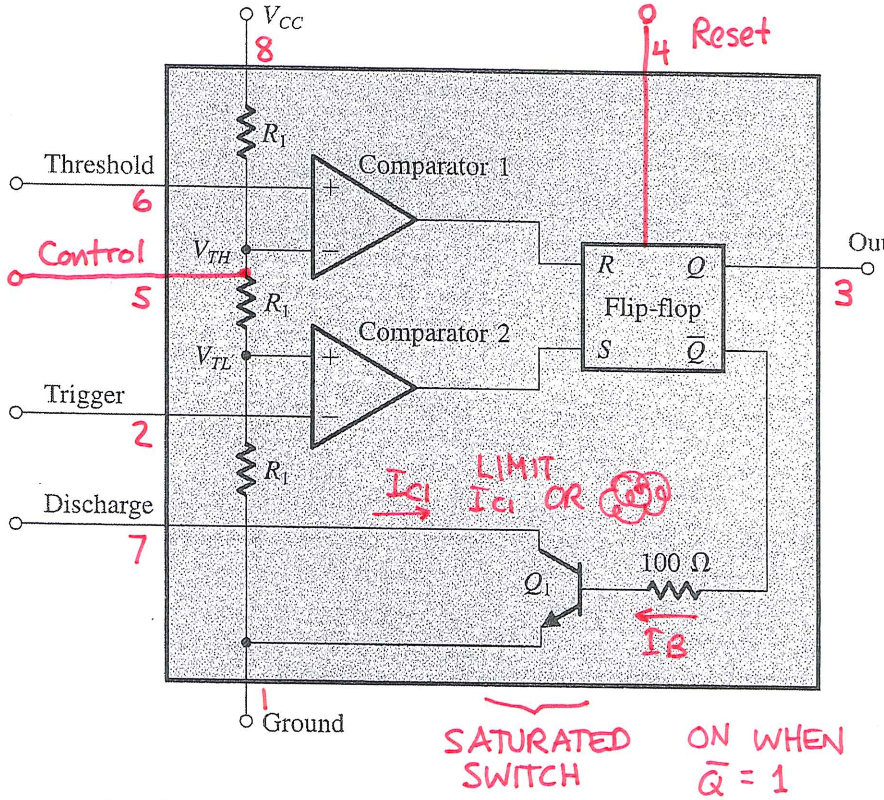
ECE3204 Lecture 15

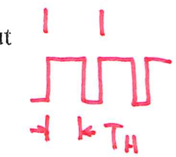
LM555 Timer (17.7)
Lab 4 Clock Circuit

Hand in: HW 4

Digital circuits are made from analog parts.



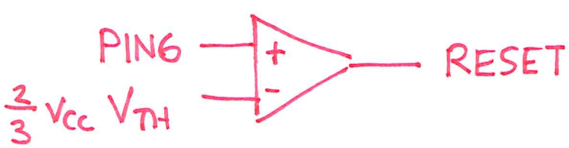

$T = \frac{1}{f}$




$\delta = \frac{T_H}{T}$

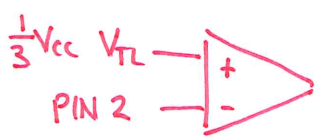
COMPARATORS IN LM555

COMP 1



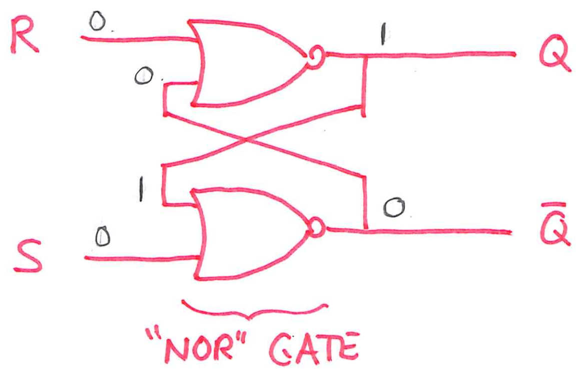

| INPUT | RESET |
|---|---|
| PIN6 > $\frac{2}{3}$Vcc | 1 |
| PIN6 < $\frac{2}{3}$Vcc | 0 |

