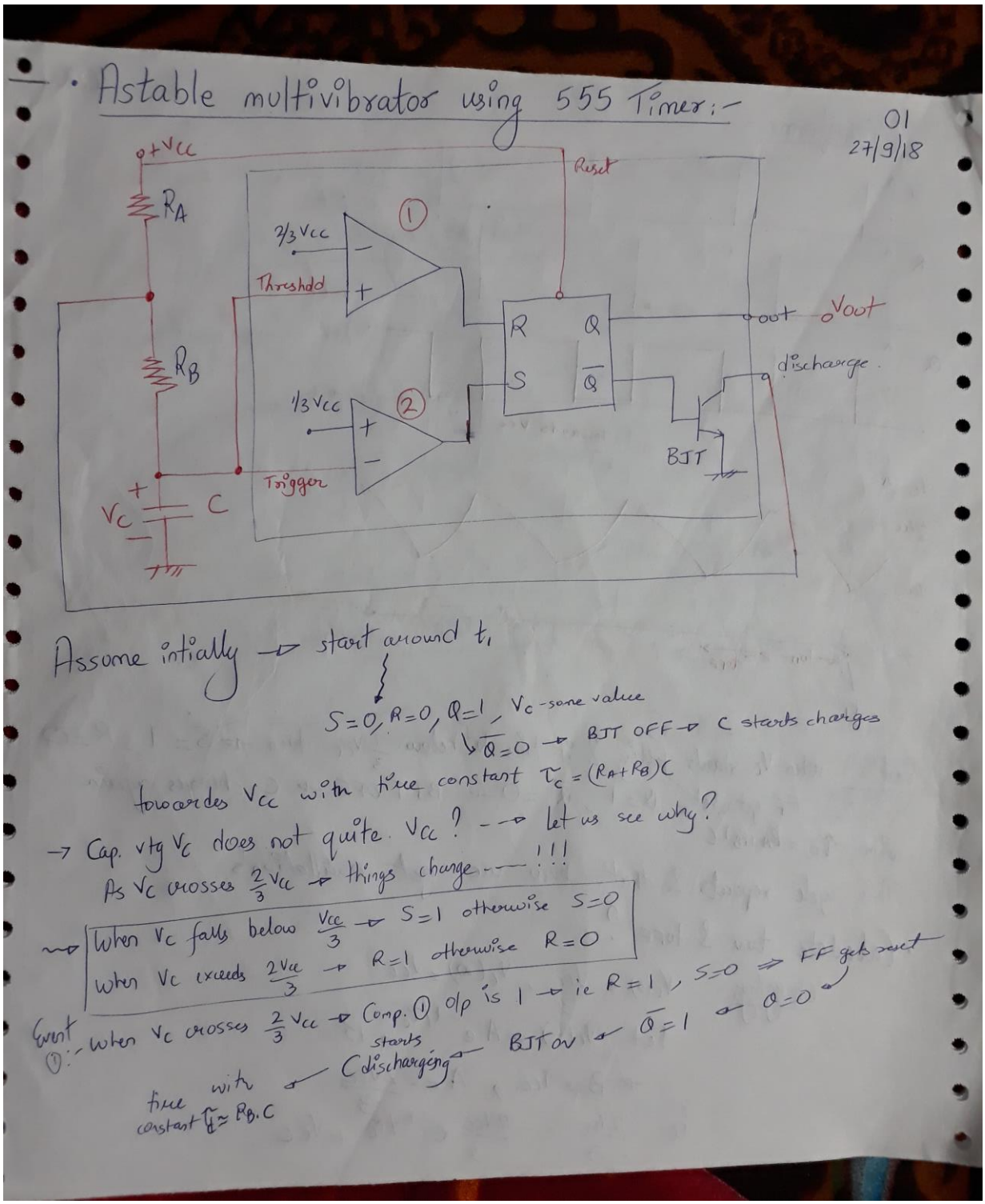
