Infrared Object Counter

Count objects with up to 255 pulses per count.

ROGER PARSELL

Most object counters around today implement a mechanical method of counting and those that don't use some very sophisticated and expensive methods of determining the presence of an object. These may take the form of magnetic induction or single ended optical detection, both of which have some major drawbacks. I required an object counter that could count objects of different size, shape, composition and orientation as they pass the sensor.

I decided that an optical method was best suited to the task. For this reason I used an infrared transmitter and receiver; this was superior to the mechanical method because there is no physical contact made between the object and the sensor. I also had the problem that the object might break the beam more than once during the pass, *eg*, a car has two sets of wheels as seen from the side, giving two counts for one object, so a programmable divider was included to count once when the beam was broken a desired number of times. The number of objects that have passed the sensor is displayed on a seven segment display.

How It Works

As can be seen in the block diagram (Fig. 1) an oscillator generates pulses of infrared light at a predetermined frequency, in this case 5kHz. This light is then detected by the receiver and amplified. The amplified signal is then fed through a filter that only allows a signal of 5kHz to pass, followed by a pulse shaping circuit which outputs one pulse every time the beam is broken. This is sent to the programmable divider or directly to the counters, whichever is required.

The counters are decade counters and directly drive the displays from their decoded outputs, thus eliminating the need for counters, decoders and drivers.

Circuit

The transmitter is based on the NE555 timer IC configured in the astable multivibrator mode (Fig. 2). The advantage of

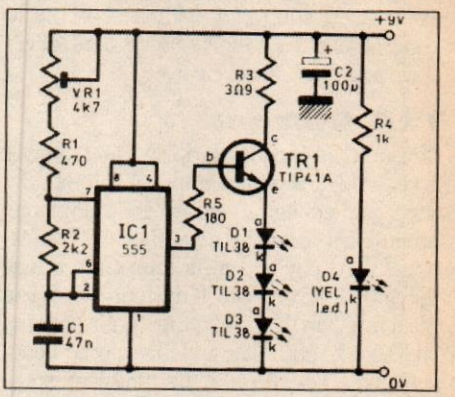


Fig. 2. Transmitter circuit diagram.

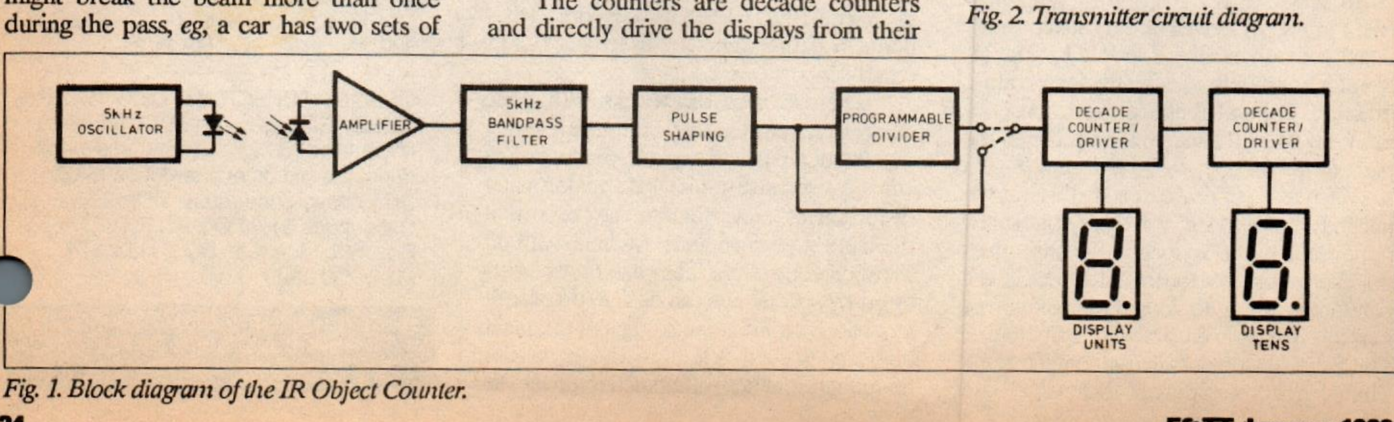


Fig. 1. Block diagram of the IR Object Counter.

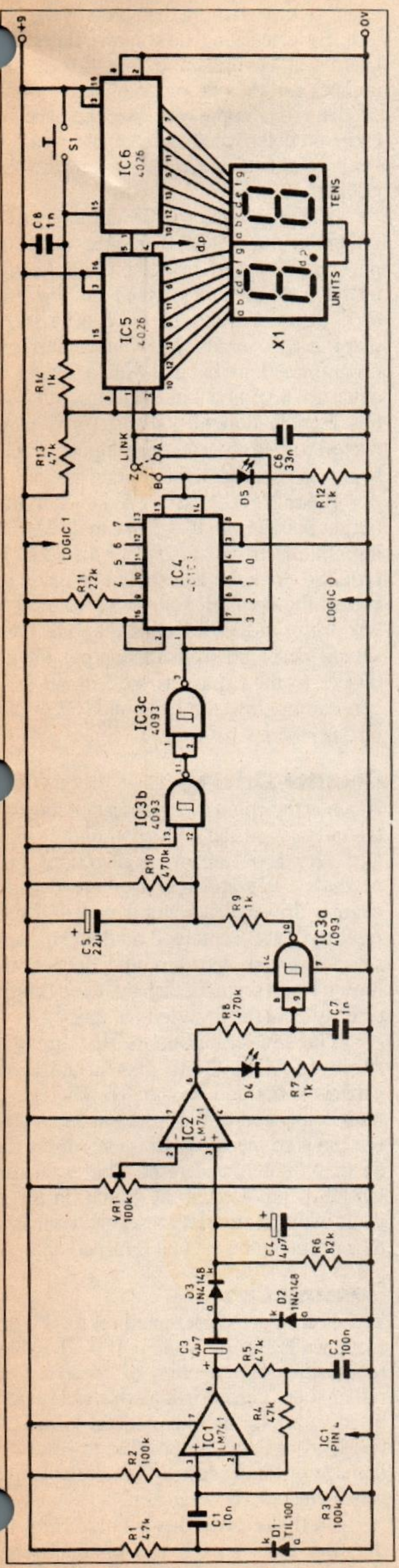


Fig. 3. Receiver and counter circuit.

using a pulsed beam in preference to a continuous beam is that the beam can be encoded in a way that the receiver can differentiate from any other light source. This allows the system to be used in optically noisy environments, such as those that are prone to lights being turned on and off or even the transition from day to night. These environmental changes can cause the receiver to trigger a false count.

There is also a power saving when using the encoded system because the output diodes are flashed on and off many times a second; the output is only on for half the time, so only half the power is used.

The timing components VR1, R1, R2 and C1 are selected to produce 5kHz at the output. VR1 is incorporated so that the transmitter can be fine tuned to the optimum for the environment. The output of the NE555 can only sink loads up to 200mA, so transistor TR1 is used to drive the output diodes as these take 100mA each.

Resistor R3 should not be replaced by a lower value than 3.9 ohms or this might damage the transistor TR1. R4 and D4 are only incorporated to indicate the connection of power to the transmitter as the output diodes do not emit any visible light.

Receiver And Filter

The device used to receive the infrared signal is the TIL100 photo diode (Fig. 3.). This diode works best when light in the infrared spectrum falls upon it. When the light falls upon the sensor the current flowing through it increases. If this diode is connected in reverse bias across the supply through a pullup resistor, we can get a change in potential at the point where they meet; this is proportional to the light falling on the sensor. This potential is also oscillating at the same frequency as the transmitter, so we can AC couple the signal to the amplifier via C1.

The amplifier is designed so that only a signal of 5kHz can pass easily due to the feedback arrangement of R4, R5 and C2. At low frequencies, the gain of the amplifier is approximately 1:1, but at 5kHz the impedance of C2 decreases so that the gain of the amplifier increases to several thousand. The 5kHz frequency at the output of the amplifier is then sent through a voltage doubler circuit D2, D3, and smoothed by R6 and C4. It then reaches the pulse shaping stage.

Pulse Shaping

Pulse shaping is required to shape the smoothed signal into a pulse with fast attack and fast decay, eliminating the risk of

PARTS LIST

TRANSMITTER

Resistors

All 1/4W, 5%

R1 470
R2 .... 2k2
R3 .... 3R9
R4 .... 1k
R5 180

Potentiometer

VR1 .... 4k7 hor. trim

Capacitors

C1 .... 47n
C2 .... 100u 16V

Semiconductors

IC1 .... 555 timer
TR1 .... TIP41A NPN
D1-3 .... TIL38 infrared diode
D4 .... LED

RECEIVER

Resistors

All 1/4W, 5%

R1,4,5,13 .... 47k
R2,3 .... 100k
R6 .... 82k
R7,9,12,14 .... 1k
R11 .... 22k

Potentiometer

VR1 .... 100k hor. trim

Capacitors

C1 .... 10n
C2 .... 100n
C3,4 .... 4u7 16V
C5 22u 16V
C6 .... 33n
C7,8 1n

Semiconductors

IC1,2 .... 741 op amp
IC3 .... 4093 quad NAND Schmitt
IC4 .... 40103 divider
IC5,6 .... 4026 counter driver
D1 .... TIL100 photo diode
D2,3 .... 1N4148
D4,5 .... LED

X1 double 7-seg. common cathode display

Miscellaneous

Short length of 16-way ribbon cable, wire, solder, etc.

a false reading by unwanted noise spikes. Noise spikes can occur by the switching on and off of light switches, etc., in the close proximity of the receiver.

The first stage of the pulse shaping is to compare the input pulses with a known potential; this is done by a comparator circuit. A 741 operational amplifier (IC2) is used to compare the potential set at pin two by the potentiometer VR1 — this is know as the reference potential. The input signal is connected to pin three and is then compared with the reference potential. If the signal is greater than the reference, then the output goes high. If the signal potential does not reach the reference potential, then the output will remain low. By using a comparator all the noise spikes less than the reference potential are eliminated. The output of the comparator then feeds R7 and D4. This diode emits light when the beam remains unbroken and stops emitting when the beam is broken.

The next stage is formed by IC3 which consists of four 2-input NAND gates, which can be used as Schmitt triggers, simplifying the task of pulse shaping. (As the Schmitt trigger is a dedicated pulse shaping device, it is an obvious choice.) The input pulse is fed into the first two gates for shaping and the third is incorporated as an inverter to invert the output of IC3b ready to be fed through the dividing circuit.

Pulse Dividing

As described previously, the pulse divider was incorporated to enable the use of the system in applications where the beam might be broken more than once by the ob- ject. By calculating how many times beam will be broken by the object, number can then be programmed into the divider so the output will only pulse once for every predetermined number of times the beam is broken, or once every time the object passes.

The programmable divider is virtually self-contained as IC4. The input is fed to pin one of IC4 and divided by the value set by the program inputs, which are pins 4, 5, 6, 7, 10, 11, 12, and 13. As can be seen, there are 8 inputs and these must be programmed in binary, with a binary 1 equal to +ve and binary 0 equal to 0V; this combination of 1's and 0's is connected to the programming inputs of IC4 to give the number to be divided by.

Resistor R12 and D5 indicate the output pulses from IC4. IC4 can divide the input pulses from 2 to 256; if a 1:1 count is required then the link should be made to bypass the counter—otherwise connect a link from divider to counters. The link should never go from the output of the divider to the bypass as the Schmitt triggers cannot drive the LED and IC3 would be destroyed.

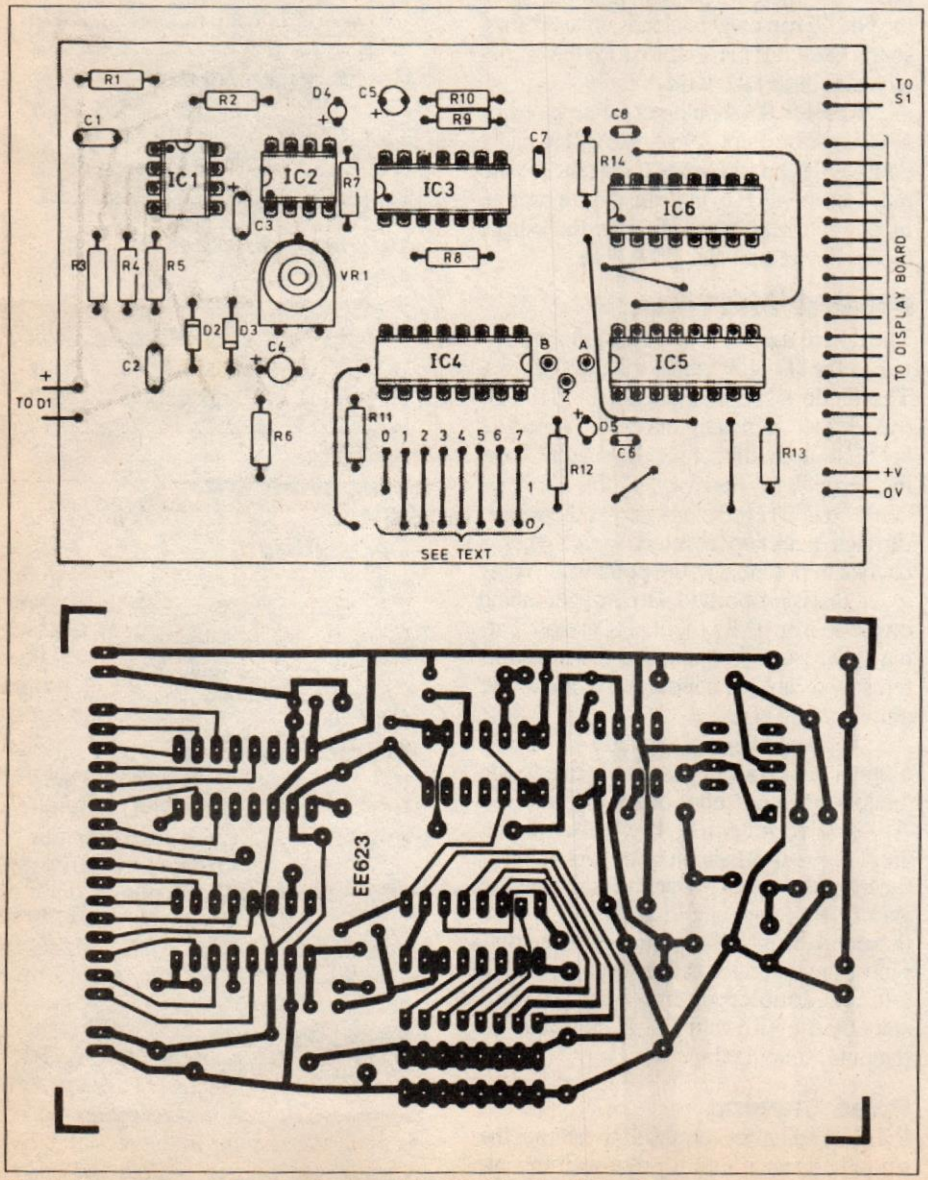


Fig. 4. The component overlay (top) and the PCB for the Object Counter.

Counter Driving

Again in the counter driver section most the circuits are self-contained in the chips and very few external connections are necessary. IC5 and IC6 are both decade counter drivers that count from 0 to 9 and reset to 0; also contained on the chips are seven segment decoders and drivers, allowing seven segment displays to be driven directly from the decoded outputs.

The few components that are associated with these ICs consist of capacitor C8 and switch S1. These are both connected to the reset pin 15. When this pin is connected to the +ve supply via S1 the counters will reset. The capacitor C8 holds pin 15 high at switch on for a short while in order to reset the counters to zero each time the unit is turned on.

Construction

The circuits are constructed on the PCBs as shown in Figs. 4, 5 and 6. It is advisable to use the PCB method of construction rather than Veroboard, as this would not be easy even for the experienced constructor. It would also be possible to severely damage or totally destroy one of the chips with an incorrect connection.

On the receiver driver board (Fig. the wire links on the top of the board should be connected first using insulated connecting wire (these replace the double-sided PCB used in the prototype). Then all resistors should be connected. The resistors should then be followed by inserting the signal diodes D2 and D3, ensuring the correct orientation. Then connect the remaining capacitors and LEDs, also ensuring the correct orientation.

The ICs should be connected using IC sockets since it's very difficult to remove them once they have been soldered in place. Components IC3, IC4, IC5 and IC6 are all CMOS devices and should be handled with all static handling precautions. D1 could be connected to the PCB or connected remotely via two connecting wires, but pay particular attention to the orientation of this device. The long lead should be connected to the positive and the short lead connected to the 0V line.

The transmitter board (Fig. 6) is assembled in much the same way, with the resistors and capacitors connected in place first. This should then be followed by D1, D2, D3 and D4 connected in forward bias with the long lead to the positive. Finally IC1 and TR1 should be connected in. The display board should cause no problem in construction but make sure that the display is the correct way around.

Setting Up

Before testing the board the programmable divider should be set up using solder links. All eight programming presets or IC4 must be connected to either positive for logic 1 or the 0V rail for logic 0. Any count can be made between 1 and 255 and this is set in binary using solder links to the supply rails as shown in the connection diagram. Having worked out the number of times the object will break the beam, the number can be set up as an eight-bit binary code.

Each preset input of IC4 corresponds to a single bit of an eight- bit binary number as follows:

0	1	2	3	4	5	6	7
1	2	4	8	16	32	64	128

Thus any number can be programmed up to 255 by connecting the appropriate input to either positive input or ground. For example, if you require one count for every 122 times the beam was broken:

$$122 = 0x128 + (1x64) + (1x32) + (1x16) + (1x8) + (1x2) + (0x1)$$

This is 01111010 in binary, set by connecting the programming inputs in the following way:

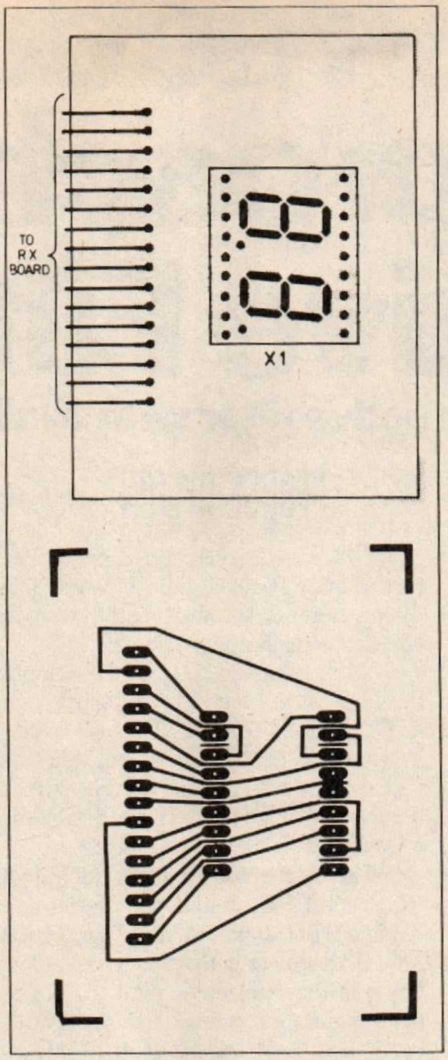


Fig. 5. The component overlay (top) and the PCB for the display.

