1

PROBLEMS

1- Consider the circuit of Fig. 3(a) with R_f removed so as to realize the comparator function. Find suitable values for all resistors so that the comparator output levels are ±6 V and so that the slope of the limiting characteristic is 0.1. Use power supply voltages of ± 10 V and assume the voltage drop of a conducting diode to be 0.7 V.

$V_R = 10V$

Slope = 0.1

$V_o = 6V$

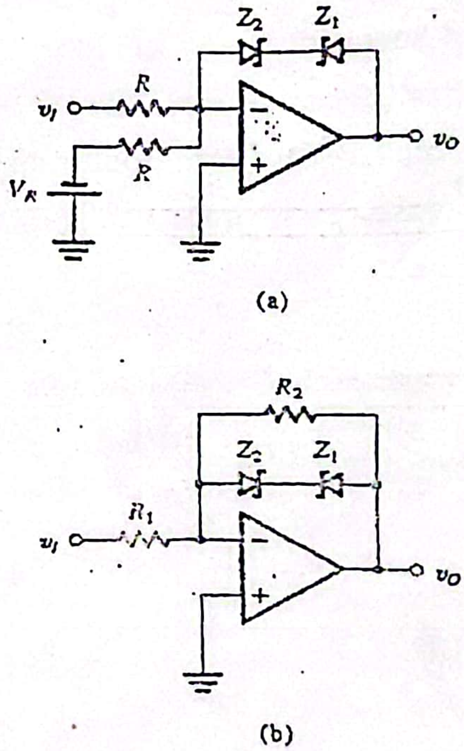


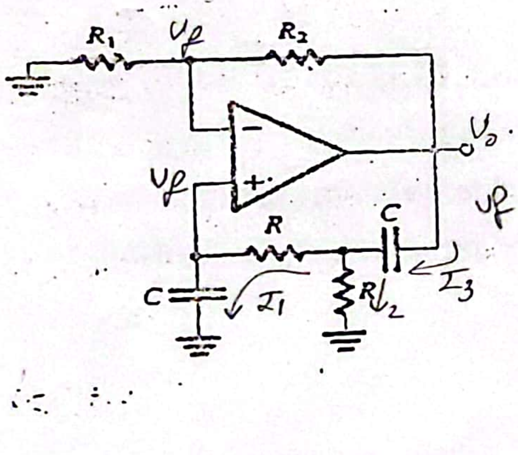
Fig. P2

2- Denoting the zener voltages of Zi and Z_2 by V_{Z1} and V_{Z2} and assuming that in the forward direction the voltage drop is approximately 0.7 V, sketch and clearly label the transfer characteristics *vo-v*, of the circuits in Fig. P12.8. Assume the op amps to be ideal.

3-For the Wien-bridge oscillator circuit in Fig. 4, show that the transfer function of the feedback network *[$V_a(s) / V_0(s)$]* is that of a bandpass filter. Find W_0 and *Q* of the poles, and find the center-frequency gain.

4-For the Wien-bridge oscillator of Fig. 4, let the closed-loop amplifier (formed by the op amp and the resistors R_1 and R_2) exhibit a phase shift of -0.1 rad in the neighborhood of $W = 1/CR$. Find the frequency at which oscillations can occur in this case, in terms of *CR*.

5- For the circuit in Fig. P5 find *L(s), L(jw)*, the frequency for zero loop-phase, and *R2/R1* for oscillation.



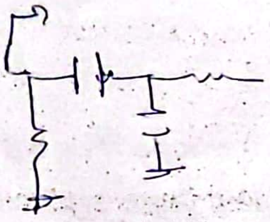
$V_o = (1+\frac{R_2}{R_1}) V_f$

وهكذا

اجيب علاقة ل V_o بدلالة V_f

Fig. P5

③.



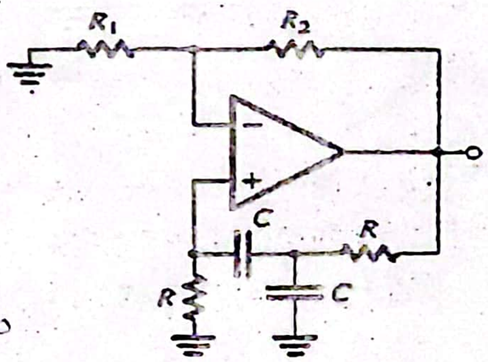


Fig. P5

6- Redesign the circuit of Fig. 6 for operation at 10 kHz using the same values of resistance. If at 10 kHz the op amp provides an excess phase shift (lag) of 5.7°, what will be the frequency of oscillation? (Assume that the phase shift introduced by the op amp remains constant for frequencies around 10 kHz.) To restore operation to 10 kHz, what change must be made in the shunt resistor of the Wien bridge? Also, to what must R_2/R_1 be changed? "

7- For the circuit of Fig. P7, connect an additional $R = 10\ k\Omega$ resistor in series with the rightmost capacitor C. For this modification (and ignoring the amplitude stabilization circuitry) find the loop gain $A\beta$ by breaking the circuit at node X. Find R_f for oscillation to begin, and find f_0

(4)

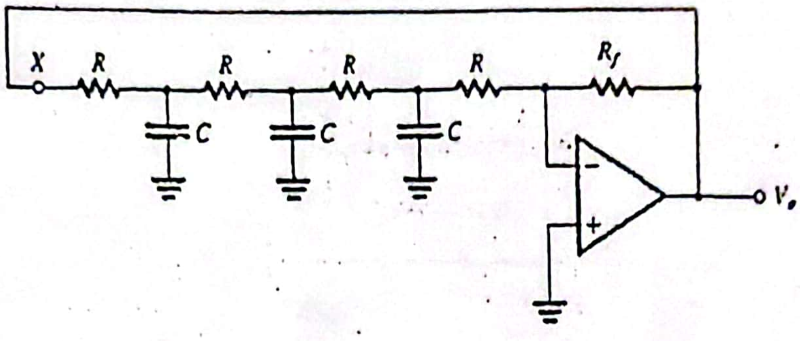
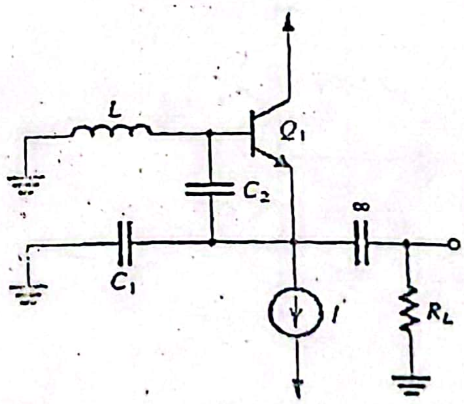


Fig. P7

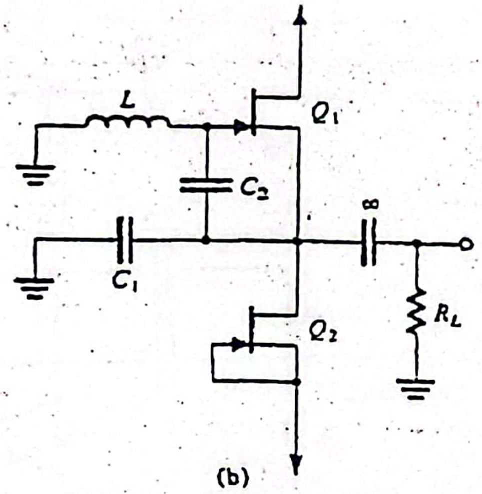
8- Figure P8 shows four oscillator circuits of the Colpitis type, complete with bias detail. For each circuit derive an equation governing circuit operation, and find the frequency of oscillation and the gain condition that ensures that oscillations start.

↳ $A\beta=1$

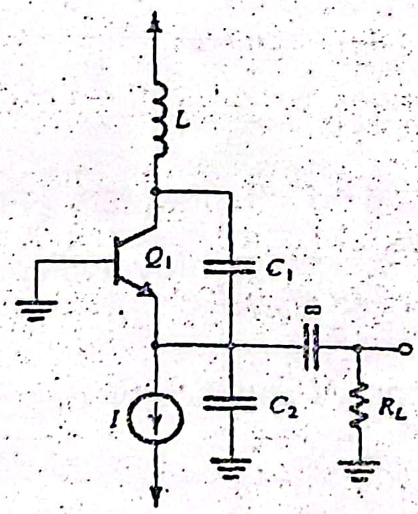


(a)

5

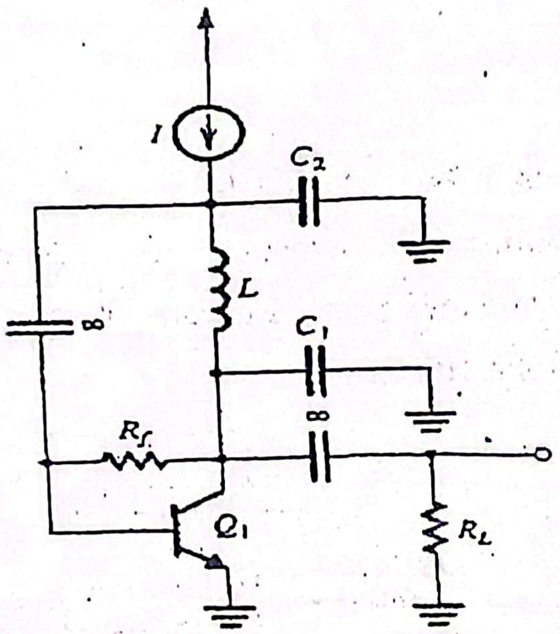


(b)



(c)

6



(Assume $R_f >> \omega_0 L_t$)

(d)

Fig. P8

Stop

9-Consider the bistable circuit of Fig. 13(a) with the op amp's positive input terminal connected to a positive voltage source V through a resistor R_3.

(a) Derive expressions for the threshold voltages V_{TL} and V_{TH} in terms of the op amp's saturation levels L+ and L−, R_1, R_2, R_3, and V.

(b) Let $L_+ = -L_- = 13$ V, V = 15 V and $R_1 = 10$ kΩ. Find the values of R_2 and R_3 that result in $V_{TL} = +4.9$ V and $V_{TH} = +5.1$ V.

10-Consider the bistable circuit of Fig. 14(a) with the op amp's negative input terminal disconnected from ground and connected to a reference voltage V_R.

(a) Derive expressions for the threshold voltages V_{TL} and V_{TH} in terms of the op amp's saturation levels $L+$ and L− R_1, R_2, and V_R.

7

(b) Let $L_+ = -L_- = V$ and $R_1 = 10\ k\Omega$. Find R_2 and V_R that result in threshold voltages of 0 and V/10.

11-For the circuit in Fig. P11; sketch and label the transfer characteristic v_O-v_I. The diodes are assumed to have a constant 0.7-V drop when conducting, and the op amp saturates at ±12 V. What is the maximum diode current?

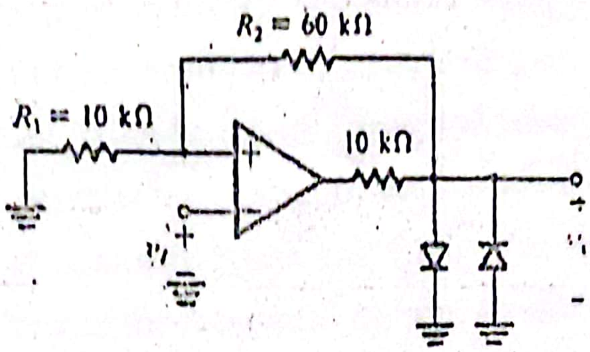


Fig. P11

11-Consider the circuit of Fig. P11 with R_1 eliminated and R_2 short circuited. Sketch and label the transfer characteristic v_O-v_I Assume that the diodes have a constant 0.7-V drop when conducting and that the op amp saturates at ± 12 V.

