EE 230
Lab-2

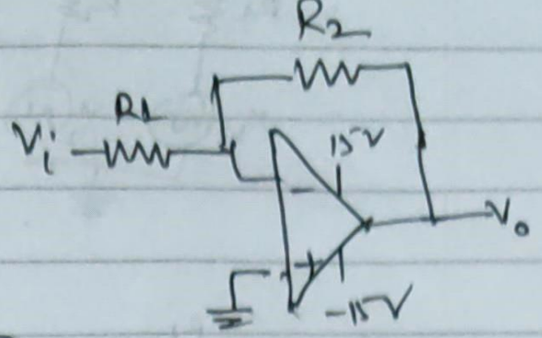
12/01/24

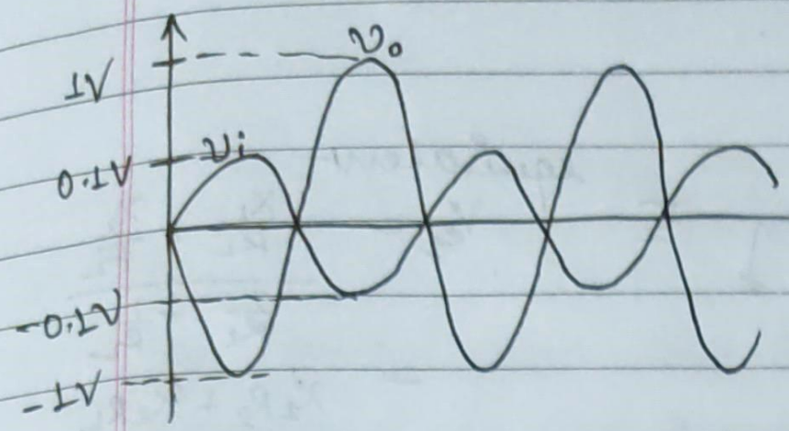
Date
Page

Ques 1

(a) i. $R_1 = 1K\Omega$

$R_2 = 10K\Omega$

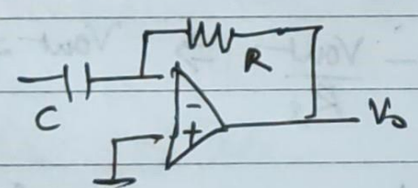




V_o is phase shifted by 180° and scaled by 11 times ideally.
actual Gain = 10.

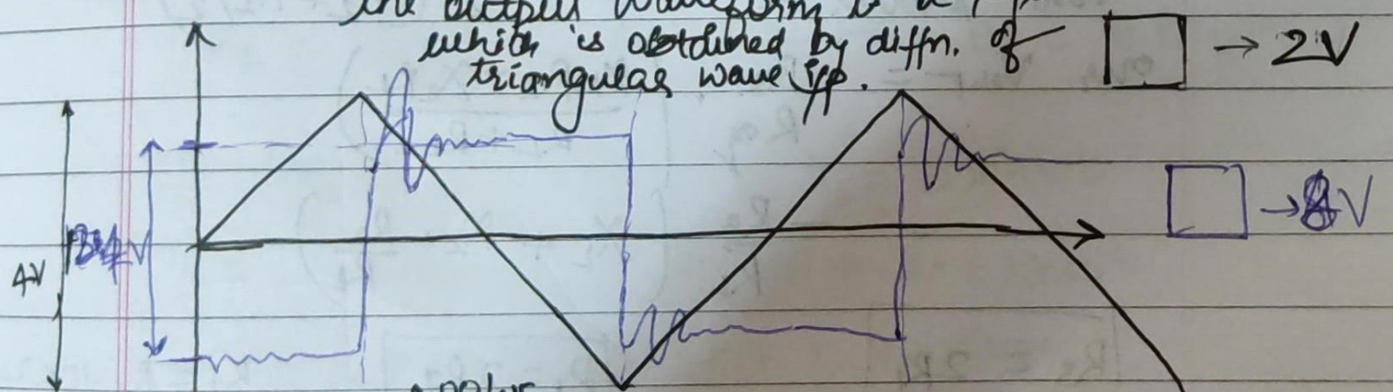
(ii) As the voltage input increases; Volt. out. increases accordingly. But after reaching out to a input value of $1.6V_{pp}$ the output starts clipping; bcuz for $1.6V_{pp}$ input; output should be 16V but it's greater than the V_{DD} value of +15V, hence it gets clipped.