Preset 7 goes to 0V
Preset 6 goes to +ve
Preset 5 goes to +ve
Preset 4 goes to +ve
Preset 3 goes to +ve
Preset 2 goes to 0V
Preset 1 goes to +ve
Preset 0 goes to 0V

A word of caution: the preset inputs 0-7 do not correspond to the IC pin numbers (see Fig. 3), so check before you start.

Testing

The transmitter may be powered by any voltage source of eight or nine volts. When powered up you will not be able to see anything being emitted, as infrared is invisible to the human eye. However, checking pin three of the NE555 with either a high impedance earphone or an oscilloscope should confirm the presence of high frequency oscillation.

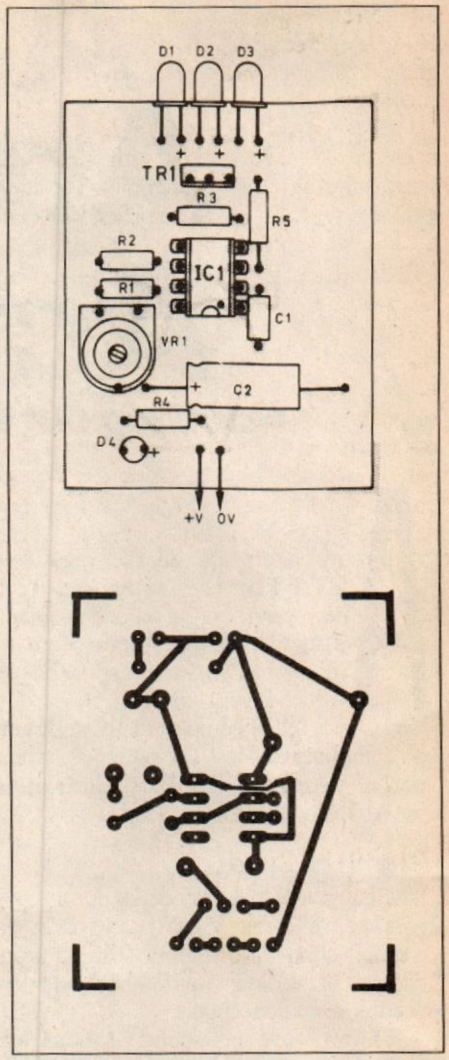


Fig. 6. The component overlay (top) and the PCB for the transmitter.

The receiver is best checked by powering up and then bringing the transmitter close to D1 of the receiver, at which point the LED D4 should light. If it doesn't, try rotating VR1, a result should be obtained when it is set to a central position. If the diode still stays unlit, check that photo diode D1 is connected the right way around, and also check that C3, D2, D3, are the right way around.

In use, the receiving diode should be covered by a light guide, thus making it more directional and less sensitive to stray pickup. A small piece of rubber sleeving is ideal for this.

An operational range of up to 3.5m is possible. The only adjustment required is to alter VR1 on the transmitter and VR1 on the receiver for optimum operation. It is also necessary to set the programming of the divider and the link to count pulses or count the output of the divider, as described earlier. ■

Zero-sensing counter yields data's magnitude and sign

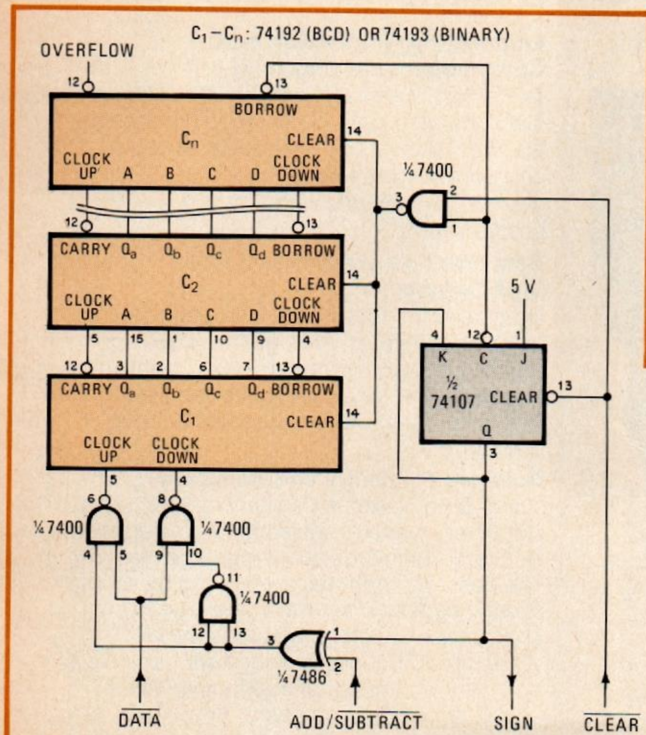
by Gary A. Frazier
Richardson, Texas

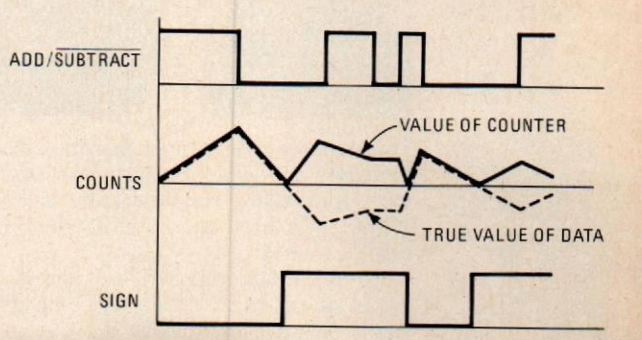
Upon sensing when an ordinary up-down counter is about to count down through zero, this circuit reverses the direction of the count to enable it to express a negative number by its magnitude and sign, instead of by the more usual but less convenient 2's complement. The circuit similarly represents positive integers, making it easy for any stored value to be handled directly by such data-system devices as digital-to-analog converters or microprocessors.

The unit shown in the figure has been found particularly useful in a digital-averaging application. Data is sampled during an interval in which the ADD/$\overline{\text{SUB}}$ line is toggled at some frequency, which in this case varies with time, as shown. Any data in phase with the ADD/$\overline{\text{SUB}}$ signal will accumulate in the n-stage counter (count-up mode), and digital noise will be averaged out (subtracted). The output of the counter is sampled at the end of the data-collection interval.

If the contents of the counter should ever decrease to zero, a borrow pulse is generated by the most significant counter, C_n, and toggles the flip-flop. In turn, the NAND gate connected to the clock-up port of C_1 is enabled. In this way, the output of the counter is mirrored about 0, as shown in the timing diagram, and is equal to the absolute value of the difference between the number of the add-to and the subtract-from counts. The sign bit is set each time the data actually drops below zero.

Note that when using the up-down counter, it is necessary to keep the counter cleared while the $\overline{\text{BORROW}}$ is low to avoid difficulties should the clock-up line suddenly become disabled while the clock-down line is activated. Otherwise, a decrement will take place. The frequency and symmetry of the ADD/$\overline{\text{SUB}}$ waveform is arbitrary so long as the counter does not overflow on any half cycle of a sampling interval. □

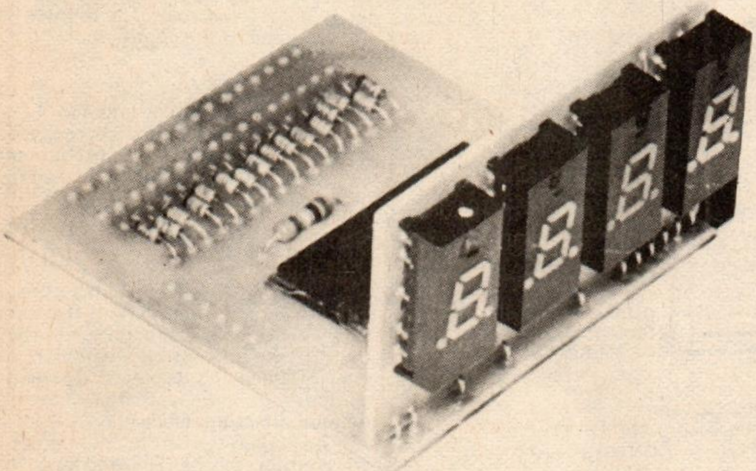




About face. Circuit inhibits up-down counters C_1–C_n from decrementing below zero, instead forcing them to count up and mirror the result of a negative-number addition in binary form. A negative-sign bit is also generated. Thus, all numbers are suitable for direct handling by a d-a converter or other data-system device.

DIGITAL MODULE

*4 digit
*up/down counting
*drives LEDs directly
*latch
*presettable
*second register
*equal and zero outpu
*DC to 2MHz
*5V operation



SPECIFICATIO

Number of digits	4
Readout	LED
Maximum frequency	2MHz
Input impedance	100k
Output drive	1 TTL load
Supply voltage	4.5 – 5.5V
Supply current	
low power mode	500μA
all eights	100mA

THE THREE DIGIT display we previously published has proved to be one of our most popular projects. We have used it in a number of projects and we know of several commercial companies using it in their own equipment.

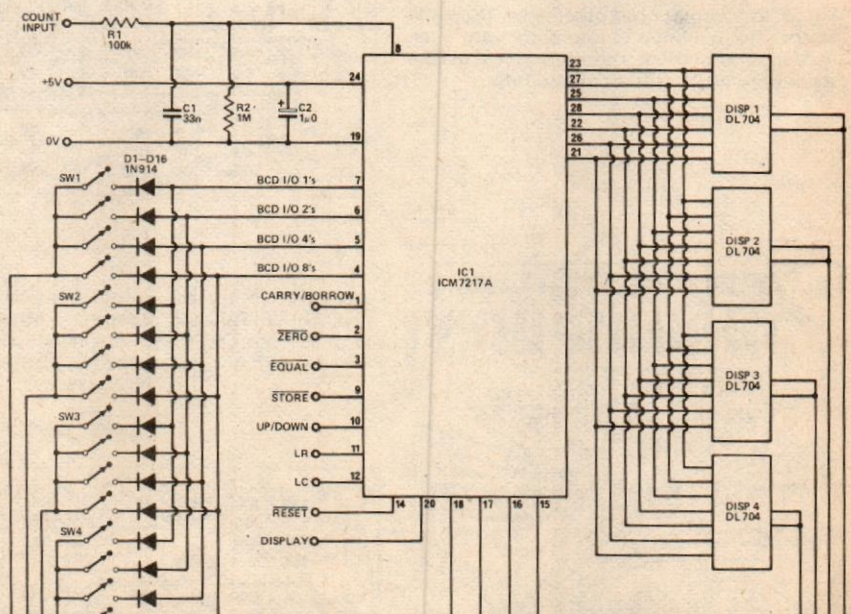
Many people have asked us for a 4 digit version and we have been looking round at ICs available. We have chosen this Intersil device because we believe it offers the best versatility at the moment. Apart from being a 4-digit counter-latch-decoder driver needing no external components except the displays, it also is an up-down counter and can be preset to any number. In addition, it has a separate register which also can be set to any number and comparators which give outputs when the counter is equal to the register and when it is zero — all in one IC!

Mod Build

The unit is built on two small PCBs which are connected together with short links of tinned copper wire. Be careful to orientate the IC correctly as it is expensive!

The preset system is designed to use a 4 digit BCD thumbwheel switch

Fig 1. Full circuit diagram of the counter module. The How It Works section for this is given overleaf — but as this is really a "How To Use It" section it don't matter — does it?



(closed = '1') but individual switches can be used if required. Input is in BCD, therefore the switches will have the weighted values 8, 4, 2 and 1. If the preset is not needed then the diodes can be left out. If a preset is needed, but always to a fixed number, links can be inserted to replace the "on" switches and the other diodes left out. ETI

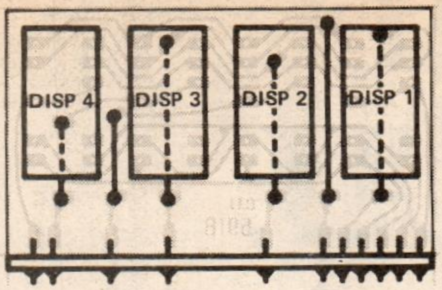


Fig. 2. The positioning of the displays and the links which must be installed before the displays.

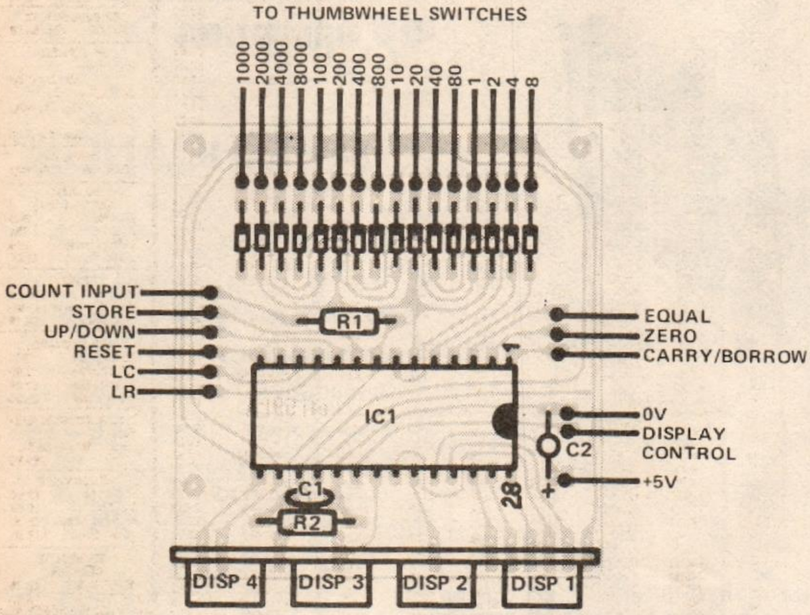
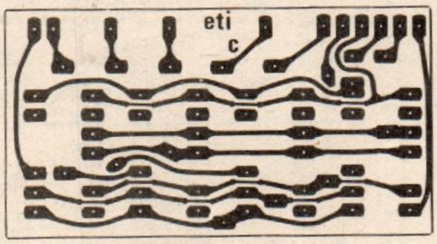
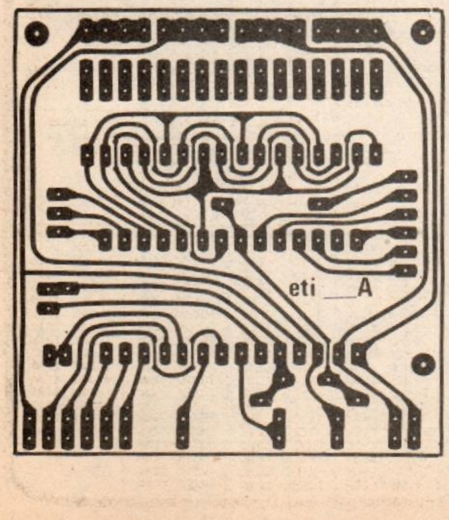
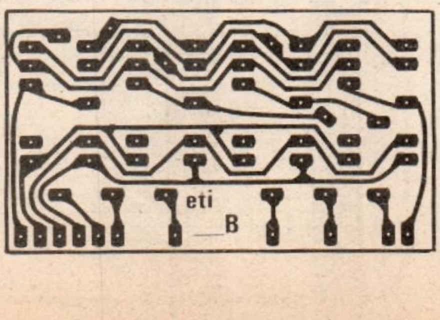


Fig. 3. The component overlay for the main board. The common connection from each of the thumbwheel switches goes to the track next to the other connections.





Full patterns for the digital module project. Shown full size. Board C — above — is to fit high brightness displays such as employed in our digital dial project.



HOW IT WORKS

Count Input — Pin 8

The counter is incremented or decremented on the leading edge of this input. A schmitt trigger is provided with a 500 mV hysteresis on a 2 V trigger point. For high speed operation, or operation from a digital output, delete R2 and C1 and short out R1. Maximum frequency of operation is about 2 MHz.

Up-Down — Pin 10

If this pin is left open or taken to +5 V the counter will be incremented by the count input. If it is taken to 0 V the counter will be decremented by the count input.

Reset — Pin 14

If this pin is left open or taken to +5 V the counter is free to be incremented or decremented. If it is taken to 0 V the counters will be reset to zero and held there until reset is taken high again.

Store — Pin 9

Ig this input is left open or taken to +5 V the latches are "closed" and the information which was in the counters at the time the store input went high will be remembered, decoded and displayed. The counters can be reset, incremented or decremented without affecting the display.

If it is taken to 0 V the counter contents will continuously be displayed for as long as this input is at 0 V. Any change in the counter contents will be shown on the display.

Load Counter — Pin 12

This is a 3 level input. If it is left open the counter works normally. If it is taken to +5 V the counter is loaded with the BCD data which is set on the thumbwheel switches. If the latch is open, this number will also be displayed. If this input is taken to 0 V the BCD I/O pins become high impedance. If a 3 level input is to be controlled by other logic outputs they must be tristate devices.

Load Register — Pin 11

This is also a 3 level input. If it is left open the counter works normally. If it is taken to +5 V the register is loaded with the BCD data. If taken to 0 V the circuit goes to a low power state with the multiplexing oscillator stopped, the display off and the BCD I/O pins in a high impedance state. The operation of the counter is unaffected except that there is no display.

BUYLINES

Since this project is based entirely upon the one chip—ICM 7217A — this is all there is to cause problems! Since it appears in most peoples catalogues we cannot foresee any trouble here. Displays can be any type really — but for outdoor work use high brightness types.

PR[redacted]JECT: [redacted]igital Module

Display Control — Pin 20

This is also a 3 level input. If it is left open, leading edge blanking occurs. If all digits are zero then all are blanked. If it is connected to +5 V the display is completely blanked irrespective of the value. If taken to 0 V all digits are ON irrespective of value.

Scan — Pin 13

The internal multiplexing frequency is nominally 10 kHz giving a digit repetition rate of 2.5 kHz. With a 20 pF capacitor from this point to 0 V the frequency drops to 5 kHz and with 90 pF it is about 1 kHz.

BCD I/O — Pin 4-7

This is a multiplexed data port, normally an output which can drive 1 TTL load. It becomes an input when either LC or LR is at +5 V. Pin 7 is the least significant bit.

Digit Drives — Pins 15-18

These are used both to drive the LEDs and to provide data indicating which digit is being presented at the BCD I/O port. Pin 18 is the least significant digit.

Zero — Pin 2

If the value of the counter is zero this output will be at 0 V.

Equal — Pin 3

If the value of the counter is equal to the value of the register this output will be at 0 V.

Carry/Borrow — Pin 1

When the counter goes from 9999 to 0000 or from 0000 to 9999 a 500 ns positive pulse occurs on this output. This is connected to the count input of a second unit when an eight digit display is needed.