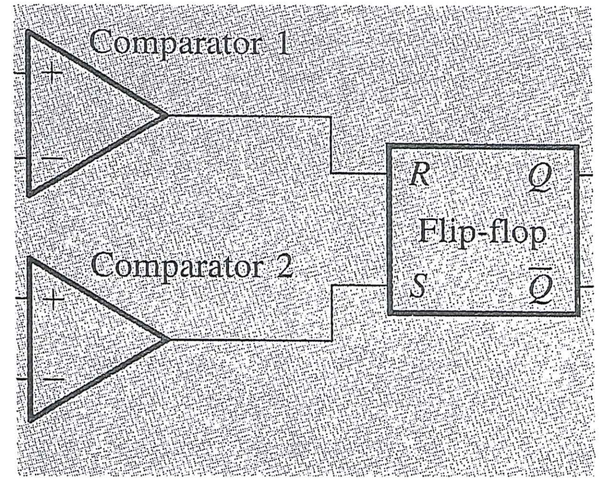
COMP 2

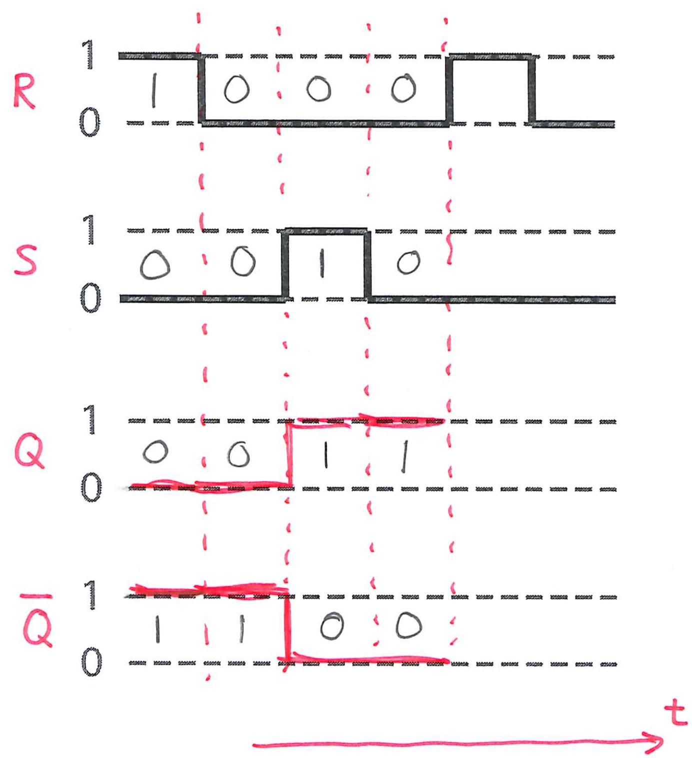



| INPUT | SET |
|---|---|
| PIN2 > $\frac{1}{3}$Vcc | 0 |
| PIN 2 < $\frac{1}{3}$Vcc | 1 |