(b) (i)

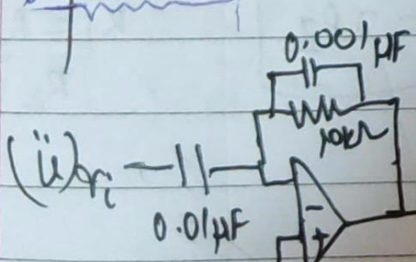


$R = 10K\Omega$ $C = 0.01\mu F$

the output waveform is a square wave; which is obtained by diffn. of triangular wave i/p.



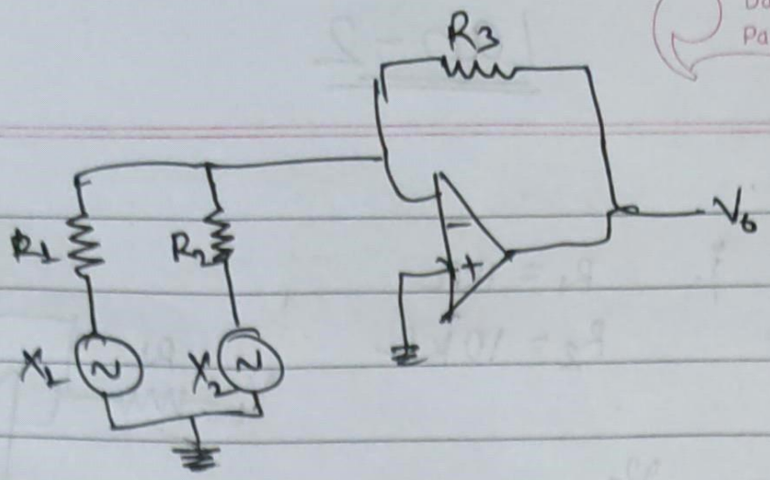
(ii)

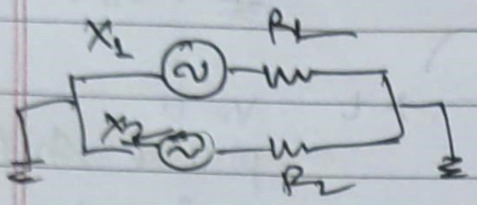


The capacitor connected in parallel with the resistor stores the extra charge and hence dampens the noise effectively.

The pk to pk Vout comes down to 5.8V

(c)

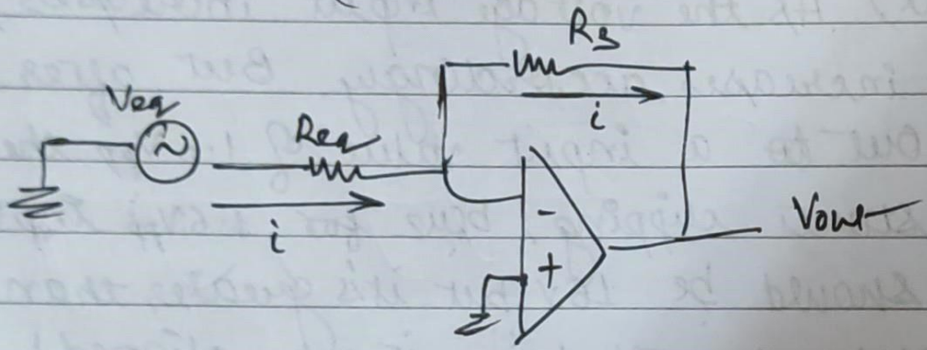




$\equiv$ equivalent

$$V_{eq} = \frac{\frac{X_1}{R_1} + \frac{X_2}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{X_1 R_2 + X_2 R_1}{R_1 + R_2}$$

equivalent $R_{eq} = \left(\frac{R_1 R_2}{R_1 + R_2}\right)$



using Kirchoff's law;

$$\frac{V_{eq}}{R_{eq}} = -\frac{V_{out}}{R_3} \Rightarrow V_{out} = -\frac{R_3}{R_{eq}} \cdot V_{eq}$$