PARTS LIST

RESISTORS (all ½W 5%)

R1	100k
R2	1M

CAPACITORS

C1	33n polyester
C2	1u0 35V tantalum

SEMICONDUCTORS

IC1	ICM 7217A
D1—D16	1N914
DISPLAYS	DL704

DIGITAL DIAL

Most AM radio dials are pretty hopeless — especially portables and car radios. This application of our counter module can be a decided improvement.

WITH MODERN RADIOS which are designed to be operated anywhere in the world, the local station call signs are no longer marked on the dial. Instead the dial is marked with frequencies making it more universal. Unfortunately the scaling on many receivers leaves a little to be desired, with many car radios lucky to have 3 or 4 markings. The use of pushbutton selection helps but when a cassette is fitted or you are out of your local area there is still the problem of knowing to what station you are tuned.

This project gives a direct readout of the station being received allowing for easy identification and selection. The display is remote from the receiver allowing it to be mounted on the dashboard for easy viewing.

Design Features

This project is the first to employ our four digit module presented elsewhere in this issue. We will be using the module again over the next few months so don't lose track of it!

If this device is to be used outdoors i.e. in the car, it is recommended that high brightness displays, such as the Hewlett Packard HDSP 4133, be used. As these have a different pin-out a new display board is presented in this article.

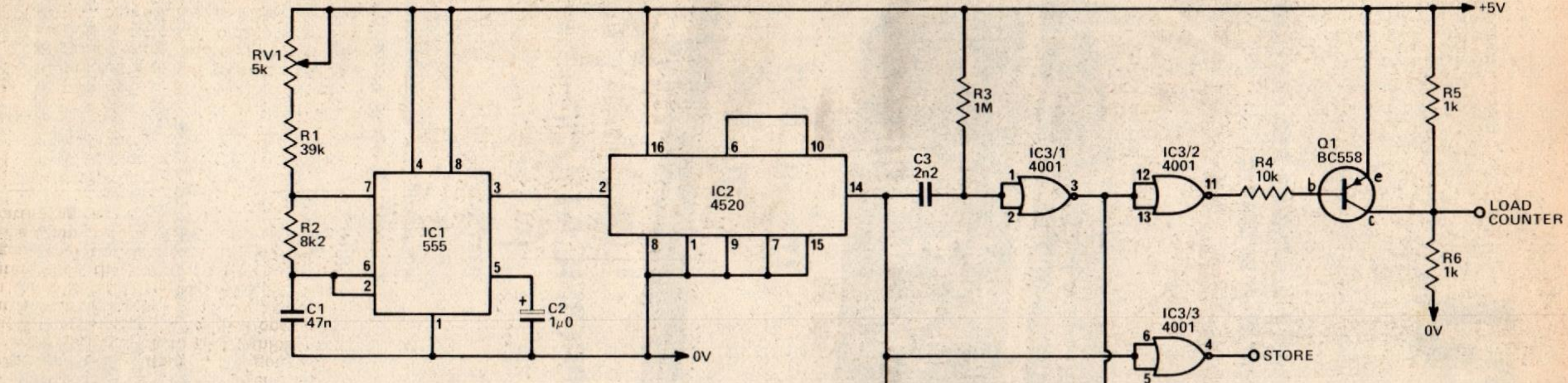
The theory of operation is that we actually measure the frequency of the local oscillator in the radio and subtract the IF frequency. While we could have subtracted this using digital logic we chose to do it by resetting the display not to zero but to 9545 (10 000-455). The first 455 pulses in the timing period are then used getting to zero and in effect, only pulses after this are counted and displayed. This number can be loaded into the counter by selecting the appropriate diodes and using the "load counter" input instead of the reset line. The only difference is that as the data is entered into the counter serially the pulse used must be longer than 4 times the internal oscillator period. Also as the LC input is a three state input it cannot be driven by conventional two-state.

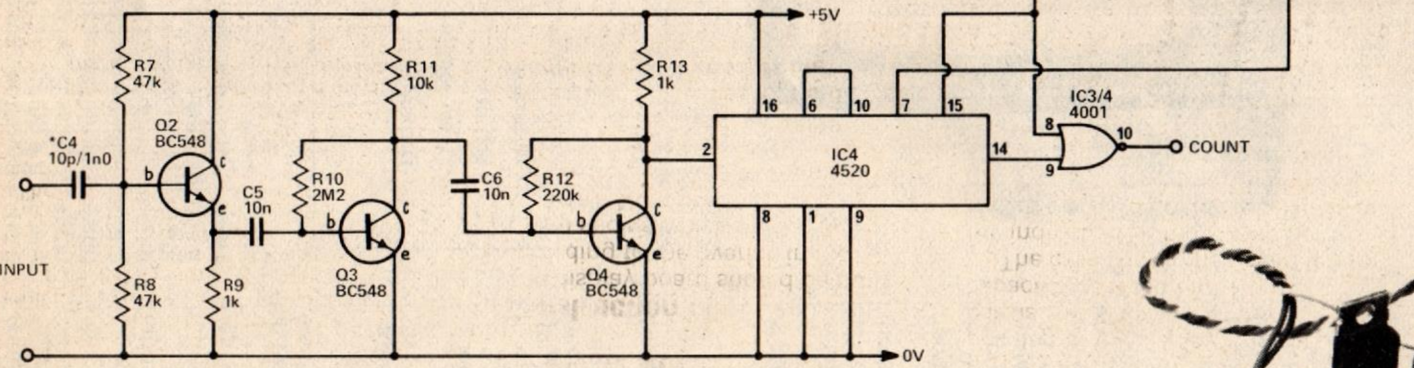
SPECIFICATION

Frequency range	500-1700 kHz
Accuracy	∓ 5 kHz
Sensor	pickup coil or direct connection
Power supply	7-20VDC @ 80mA or 240VAC
Display	4 digit LED

Out of Tune

We initially tried capacitive coupling onto the tuning capacitor of our portable radio (oscillator section!) but the loading detuned the set too much. We then tried a pickup coil and found enough signal with it in the correct place not to require any electrical connection to the set. With ►





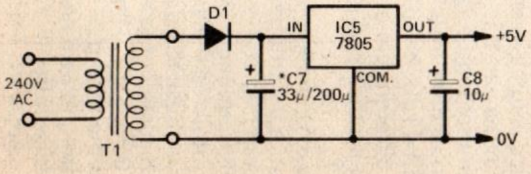
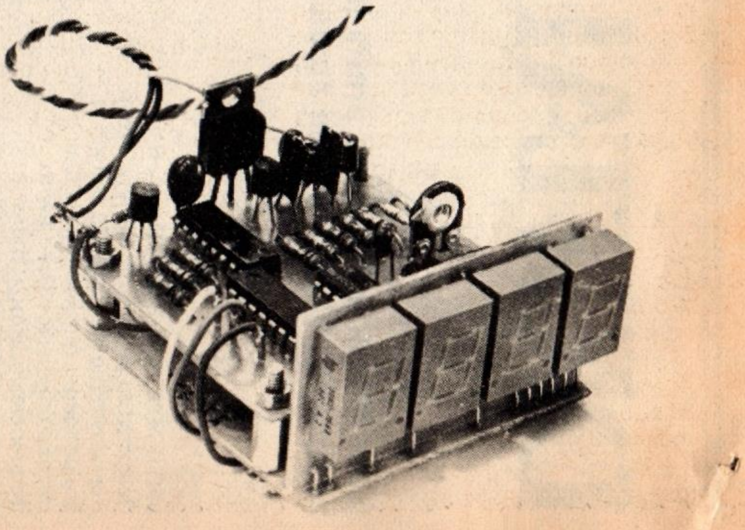


Fig. 1. The full circuit diagram for the control logic board. The PSU is shown lower right.

The photo to the right shows the module with the HP 5082-7663 displays. Suitable displays and their light outputs are given below.

Type	Colour	Size	Light output
HDSP 4133	yellow	10.9 mm	2100μCd @ 20mA
HDSP 3733	red	10.9 mm	1800μCd @ 20mA
5082-7663	yellow	10.9 mm	1500μCd @ 20mA
5082 -7653	red	10.9 mm	1720μCd @ 20mA
DL704	red	7.6 mm	320μCd @ 25mA



HOW IT WORKS

A signal from the local oscillator in the tuner is picked up either by a pickup coil or by direct connection to the set. It is then amplified by Q2-Q4 to give a square wave on the collector of Q4. The gain of this amplifier is about 250 (48 dB). The frequency of this signal will vary from around 1 MHz to about 2 MHz and this signal is then frequency divided by 256 (2^8) in IC4. This is used to clock the display module.

To measure the frequency we have to count the number of these pulses for 256/1000 seconds (256 because we divided the input by 256 and 1000 as we want a 1 kHz resolution). We used a 555 oscillator for the time base and its output is also divided by 256 (by IC2). This improves the stability of the time base by averaging out any short term variations in the 555 frequency.

The output of IC2 is a symmetrical square wave and when the output goes low a 1.5 ms wide pulse is generated by R3, C3 and IC3/1. This is inverted by IC3/2 which turns Q1 on for the 1.5 ms period. Two resistors are used to bias the output of Q1 to 2.5V to ensure that the three level input will work.

This pulse "loads" 9545 into the counters (in the display module). Counting now starts from this number and after 455 pulses it is passing through zero. 256 ms after the load pulse ended the output of IC2 goes high. This resets IC4 back to zero, inhibits any further clocking via IC3/4 and opens the latches via the strobe line allowing the total in the counter to be displayed. 257.5 ms later when the output of IC2 goes low again, the store is closed, the counter is once again preset to 9545 with the process starting again.

the car radio however the coils are shielded so well that reliable operation was not possible. However it was found that we could tap onto one side of the oscillator coil without affecting the operation.

We use a NE55 as the time base with its output being divided by 128 to improve stability. However if an accuracy of ± 5 kHz is to be maintained its frequency has to be better than ¼% and a polystyrene capacitor for C1 and 2% resistors for R1 and R2 are recommended.

Construction

The display board should be built according to the overlay in Fig. 4 which shows which diodes are required. Note that R1, 2 and C1 are not used in the display module and a link is used in place of R1.

The control card can now be assembled and wired to the display module. The two boards are mounted one above the other using 9.6 mm spacers. Check that these screws do not touch any tracks and insulate them if too close.

Depending on whether the unit is going to be used with a car radio or portable the values of C4 and C7 will vary. The pickup coil is made by winding about 80 turns of 0.25 mm enamelled wire onto a 25 mm long piece of 10 mm ferrite rod with the end terminated onto a twisted pair of plastic covered wires long enough to go between the radio and the position of the display. Do not use coaxial cable for this as the capacitance is too high.

The case chosen has been left to the individual with our own being from a discarded digital clock. If you use the 240 V powered version be careful with the high voltage wiring. For the 12 V version the power can come from the radio via a twisted lead (3 wires).

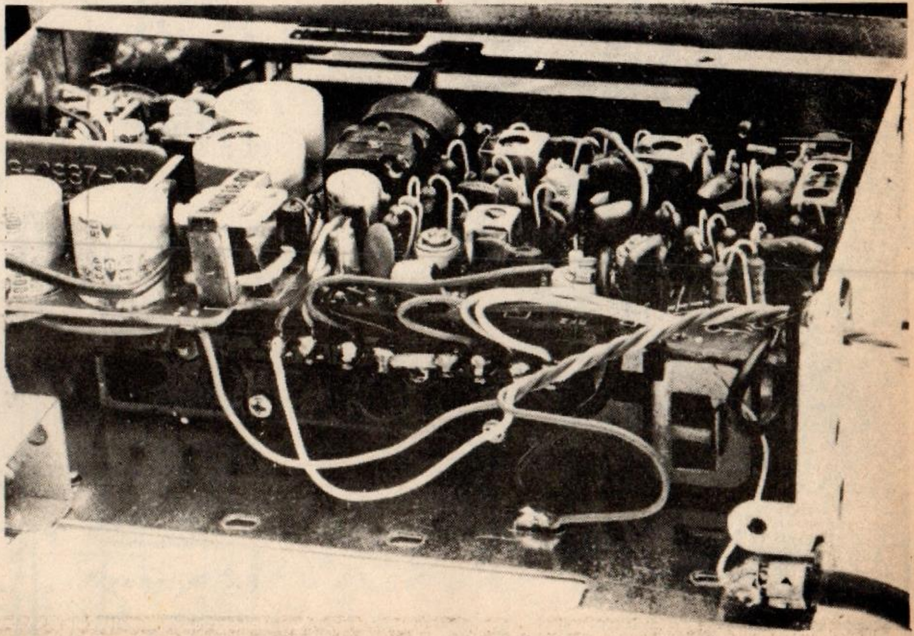
When connecting into a car radio, tune the set to a local station and try the pickup wire on the terminals of the tuning coils in turn until one is found which will give a reading without moving it off station. Permanently connect to this point. With a portable radio try moving the pickup coil around the set, probably in line with the aerial coil, until the best results are obtained.

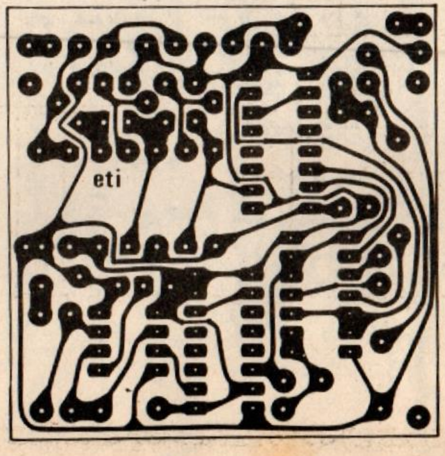
Calibration

Place the pickup coil in position such that reliable operation is obtained and tune to a known station (preferably near the top end of the dial). Now adjust RV1 until the digital dial agrees with that station. Check then with other stations.

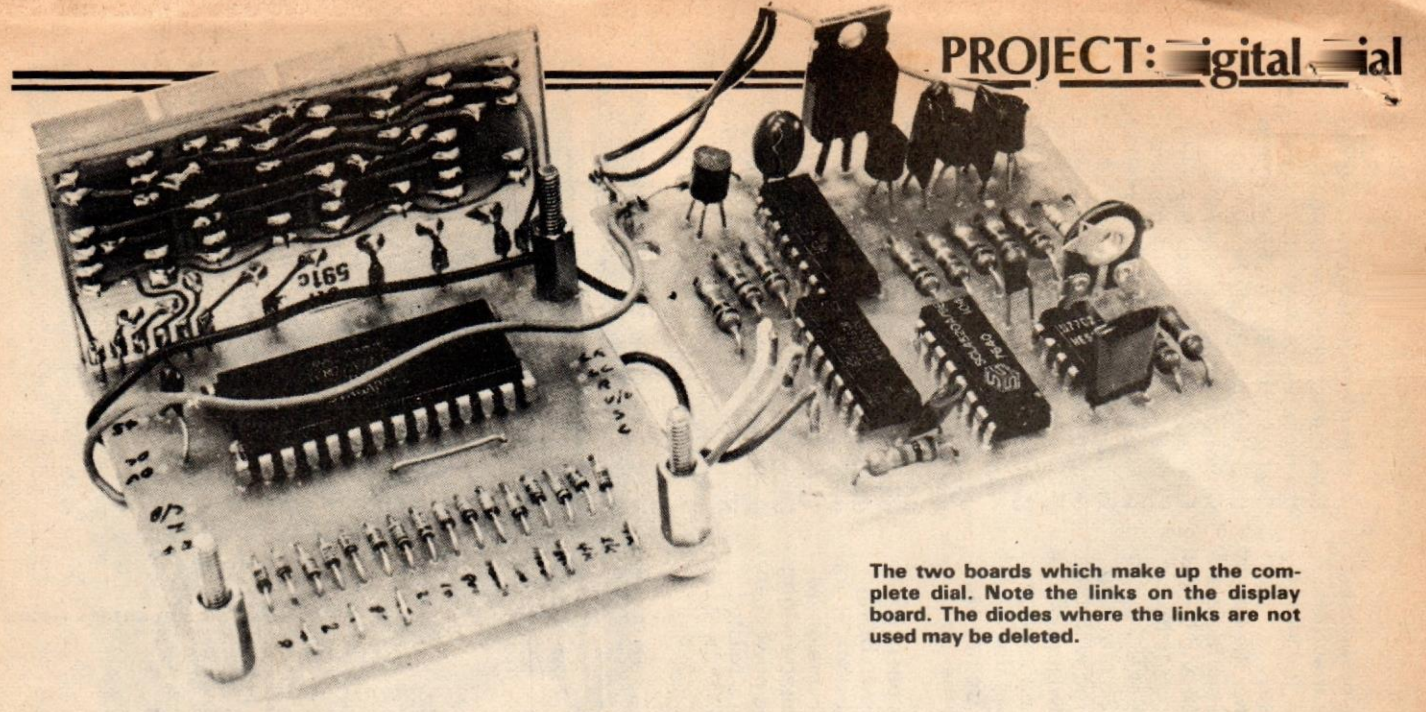
Alternatively feed a known signal of between 1 and 2 MHz from an oscillator into the input and adjust RV1 until it reads 455 less than that frequency. ►

Photo showing where we tapped into the car radio.





Right: full site foil patterns for the Digidial control board. Refer to the module article for details of those PCBs. Not shown here i.e. the two display boards and the third for high brightness seven segment types.



The two boards which make up the complete dial. Note the links on the display board. The diodes where the links are not used may be deleted.

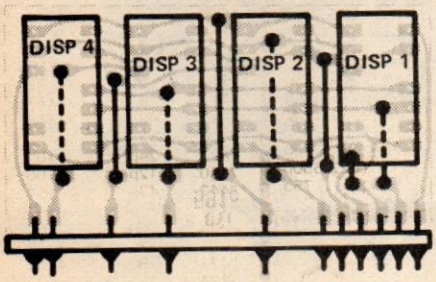
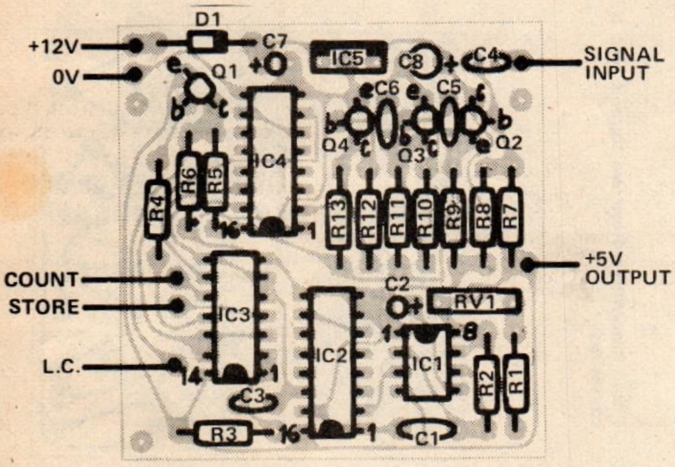


Fig 3(a) The overlay for the display board employing the high brightness displays. (b) Below that (left) the control board overlay.



