designed to obtain a phase-controlled power supply to use with a ¼ horsepower stepping motor. The phase angle can be varied over the complete cycle period and is dependent on the *frequency* of the input. Clearly the circuit can be used to control resistive loads such as lamps or motors.

The first stage of the circuit consists of a frequency-to-voltage converter. C1, R1, and Q1 effectively differentiate and amplify the input signal waveform to provide triggering pulses for the 555 timer, which is used in the monostable mode. The output of the monostable is used to charge C3 by a constant amount of charge every time a pulse is received at the base of Q2. The voltage across C3 acts as an input to the common collector stage formed by Q3. The voltage across C3 is DC-shifted by means of the zener diode ZD2 to a suitable value, providing the input to the trigger IC (the Mullard TCA280A). The TCA280A provides the phase control signal for the gate of the thyristor.

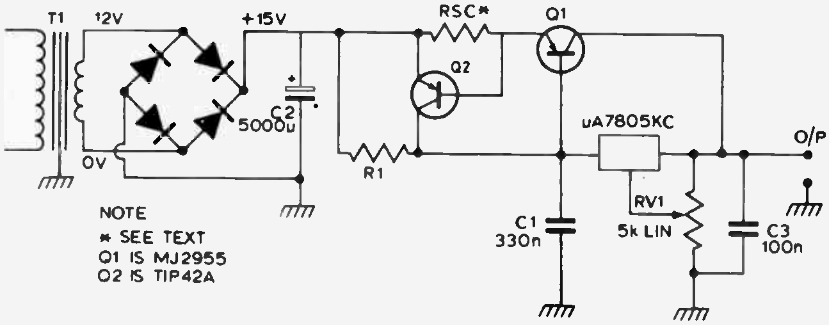
A triac may be used in place of the thyristor, if phase-controlled AC is required.

The component values shown are suitable for providing phase control using frequencies in the range 200 Hz-8 kHz on the control input. The firing angle can be varied from 0° at 8 kHz to 170° at 200 Hz.

High current regulator

This circuit can supply 10A at 5V which falls to about 8A at 15V, (make sure your transformer can take it!). The circuit is fairly straightforward. Most of the output current flows through Rsc and Q1 (less than 1A flows through the e-b junction of Q1. Voltage is regulated by the μA7805 and controlled by RV1, giving a variation from 5V to 15V.
Output current is limited by Rsc and can be calculated from

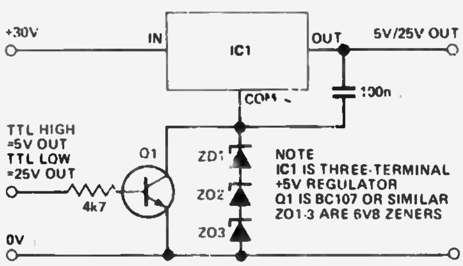
$$Rsc = \frac{0.9}{I\ max}$$



For currents greater than 5A, Q1 should be mounted on a heatsink. Q2 and the regulator should run cold (if not there's something wrong!).

Switched supply for EPROMS

While developing an EPROM programmer for my computer, the need arose for a circuit which would supply +5 V or +25 V stabilised to the programming pin on a 2716/2732 EPROM, selected by a TTL level signal on an output port. After trying various sorts of transistor switches (all of which suffered from an unacceptable voltage loss), the following simple circuit was evolved. The transistor shorts out the zener diodes when it is turned on by a high level (greater than 2V4) signal at the input. Under these conditions, the regulator has its common lead virtually



at ground, so it produces +5 V at its output.

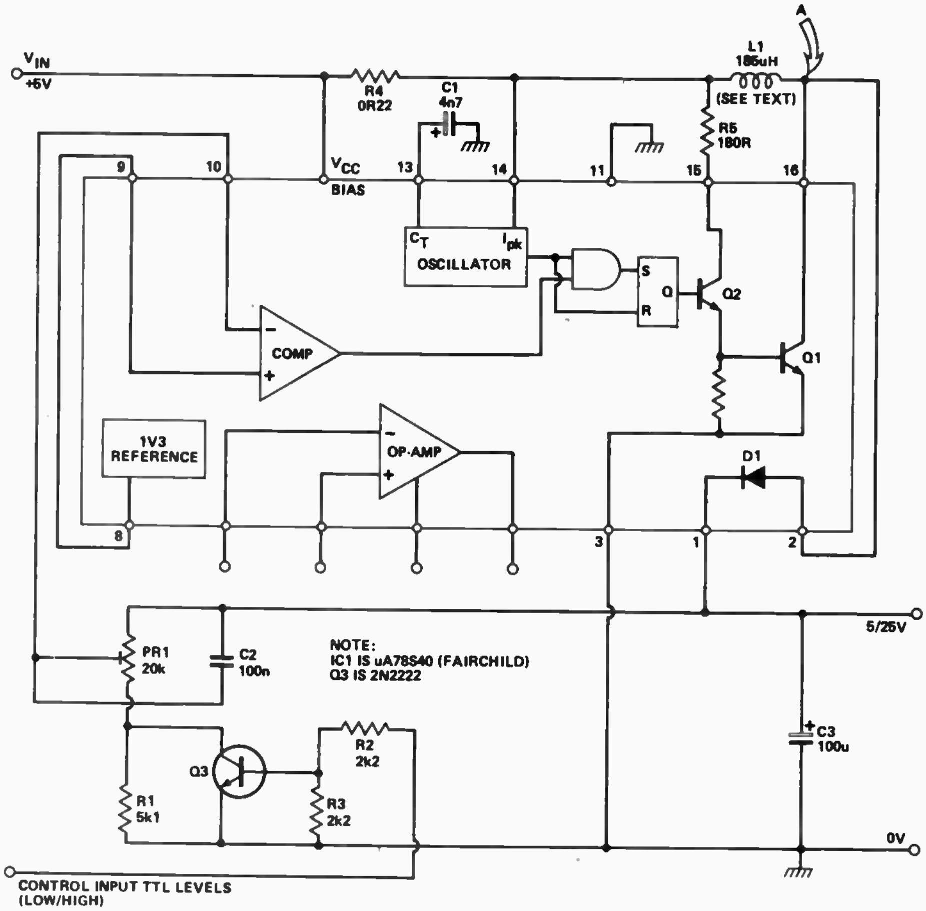
With a TTL low signal at the input (less than 0V7), the transistor turns off, the zeners conduct, and about 20 V appears at the regulator common terminal, producing +25V at its output. As the programming current to an EPROM is only a few milliamps, dissipation in the regulator is not a problem when it's producing 5 V; if other uses are envisaged, however, this point should be considered. It would be possible with suitable choice of zeners to use a number of transistors to digitally switch more than two voltages, in other applications.

5 V to 25 V Switched Mode PSU For EPROM Blowing

The circuit shows the application of a Fairchild 78S40 switched mode power supply chip used to generate a 25 V or 5 V (binary selectable) V_{pp} input to a 2716 type EPROM. The supply was designed to be quite small and compact so that it could fit onto a single card EPROM programmer. All the necessary power input requirements were satisfied by a single 5 V V_{cc} input; this circuit will therefore eliminate the need for a transformer derived 25 V supply and the additional supply distribution on an already overcrowded microcomputer backplane.

The 78S40 is designed into a 'step up' circuit configuration. The output is derived from pin 1 of the IC, the cathode of the internal charge pump diode D1, to a reservoir capacitor C3. When the internal transistor Q1 is turned on, current flows through inductor L1 causing energy to be stored in the magnetic flux around the windings; the charge pump diode is reversed biased when Q1 is conducting. When Q1 turns off the magnetic flux collapses, inducing a positive voltage at node A. If this node voltage exceeds the voltage on the positive plate of capacitor C3, D1 will conduct and the capacitor will charge to a more positive potential. To regulate the output voltage it is necessary to control the switching of Q1. This is achieved by tapping V_{OUT} so V_{OUT} will rise to +25 V. When off, feedback is increased and the output will fall to +5 V. To set the output voltage range it is necessary to adjust the multiturn cermet type trimpot, PR1. This should be done off load because high voltages can be generated if the feedback has been initially set up incorrectly. The CONTROL input may be CPU-

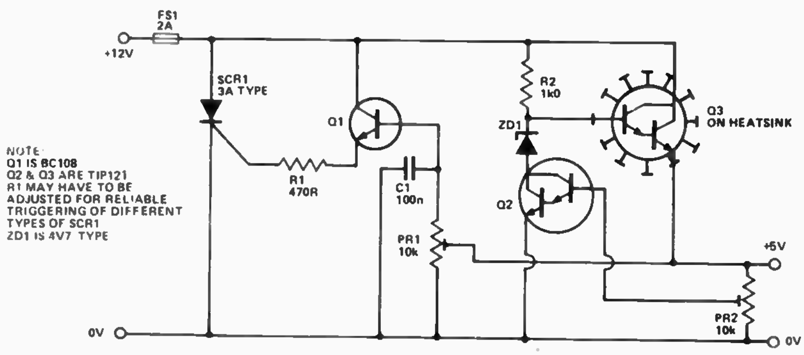
Regarding the performance, the circuit provides an excellent stabilised output of 25 V for loads requiring up to 75 mA. The +5 V supply does exhibit 500 mV of switching ripple, but superimposed on a mean 5 V DC level this will not violate the static input requirements of the 2716's V_{pp} input. The conversion efficiency of the entire supply was about 60%.



5 V TTL Supply

The circuit shown was designed to eliminate expensive accidents with TTL caused by inadvertently turning up the knob on the (heavily smoothed) train controller normally used as a bench PSU. It is provided with crowbar protection just in case, though.

Power Darlington Q3 is biased to just over 5 V by ZD1 and Q2 (this does not have to be a Darlington, although the output will not be as stable if it is not). Any change in output voltage is sensed by Q2 and it adjusts ZD1's reference level accordingly. Any change in input voltage is adjusted by normal zener operation. The output level may be set using PR2 and it will remain fairly stable (±0V5) for a change in input from 8 V to 12 V. If, for some reason, the output voltage should rise above the preset level to, say, 6 V, SCR1 will be triggered and the fuse will blow. This trigger level may be set by PR1. C1 reduces the (extreme) sensitivity to noise. SCR1 is not critical, but it should be capable of sinking the required current.



240 V To 120 V Converter For Resistive Loads

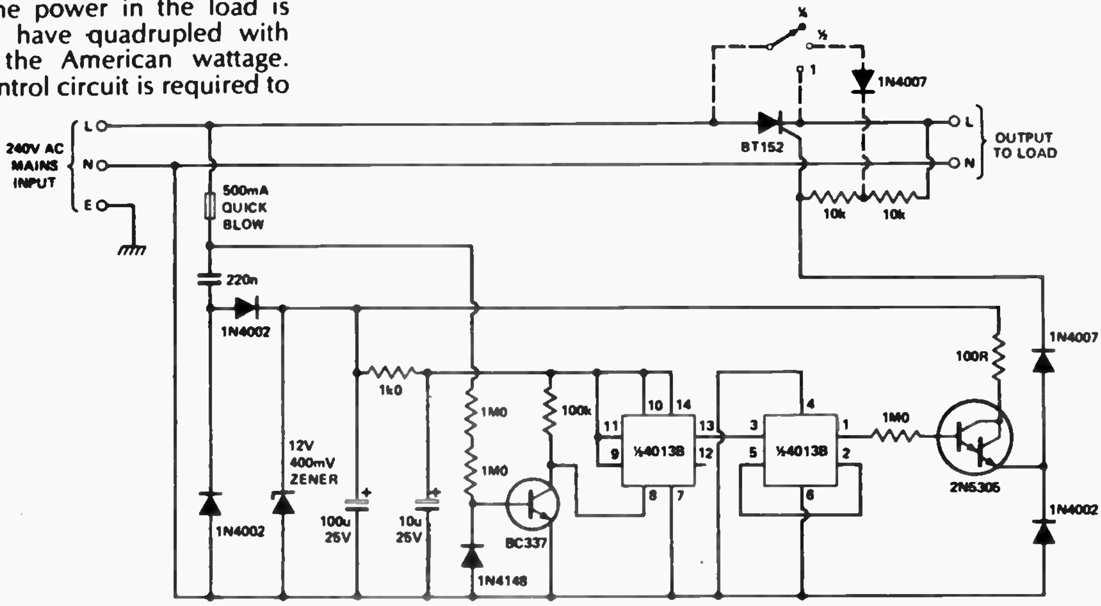
A friend visiting the USA has brought back with him a percolator and an electric stewing pan, both for 110 V operation, rated at 600 W and 1.2 kW respectively. He was under the impression that a small transformer would do but this, of course, was not practical and the solution had to be electronic.

Since the power in the load is V^2/R it will have quadrupled with respect to the American wattage. Thus the control circuit is required to produce one half-cycle in every two mains cycles, using a thyristor. Switching at the zero-crossing point of the mains cycle eliminates the need for RFI suppression.

The circuit consists of a 12 V 50 Hz square wave shaper, this being a BC337 transistor followed by one flip-flop within a 4013 CMOS IC. The signal is then divided by two, using the other flip-flop of the IC, producing a 25 Hz square wave which is further buffered by a 2N5305 Darlington transistor. The latter drives the thyristor, a BT152. Note the two 1M0 and two 10k resistors in series; this combination overcomes the resistor voltage rating limitation.

Power to the logic circuit is provided by means of a diode pump. The 220n pump series capacitor is effectively connected across the mains and it should have a corresponding voltage rating (250 V AC suppression capacitor).

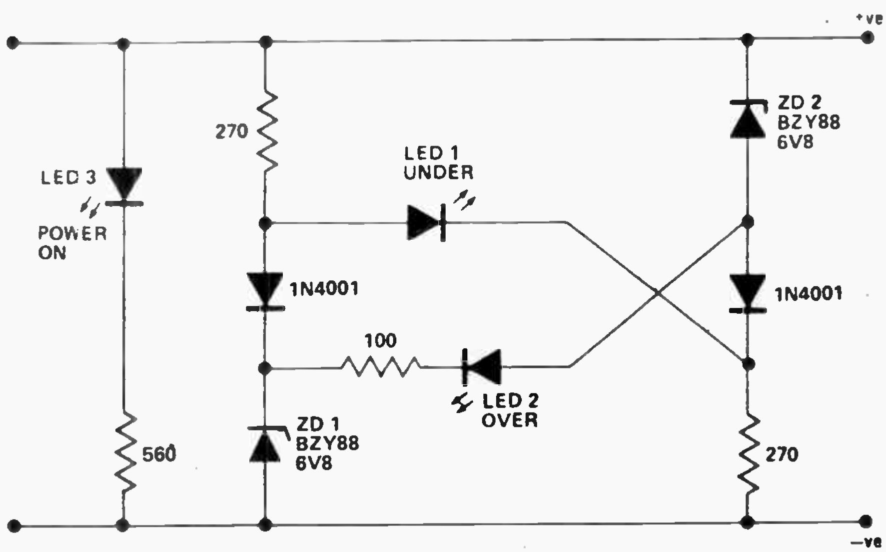
The circuit was tried with resistive loads of up to 1.5 kW. A further application would be to control resistive loads rated for 240 V AC operation (eg a 1 kW bar heater) to full, half or quarter power. This can be done using the additions shown in dotted lines.



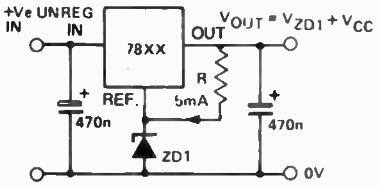
Supply telltale

Here is an idea for supply voltage monitoring, in the form of a voltage monitor for 12V supplies, indicating both over or under tolerance voltages. Using three LED's the user can see at a glance whether power is on, over-voltage or under-voltage.

This is achieved by means of a balanced bridge that uses zener diodes ZD1 and ZD2 in the bridges opposite arms and back-to-back LED's between the mid-points of the bridge arms, if the input voltage does not exceed the two zener breakdown voltages (2 x 6V8 = 13V6), LED1 lights but above 13V6 LED1 becomes reverse biased and remains off when the input voltage increases to the extent that at the junction of ZD2, it exceeds the zener voltage of ZD1, plus the LED voltage of 1.6V, then LED2 is turned on, with resistor 100R limiting the current through the LED. Note total drain of unit is about 50 mA.



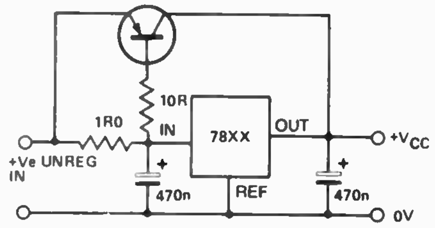
Increasing Regulator Voltages



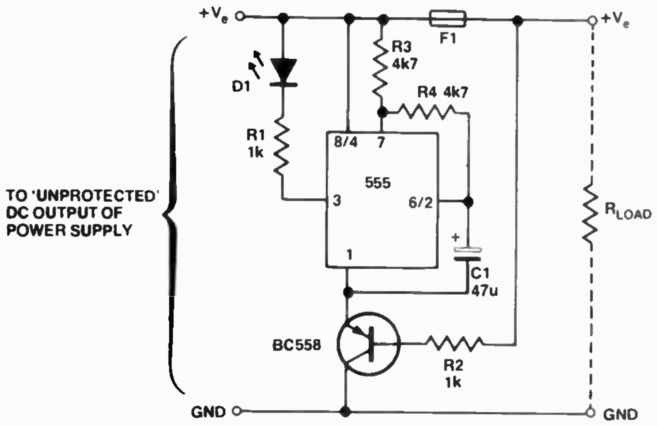
Increasing the output voltage using a zener diode.

The output voltage of three-terminal voltage regulators can be increased by increasing the voltage on the reference or common lead on the regulator. This can be done as shown in the circuit diagram with the use of a zener diode. The resistor R should be selected to ensure sufficient current through the zener for a stable voltage reference.

Increasing Regulator Currents



Using a bypass transistor to increase the output current drive. The first 600 mA flows through the regulator, the rest via the external transistor.



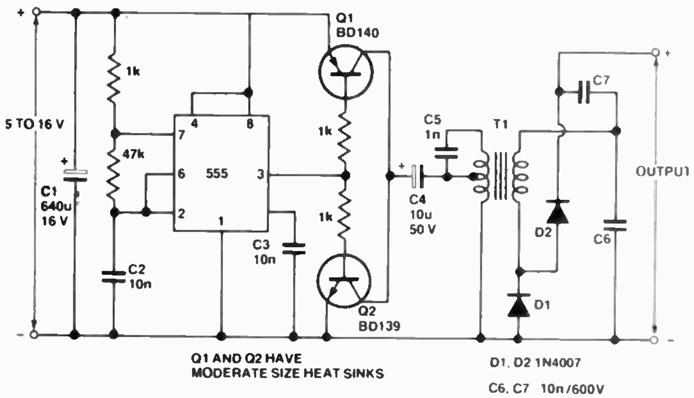
Fuse fail indicator

R.N. Sinclair of Coogee NSW sent in this circuit which indicates an open circuit fuse by flashing the LED D1.