12-Consider a bistable circuit having a noninverting transfer characteristic with $L_+ = L_- = 12$ V, $V_{TL} = -1$ V, and $V_{TH} = +1$ V.

(a) For a 0.5-V-amplitude sine-wave input having zero average, what is the output?

(b) Describe the output if a sinusoid of frequency f and amplitude of 1.1 V is applied at the input. By how much can the average of this sinusoidal input shift before the output becomes a constant value?

13-Find the frequency of oscillation of the circuit in Fig. 15(b) for the case R_1 = 10 kΩ. R_2 = 16kΩ, C = 10 nF, and R = 62 kΩ.

14-The circuit of Fig. P14 consists of an inverting bistable multivibrator with an output limiter and a noninverting integrator. Using equal values for all resistors except R-, and a 0.5-nF capacitor, design the circuit to obtain a square wave at the output of the bistable multivibrator of 15-V peak-to-peak amplitude and 10-kHz frequency. Sketch and label the waveform at the integrator output. Assuming ±13-V op amp saturation levels, design for a minimum zener current of 1 mA. Specify the zener voltage required, and give the values of all resistors.

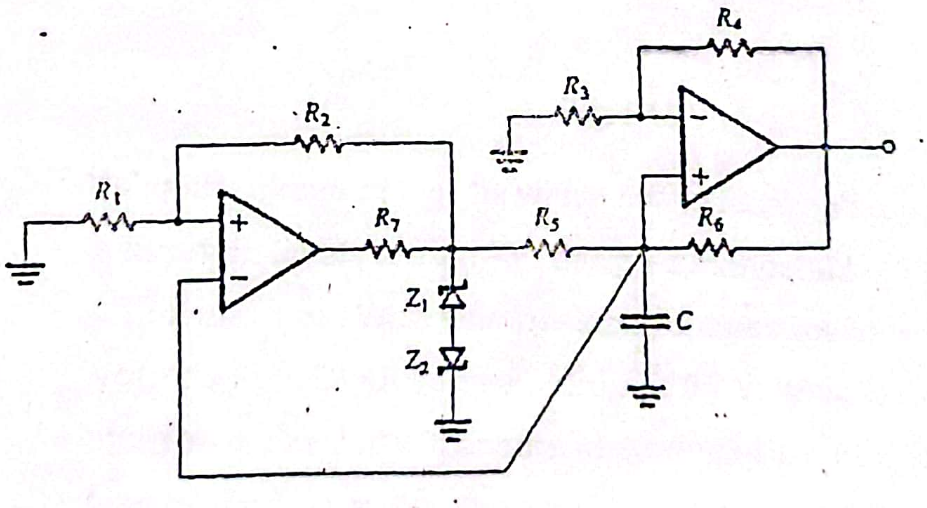


Fig.P14

9

15-Figure Pi5 shows a monostable multivibrator circuit. In the stable stat $v_O = L+$, v_A — 0, and $v_B = -V_{ref}$. The circuit can be triggered by applying a positive input pulse of height greater than V_{ref}. For normal operation, $C_1R_1 << CR$. Show the resulting waveforms of v_O and v_A. Also, show that the pulse generated at the output will have a width T given by

$$T = RC\ \ln(L+ \ - L-)/V_{ref}$$

Note that this circuit has the interesting property that the pulse Width can be controlled by changing V_{ref}.

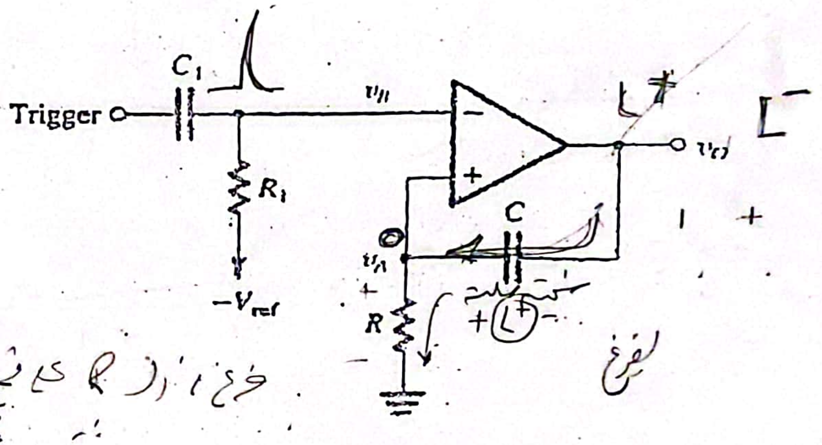


Fig. P15

16-Using the circuit of Fig. 19, with a nearly ideal op amp for which the saturation levels are ± 13 V, design a monostable multivibrator to 0.1 nF and 1 nF. Wherever possible, choose resistors of 100 left in your design. Diodes have a drop of 0.7 V. What is the minimum input step size that will ensure triggering? How long does the circuit take to recover to a state in which retriggering is possible with a normal output?

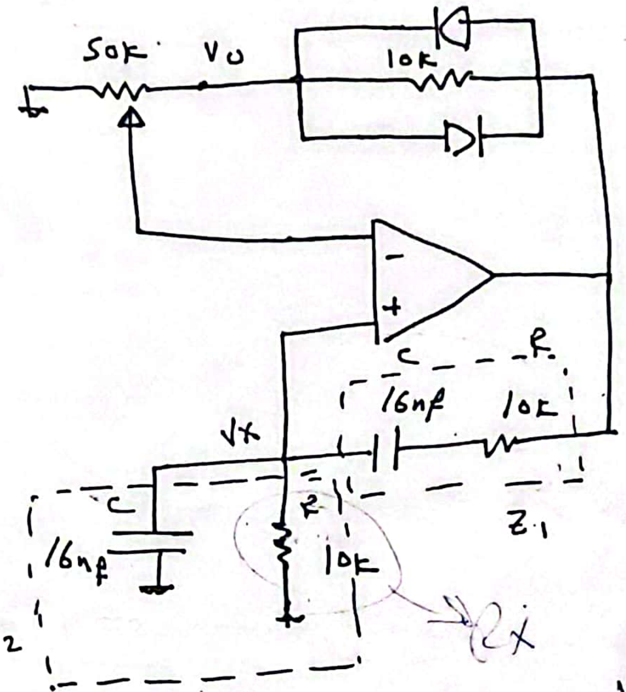
W_1

[illegible]

* analog

sheet oscillators

P. 6 :



Wien bridge oscillator

$$f_o = 10\,kHz = 10^4\,Hz$$

$$\omega_o = 2\pi f_o = \frac{1}{RC} \quad , \quad R = 10\,k\Omega = 10^4\,\Omega$$

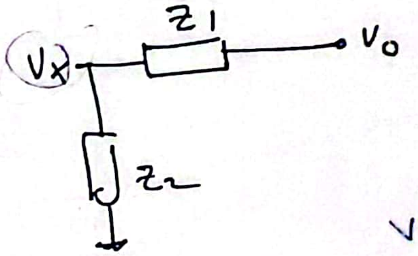
$$\Rightarrow \quad 2\pi \times 10^4 = \frac{1}{10^4 \times C}$$

$$C = \frac{1}{2\pi \times 10^8} = \underline{1.6\,nf}$$

$$\Rightarrow \quad \boxed{\begin{array}{l} f = 10\,kHz \\ , C = 1.6\,nf \end{array}}$$

$$Z_1 = R + \frac{1}{sC} = \frac{RsC + 1}{sC}$$

$$Z_2 = \frac{R \cdot \frac{1}{sC}}{R + \frac{1}{sC}} = \frac{R}{1 + sCR}$$



$$V_x = \frac{V_o \; Z_2}{Z_1 + Z_2}$$

$$\frac{V_x}{V_o} = \beta = \frac{Z_2}{Z_1 + Z_2}$$

$$\beta = \frac{V_f}{V_J}$$

$$1/\beta = \frac{Z_1 + Z_2}{Z_2} = 1 + \frac{Z_1}{Z_2}$$

$$= 1 + \frac{\frac{sCR + 1}{sC}}{\frac{R}{sCR + 1}} =$$

$$= 1 + \frac{(sCR + 1)^2}{sCR}$$

$$= 1 + \frac{s^2C^2R^2 + 2sCR + 1}{sCR}$$

$$= 1 + sCR + 2 + \frac{1}{sCR}$$

$$= 3 + sCR + \frac{1}{sCR}$$

$\frac{4}{3}$

$$\beta = \left[3 + sCR + \frac{1}{sCR}\right]^{-1}$$

$$\beta(j\omega) = \left[3 + j\omega CR + \frac{1}{j\omega CR}\right]^{-1}$$

$$\beta(j\omega) = \left[3 + j\left(\omega CR - \frac{1}{\omega CR}\right)\right]^{-1}$$

$$\phi(\omega) = -\tan^{-1}\left(\frac{\omega CR - \frac{1}{\omega CR}}{3}\right)$$

imag part

real part

سالب لقيمة في المقام
$\left(\beta = \frac{1}{3+j\ldots}\right)$

قانون رياضيات

$$\frac{\partial \tan^{-1} y}{\partial \omega} = \frac{1}{1+y^2}\,\frac{\partial y}{\partial \omega}$$

Four Brothers 4B

Bihe

$$y = \frac{\omega CR - \frac{1}{\omega CR}}{3}$$

$$\frac{\partial y}{\partial \omega} = \frac{RC + \frac{1}{\omega^2 RC}}{3}$$

$$\therefore \boxed{\frac{\partial \phi(\omega)}{\partial \omega}} = -\frac{\partial \tan^{-1} y}{\partial \omega} = \frac{-1}{1+y^2}\,\frac{\partial y}{\partial \omega}$$

~~W4~~

$$\therefore \frac{\partial \varphi(\omega)}{\partial \omega} = \frac{-1}{1+\left(\frac{\omega CR - \frac{1}{\omega CR}}{3}\right)^2} \cdot \left(\frac{RC + \frac{1}{\omega^2 RC}}{3}\right)$$

at $\omega = \omega_0 = \frac{1}{RC}$

$$\therefore \frac{\partial \varphi(\omega)}{\partial \omega} = \frac{-1}{1+\left(\frac{1-1}{3}\right)^2} \cdot \frac{RC + \frac{1}{\frac{1}{R^2C^2}\cdot RC}}{3}$$

$$\boxed{\frac{\partial \varphi(\omega)}{\partial \omega} = \boxed{-\frac{2}{3} RC}}$$

$$\partial \varphi = \underline{5.7^\circ} = \frac{5.7 * \pi}{180} = \boxed{0.1 \text{ rad}}$$