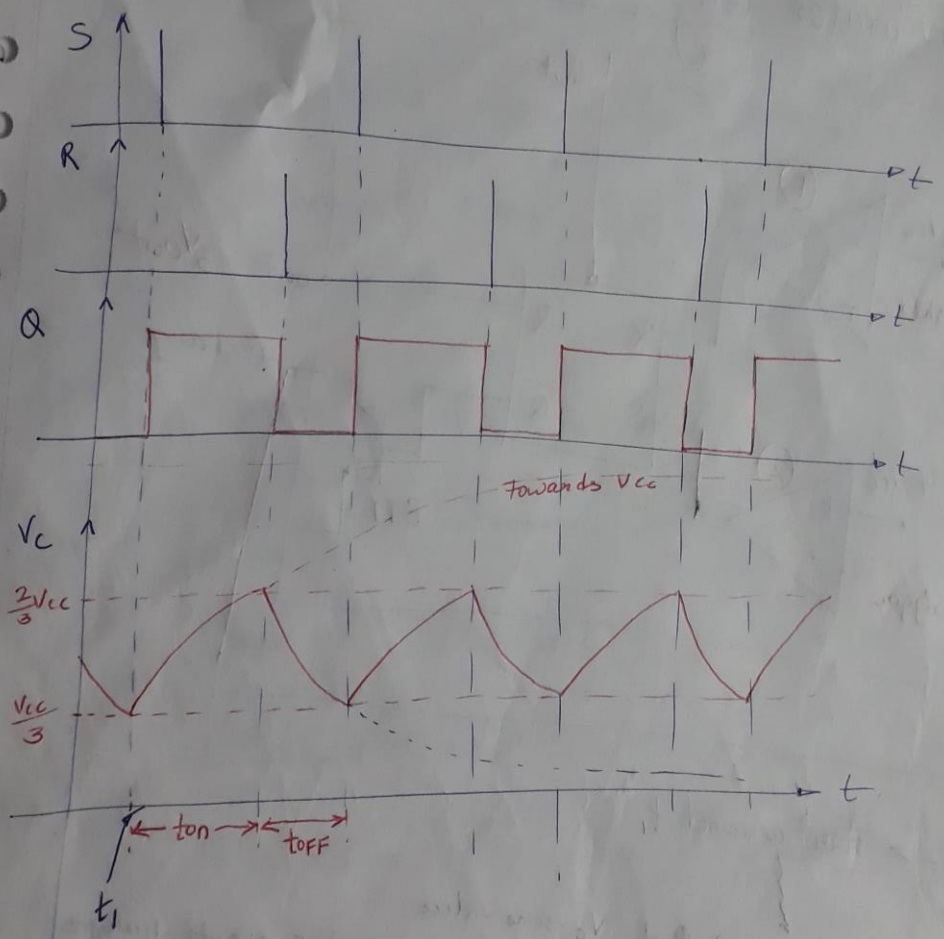
LICD 32 dated 28-09-2018