The circuit is based around the popular 555 timer IC which is arranged as a multivibrator with its frequency/period determined by C1, R3 and R4. R1 is the current limiter for D1.

When the fuse is intact, the BC558 is off but when the fuse fails and there is an open circuit the BC558 switches on, supplying power to the input of the 555 (pin 1). A load must be present to switch the transistor on and consequently the LED.

The fuse fail indicator must not be used when the power supply is greater than 15 V.



Cheap, high voltage low current dc-to-dc inverter

Alec Phillips of Myrtleford Victoria designed this circuit, without a special inverter transformer, when he needed a high dc voltage from a low dc voltage supply. It cost him about $7.

The 555 IC drives Q1 and Q2 alternately. Q1 charging via the transformer and Q2 discharging C4 into the transformer. C5 reduces power consumption and increases the output voltage. The output is fed into a voltage doubler and, with a 15 Vdc supply, the output can exceed 600 V. D1 and D2 must be 1 kV, 1 A diodes.

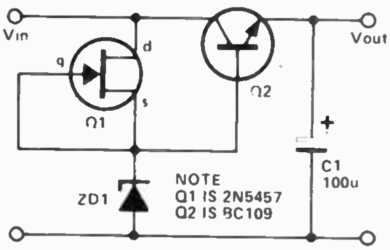
The transformer is a 12.6-0-12.6 V, 150 mA type. The oscillator drives the centre tap of the primary low voltage winding and the output is from the 240 V end.

Q1 and Q2 must be on a heatsink of moderate size.

If higher output voltages are required, just add more voltage doublers, but obviously it will handle a smaller load on the output. The circuit will operate at input voltages ranging from 5 to 16 volts.

Voltage stabiliser

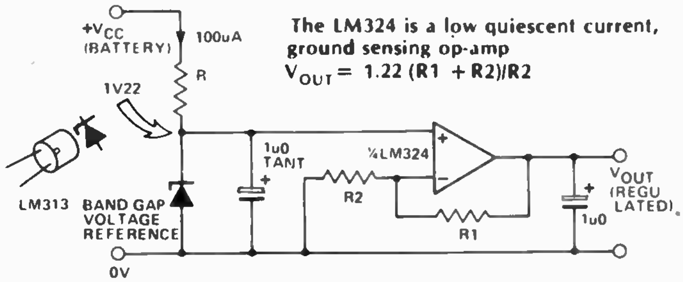
Here is a voltage stabiliser with good performance and low component count which will operate well, even when $V_{in}-V_{out}$ drops to 2 V. Only a few milliamps are dissipated through the zener, making it suitable for battery operated equipment.



Most circuits of this type (but with the FET replaced by a resistor) suffer from zener saturation when V_{in} is getting low, or in excessive zener current when V_{in} is high.

Actual component values can be varied to suit individual applications.

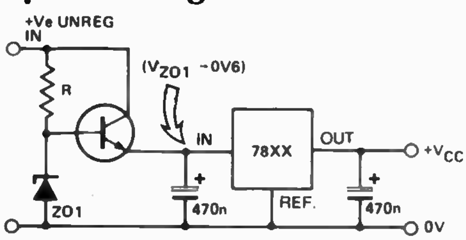
Low Current/Precision Supply



The LM324 is a low quiescent current, ground sensing op-amp
$V_{OUT} = 1.22\,(R1 + R2)/R2$

This circuit is useful whenever a precision voltage reference is necessary or as a low current, well-regulated supply. The value of the resistor R is calculated from the battery voltage to ensure around 1 uA through the LM313. Use the equation R = V_{cc} x 1000 ohms.

Low Dissipation Regulator

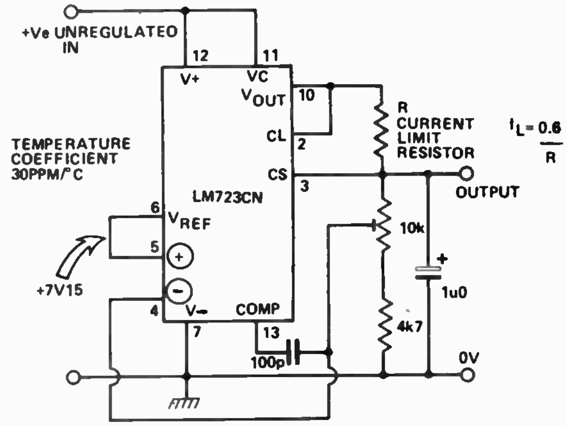


The three-terminal IC regulator is probably the most-used integrated circuit, offering a simple and effective solution to the problem of power supply design. These devices, however, have a maximum input voltage of around 35 V (40 V for some). The circuit shown here enables the regulator to function from a higher supply voltage by dropping the excess voltage across an external transistor. You should ensure that the voltage drop across the transistor is within the capabilities of the particular device used. The zener diode ZD1 sets the voltage that appears at the input of the IC regulator. (The actual voltage will be ZD1-0.6). The resistor R should be selected to ensure adequate current through the zener diode so that it will provide an effective voltage reference for the pass transistor. This is determined by the maximum power dissipation of the zener. Set the required power dissipation for the zener at about half its maximum rating then calculate the required zener current from Ohm's law; i.e: I = P/ZD1. The value of the required resistor is then given by R = (V e−ZD1)/I.

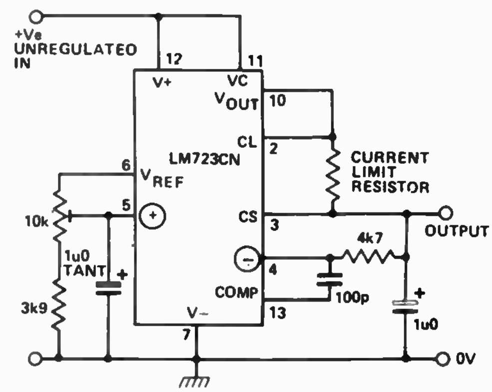
The circuit can also be used to decrease the power dissipation in the IC regulator. These require an input at least 2 - 3 volts above their rated output voltage. If this voltage is set by the zener the remainder of the power dissipation will be done by the pass transistor. Once again, ensure that the maximum power dissipation expected of the transistor is within its capability. If the device becomes excessively hot an additional heatsink should be used.

Precision Power Supplies

723 general specifications:
Maximum input voltage = 40 V
Maximum current output = 150 mA
Output voltage range = 2 to 37 V



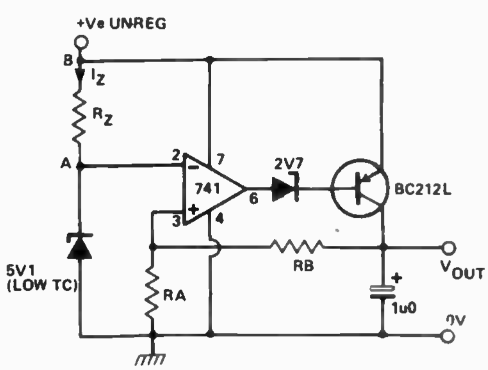
Adjustable +7 V to +21 V

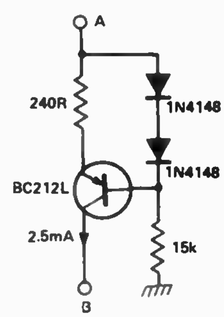


Adjustable +2 V to +7 V

The 723 is a precision, variable voltage regulator. Output voltage is adjusted by the 10k preset and a current limit can be set by a suitable choice of resistor R.

Battery Regulator





Better regulation can be obtained by replacing RZ with this 2.5 mA current source. However, the unregulated supply rail must not drop below (5V1 + 1V2) = 6V3

Select R_Z for an I_Z of about 2.5 mA

V_{OUT} = 5V1 X (RA + RB)/RA

Minimum $V_{OUT} \sim 6V$

Dropout voltage = V_{CE}(Q1 saturated) ∿ 0V3

Keep I_{OUT} less than 50 mA

A very low dropout voltage can be obtained by allowing Q1 to saturate. This gives maximum lifetime on battery power.

Simple UHF antenna

A simple, make-in-an-afternoon antenna from scrounged parts.

THE ARRIVAL of UHF translators on the Adelaide scene offered new hope for the 10% of viewers in poor locations. The translators are grouped on top of the Grenfell Centre, a 28-storey building in the city centre, and the antennas are aimed to give about 180° coverage to the foothills area. About this time we graduated from a 12" B&W to 14" colour TV — with UHF tuner, naturally — and although we have line-of-sight to the main VHF towers about 15 km away, we now had glorious colour ghosts, courtesy of a large, steel-clad factory about 600 m away. Hence the desire to try UHF. Figure 1 shows the problem!

Some careful study suggested a corner reflector would do the job, needing a reflector about 300 x 1000 mm. Alas, the nearest piece of junk was a punched metal sheet 300 x 900 mm. Reference to the RSGB UHF handbook revealed a version known as the 'trough' and away we went.

Figure 2 shows the theoretical sizes of the 'corner' and the 'trough'. Punched or expanded metal is recommended to reduce wind loads on the antenna.

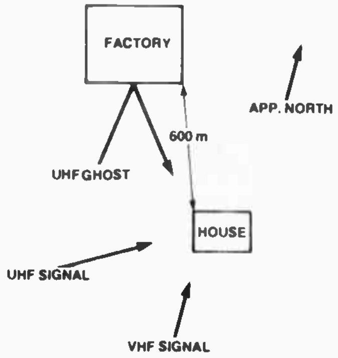


Figure 1. **A nearby factory brings UHF ghosts!**

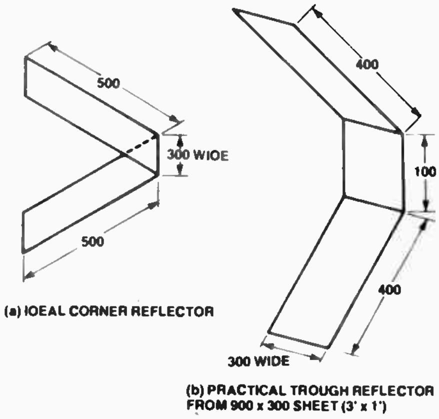


Figure 2. **'Corner' and 'trough' reflectors. Apex angle in both cases is 45°.**

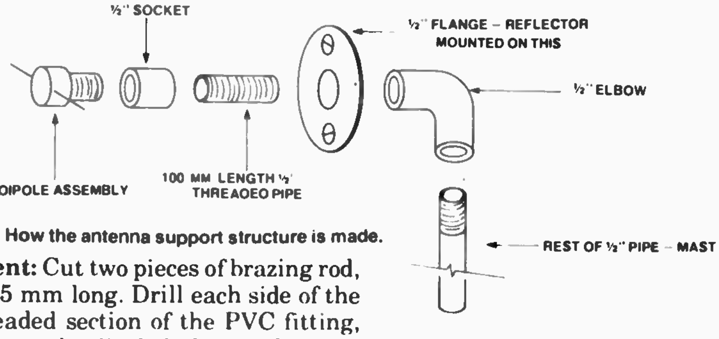


Figure 3. **How the antenna support structure is made.**

Parts List

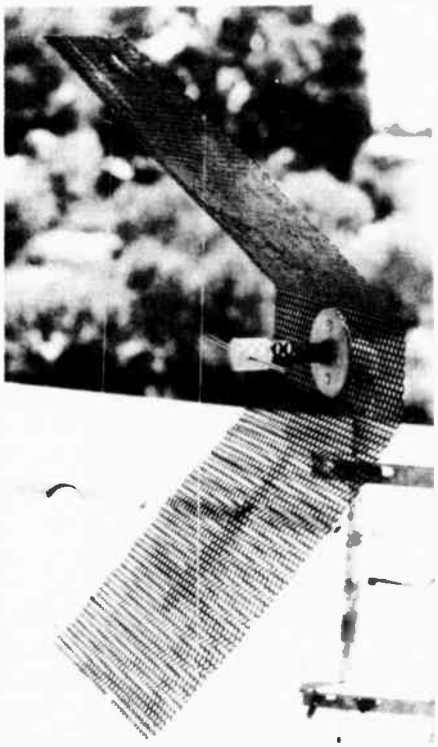
The following was all scrounged from my shed:

- at least 600 mm of ½" galv. waterpipe.
- ½" galv. socket.
- ½" galv. flange
- ½" galv. elbow.
- ½" PVC connector — PVC pipe to threaded ½" male.
- about 200 mm of 3/16" brazing rod.
- 300 x 900 mm of punched or expanded metal sheet.
- 75 ohm coax
- auto body filler — two-part polyester.
- Superglue — a few drops.
- 2 x 3/16" gutter bolts.

Reflector: The 900 x 300 mm sheet of punched metal is bent up 45°, 400 mm from each end, to form the reflector 'trough'. Cut a clearance hole, about 20 mm diameter in the centre to pass the ½" pipe through. Drill and bolt the reflector to the ½" flange.

Support: Cut a thread onto the ½" pipe about 120 mm long. Cut off 100 mm of the threaded pipe using a few drops of Superglue, or wrap pipe thread tape on pipe to lock the flange.

Element: Cut two pieces of brazing rod, each 95 mm long. Drill each side of the unthreaded section of the PVC fitting, and insert the dipole halves. Solder the coax feedline to the dipoles, set up so that a 10 mm gap exists at the feedpoint, and fill the PVC fitting with auto body filler and allow to set. Push the feedline through the pipe and screw the dipole into place.



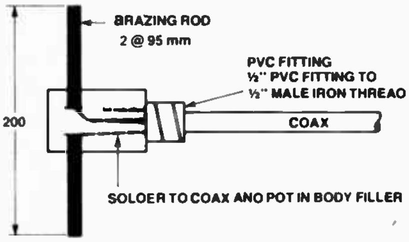


Figure 4. **Construction of the dipole.**

Install the complete antenna on your choice of mounting — chimney, barge or whatever.

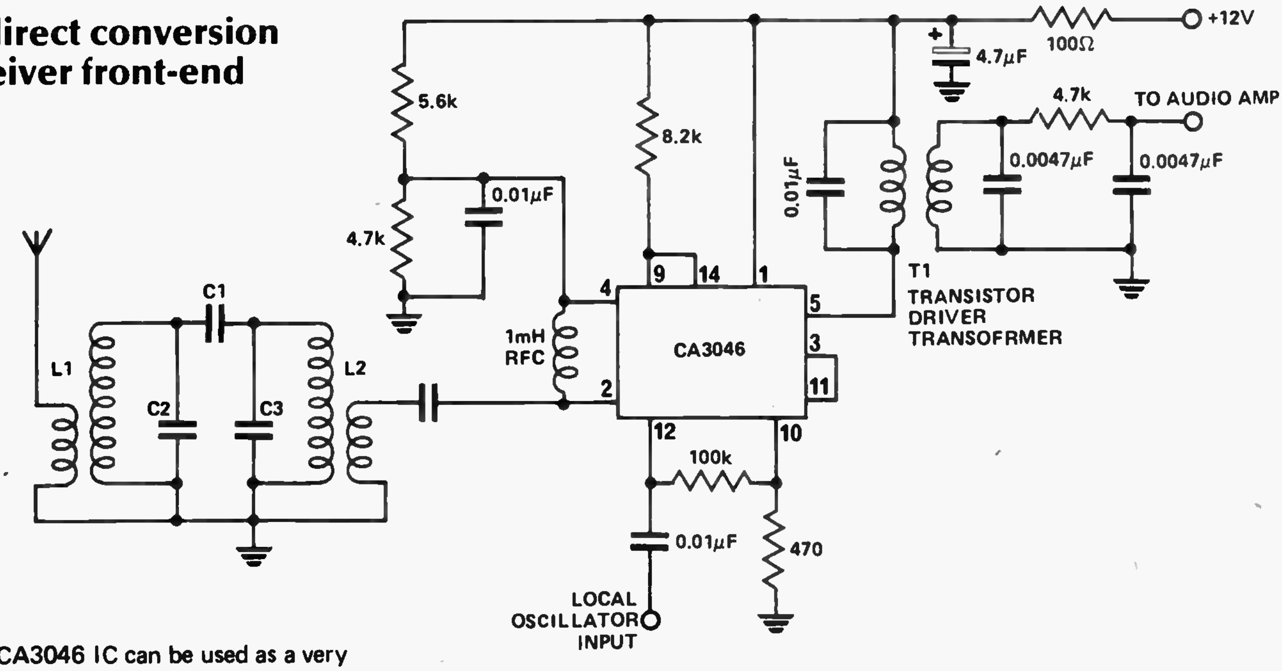
Results

The antenna has been in use since September '80, and no problems have been evident. The actual installation is aimed at a point halfway between the commercials and the local ATV repeater, and all signals are rock solid and free of ghosts.

The range to the commercials is about 10 km, the ATV repeater is 25 km away, and the lines are 12° apart. There is a large gum tree plumb centre in the sight line to the commercials!

All dimensions are derived from ARRL and RSGB formulae, and are tailored to cover from channel 34 (ATV) to channel 52.

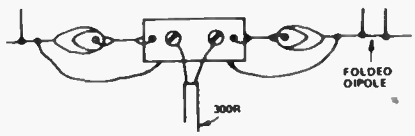
IC direct conversion receiver front-end

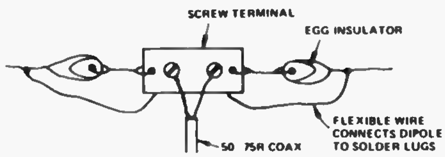


The CA3046 IC can be used as a very efficient mixer in a direct conversion receiver front-end. Some buffering and amplification of the local oscillator is provided and the mixer has a small amount of conversion gain.

The input tuned circuit can be made to suit the desired range. Cl is a coupling capacitor that determines front-end selectivity. For 3.5 to 4 MHz, L1 and L2 are 13 turns of #26 B&S enamel wire wound around 2/3 of a Philips toroid type 020-91010. C2 and C3 are 33 pF capacitors parallelled by 3-30 pF trimmers. C1 is 15 pF or larger for more bandwidth.

Simple dipole connector

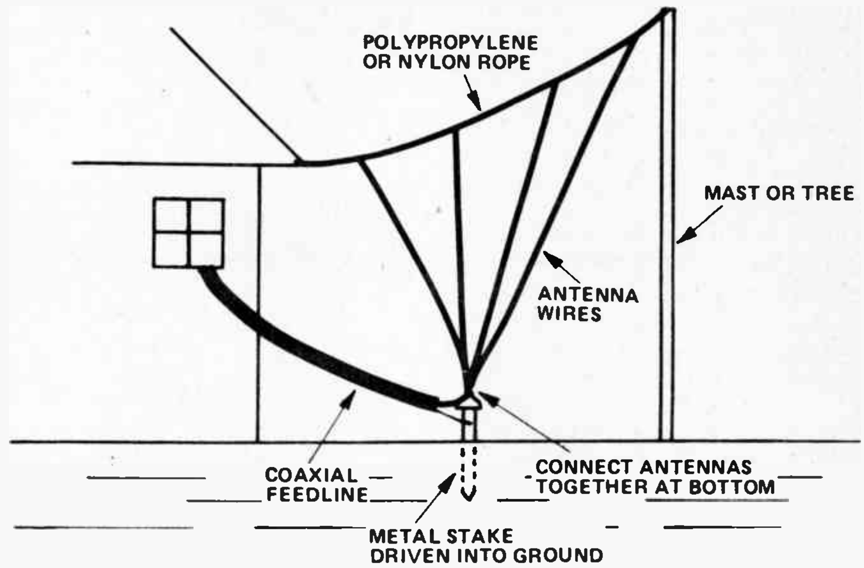




This idea may save you a bit of cash. It comes from G. Armitage of Melbourne.

