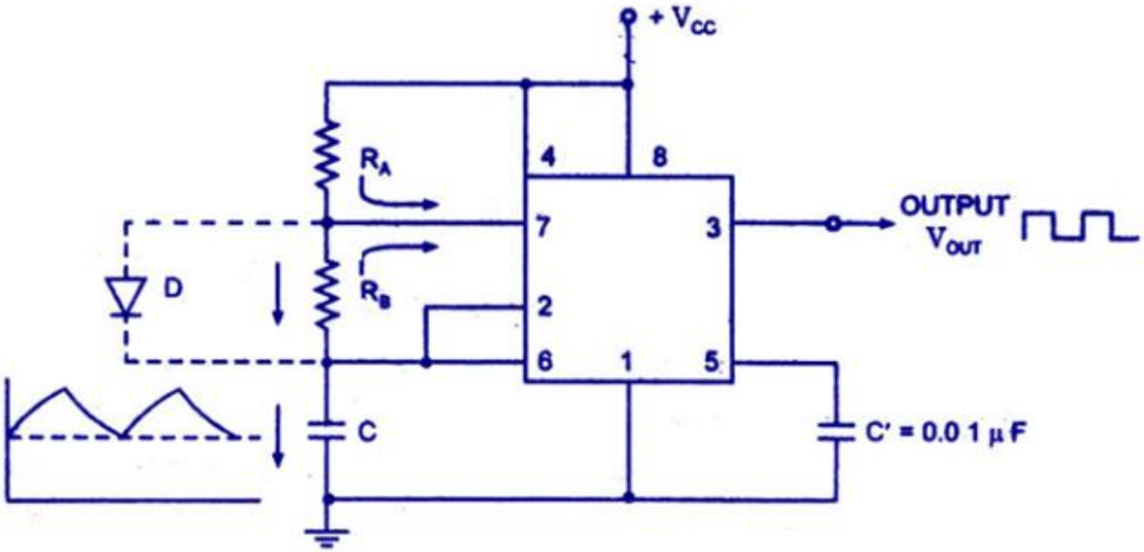
IC555 as Astable multivibrator

Contents:

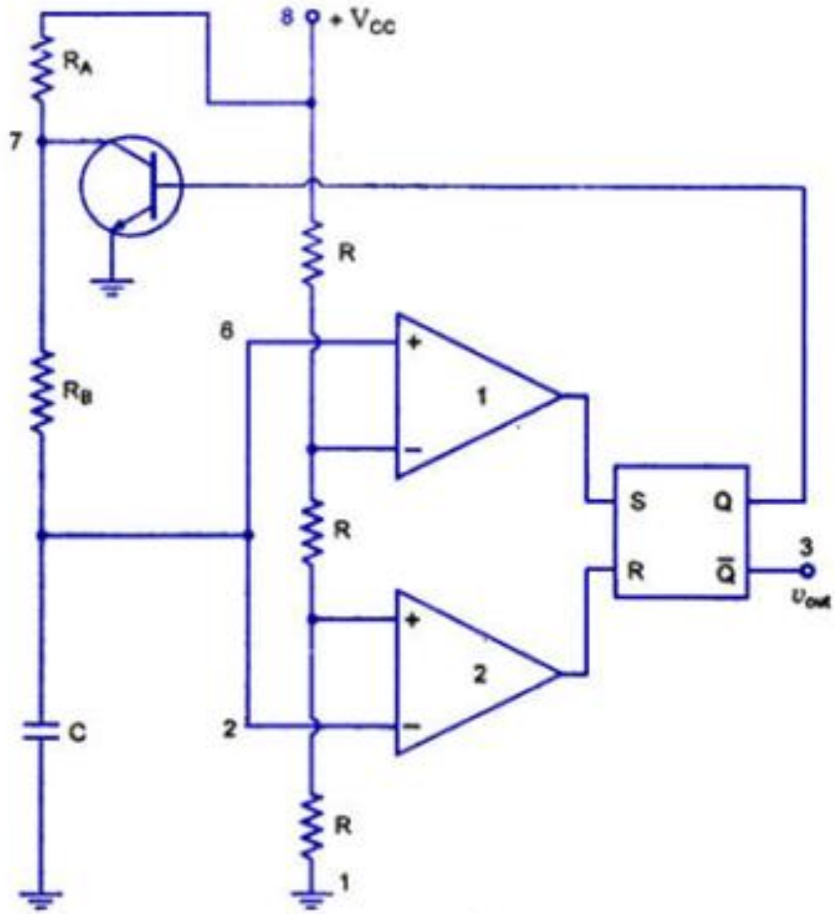
Introduction

One popular application of the 555 timer IC is as an astable multivibrator or clock circuit. An astable multivibrator, often called a free-running multivibrator, is a rectangular-wave generating circuit. Unlike the monostable multivibrator, this circuit does not require any external trigger to change the state of the output, hence the name free-running. An astable multivibrator can be produced by adding resistors and a capacitor to the basic timer IC, as illustrated in figure. The timing during which the output is either high or low is determined by the externally connected two resistors and a capacitor. The details of the astable multivibrator circuit are given in figure .

