END SEMESTER EXAM SOLUTION

EE 230

Maximum Marks
43

Section - 1

working of the circuit $\boxed{2.5M}$

1.D. (i). As $V_{trig} < LTP$, R become 1 (SR LATCH Resets)

(ii). Q becomes 0 and Q_1 (BJT) turns OFF
$\overline{Q}$ becomes 1 which is V_{out}

(iii). Now C_1 (Capacitor) charges.

(iv). This will continue until $V_{c_1} \geq UTP$
now $S=1$
$R=0$

(v). Now for this $\overline{Q}=0=V_{out}$
$Q=1$ which turns on Q_1 (BJT)
and C_1 dis-charges

(vi). Now $S=0, R=0$ so Q & $\overline{Q}$ latches to 1, 0 respectively

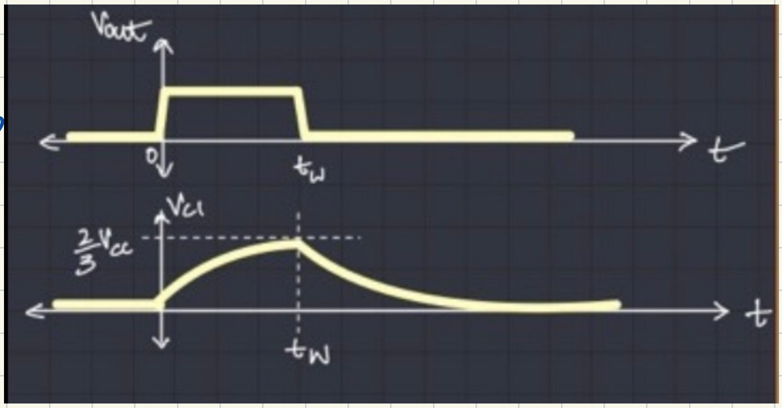
(vii) $V_{out}=0$ Which is the stable State of V_{out}.

Maximum Value of Trigger Voltage
$V_{LTP} = \frac{1}{3} V_{cc} = 3$ Volts. (1 M)

output waveforms (waveforms for derivation)

1.2).

Vout →



Vc →

} optional

derivation

Equation of 1st order RC circuit :

$$V_{C_1}(t) = V_{cc}\,(1 - e^{-t/\tau})\,; \quad \tau = R_1 \cdot C_1$$

$$\frac{2}{3} V_{cc} = V_{cc}\,(1 - e^{-t_W/\tau})$$

$$e^{-t_W/\tau} = 1/3$$

$$t_W = \ln 3 . \tau = 1.1\, R_1 C_1$$

2.5M

pulse width depends upon circuit Parameters

1.3). Table filling

Instantaneous Time	V_{trig}	S	R	Q	$\bar{Q}$	BJT (Q_1) (ON/OFF)	V_{C1} (Charging or Discharging)	V_{C1} (Voltage)	
0	V_{cc}	0	0	1	0	ON	Discharge	0	→ R1
0^+	0	0	1	0	1	OFF	charge	0	→ R2
t_W	V_{cc}	0	0	0	1	OFF	Charge	>0	→ R3
t_W^+	V_{cc}	1	0	1	0	ON	discharge	$\frac{2}{3} V_{cc}$	→ R4
$>t_W$	V_{cc}	0	0	1	0	ON	discharge	$<\frac{2}{3} V_{cc}$	→ R5

Each row carries 0.6M

0.6 × 5 = 3M

Section-2

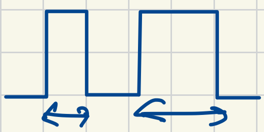
2.1). PWM generator

$PW_{min} \approx 1.5-2$ ms (1.25M)

$PW_{max} \approx 3-4$ ms (1.25M)

Showing the o/p to TA → (1.5M) ⟨just check for Max and Min Pulse width⟩

Example



2.2). derivation of Maximum & Minimum pulse width.

for PWM the circuit is same as monostable with UTP with extra signal added with DC