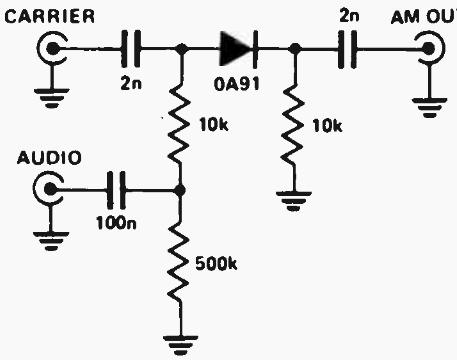
Those cheap two-way screw connectors made out of a bit of cardboard or plastic with a couple of terminals screwed into them can be used as centre connectors for dipoles. The egg insulators take the strain off the solder connections. They can be tied to the connector using a bit of string or nylon rope. The flexible wire shown connecting the dipole to the solder lugs should be included in the dipole length.

Simple effective short-wave listening antenna



The simple shortwave listening antenna illustrated here is inexpensive and very effective. A poly-propylene or nylon rope is strung between a high support such as a suitable erected mast or perhaps a tree, and a low point such as the edge of a house roof or a fence. Keep the low end above head height or away from where people can walk. Four odd lengths of hookup wire are attached to the rope at different points prior to putting the rope up. Lengths are not too important. At a convenient point below the rope a metal stake is driven into the ground for several feet. On the above-ground end is mounted an insulator to which are tied the ends of the antenna wires, the ends being connected together. A ceramic cone insulator or something similar is good. A piece of bakelite or fibreglass is also suitable. A coaxial feedline is connected with the centre conductor to the ends of the antennas and the outer braid connected to the metal stake which acts as a ground.

All-round modulator



A very handy device around any hobbyists workshop or serviceman's bench is a simple modulator. For aligning IF amplifiers, receiver front ends etc – especially with only basic test instruments, it's a must.

Reader, G.J. Armitage of Melbourne Vic, sent this circuit in. A common signal diode is used as a 'mixer'. You'll need to drive the audio input with more signal than the RF input to get good modulation depth.

The circuit will work across a very wide frequency range, from very low frequencies to well into the VHF region. The diode can be any germanium signal diode, such as OA90, OA91, OA95, OA202 etc. The RF drive will need to be around several hundred millivolts.

A silicon signal diode, or a hot-carrier, diode may be used, but you'll need around half a volt of RF drive.

Constructed in a small shielded container, with coax input and output connectors (RCA connectors are good), prevents radiation of signals and a switched attenuator may be connected on the output.

The circuit may also be used as a product detector. BFO injection should be fed in the 'Audio' input and the resultant audio taken from the output (add a 'pi' RF filter using two 1n capacitors and a 1nH RF choke).

'Broadcast Booster' for AM band DXers

Here is an inexpensive method of providing some receiver front end selectivity and signal boosting for transistor AM receivers, an idea passed on by **Paul Spresser of Ipswich, Queensland**.

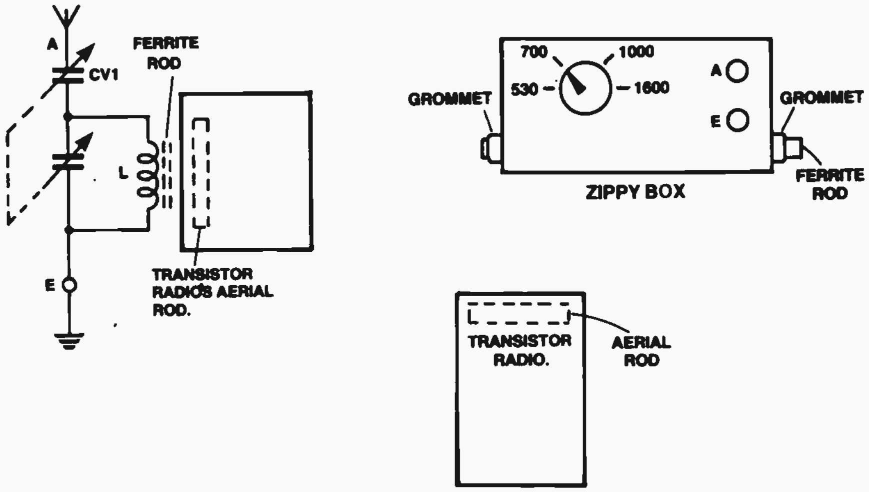
The unit is comprised of a ferrite rod (like those generally used for transistor radio antenna coils) with a coil-cum-antenna wound on it, tuned by a dual-gang 'broadcast' capacitor. The ferrite rod and coil acts as an inductive 'link' to the transistor radio's loopstick antenna. Construction is fairly non-critical. Using a ferrite rod around 150 mm or so long by 9.5 mm diameter, wind 50 to 60 turns of 20 gauge insulated wire (exact gauge is unimportant, but nothing thinner than, say, 26 gauge) onto the ferrite rod — not too near one end. Secure the coil with insulating tape. This can be mounted in a plastic zippy box as shown in the drawings, along with the dual-gang capacitor. This capacitor should have a maximum capacitance of around 400 pF.

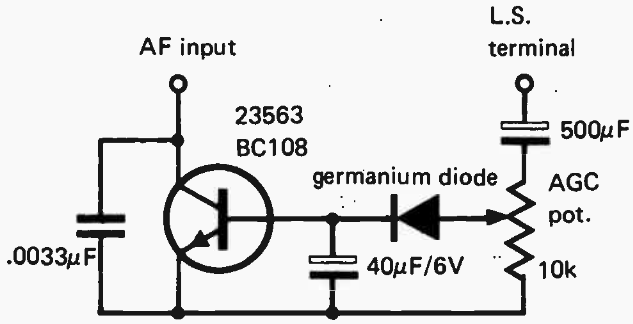
For best reception, connect up a good 'ground' and a long wire antenna, at least six metres long. Place the transistor broadcast radio with its loopstick antenna aligned parallel to the ferrite rod and reasonably close to it (about 30 mm), tune in a station and tune the dual-gang capacitor for best reception. Further improvement can be made by increasing or decreasing the coupling between the booster and the transistor radio.

If the station tuning on the booster is crowded toward the minimum capacitance end of the dial, take a few turns off the ferrite rod coil. If the station tuning is crowded toward the other end, add a few turns.

This booster improves front end selectivity and image rejection quite noticeably. Adjacent stations can generally be adequately separated, although both will be heard.

If you mount the booster in a zippy box having a metal lid, connect the lid to the circuit earth. Banana sockets make good aerial and earth connectors.



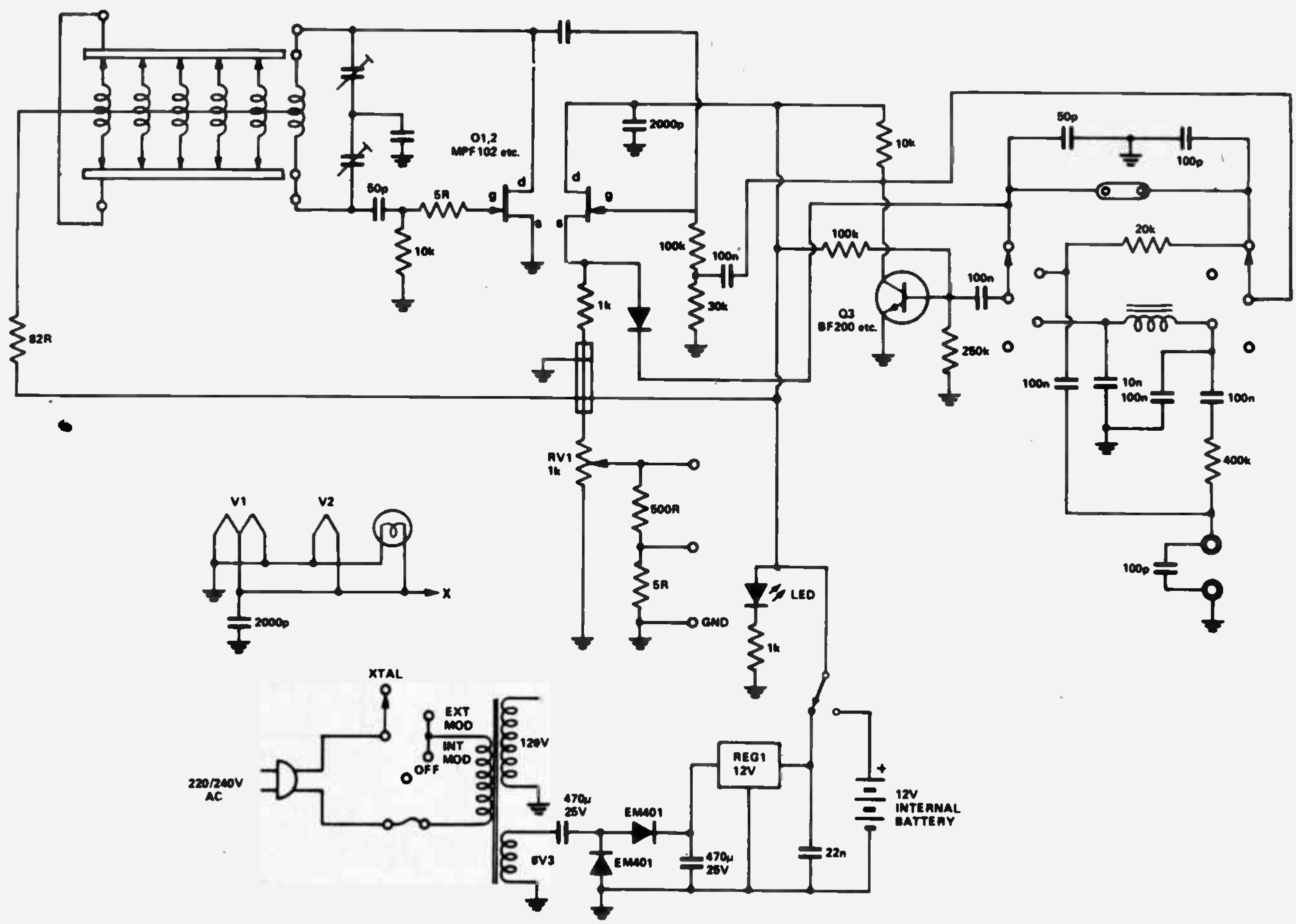


Simple AGC

Audio derived automatic gain control is one of the simplest methods of obtaining signal compression in a radio receiver. It is of particular value with short wave receivers used in areas where deep fading is prevalent.

The simple circuit shown here requires a minimum of components and may be used with both valve and transistor receivers.

In use, the main volume control should be set for the desired signal strength whilst the radio is tuned to a weak station, the radio is then tuned to a strong station and the AGC potentiometer adjusted to a comfortable listening volume.



Solid state conversion of the TD20D RF Generator

One of the most common pieces of test equipment sold in this country is the TD20D RF signal generator. The instrument can be made battery operated for portable use and an improvement in stability gained by replacing the two valves with solid state components. This technique was very popular about 10 years ago to improve the performance of the older valve communications receivers.

The circuit shows the modifications. The 12BY7 has been replaced with a pair of MPF102s (or similar FETs) and the 6AQ5 with a BF200 or similar bipolar transistor.

The high voltage power supply has been dispensed with and the power is taken from the 6.3 V heater winding through a rectifier and regulator, or an internal battery. The panel lamp has been replaced with a LED.

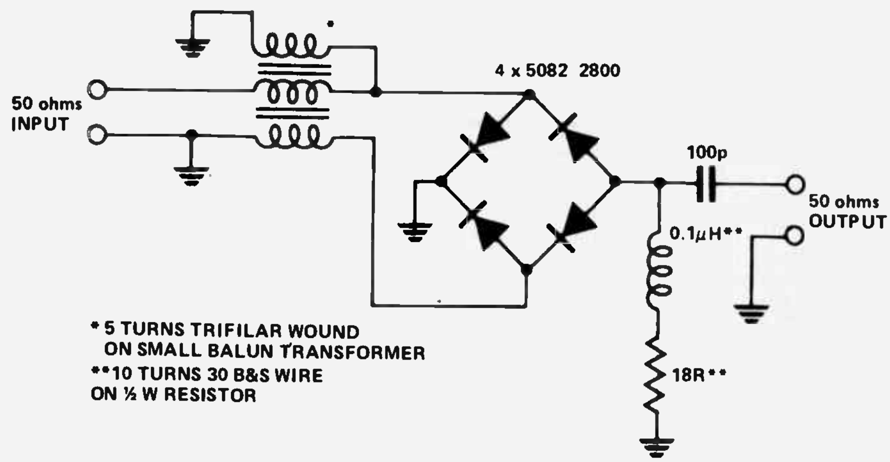
This note comes from **Richard Hannam of Townsville, Qld.**

Frequency doubler

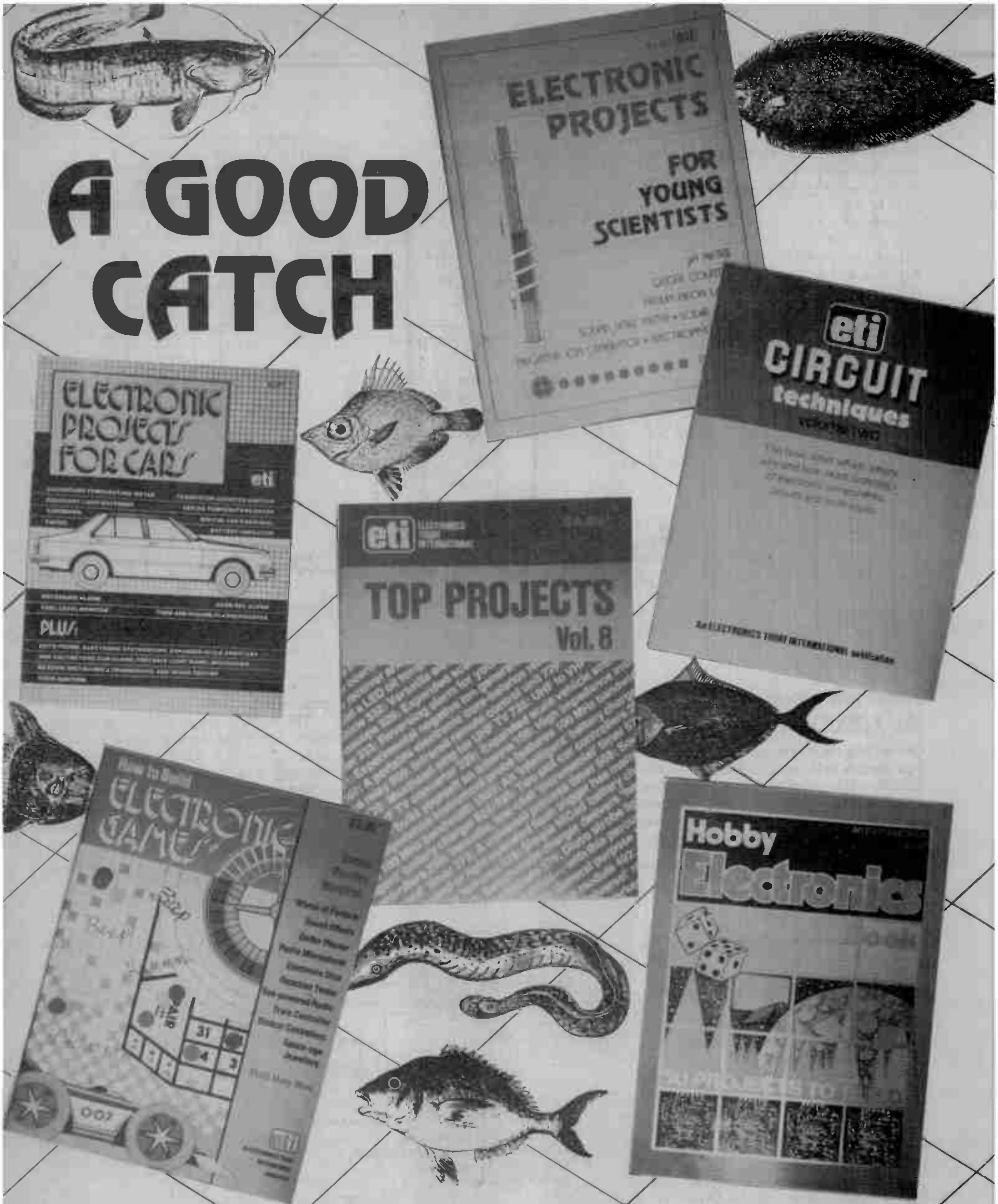
This circuit from staff files can be used to double the frequency of an RF signal generator. A generator with a top range of say, 100 MHz, can be used to provide signals of up to 200 MHz. Fundamental, third and fourth harmonic are about 20 dB or more below the second harmonic (desired) content provided the diodes are all well matched.

Input and output impedances are around 50 ohms. All wiring should be as short and direct as possible. The whole circuit may be mounted in a short piece of tube with a BNC connector on each end.

This could also be used in an oscillator/multiplier chain and for VHF/UHF converters or transverters and would most likely be followed by some sort of tuned amplifier.



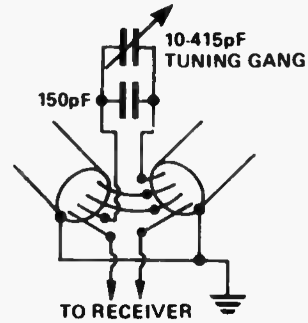
A GOOD CATCH

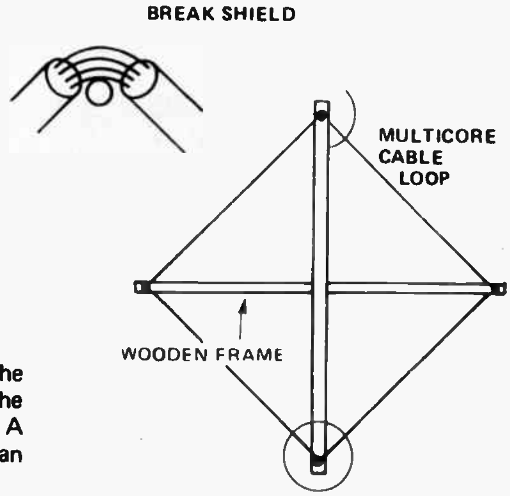


Available from newsagents, selected electronic suppliers or direct from ETI Magazine, P.O. Box 227, Waterloo NSW 2017. Please add $1.00 for post and handling if buying by mail order.