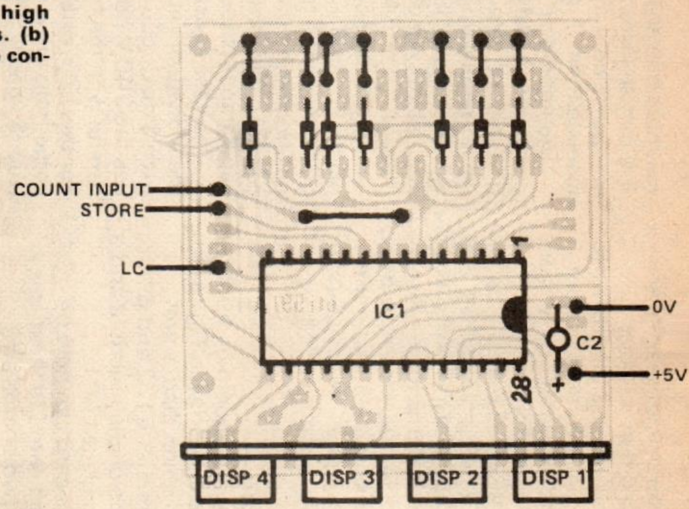


Fig. 4. The component overlay of the display module showing the diodes and links required.

PARTS LIST

RESISTORS	all ½W, 5%	*C7	33u tantalum
R1	39k	C8	10u 25V electrolytic
R2	8k2		
R3	1M	SEMICONDUCTORS	
R4, 11	10k	IC1	555
R5, 6, 9, 13	1k	IC2	4520
R7, 8	47k	IC3	4001
R10	2M2	IC4	4520
R12	220k	IC5	7805
		Q1	BC558
POTENTIOMETER		Q2-Q4	BC548
RV1	5k trimmer	D1	1N4004
CAPACITORS		MISCELLANEOUS	
C1	47n polystyrene	*Transformer 240V-12V6, 150 mA	
C2	1u0 tantalum		
C3	2n2 polyester		
*C4	10p ceramic		
C5, 6	10n polyester		

*For 12 V operation delete transformer. For 240 V version C7 should be 220u 25 V. For use with pickup coil increase C4 to 1n0.

BUYLINES

Any displays mentioned here are of course suitable and should be easily obtainable. The semiconductors are all available from Technomatic, or indeed from most other mail-order suppliers.

Power Supply

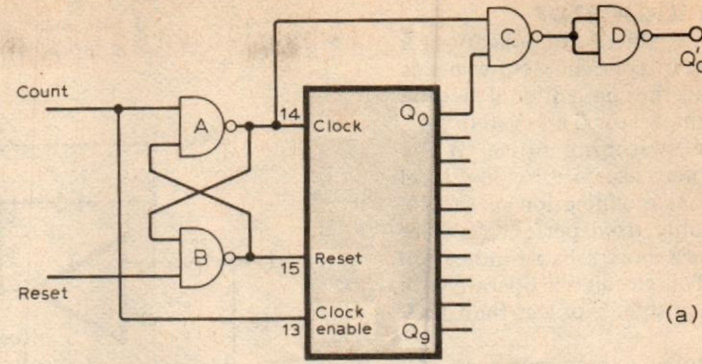
The unit can be powered by an AC or DC voltage of between 7 and 20 volts. If an AC voltage is used the capacitor C7 should be increased to 220 u. A 240 V to 12V6, 150 mA transformer is recommended. ETI

Decade counter with suppressed zero output

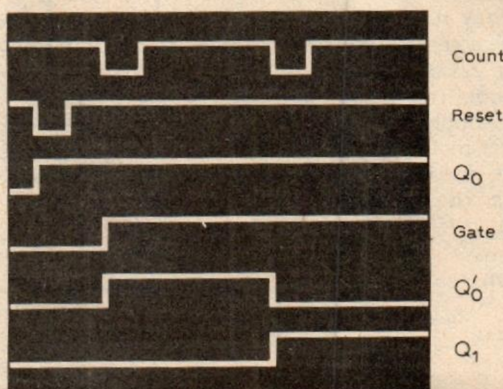
At least one output from a typical decade counter, such as the 4017, is always activated, and normally the Q_0 state becomes a 1 on reset. There are times when no output from the zero state is required, while a true count of ten is still wanted. The most economical circuit is accomplished by the addition of a bistable stage using two dual-input NAND gates. Decoding uses a third gate and the fourth gate is used as an inverter.

With the circuit in the reset state, Q_0 is a 1, but because of gate A of the bistable is at 0 the output of gate C is 1 and Q_0' is 0. Application of an input pulse resets the bistable without incrementing the counter, so the Q_0' output becomes 1. Subsequent pulses step the 4017 in the conventional manner. A negative pulse resets b both the counter and the bistable.

D. Price
Knockholt
Kent



(a)



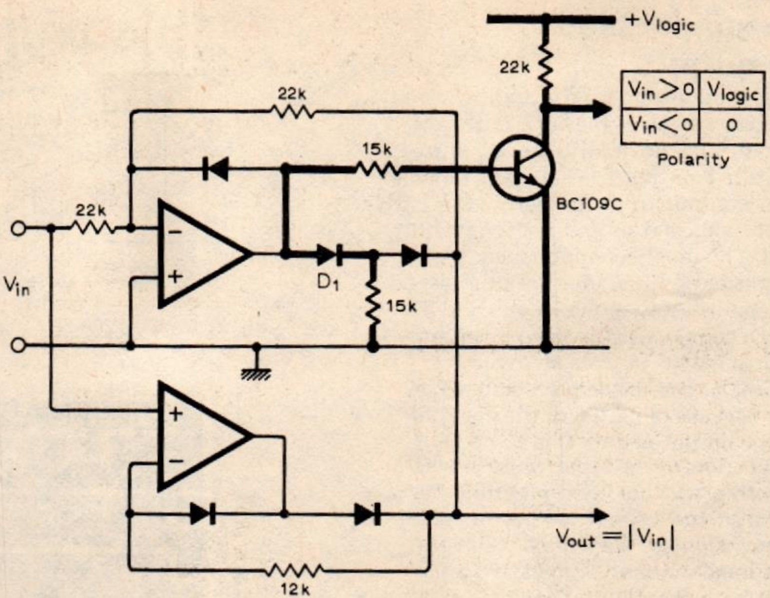
(b)

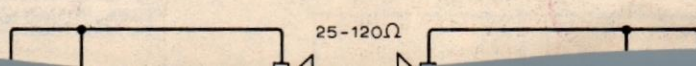
Polarity indicator

In applications where the polarity of a signal applied to a perfect rectifier needs to be detected, the conventional method is to use a comparator. This system adds undesirable switching noise to the signal, and may oscillate for low-level signals. A small modification, as shown, to a commonly used perfect rectifier circuit offers a more reliable indication of polarity. This circuit will operate with low frequency signals of less than 1mV pk-pk.

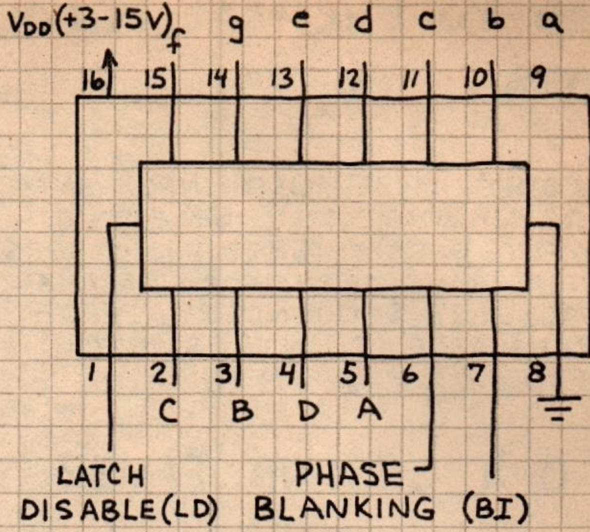
The additional voltage drop across D_1 ensures that the transistor switches correctly as the polarity of the input signal changes. Frequency response of this rectifier is not quite so good as the unmodified circuit. The 22kΩ collector pull-up resistor is suitable for driving c.m.o.s. from any logic supply voltage. For t.t.l., the pull-up resistor should be changed to 3k9 to drive one input. For precision applications, the op-amps should be offset nulled.

T. Hughes
University of Cape Town
South Africa





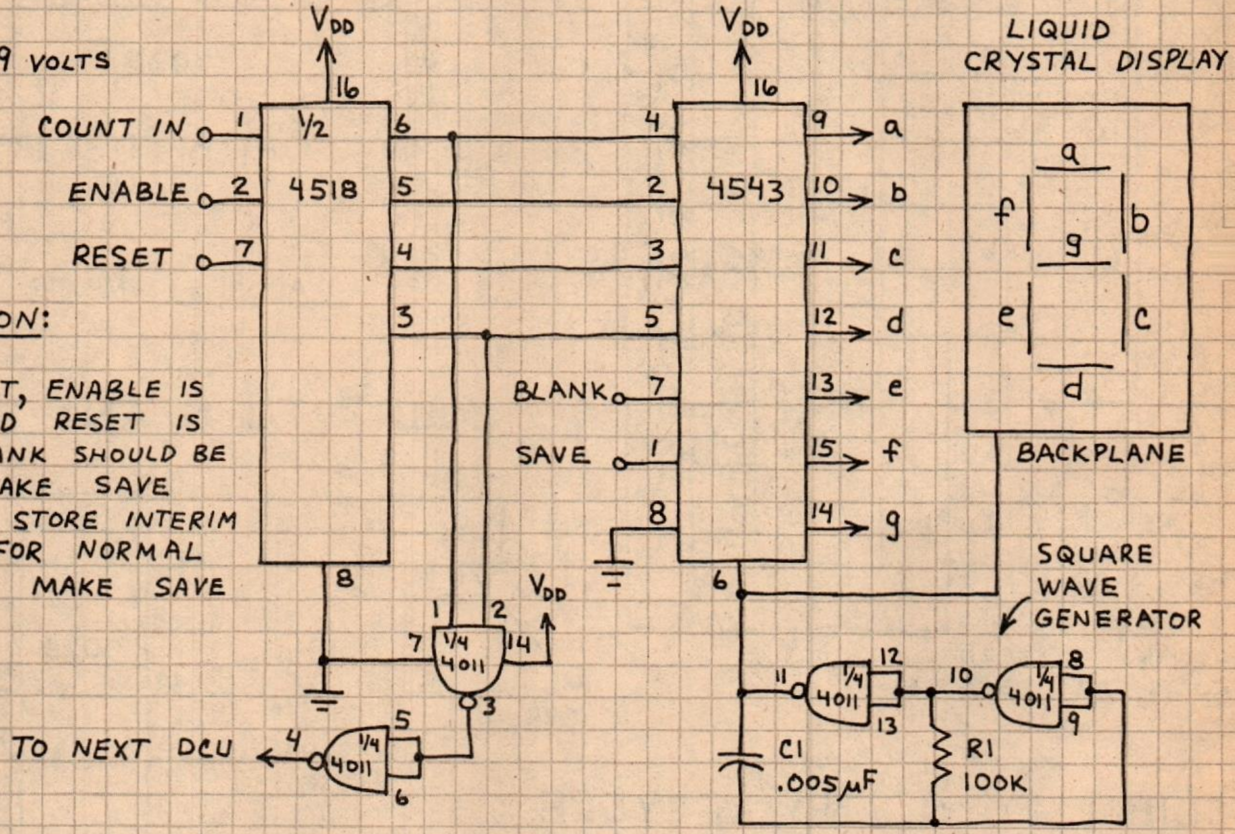
BCD-TO-7-SEGMENT LATCH/DECODER/DRIVER 4543 (14543)



DESIGNED TO DRIVE LIQUID CRYSTAL (LC) DISPLAYS BUT WILL DRIVE OTHER DISPLAYS ALSO. INCLUDES BUILT-IN 4-BIT LATCH TO STORE DATA TO BE DISPLAYED (WHEN PIN 1 IS LOW). WHEN LATCH IS NOT USED (PIN 1 HIGH), THE 7-SEGMENT OUTPUTS FOLLOW THE BCD INPUTS. MAKE PIN 7 HIGH TO BLANK THE DISPLAY AND LOW FOR NORMAL OPERATION.

LIQUID CRYSTAL DISPLAY DECIMAL COUNTING UNIT

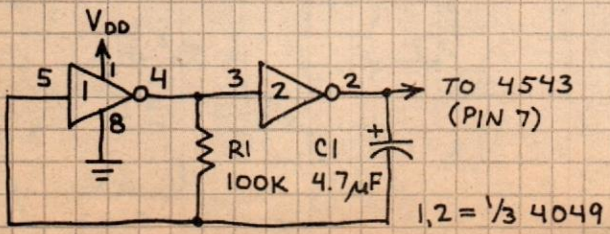
VDD: +3–9 VOLTS



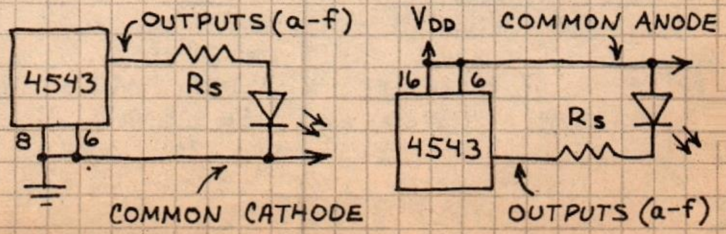
OPERATION:

TO COUNT, ENABLE IS HIGH AND RESET IS LOW. BLANK SHOULD BE LOW. MAKE SAVE LOW TO STORE INTERIM COUNT. FOR NORMAL COUNTING MAKE SAVE HIGH.

DISPLAY FLASHER

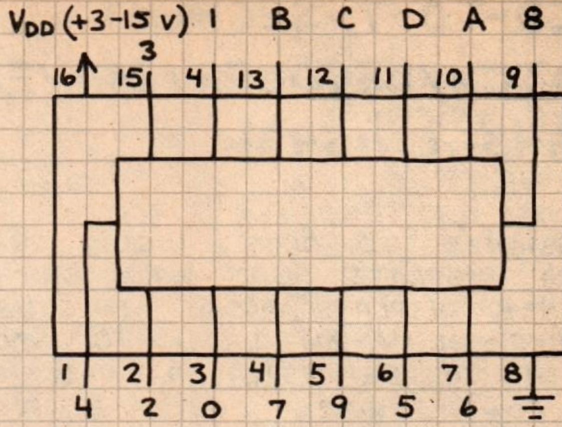


DRIVING LED DISPLAYS

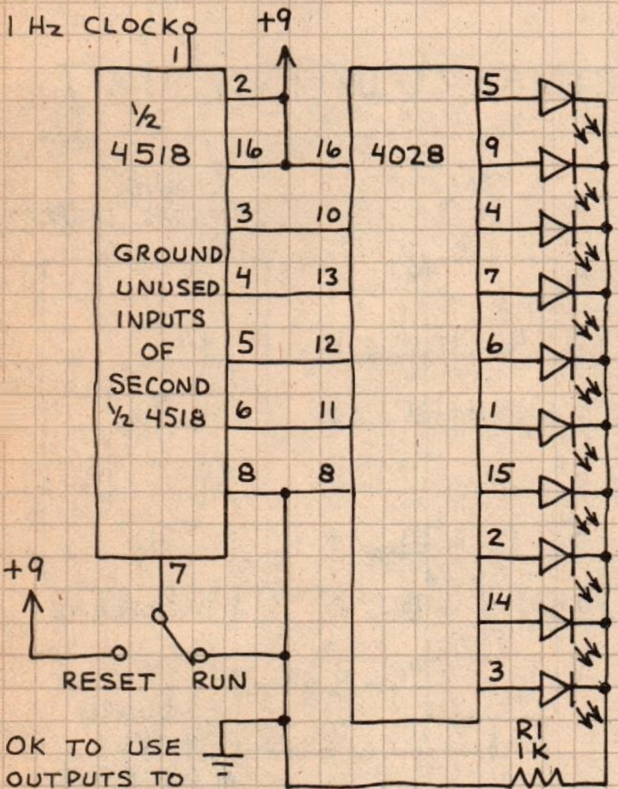


[redacted]CD-T[redacted] [redacted]ECI[redacted]AL [redacted]EC[redacted]ER
4028

DECODES 4-BIT BCD INPUT INTO 1-OF-10 OUTPUTS. SELECTED OUTPUT GOES HIGH; ALL OTHERS STAY LOW. USE FOR DECIMAL READOUTS, SEQUENCERS, PROGRAMMABLE COUNTERS, ETC.

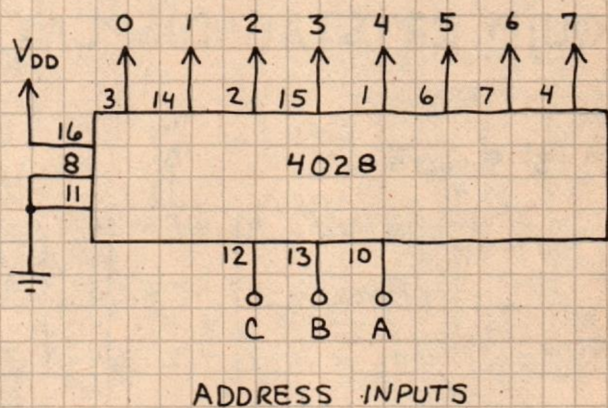


0-9 SECOND TIMER

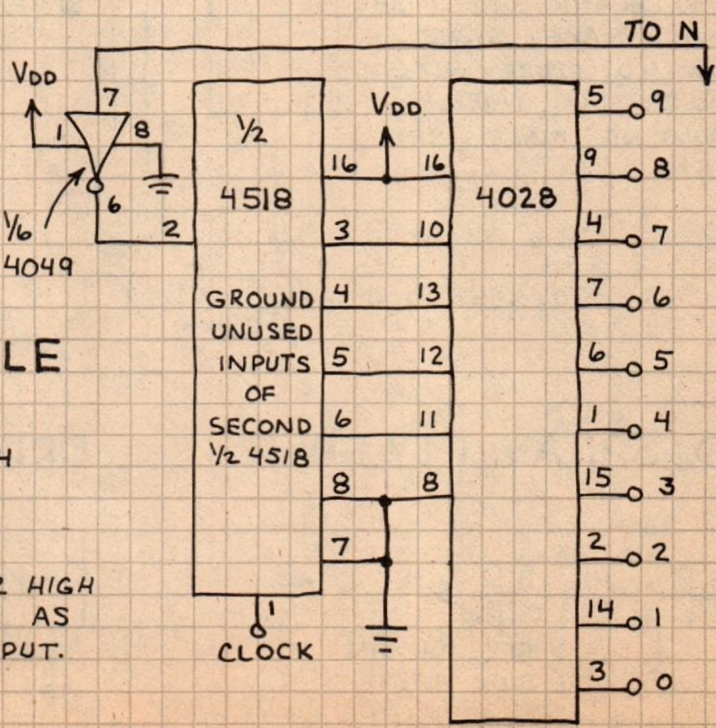


OK TO USE OUTPUTS TO CONTROL EXTERNAL LOGIC OR DEVICES.