Vout should be $= -2(X_2 + X_1/2)$

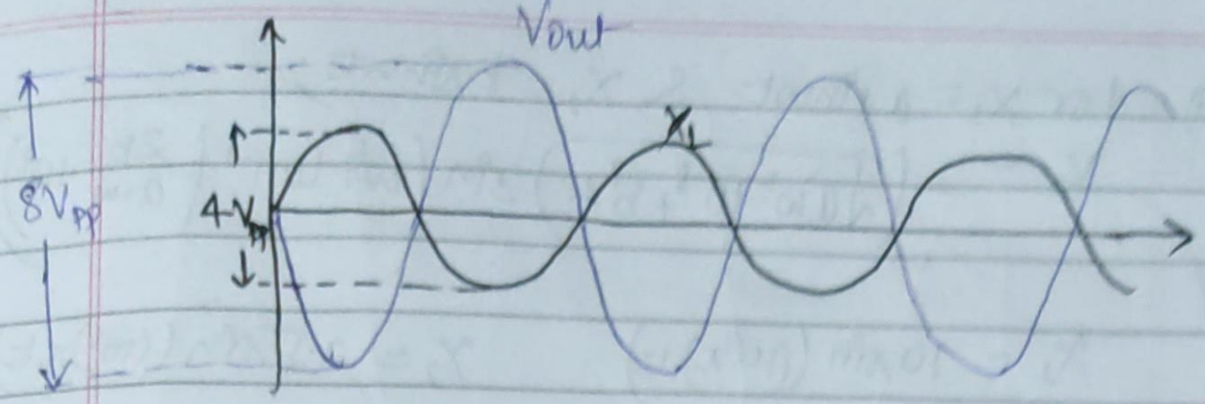
our $V_{out} = -\frac{R_3}{R_{eq}} \cdot \left(\frac{X_1 R_2 + X_2 R_1}{R_1 + R_2}\right)$

$$= -\frac{R_3}{R_1}\left(X_1 + X_2 \cdot \frac{R_2}{R_1}\right)$$

$\boxed{R_3 = 2R_1}$ $\boxed{R_4 = 2R_2}$ $\boxed{R_4 = R_3}$

$R_1 = R_3 = 10K\Omega$

$R_2 = 5K\Omega$



$X_1 = 4V_{pp}$ $\quad X_2 = 2V_{pp}$

$V_{out} = -2(2 + 4/2) = -8$ Volts

as expected from calculations the output voltage is twice of X_1 and phase shifted by 180°.

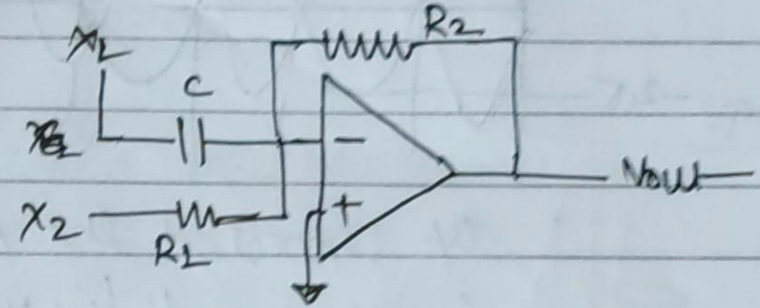
(d) Equation solver:

(i)

$$V_o = -\left(0.0001 \frac{d}{dt} X_1 + 2X_2\right)$$

$$\frac{V_{out}}{X_2} = -\frac{R_2}{R_1} = -\frac{1}{2}$$

$R_2 = 2R_1$



$R_1 C_1 = 10^{-4}$ sec.