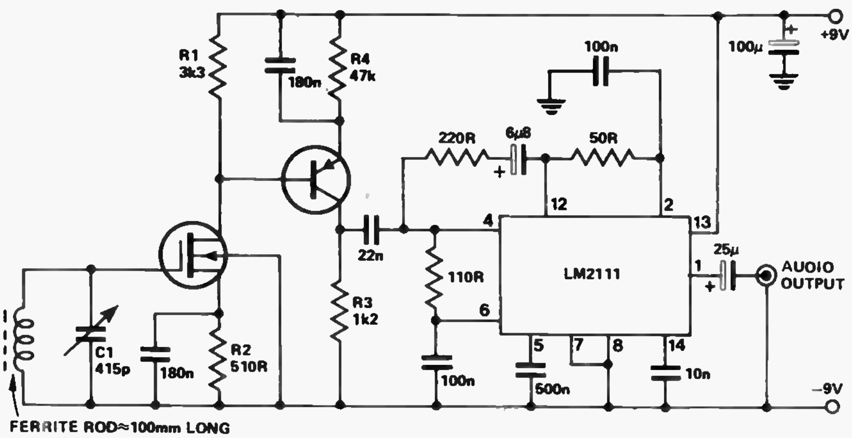
Broadcast band loop antenna

A loop receiving antenna is useful when receiving broadcast-band signals from a distance where interference is a problem. A multicore shielded cable is used to make up a shielded loop with a number of the wires connected in series to form a multi-turn loop which is tuned as shown here. One wire is left to serve as a coupling loop. The cable shield is broken at the top, as shown, but connected together at the feedpoint down at the bottom. For balanced input connect the single turn to the receivers. Earth one end of the single turn and the shield for unbalanced input. This shield should be earthed and connected to the receiver chassis at all times. The antenna exhibits a sharp null in the direction of the plane of the loop. A multicore cable having more wires can be used if so desired.





Synchrodyne tuner

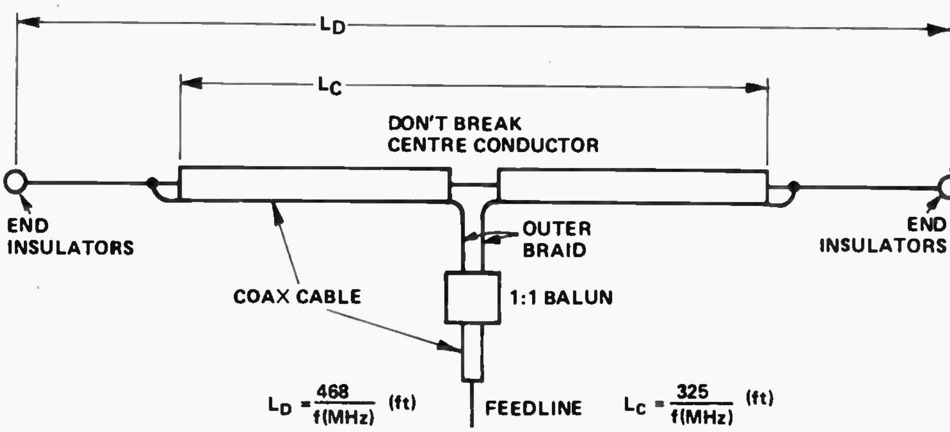


The main component of this design, from H. Lee of Vaucluse NSW, is the integrated circuit which can be any of the many types of FM detector and limiter chips such as LM 1351, MC 1351, LM 1841, ULN 2136A, LM 2111, ULN 2111A, LM 2113 and ULN 2113A. There is very little difference among these ICs, except the pin connections. The detection of the AM signal takes place when two synchronous signals are fed into the balanced product detector (or multiplier) section of the chip. The two signals are obtained from the same RF amplifier, MOSFET-PNP combination, Q1 and Q2 (hence the name synchrodyne). The de-emphasising capacitor, C2 at pin 14 of the LM 2111 IC smooths the audio output at pin 1. The author does not find it necessary to incorporate a 10 kHz whistle filter.

The selectivity is rated fair for the high frequency end of the AM band but stations like 2FC Sydney on the lower end are entirely satisfactory. However at a small increase in cost and a little effort of alignment, selectivity can be increased greatly if R3 is replaced by another LC tuned circuit similar to L1 C1. This was not used since the author is a 2FC fan most of the listening time! If a replacement is used for Q2 then it must be a high fT variety and R4 can be trimmed for the required gain of the RF stage.

Broadband HF dipole

A wire dipole at HF typically has a bandwidth of 4% to 5% for an SWR of 2:1 either side of resonance. The bandwidth can be increased to greater than 17% by constructing the dipole with a portion of it of small diameter (1/4" or 1/8") coaxial cable. Tape the coax to a nylon bearer line, either rope or heavy fishing line to give it strength and support. This is an old tip but not well remembered.



Interlocking touch switch

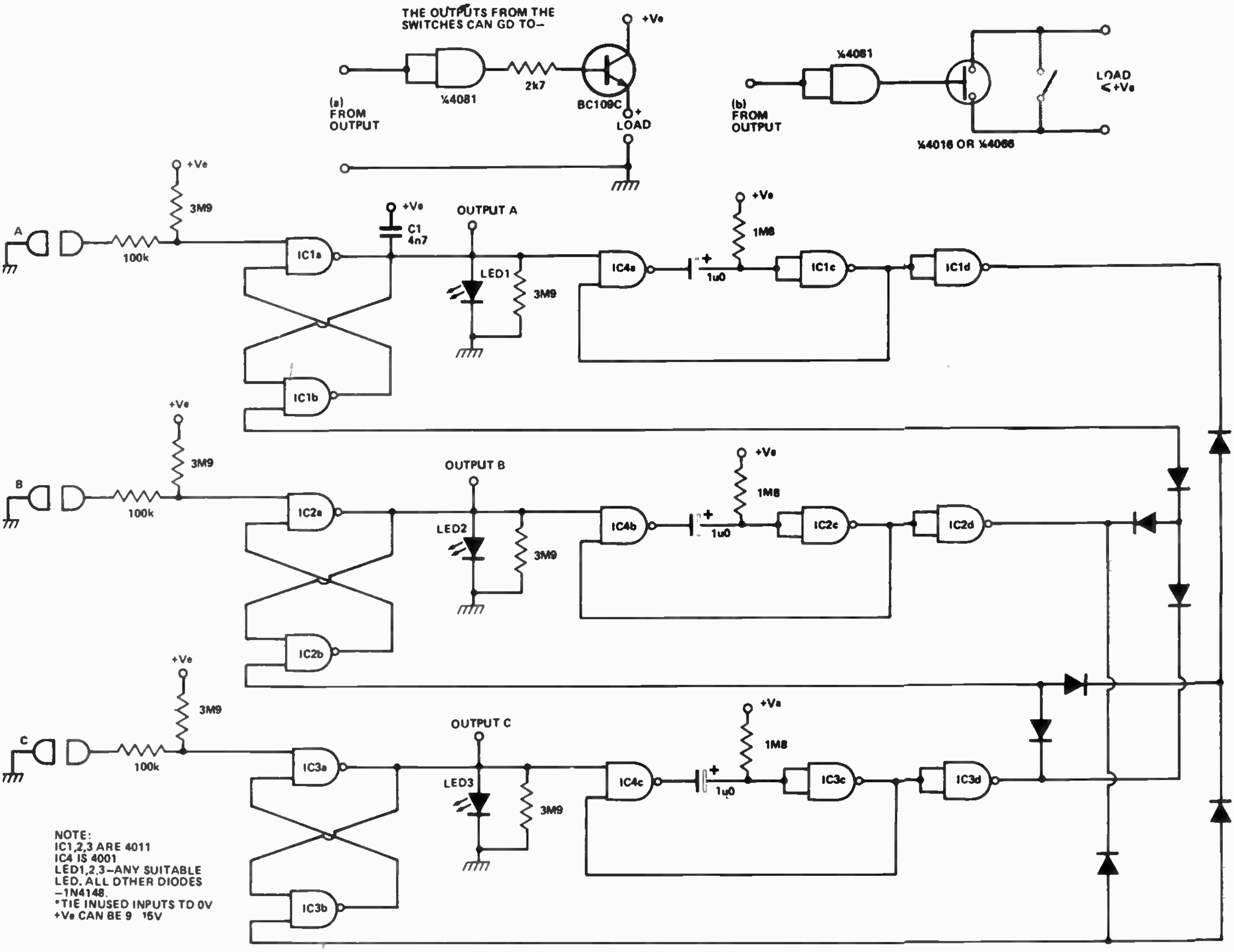
The diagram shows a circuit for a bank of touch switches. The physical operation is similar to wavechange switches of the push variety on a radio or television. The circuit shows a three way switch, but this could be extended.

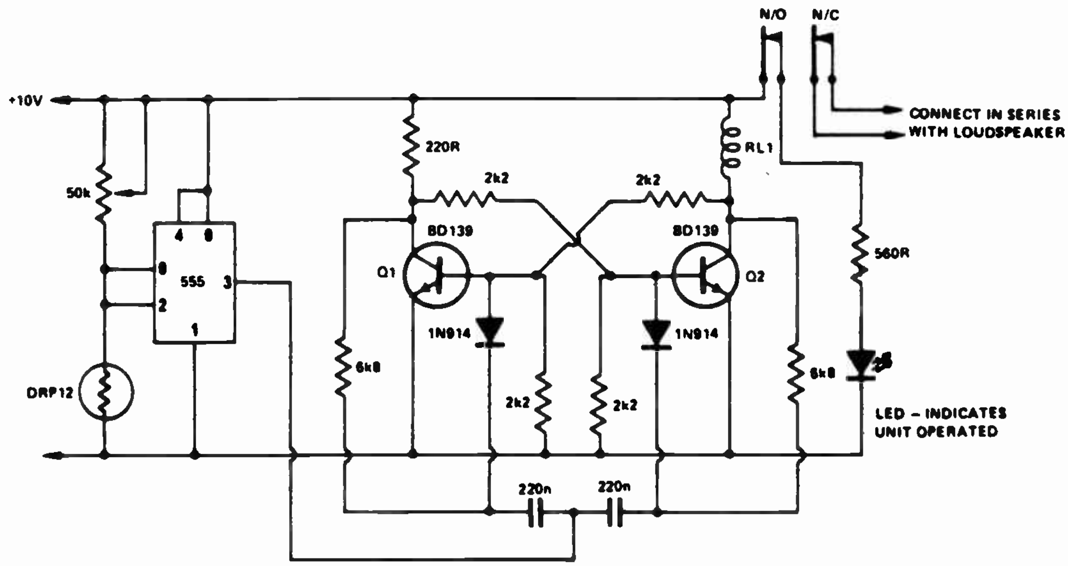
One of the inputs of IC1a is held high by a 3M9 resistor. If the touch plates are bridged, the input is pulled low by a 100k resistor. This triggers a latch formed by IC1a and b. The output of the latch is locked high, making the pilot LED light and the switch output go high. This output also goes to a simple monostable formed by IC4a and IC1c. This is held low by another 3M9 resistor and, once triggered, sends an output pulse of about 1 S in duration to a simple inverter formed by IC1d. This short low pulse resets the other switches in the interlocking bank via a string of diodes, so only the other switches are reset and the switch does not reset itself!

If another switch is activated, the first switch is reset and its output goes low again. At switch on, C1 sends a brief pulse to activate switch 'A'. Therefore, at switch-on, switch 'A' always comes on. If the capacitor is connected to another switch, that one will then come on at switch-on.

The output from each touch switch can go to one of two things as shown in the diagram: (a) a switching transistor, which can be used to operate a relay, or (b) a solid state CMOS switch (not to be used for voltages above supply)

The touch switch can be used on a radio for wave changing, or on a stereo amplifier as an input selector where noiseless switching can be achieved.





Silence those ads!

This circuit, from **G.B. Wolfe of Bombala NSW**, will switch off the sound from a TV when those annoying adverts come on just as the programme is getting interesting. All you need is a torch handy in order to flash a light at an LDR.

The circuit operates as follows: when light is incident on the photodiode its resistance drops, driving pins 6/2 of the 555 towards 0V. This produces a positive-going pulse from pin 3 which is passed to the collectors of Q1 and Q2. Suppose the flip-flop is set with Q1 on, Q2 off when power is switched on. The positive pulse on the collector of Q2 has no effect but the positive pulse on Q1 collector is passed on to the base of Q2 via the 2k2 resistor and Q2 begins to switch on. The collector voltage of Q2 now begins to fall rapidly and this drives base of Q1 towards 0V, switching the transistor off. The circuit thus rapidly changes state to Q1 off, Q2 on. When Q2 is on, the relay operates, the loudspeaker is disconnected and the LED goes on.

A further flash of the torch on the photodiode will cause a pulse from the 555 and the flip-flop switches back to Q1 on, Q2 off. The loudspeaker is reconnected and "Cop-Shop" comes back into your living room!

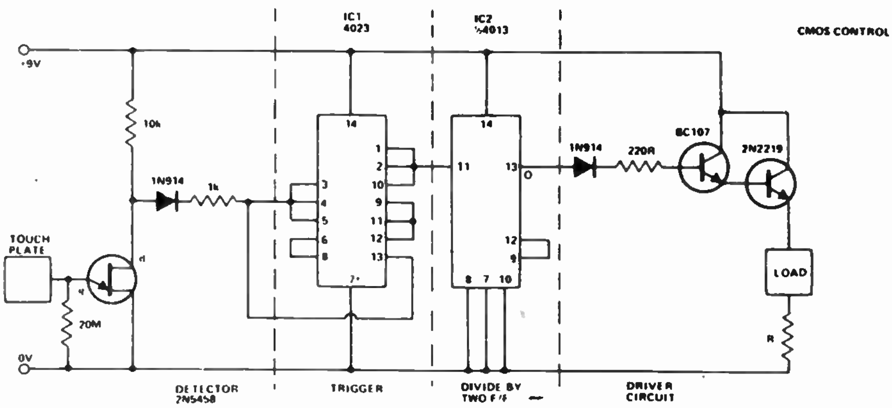
Deaf touch switch

Many designs for touch controls suffer from the disadvantage of low noise immunity, and this circuit was designed seeking to rectify this vault.

AC voltage from, for example, the hand is applied to the gate of the FET buffer. The resultant positive signal is applied via the diode, to the input of IC1. This IC is made up from three triple gates connected in a Schmidt trigger configuration. At the threshold voltage, a positive pulse is fed to the clock input of IC2, a D-type flip-flop. Connection is made between Q and the D input, so as to cause the flip-flop to run in the 'triggered' mode. Thus the input signals are divided by two and the output appears at the Q terminal.

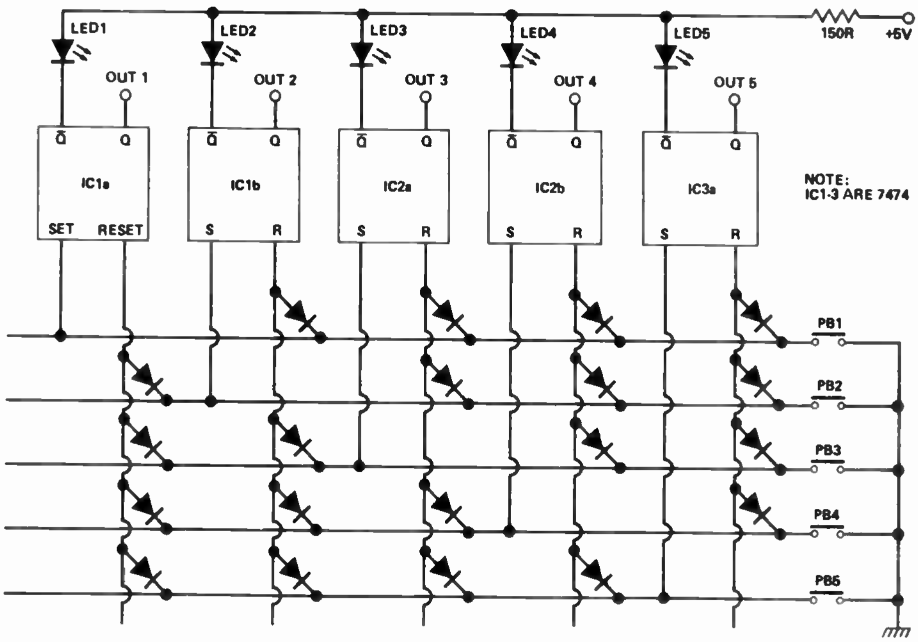
In operation, a single positive pulse sets the Schmidt trigger to its low level. (Removel of the hand causes reversion to the 'high' state). This, in turn, feeds the clock input of IC2, which changes the state of the Q output. When this is high, the output stage is driven on, enabling current to flow in the external load and the current limiting resistor, R.

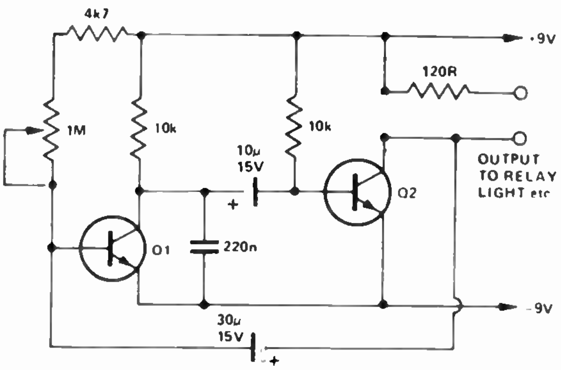
A second positive pulse changes the state of Q to its low level, causing the output stage to be biased off.



Electronic Switch

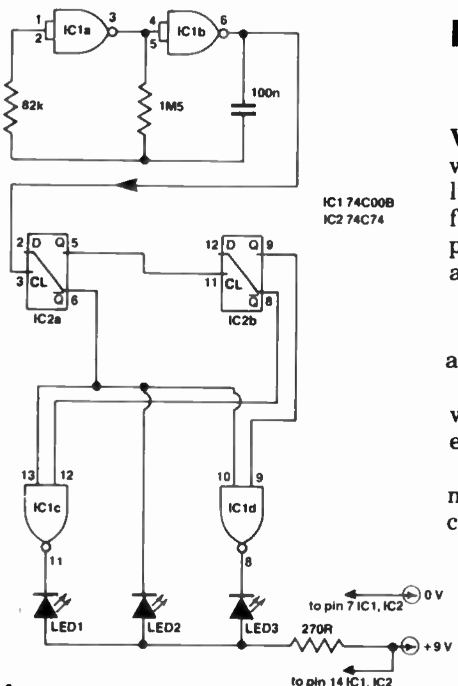
This circuit is the electronic equivalent of the interlocking push-button switch bank commonly used as an input selector in amplifiers, and in many other applications. This circuit has the advantage that it only requires small SPST switches on the front panel, thus simplifying mounting, and it is cheaper than mechanical switch banks. The outputs can be used to drive CMOS analogue switches (after buffering), or reed relays. The circuit is quite simple, consisting of set-reset flip-flops arranged so that when one is set (by pressing one of buttons 1-5) all the others are reset by the diode OR gates on the reset inputs. LEDs 1-5 are to show which input or channel is activated, and are best mounted above the appropriate button. The circuit can easily be extended or reduced for any number of channels required.