## Set - Reset Flip Flop



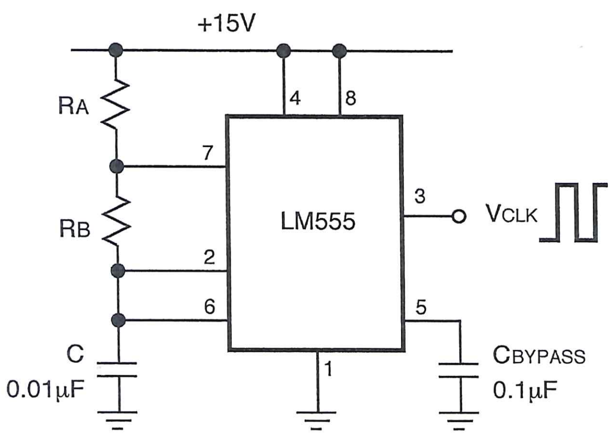

TRUTH TABLE

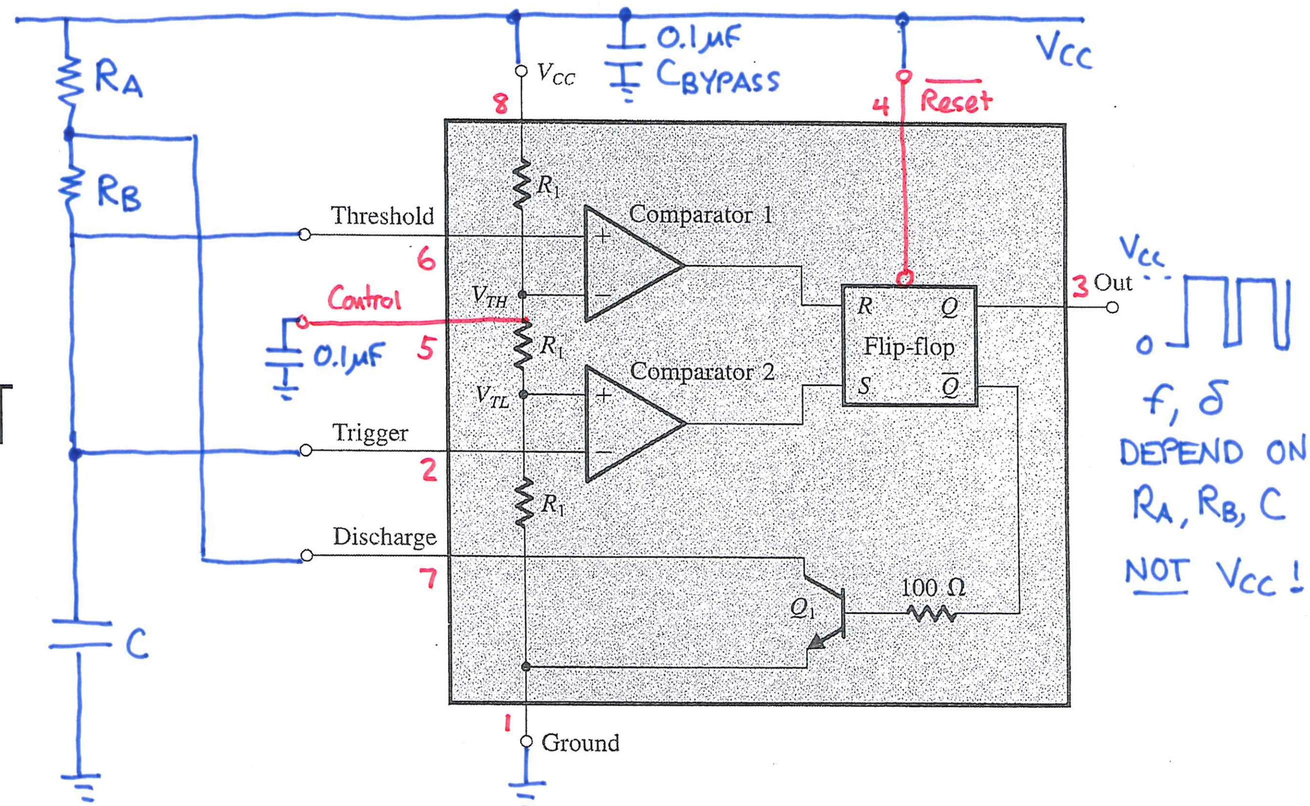
| R | S | Q | $\bar{Q}$ |
|---|---|---|---|
| 0 | 0 | ~~0~~ 1 | ~~1~~ 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 |
| 1 | 1 | | |