$R_1 = 10K\Omega$ $\quad R_2 = 20K\Omega$ $\quad C_1 = 0.01\mu F$

(ii) $X_1 = a \sin\omega t$ $\quad X_2 = b \sin\omega t$

$$V_o = -\left(0.0001 \frac{d}{dt}(a \sin\omega t) + 2 * b \sin\omega t\right)$$

$$= -\left(a \cdot \omega \cdot 10^{-4} \cos\omega t + 2b \sin\omega t\right)$$

$$= -\left(\sqrt{a^2\omega^2 10^{-8} + 4b^2}\right) \sin\left(\omega t + \tan^{-1}\left(\frac{2b}{a\omega 10^{-4}}\right)\right)$$

(iii) for $X_1 = a\sin\omega t$ & $X_2 = b\sin\omega t$;

$$V_o = -\left(\sqrt{a^2\omega^2 10^8 + b^2 4}\right)\sin\left(\omega t + \tan^{-1}\left(\frac{2b}{a\cdot\omega}\cdot 10^4\right)\right)$$

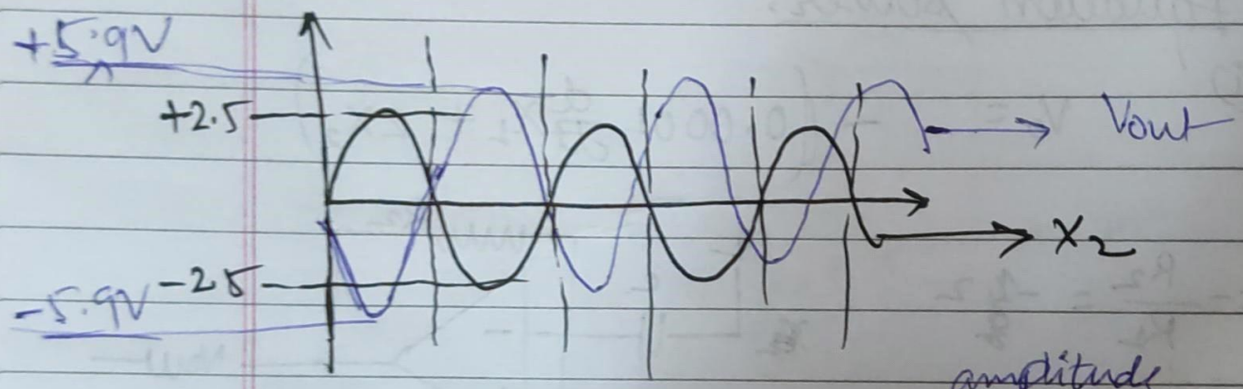
$X_1 = 10\sin((10^3\pi)t)$ $\quad X_2 = 2.5\sin((10^3)\pi t)$

$\omega = 10^3\pi$ $\quad a = 10$ $\quad b = 2.5$

$$V_o = -\left(\sqrt{10^8\cdot 10^{-6}\pi^2 + 4\times 6.25}\right)\sin\left(10^3\pi t + \tan^{-1}\left(\frac{5}{10^3\pi}\times 10^4\right)\right)$$

$$= -\left(\sqrt{26}\right)\sin(1000\pi t + 3.65)$$

$$= -5.9\sin(2\pi\times 500\,t + 0.304),$$

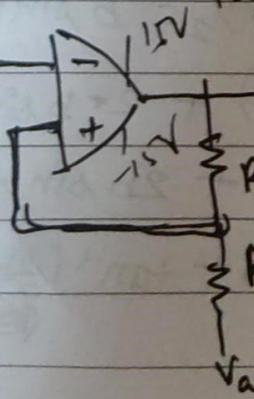


amplitude

As expected the output is 5.9 Volts and is inverted and further phase shifted by 0.3 radians

Ques2 (a) Schmitt Trigger Ckt.

