



## Seven Segment Dice



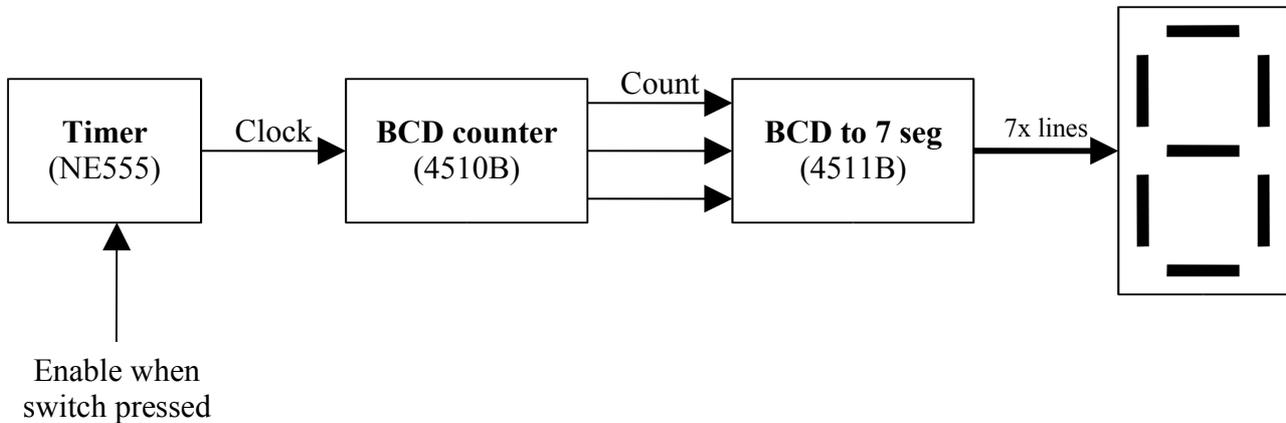
## Application Notes

### Overview

This application note describes how a 555 timer can be used to clock a binary counter, which is then shown on a seven segment LED display. The parts are connected such that only numbers 1 to 6 are used, resulting in an electronic dice application.

## Introduction

This application note explains how to make a dice using a seven segment display. The basic block diagram for the system is shown below:



On the left of the diagram is a 555 timer IC. When the switch is pressed this is held out of the reset state and begins to generate a square wave clock signal. This signal changes many times each second and is used to clock a binary coded decimal counter. The counter is setup so that it counts down from six until it reaches zero. At zero the counter is reloaded with the value six. This cycling through the numbers continues whilst the button is pressed and the clock from the timer is present. As soon as the button is released the counting stops, at this point whatever number the counter is on is where it stays. The final stage in the process is to convert the binary number into an output which can be shown on the 7 segment display.

## Parts List

You will need the following parts to build your seven segment dice. You may additionally want to use 8 and 16 pin IC holders.

Part	Description	Quantity
NE555	Timer IC	1
4510B	BCD up / down counter IC	1
4511B	BCD to 7 segment driver IC	1
100K	Resistor 100K 5%	3
300Ω	Resistor 100Ω 5%	7
47K	Resistor 47K 5%	1
BC547	NPN transistor (any NPN transistor will do)	1
10nF	Ceramic disk capacitor 10nF	1
100nF	Ceramic disk capacitor 100nF	1
	Seven segment display (common cathode)	1
	Push button switch (push to make)	1

## 555 timer

The 555 timer needs to be configured as an astable timer (it outputs a continuous alternating signal). In order to ensure the dice is random the counter needs to be clocked as fast as possible, however a better visual effect (whilst the button is pressed) can be achieved by clocking the counter at a speed where the changing numbers can be perceived, but the value not determined. In practice a speed of 75Hz is about right, which can be achieved with  $R_a = 100K$ ,  $R_b = 47K$  and  $C = 100nF$ .