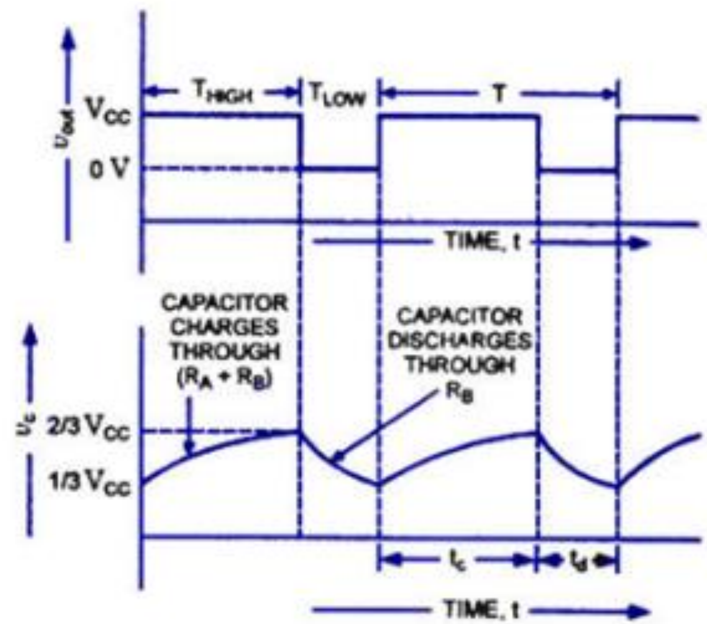


Circuit of The Timer 555 as an Astable Multivibrator

Introduction

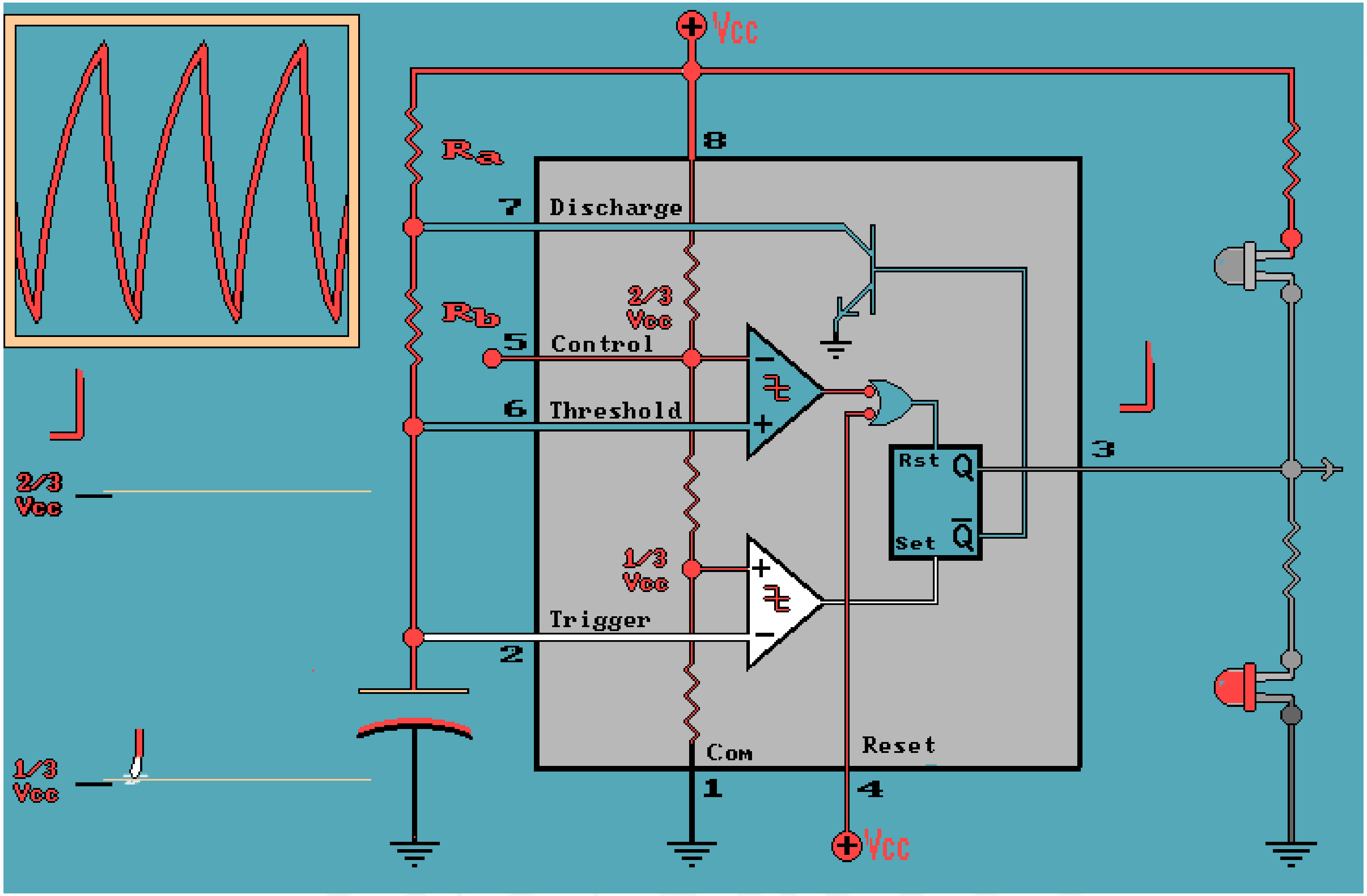


Internal Circuitry With External Connections



Capacitor and Output Voltage Waveforms

Astable Operation


Vcc
8
Ra
7
Discharge
Rb
2/3 Vcc
5
Control
6
Threshold
3
Rst
Q
Set
Q̄
2/3 Vcc
1/3 Vcc
Trigger
2
1/3 Vcc
Com
Reset
1
4
Vcc

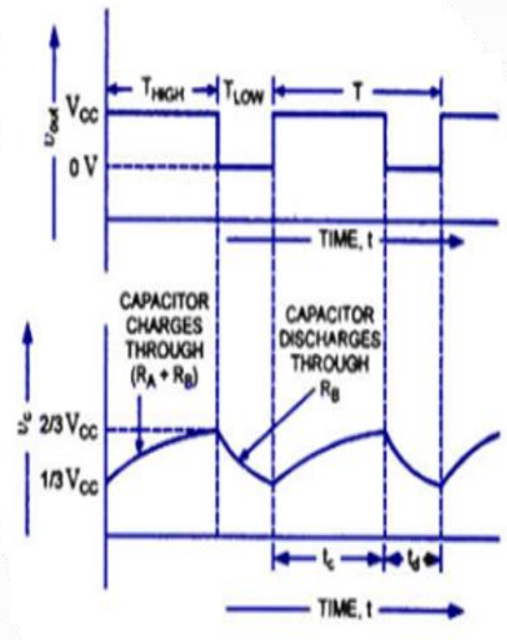
Working:

In the circuit, when Q is low, the discharging transistor is cut-off and the capacitor C begins charging toward V_{CC} through resistances R_A and R_B. Because of this, the charging time constant is (R_A+R_B) C.

Eventually, the threshold voltage exceeds +2/3 V_{CC}, the comparator 1 has a high output and triggers the flip-flop so that its Q is high and the timer output is low. With Q high, the discharge transistor saturates and pin 7 grounds so that the capacitor C discharges through resistance R_B with a discharging time constant R_B C .

With the discharging of capacitor, trigger voltage at inverting input of comparator 2 decreases. When it drops below 1/3V_{CC}, the output of comparator 2 goes high and this reset the flip-flop so that Q is low and the timer output is high. This proves the auto-transition in output from low to high and then to low as, illustrated in figures. Thus the cycle repeats. The time during which the capacitor C charges from 1/3 V_{CC} to 2/3 V_{CC} is equal to the time the output is high and is given as:

t_c or $T_{HIGH} = 0.693\ (R_A + R_B)$ C.



Capacitor and Output Voltage Waveforms

Working:

Voltage across the capacitor at any instant during charging period is given as,

$V_C = V_{CC}(1\text{- } exp.^{-t/RC})$

The time taken by the capacitor to charge from 0 to +1/3 V_{CC}:

$1/3\ V_{CC} = V_{CC}\ (1\text{- } exp.^{-t_1/RC})$

t_1 = RC log_e 1.5 = 0.405 RC

Similarly, the time taken by the capacitor to charge from 0 to +2/3 V_{CC} is given by:

t_2 = RC log_e 3 = 1.0986 RC So the time taken by the capacitor to charge from +1/3 V_{CC} to +2/3 V_{CC}:

$t_c = (t_2 - t_1)$ = (1.0986−0.405) RC = 0.693 RC

Substituting R = (RA + RB) in above equation we have,

$T_{HIGH} = t_c = 0.693\ (R_A + R_B)$ C

where R_A and R_A are in ohms and C is in farads. The time during which the capacitor discharges from +2/3 VCC to +1/3 VCC is equal to the time the output is low and is given as:

t_d or T_{LOW} = 0.693 R_B C where R_B is in ohms and C is in farads.

Working:

The above equation is worked out as follows: Voltage across the capacitor at any instant during discharging period is given as: $V_C = (2/3)V_{CC}exp.^{-t/R_BC})$

Substituting $V_C = 1/3\ V_{CC}$ and t = t_d in above equation we have $+1/3\ V_{CC} = +2/3\ V_{CC}exp.^{-t_d/R_BC})$

Or td = 0.693 R_BC

Overall period of oscillations,

T = $T_{HIGH} + T_{LOW}$ = 0.693 $(R_A + 2R_B)$ C

The frequency of oscillations being the reciprocal of the overall period of oscillations T is given as:

f = 1/T = 1.44/ (RA+ $2R_B$)C

Equation indicates that the frequency of oscillation / is independent of the collector supply voltage $+V_{CC}$.

Often the term duty cycle is used in conjunction with the astable multivibrator.

References:

- Digital Principles and Applications, A.P. Malvino, D. P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill
- Digital Fundamentals, Thomas L. Floyd, 11th Ed., 2015, Pearson Education Limited
- Modern Digital Electronics, R P Jain, 4th Ed., 2010, Tata McGraw Hill