TUTORIAL-5

PRE-TUTORIAL ASSIGNMENT- SOLUTION

Solution-1:

$$V_{BB} = \left(\frac{50}{100+50}\right)15 = 5V, R_B = R_1 \,||\, R_2 = 33.33K\Omega$$

This transistor obviously cannot be in saturation because in that case V_E will be 14.9 V which would make V_B=15.6 V which certainly cannot happen with a +15V supply!

If the transistor is in the active region –

$$V_{BB} - 0.7 = I_B R_B + (\beta+1) I_B R_E$$

$$4.3 = I_B(33.33 + 101\times 5) \quad \Rightarrow \quad I_B = 0.008\, mA$$

$$I_E = 0.808\, mA \quad \Rightarrow \quad I_C = 0.8\, mA$$

$$V_E = 4.04\,V, V_B = 4.74\,V$$

Since $V_C = 15V$, $V_{CE} = 10.96V$ and the transistor is confirmed to be in the active region as the B-C junction is reverse biased.

Therefore, Q-Point is V_{CE}=10.96 V, I_C=0.8 mA, I_B=0.008 mA

and $r_e = \frac{V_T}{I_E} = 0.032\; K\Omega$

Solution-2:

The period of the waveform is T = 4 sec. Over a period, the voltage waveform can be written as

$v(t) = -5t,\ 0 \le t < 2$ and $v(t) = 10,\ 2 \le t < 4$

The RMS voltage is

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T v^2(t)dt} = \sqrt{\frac{1}{4}\left[\int_0^2 (-5t)^2 dt + \int_2^4 10^2 dt\right]} = \sqrt{\frac{1}{4}\left[\frac{25t^3}{3}\Big|_0^2 + 100t\Big|_2^4\right]} = 8.165 \text{ V}$$

The power absorbed by the resistor = $V_{rms}^2/2$ = 33.33 W

TUTORIAL-5: SOLUTIONS

Solution-1:

(a) Since the two transistors are identical, $I_{E1} = I_{E2} = 0.5I_{RE} = 0.5[5\text{-}0.7]/10 = 0.215$ mA
Therefore, assuming transistors are in the active region, we have

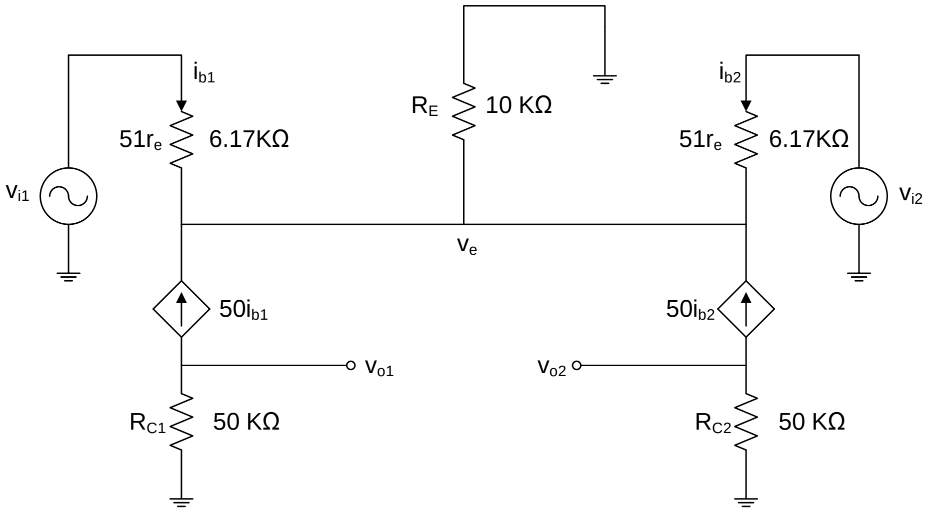
$\mathbf{I_{B1} = I_{B2} = 0.215/51 = 0.004216}$ **mA** and $\mathbf{I_{C1} = I_{C2} = 0.211}$ **mA**

$V_{C1} = V_{C2} = 12 - 0.211(50) = 1.461$ V $\quad V_{B1} = V_{B2} = 0$ V $\quad V_{E1} = V_{E2} = -0.7$V

$\mathbf{V_{CE1} = V_{CE2} = 1.461\text{-}(-0.7) = 2.161}$ **V**

Note that $V_{BC1} = V_{BC2} = -1.461$ V implying that the B-C junction is reverse biased. Since the B-E junction is forward biased, the transistor is operating in the active region.