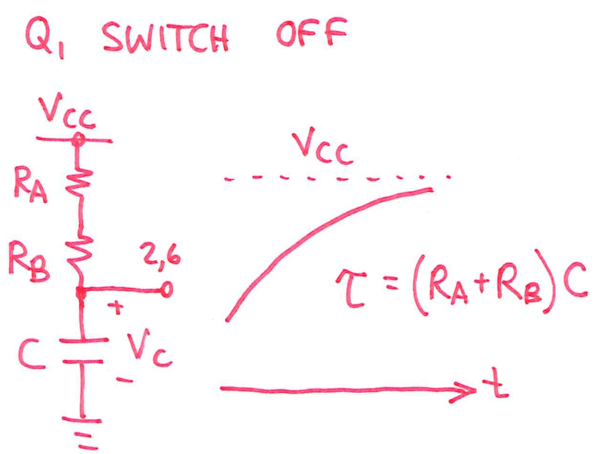
TRUTH TABLE

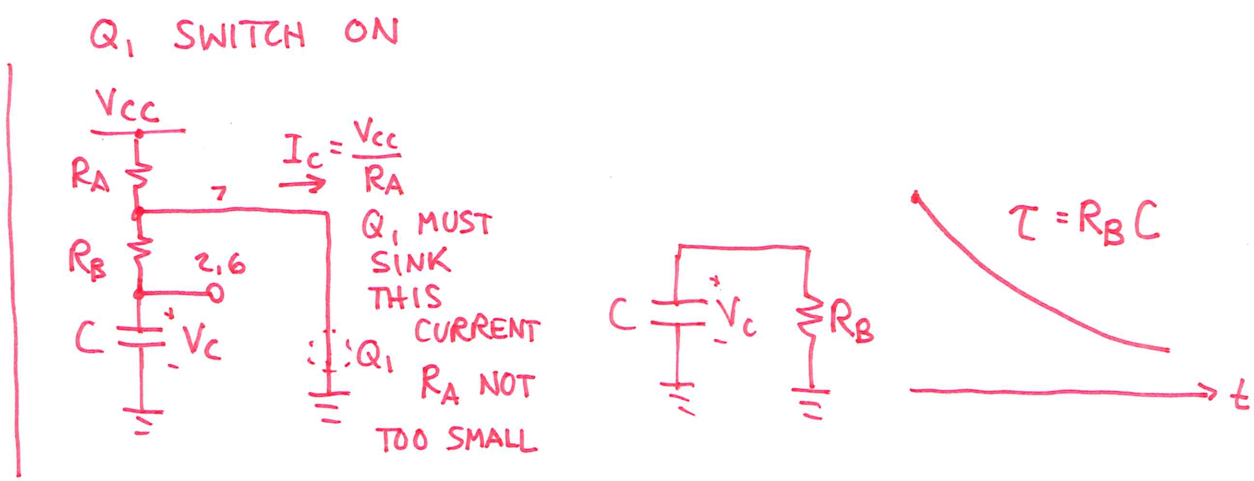
| R | S | Q | $\bar{Q}$ | HISTORY! |
|---|---|---|---|---|
| 0 | 0 | $Q_0$ | $\bar{Q}_0$ | HOLDS PREVIOUS STATE |
| 0 | 1 | 1 | 0 | ~~RESET~~ SET |
| 1 | 0 | 0 | 1 | ~~S~~ RESET |
| 1 | 1 | 0 | 0 | NOT USED (NOT STABLE) |