So ⇒ $V_{c_1}(t) = V_{cc}(1-e^{-t/\tau}) = UTP$

$$e^{-t/\tau} = 1 - \frac{UTP}{V_{cc}}$$

$$= 1 - \left(\frac{\frac{2}{3}V_{DD} + V_m(t)}{V_{cc}}\right)$$

$$e^{-t/\tau} = \frac{1}{3} + \left(\frac{V_m(t)}{V_{cc}}\right)$$

$$t_p = -\tau \ln\left(\frac{1}{3} + \frac{V_m(t)}{V_{cc}}\right)$$

1M

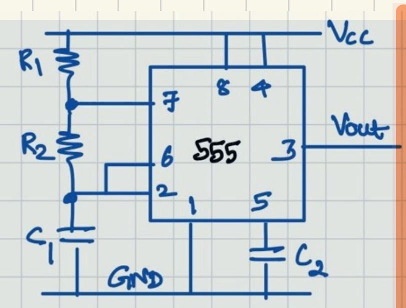
If $V_m(t) = A \sin \omega t$

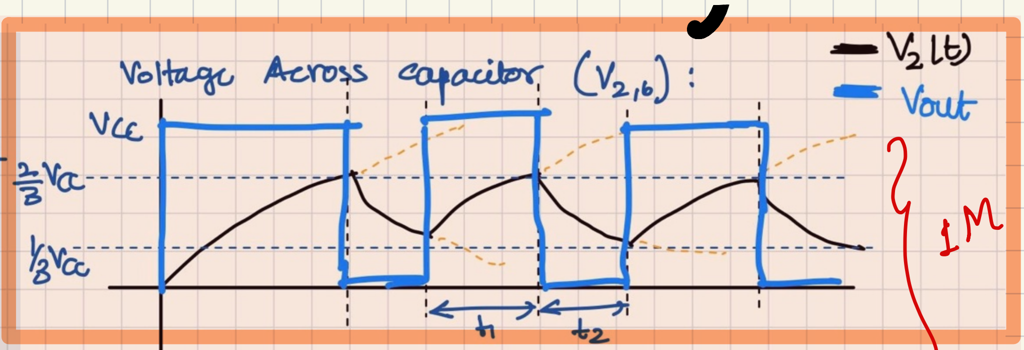
So Width max $= -\tau \ln\left(\frac{1}{3} - \frac{A}{V_{cc}}\right)$ (0.5M) $\tau = 2.2$ms

Width min $= -\tau \ln\left(\frac{1}{3} + \frac{A}{V_{cc}}\right)$ (0.5M) $W_{max} = 3.3$ ms, $W_{min} = 1.78$ ms

→ These will include discuss & compare part.

2.3). Astable Timer circuit





1M

Initial conditions

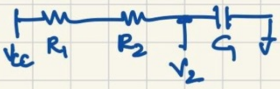
$Q=0$, $\bar{Q}=1$

↓ goes to BJT Base

↳ pin3

0.5M

1) From $\frac{1}{3}$Vcc it charges till $\frac{2}{3}$Vcc by the path <just skip on cycle>



$$V_2(t) = V_{final} + (V_{int} - V_{final})\, e^{-t/\tau_1}$$

where $\tau_1 = (R_1+R_2)C_1$

$V_{final} = V_{cc}$

$V_{int} = \frac{1}{3} V_{cc}$

$$V_2(t) = V_{cc} - \frac{2}{3} V_{cc}\, e^{-t/\tau_1}$$

1/2M

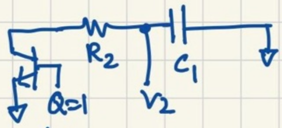
$$V_2(t_1) = V_{cc} - \frac{2}{3} V_{cc}\, e^{-t_1/\tau_1} = \frac{2}{3} V_{cc}$$

$$\Rightarrow \frac{2}{3} V_{cc}\, e^{-t_1/\tau_1} = \frac{1}{3} V_{cc}$$

$$\Rightarrow t_1 = \ln 2 \cdot (R_1+R_2) C_1$$

1/2M

2). From $\frac{2}{3}$Vcc it discharges till $\frac{1}{3}$Vcc by the path



$$V_2(t) = V_{final} + (V_{int} - V_{final})\, e^{-t/\tau_2}$$

where $\tau_2 = R_2 C_1$

$V_{final} = 0$

$V_{int} = \frac{2}{3} V_{cc}$

$$\therefore V_2(t) = \frac{2}{3} V_{cc}\, e^{-t/\tau_2}$$

1/2M

$$@ t_2 \Rightarrow V_2(t_2) = \frac{2}{3} V_{cc}\, e^{-t_2/\tau_2} = \frac{1}{3} V_{cc}$$