Topics Covered: 555 as Astable multivibrator working with functional block diagram and waveforms, derivation of t high and t low, % duty cycle for astable multivibrator, Numerical discussed in class on Astable multivibrator using 555 timer and it's verification in LT Spice simulation and hands-on calculations.



Waveforms:-



Event 2:- When V_C starts falling & it tries to go below $\frac{1}{3}V_{cc}$ then → $S=1$, $R=0$

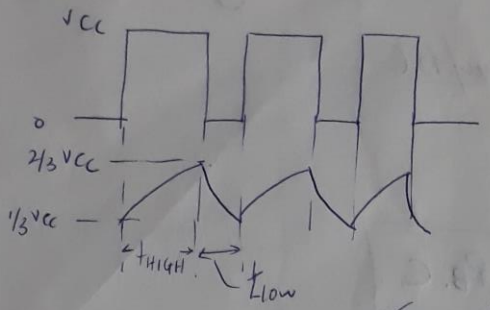
FF get set, $Q=1$, $\bar{Q}=0$ → BJT OFF → C charges again

with $\tau_C = (R_A+R_B)C$

This cycle repeats & that's how we get oscillation's

Calculation of t_{HIGH} & t_{low} (Astable multivibrator)

01
27/9/18



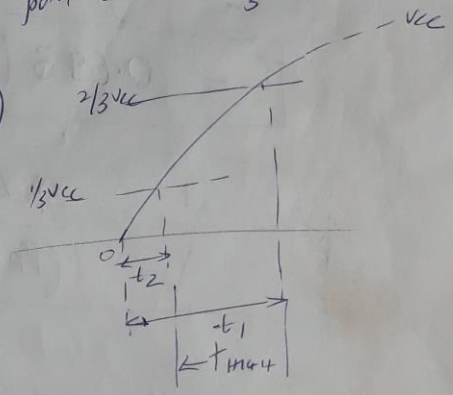
o/p

The capacitor voltage for charging instant, (RC ckt)

$\tau_c \simeq (R_A + R_B)C$.

$$V_c(t) = V_{cc}\left(1 - e^{-t/RC}\right)$$

The time t_1 taken by the ckt to charge from 0 to $\frac{2}{3}V_{cc}$



$$ie\ \frac{2}{3}V_{cc} = V_{cc}\left(1 - e^{-t_1/RC}\right)$$

$$V_{cc}\, e^{-t_1/RC} = \frac{V_{cc}}{3}$$

$$-\frac{t_1}{RC} = \log_e\left(\frac{1}{3}\right) = -1.09$$

$$t_1 = 1.09RC \quad \tau_c$$

The time t_2 to charge from 0 to $(1/3)V_{cc}$ is

$\tau_c = (R_A + R_B)C$

$$\frac{1}{3}V_{cc} = V_{cc}\left(1 - e^{-t_2/RC}\right)$$

$$t_2 = 0.405\,RC \quad \tau_c$$

$$t_{HIGH} = t_1 - t_2 = (1.0986 - 0.405)\,\tau_c$$

$$\boxed{t_{HIGH} = 0.693(R_A + R_B)C}$$

The o/p is low while capacitor C discharges from $\left(\frac{2}{3}V_{CC}\right)$ to $\left(\frac{1}{3}V_{CC}\right)$ & vtg across C is given by

$$\left(\frac{1}{3}V_{CC}\right) = \left(\frac{2}{3}\right)V_{CC}\, e^{-t_{low}/R_B C}$$

$$\Rightarrow \boxed{t_{low} = 0.693\, R_B C}$$

$$T = t_{high} + t_{low}$$

$$\boxed{T = 0.693\,(R_A + 2R_B)\,C}$$

$$\boxed{f = \frac{1}{T} = \frac{1.45}{(R_A + 2R_B)\,C}}$$

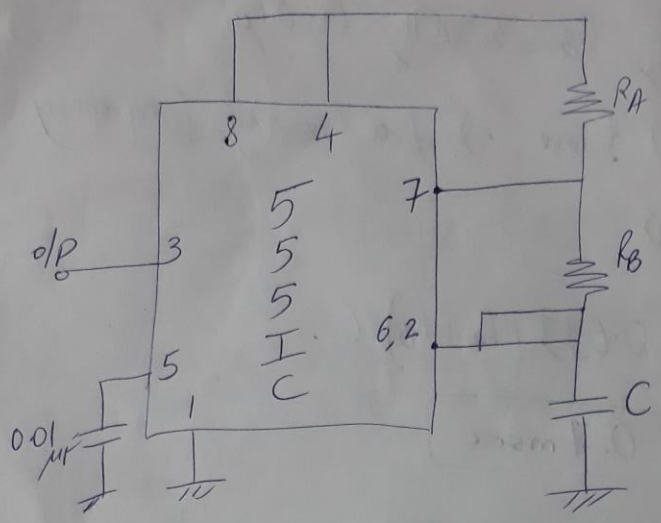
∴ Duty cycle of a ckt is defn as the ratio of on time to total time period (T)