Flip-Flop flasher

This simple flip-flop circuit from Paul Taylor, of Eltham Vic, can be used to operate a relay or flash a lightbulb on and off at a rate that may be varied between three flashes per second to one flash every five seconds. The speed is altered by the 1M potentiometer. Component values are not critical and most general purpose NPN transistors will work. A relay with a coil resistance between 50 and 180 ohms should work well (delete 120 ohm resistor).



Electronic pendulum

The following circuit, from **G.N. Vayro of Broadmeadows, Victoria,** was used to provide a simulated pendulum effect in an electronic clock by flashing three LEDs in a particular repetitive sequence. The LEDs were arranged as follows,

O 1   O 2   O 3

and the sequence is 1, 2, 3, 2, 1.

The sequence is set for one second with the values shown and the visual effect is excellent.

The clock is a digital modular type, mounted in a highly polished wooden cabinet, resembling the grandfather clock style, but it is only 150 mm high.

The circuit was added to my clock for aesthetic reasons and has nothing to do with the clock timing. Readers may find other uses for the circuit as it is simple and uses all gates of two ICs.

It works as follows. Two gates of the 74C00 are used as a clock driving the two D-type flip-flops, which are connected to toggle by joining the D and Q.

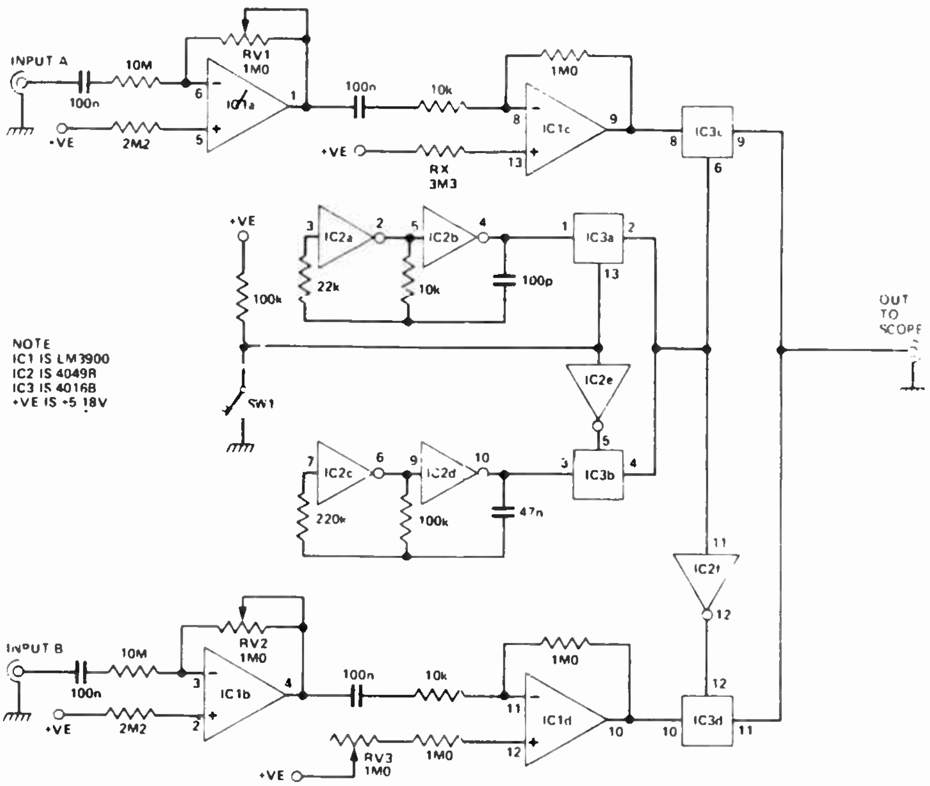
Frequency of operation can be changed by changing the C on the clock circuit. The two flip-flop outputs are decoded using the remaining two 74C00 gates to provide the required effect.

Dual Trace On Single Beam Scope

Three inexpensive ICs form the basis of this electronic switch to give a dual trace on a single beam scope. Operation of SW1 gives either a chopped display or alternate display. RV1 and RV2 are gain controls and RV3 varies the separation of the two displays. IC1a and IC1b are impedance converters and have input impedance of 10M. IC1c and IC1d (with gains of 100) combined with IC1a and b, control the display amplitude. Also the DC operating points of IC1c and d, controlled by RX and RV3, determine the separation.

CMOS switches IC3a,b (controlled by SW1) pass either high or low frequency square waves, generated by the two astables built around CMOS inverters IC2a-d. These square waves control switches IC3c,d, passing chopped (HF switching) or alternate (LF switching) signals to the scope (which must have an input impedance greater than 10k). The remaining two inverters invert the control signals to one of each pair of switches so that one is on and the other off at any instant. Power supply requirements are simplified by the use of the quad op-amp LM3900.

The lead to the scope should be short to avoid trouble at the higher switching rate.

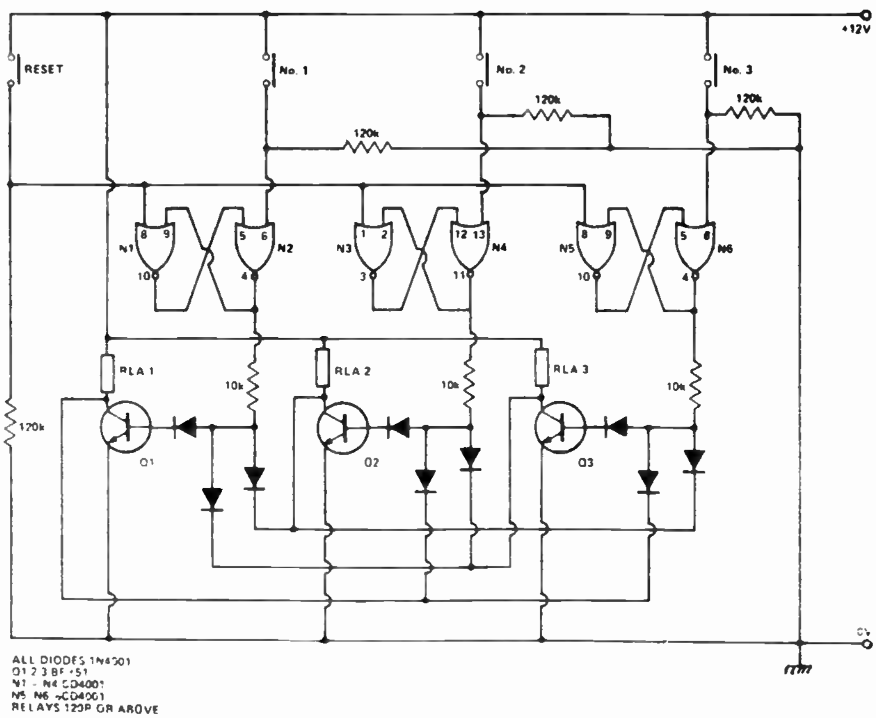


Sequence switch

The circuit right was designed to enable three relays to be individually switched by their appropriate buttons but such that only one relay can be energised at any one time. When any one relay has been energised the corresponding collector falls to near zero volts, which is connected to the base of the remaining two transistors; now if another relay is attempted to be energised the base of it's transistor will remain bottomed and keep the relay off. The rest button must be pressed before another relay can be energised. D1 ensures that each transistor is kept off until the voltage applied to the base exceeds 0.6 V.

The flip-flops and push buttons can of course be replaced with standard switches if momentary action is not required.

The circuit was used to control three radio transmitters where it was important that two should not be switched on at the same time. The circuit lends itself to further applications; for example, switching various inputs into an amplifier where it can replace the self-cancelling selector buttons.

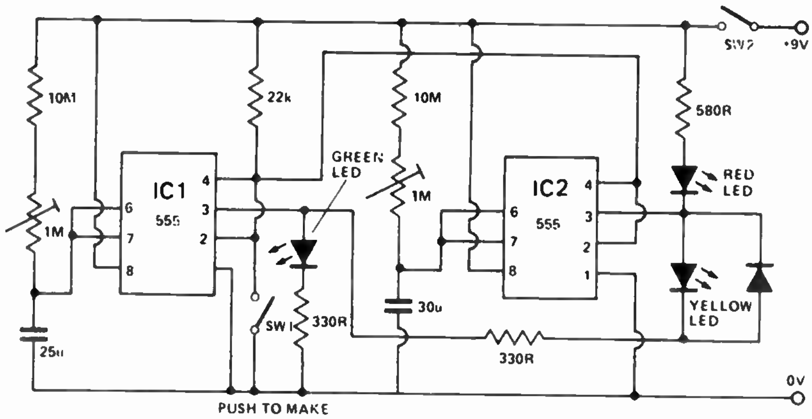


Talk timer

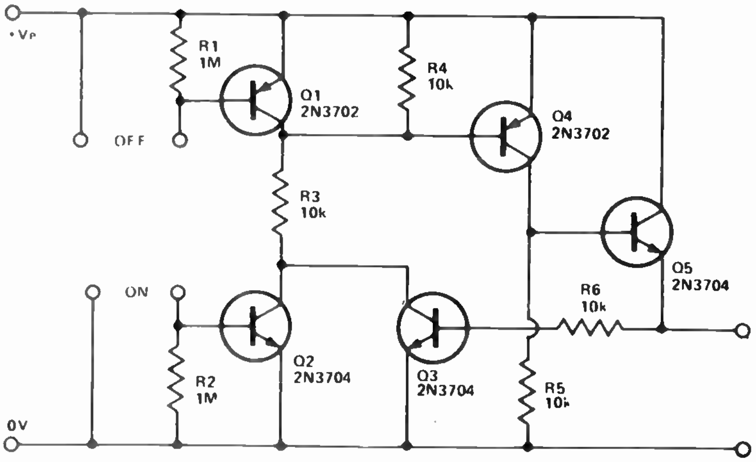
This circuit was designed for use as a timer for educational talks, providing a timing period of 5 minutes. During the talk, a green LED is turned on, but half a minute before the end, the green LED is extinguished and the yellow LED lit, giving a warning that only half a minute remains. At the end of the 5 minutes, the yellow LED turns off and the red LED turns on.

The circuit is simply two one-shot monostables connected together, the first with a timing period of 4½ minutes, and the second ½ minute.

Timing is started by momentarily closing S1, pin 3 of both ICs go high turning on the green LED and off the red and yellow LEDS.



At the end of the first timing period, pin 3 of IC1 goes low turning the green LED off and the yellow LED on. When at the end of the second timing period, pin 3 of IC2 goes low, the yellow LED is turned off and the red LED lit.



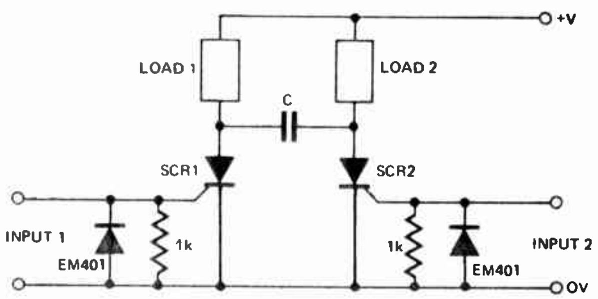
Solid state switch

The circuit was designed for use as a solid-state calculator on-off switch, as the mechanical equivalent was found to be unreliable.

Layout is not critical and the switch will operate with a supply from +6V to +15V and current consumption in the 'OFF' state is a negligible 30μA.

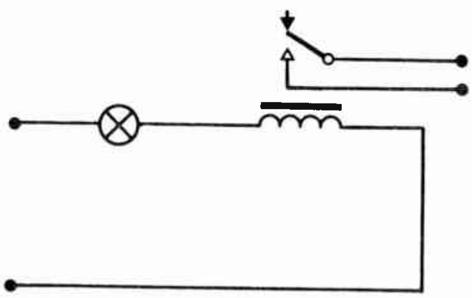
A finger across the 'OFF' contacts turns Q1 off and takes the base of Q4 to the +ve rail, turning Q4 off. This in turn stops Q5 conducting, and R6 and Q3 latch the circuit in this state.

Touching the 'ON' contacts takes R3 to ground turning Q4 on. Q5 now contacts and again R6 and Q3 latch the circuit.



SCR multivibrator

A triggered multivibrator — an input to 1 energizes load 1. A subsequent input to 2 energizes load 2, thus turning off SCR1 and de-energizing load 1.



Speed relay closing time

Relay closing times can be substantially reduced by overdriving the relay coil.

This can be achieved both easily and safely by utilising the change in resistance of a filament lamp connected in series with the relay.

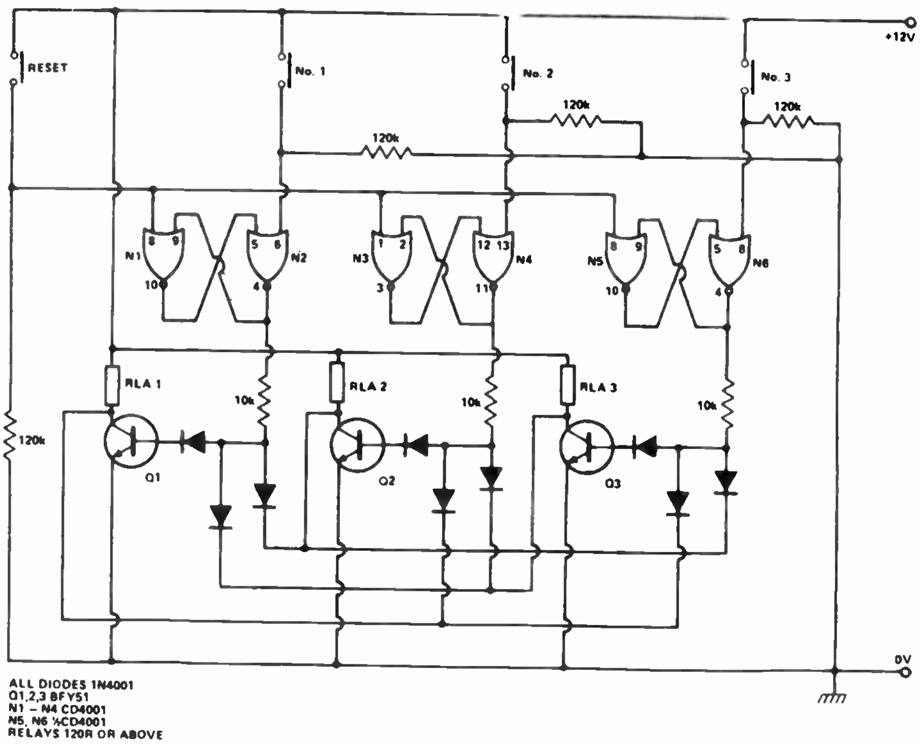
The relay coil should be rated at approx. half the circuit voltage, and a lamp chosen that will have a series resistance (when warm) equal to the relay coil resistance.

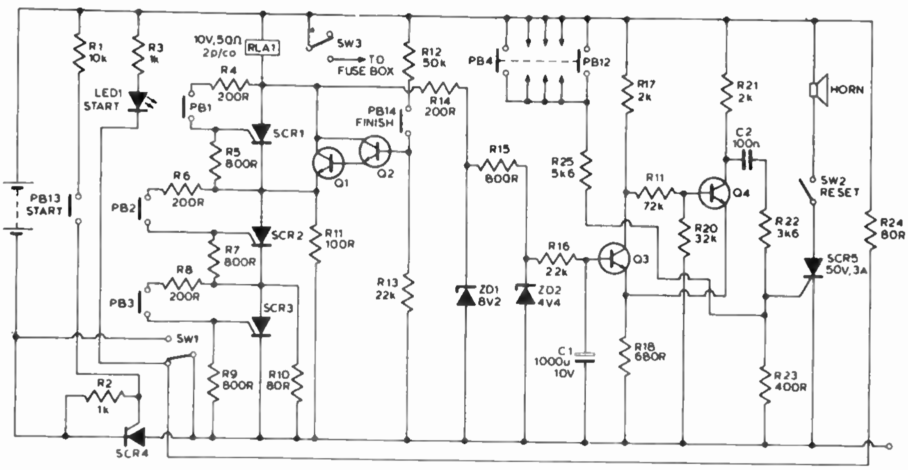
Push-button selector

This circuit was designed to enable three relays to be individually switched by their appropriate buttons such that only one relay can be energised at any one time. When any one relay has been energised the corresponding collector falls to near zero volts, which is connected to the base of the remaining two transistors; now if an attempt is made to energise another relay the base of it's transistor will remain bottomed and keep the relay off. The reset button must be pressed before another relay can be energised. D1 ensures that each transistor is kept off until the voltage applied to the base exceeds 0.6 V.

The Flip-flops and push buttons can of course be replaced with standard switches if momentary action is not required.

The circuit was used to control three radio transmitters where it was important that two should not be switched on at the same time. The circuit lends itself to further applications; for example, switching various inputs into an amplifier, where it can replace the self-cancelling selector buttons.





Electronic ignition switch

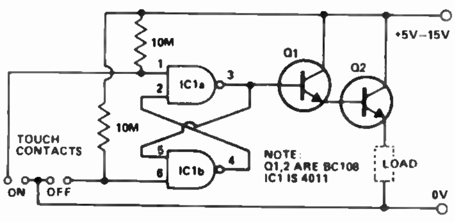
When used with a calculator type keyboard, this circuit provides a 'combination lock' ignition switch which only activates if the correct sequence of three numbers is keyed in. The keyboard has 14 keys numbered 1 to 12, 'START' and 'FINISH'. To start the car, the 'start' key is pressed and the start LED will light. The correct sequence of 3 numbers is then keyed in. If the sequence is wrong, the cars horn will be sounded. If the right sequence is entered, the 'START' LED will extinguish and the ignition will be energised. The correct sequence will be PB1, PB2, PB3, but these can be arranged amongst the other keys in the keyboard and given any numbers.

Low current touch switch

The cost of many CMOS ICs is now lower than a mechanical on/off switch. Using only one half of a 4011, plus a couple of general purpose transistors, a touch operated switch can be constructed which is ideal for many battery powered projects.

Assuming that the inputs to the remaining half of the 4011 are tied low, the current drawn in the off state is almost negligible and battery life is hardy affected.

Touching the 'on' contacts with a finger brings pin 3 high, turning on the darlington pair and supplying power to the load (transistor radio etc). Q1 must be a high gain transistor, and Q2 chosen for the current required by the load circuit.