$$\Rightarrow t_2 = \ln 2 \cdot R_2 C_1$$

$$\text{Time period} = t_1 + t_2 = \ln 2 \cdot (R_1 + 2R_2) \cdot C_1 = 0.693\,(R_1+2R_2) \cdot C_1$$

$$f_{out} = \frac{1.44}{(R_1+2R_2) \cdot C_1}$$

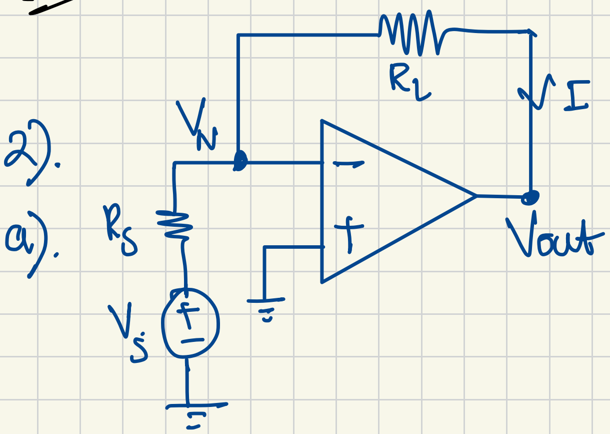
2M

Section → 3 → IC Testing (1M)

4.1).

By Virtual Ground

2). a).



$$\left.\begin{aligned} I &= \frac{V_S - V_N}{R_S} \\ I &= \frac{V_N - V_{out}}{R_L} \end{aligned}\right\}$$

$$I = \frac{V_S}{R_S} = -\frac{V_{out}}{R_L}$$

$$\boxed{I = \frac{V_S}{R_S}}$$

1M

Clearly I depends on V_S, R_S and V_{out} will vary according to R_L to leve constant current until the op-Amp will saturates. 1M

2). b).

$$|Gain| = \left|\frac{V_{out}}{V_{in}}\right| = \frac{R_L}{R_S}$$

For the op-Amp not to be in Saturation $\Big\}$ $|V_{out}| < V_{SAT}$

$$\frac{R_L}{R_S} \times |V_{in}| < V_{SAT}$$

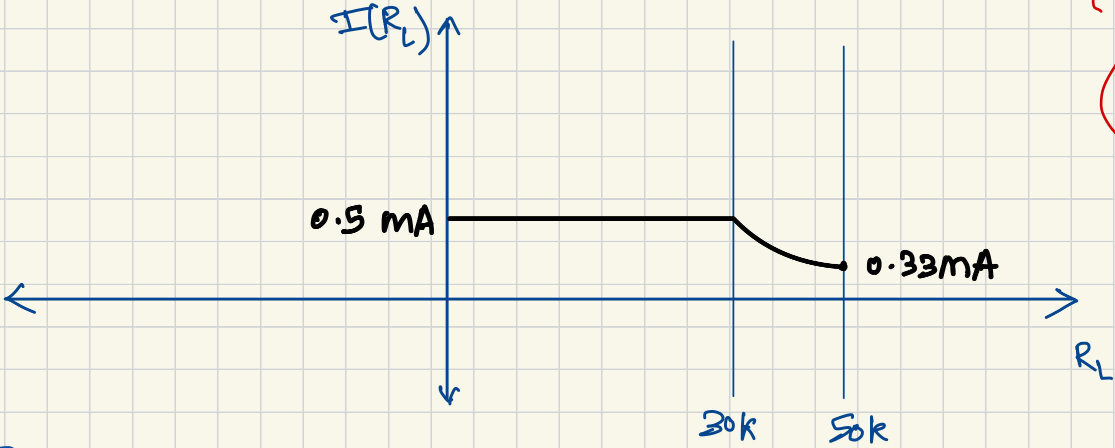
$$R_L < \frac{V_{SAT} \times R_S}{|V_{in}|} = \frac{15 \times 10k}{5}$$

$$R_L < 30k\Omega$$

$$I(R_L) = \begin{cases} \dfrac{V_S}{R_S} & \text{for } R_L < 30k\Omega \\[2ex] \dfrac{V_S + V_{SAT}}{R_S + R_L} & \text{for } R_L \geq 30k\Omega \end{cases}$$