(lag)

$$\therefore \Delta\omega = \Delta\omega_0 = \frac{\Delta\varphi}{-2/3\, RC} = \frac{\pm 0.1}{-2/3\, RC}$$

$$= 0.15 \frac{1}{RC} = 0.15\, \omega_0$$

at $\omega_0 = 2\pi f_0 = 2\pi * 10^4$ Hz

$$\Delta\omega_0 = 0.15\, \omega_0 = 0.15 * 2\pi * 10^4 =$$

$$= 9.4 \text{ KHz}$$

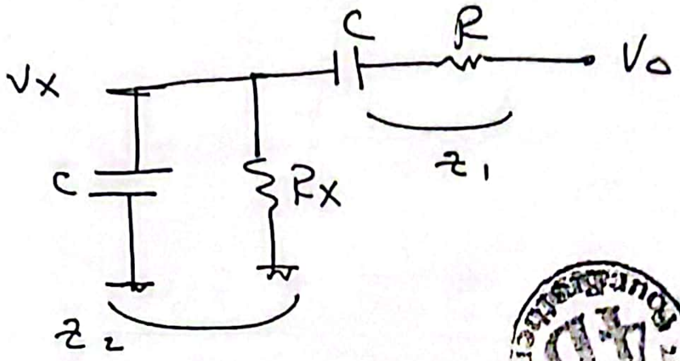
Then the new frequenuly of oscillation

is $\omega_0 - \Delta\omega_0 = 10 - 9.81$ $\div 2\pi$ الرقم ٥١ $\boxed{8.5 \text{KHz}}$

$$= 0.6 \text{ KHz} = 600 \text{ Hz}$$

ws

To restore operation at 10 kHz



$$\frac{V_o \, Z_2}{Z_1+Z_2} = V_x$$

$$\beta = \frac{V_x}{V_o} = \frac{Z_2}{Z_1+Z_2} = \frac{\dfrac{R_x \frac{1}{sC}}{R_x+\frac{1}{sC}}}{R+\frac{1}{sC} + \dfrac{R_x \frac{1}{sC}}{R_x+\frac{1}{sC}}}$$

$$= \frac{R_x/sC}{\frac{R_x}{sC} + RR_x + \frac{R_x}{sC} + \frac{R}{sC} + \frac{1}{s^2C^2}} \times \frac{\frac{sC}{R_x}}{\frac{sC}{R_x}}$$

$$= \frac{1}{2 + RsC + \frac{R}{R_x} + \frac{1}{sCR_x}}$$

$$\therefore \beta(s) = \frac{1}{2 + RsC + \frac{R}{R_x} + \frac{1}{sCR_x}}$$

$$= \frac{1}{\left(2+\frac{R}{R_x}\right) + \left(RsC + \frac{1}{sCR_x}\right)}$$

real imag

3.7

#6

$$\phi = -\tan^{-1} \frac{\omega c R - \frac{1}{\omega R_x c}}{2 + \frac{R}{R_x}}$$

to restore operation then

$$\boxed{\tan(-5.7) = \frac{\omega_o c R - \frac{1}{\omega_o R_x c}}{2 + \frac{R}{R_x}}}$$

$$\omega_o = \frac{1}{Rc}$$

$$\Rightarrow \quad 1 - \frac{1}{\frac{1}{R\cancel{c}} R_x \cancel{c}} = \left(2 + \frac{R}{R_x}\right)(-0.1)$$

$$1 - \frac{R}{R_x} = \left(2 + \frac{R}{R_x}\right)(-0.1)$$

$$1 + 0.2 = -0.1\, R/R_x + \frac{R}{R_x}$$

$$1.2 = 0.9 \frac{R}{R_x}$$

$$\frac{R}{R_x} = \frac{1.2}{0.9} = \frac{12}{9} = \frac{4}{3}$$

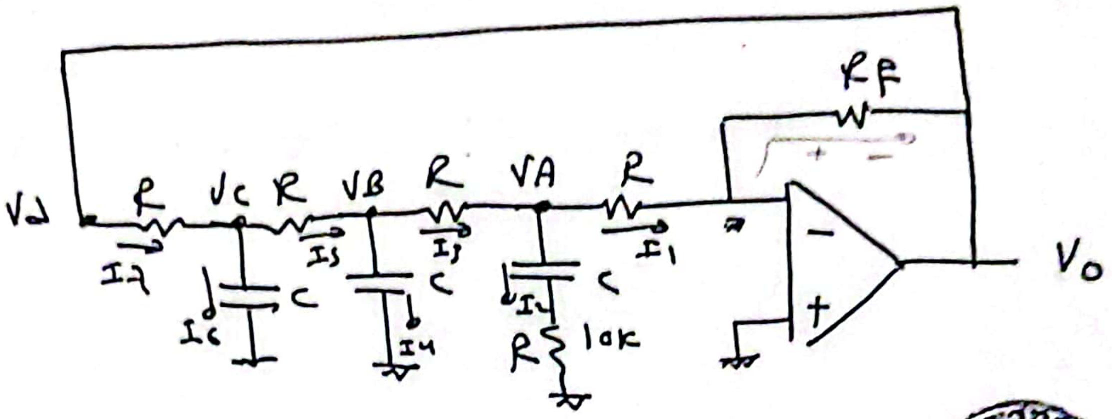
for $R = 10\,k\Omega = 10^4\,\Omega$

$$\therefore R_x = \frac{R}{4} * 3 = 7.5\,k\Omega$$

$$\boxed{R_x = 7.5\,k\Omega}$$ for restore operation

#7

P ⑦



$\boxed{R = 10k\Omega}$

$$V_o = -\frac{R_f}{R} V_A$$

A

$$A = \frac{V_o}{V_A} = -R_f/R \longrightarrow ①$$

$$I_1 = V_A/R$$

$$I_2 = \frac{V_A}{1/sC + R}$$

$$I_3 = I_1 + I_2 = \frac{V_A}{R} + \frac{V_A}{1/sC + R}$$

$$= \left(\frac{1}{R} + \frac{1}{\frac{1}{sC} + R}\right) V_A$$

$$= \left[\frac{1}{R} + 1\Big/\left(\frac{1 + sCR}{sC}\right)\right] V_A$$

$$= \left(\frac{1}{R} + \frac{sC}{1 + sCR}\right) V_A$$

$$V_B = I_3 R + V_A$$

ناخد المعادلة

$$= \left(\frac{1}{R} + \frac{sc}{1+scR}\right) V_A * R + V_A$$

$$= \left(1 + 1 + \frac{scR}{1+scR}\right) V_A$$

$$= \left(2 + \frac{scR}{1+scR}\right) V_A$$

$$I_4 = \frac{V_B}{1/sc} = sc\left(2 + \frac{scR}{1+scR}\right) V_A$$

$$= \left(2sc + \frac{s^2c^2R}{1+scR}\right) V_A$$

$$I_5 = I_3 + I_4$$

$$= \left(\frac{1}{R} + \frac{sc}{1+scR}\right) V_A + \left(2sc + \frac{s^2c^2R}{1+scR}\right) V_A$$

$$= \left[\frac{1}{R} + 2sc + \frac{sc + s^2c^2R}{1+scR}\right] V_A$$

$$V_C = I_5 R + V_B$$

الخطوات

اجيب معادلات للتيارات اللي
ومنها اجيب المصدر وبعد كده
اجيب منه التيار، كمل أمام وصل
للآخر node . هي الـ V_o

$$V_c = \left(1 + 2sCR + \frac{sCR + s^2C^2R^2}{1+sCR}\right)V_A + \left(2 + \frac{sCR}{1+sCR}\right)V_A$$

$$= \left(3 + 2sCR + \frac{2sCR + s^2C^2R^2}{1+sCR}\right)V_A$$

$$I_6 = \frac{V_c}{1/sC} = sC\left[3 + 2sCR + \frac{2sCR + s^2C^2R^2}{1+sCR}\right]V_A$$

$$= \left(3sC + 2s^2C^2R + \frac{2s^2C^2R + s^3C^3R^2}{1+sCR}\right)V_A$$

$$I_7 = I_6 + I_5$$

$$= \left[3sC + 2s^2C^2R + \frac{2s^2C^2R + s^3C^3R^3}{1+sCR} + \right.$$

$$\left. \frac{1}{R} + 2sC + \frac{sC + s^2C^2R}{1+sCR}\right]V_A$$

$$= \left[\frac{1}{R} + 3sC + 2sC + 2s^2C^2R + \right.$$

$$\left. + \frac{3s^2C^2R + sC + s^3C^3R^3}{1+sCR}\right]V_A$$

$$V_d = V_o = I_7R + V_c$$

$$V_d = V_o = \Big[1 + 3sCR + 2sCR + 2s^2C^2R^2 + \frac{3s^2C^2R^2 + sCR + s^3C^3R^4}{1+sCR} + 3 + 2sCR + \frac{2sCR + s^2C^2R^2}{1+sCR}\Big]V_A$$

$$= \Big[4 + 7sCR + 2s^2C^2R^2 + \frac{4s^2C^2R^2 + 3sCR + s^3C^3R^4}{1+sCR}\Big]V_A$$

$$\boxed{\beta = \frac{V_A}{V_o}}$$

$$\Rightarrow \frac{1}{\beta} = \frac{V_o}{V_A} = \left(4 + 7sCR + 2s^2C^2R^2 + \frac{4s^2C^2R^2 + 3sCR + s^3C^3R^4}{1+sCR}\right)$$

$$\boxed{A = -\frac{R_f}{R}} \quad \text{from (1)}$$

The condition of oscillation is

$$A\beta = 1$$

or $A = \dfrac{1}{\beta}$

$$-\frac{R_f}{R} = 4 + 7sCR + 2s^2C^2R^2 + \frac{4s^2C^2R^2 + 3sCR + s^3C^3R^4}{1+sCR}$$

mul both sides by $(1+sCR)$

$$-\frac{R_f}{R}(1+sCR) = 4(1+sCR) + (7sCR)(1+sCR) +$$

$$+ 2s^2C^2R^2(1+sCR) + 4s^2C^2R^2 + 3sCR + s^3C^3R^4$$

$$-\frac{R_f}{R} - \frac{R_f}{R}sCR = 4 + 4sCR + 7sCR + 7s^2C^2R^2 +$$

$$+ 2s^2C^2R^2 + 2s^3C^3R^3 + 4s^2C^2R^2 + 3sCR + s^3C^3R^4$$

$$-\frac{R_f}{R} - 4 = sCR\left(\frac{R_f}{R} + 4 + 7\right) + s^2C^2R^2(7+2+4+3) +$$

$$+ 2s^3C^3R^3 + s^3C^3R^4$$

$$-\frac{R_f}{R} - 4 = sCR\left(\frac{R_f}{R} + 11\right) + 16s^2C^2R^2 +$$

$$+ 2s^3C^3R^3 + s^3C^3R^4$$

Real part :

$$-\frac{R_f}{R} - 4 = 16s^2C^2R^2 \qquad s = j\omega$$

$$-\frac{R_f}{R} - 4 = -16\,\omega^2 C^2 R^2 \qquad * R$$

$$\cancel{-} R_f \cancel{-} 4R = \cancel{-}16\,\omega^2 C^2 R^3$$

$$\omega^2 = \frac{R_f + 4R}{16\, C^2 R^3}$$

$$\boxed{\omega = \sqrt{\frac{R_f + 4R}{16\, C^2 R^3}}}$$

Imaginary part

$$0 = \left(\frac{R_f}{R} + 11\right) \cancel{j\omega C R} + \cancel{j}\,\omega^{\cancel{3}\,2} * 2\, C^{\cancel{3}\,2} R^{\cancel{3}\,2} -$$