(b) For both transistors, $r_e = 26/0.215 = 121\ \Omega$. Using this, the overall equivalent circuit for AC analysis may be drawn as follows.



$$i_{b1} = \frac{v_{i1} - v_e}{6.17} \qquad i_{b2} = \frac{v_{i2} - v_e}{6.17}$$

At the output,

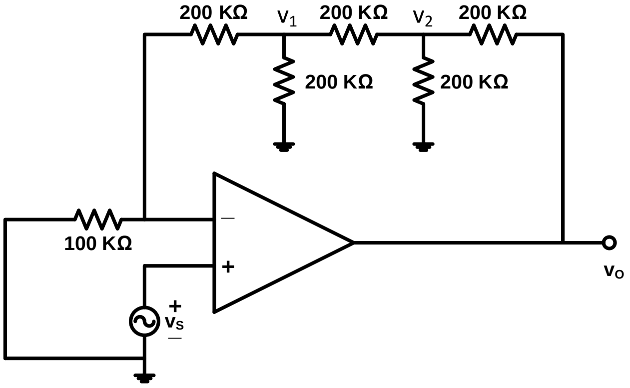
$$v_{o1} = -50 i_{b1} R_{C1} = -2500 i_{b1} \qquad v_{o2} = -50 i_{b2} R_{C2} = -2500 i_{b2}$$

$$v_{o1} - v_{o2} = -2500(i_{b1} - i_{b2}) = -405.3(v_{i1} - v_{i2})$$

$$\text{Therefore, } A_V = \frac{v_{o1} - v_{o2}}{v_{i1} - v_{i2}} = -405.3$$

Solution-2:

Note that $v_- = v_+ = v_s$



$$\frac{v_1\text{-}v_s}{200} = \frac{v_s}{100} \Rightarrow v_1 = 3v_s$$

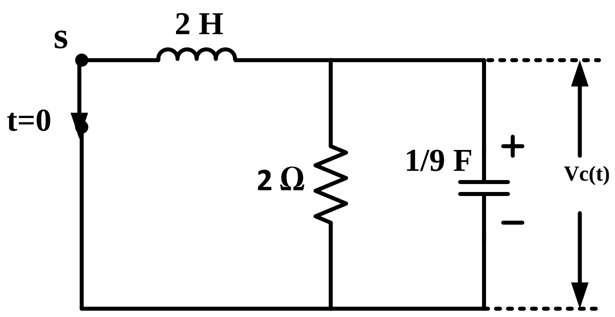
$$\frac{v_2\text{-}v_1}{200} = \frac{v_1}{200} + \frac{v_s}{100} \Rightarrow v_2 = 2v_1 + 2v_s = 8v_s$$

$$\frac{v_o\text{-}v_2}{200} = \frac{v_2}{200} + \frac{v_2\text{-}v_1}{200} \Rightarrow v_o = 3v_2\text{-}v_1$$

$$\Rightarrow v_o = 21v_s \qquad \text{Gain} = A_V = 21$$

Solution-3:

The inductor is short-circuited and capacitor open-circuited in steady state for $t < 0$. Then, using continuity principle $i_L(0^-) = i_L(0^+) = 10$ A and $v_c(0^-) = v_c(0^+) = 20$ V.
When the switch is connected to the position '2', the circuit diagram becomes:



KCL at the top central node yields $v_c(t)/R + C\, dv_c(t)/dt + i_L = 0$ .... (1)
Since $v_c(t) = L\, di_L/dt$, then (1) can be written as

$(L/R)\, di_L/dt + LC\, d^2i_L/dt^2 + i_L = 0$ ....(2)

