Solutions to Quiz-2 Paper (Group-A) IEC103

(Q1) For the oscillator circuit shown in Fig. Q1, find the frequency of oscillation and condition on ratio $\frac{R_2}{R_1}$ for oscillation

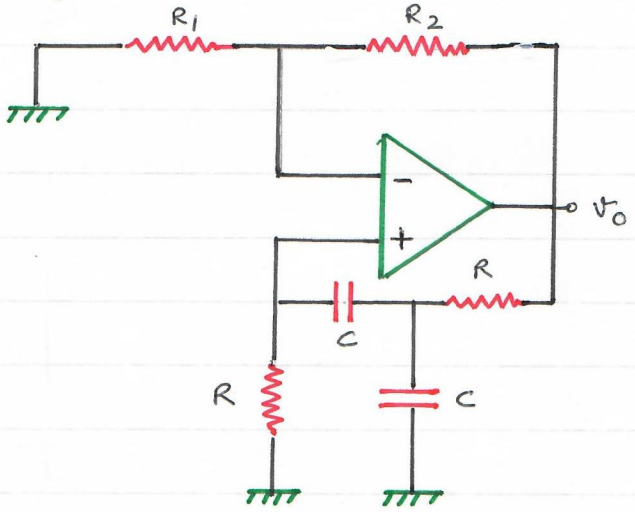
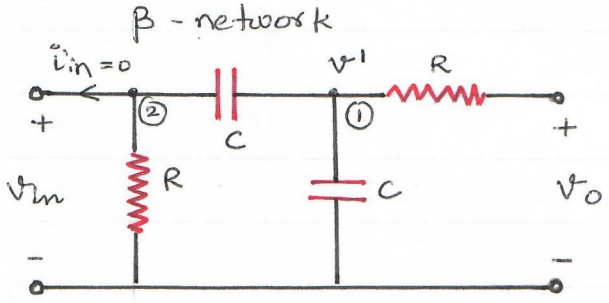



Fig. Q1

Sol.




$$v_o = A v_{in}$$
$$= \left(1 + \frac{R_2}{R_1}\right) v_{in} \quad \ldots (I)$$

Applying KCL at node (1)

$$\frac{v' - v_o}{R} + \frac{v'}{(1/sC)} + \frac{v' - v_{in}}{(1/sC)} = 0 \quad \ldots (A)$$

Applying KCL at node (2) (ie., i/p node)

$$\frac{v_{in}}{R} + \frac{v_{in} - v'}{(1/sC)} = 0 \quad \ldots (B)$$

$$\Rightarrow v_{in}\left(\frac{1}{R} + sC\right) = sCv'$$

Let $\frac{1}{R} = a$

$$\therefore v_{in}(a + sC) = sCv'$$

$$\Rightarrow v' = \frac{(a+sC)}{sC} v_{in} \quad \ldots (C)$$

Eq.n (A)

$$\frac{v'-v_o}{R} + \frac{v'}{(1/sc)} + \frac{v'-v_{in}}{C'/sc)} = 0$$

$$\Rightarrow v'(G+sc+sc) - Gv_o - scv_{in} = 0$$

$$\Rightarrow v'(G+2sc) - Gv_o - scv_{in} = 0 \qquad G = \frac{1}{R}$$

subst. $v'$ in eqn (C) in the above equation

$$(G+2sc)\frac{(G+sc)}{sc} v_{in} - GAv_{in} - scv_{in} = 0$$

$$\Rightarrow (G+2sc)(G+sc) - AG(sc) - (sc)^2 = 0$$

$$\Rightarrow (G^2 + 3GCs + 2s^2C^2) - (AGC)s - C^2s^2 = 0$$

$$\Rightarrow (2C^2 - C^2)s^2 + (3GC - AGC)s + G^2 = 0$$

$$\Rightarrow C^2s^2 + (3-A)GCs + G^2 = 0$$

put $s = jw$

$$\Rightarrow -C^2w^2 + j(3-A)GCw + G^2 = 0$$

$$\Rightarrow (G^2 - C^2)w^2 + j(3-A)GCw = 0$$

Equating real & imaginary parts of LHS & RHS

$$(G^2 - C^2)w^2 = 0$$

$$\Rightarrow \left(\frac{1}{R^2} - R^2C^2\right)w^2 = 0$$

$$\Rightarrow R^2C^2w^2 = 1$$

$$\Rightarrow \boxed{w_o = \frac{1}{RC}}$$

$$(3-A)GCw = 0$$

$$(3-A)GC = 0$$

$$\Rightarrow A = 3 = 1 + \frac{R_2}{R_1}$$

$$\Rightarrow \boxed{\frac{R_2}{R_1} = 2}$$

(Q2) Determine the output waveform (Vout) of the diode circuit shown in Fig. Q2 below. Use simplified model of the diode. Both the diodes are silicon diodes.