# Lab 4 Clock Circuit

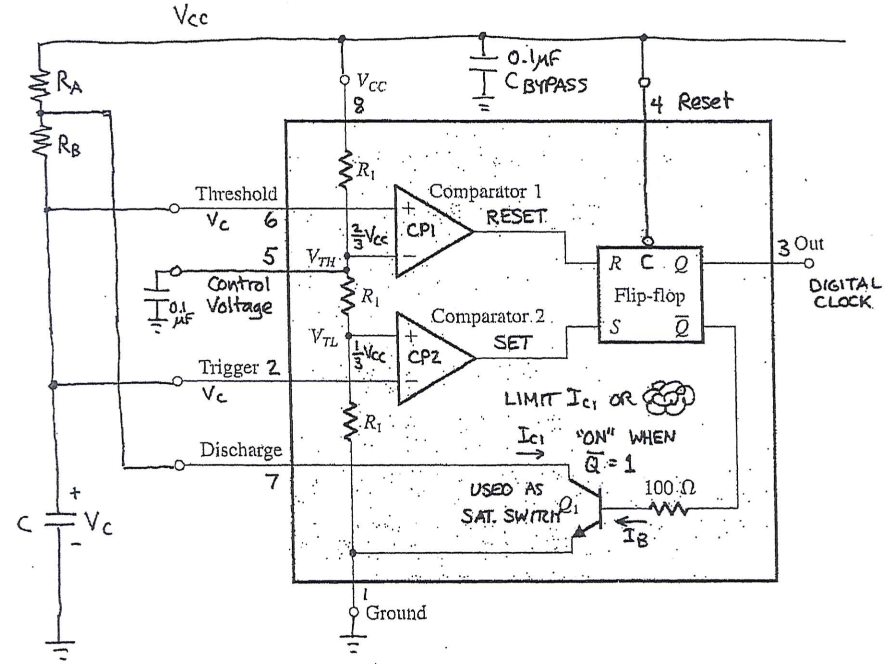


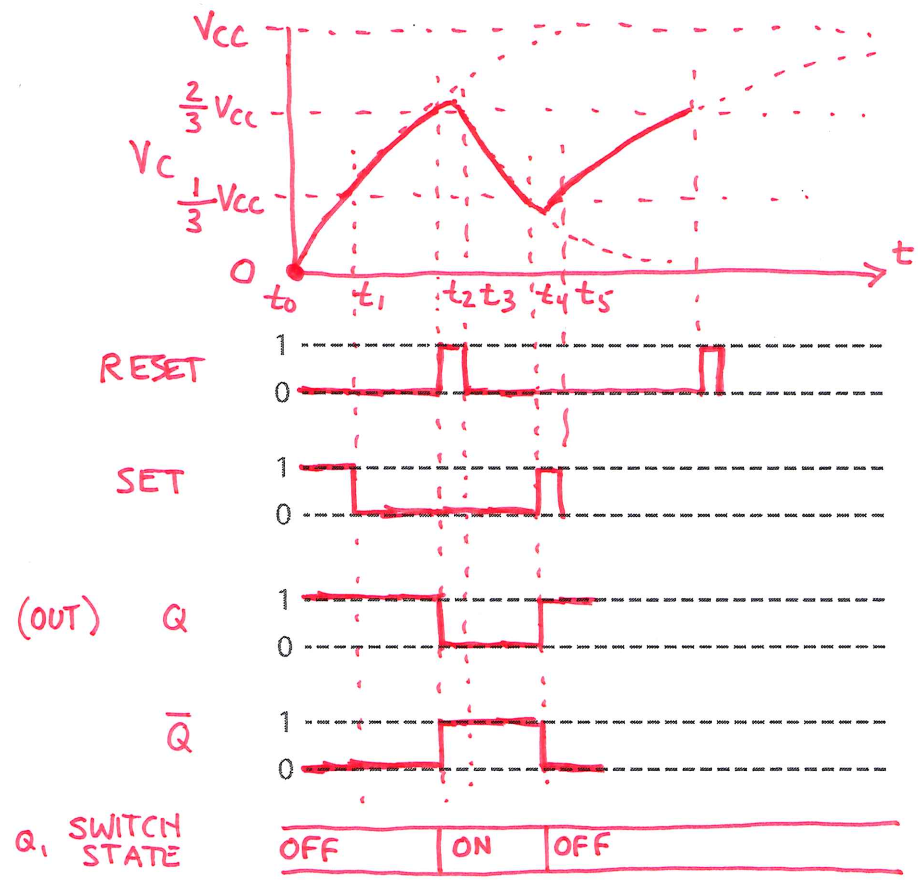



# Lab 4 Clock Circuit Timing




START ANALYSIS

$\underline{t=0}$ SHORT $V_C = 0V$

CP1 (RESET) = 0

CP2 (SET) = 1 → Q=1

SWITCH OFF

C CHARGES UP TOWARD $V_{CC}$

$\underline{t_1}$ $V_C > \frac{1}{3}V_{CC}$

CP2 → 0

$Q, \bar{Q}$ HOLD STATE

$\underline{t_2}$ $V_C > \frac{2}{3}V_{CC}$

CP1 (RESET) → 1

CP2 (SET) = 0

S-R FLIP FLOP CHANGES STATE

$Q=0$, $\bar{Q}=1$

SWITCH ON

C DISCHARGES THROUGH $R_B$ TOWARDS GND

$\underline{t_3}$ $V_C < \frac{2}{3}V_{CC}$

CP1 (RESET) → 0

$Q, \bar{Q}$ HOLD STATE

$\underline{t_4}$ $V_C < \frac{1}{3}V_{CC}$

CP2 (SET) → 1

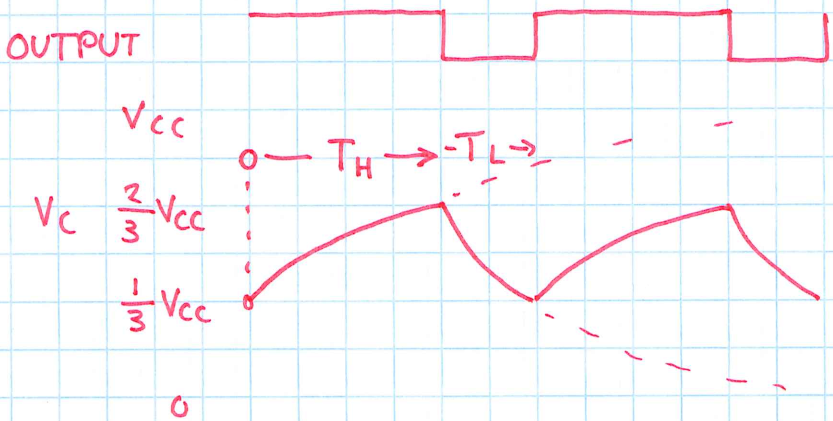
CHANGE STATE

$Q=1$, $\bar{Q}=0$

SWITCH OFF

CHARGES UP

$t_5$ $V_C > \frac{1}{3}V_{CC}$




RISING EXPONENTIAL

