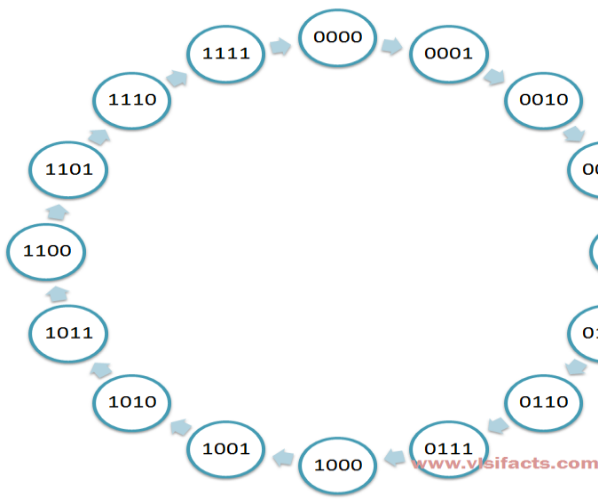
4-BIT BINARY COUNTER

Discussion

A counter is a sequential circuit that goes through a prescribed sequence of states upon the application of input pulses is called a counter. The input pulses, called count pulses, may be clock pulses.

In a counter, the sequence of states may follow a binary count or any other sequence of states. Counters are found in almost all equipment containing digital logic. They are used for counting the number of occurrences of an event and are useful for generating timing sequences to control operations in a digital system. Of the various sequences a counter may follow, the straight binary sequence is the simplest and most straight forward. A counter that follows the binary sequence is called a binary counter. An n-bit binary counter consists of n flip-flops and can count in binary from 0 to 2n- 1.

Procedure in designing a 4-bit binary counter



1. **Obtain the state table using the state diagram**

PRESENT STATE				NEXT STATE			
0	0	0	0	0	0	0	1
0	0	0	1	0	0	1	0
0	0	1	0	0	0	1	1
0	0	1	1	0	1	0	0
0	1	0	0	0	1	0	1
0	1	0	1	0	1	1	0
0	1	1	0	0	1	1	1
0	1	1	1	1	0	0	0
1	0	0	0	1	0	0	1
1	0	0	1	1	0	1	0
1	0	1	0	1	0	1	1
1	0	1	1	1	1	0	0
1	1	0	0	1	1	0	1
1	1	0	1	1	1	1	0
1	1	1	0	1	1	1	1
1	1	1	1	0	0	0	0

2. **Derive the transition table.**

Use the equation below to determine the number of flipflops to be used in the design of the circuit.

$$\boldsymbol{number\ of\ flipflops = \frac{Log_{10}(Number\ of\ states)}{Log_{10}\, 2}}$$

Since there are sixteen (16) states, the number of flipflops required would be four.

Now we want to implement the counter design using D flipflops. Next step is to develop an excitation table from the state table.

PRESENT STATE				NEXT STATE				flip-flop inputs			
A	B	C	D	A	B	C	D	DA	DB	DC	DD
0	0	0	0	0	0	0	1	0	0	0	1
0	0	0	1	0	0	1	0	0	0	1	0
0	0	1	0	0	0	1	1	0	0	1	1
0	0	1	1	0	1	0	0	0	1	0	0
0	1	0	0	0	1	0	1	0	1	0	1
0	1	0	1	0	1	1	0	0	1	1	0
0	1	1	0	0	1	1	1	0	1	1	1
0	1	1	1	1	0	0	0	1	0	0	0
1	0	0	0	1	0	0	1	1	0	0	1
1	0	0	1	1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	1	1	0	1	1
1	0	1	1	1	1	0	0	1	1	0	0
1	1	0	0	1	1	0	1	1	1	0	1
1	1	0	1	1	1	1	0	1	1	1	0
1	1	1	0	1	1	1	1	1	1	1	1
1	1	1	1	0	0	0	0	0	0	0	0

3. **Derive the simplified Boolean expression for each flipflop input using Karnaugh map.**

DA	CD			
AB	00	01	11	10
00				
01			1	
11	1	1		1
10	1	1	1	1

DA AD' + AB'+ AC'+A'BCD

DB	CD			
AB	00	01	11	10
00			1	
01	1	1		1
11	1	1		1
10			1	

DB: BC'+BD'+B'CD

DC	CD			
AB	00	01	11	10
00		1		1
01		1		1
11		1		1
10		1		1

DC= C'D+CD'=C XOR D

DD	CD			
AB	00	01	11	10
00	1			1
01	1			1
11	1			1
10	1			1

DD=D'

4. **Construct the sequential circuit.**
   Implement the combinational logic from the equations and connect the flip-flops to form the sequential circuit.