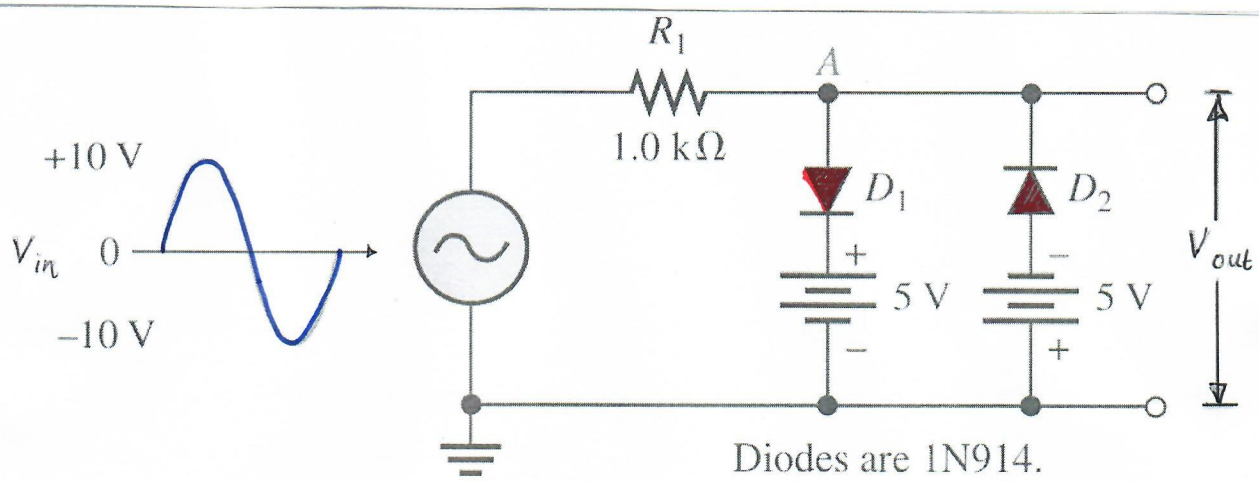
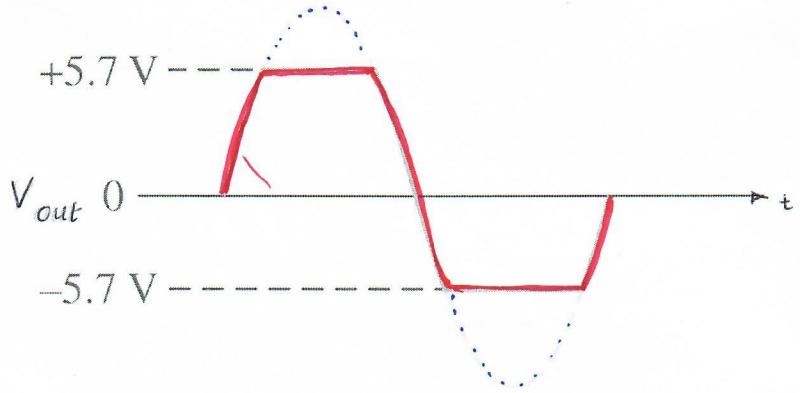


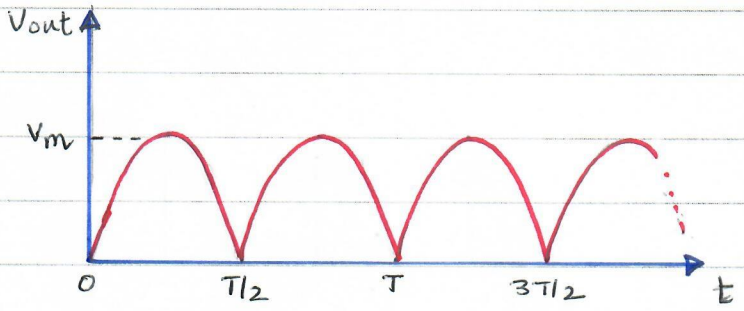

Fig. Q2

Sol. When the voltage at point A reaches +5.7V, diode $D_1$ conducts and limits the waveform to +5.7 V. Diode $D_2$ does not conduct until the voltage reaches −5.7V. Therefore, positive voltages above +5.7V and negative voltage below −5.7 are clipped off. The resulting output waveform is shown below.



(Q3) Derive the expression and the value of rectifier efficiency of a full wave rectifier.

Sol. The output of a full wave rectifier is as shown below.




T is the time period of the input supply.

$$\text{Rectifier efficiency} = \frac{\text{DC power output}}{\text{AC power output}}$$

Let load resistance be $R_L$.

For the output waveform

$$V_{DC} = \frac{2V_m}{\pi} \quad ; \quad V_{(RMS)} = \frac{V_m}{\sqrt{2}}$$

$$\text{DC power output} = (V_{DC})^2/R_L = P_{DC}$$

$$\text{AC power output} = (V_{(RMS)})^2/R_L = P_{AC}$$

$$\text{Rectifier efficiency} = \frac{P_{DC}}{P_{AC}} = \left(\frac{V_{DC}}{V_{AC}}\right)^2 = \frac{(2V_m/\pi)^2}{(V_m/\sqrt{2})^2}$$

$$= \frac{4/\pi^2}{1/2} = \frac{8}{\pi^2} = 0.81$$

$$= 81\%$$