$$V(t) = \underbrace{V_F}_{V_{CC}} - \underbrace{(V_F - V_I)}_{V_{CC} - \frac{1}{3}V_{CC}} e^{-t/\underbrace{\tau}_{(R_A+R_B)C}}$$

AT $V(T_H) = \frac{2}{3} V_{CC}$: WITH THIS CONDITION

$$\frac{2}{3}\cancel{V_{CC}} = \cancel{V_{CC}} - \frac{2}{3}\cancel{V_{CC}}\, e^{-T_H/(R_A+R_B)C}$$

$V_{CC}$ CANCELS OUT! NICE!

$$\frac{-1}{3} = \frac{-2}{3} e^{-T_H/(R_A+R_B)C}$$

$$\frac{1}{2} = e^{-T_H/(R_A+R_B)C}$$

$$\ln\left(\frac{1}{2}\right) = \frac{-T_H}{(R_A+R_B)C}$$

$$\ln(2) = \frac{T_H}{(R_A+R_B)C}$$

$$T_H = \ln(2)(R_A+R_B)C$$

FOR ~~RISING~~ FALLING EXPONENTIAL

$$T_L = \ln(2) R_B C$$

TOTAL PERIOD $T = T_H + T_L = \ln 2 \, (R_A + 2R_B) C$

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

DUTY CYCLE

$$\delta = \frac{T_H}{T} = \frac{\cancel{\ln(2)}(R_A+R_B)\cancel{C}}{\cancel{\ln(2)}(R_A+2R_B)\cancel{C}} = \frac{R_A+R_B}{R_A+2R_B}$$