From the 555 manufactures data sheet the frequency is determined as follows:

$$f = \frac{1.49}{(R_a + 2R_b)C}$$

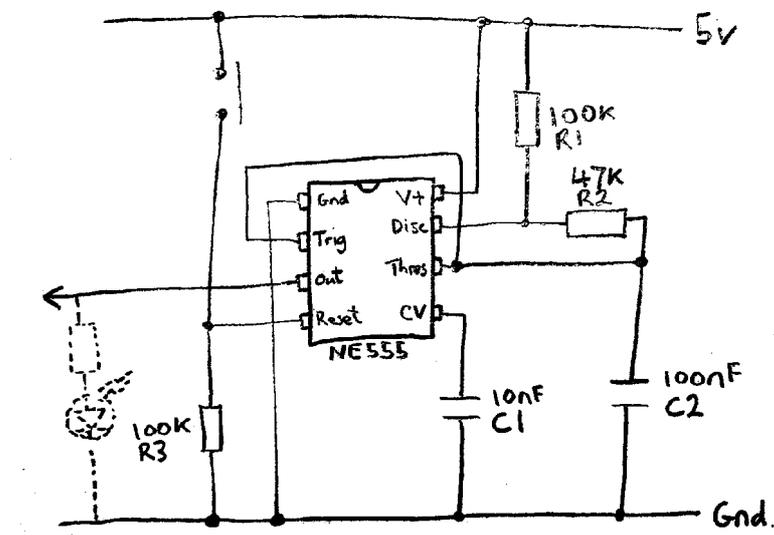
$$f = \frac{1.49}{(100K + 94K)100nF}$$

Hence  $f$  is approx. 75 Hz.

The reset line is active low, this means that to hold the timer in reset so that the timer stops the reset line is taken low and in normal operation it is taken high. This can be implemented with a pull down resistor and a switch between the reset pin and the supply line.

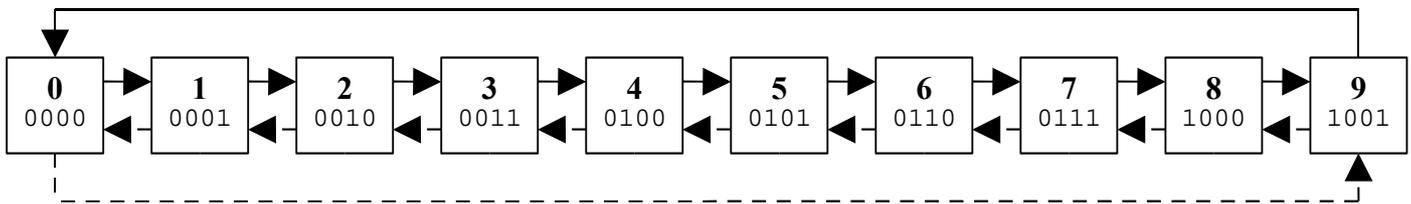
The capacitor on the control voltage (CV) pin is present for improved noise immunity.

The dotted LED, is not required but may be useful for debugging your circuit as detailed later.



## Counter

The counter selected is a binary coded decimal four bit up down counter (4510B). This means that it can either count up from zero to nine or down from 9 to 0 and that the output of this is indicated in binary.



The diagram above shows how the counter operates when clocked, the solid line indicating a clock when set to up and the dotted line shows the step when clocked in the down mode. The second number in each of the boxes is the binary representation of the data that will be present on the counter outputs  $Q_3$  to  $Q_0$ .

The chip has a Terminal Count (TC) output, this is normally present to allow one counter to trigger another counter when the count wraps around. This pin can however be used to reset the counter itself. The pin is active low so will be low: if counting up - when it reaches nine or if counting down - when it reaches zero.

The chip also has a Parallel Load (PL) function. When the PL pin is taken high the data on the inputs  $P_3$  to  $P_0$  are loaded into the counter. This functionality can be used to reload the counter with any value. So it is possible to load six and count down. When zero is reached the TC pin will change from high to low and this can be used to reload the counter to six.