⇨ $d^2i_L/dt^2 + 1/(RC)\, di_L/dt + 1/(LC)\, i_L = 0$ ....(3)

⇨ $d^2i_L/dt^2 + 4.5\, di_L/dt + 4.5\, i_L = 0$ ....(4)

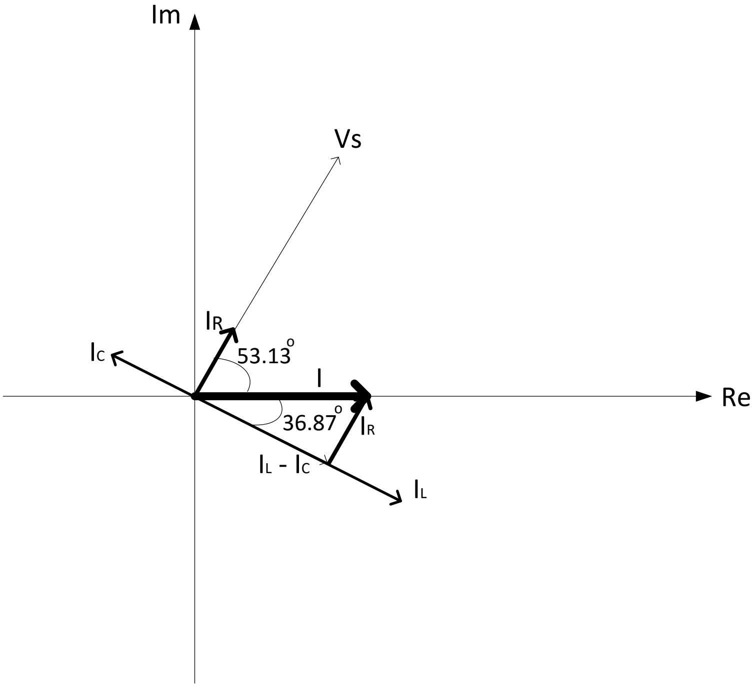
Characteristic equation of (4) gives the distinct real roots

$r1 = (-4.5 + \sqrt{(4.5^2 - 4x4.5)})/2 = -1.5$ and $r2 = (-4.5 - \sqrt{(4.5^2 - 4x4.5)})/2 = -3$

Since the RLC circuit has no source and the roots are real and distinct, $i_L(t) = A_1 e^{(-1.5t)} + A_2 e^{(-3t)}$ ....(5)
Using the initial condition $i_L(0^+) = 10$ and (5), we get $A_1 + A_2 = 10$ ....(6)
Also, $v_c(t) = L\, di_L(t)/dt = -3A_1 e^{(-1.5t)} - 6A_2 e^{(-3t)}$.
Then, setting $t = 0^+$ in the above expression one gets
$L\, di_L(0^+)/dt = -3A_1 - 6A_2 = v_c(0^+)$............(7)
Using the initial condition $v_c(0^+) = 20$ and (7), we get $-3A_1 - 6A_2 = 20$ ....(8)
Simultaneous solution of (6) and (8) yields $A_1 = 26.66$ and $A_2 = -16.66$.
Then, expression for $v_c(t)$ becomes
$v_c(t) = -80 e^{(-1.5t)} + 100 e^{(-3t)}$ V (approx.)

Solution-4:

Source in phasor form is $V_s = 100 \angle 53.13^0$
Impedance seen by the source = $Z = 3.33 \,||\, j1.43 \,||\, (-j3.33) = 1.2 + j\,1.6 = 2 \angle 53.13^0$ (approx.)
Source current = $I = V_s/Z = 50 \angle 0^0$
$I_R = V_s/3.33 = 30 \angle 53.13^0$
$I_L = V_s / (j1.43) = 69.93 \angle -36.87^0$
$I_C = jV_s/3.33 = 30 \angle 143.13^0$
The current phasor diagram is shown below:



Im
Vs
IR
IC
53.13°
I
Re
36.87°
IR
IL - IC
IL