$$- \cancel{j}\,\omega^{\cancel{3}\,2} C^{\cancel{3}\,2} R^{\cancel{4}\,3}$$

$$0 = \left(\frac{R_f}{R} + 11\right) - \omega^2 * 2\, C^2 R^2 - \omega^2 C^2 R^3$$

$$\omega^2 \left(2 C^2 R^2 + C^2 R^3\right) = \frac{R_f}{R} + 11$$

$$\frac{R_f + 4R}{16\, C^2 R^3} \left(2 C^2 R^2 + C^2 R^3\right) = \frac{R_f}{R} + 11$$

$$R_f + 4R \left(\frac{1}{8R} + \frac{1}{16}\right) = \frac{R_f}{R} + 11 \qquad * 16R$$

$$(R_f + 4R)(2 + R) = 16 R_f + 176 R$$

$$2R_f + R_f R + 8R + \underline{4R^2} = 16 R_f + \underline{176 R}$$

$$\boxed{4R^2 - 168 R = 14 R_f - R R_f}$$

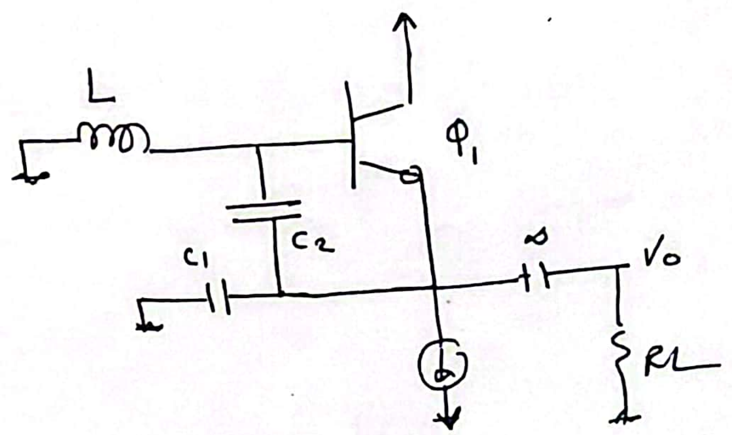
العلاقة بين R , Rf

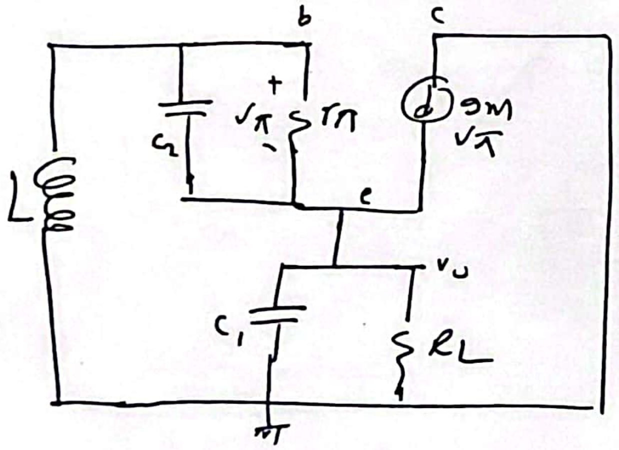
(ملحوظة: ما ورد اعلاه من حلول [illegible]

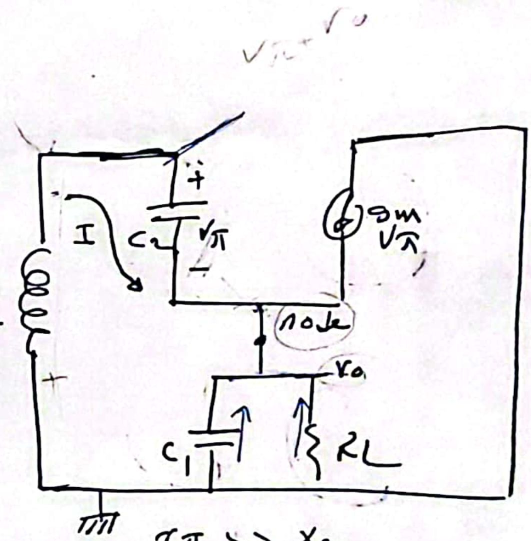
[illegible]

#13

P. 8 / 9







$r_\pi >> X_{C_2}$

$$I = V_\pi \cdot sC_2 = \frac{-[V_o + V_\pi]}{sL} \longrightarrow 1$$

$$V_o = V_\pi sC_2 \cdot sL - V_\pi$$

$$V_o = (s^2 C_2 L - 1) V_\pi \longrightarrow 1$$

$$= I = \frac{-V_\pi}{1/sC_2}$$

Node:

$$V_0 / \frac{1}{SC}$$

$$I) + g_m V_\pi + \frac{V_0}{R_L} + V_0 \cdot SC_1 = 0$$

$$V_\pi SC_2 + g_m V_\pi = -V_0 \left(\frac{1}{R_L} + SC_1 \right) = 0$$

From ①:

$$V_\pi SC_2 + g_m V_\pi = -\left[(S^2 C_2 L - 1) V_\pi\right]\left[\frac{1}{R_L} + SC_1\right]$$

$$\cancel{V_\pi} SC_2 + g_m \cancel{V_\pi} = (1 - S^2 C_2 L) \cancel{V_\pi} \left(\frac{1}{R_L} + SC_1 \right)$$

$$SC_2 + \boxed{g_m} = \boxed{\frac{1}{R_L}} + SC_1 - \boxed{\frac{S^2 C_2 L}{R_L}} - S^3 C_1 C_2 L$$

R R R

imaginary part:

$$SC_2 = SC_1 - S^3 C_1 C_2 L$$

$$S = j\omega$$

$$S^2 = -\omega^2$$

$$S^3 = -j\omega^3$$

$$\cancel{j\omega} C_2 = \cancel{j\omega} C_1 + \cancel{j}\omega^{\cancel{3}\,2} C_1 C_2 L$$

$$C_2 = C_1 + \omega^2 C_1 C_2 L$$

$$\omega^2 = \frac{C_2 - C_1}{C_1 C_2 L}$$

$$\boxed{\omega = \sqrt{\frac{C_2 - C_1}{C_1 C_2 L}}}$$

15

Real part:

$$g_m = \frac{1}{R_L} - \frac{s^2 C_2 L}{R_L}$$

$$g_m = \frac{1}{R_L} + \frac{\omega^2 C_2 L}{R_L}$$

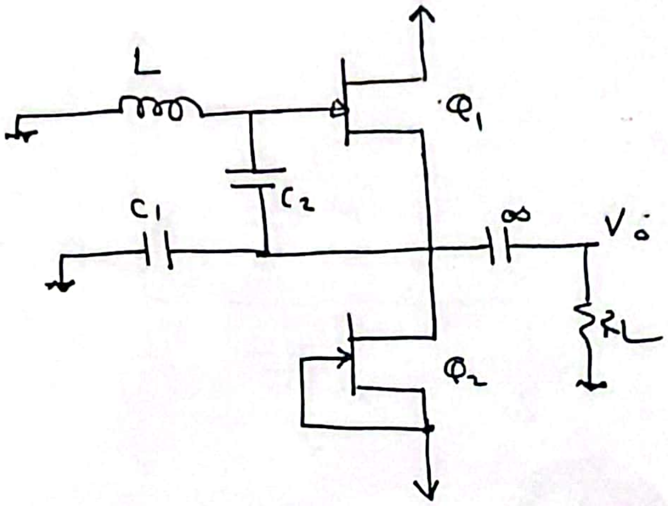
$$g_m = \frac{1}{R_L} + \frac{1}{R_L} \cdot \frac{C_2 - C_1}{C_1 \cancel{C_2} \cancel{L}} \cdot \cancel{C_2} \cancel{L}$$

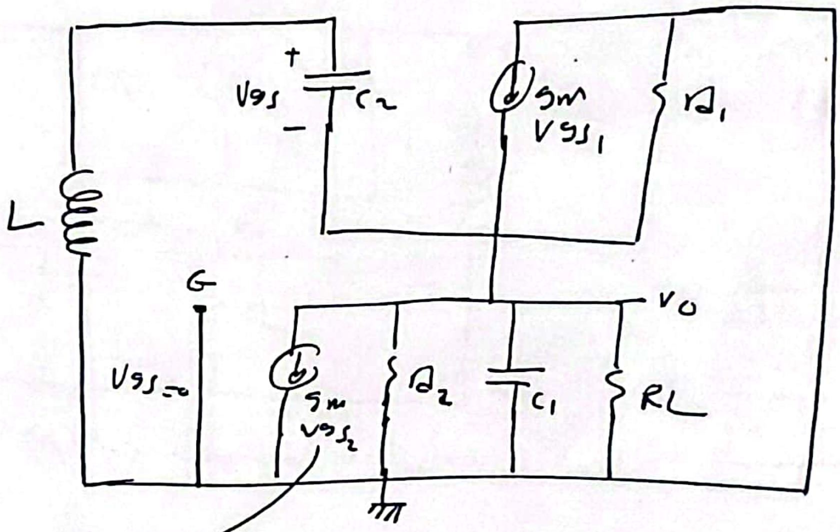
$$= \frac{1}{R_L}\left(1 + \frac{C_2 - C_1}{C_1}\right) = \frac{1}{R_L}\left(\cancel{1} + \frac{C_2}{C_1} \cancel{- 1}\right)$$

$$g_m = \frac{C_2}{C_1 R_L}$$

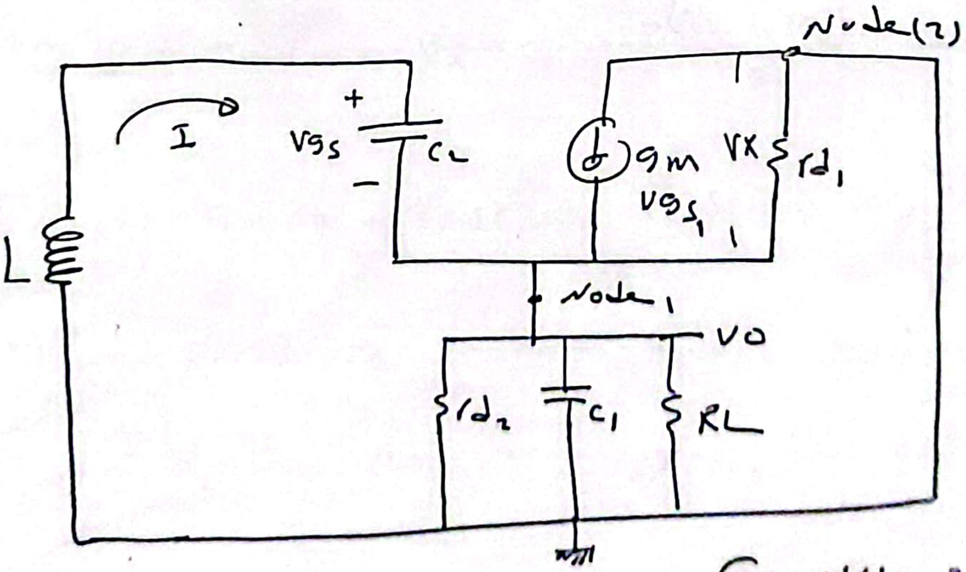
$$\boxed{R_L = \frac{C_2}{g_m C_1}}$$

(b)