1-OF-8 DECODER

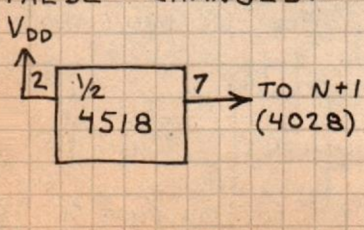


COUNT TO N AND HALT



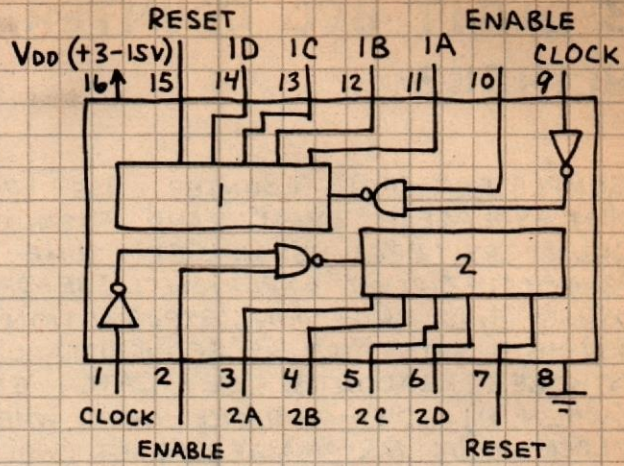
COUNT TO N AND RECYCLE

USE THE ADJACENT CIRCUIT WITH THESE CHANGES:



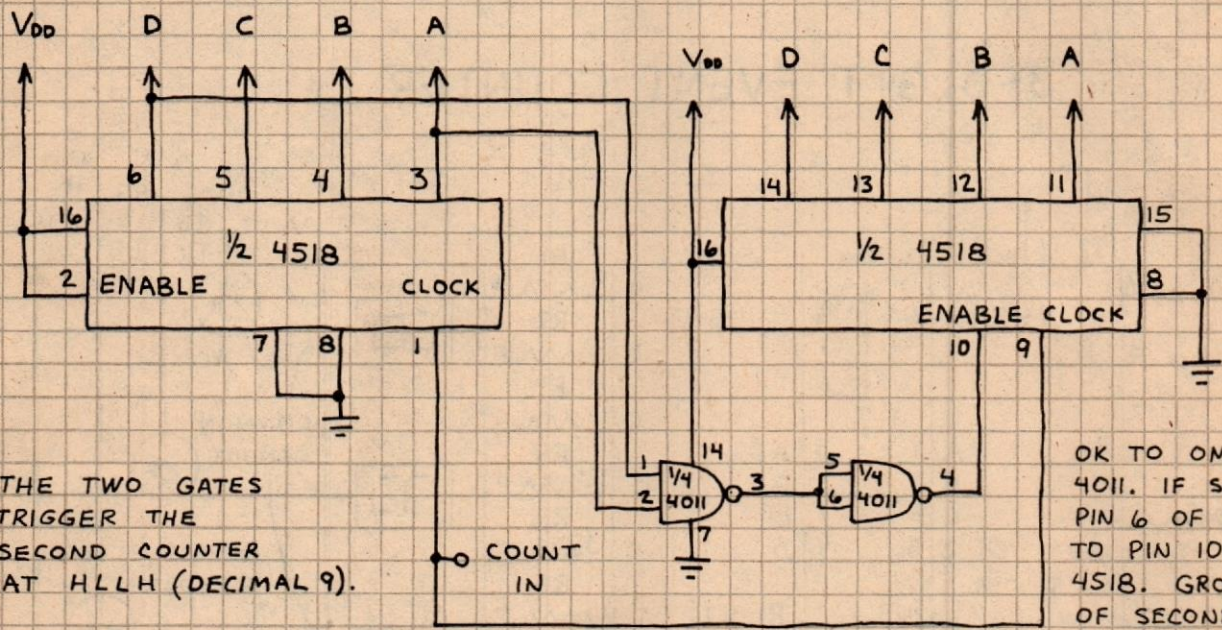
1. OMIT 4049
2. MAKE PIN 2 HIGH
3. USE PIN 7 AS CONTROL INPUT.

DUAL BCD COUNTER
4518



TWO SYNCHRONOUS DECADE COUNTERS IN ONE PACKAGE. WHEN ENABLE IS HIGH AND RESET IS LOW, EACH COUNTER ADVANCES ONE COUNT PER CLOCK PULSE.

CASCADED BCD COUNTERS

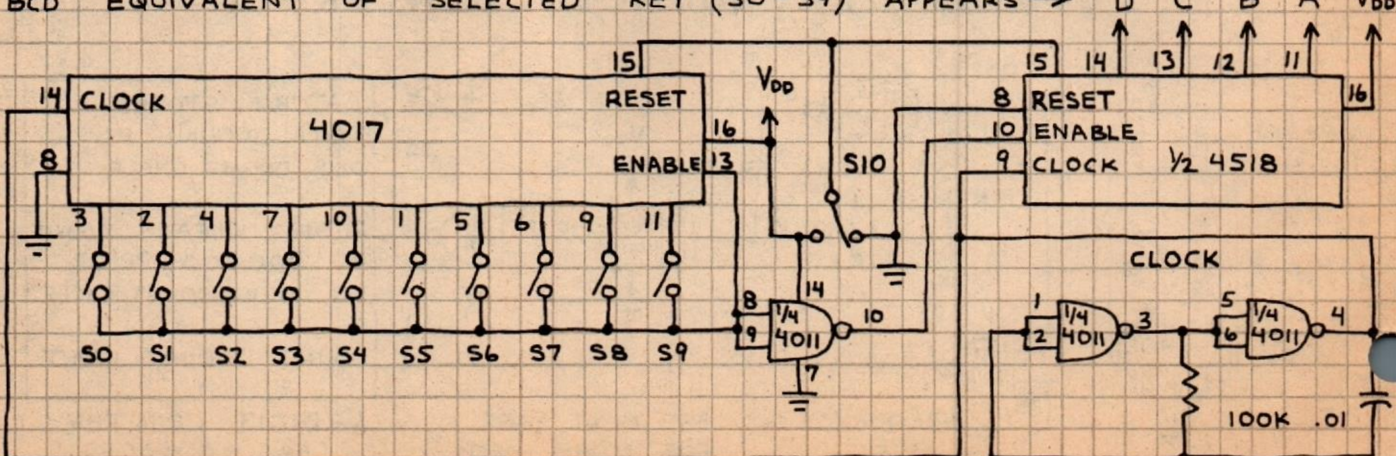


THE TWO GATES TRIGGER THE SECOND COUNTER AT HLLH (DECIMAL 9).

OK TO OMIT THE 4011. IF SO, CONNECT PIN 6 OF FIRST 4518 TO PIN 10 OF SECOND 4518. GROUND PIN 9 OF SECOND 4518 AND APPLY INPUT TO PIN 1 OF FIRST 4518.

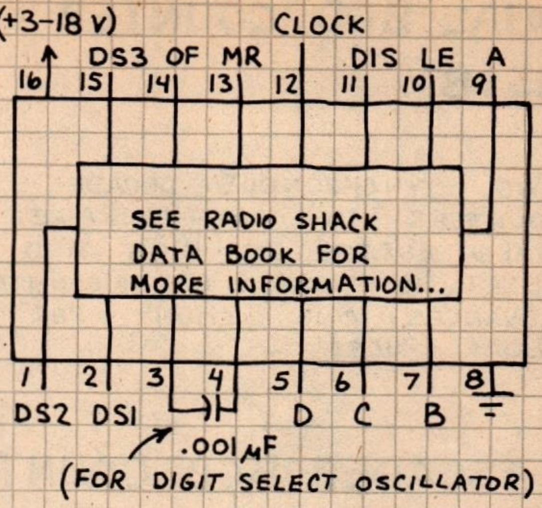
BCD KEYBOARD ENCODER

PRESS S0-S9, THEN TOGGLE RESET SWITCH S10 TO VDD AND BACK TO GROUND.
BCD EQUIVALENT OF SELECTED KEY (S0-S9) APPEARS → D C B A VDD

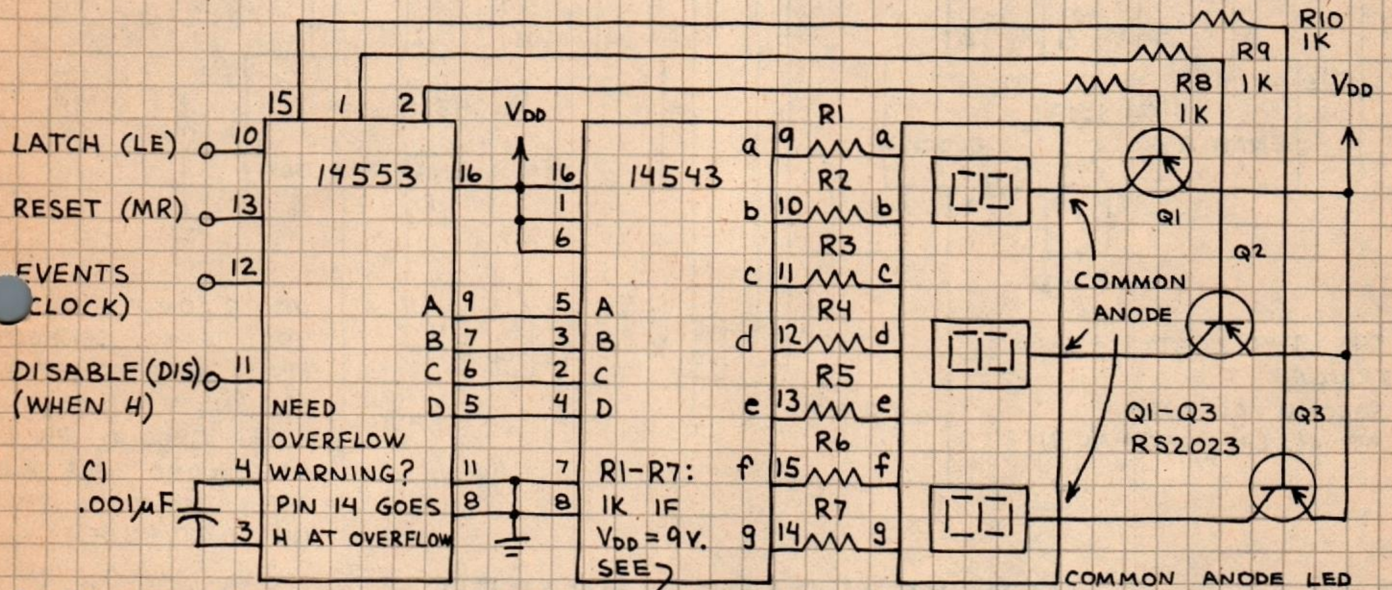


-DIGIT BCD COUNTER
C14553

COMPLETE 3-DIGIT COUNTER. USE FOR DO-IT-YOURSELF EVENT AND FREQUENCY COUNTERS. BEGINNERS: GET SOME PRACTICAL CIRCUIT EXPERIENCE BEFORE USING THIS CHIP. PIN EXPLANATIONS: DS (DIGIT SELECT) 1, 2, 3 — SEQUENTIALLY STROBES READOUTS. LE — LATCH ENABLE (WHEN H). DIS — INHIBITS INPUT WHEN H. CLOCK — INPUT. MR — MASTER RESET (WHEN H). OF — OVERFLOW. A, B, C, D — BCD OUTPUTS.



3-DIGIT EVENT COUNTER

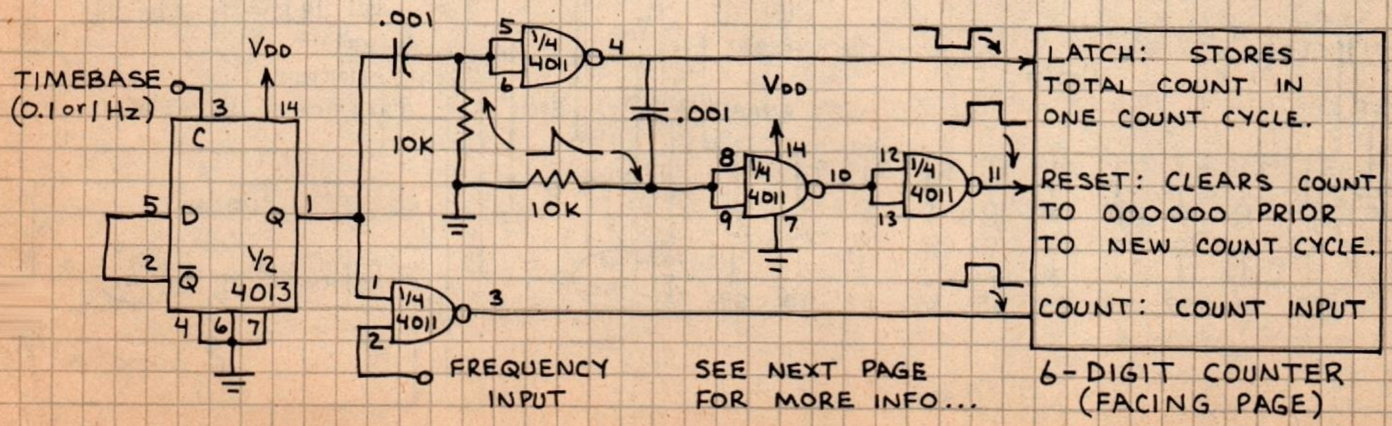


OK TO USE LIQUID CRYSTAL DISPLAY OR COMMON CATHODE LED DISPLAY. SEE 14543 FOR DETAILS.

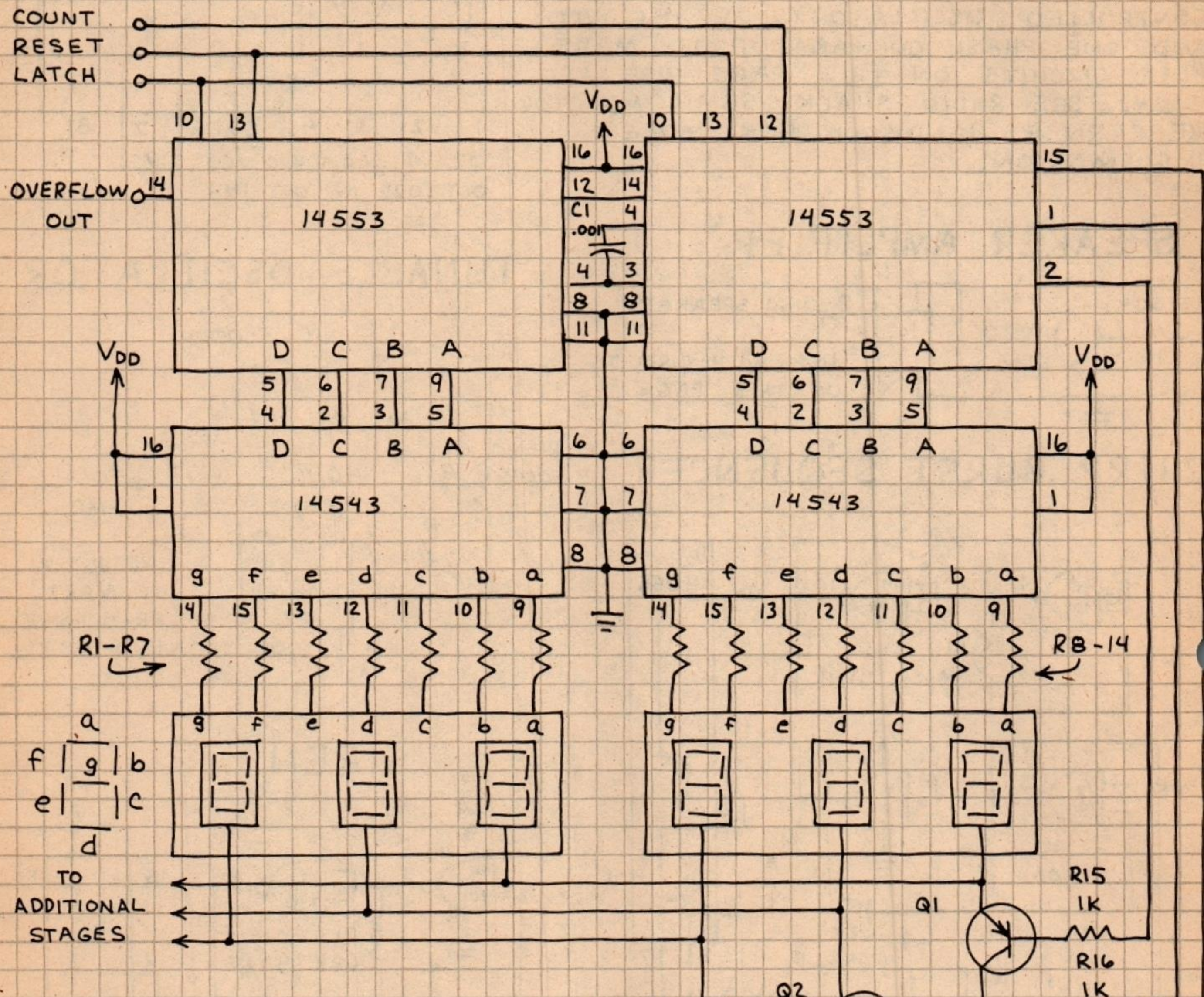
SELECT R1-R7 SO LED CURRENT DOES NOT EXCEED 10 mA.

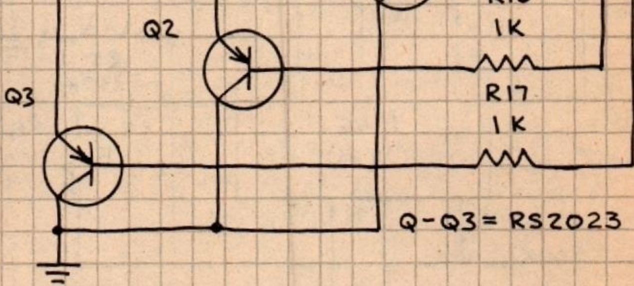
COMMON ANODE LED DISPLAYS. USE MULTI-DIGIT DISPLAY OR WIRE TOGETHER MATCHING CATHODES OF 3 DISPLAYS.

6-DIGIT FREQUENCY COUNTER



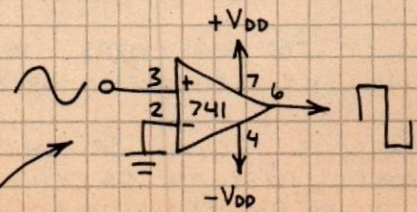
6-DIGIT COUNTER





THIS CIRCUIT SHOWS HOW TO CASCADE TWO 3-DIGIT COUNTERS. MAXIMUM COUNT IS 999,999. DISPLAYS ARE COMMON CATHODE (COMMON ANODE CONFIGURATION SHOWN ON PREVIOUS PAGE.) NOTE THAT PIN 6 OF 14543 (OR 4543) GOES TO GND INSTEAD OF V_{DD} WHEN COMMON CATHODE DISPLAY IS USED.