Six-range FET dc voltmeter has 11M input impedance

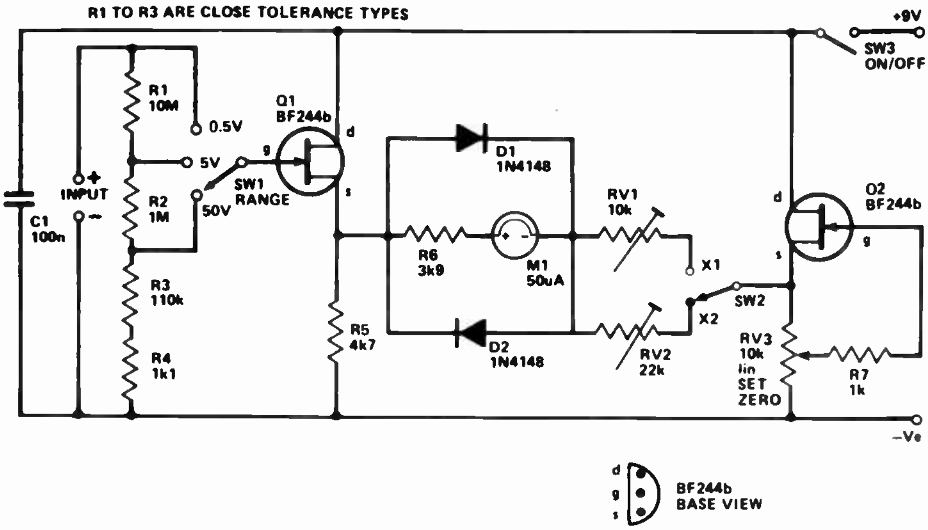
This circuit can be made as a handy add-on unit for a multimeter or as a stand-alone test instrument.

ALTHOUGH an ordinary multimeter is suitable for most dc voltage measurements, it can occasionally prove to be inadequate — usually just when you need it most! This is the case when making measurements on high impedance circuits which cannot supply the input current required to operate even a very sensitive moving coil meter of the type normally employed in a multimeter. The loading effect of the meter then causes the voltage at the test point to fall substantially, resulting in a misleading reading.

The problem is overcome by this FET voltmeter circuit which has six ranges, from 0.5 V (500 mV) to 100 volts full scale deflection (FSD). The circuit features an input impedance of a little over 11M on all ranges. This provides a sensitivity of more than 22M/volt on the half-volt (lowest) range, falling to a little over 110k/volt on the 100 V range. Most common multimeters have a sensitivity of 20k/volt, good quality types 50k/V and top-line models 100k/V, so this unit should compare quite favourably by the time you want to measure high voltages.

The high input impedance is achieved by using Q1 as a unity voltage gain buffer (source-follower). The FET has an inherently high input impedance. The actual input impedance is really set by the value of the series combination of the input attenuator consisting of resistors R1, R2, R3 and R4.

A simple voltmeter circuit is driven from the source of Q1. Ignoring the two diodes, D1 and D2, for the moment, the meter (M1) is arranged with several 'range' resistors in series: R6, RV1 and RV2. The latter two are switched to provide 'x1' and 'x2' ranges. In the x1 range, M1 has a full scale deflection sensitivity of 0.5 V, while in the x2 range it has an FSD sensitivity of 1 V. The unit is set up by adjusting RV1 and RV2 to give the appropriate full scale readings.



As the input FET develops a small bias voltage across R5, the negative side of the meter circuit has to be 'biased up' to counteract a permanent meter deflection. This is provided by another FET connected as a source-follower, Q2. Its gate is returned to the source bias, a potentiometer, so that the 'zero point' on the meter may be adjusted. This arrangement also provides a measure of stability, and little 'drift' in the meter reading is noticeable.

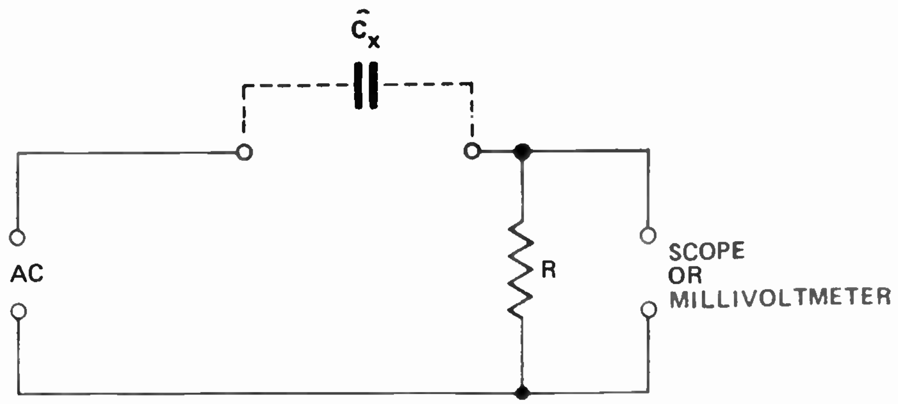
Diodes D1 and D2 protect the meter against serious overloads. When the voltage drop across R6 and M1 exceeds about 550 - 600 mV, of either polarity, one diode or the other will conduct, shunting the meter with a low impedance, reducing any further increase in current flow through the meter. A high reverse voltage at the input may destroy Q2, but the meter will be protected.

A simple input attenuator is arranged to provide three basic ranges of 0.5 V, 5 V and 50 V full scale, in the x1 range, these double to 1 V, 10 V and 100 V respectively.

The circuit is not critical as to layout, apart from the usual precautions to avoid possible accidental shorts, but a good quality switch having excellent insulation resistance impervious to humidity variations should be employed for the RANGE switch, SW1. A switch with ordinary bakelite insulation would be unsatisfactory. The circuit need not be built as a stand-alone unit, but makes an excellent add-on for a multimeter that has a 50 uA current range. Alternatively, if your meter has a 0.5 V range and is protected, delete D1, D2 and R6, connecting the meter between R5 and the junction of RV1 and RV2.

If building it as a stand-alone unit, buy a meter with a good-sized face (80 mm wide, for example). If you can get a mirror-scale type, so much the better.

Capacitance measurement

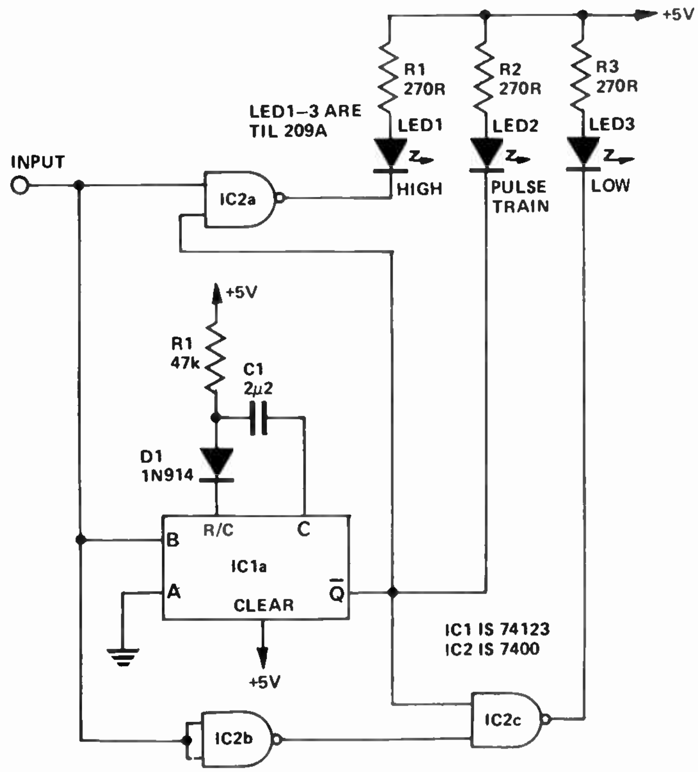


Few amateurs have a reliable method for measuring small capacitors. They may have a 50 Hz bridge, but the reactance of 10 pfs. at 50 Hz is some 320 megohms, which can well be of the same order as the bridge insulation, which leads to indeterminate and incorrect results. However if one has an A.F. signal generator and a measuring oscilloscope (or a.c. millivoltmeter), one can measure down to 2 or 3 pfs. with quite as good an accuracy as more complicated methods using square waves generators and diode pumps. The following very simple circuit is all that is necessary.

As long as the reactance of the capacitor is several times larger than the resistance of R, the output voltage will be directly proportional to the capacitance of C. By supplying a 1.6 volt input signal, the mathematics are simplified, and the output measurements are as the table given below.

Capacity Range	Input Frequency	Value of R	Output
0 to 20 p	100 kHz	10 k	10 mV. per p
20 to 200 p	10 kHz	10 k	1 mV per p
200 to 2000 p	1 kHz	10 k	0.1 mV per p
2000 to 20 000 p	1 kHz	1 k	0.01 mV per p
0.02 to 0.2 μF	1 kHz	100 R	0.001 mV per p

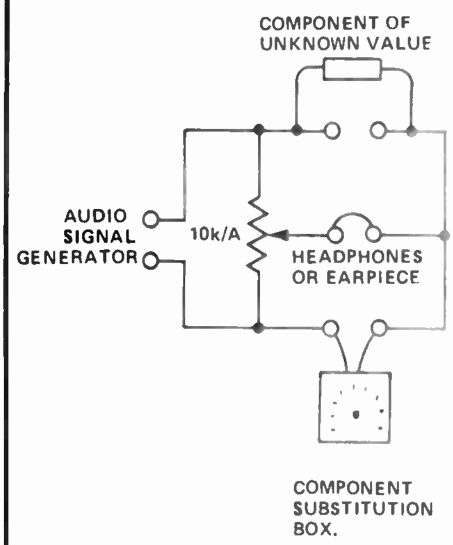
The input waveform should be fairly good, as any harmonics present are exaggerated by the capacitor, and the shape of the output waveform can be anything but a pretty sine wave. However it has to be a poor signal generator that does this.



TTL logic probe

This two-IC circuit indicates one of three states: 1) high 2) low or 3) pulse train at greater than 40 Hz. IC1a is a monostable and with the component values given, the Q output will be high for as long as there is a pulse train present with a frequency of 40 Hz or greater. The 7400 buffers the input to the LEDs and its logic prevents either the 'high' or 'low' LED from being lit when a pulse train is present.

Simple RLC bridge



A simple RLC bridge can be made from a few components as shown above. The audio generator provides a signal to a bridge network formed by the potentiometer, the component substitution box and the unknown value component. The head phones or earpiece serve as a null detector – alternatively a CRO can be used.

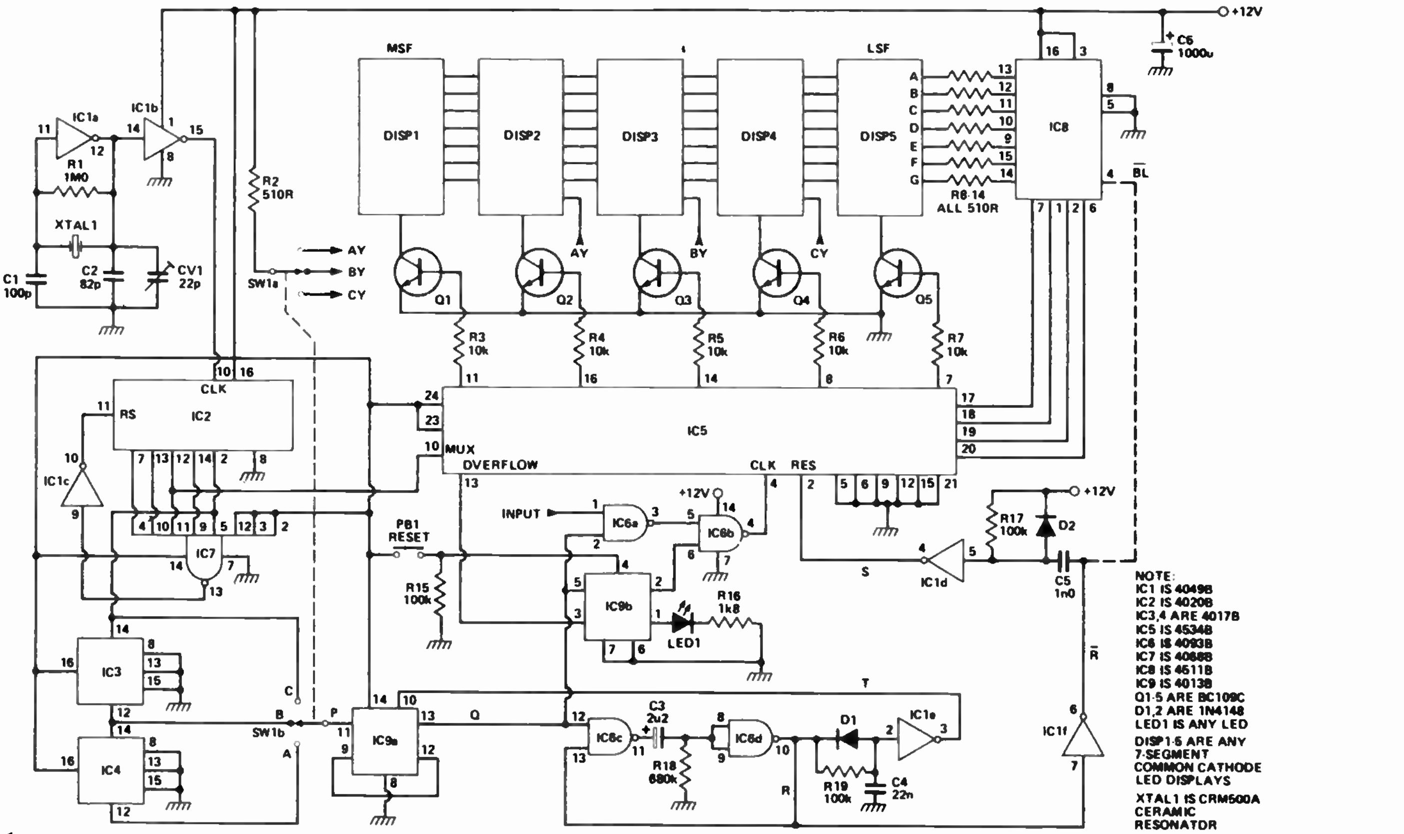


Fig. 1

Digital Frequency Meter

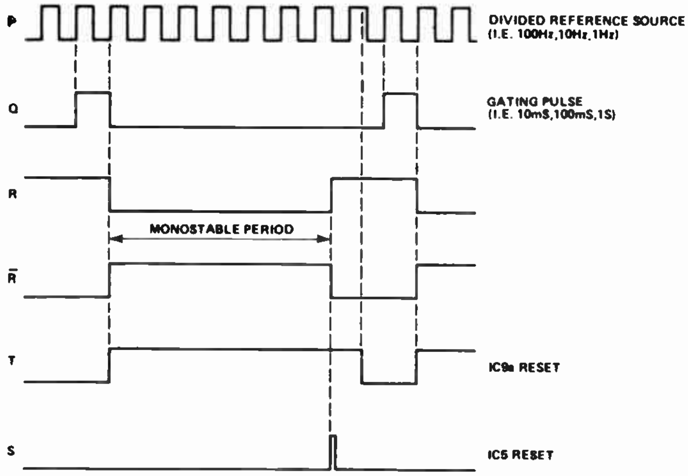


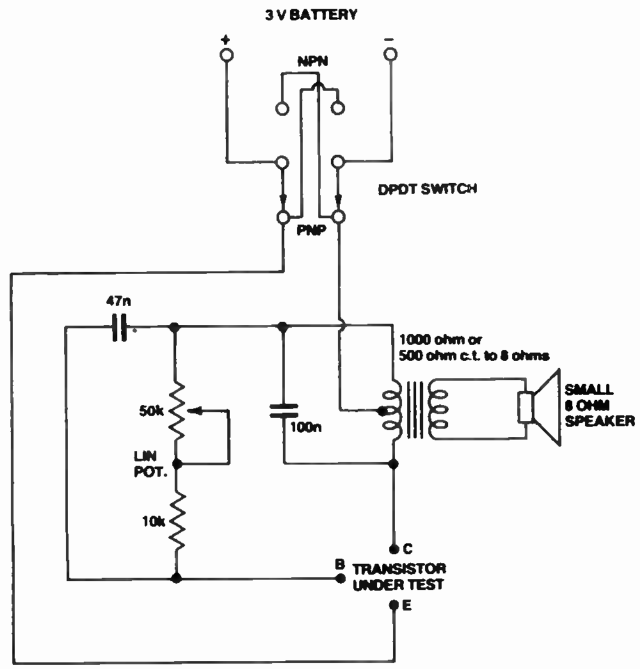
Fig. 2

The design shown is an alternative to those projects for DFMs that utilise one of those new-fangled all-in-one DFM chips. As you can see from the circuit diagram, the only additional circuitry required is an input preamplifier and a suitable regulated 12 V power supply.

IC5 is a real-time five-decade counter incorporating a multiplexed BCD output. With the aid of IC8 (a BCD-to-seven-segment decoder) and transistors Q1—5, the counter and display section of the DFM is formed. The $\overline{\text{BLANK}}$ pin on IC8 is used to extinguish the displays while IC5 is counting, otherwise pin 4 of IC8 should be connected to the positive rail. The frequency reference oscillator is somewhat unique in that a 500 kHz ceramic resonator is used. In practice it offers reasonable accuracy: however, the circuit can be easily modified to use a 1 MHz quartz crystal. In this case, the connections between IC2 and IC7 of the frequency divider section will require the inputs of IC7 to be connected to pins 3, 5, 12, 14 and 15 of IC2. Pin 14 of IC3 should also be connected to IC2 pin 2, and a suitable multiplexing frequency of around 1 kHz should be fed to pin 10 of IC5.

Depending on the position of SW1b, either 1 Hz, 10 Hz or 100 Hz will appear at IC9 pin 11 (see Fig. 2, point P), where IC9a is a D-type flip-flop configured to divide by two. Should IC9a be continuously enabled, the output of IC9a will, in fact, be a square wave of half the applied frequency with a mark/space ratio of 1:1. This means that for a 1 Hz applied frequency, 0.5 Hz will appear at IC9a pin 13 and the time for which the cycle will be high is, in fact, one second. This is then fed to the gate IC6a. However, only one such gating pulse is produced, after a certain time period set by C3 and R18. The monostable formed round IC6c,d is used to give the reading period of the display, when triggered, by enabling IC8 and disabling IC9a. At the end of the monostable period, a short pulse is produced at S which resets the counter. IC1e is there to ensure that IC9a is not enabled before the reset pulse to the counter is produced (see T), otherwise all hell will break out!

Finally, the D-type flip-flop that remains is used as the basis of the overflow indicator; on the transition of the counter from 99999 to 00000, a pulse is produced at IC5 pin 15 which latches IC9b pin 1 high, thus lighting up the LED. Pressing PB1 resets the whole system.



Quick transistor checker

This simple little circuit is quite effective for testing bipolar transistors, being a favourite of **Agostino Greco of Clayton in Victoria**, who has used it over the last few years.

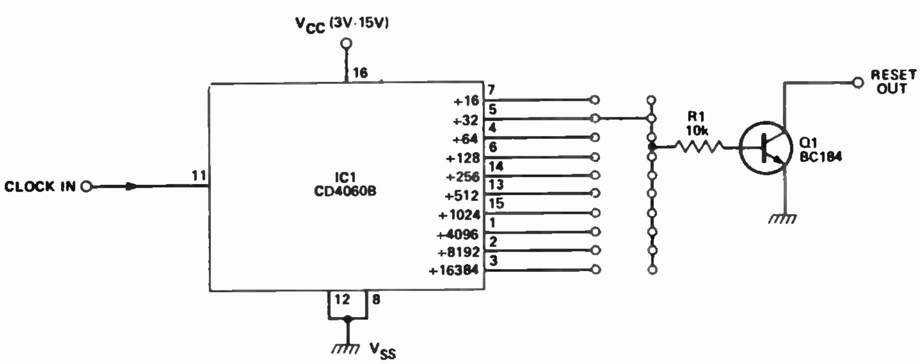
The circuit is a basic Hartley oscillator using a centre-tapped audio output transformer of the type commonly found in small transistor radios, driving a small 8 ohm speaker. The latter is a common item, stocked by many suppliers, or you can salvage one from a defunct transistor radio. You could salvage a suitable transformer from a defunct radio also, or you could obtain one of the models stocked by Tandy (catalogue No. 273-1380) or Dick Smith (catalogue No. M-0216).