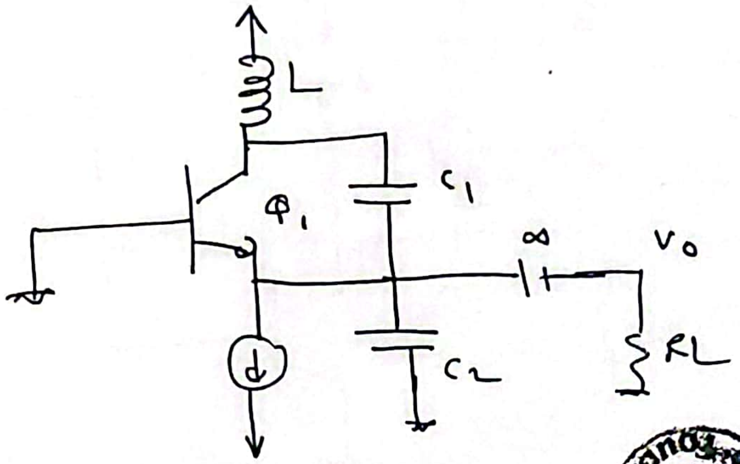
$V_{gs}=0 \rightarrow$ open cct

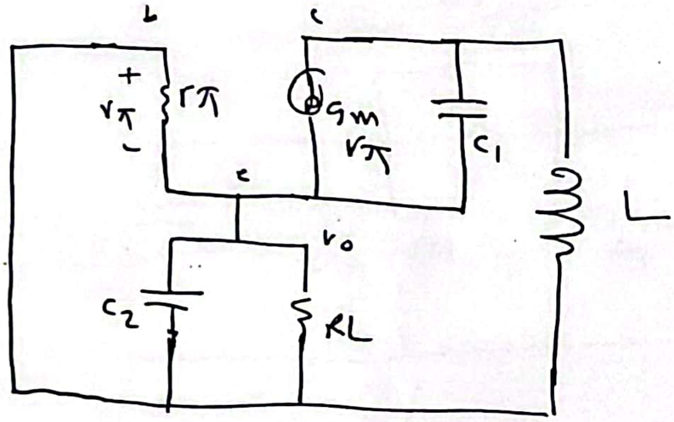


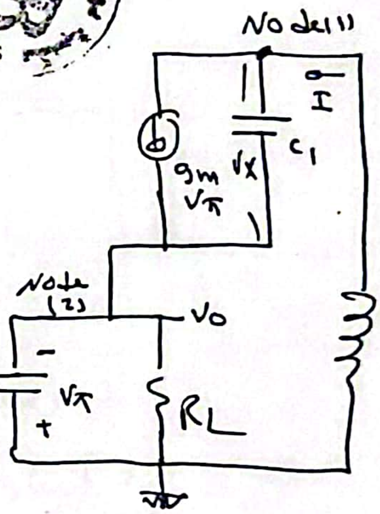
طريقة الحل مثل الحالة (a)

$V_x = -V_o$

(c)







r_π >> Can be neglected

$$V_o = -V_\pi$$

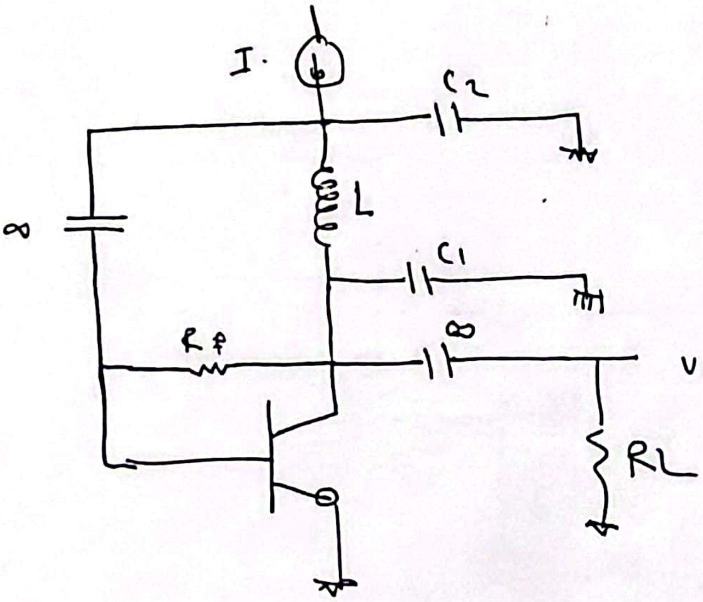
Node (1) : $g_m V_\pi + V_x S C_1 = \dfrac{-(V_x + V_o)}{SL} \longrightarrow (1)$

Node (2) $g_m V_\pi + V_x S C_1 = V_o S C_2 + V_o/R_L \longrightarrow (2)$

نلاحظ
كن تختصر
ال (ω)

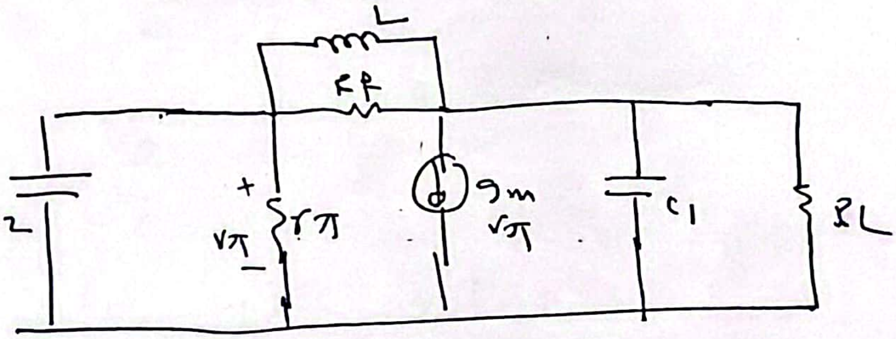
{ find V_x in both sides and equal the two terms you can determine (ω)

(d)



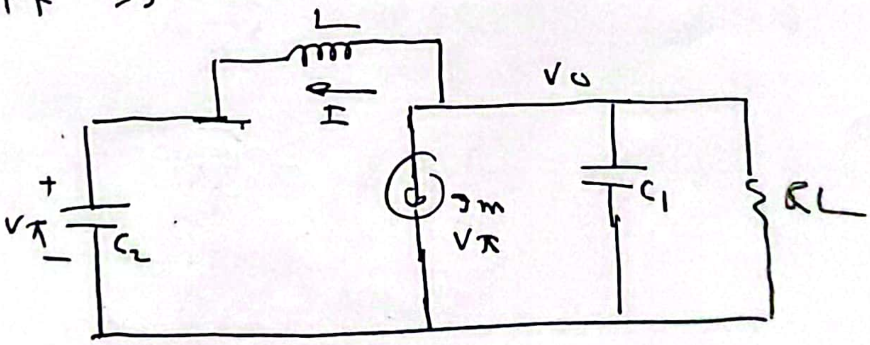
(معطى)
$R_f >> \omega_o L$

نخلي المكتوب عليه ∞ يكون Short cct



$r_\pi >> C_2$ can be neglected

علشان $R_f >> \omega_o L$ can be neglected

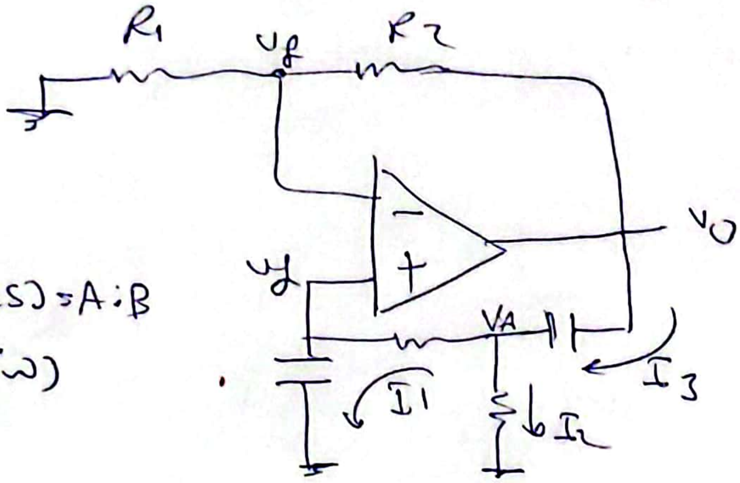


$$I = \frac{V_o - V_\pi}{sL} = V_\pi s C_2$$

$$\Sigma I + g_m v_\pi + V_o s C_1 + \frac{V_o}{R_L} = 0$$

أكمل حتى تصل لـ ١ ، (٢)

prob 5



Find $L(s) = A \cdot B$
and $L(j\omega)$

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

$$A = \frac{V_o}{v_f} = 1 + \frac{R_2}{R_1}$$

$$I_3 = (V_o - V_A) sC = I_2 + I_1$$

$$I_2 = V_A / R$$

$$I_1 = \frac{V_A - v_f}{R} = v_f sC$$

$$\therefore V_A - v_f = v_f RsC$$

$$\boxed{V_A = (1 + RsC) v_f}$$

$$(V_o - V_A) sC = \frac{V_A}{R} + v_f sC$$

$$V_o sC - V_A sC = \frac{V_A}{R} + v_f sC$$

$$V_o sC = V_A\left(sC + \frac{1}{R}\right) + v_f sC$$

$$V_o SC = (1+RSC)(SC+1/R)V_f + V_f SC$$

$$V_o SC = (3SC + RS^2C^2 + \frac{1}{R})V_f$$

$$V_o = (3 + RSC + \frac{1}{RSC})V_f$$

$$L(s) = A \cdot B$$

$$\beta = \frac{V_o}{V_f} = (3 + RSC + \frac{1}{RSC})$$

$$A = (1 + \frac{R_2}{R_1})$$

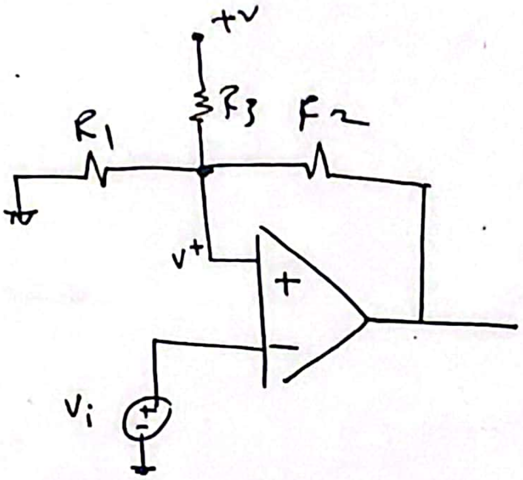
$$\therefore \; A \cdot B = L(s) = (3 + RSC + \frac{1}{RSC})(1 + \frac{R_2}{R_1})$$

$$\boxed{L(j\omega) = (3 + j\omega RC - \frac{j}{R\omega C})(1 + \frac{R_2}{R_1})}$$

H_{19}

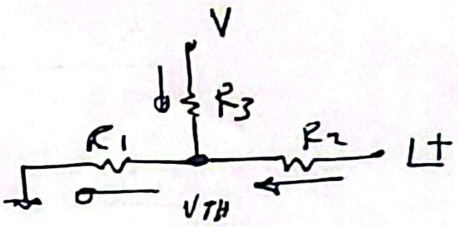
P. (9)

(a)



يعني المؤثر على الطرف الموجب

(a) * when $V^+ = V_{TH} \longrightarrow V_o = L^+$



$$\frac{V_{TH}}{R_1} = \frac{V - V_{TH}}{R_3} + \frac{L^+ - V_{TH}}{R_2}$$

$$V_{TH}\left(\frac{1}{R_1} + \frac{1}{R_3} + \frac{1}{R_2}\right) = \frac{V}{R_3} + \frac{L^+}{R_2}$$

$$V_{TH}\left(\frac{1}{R_t}\right) = \frac{V}{R_3} + \frac{L^+}{R_2} \quad , R_t = R_1 \parallel R_2 \parallel R_3$$

$$\boxed{V_{TH} = R_t\left(\frac{V}{R_3} + \frac{L^+}{R_2}\right)}$$

* when $V^+ = V_{TL} \longrightarrow V_o = L^-$

in the same way

$$\boxed{V_{TL} = R_t\left(\frac{V}{R_3} + \frac{L^-}{R_2}\right)} \quad , R_t = R_1 \parallel R_2 \parallel R_3$$

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(5) $L^+ = -L^- = 13\,v$. $v = 15\,v$

$R_1 = 10k\Omega$. R_2, R_3 ??