INPUT BUFFER

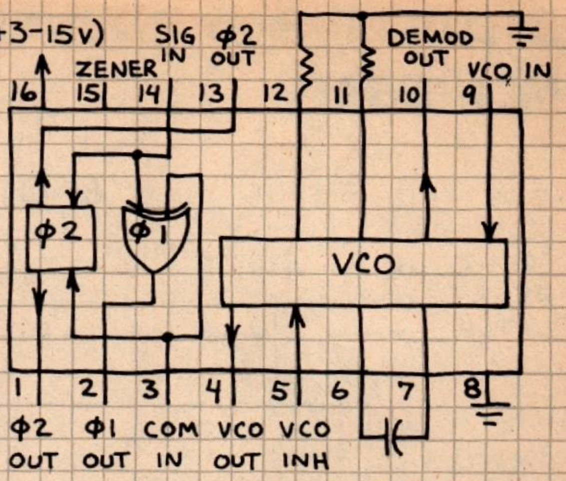


FREQUENCY COUNTER:

USE INPUT AND CONTROL CIRCUIT ON PREVIOUS PAGE. INPUT FREQUENCY SHOULD NOT EXCEED V_{DD}. NON-SQUARE WAVE INPUTS MAY REQUIRE INPUT TAILORING. USE COMPARATOR TO SHARPEN SLOW RISING WAVES.

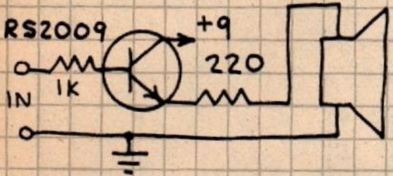
ASE-LOCKED LOOP (PLL)

4046



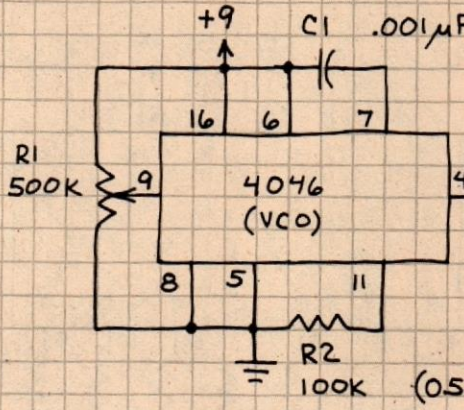
EXCEPTIONALLY VERSATILE CHIP. CONTAINS TWO PHASE COMPARATORS AND VOLTAGE CONTROLLED OSCILLATOR (VCO). USE VCO AND ONE PHASE COMPARATOR TO MAKE PLL. CIRCUITS ON THIS PAGE USE VCO ONLY. SEE RADIO SHACK SEMICONDUCTOR REFERENCE HANDBOOK FOR MORE INFORMATION.

SPEAKER AMPLIFIER*



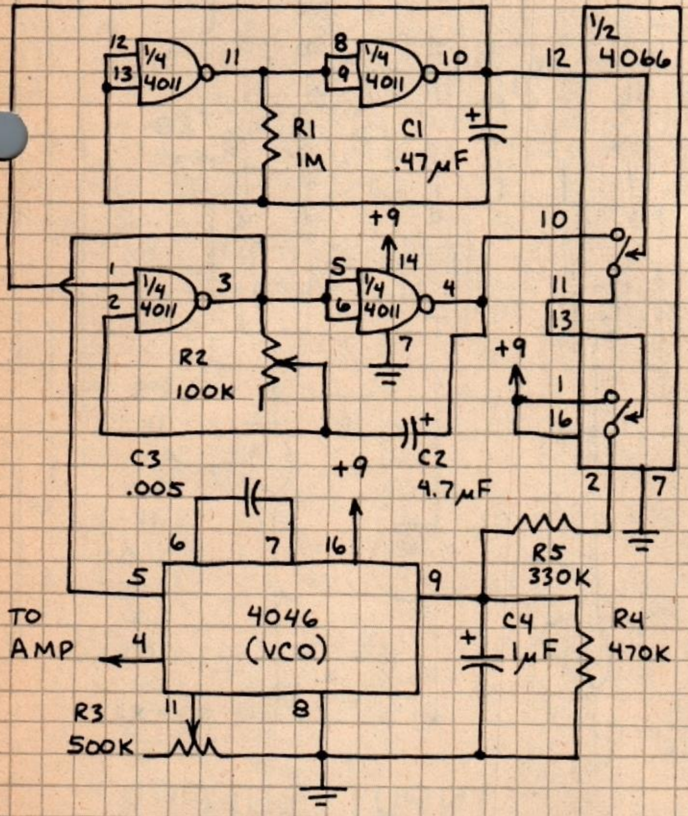
*USE WITH CIRCUITS ON THIS PAGE.

TUNABLE OSCILLATOR



ADJUST R1 TO VARY FREQUENCY (0.5 Hz → 18.5 KHz)

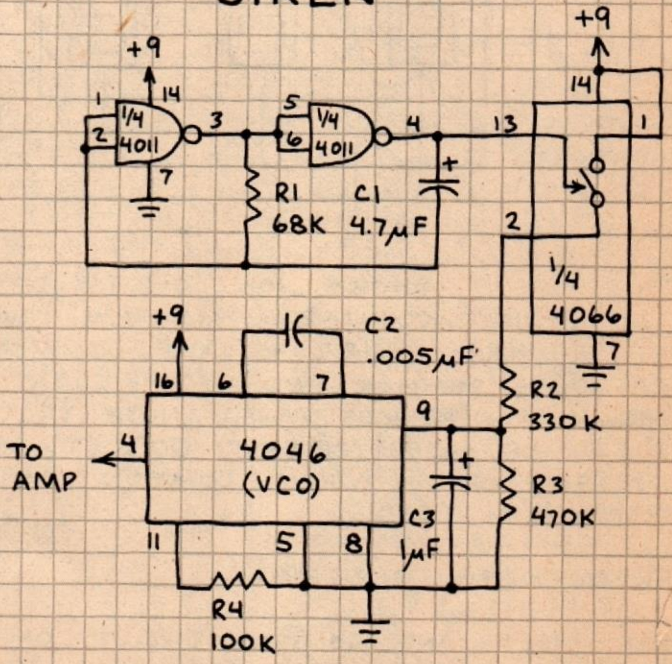
CHIRP BURST SEQUENCER



R2: ADJUST FOR 1-4 CHIRPS PER CYCLE. CHIRPS WILL HAVE DIFFERENT FREQUENCIES.

[redacted]: CONTROLS PITCH OF CHIRPS. FOR TONES INSTEAD OF CHIRPS, CONNECT TO PIN 12 INSTEAD OF PIN 11.

SIREN

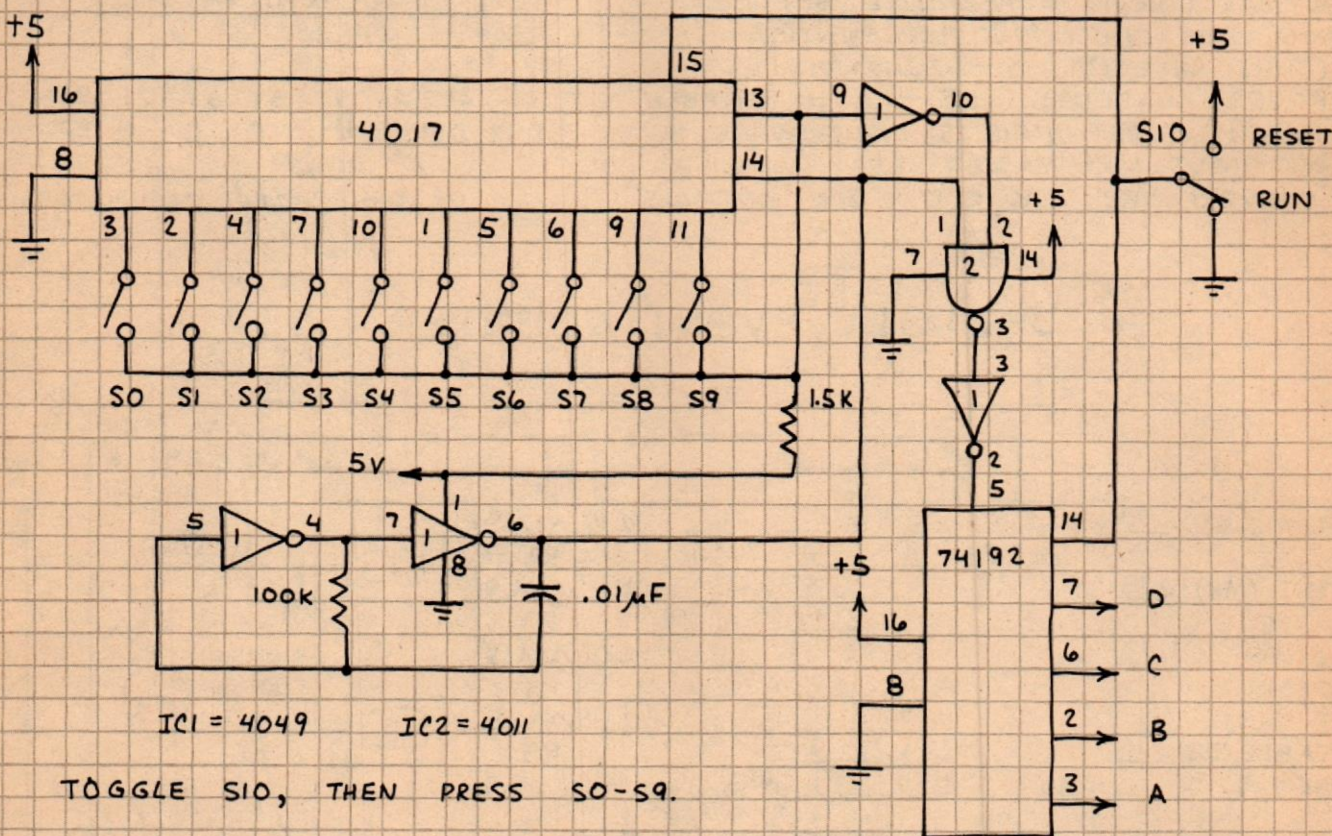


CHANGE R1 OR C1 TO ALTER CYCLE TIME
CHANGE R4 OR C2 TO ALTER FREQUEN
CHANGE R3 OR C3 TO ALTER WAIL.

CADE COUNTER/DIVIDER (CONTINUED)

4017

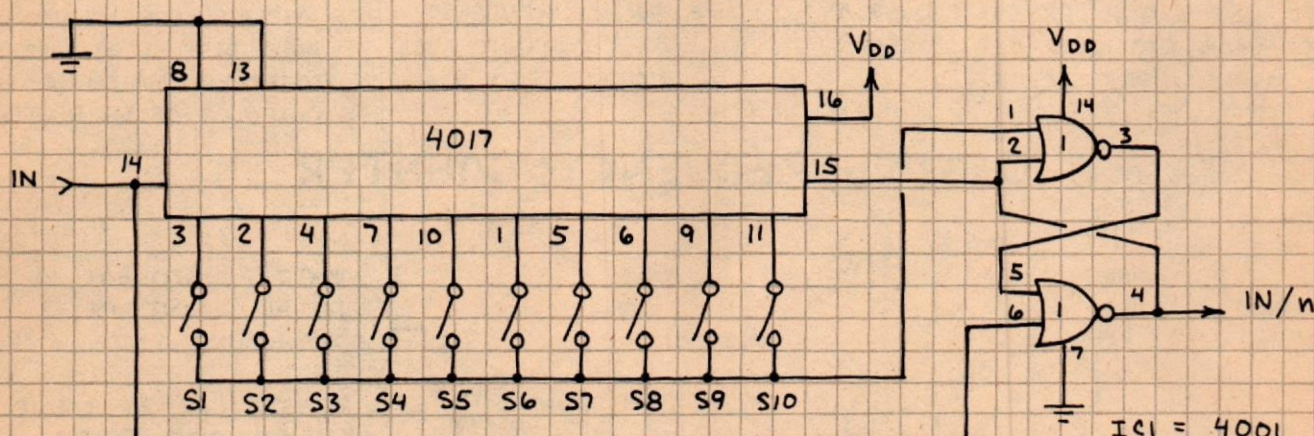
BCD KEYBOARD ENCODER



IC1 = 4049　　IC2 = 4011

TOGGLE S10, THEN PRESS S0-S9.

FREQUENCY DIVIDER

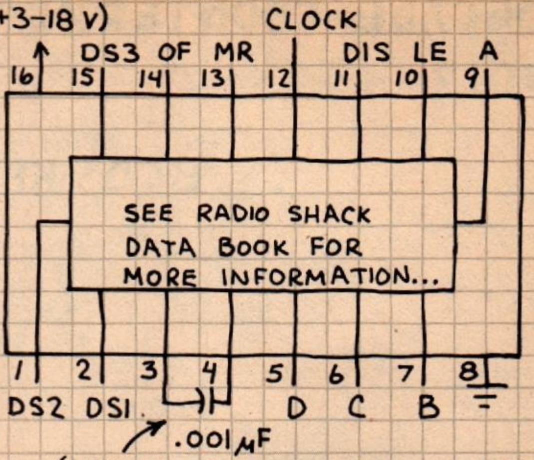


IC1 = 4001

CLOSE S1-S10 TO DIVIDE FREQUENCY BY FROM 1 TO 10.

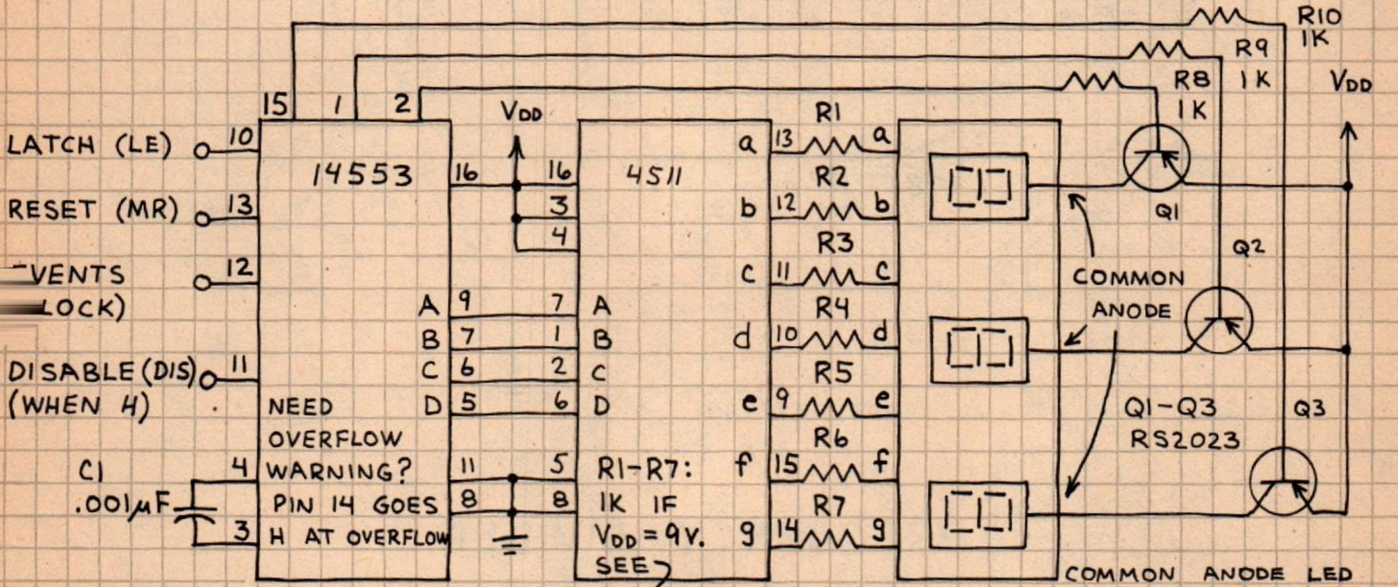
-DIGIT BCD COUNTER
C14553

COMPLETE 3-DIGIT COUNTER. USE FOR DO-IT-YOURSELF EVENT AND FREQUENCY COUNTERS. BEGINNERS: GET SOME PRACTICAL CIRCUIT EXPERIENCE BEFORE USING THIS CHIP. PIN EXPLANATIONS: DS (DIGIT SELECT) 1,2,3 — SEQUENTIALLY STROBES READOUTS. LE — LATCH ENABLE (WHEN H). DIS — INHIBITS INPUT WHEN H. CLOCK — INPUT. MR — MASTER RESET (WHEN H). OF — OVERFLOW. A, B, C, D — BCD OUTPUTS.



(FOR DIGIT SELECT OSCILLATOR)

3-DIGIT EVENT COUNTER

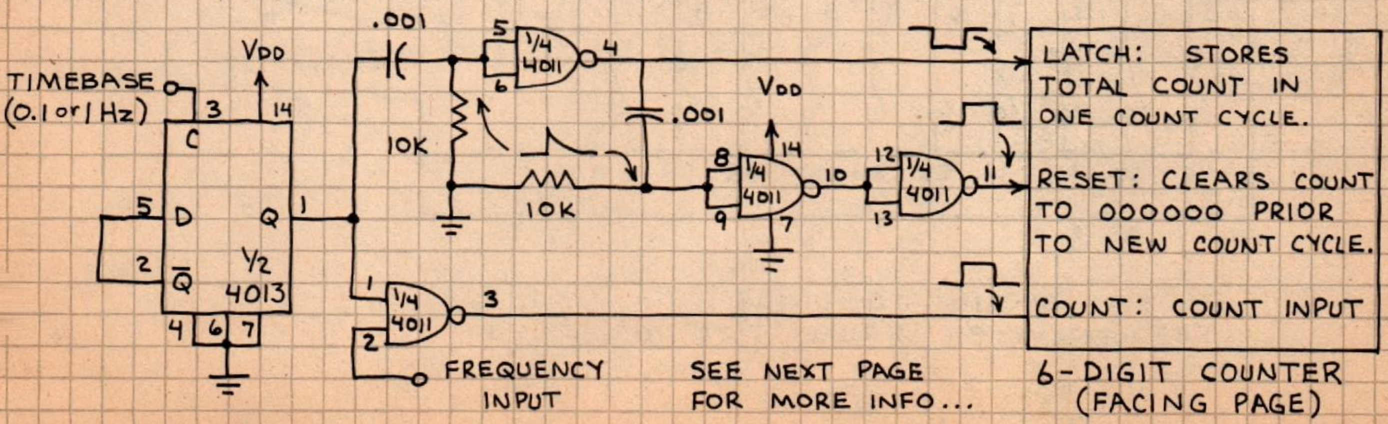


OK TO USE LIQUID CRYSTAL DISPLAY OR COMMON CATHODE LED DISPLAY. SEE 14543 FOR DETAILS.