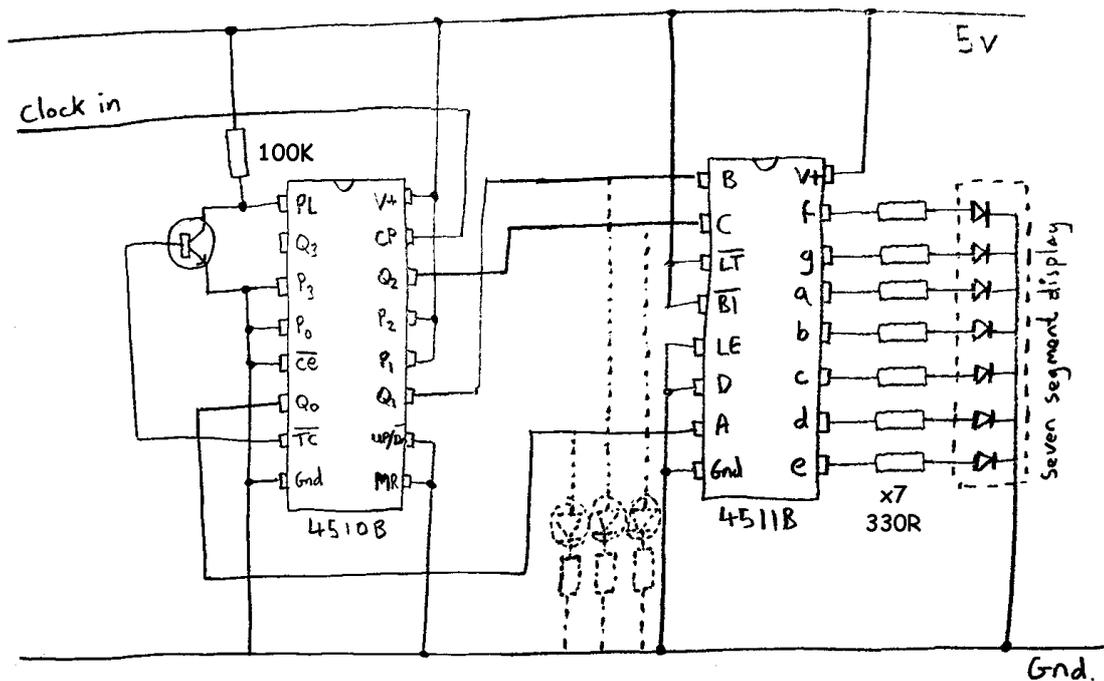
Unfortunately the PL pin is active high and the TC pin is active low, so they can't be connected directly. Instead an NPN transistor and pull up resistor need to be used to invert the signal.

The following table lists the pins not mentioned so far and their setting:

Pin name	Description	Connection
CE	Count enable (active low) Low = Counting functionality enabled High = Clocking the count line has no effect, the previous value is held	Low
CP	Clock in - causes the count to either go up or down by one	To the 555 timer output
UP / DN	Up / Down mode Low = down High = up	Low
MR	Master Reset (active high) Low = normal operation High = hold the device in a reset state, where CP, PL and outputs $Q_3$ to $Q_0$ are disabled.	Low

### Notes:

The counter can be clocked millions of times per second, if a switch is connected to the CP pin as the switch is pressed it will change state many times and cause the counter to count several pulses. A much better solution for development is to slow the 555 timer down; changing  $C_2$  to a  $47\mu\text{F}$  will give a delay of around 10 seconds allowing the counter to be observed. If the LED on the 555 timer and those shown on the next page are included, they can be seen turning on and off and will follow the pattern as shown in the diagram above. Use a  $330\Omega$  current limit resistor with the LEDs.



## 7 segment converter

The final step in the process is to turn the binary encoded number into outputs that can drive a seven segment display. This is done with a BCD to seven segment converter IC, specifically the 4511B. This part has four input lines in BCD format and 7 output lines to drive the seven segments on the number. A few extra control lines are present as follows:

Pin name	Description	Connection
LT	Lamp Test (active low) Low = Turns all segments on, for test purposes High = normal operation	High
BI	Blanking (active low) Low = turns all segment off High = displays the required number The Blanking pin can be used with a high speed variable width square wave to provide a dimming function	High
LE	Latch Enable (active high) Low = normal operation High = previously displayed number is latched and held	Low

The final step is to connect the seven segment display to the IC. You will need to check the data sheet for the seven segment display you have chosen. In general the segment consists of one LED and a 330R current limit resistor will give a good brightness. However bigger displays may use more than one LED per segment, as these are connected in series the voltage drop across the combined LEDs will be higher and a lower value resistor will be required.