EE101
Solution Tutorial 4 (30-AUG-2013)

1. (a)

(i) Assuming the transistor to be in the active region –

$$V_{CC} = R_C(I_C + I_B) + I_B R_B + 0.7 + I_E R_E$$

$$I_B = \frac{10-0.7}{R_C(\beta+1) + R_B + (\beta+1)R_E}$$

$$= \frac{9.3}{101*4.7 + 250 + 101*1.2} = 0.011 \text{ mA}$$

$$I_C = 1.1 \text{ mA}$$

$$V_C = 10 - 4.7*(1.1 + 0.011) = 4.78 \text{ V}$$

$$V_E = 1.2*101*(0.011) = 1.33 \text{ V}$$

Therefore $V_{CE} = V_C - V_E = 3.45$ V

Note that V_B=2.03 V implying that the C-B junction is reverse biased as it should be for the transistor to operate in the active region.

(ii) Assuming the transistor to be in the active region –

Thevenin's Equivalent of the Base Voltage supply gives

$$V_{BB} = \frac{10}{3} \text{ V} \qquad R_B = R_1 \,||\, R_2 = 13.333\ K\Omega$$

$$V_{BB} = I_B R_B + 0.7 + I_E R_E$$

$$I_B = \frac{3.333 - 0.7}{13.333 + (101)1.2} = 0.0196 \text{ mA}$$

$$I_C = 1.96 \text{ mA}$$

$$V_C = 10 - 2.8*1.96 = 4.51 \text{ V}$$

$$V_E = 1.2*(101)*0.0196 = 2.38\,V$$

$$V_B = V_E + 0.7 = 3.08V$$

Therefore $V_{CE} = V_C - V_E = 2.13$ V

Note that B-C junction will be reverse biased so transistor is indeed in the active region

(a) In this case, V_{BB}=5V and R_B=10 KΩ.

If transistor is assumed to be in the active region, then –

$$I_B = \frac{5-0.7}{10+101*1.2} = 0.0328 \text{ mA} \qquad I_C = 3.28 \text{ mA} \quad I_E = 3.313 \text{ mA}$$

and V_E = 3.976 V V_B = 4.676 V V_C = 0.816 V

But this would make B-C forward biased which is clearly impossible. Therefore, **transistor cannot be in the active region.**

If transistor is assumed to be in the saturation region, then –

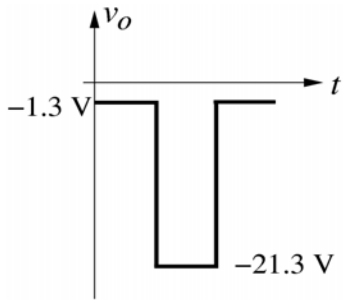
$$5 - 0.7 = 10 I_B + 1.2(I_B + I_C) \qquad 11.2 I_B + 1.2 I_C = 4.3$$

$$10 - 0.1 = 2.8 I_C + 1.2(I_B + I_C) \qquad 1.2 I_B + 4 I_C = 9.9$$

Solving, we get I_B=0.122 mA I_C=2.44 mA I_E=2.562 mA

Note that $I_C < \beta I_B$, therefore **the transistor is indeed in saturation**

2. (a) Time constant $\tau = RC = (56k\Omega)(0.1\mu F) = 5.6ms$



(b) $\frac{T}{2} = \frac{1ms}{2} = 0.5ms << 5\tau = 28ms$ and the ratio is 1:56

(c) For positive pulse of v_i :

The diode is "ON" and $v_o = -2V + 0.7V = -1.3V$

The capacitor charges to $10V + 2V - 0.7V = 11.3V$

For negative pulse of v_i :

The diode is "OFF" and $v_o = -10V - 11.3V = -21.3V$

3. (a) $I_E = \frac{V_E}{R_E} = \frac{2.1V}{0.68k\Omega} = 3.09mA$, assuming I_C�I_E $\beta = \frac{I_C}{I_B} = \frac{3.09mA}{20\mu A} = 154.5$

(b) $V_{CC} = V_{R_C} + V_{CE} + V_E = (2.7k\Omega)(3.09mA) + 7.3V + 2.1V = 17.74V$

(c) $R_B = \frac{V_{R_B}}{I_B} = \frac{V_{CC} - V_{BE} - V_E}{I_B} = \frac{17.74V - 0.7V - 2.1V}{20\mu A} = \frac{14.94V}{20\mu A} = 747\Omega$

4. (a) $P_1 = \frac{v_m i_{1m}}{2}\cos\theta_1 = \frac{141\times 7.07}{2}\cos 60^\circ = 250\text{ W}$,

$P_2 = \frac{v_m i_{2m}}{2}\cos\theta_2 = \frac{141\times 10}{2}\cos 30^\circ = 610.5\text{ W}$

Total Power = 250+610.5 =860.5 W

(b) $V = (141/\sqrt{2})\angle 0^\circ = 100)\angle 0^\circ$ V, $I_1 = (7.07/\sqrt{2})\angle\text{-}60^\circ = 5\angle\text{-}60^\circ$ A,

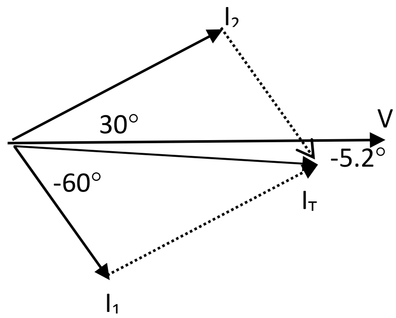
$I_2 = (10/\sqrt{2})\angle 30^\circ = 7.07\angle 30^\circ$ A; $I_T = 5\angle\text{-}60^\circ + 7.07\angle 30^\circ = 8.66\angle\text{-}5.2^\circ$ A

Apparent power, S = 100×8.66 = 866 VA

Power factor = cos(-5.2°) = 0.996 (lag)

(c) Expression for total current is: $i_T = 8.66\times\sqrt{2}\sin(\omega t - 5.2^\circ)$ A

(d) The vector diagram is as shown.



5. $Z = R + j\omega L + \frac{1}{j\omega C}$. Therefore, $|Z| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$

The current maximum occurs at $\omega = \omega_0$, when $\left(\omega_0 L - \frac{1}{\omega_0 C}\right) = 0$ or $\omega_0 = \frac{1}{\sqrt{LC}}$

$$\cos\theta = \frac{R}{|Z|} = \frac{R}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} = \frac{R}{\sqrt{R^2 + \omega L\left(1 - \frac{\omega_0^2}{\omega^2}\right)^2}}$$

Given that at $\omega = 2\omega_0$, $\cos\theta = \frac{1}{\sqrt{2}}$. Therefore, $R^2 + 2\omega_0 L\left(1 - \frac{1}{4}\right)^2 = 2R^2$

$$R^2 = 2\frac{L}{\sqrt{LC}}\left(\frac{3}{4}\right)^2 = 2\sqrt{\frac{L}{C}}\left(\frac{3}{4}\right)^2 = 4\left(\frac{3}{4}\right)^2 \Rightarrow R = \frac{3}{2}\Omega$$