0.5 M

$R_s = 10k\Omega$ $\quad V_s = 5V$



1.5M with all labelling

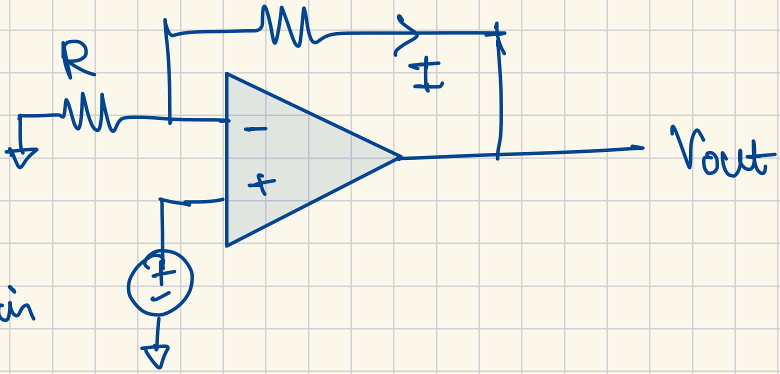
(E) Bread Board Implementation (2M)

↳ Reporting RL Value

Hardware

4(2).

a)



3M

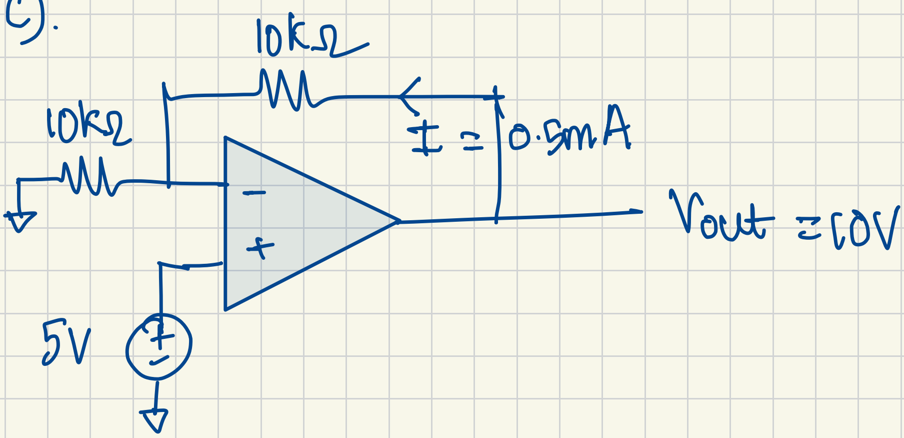
b). $I = 0.5mA$

$$\frac{V_{out}}{V_{in}} = 1 + \frac{R}{R} = 2$$

$$\frac{V_{in}}{R} = \frac{5}{0.5mA} = R \Rightarrow 10k\Omega \quad (R > 10k\Omega)$$

Any value

c).

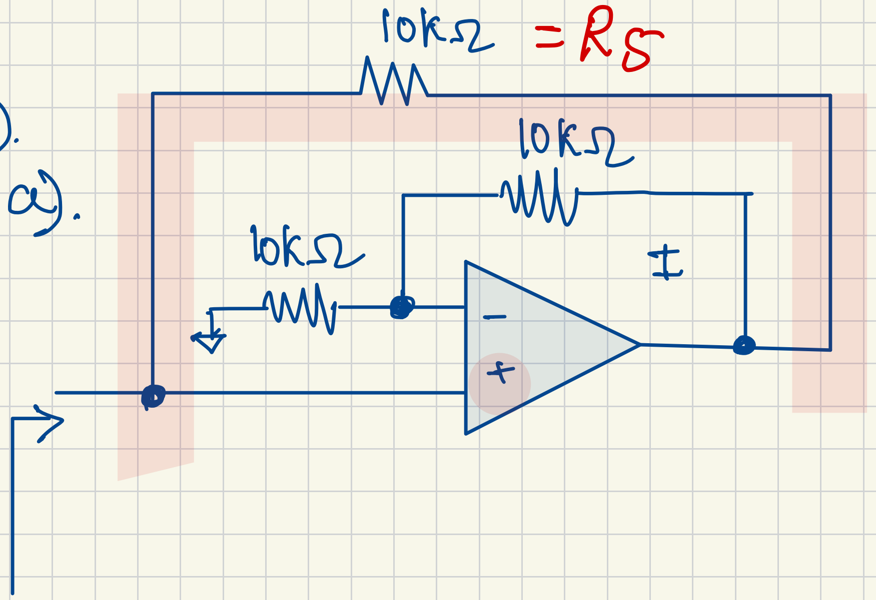


2M : diagram + Values

d) Showing Result to TA :- gain :- 2 $\quad$ 2M

2).

a).

