Indian Institute of Information Technology, Allahabad
ELECTRONICS AND COMMUNICATION ENGINEERING DEPARTMENT

Course Name: Analog Electronics Laboratory

EXPERIMENT NO: 9

Objective:

Operating modes of 555 Timer ICs and Working

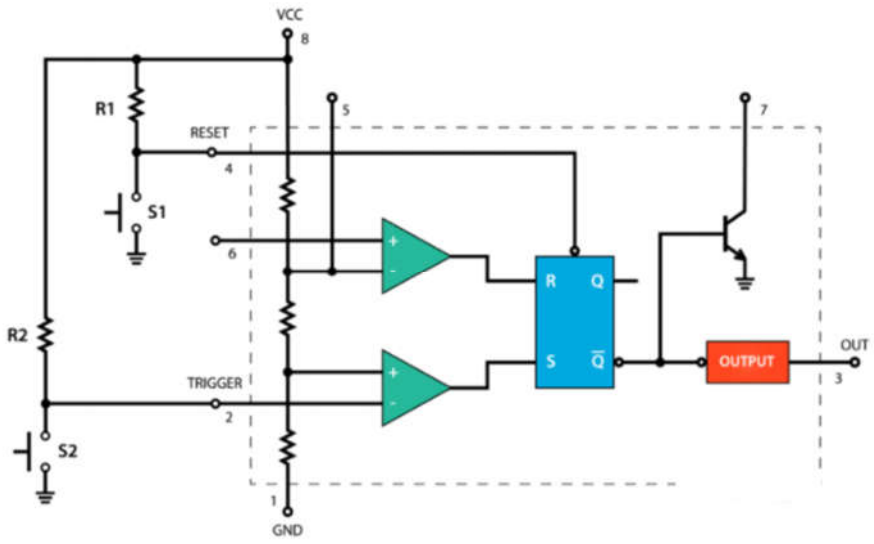
Components:

Components	Quantity	Values
555 Timer ICs		
Resistances	2	3.9 kΩ, 5.1 kΩ
Capacitors	2	0.1 µf, 0.01 µf
Power Supply	1	5-9 V
DSO	1	

Mode of Operations:

1. **Bistable Multivibrator**
2. **Monostable Multivibrator**
3. **Astable Multivibrator**

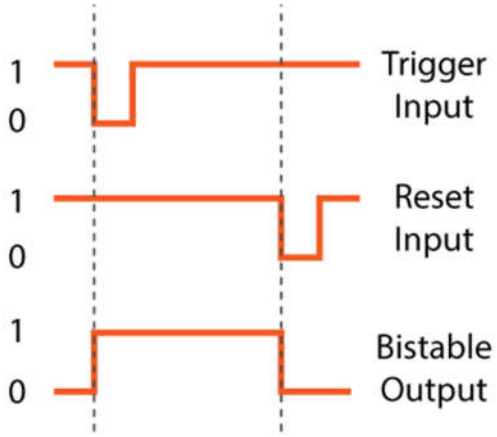
1. **Bistable Mode of Operation:**



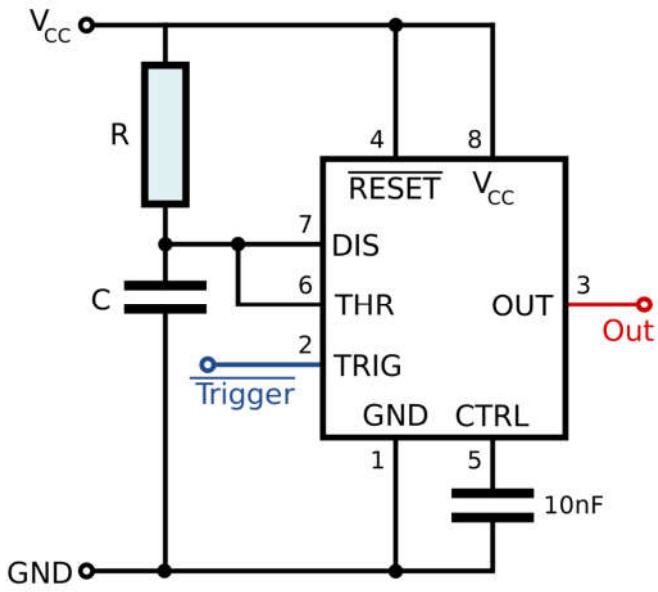
Working:

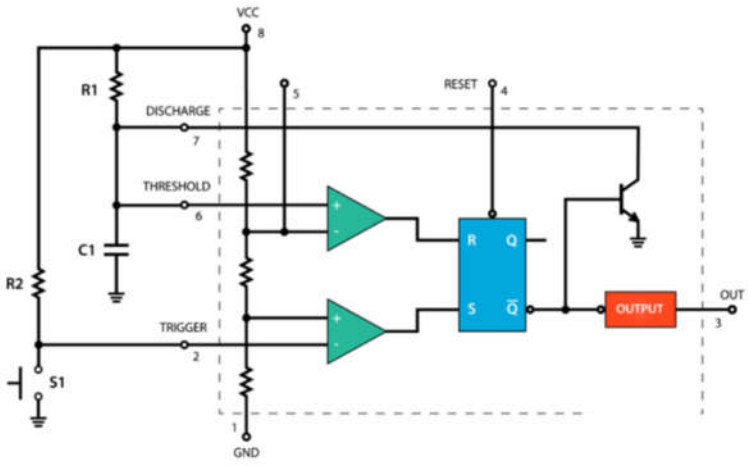
- As per the circuits given above, it needs 2 resistances and 2 input supply either by direct connection or by switches (S1, S2) at pin 4 (Reset) and pin 2 (Trigger)
- Both are connected to V_{cc} by 2 resistances and hence they remain always high when not connected.