$V_{TL} = 4.9\,v$ $V_{TH} = 5.1\,v$

$$V_{TH} * \left(\frac{1}{R_1} + \frac{1}{R_3} + \frac{1}{R_2}\right) = \frac{V}{R_3} + \frac{L^+}{R_2}$$

$$5.1\left(\frac{1}{10} + \frac{1}{R_3} + \frac{1}{R_2}\right) = \frac{15}{R_3} + \frac{13}{R_2}$$

$$0.51 = \frac{7.9}{R_2} + \frac{9.9}{R_3} \longrightarrow (1)$$

$$V_{TL} * \left(\frac{1}{R_1} + \frac{1}{R_3} + \frac{1}{R_2}\right) = \frac{15}{R_3} - \frac{13}{R_2}$$

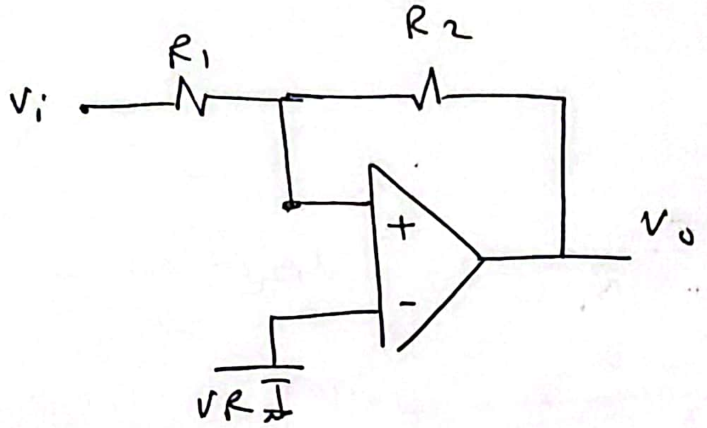
$$0.49 = \frac{-17.9}{R_2} + \frac{10.1}{R_3} \longrightarrow (2)$$

from (1) , (2)

$$\boxed{R_2 = 856.8\,k\Omega}$$

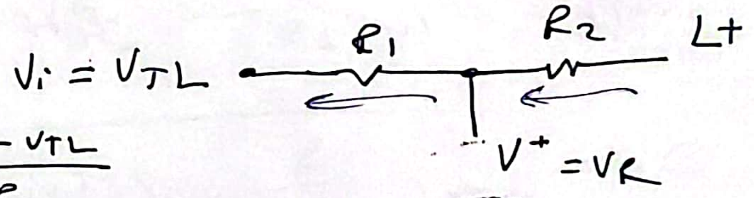
$$\boxed{R_3 = 19.8\,k\Omega}$$

P. 10



(a) at $V_{TL} \longrightarrow v_o = L^+ \;,\; V^+ = V_R$

لأن الـ V_i لو بدأت تقل حتى يصل أقل من الـ V_R وبالتالي بيكون الـ V_o بـ L^- هكذا.



$$\frac{L^+ - V_R}{R_2} = \frac{V_R - V_{TL}}{R_1}$$

$$\frac{V_{TL}}{R_1} = \frac{V_R}{R_1} + \frac{V_R}{R_2} - \frac{L^+}{R_2}$$

$v_i > V_{Th}$
$v^+ > V_R$
$v_o = L^+$

$$V_{TL} = V_R + \frac{R_1}{R_2} V_R - \frac{R_1}{R_2} L^+$$

$v_i < V_{Th}$
$v^+ < V_R$
$v_o = L^-$

$$\boxed{V_{TL} = V_R\left(1 + \frac{R_1}{R_2}\right) - \frac{R_1}{R_2} L^+}$$

$\longrightarrow$ (1)

$$\frac{L^+}{R_2} - \frac{V_R}{R_2} = \frac{V_R}{R_1} - \frac{V_{TL}}{R_1}$$

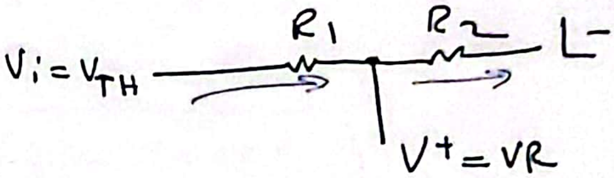
$$\frac{V_{TL}}{R_1} = V_R\left(\frac{1}{R_1} + \frac{1}{R_2}\right) - \frac{L^+}{R_2}$$

$$V_{TL} = V_R\left(1 + \frac{R_1}{R_2}\right) - \frac{L^+}{R_2} R_1$$

also :

at $V_{TH} \longrightarrow V_O = L^-$, $V^+ = V_R$

L^-



$$\frac{L^- - V_R}{R_2} = \frac{V_R - V_{TH}}{R_1}$$

$$\frac{V_{TH}}{R_1} = \frac{V_R}{R_1} + \frac{V_R}{R_2} - \frac{L^-}{R_2} \qquad \frac{V_{Th} - V_R}{R_1} = \frac{V_R - L^-}{R_2}$$

$$\boxed{V_{TH} = V_R\left(1 + \frac{R_1}{R_2}\right) - \frac{R_1}{R_2} L^-} \longrightarrow ②$$

ⓑ $L^+ = -L^- = V$, $R_1 = 10k$

$V_{TL} = 0 \qquad V_{TH} = \frac{V}{10}$

from ① :

$$0 = V_R\left(1 + \frac{10}{R_2}\right) - \frac{10}{R_2} V \longrightarrow ①$$

from ② :

$$\frac{V}{10} = V_R\left(1 + \frac{10}{R_2}\right) + \frac{10}{R_2} V$$

from ② - ① :

$$\frac{10}{R_2}\cancel{V} + \frac{10}{R_2}\cancel{V} = \frac{\cancel{V}}{10} - 0$$

$$\frac{20}{R_2} = \frac{1}{10} \qquad \boxed{R_2 = 200k\Omega}$$

from ① :

$$0 = V_R\left(1 + \frac{10}{200}\right) - \frac{10}{200}V$$

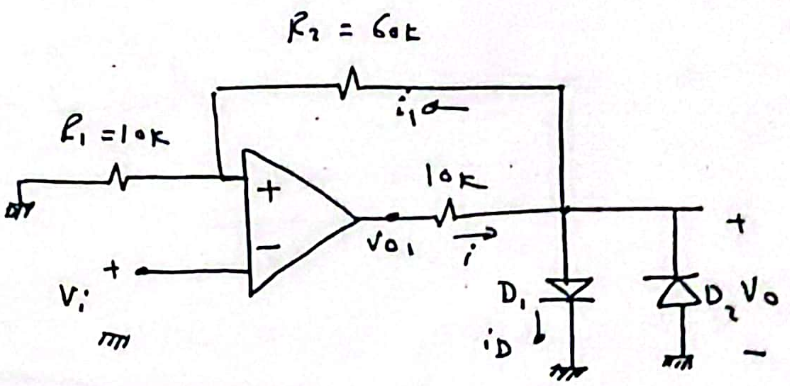
$$V_R\left(\frac{21}{\cancel{20}}\right) = \frac{1}{\cancel{20}}V$$

$$\boxed{V_R = \frac{V}{21}}$$

P.⑪

sketch $V_o - V_i$

$V_o = 0.7v$



$V_o = L^+ , L^- = \pm 0.7v$ لأنه الـ Vo عليه ديود

عندما يكون الـ Vo موجب فانه D_1 on ويكون الـ $V_o = 0.7v$

وعندما يكون الـ Vo سالب فانه D_2 on ويكون الـ $V_o = -0.7v$

$$\Rightarrow V_{TL} = \frac{-0.7}{10+60} * 10 = -0.1v$$

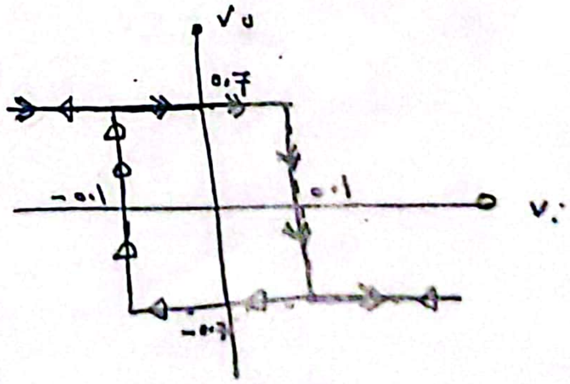
$$V_{TH} = \frac{+0.7}{10+60} * 10 = +0.1v$$

$$i = \frac{12-0.7}{10} = \frac{11.3}{10} = 1.13 \, mA$$

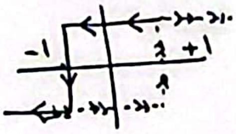
$$i_1 = \frac{0.7}{10+60} = 0.01 \, mA$$

$$i_{D\,max} = i_{D_1} = i - i_1 = 1.13 - 0.01$$

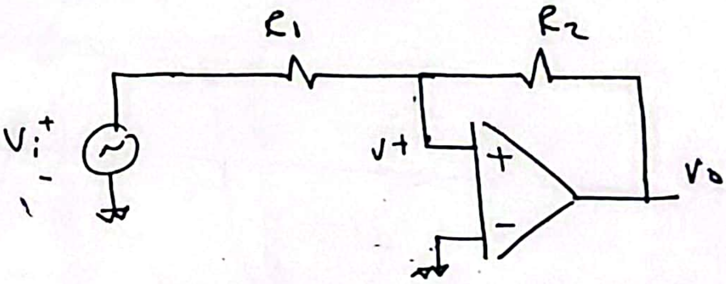
$$= \underline{\underline{1.12}} \, mA$$



P.(12) a bistable circuit having a non inverting transfer chars

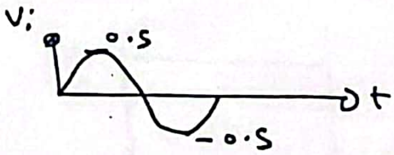


$L^+ = L^- = 12v \qquad V_{TL} = -1v \qquad V_{TH} = +1v$



non-inv. bistable

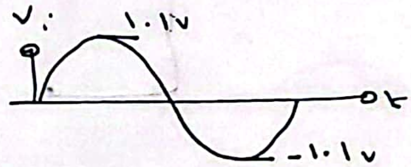
(a) $V_{im} = 0.5v$



هذا الدخل لا يكفي لتغيير حالة الدائرة لأنه أقل من V_{TH} ،

وأكبر من V_{TL} ولذلك تكون $\underline{\underline{V_o = \pm 12}}$ (إما $\underline{12v}$ أو $-12v$)