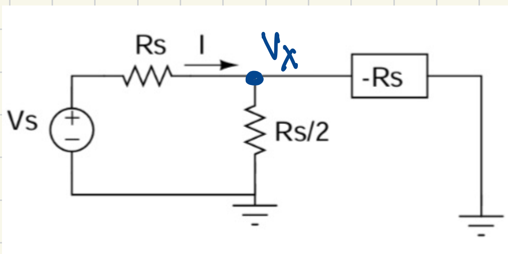


$R_{in} = -10\,k\Omega$

2M

- Rs circuit

b).



$V_x = V_s/2$

$I = \dfrac{V_s}{2R_s}$

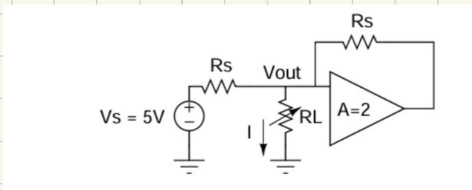
2M

(c) Breadboard Implementation

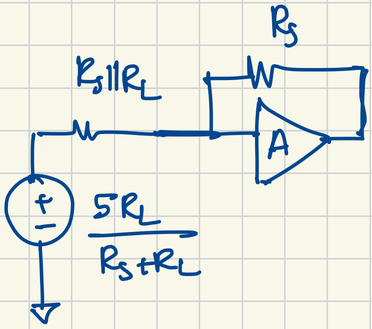
→ Verifying the current (TA) → 2M

3).

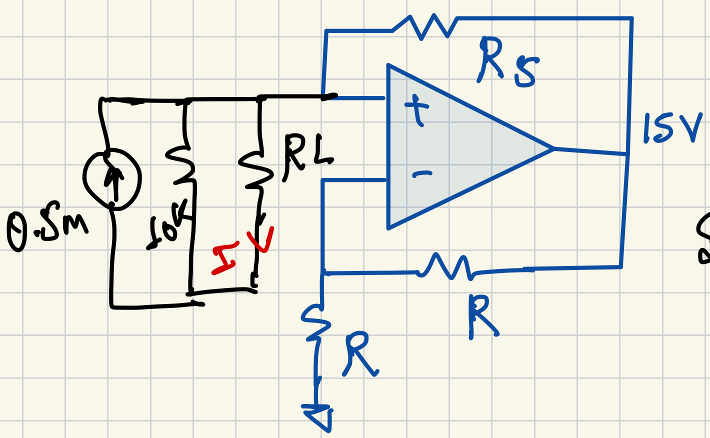
a).



⇒



Since $V_{cc} = \pm 15$ Volt

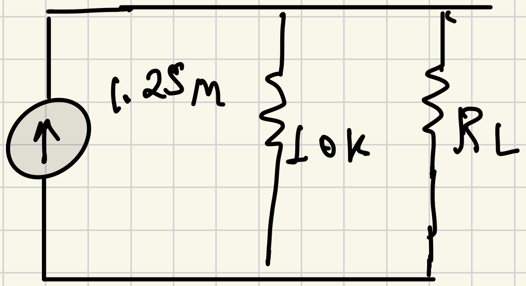


$V- \Rightarrow \frac{15}{2} = 7.5\,V$

$V- = V+ = 7.5\ V$

So $I =$ constant $= \frac{V}{R_L}$

$I_{10K} = \frac{7.5}{10} = 0.75\,mA$



7.5V ($V^- = V^+$) For Limiting Value of R_L

$I_{R_L} = 0.5m \Rightarrow \frac{10K}{10K + R_L} \times 1.25$

Solving $\boxed{R_L = 15K}$ (3M)