$$\%D = \frac{t_{HIGH}}{T} \times 100$$

$$= \frac{(R_A + R_B)\,C}{(R_A + 2R_B)\,C} \times 100$$

$$\boxed{\%D = \frac{(R_B + R_A)}{R_A + 2R_B} \times 100}$$

555 Astable multivibrator summary :-



$$t_{HIGH} = 0.693(R_A + R_B).C$$

$$t_{low} = 0.693\, R_B.C$$

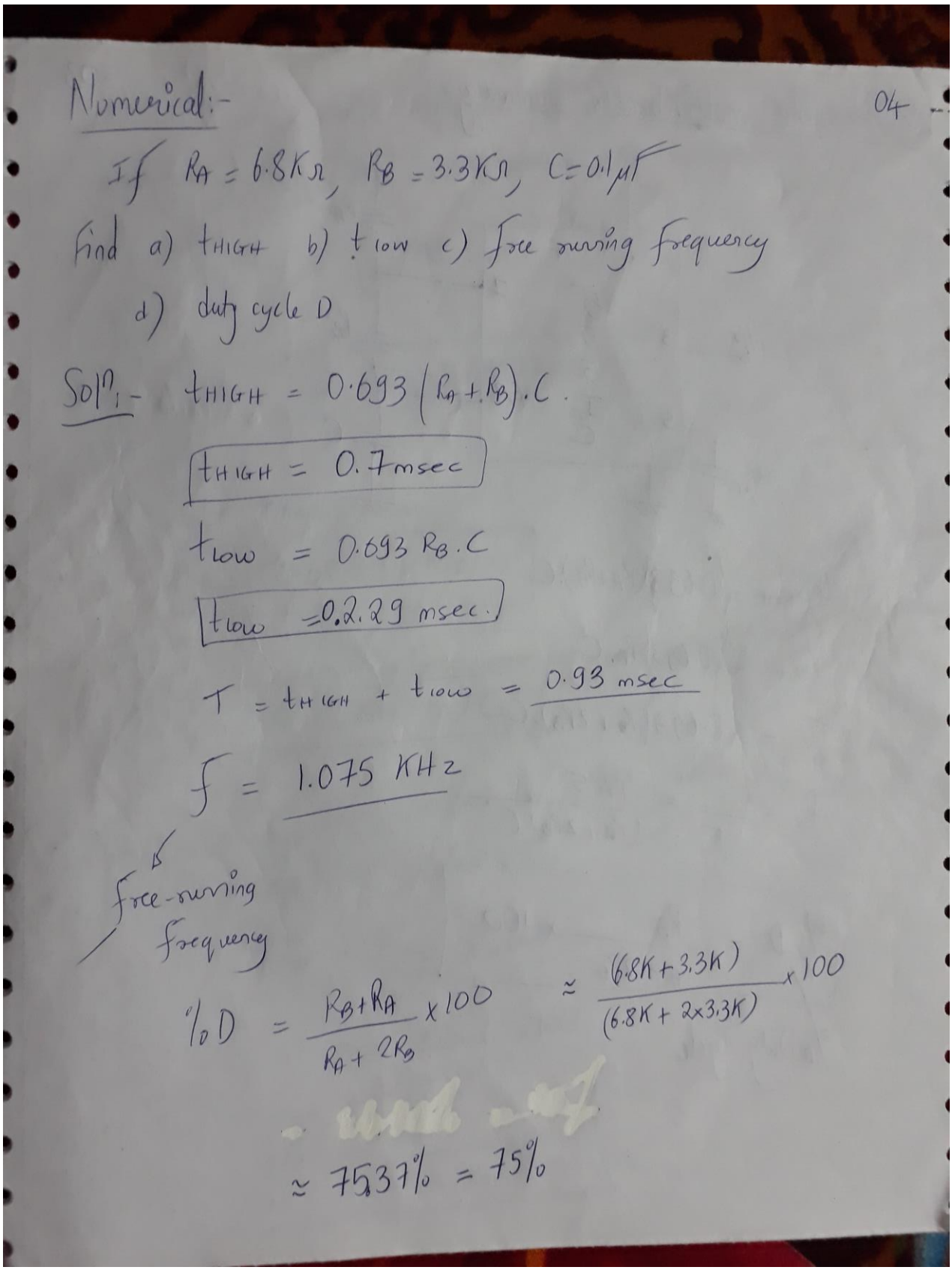
$$T = 0.693(R_A + 2R_B).C$$

$$f = \frac{1}{T} = \frac{1.45}{(R_A + 2R_B)\,C}$$

$$\%D = \frac{(R_B + R_B)}{R_A + 2R_B} \times 100$$

%D Duty cycle

Numerical 01



Numerical:- 04

If $R_A = 6.8K\Omega$, $R_B = 3.3K\Omega$, $C = 0.1\mu F$

Find a) t_{HIGH} b) t_{low} c) free running frequency

d) duty cycle D

Soln:- $t_{HIGH} = 0.693 (R_A + R_B).C$.