SELECT R1–R7 SO LED CURRENT DOES NOT EXCEED 10 mA.

COMMON ANODE LED DISPLAYS. USE MULTI-DIGIT DISPLAY OR WIRE TOGETHER MATCHING CATHODES OF 3 DISPLAYS.

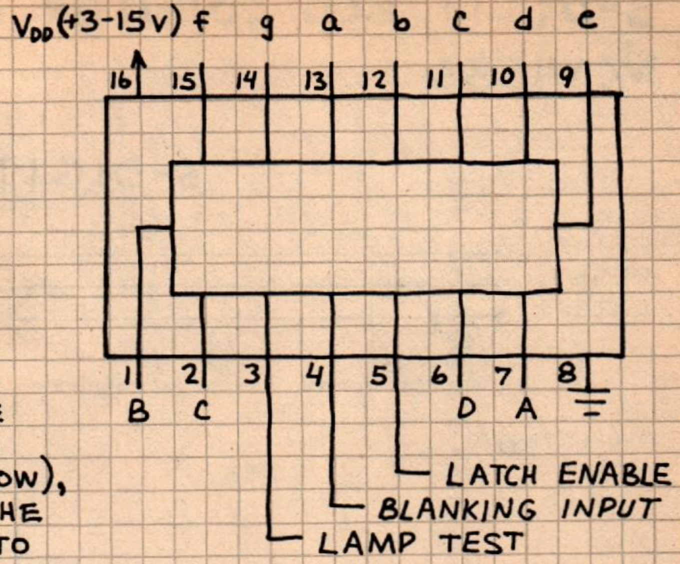
6-DIGIT FREQUENCY COUNTER



SEE NEXT PAGE FOR MORE INFO...

6-DIGIT COUNTER (FACING PAGE)

[redacted]D-TO-7-SEGMENT LATCH/DECODER/DRIVER
[redacted]511

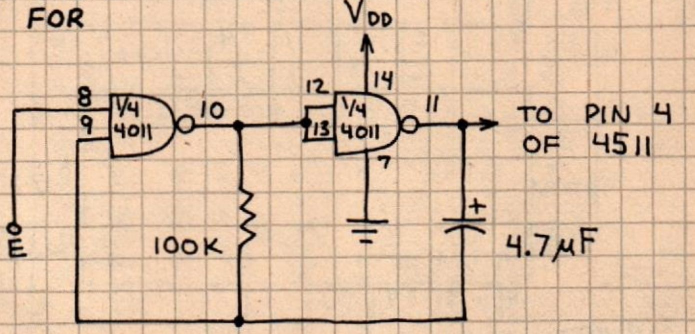


CONVERTS BCD DATA INTO FORMAT SUITABLE FOR PRODUCING DECIMAL DIGITS ON 7-SEGMENT LED DISPLAY. INCLUDES BUILT-IN 4-BIT LATCH TO STORE DATA TO BE DISPLAYED (WHEN PIN 5 IS HIGH). WHEN LATCH IS NOT USED (PIN5 LOW), THE 7-SEGMENT OUTPUTS FOLLOW THE BCD INPUTS. MAKE PIN 4 LOW TO EXTINGUISH THE DISPLAY AND HIGH FOR NORMAL OPERATION. MAKE PIN 3 LOW TO TEST THE DISPLAY AND HIGH FOR NORMAL OPERATION.

DISPLAY FLASHER

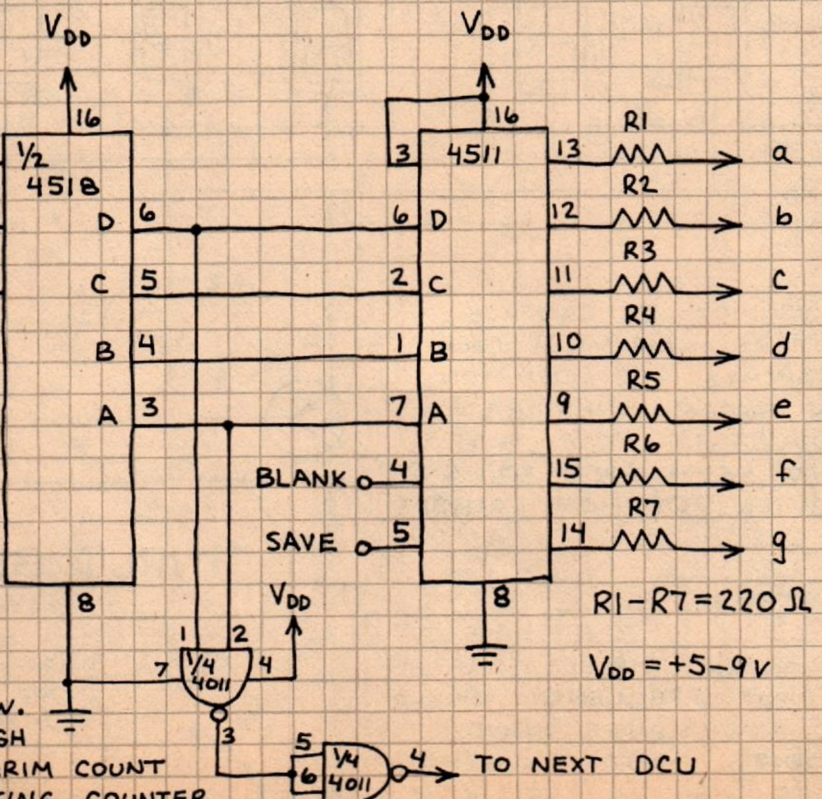
DISPLAY FLASHES ONCE PER SECOND WHEN E IS HIGH.

E	DISPLAY
H	FLASHES
L	OFF

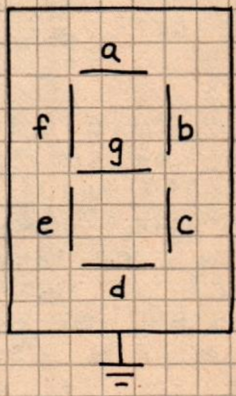


DECIMAL COUNTING UNIT (DCU)

COUNT IN 1
ENABLE 2
RESET 7



IMPORTANT: ALL INPUTS MUST GO SOMEWHERE!



R1–R7 = 220 Ω

V_{DD} = +5–9V

COMMON CATHODE LED DISPLAY

OPERATION:

TO COUNT, ENABLE IS HIGH AND RESET IS LOW. BLANK SHOULD BE HIGH (LOW TURNS OFF [redacted]SPLAY). SAVE [redacted]HOULD BE LOW. MAKE SAVE HIGH TO STORE INTERIM COUNT WITHOUT AFFECTING COUNTER.

R_5 such that its nominal resistance is 500 ohms.

The voltage at the noninverting input of A_{1b} is amplified and applied to the voltage doubler (C_1, D_5, and D_6). A_{2b} and its associated circuit perform the averaging function that provides a feedback current to the variable-gain stage. The gain from input to output is unity until the amplifier's input threshold—set at 50 mV—is exceeded. The acoustic shock protector then operates as an automatic gain control for inputs up to 150 mV. The output distortion up to that point does not exceed 4%. Beyond 150 mV, however, the protector simply clamps the output to 50 mV p-p without regard to distortion.

Because the phone receiver is an inductive device, its impedance increases with frequency. C_4 is placed across R_{14} to compensate for this rise in impedance. The overall gain of the acoustic shock protector is thus held flat to within 1 decibel from 300 hertz to 3 kilohertz so long as the output of A_{1b} is below 600 mV or so. □

Time-shared counters simplify multiplexed display

by Darryl Morris

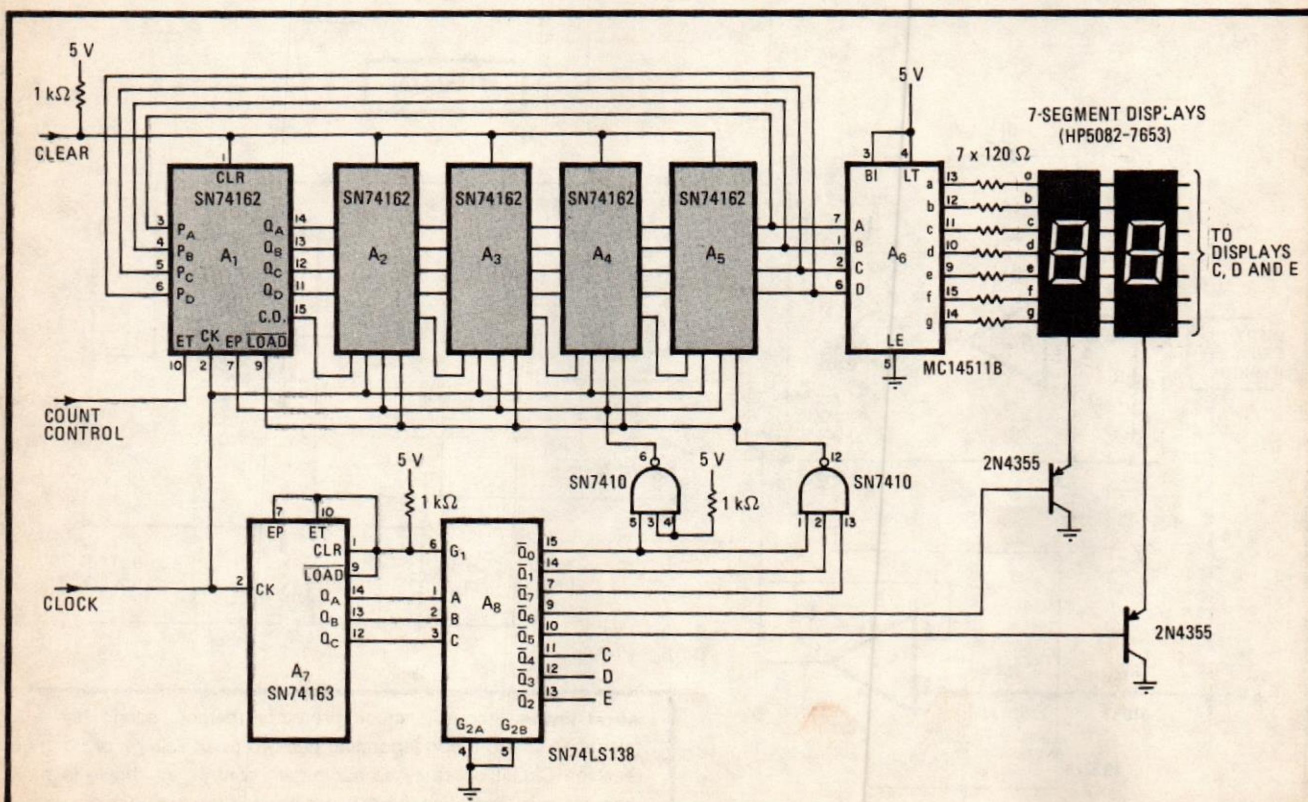
Northeast Electronics, Concord, N. H.

Although multiplexed display circuits reduce the number of components otherwise required for decoding on a per-digit basis, additional hardware is then needed to select and multiplex various lines to the display. But if a display is driven by a frequency counter, as is often the case, the counter itself can be made to perform the multiplexing with only minimal extra circuitry.

Multiplexing is done by using a master clock having several times the frequency of the normal clock, depending on the number of digits to be multiplexed, and by time-sharing the counters between the count and display mode. In the count mode, the $\overline{\text{LOAD}}$ and enable-P (EP) inputs of the counters shown are high and A_1–A_5 function as a conventional cascaded counter circuit under control of the enable-T (ET) input of A_1. The counter circuit advances one count for each clock period during which the count control line is high.

During the display mode, the control line and $\overline{\text{LOAD}}$ input of A_1–A_5 move low. The counters now accept data at their preload inputs, P_A–P_D. Because the preload inputs are connected to each preceding set of a counter's outputs, A_1–A_5 operates as a 4-bit-wide recirculating shift register when clocked. Thus, the contents of each counter is rotated past the seven-segment decoder (A_6) during its display interval, and the appropriate digit in the display is strobed by the mode controller, A_7 and A_8.

This technique offers the best saving in chip count when the count rate is slow or numbers are to be displayed only after the counted event has terminated. □



Time-shared. Counter circuit switches between count and display modes without selector devices. Counter operates as 4-bit-wide recirculating shift register. Master clock frequency is assumed to be several times that used for the counting circuits.

Acoustic protector [redacted] telephone-line transients

by Gil Marosi
Intech Function Modules Inc., Santa Clara, Calif.

By limiting the transients on telephone lines, this acoustic shock protector prevents those sudden high sound levels that can damage the ear badly enough to cause loss of hearing. It holds the maximum peak-to-peak voltage at the receiver of a telephone headset to 50 millivolts.

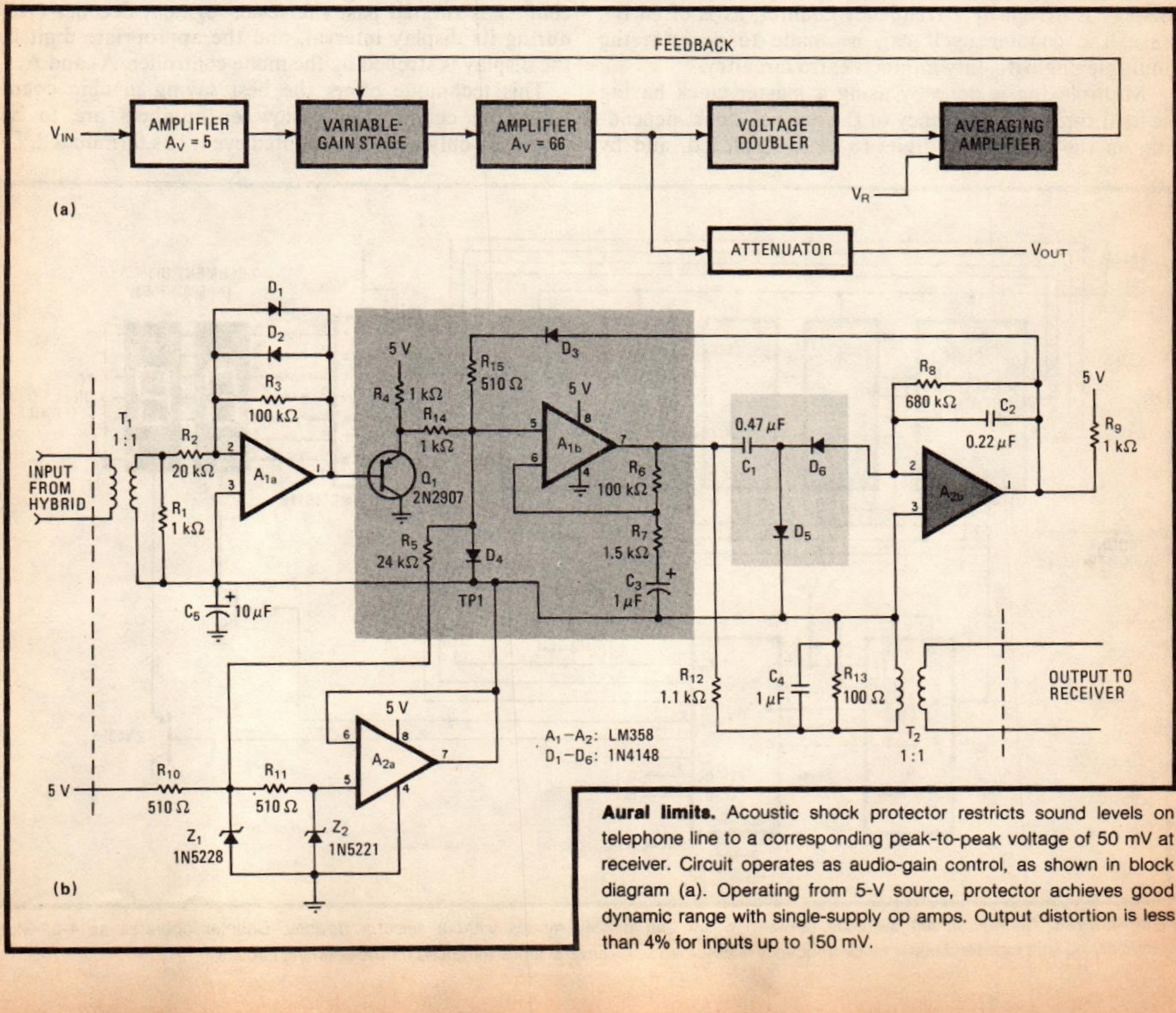
A four-terminal device, the shock protector is inserted between the receiver side of the telephone hybrid and the receiver proper. A block diagram of the circuit, which operates from a single 5-volt supply, is shown in (a). Input signals are amplified by a factor of 5 and applied to a voltage-controlled, variable-gain stage. Because this stage also attenuates the signal to the degree indicated by the actual level of a feedback signal, further amplification may be needed, and is available, to retain the loop's gain margin. A voltage doubler then converts the amplifier signal to a dc voltage. This voltage is compared with a preset reference at the inputs of an averaging amplifier.

The output of the averager, which is essentially an integrating network, is connected to the variable-gain stage. As the input voltage from the hybrid becomes greater, so does the feedback voltage, and thus still more attenuation is provided for the variable-gain stage.

As for the actual circuit (b), transformers T_1 and T_2 isolate the protector from the floating telephone line, so that the circuit operates from a 5-V supply referred to ground. A_{1a}, one half of an LM358 operational amplifier, provides the required amplification of the input signal. D_1 and D_2 clamp A_{1a}'s output to 0.7 V and introduce the signal to buffer Q_1. This transistor, along with R_4–R_7, R_{14}, D_4, A_{1b}, and C_3, make up the variable-gain stage.

Zeners Z_1 and Z_2 and op amp A_{2a} bias A_{1a} and A_{1b} so that input signals to those stages swing about a quiescent point of 2 V. The circuit thus provides maximum dynamic range. Note that most op amps require a 12-V supply to achieve a comparable range.

Q_1's output is converted to a current with the aid of R_{14}. Current flows through D_4, which operates as a current-controlled variable resistor. D_4 is biased through



Aural limits. Acoustic shock protector restricts sound levels on telephone line to a corresponding peak-to-peak voltage of 50 mV at receiver. Circuit operates as audio-gain control, as shown in block diagram (a). Operating from 5-V source, protector achieves good dynamic range with single-supply op amps. Output distortion is less than 4% for inputs up to 150 mV.

HARDWARE HACKER

This month we'll take a look at walking-ring counters, electronic dice, vortex coolers, and lots more.

DON LANCASTER

Some of you hardware hackers seem to make a big deal out of getting one or two pieces of newer electronic parts. As a general rule, if a chip house has a stiff minimum order, they often will be rather liberal with free evaluation samples. All you usually have to do is ask for them in a professional manner.

other times, some other hacker will recognize a need and fill it for you. For instance, Mike Giamportone of his *Thumb Electronics* is stocking the LSI melody chips for you at $1.50 each. Many of the other great LSI hacker chips are available in small quantities from *Belco Electronics*.