A 50k potentiometer provides a means of varying the tone of the oscillator, from a low frequency at high values of resistance to higher frequencies at lower values of resistance. The series resistor is provided to limit the high frequency range, as otherwise the circuit may cut off, depending on the particular transistor being tested, and further to limit the maximum current drawn by the circuit to a value well under 50 mA at full setting of the potentiometer.

The two capacitors are in no way critical and serve to set the frequency of operation of the oscillator. They have been chosen to give a pleasing tone with a 50k potentiometer. Increasing the value of either capacitor will result in a decrease in the frequency of the oscillator.

In use, the transistor to be tested is connected to the circuit via crocodile clips. If there is no response from the circuit, then the polarity change switch should be toggled, and hopefully there will now be a tone output from the speaker. If there is no result with the switch in either position, then the device is faulty; alternatively it may be an FET, UJT or SCR, etc, type device, in which case this tester will be of no use.

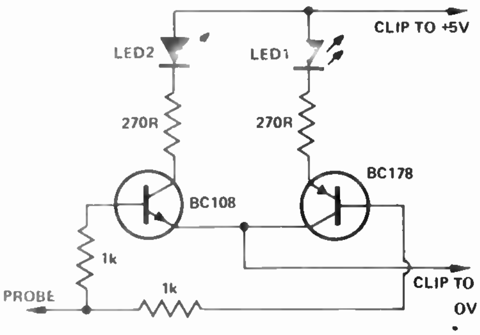
Note that there will be no harm done to a transistor if it is initially connected up to the circuit with the polarity switch in the wrong position, as it will be reverse biased and hence will draw only small leakage currents.



Microprocessor Debugging Aid

If you have ever built a microcomputer system, switched on the power, and found that nothing happened, this simple debugging aid may of interest to you. The problem with troubleshooting microprocessor circuits is the lack of comprehensible signals when probing around the board with an oscilloscope. The answer is simple: the operation of any microcomputer system is predictable, following a pulse applied to the reset line of that system. A 6502, for instance, will spend six clock cycles sorting itself out internally, then make two memory fetches from the reset vector at address FFFC and FFFD. Using the circuit shown it is possible, when connected to a faulty microprocessor system, to examine the address bus, data bus and control signals for several clock cycles after a reset with a simple oscilloscope. (It will be necessary to trigger the oscilloscope timebase from the reset signal generated by the debugging aid.) The user should be looking for such things as broken printed circuit tracks, solder bridges or even high resistance links between tracks, many of which may be easily detected by tracing the system operation during the first few clock cycles after reset.

The debugging aid consists of a CD4060B CMOS divider integrated circuit which is fed from the clock signal of the micro system under test. The output of the CD4060 drives a transistor which in turn may be used to drive the reset line of the microprocessor. This debugging reset signal may be switched to any one of 10 outputs from the CD4060 allowing a choice of the number of clock cycles to be examined.



Simple logic probe

This probe is so simple in its operation that it needs almost no explanation. None of the components are at all critical. The circuit may be of use in designing a larger unit, with perhaps one of these probes for each of the pins of an IC clip.

It might be a good idea to make the LEDs different colours, so that the state of the circuit under test can be seen at a glance. The NPN transistor (the left-hand one) will turn on the left-hand LED if the voltage on the test probe is high (nearer the + supply rail). The other LED will come on if the probe voltage is near zero.

Simple anemometer

Having managed to pronounce the heading (an-ee-mom-meter), no doubt you're wondering what it is. It's a wind speed indicator.

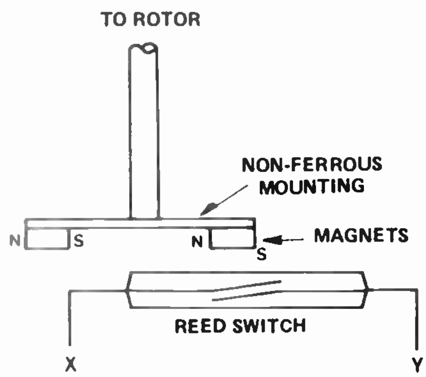
The idea comes from 14-year-old **Wayne Brown of Dromana in Victoria.** Make up an anemometer rotor and attach two small magnets to a mounting on the bottom. A reed switch is then placed under this assembly such that the two magnets operate the reed switch twice per revolution of the rotor shaft.

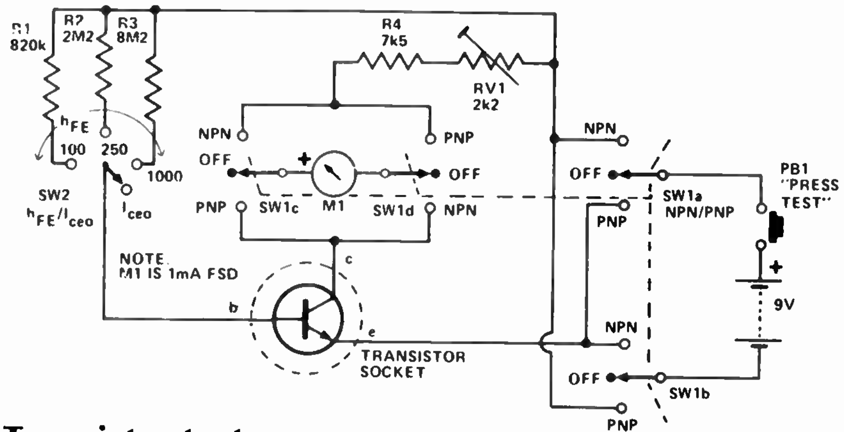
The reed switch gates on and off a 555, the output of which is rectified and integrated to drive a meter (M1). You can use a meter having a sensitivity up to 150 microamps, but the resistor in series with the 1N914 will have to be selected to suit.

To calibrate it, you will need:

one daring passenger
one car
plenty of road
no radar traps.

With the anemometer's rotor held outside the vehicle (clamped to a roof rack, for example), drive at a variety of speeds for a short distance at each speed. The passenger can then mark down the meter reading against the car's speed so that the meter scale can be later marked with the calibrations.



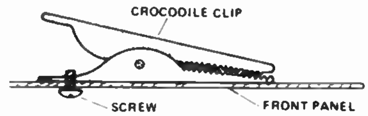


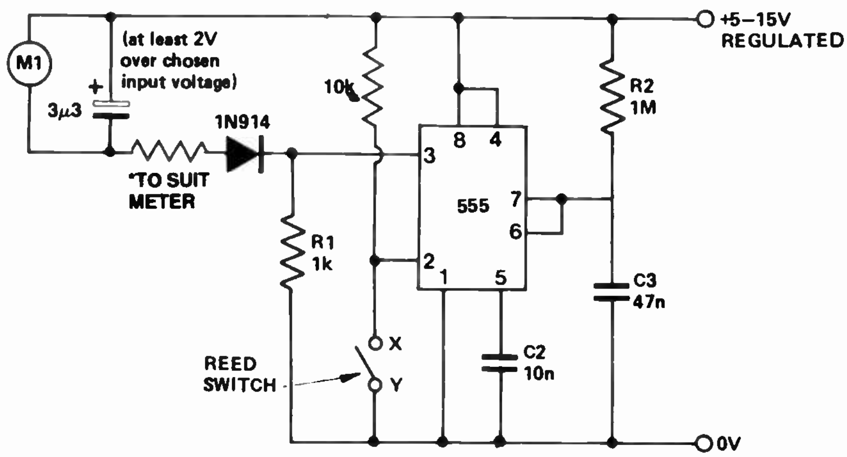
Transistor tester

This transistor tester works by injecting a known current into the base of the transistor under test, and measuring the collector current. The values of R1, R2 and R3 give a base current of 10, 4 and 1μA which gives a FSD on the meter for transistors with a gain of 100, 250, and 1000 respectively. Since the gain of the transistor is proportional to its I_C, the gain can be easily deduced from the reading on the meter. Leakage current is measured by leaving the base open circuit.

SW2 reverses the polarity of the battery and the meter to allow the testing of both NPN and PNP transistors. R4 and RV1 protect the meter from excessive currents, and do not affect the reading on the meter. RV1 should be adjusted so that the meter needle just touches the end stop when the collector and emitter terminals are connected together.

A simple transistor socket can be made by mounting three crocodile clips as shown in the diagram.



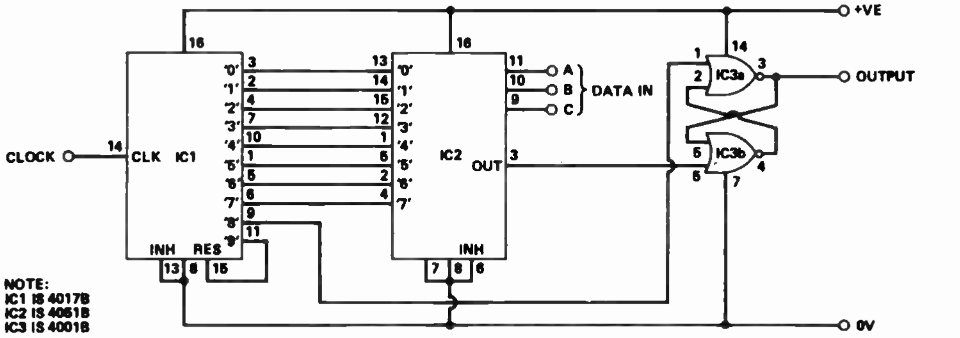


Low Resolution Pulse Generator

This circuit produces pulses whose width is controlled by a three bit word and which can be used to control motors and similar devices where high resolution isn't needed.

IC1 is a decade counter with outputs '0' to '9' going high in turn. Here it counts from '0' to '8' and is reset by the '9' output which is connected back to the reset pin. Outputs '0' to '7' are connected to IC2, an eight-line-to-one-line multiplexer. The output which is connected to pin 3 by the internal switches of the IC depends on the value of the three-bit word on pins 9, 10, 11.

IC3 is configured as a bistable and is set by the '8' output of IC1. It is reset by one of the other outputs of IC1; the one selected by IC2. The length of the output pulse at pin 3 of IC3a depends on which output of IC1 is used to reset the bistable, the output being selected by the three-bit word input to IC2. Note that the 4051 could be replaced by a 4512 data selector.

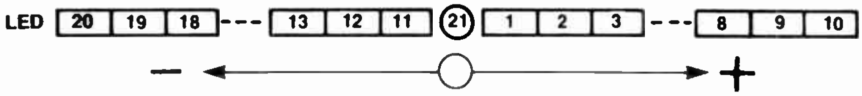


CONNECT PINS 8,9,12,13 OF IC3 TO GROUND

Centre zero LED bar/dot meter

THIS CIRCUIT drives twenty LEDs with a single bar/dot driver. Ten LEDs (green) are for a positive input signal and ten LEDs (red) for a negative input signal. A yellow LED, which is lit permanently, gives the centre zero indication. The LEDs would, for best effect, be mounted on a panel as shown below:

CENTRE ZERO BAR/DOT METER



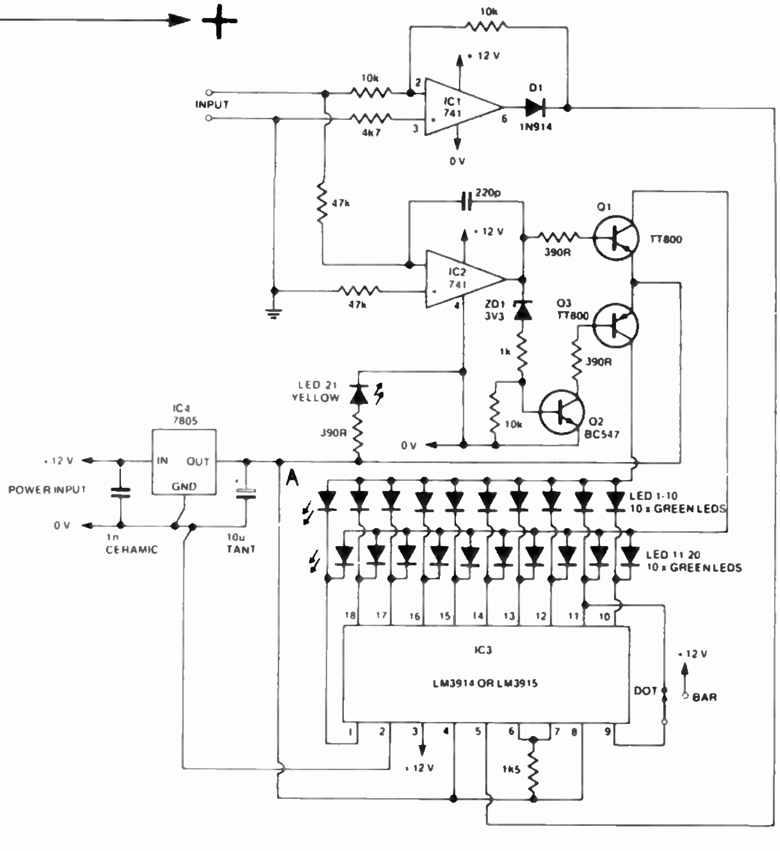
When used in the bar mode, the bar of light elongates to the left for an increasing negative signal and to the right for an increasing positive signal.

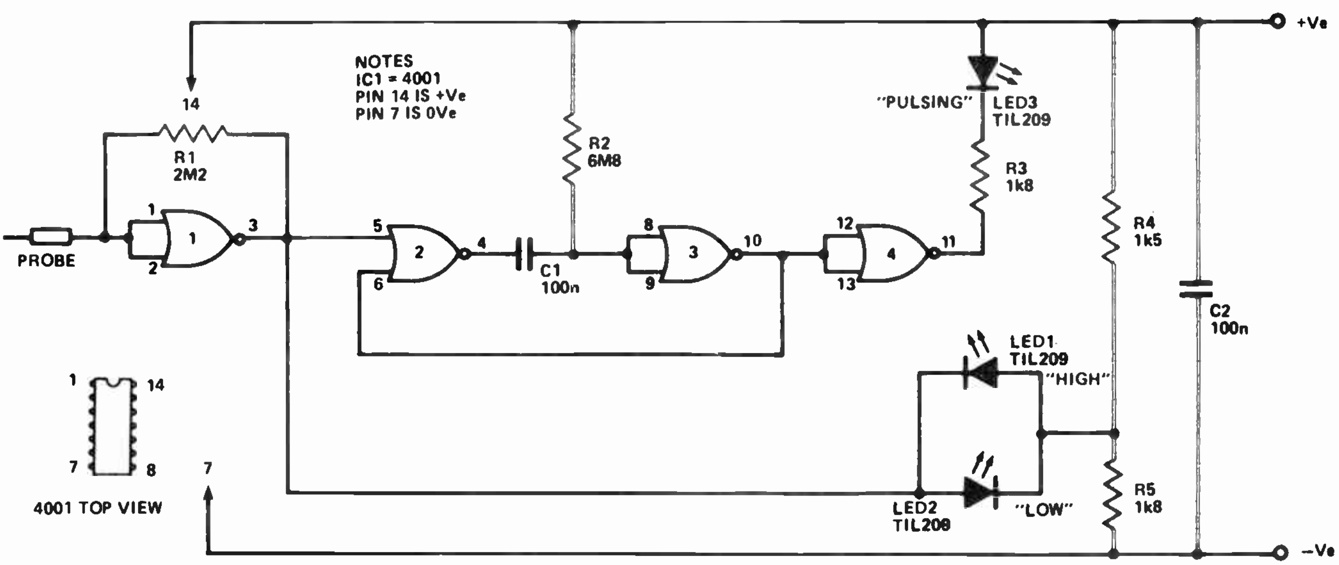
The circuit runs from a single 12 Vdc supply. A 5 V regulator is included, which serves both to power the LEDs and to provide a reference line for the positive and negative input signals.

IC1 is connected as a simple (but effective) 'absolute value' amplifier. This drives the LM3914, which will only accept positive input signals. IC2 is connected as a comparator, and serves as a polarity indicator. When the input is positive the output of the comparator is high, which drives Q3 via ZD1 and Q2, enabling LEDs 1-10.

When the input is negative, the output of the comparator swings low, switching off Q3 and switching on Q1, which enables LEDs 11-20. As there is no gain in the absolute value amplifier, the full-scale reading is equal to that set by the internal reference of IC3. This means that the full-scale value of this circuit is about ±1.2 V. This value can be altered by conditioning the required input signal. The LM3915 may be substituted for the LM3914 if a logarithmic, rather than a linear, scale is desired.

This circuit can, apart from its obvious applications as a general centre zero meter, be used to display the difference between two voltage levels, e.g: a reference level and an unknown level. In this application the position on the circuit marked 'A' would be separated from the +5 V line and would be connected to the reference voltage. The unknown voltage to be compared would be connected to the input terminal. Both the reference and the unknown would be referred to 0 V. The only limitation is that the reference voltage should be between 4 and 8 volts above 0 V when using a 12 V supply.





CMOS logic probe

A LOGIC PROBE is a device which is used when testing digital circuits, and it shows the logic state at the selected test point. In common with most designs, this one can indicate four input states, as follows:

1. Input high (logic 1).
2. Input low (logic 0).
3. Input pulsing.
4. Input floating.

The circuit uses the four two-input NOR gates contained within the 4001 CMOS device and is primarily intended for testing CMOS circuits. The probe derives its power from the supply of the circuit being tested. The first gate has its inputs tied together so that it operates as an inverter, and it is biased by R1 so that roughly half the supply potential appears at its output. A similar voltage appears at the junction of R4 and R5, and so no significant voltage will be developed across D1 and D2, which are connected between this junction and gate 1 output. Thus under quiescent conditions, or if the probe is connected to a floating test point, neither D1a or D2 will light up. If the input is taken to a high logic point, gate 1 output will go low and switch on D1, giving a 'high' indication. If the input is taken to a low test point, gate 1 output will go high and D2 will be switched on to indicate the 'low' input state.

A pulsed input will contain both logic states, causing both D1 and D2 to switch on alternately. However, if the mark to space ratio of the input signal is very high, this may result in one indicator lighting up very brightly while the other does not visibly glow at all. In order to give a more reliable indication of a pulsed input, gates 2 to 4 are connected as a buffered output monostable multivibrator. The purpose of this circuit is to produce an output pulse of predetermined length (about half a second in this case) whenever it receives a positive-going input pulse.