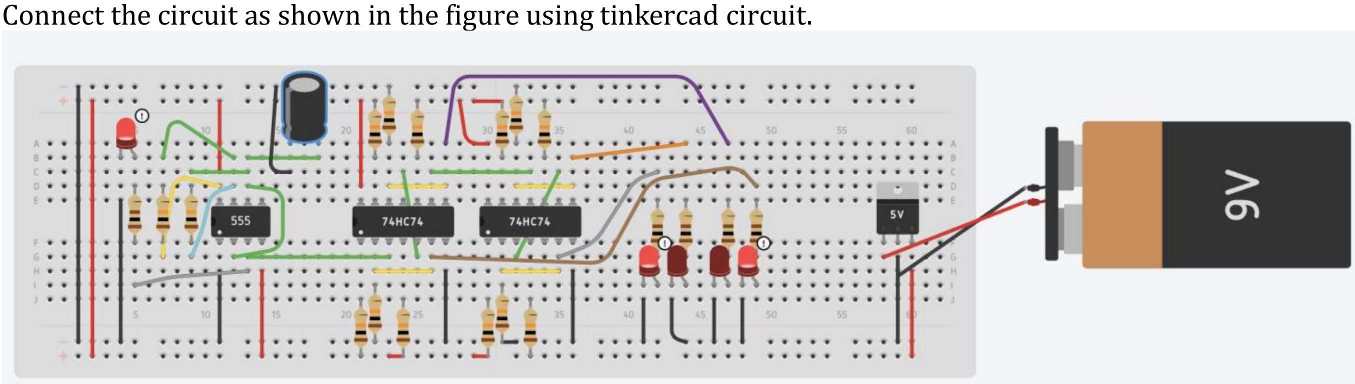
Components

- 9v BATTERY
- 14 10kOHMS
- 5 100 OHMS
- 5 RED LEDS
- BATTERY CONNECTOR
- 7805 5V REGULATOR
- 100 uF CAPACITOR
- 7474 FF
- 555 TIMER

Tinkercad Circuit

Steps:

1. Connect the circuit as shown in the figure using tinkercad circuit.



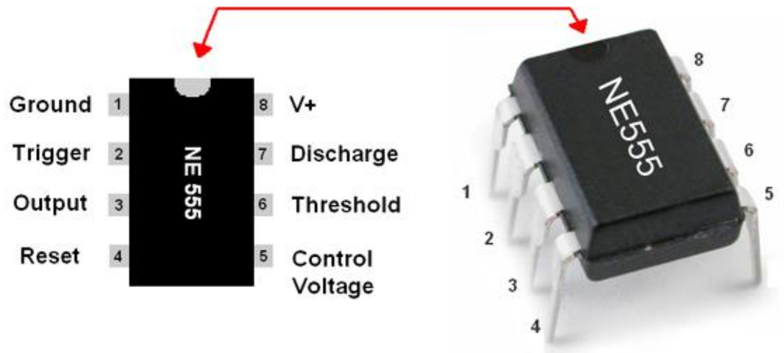
2. Start simulation.
   What happens to the circuit?

3. Replace the 100 uF with 10 uF, what happens?

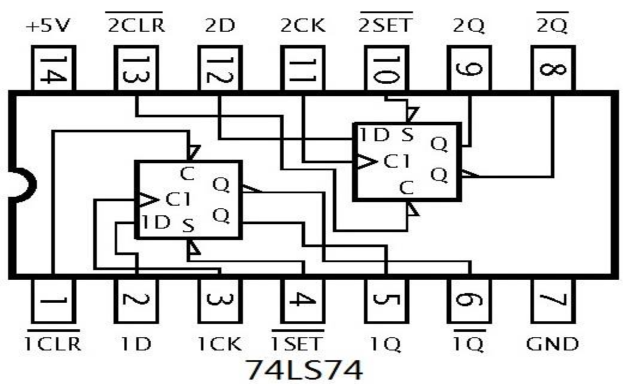
Conclusion and observation:

Pinout

555 timer



74LS74 Pinout



Excitation table

SR Flip-flop			
Q(t)	Q(t+1)	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

D Flip-flop		
Q(t)	Q(t+1)	DR
0	0	0
0	1	1
1	0	0
1	1	1

JK flip-flop			
Q(t)	Q(t+1)	J	K
0	0	0	x
0	1	1	x
1	0	x	1
1	1	x	0

T flip-flop		
Q(t)	Q(t+1)	DR
0	0	0
0	1	1
1	0	1
1	1	0