(i)



$$\frac{V_o - V_{in}}{R_1} = \frac{V_{in} - V_a}{R_2}$$

$V_a = 0$ (given)

$$\frac{V_o - V_{in}}{R_1} = \frac{V_{in}}{R_2}$$

$$V_o = R_1\left(V_{in}\left(\frac{1}{R_2} + \frac{1}{R_2}\right)\right)$$

$V_{TH}(UTL) = 2.5V$ $\quad V_{TH}(LTL) = -2.7V$

$$V_o = V_{in}\, R_1\left(\frac{1}{R_2} + \frac{1}{R_1}\right)$$

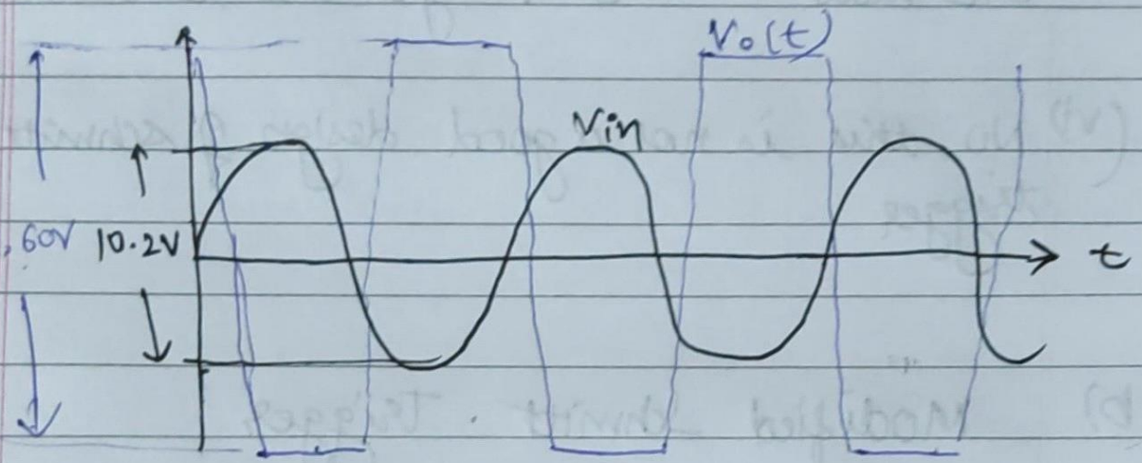
$$15V = (2.5V)\left(1 + \frac{R_2}{R_1}\right)$$

$$5 = \frac{R_1}{R_2}$$

$$R_1 = 5R_2$$

$R_2 = 1K\Omega \quad R_1 = 5K\Omega$

(ii)



(iii) Observed threshold voltage comes out to be $\pm 2.7V$.

(iv) $$\frac{V_o - V_{in}}{5K\Omega} = \frac{V_{in} - 2V}{1K\Omega} \Rightarrow V_o = 5\left(V_{in}\left(1+\frac{1}{5}\right) - 2\right)$$