(b) $V_i = 1.1 \sin\theta$



$\therefore V_{TH} = \underline{\underline{1v}}$

∴ عندما يصل $\underline{V_i}$ الى $\underline{1v}$ فأكثر فإن $V^+ > 0$ وبالتالي

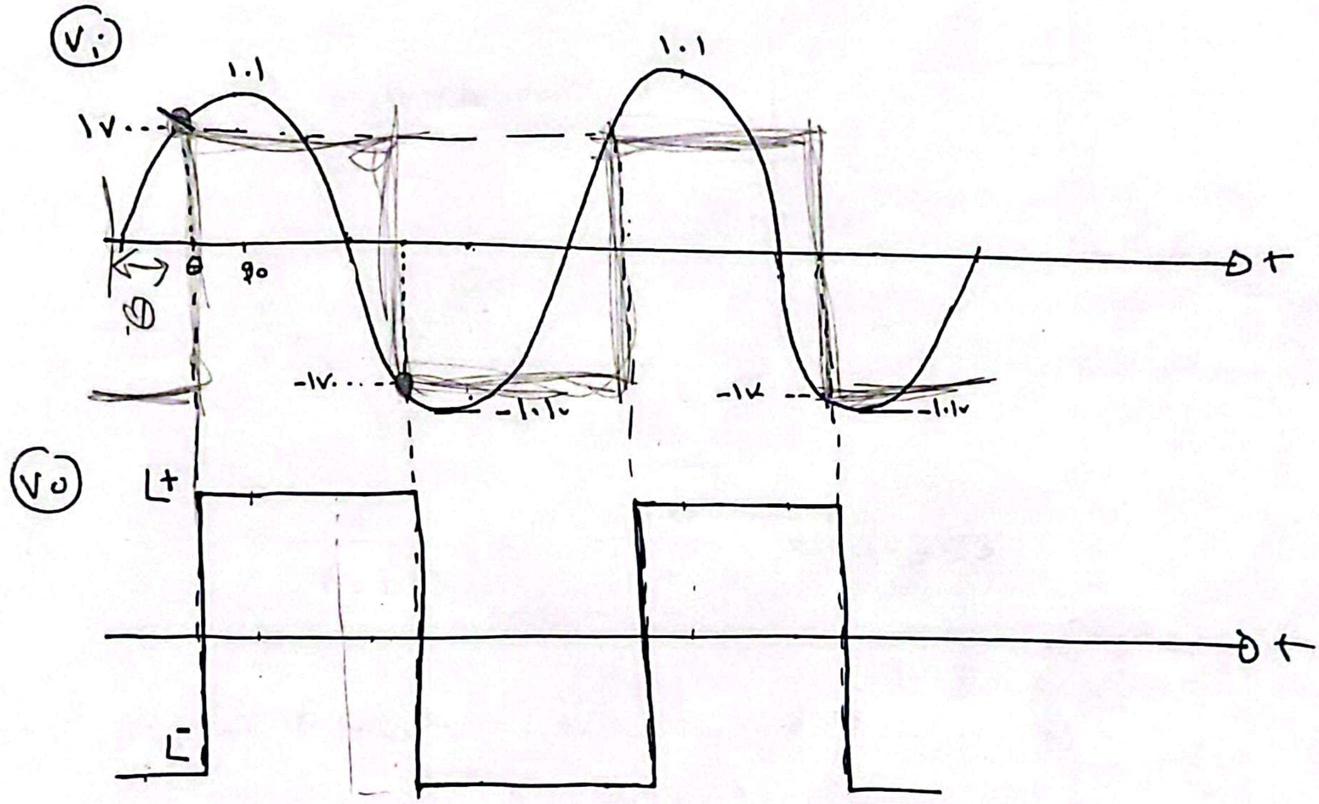
فإن $\underline{\underline{V_o = L^+}}$.

وعندما يصل V_i إلى $-1v$ فأقل فإن $V^+ < 0$ وبالتالي

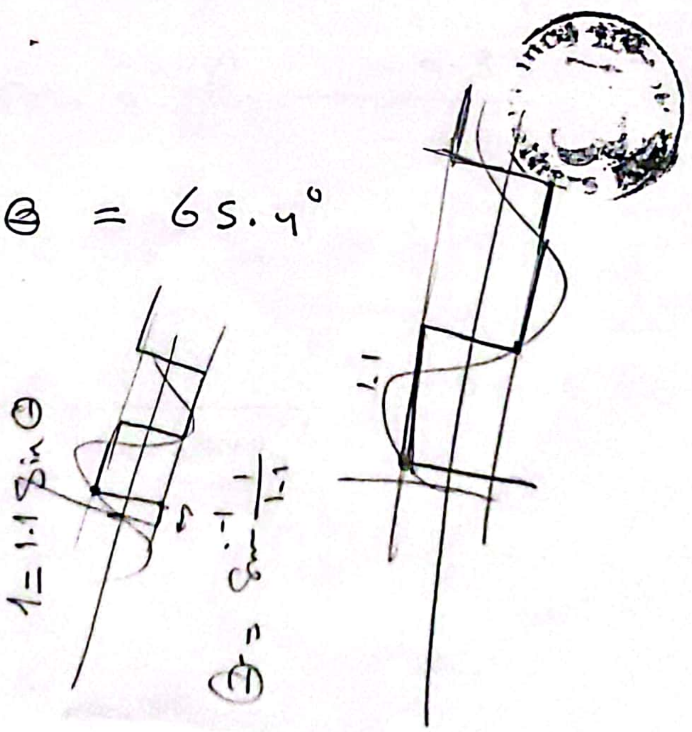
فإن $\underline{V_o = L^-}$.

$1 = 1.1 \sin\theta$

$\sin\theta = \frac{1}{1.1}$ $\qquad \theta = \underline{\underline{65.4^\circ}}$



shift $= \Delta\theta = 65.4^\circ$



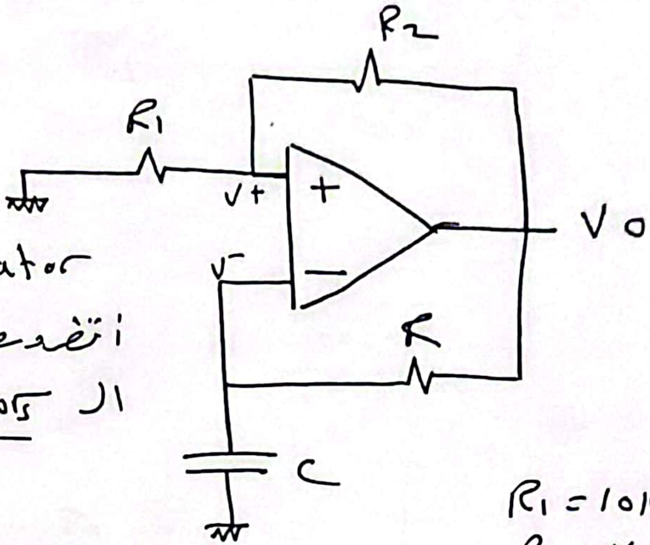
P. 13

هذه الدائرة عبارة عن

Square wave generator

اتقدم بشرح ص W7 علشان

ال multivibrators



$R_1 = 10k\Omega$
$R_2 = 16k\Omega$
$C = 10nf$
$R = 62k\Omega$

$$T = 2\tau \ln \frac{1+B}{1-B}$$

$$B = \frac{R_1}{R_1+R_2} = \frac{10}{10+16} = 0.385$$

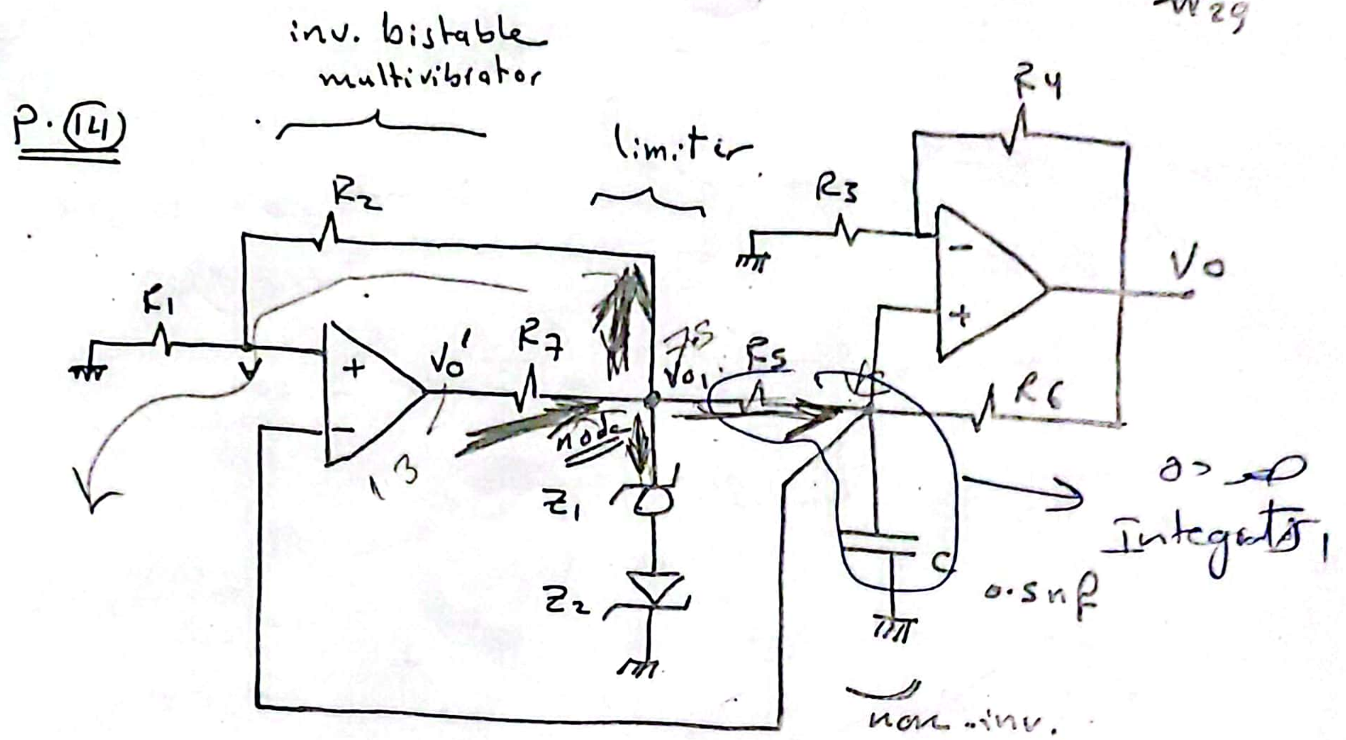
$$\tau = RC = 62 * 10^{3} * 10 * 10^{-9}$$
$$= 62 * 10^{-5} \text{ sec}$$

$$\therefore T = 2 * 62 * 10^{-5} \ln \frac{1+0.385}{1-0.385}$$

$$T = 1.006 * 10^{-3} \text{ sec}$$

$$f = \frac{1}{T} = \frac{1}{1.006*10^{-3}} = 994.04 \text{ Hz}$$

P.(14)



$V_{o1_{p-p}} = \pm 15v$, $f = 10kHz$ (square wave)