$t_{HIGH} = 0.7 msec$

$t_{low} = 0.693 R_B.C$

$t_{low} = 0.2.29 msec.$

$T = t_{HIGH} + t_{low} = 0.93 msec$

$f = 1.075 KHz$

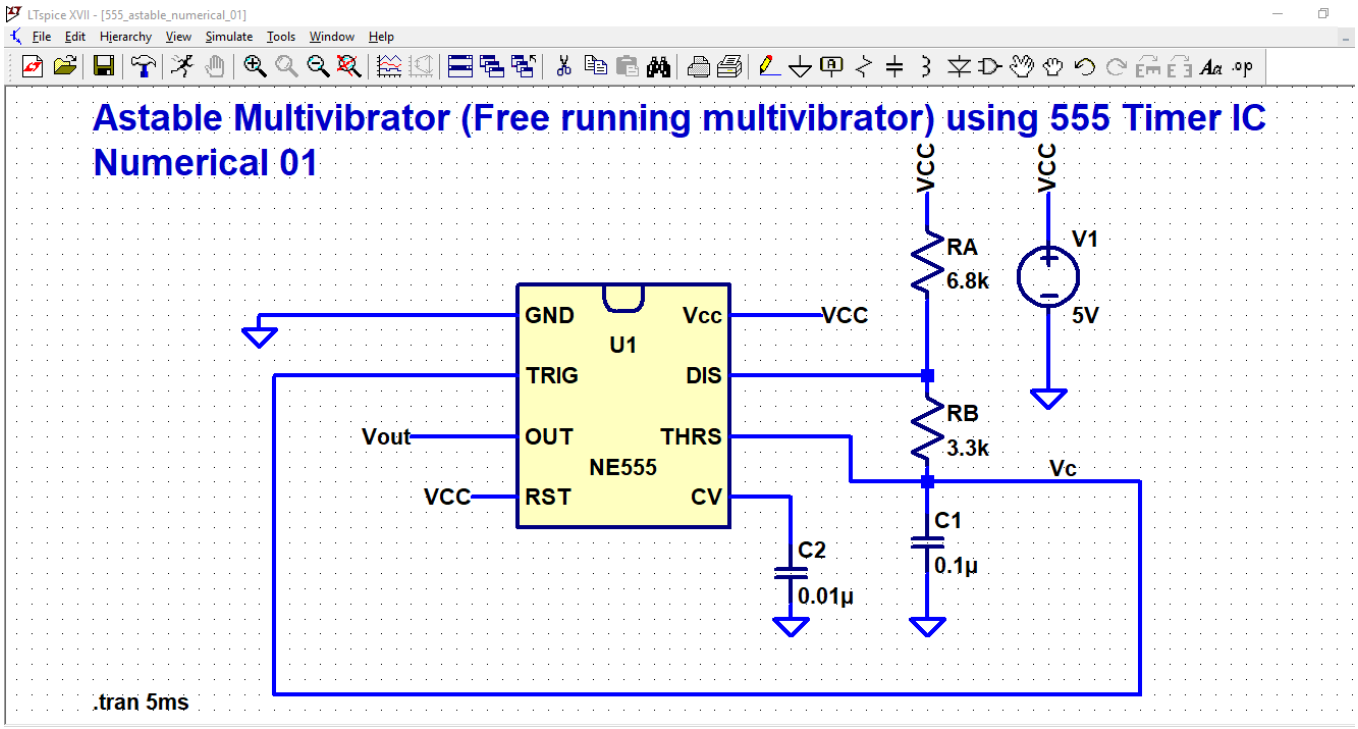
free-running frequency

$\%D = \frac{R_B + R_A}{R_A + 2R_B} \times 100 \simeq \frac{(6.8K + 3.3K)}{(6.8K + 2 \times 3.3K)} \times 100$

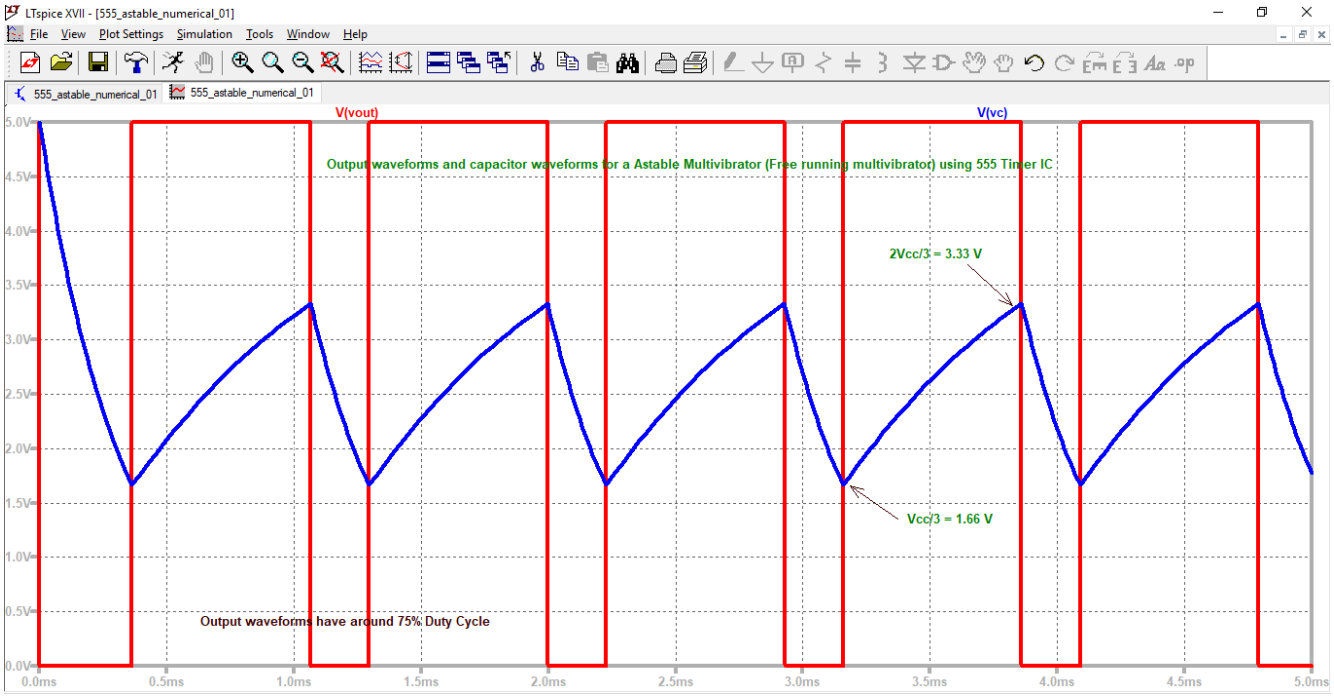
$\simeq 7537\% = 75\%$

Simulation was carried out in LT Spice and simulation results were discussed in class

Topics: Astable multivibrator circuit designed for specifications as per numerical 01



Waveforms for Astable multivibrator designed for specifications as per numerical 01



One can clearly observe that; the circuit operates without any external input.