$$\boxed{V_o = 6V_{in} - 10}$$

$V_o = 15V$

$15V = 6V_{in} - 10$

$V_{in} = 25/6\,V$

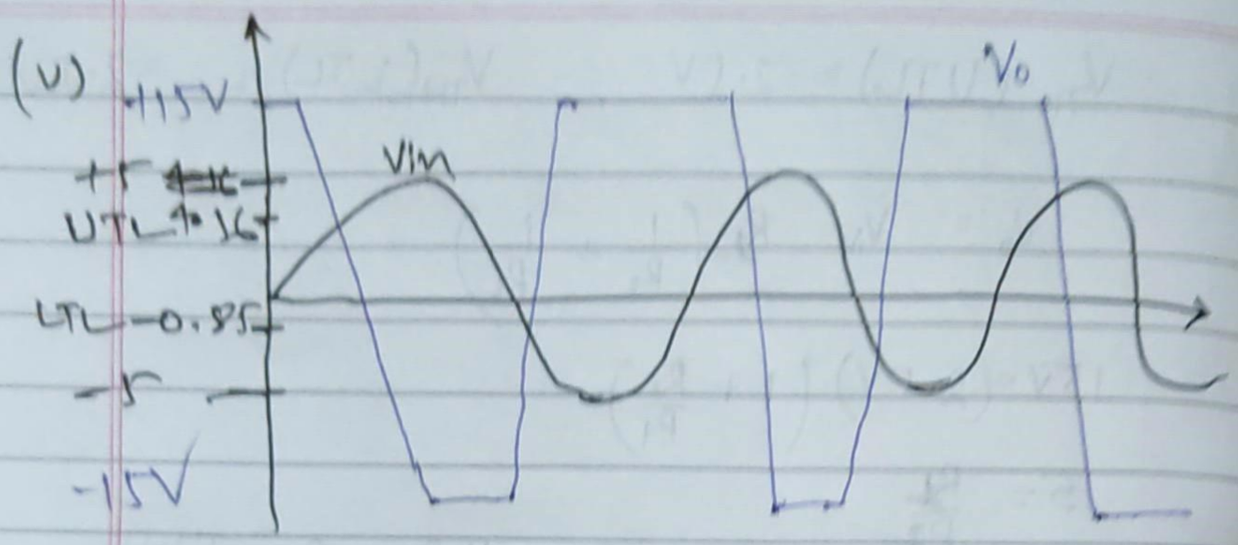
$= 4.166V$

$-15V = 6V_{in} - 10$

$V_{in} = -5/6\,V$

$= -0.85V$

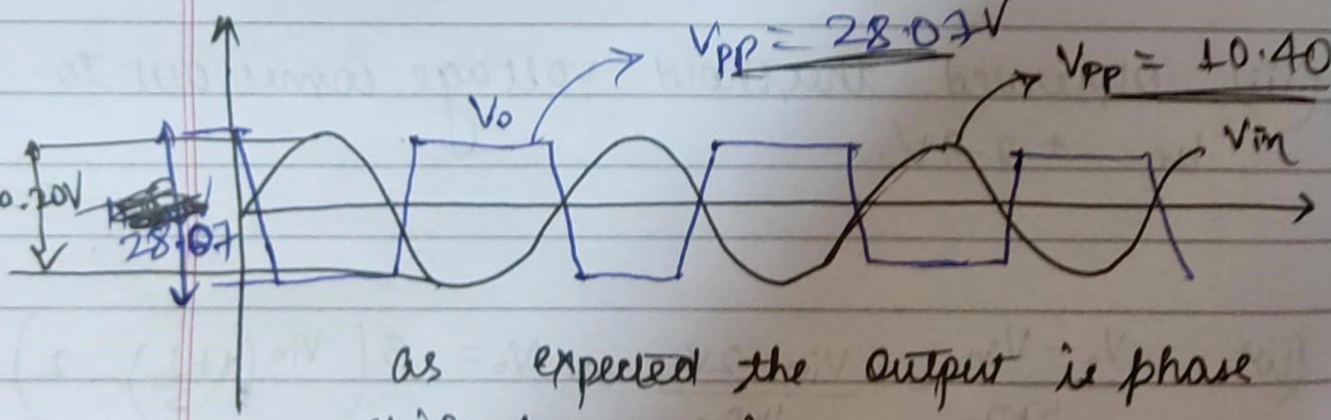
(v)



the observed UTL value → 4.16 V &
LTL value → −0.85 V agree with our calculations

(vi) NO, this is not a good design of schmitt trigger

(b) Modified Schmitt Trigger



as expected the output is phase shifted by 180°.

observed $V_{TH} = +3.2V$ $V_{TL} = -3V$

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12/01/24