The length of the input pulse has no significant effect on the output pulse. D3 is connected at the output of the monostable, and is switched on for about half a second whenever the monostable is triggered, regardless of how brief the triggering input pulse happens to be. Therefore a pulsing input will be clearly indicated by D3 switching on.

The various outputs will be:

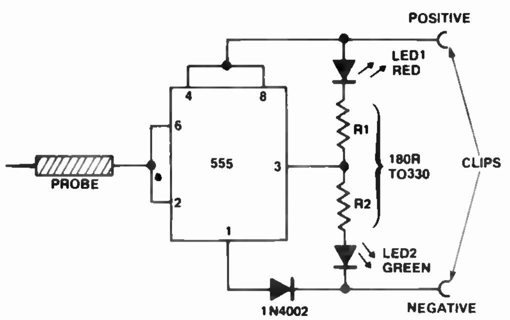
Floating input — all LEDs off.

Logic 0 input — D2 switched on (D3 will briefly flash on).

Logic 1 input — D1 switched on.

Pulsing input — D3 switched on, or pulsing in the case of a low frequency input signal (one or both of the other indicators will switch on, showing if one input state predominates).

Positive-negative probe



This circuit, which acts as a simple substitute for a voltmeter, was designed by **David Pye of Happy Valley SA.**

I've found in many cases that all I wanted to know was whether the reading was positive or negative. This is particularly useful in car or motorcycle electrical repairs and, as the unit can be made extremely small, it will fit in any tool kit.

It will fit in a small plastic pill container, operate on any voltage between 5 V and 15 V and is quite cheap as it only requires a few components.

When the positive and negative clips are connected to the circuit both LEDs will light. Then when the probe touches a positive point the green LED is extinguished, leaving the red LED on, signifying positive. Touching the probe to a negative point extinguishes the red, leaving the green LED on. The 1N4002 is a protective diode for reverse polarity.

1 kW dummy load for testing audio power amplifiers

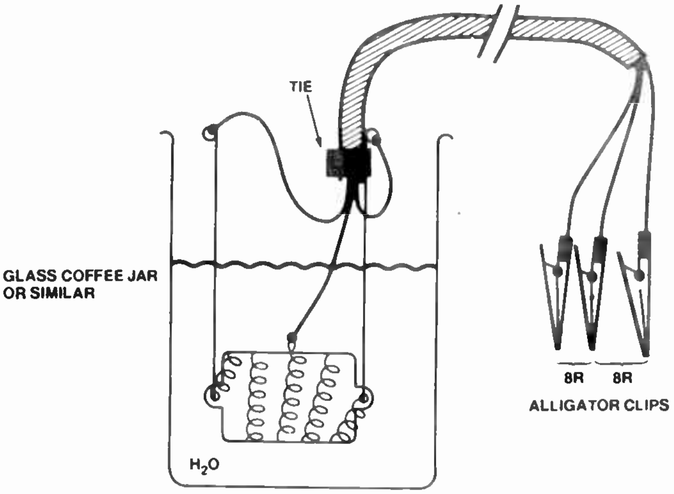
Philip Allison of Summer Hill NSW has worked out a cheap, simple method for testing audio power amplifiers.

You'll need a 1.6 kW electric jug replacement element, complete with its supporting arms, which you can buy from a hardware store.

The coil of Ni-Chrome wire on these elements has a resistance of about 36 ohms which needs to be reduced to 16 ohms for our purpose. To do this, first remove the coil and cut it at 16 ohms. Then stretch this length so that it equals the original length and carefully rewind it on the ceramic former.

Find the centre of this coil (8 ohms) and make a small twist. Using a length of three core mains flex attach the green wire to the twist and the blue and brown wires to the ends of the brass rods as shown in the diagram. Fit alligator clips or plugs to the other ends of this lead.

When immersed in water this unit will comfortably dissipate 500 watts per 8 ohm side or 1000 watts with a 4 ohm load (blue and brown linked) or with a 16 ohm load (using blue and brown only).



Comprehensive CMOS Logic Gate Test Rig

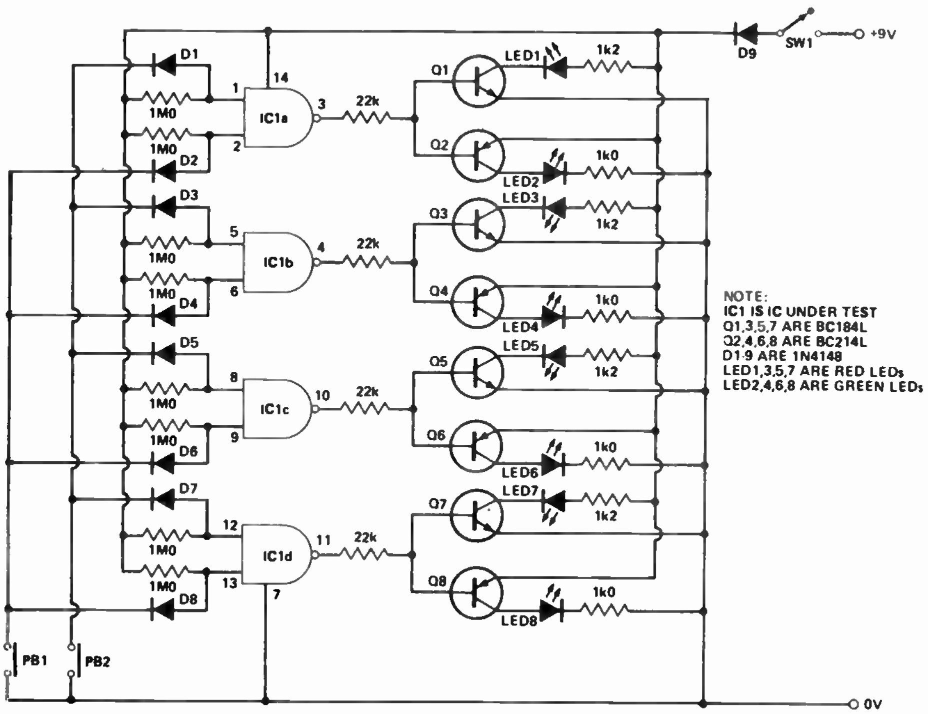
This simple test rig will check out all possible functions of any type of dual input CMOS logic gate allowing, for example, a faulty gate to be pinpointed so that the rest of the IC may still be used.

Each gate is provided with a green LED to indicate a high output and a red LED to show a low output.

Use a 14-pin holder for the IC and orientate the LEDs to relate to their appropriate gate.

SW1 connects power and a logic 1 to all inputs: press A to put a 0 onto one input of each gate; B puts 0 onto the other inputs; A and B togther force all inputs low.

A milliammeter in series with a 9 V supply should only indicate the current drawn by the LEDs, ie about 7 mA per LED. An appreciably higher reading indicates a completely faulty IC.



4011 (NAND)	GREEN	RED
SW1	ON	OFF
PB1	OFF	ON
PB2	OFF	ON
BOTH	OFF	ON

4081 (AND)	GREEN	RED
SW1	OFF	ON
PB1	ON	OFF
PB2	ON	OFF
BOTH	ON	OFF

4070 (EXOR)	GREEN	RED
SW1	ON	OFF
PB1	OFF	ON
PB2	OFF	ON
BOTH	ON	OFF

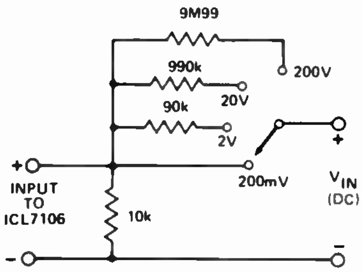
4001 (NOR)	GREEN	RED
SW1	ON	OFF
PB1	ON	OFF
PB2	ON	OFF
BOTH	OFF	ON

4071 (OR)	GREEN	RED
SW1	OFF	ON
PB1	OFF	ON
PB2	OFF	ON
BOTH	ON	OFF

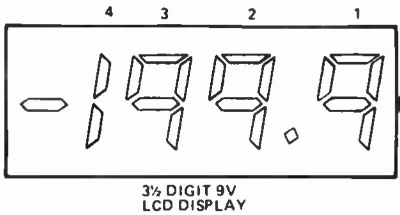
4077 (EXNOR)	GREEN	RED
SW1	OFF	ON
PB1	ON	OFF
PB2	ON	OFF
BOTH	OFF	ON

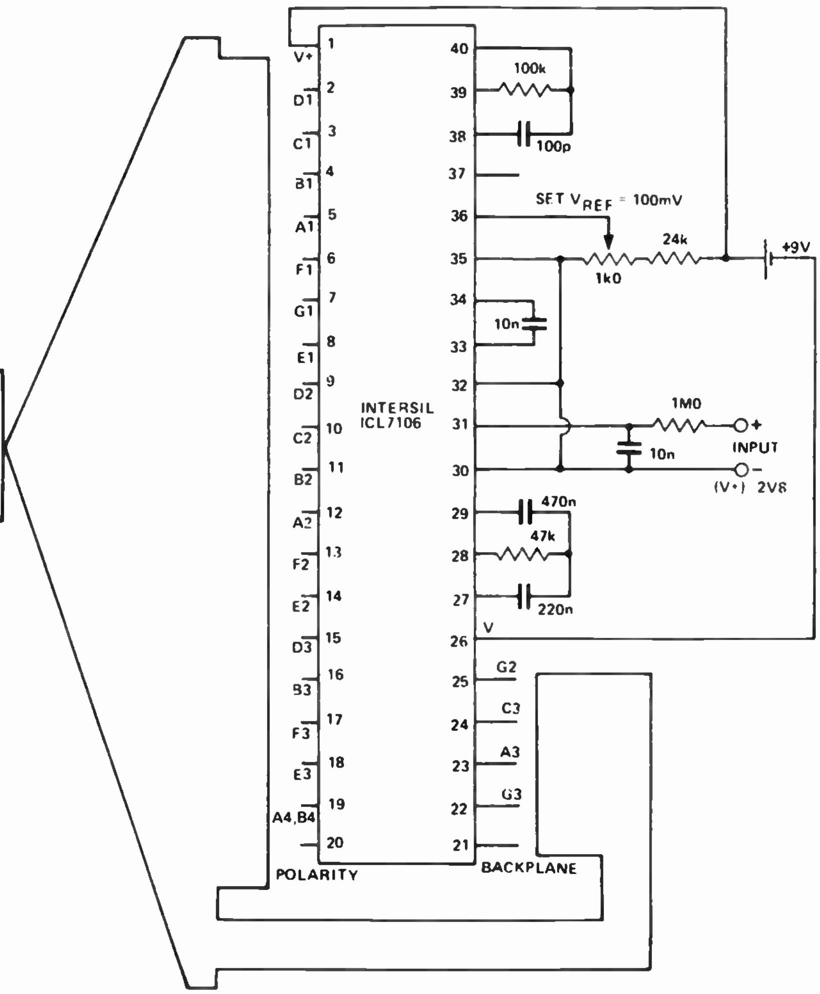
SW1 ONLY – BOTH INPUTS HIGH
PB1 PRESSED – ONE INPUT LOW
PB2 PRESSED – OTHER INPUT LOW
BOTH PRESSED – BOTH INPUTS LOW

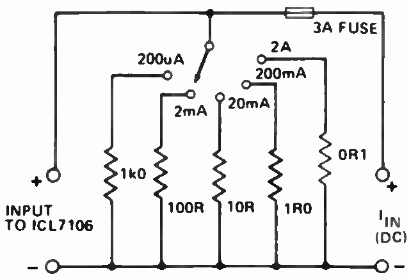
3½ Digit LCD DVM



DC voltage inputs







DC current inputs

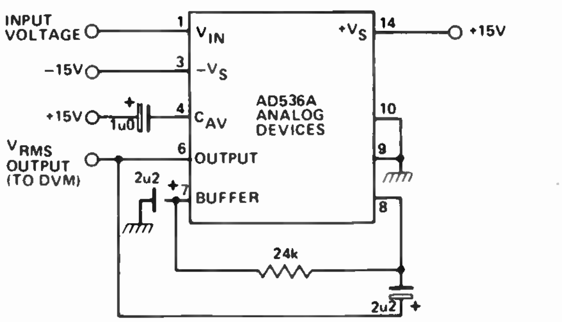
Input voltage range = ±200 mV
Quiescent current = 0.8 mA
Common mode input range = (V+)−0V5 to (V−)+1V
Decimal point must be driven externally by EXORing the decimal point data with the backplane strobe

The Intersil ICL7106 is a high-performance CMOS 3½-digit analogue-to-digital converter capable of driving a liquid crystal display directly. The device uses dual-slope integration to ensure accurate performance independent of component variation. The accuracy is guaranteed to ± 1 count in 2000 counts and draws only 10 mW from a 9 V battery. Intersil market a 'Single Chip Panel Meter Evaluation Kit' that contains all the necessary components for this circuit.

True RMS Measurement

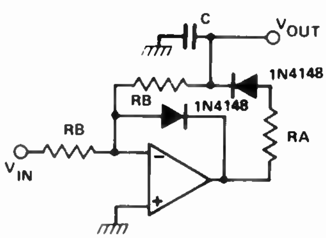
Input voltage 7 V_{RMS} maximum
Bandwidth: 300 kHz, V_{RMS} > 0V1
Error of 1% for a crest factor of 7

Quiescent current = 1mA
60 dB range



Inverting Peak Voltage Detector

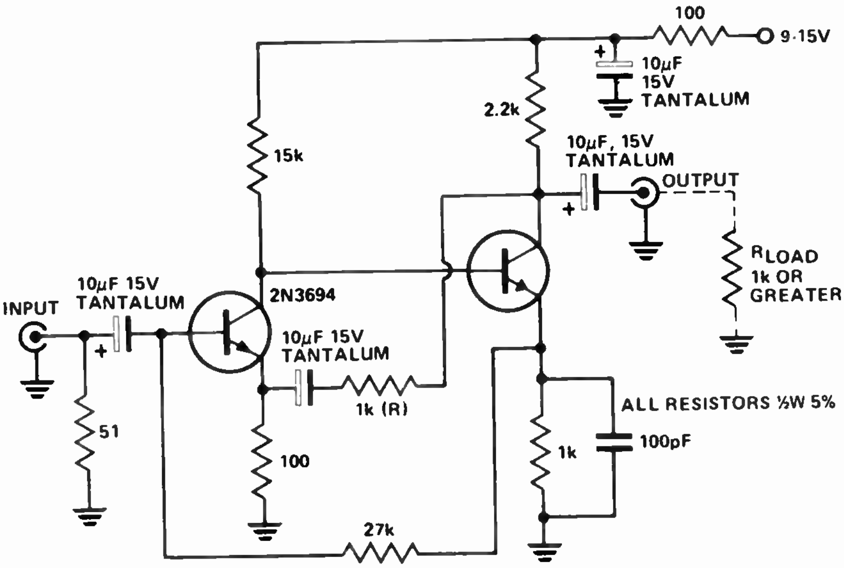
Attack time constant = C.RA
Decay time constant = C.RB



This circuit works well at high frequencies

Wideband amplifier

The wideband amplifier illustrated above provides a gain of 20 dB from below 10 kHz to above 100 MHz, flat within 1 dB. Gain at 200 MHz is about 3 dB. Several amplifiers can be cascaded but remove the 51 ohm input resistor on following stages if this is done. Shielding may be necessary to prevent instability. Maximum output level is about 1 V peak-to-peak before overload, greater gain can be realised by increasing R. Maximum gain is about 40 dB, however, bandwidth is reduced and the top cutoff frequency drops to about 30 MHz. The output load impedance should not be less than 1 k. A source follower using a MOSFET can be used to transform to lower impedances without significantly affecting the frequency response.



Temperature probe for a DMM

The circuit diagram below is for an adaptor unit which converts a digital multimeter, which has a 200 mV range, into a digital thermometer. The temperature can be read directly, as 1 mV corresponds to 1°C.

As shown, the circuit can be regarded as two sections. Section A is a regulated battery power supply. This is based on a circuit in ETI, Feb. '82 (p. 21). As configured, the output voltage is 7.4 V. Section B is the actual temperature transducer. The LM334 is a temperature controlled current regulator. Its current, I_t, is given by the equation:

$I_t = F.T_k$

where T_k is the temperature in °K, and F is the current-to-temperature ratio. The value of F is set by adjusting RV3. In this circuit F is set to 1 uA/°K.

Now, RV2 is set to 1k so the potential drop across it, E_t, is given by:

$E_t = I_t.1000$

Therefore, substituting for I_t, using the first equation and the given value of F, we find:

$E_t = 10^{-6}.T_k.10^3$

and so,

$E_t = T_k/1000$

Hence the potential drop across RV2 (in millivolts) corresponds *directly* to the temperature of the LM334, in °K.

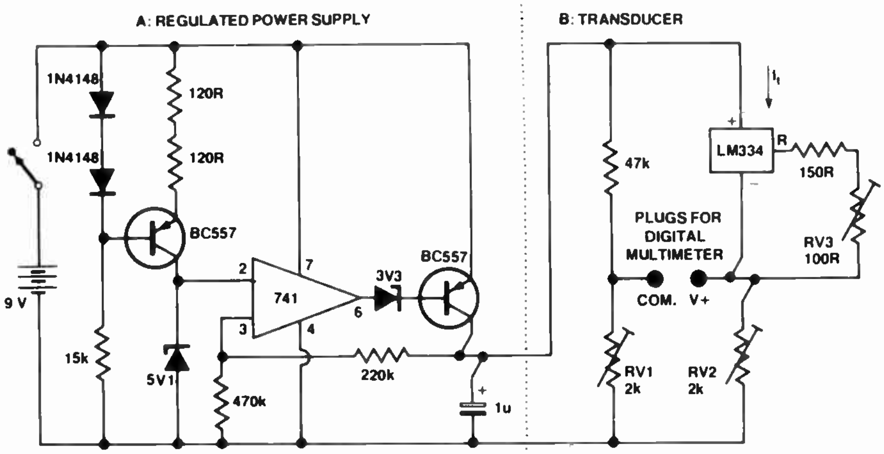
However, we want the temperature to be in °C, and we know that:

$T_k = T_c + 273.2$

where T_c is the temperature in °C. So the 47k resistor and RV1 are set up as a voltage divider, to provide an offset voltage of 273.2 mV. So the voltage across the multimeter plugs, in millivolts, corresponds directly to the temperature of the LM334, in °C, as desired.

The device was built on a small piece of Veroboard, and housed in a very small zippy box. The banana plugs for the multimeter were screwed directly onto the back of the box, so the unit sits on top of the multimeter. The LM334 was put into a probe on the end of a short piece of cable. The leads were soldered onto the cable, and each covered with heat-shrink tubing to prevent shorts. The probe body was formed from a larger piece of heat-shrink tubing. The top half of the LM334 was allowed to protrude, to provide good thermal contact with the body being measured.

Before the leads to the probe are connected, adjust RV2 to 1k as accurately as possible. Then adjust RV1 to give 273.2 mV potential drop. Finally, with the probe connected and immersed in ice water, adjust RV3 so that there is no potential drop across the multimeter plugs. The probe should be wrapped in plastic to protect it from direct contact with the ice water.



NOTES

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