My new PostScript 4BBS is already going great guns on *Genie*. Yes, all of the "lost" Guru columns are here, as is much of the *Midnight Engineering* stuff. You'll find my insider hacker secrets brochure available as library downloads #112 and #113. You can also reach me here for email and such at SYNERGETICS.

All this is on Genie's PSRT, short for the *PostScript Roundtable*. For local connect info, call *Genie* (voice) at (800) 638-9636.

While I was wandering around a few of those other RoundTables on *Genie*, I did find a great radio and electronics board up at M345. These folks are heavily into monitor and scanner listings, satellite stuff, unusual receiver circuitry, general communications, and bunches more. They have thousands of downloads available for you.

Let's start off with some unique circuits known as...

Walking-ring counters

I have always been attracted to *elegant simplicity*, circuits or software that does more with less in some superb or unique manner. In these days of FASTER CPU'S! and MORE MEMORY!, any elegant simplicity seems to have fallen by the wayside.

For instance, the game paddle port on an Apple IIe runs a LaserWriter *twice* as fast as the Mac IIcx and *three times* as fast as any other Mac. Yet for some strange reason, Apple does not appear to be shouting this fact from their Cupertino rooftops.

Since no good deed will ever go unpunished, elegant simplicity will *always* get ruthlessly stomped upon whenever and wherever it occurs in the real world.

One older and classic example of elegant simplicity is the walking-ring counter. This is a hardware circuit or a software routine which generates a unique count sequence in a simple, unusual, and quite sophisticated manner. When used in the right place at the right time, walking-ring counters can provide very clean solutions to electronic problems that otherwise are often sloppily or klutzily done.

Walking-ring counters are also sometimes called Johnson counters. To build a walking-ring counter, take a string of type D flip-flops or adjacent bits in a software word. Cascade the flip flops as an ordinary serial shift register, but connect the $\overline{Q}$ output of the last stage back to the D input of the first stage. Then you clock all of the flip flops from a common source.

Figure 1 shows you a three stage walking-ring counter we'll be looking at shortly in more detail. For now, pretend that this is a *five-stage* counter instead of being only three stages long. Furthermore, assume we have reset the counter to its 00000 state.

As you clock a five-stage walking-ring counter, the following sequence is generated...

0 0 0 0 0
1 0 0 0 0
1 1 0 0 0
1 1 1 0 0
1 1 1 1 0
1 1 1 1 1
0 1 1 1 1
0 0 1 1 1
0 0 0 1 1
0 0 0 0 1
0 0 0 0 0 (repeats)

Since we repeat after ten counts, we apparently have built a *decade*, or divide-by-ten counter. In fact, it turns out that the count length of a walking-ring counter is normally *twice* the number of stages in use. Thus, three D-flops give you a divide-by-six, four a divide-by-eight and so on.

This is a *synchronous* counter, since all stages are clocked simultaneously. There are none of the glitches that get produced by a ripple counter.

Note that there are no intermediate frequencies. You have your input frequency and an output square wave of frequency *input/2n*, where "n" is your number of stages. That makes the walking-ring counter ideal for very high frequency use, especially as UHF and VHF prescalers.

Another unique property is that *all* of the counter states can be decoded using only a single two-input NAND gate per state. Furthermore, a full decode uses *all* of the Q and $\overline{Q}$ outputs in a balanced and symmetrical manner. Back in the days when you worried about the *fanout* of a logic block, that was a really big deal.

I'll save the details on this for you to ponder over on your own, but most states decode using the Q output of one stage NANDED with the $\overline{Q}$ output of an adjacent one. Again, this is a very clean layout that is superb for high frequency use.

What is wrong with the walking-ring counter? Elegantly simple or not, it does have two bad habits. The first is that you need half as many flip flops

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:
Don Lancaster
Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

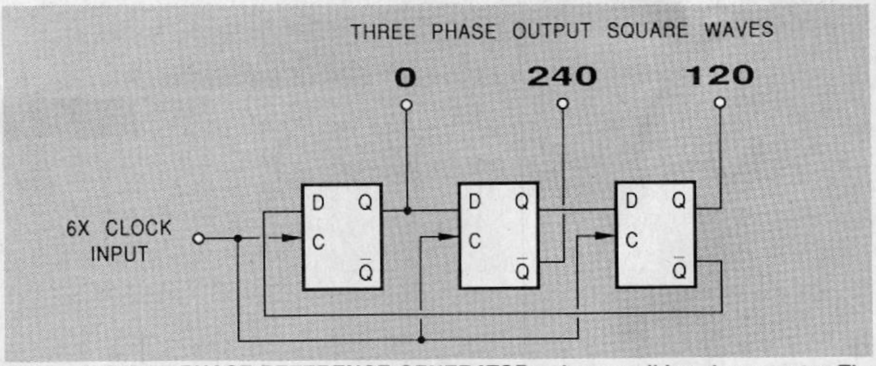


FIG. 1—A THREE PHASE REFERENCE GENERATOR using a walking-ring counter. The three-output square waves produced are at one sixth the clock frequency and are precisely shifted by 120 and 240 degrees.

or word bits as your count module. Using five flip flops to divide by ten seems like no big deal. However using 32 of them for a divide-by-64 gets old in a hurry. Thus, walking-ring counters are rarely used beyond a divide-by-twelve.

Any flip flop counter of any length can get into 2^n possible states. Thus, a five flip flop walking-ring counter can get into 32 possible states, only ten of which are legal and allowed. If you inadvertently get into one of those "wrong" count states, you can get into a *disallowed sequence* that can cause you grief.

For instance, the three stage, divide-by-six counter of Fig. 1 normally provides this sequence...

0 0 0
1 0 0
1 1 0
1 1 1
0 1 1
0 0 1
0 0 0 (repeats)

But if you ever get into the 0 1 0 sequence, here's what results...

0 1 0
1 0 1 (repeats)

All of a sudden you now have a divide-by-two counter instead of the divide-by-six, which could really be bad news. Thus, you somehow have to guarantee that a walking counter *never* gets into its disallowed state sequence!

Resetting the counter or else preloading your software registers are two good ways to prevent disallowed sequences. A sledgehammer cure is to always force internal 1 states whenever the two ends of the counter are also both set to 1. For instance, you could AND decode the outside Q outputs and use these to preset all the internal stages to their 1 state. That will quickly find any disallowed sequence and repair it on the fly.

Let's look at three uses for walking-ring counters. I can't believe how many really dumb circuits have been published in the trade journals that were intended to generate three-phase power control signals.

As Fig. 1 shows us, all you really need is a divide-by-six walking-ring counter. Provide six times your desired frequency, and you get three square waves out, all phase shifted by precisely 120 degrees.

You can obviously change your number of stages for a quadrature output, for quad-phase, five-phase, and so on. More details on all of this is in my *CMOS Cookbook*.

Another great place to find lots of really klutzy circuits is in an electronic dice game. Figure 2 shows you the elegant simplicity of a walking-ring die.

To understand this circuit, you first define your die spot count sequence as 1-3-5-6-4-2. This gives you a "free" even-odd decoding for the middle spot, and a "free" 4-5-6 decoding for two diagonal outside spots.

Use a NAND gate to decode "not 1" for the other two diagonal outside spots. Use an AND gate (or else two diodes) to decode "six" for the two outside middle spots. A medium frequency-gated oscillator clocks the die, and a second die can be cascaded off the first one. Additional details can be found in the *CMOS Cookbook*.

Finally, Fig. 3 shows you a digital-sine wave generator that produces a pair of sine waves that are frequency shifted precisely by 90 degrees. That circuit is based on stuff we looked at back in the 1989 January issue of **Radio Electronics**. See my *Hardware Hacker II* reprints for the full details.

I've purposely left the part numbers off all our figures this month, to encourage you to experiment on your own. Your best choices will be such chips as a 4013 or 74HC74 dual-type D flip flop. Most any parallel out shift register could also be used, as can software shift commands applied to any old alterable byte.

For our contest this month, either (1) Show me an unusual use for a walking-ring counter, or (2) show me some other circuit, tool, or technique that is elegantly simple.

There will be all of those usual *Incredible Secret Money Machine* book prizes for the dozen top entries, with an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all.

As usual, do send all of your written entries directly to me here at *Synergetics*, rather than over to the people at **Radio Electronics** editorial.

tangentally faster than the speed of sound and forms a rapidly spinning hollow vortex cylinder having a very high angular velocity. When it gets to the hot end, some of it is released to ambient, and the rest of it spirals back *inside* the spinning hollow inlet air vortex cylinder.

Now for the tricky part. The inlet air and the outlet air are both spinning at the same radial velocity, since they are in contact with each other. But the *momentum* of the inside air has to be less since it has a smaller radius of rotation, and since angular momentum is inversely proportional to the spinning radius.

Because the momentum must be preserved, energy is transferred from the inside spinning air cylinder to the outside one. That cools the cold end exit air at the same time that it heats the inlet air.

Full details appear in the *Vortec* application notes.

There is usually an adjustment screw that lets you vary the ratio of hot to cold exit air. One setting gives you the lowest possible exit temperature, which routinely can go as low as −40 degrees. A different setting gives you the most efficiency and the maximum cooling at a higher exit temperature. The air consumption and the overall efficiency are acceptable for most current uses.

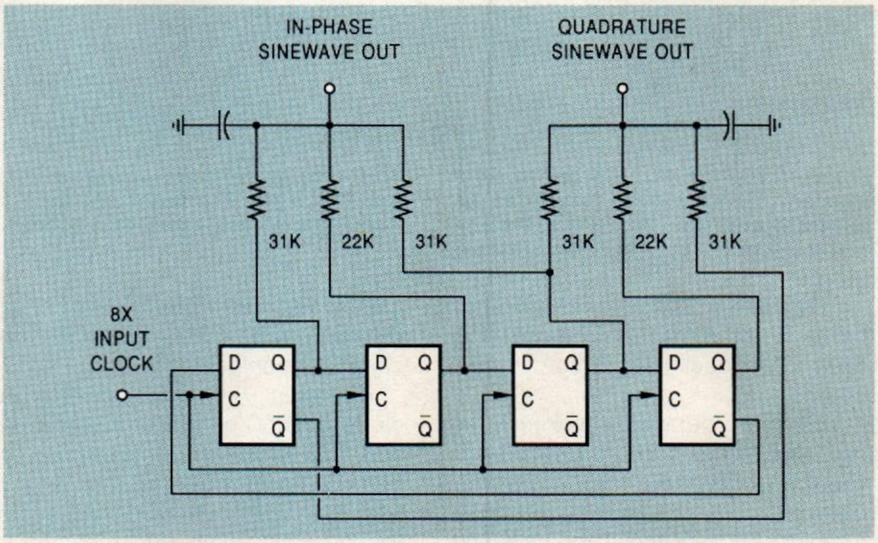


FIG. 3—QUADRATURE SINE WAVES which are phase shifted by precisely 90 degrees are easily generated with a walking-ring counter. The uses include single sideband communications and synchronous demodulation.

What are the limitations to vortex cooling? Obviously, you do need an air supply. And your air has to be extremely clean and extremely dry if the cooler is not going to freeze or jam. That can be a noisy situation. And the pricing in single quantities often approaches $100 for industrial units.

Question: Could you put a vortex cooler in a car vent? Let's have your thoughts on this.

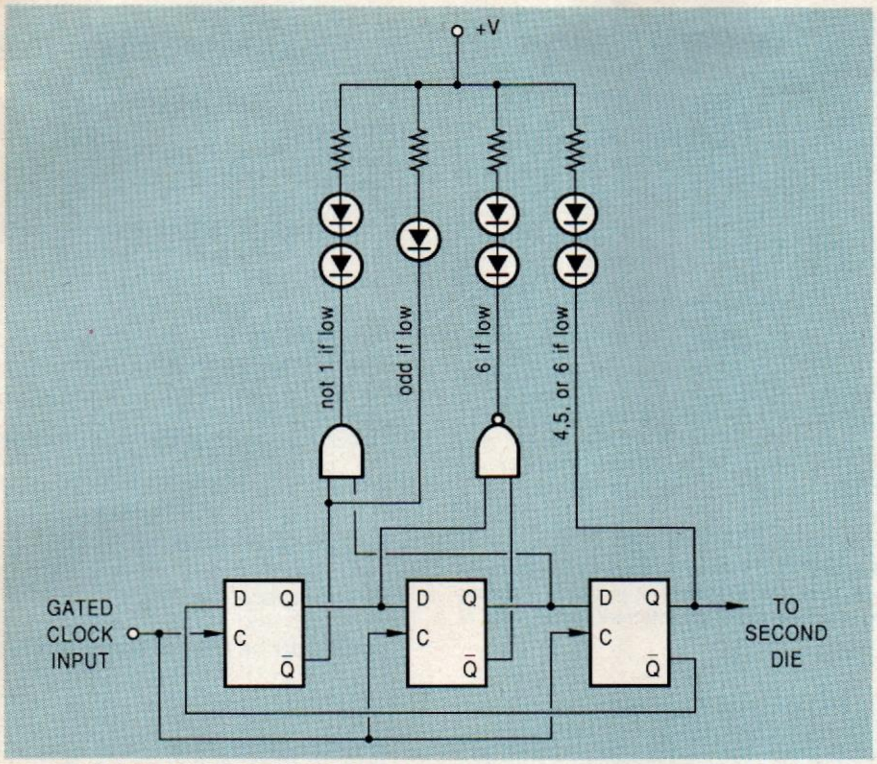


FIG. 2—ELECTRONIC DICE USES A walking-ring counter in an unusual 1-3-5-6-4-2 sequence to greatly simplify the spot decoding.

Electronic trade journals

As we've seen a number of times in the past, there's simply no way you can be serious about hardware hacking if you do not aggressively subscribe to the industry trade journals. For our resource sidebar this month, I have gathered together a few of what I feel are the more interesting and more important electronic magazines for you.

Most of those are free to "qualified" subscribers. You usually can qualify by using your PostScript business letterhead and your company name, and then telling them what they want to hear on their qualification card. The whole reason for the qualification process is so the magazines can get a special *controlled circulation* postage rate. As long as you are genuinely interested in what their advertisers have to offer, you're wanted as a subscriber.

To find other magazines that are not on this list, you'll want to once again refer to the *Hacker's Holy Grail*, which is otherwise known as the *Uhlrichts Periodicals Directory* that can be found on the reference shelf of your local library.

Let's see. I guess the three "best" and most useful of those would be *E.E. Times*, *EDN*, and *Electronic Design*. But all of those others are certainly worth a look.

Once you get a subscription, you use the bingo cards, fax sheets, and mail coupons to pick up data books, samples, application notes, and the whole bit. Many of the magazines

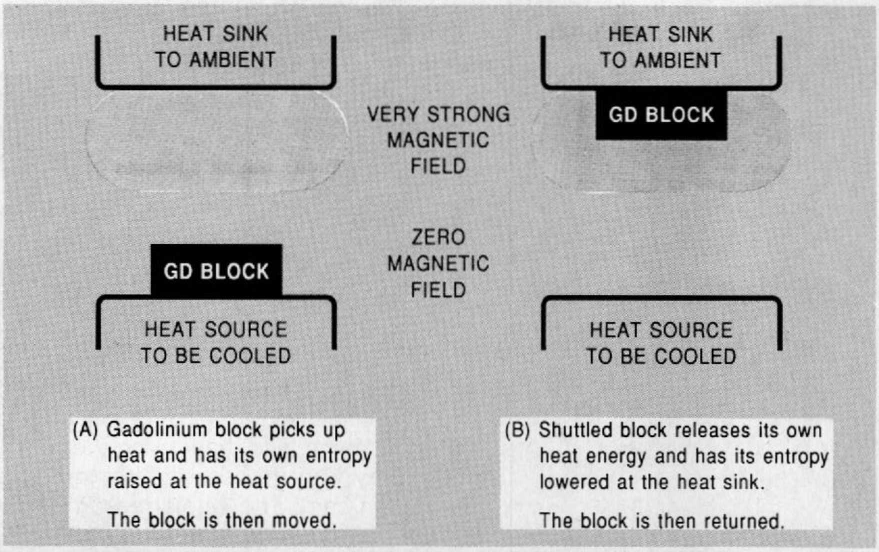


FIG. 4—THE SHUTTLE TYPE MAGNETIC REFRIGERATOR moves a block of Gadolinium between a heat source in a magnetic field free area and a heat sink in quite a strong magnetic field area. This type of heat pumping can be extremely efficient, especially at cyrogenic temperatures.

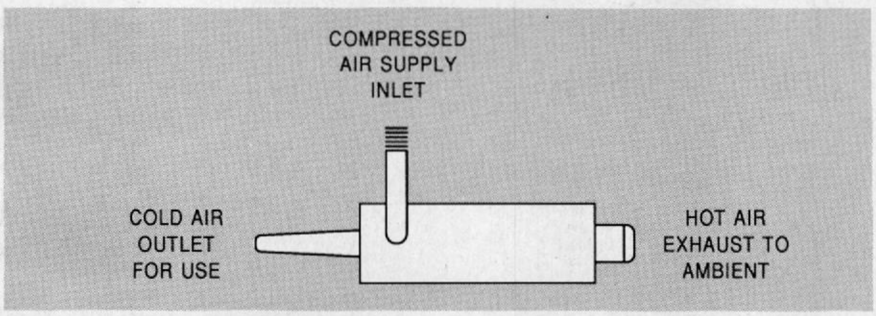


FIG. 5—A VORTEX COOLER has no moving parts, yet can easily provide an air stream as cold as −40 degrees. The key secret is a pair of coaxial vortex streams. In order to preserve angular momentum, heat energy gets transferred from the cold output stream back to the input air stream.

also offer annual directories that can prove to be most useful in pinning down an oddball part or an obscure source.

Lots more details on making your hardware hacking into a useful tech venture do appear in my *Incredible Secret Money Machine* book and in *Midnight Engineering*. If you have any favorite trade journals not already on this list, please let me know some more about them.

New tech literature

A pair of data books and a postcard sample order form from Maxim includes *Analog Product Highlights* and their *New Releases Data Book*. From PMI, a humongous *Analog Integrated Circuits Data Book #10—four pounds and several thousand pages. Included are all of the old SSM* (solid state music) circuits.

One additional source for the FM stereo broadcaster kits is *Ramsey Electronics*, while the BA1404 chips themselves do remain available from Ohm Electronics.

The latest *All Electronics* flyer includes $6.50 strip chart recorders and $15 COSMAC microcomputer trainers. For those of you that came in late, the CDP1804 COSMAC architecture gave totally new meaning to the term *bizarre*. A most wondrous beast.

Three other interesting surplus catalogs this month include *Johnson Shop Products*, *Windsor Distributors*, and *Consumertronics*. Neat stuff.

Our new magazines for this month include 8/16 on Apple programming from Ariel Publishing, and World Cogeneration, a generate-your-own-power magazine that can be found at the extreme opposite end of the spectrum from the great folks at Home Power.

Turning to mechanical stuff, free

ELECTRONIC TRADE JOURNAL

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