$R_1 \rightarrow R_6 = R$

$L^+, L^- = \pm 13v$

$I_{Z min} = 1mA$ $\quad V_{o1 max} = \frac{\pm 15}{2} = \pm 7.5v = V_p$ peak

when $V_{o1} = +7.5v$ (Z_1 break, Z_2 forward)

$V_{o1} = V_{Z_1} + V_{\gamma_2}$

$V_{Z_1} = V_{o1} - V_{\gamma_2} = \left(\frac{15}{2}\right) - (0.7)$

$= 6.8v$

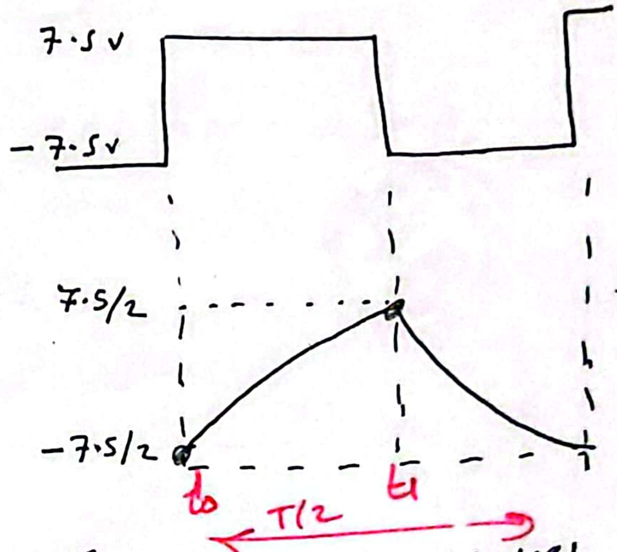
Also when $V_{o1} = -7.5v$ (Z_1 for, Z_2 break)

$V_{Z_2} = -7.5 - (-0.7) = -6.8v$

$|V_{Z_2}| = 6.8v$

$V_{Z_1} = V_{Z_2} = 6.8\,V \quad , \quad V_\gamma = 0.7\,V$

$$V = \frac{V_{o1}\, R}{R + R}$$



$$V = \frac{V_{o1}}{2}$$

$$= \pm 7.5/2$$

مثلاً حظ انه عندما يكون
الـ V_{o1} +7.5 فيشحن المكثف حتى
يصل الى 7.5/2 عندما يكون الـ V^- اعلى من الـ $V^+ = V$ فيتغير
الـ V_{o1} الى -7.5 وهكذا

السالب الخاص بالـ op amp بيكون ثابت وهذا المكثف والمقاوم

$$V_c(t_1) = \frac{1}{RC}\int_{t_0}^{t_1} V\,dt + V_c(t_0)$$

شحن

$$\frac{7.5}{2} = \frac{1}{RC}(t_1 - t_0)(7.5 - (-7.5)) - \frac{7.5}{2}$$

$$t_1 - t_0 = \frac{T}{2}$$

$$\therefore 7.5 = \frac{1}{RC}\frac{T}{2}(15)$$

$$\frac{T}{RC} = 1 \qquad R = \frac{T}{C}$$

$$\boxed{T_1 = R_g \ln(3)}$$

$$R = \frac{1}{FC}$$

$7.5 = \frac{1}{RC} T\, 7.5$

$T = 2$

$V(t) = \frac{7.5}{2} = 7.5 - (7.5 + \frac{7.5}{2}) e^{-T/RC}$

$\frac{7.5}{2} = 7.5 - (7.5 + \frac{7.5}{2}) e^{-T/RC}$

$\frac{7.5}{2} = 7.5(1 - (1 + \frac{1}{2}) e^{-T/RC})$

$T = RC \ln(3)$

31

$$R = \frac{1}{10^4 (0.5 \times 10^{-9})(2)} = 200\,k\Omega \qquad \frac{1}{2\ln(3) R C}$$

$f \quad C$ $\qquad \ln(3) \simeq 1$

$$\therefore \boxed{R_1 \to R_6 = \cancel{200}\,k\Omega \quad 100k} \qquad R_1 \to R_6$$

for minimum zener current = 1mA

node : , $V_o' = \pm 13$

$$\frac{13 - 7.5}{R_7} = 1 + \frac{7.5}{R_1 + R_2} + \frac{7.5 - V_c}{R_5}$$

The maximum current in the integrator is

when $V_c = -\frac{7.5}{2}$ → Capacitor

$$\frac{5.5}{R_7} = 1 + \frac{7.5}{400} + \frac{11.25}{200}$$

$$\therefore \boxed{R_7 = 5.12\,k\Omega}$$

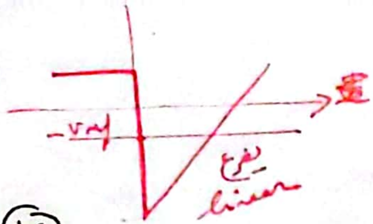
$\frac{5.5}{R7} = 1 + \frac{7.5}{200} + \frac{15}{100}$

$1.1875 = \frac{5.5}{R7}$

$7.5 - (-7.5)$

0.05625
0.01875
+1
1.075 = $\frac{5.5}{R7}$

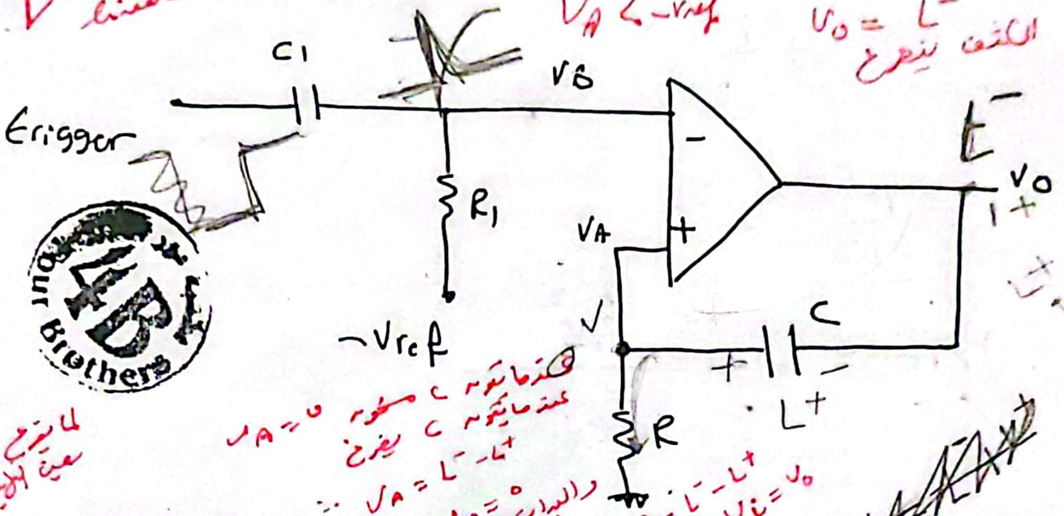
#32



$V_A > -V_{ref}$ $V_o = L^+$ المكثف مشحون

$V_A < -V_{ref}$ $V_o = L^-$ المكثف يتفرغ

P.15



عندما يتم C مشحون $V_A = 0$
عندما يتم C يفرغ
$\therefore V_A = L^- - L^+$
والبداية من $V_{oo} = 0$
when $V_A = L^- - L^+$ $V_i = V_o$

لما نفرغ ∴ يبتدي مشحون
قيمة الـ $V_A = 0$ ← $V_{oo} = 0$

$V_o = L^+$, $V_A = 0$, $V_B = -V_{ref}$

∴ المكثف مشحون بقيمة L^+ وعند تقطع الـ V_A تساوي zero

$V_A = -L^+ + L^+ = 0$

V_A —||— L^+ (L^+)

وعندما نقطع Erigger فيكون التحول عند V_B

هو فيكون أعلى من الـ $V_A = 0$ فيتحرك لـ $V_o = L^-$

وفي هذه اللحظة (عندوضع الـ Erigger) V_A —||— L^- (L^+)

تكون الـ V_A هو $V_A = -L^+ + L^-$

$= -(L^+ - L^-) = 2L^-$

وهي النقطة التي يبدأ عندها المكثف في تفريغ شحنته (L^+)

وكلما فرغ المكثف كلما قلت الـ (L^+) التي تسحب وبذلك تقل قيمة

الـ V_A بهذه إشارة أي $\boxed{\text{تزيد قيمة الـ } V_A}$ لأنه بإشارة سالبة

كلما فرق الـ R قيمة الـ V_A

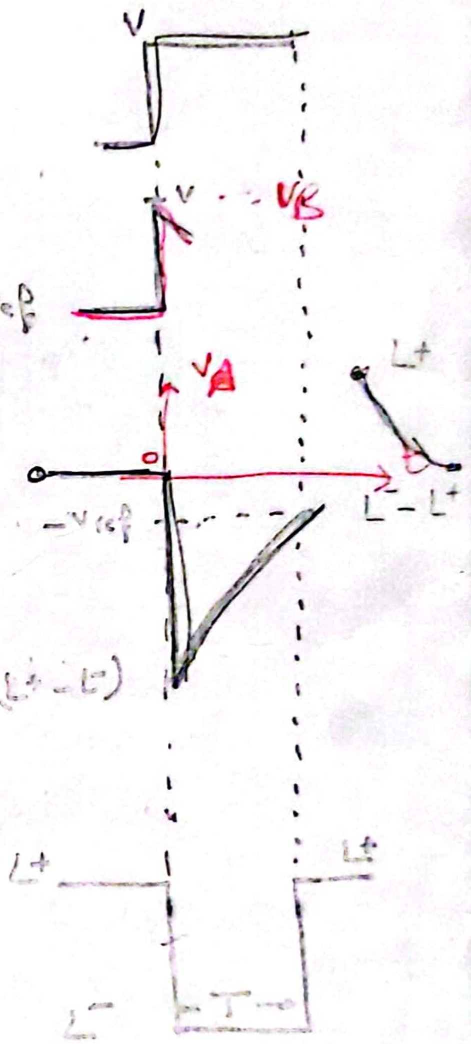
تزيد

حتى يصل الفولتية لـ VA إلى أعلى من الـ $-V_{ref}$ - ينعكس؟

الـ V_o بـ L^+ مرة أخرى وهكذا ...

لإيجاد الفترة T التي ظلت بـ $V_o = L^-$

ويفرغ المكثف شحنته تكون المعادلة للمكثف كالآتي



$$V_c = \underbrace{V_f}_{\to 0} + (V_i - V_f)\, e^{-t/\tau}$$

$$\boxed{V_f = 0} \qquad \boxed{V_i = -(L^+ - L^-)} = \boxed{L^- - L^+}$$

$$V_c = -(L^+ - L^-)\, e^{-t/\tau} \quad + L^+ -$$

$L^- - L^+$

at $\boxed{t = T}$ بس يفرغ $\quad \boxed{V_c = -V_{ref}}$

$$\cancel{-}V_{ref} = \cancel{-}(L^+ - L^-)\, e^{-T/\tau}$$

$$-T = \tau \ln \frac{V_{ref}}{L^+ - L^-}$$

$$T = \tau \ln \frac{L^+ - L^-}{V_{ref}} \qquad \tau = RC$$

$$\therefore \boxed{T = RC \ln \frac{L^+ - L^-}{V_{ref}}}$$

ملاحظة شرح ... في الحل

$$L^- - L^+ = -(L^+ - L^-) \qquad L^- \quad - L^+$$