- Initially assuming that the Flip-Flop (FF) is resetted previously hence Q=0 and Q_{bar}=1 leads to Out=0.
- Now, S2 are switched on making pin 2 (Trigger low).
- Lower comparator out =1 (as $1/3V_{cc}>0$) and upper comparator out=0 (as pin 6 is disconnected).
- Now the current input to FF is (S, R) = (1, 0) => Set Condition, making (Q, Q_{bar})=(1, 0) leads to Out=1.
- If, the connection from pin2 removed, Lower comparator out = 0, upper comparator out = 0, (S, R)=(0, 0) i.e. No change condition. Hence even after switching off the input trigger connection, the output value holds, Out=1.
- Now, Switch S1 get connected making pin 4 (Reset) low which completely reset the FF leads to (Q, Q_{bar})=(0, 1) => Out=0.
- The complete waveform is given below.



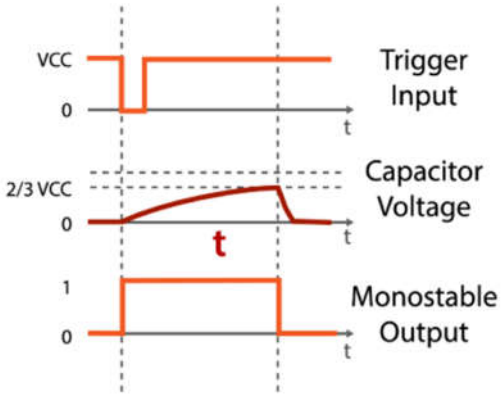
2. Monostable Mode of Operation:



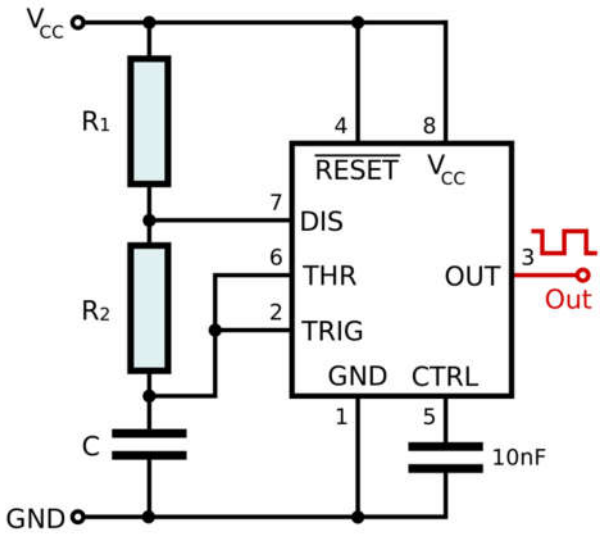


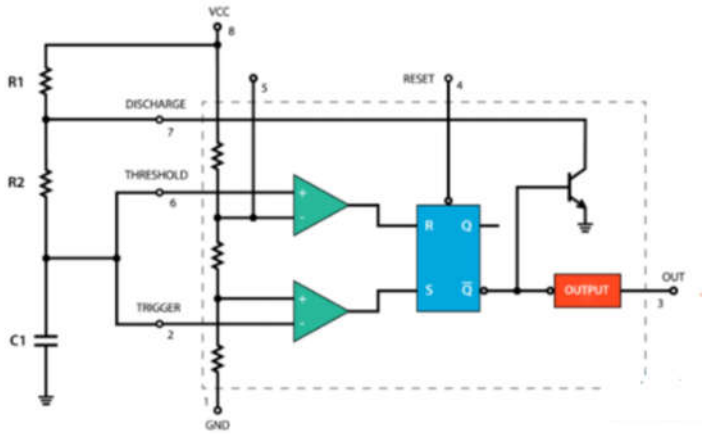
Working:

- Pin 7 (Discharge) and pin 6 (Threshold) held short circuited and connected to V_{cc} by resistance R1. Again the same connection is attached to a charging-discharging capacitor C1 with the ground.
- Pin 2 (trigger) is the only controlling input and this input either can be directly given a lower voltage by a power supply (upper diagram) or may be connected to V_{cc} by a current limiting resistance with switch making ground if on.
- Initially, assuming switch is off and C1 do not holds any charge => Pin 6=0 and Pin 2=V_{cc} (1).
- Upper comparator out=0 ($0<2/3V_{cc}$) and lower comparator out=0 ($1/3V_{cc}<V_{cc}$) => (S, R)=(0, 0) i.e. No change condition.
- Assuming, FF is being resetted previously => (Q, Q_{bar})=(0, 1) => Out=0.
- At the same time, Q_{bar}=1 making the NPN transistor ON which provides the connection between the Pin 7 to ground which in turn provides the least resistance path for both V_{cc} and discharging the capacitor.
- Now, as soon the switch S1 get connected making Pin 2 (trigger) low => Lower comparator out switches to=1 ($0<1/3V_{cc}$). The conditions for upper comparator remain same at this time.
- Now (S, R)=(1, 0) Set condition => (Q, Q_{bar})=(1, 0) => Out=1
- At same time, Q_{bar}=0 switching off the transistor. And hence C1 get connected to V_{cc} and starts charging via R1 (This charging time depends upon R1C1 factor and on time will be decided by this).
- The capacitor keep charging and reache to $V_{c1}>1/3V_{cc}$ => Lower comparator out = switches to 0 and upper comparator condition still same => (S, R)=(0, 0) i.e. No change condition hence Out=1.
- Next condition, $V_{c1}\geq 2/3V_{cc}$, Upper comparator output now switches to '1' => (S, R) = (0, 1) i.e. Reset condition => (Q, Q_{bar})=(0, 1) => Out=0
- At the same time, NPN transistor switched on and provided the low resistance path to discharge the capacitor.
- The detailed waveform is given below.
- ON time of pulse can be calculated by $T_{ON}=1.1\times R1\times C1$.



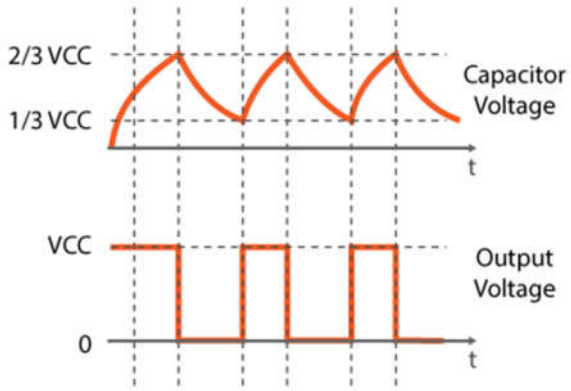
3. Astable Mode of Operation:





Working:

- It is also known as free running multivibrator and doesn't have any stable state. It keeps switching between high and low states without any external trigger or input except V_{cc}.
- Detailed connection is given above.
- Initially, assuming that there is no charge stored in capacitor C1 => making Pin 6 (Threshold) and Pin 2 (Trigger) low.
- Due to this, Upper comparator out = 0 ($0<2/3V_{cc}$) and lower comparator out = 1 ($1/3V_{cc}>0$) => (S, R) = (1, 0) Set condition => (Q, Q_{bar})=(1, 0) => Out = 1 (high).
- At the same time, Q_{bar}=0 keeping NPN transistor off => Pin 7 (Discharge) is disconnected to ground.
- Hence, C1 starts charging via R1 and R2 by V_{cc} (Charging time depends upon (R1+R2)×C1).
- Now, as C1 is charging, Vc reaches to $1/3V_{cc}$ ($V_c \geq 1/3V_{cc}$, switching condition of lower comparator) Lower comparator output switches to '0' => (S, R)=(0, 0) (as upper comparator conditions intact) i.e. No change condition => Out=1 (Hold)
- Next V_c reaches to $2/3V_{cc}$ ($V_c \geq 2/3V_{cc}$, Switching condition of upper comparator), Upper comparator switches to '1' => (S, R) = (0, 1) (as lower comparator conditions intact) i.e. Reset condition making (Q, Q_{bar})=(0, 1) => Out = 0.
- At the same time Q_{bar} = 1 making NPN transistor ON hence providing a least resistance path to Capacitor C1 to discharge via R2 only (Discharge time depends on R2×C1).
- As soon as $V_c<2/3V_{cc}$, Upper comparator again switches to '0' => (S, R) = (0, 0) => Hold condition => Out = 0.
- On discharging, V_c again reaches to $1/3V_{cc}$ ($V_c \leq 1/3V_{cc}$), Lower comparator out = 1 => (S, R) = (1, 0) i.e. Set condition => (Q, Q_{bar}) = (1, 0) => Out = 1.
- At the same instant, NPN become off again, Disconnect to ground. And hence C1 again starts charging.
- The above steps keep repeating between the values of $1/3V_{cc}$ to $2/3V_{cc}$.
- T_{ON}=0.693 (R1+R2)×C1
- T_{OFF}=0.693 R2×C1
- Time period $T=T_{ON}+T_{OFF}$= 0.693 (R1+2R2)×C1
- The detailed waveform is given below.



References:

1. https://www.electronics-tutorials.ws/waveforms/555_timer.html
2. https://www.jameco.com/Jameco/workshop/TechTip/555-timer-tutorial.html
3. https://howtomechatronics.com/how-it-works/electronics/555-timer-ic-working-principle-block-diagram-circuit-schematics/