

Tutorial -6 Solution (Part-1)

1) Given $J_{\max} = 1\text{MA/cm}^2$, $l=500\mu\text{m}$, $w=3\mu\text{m}$, $t=1\mu\text{m}$, $\rho=1/\sigma=2.7*10^{-8}$ ohm-meter.

$$I_{\max} = J_{\max} * \text{area}$$

$$I_{\max} = 1\text{MA/cm}^2 * 3\mu\text{m} * 1\mu\text{m} = 30\text{mA}.$$

$$J=E * \sigma \Rightarrow E_{\max} = J * \rho = 270\text{V/m}$$

$$V_{\max} = E_{\max} * l = 135\text{mV}.$$

2) The voltage at the cathode of the diode is $5*1\text{K}/(1.5\text{K}+1\text{K}) = 2\text{V}$.

a) For $V_{\text{in}} = 1\text{V}$, the diode will be reverse biased and $V_{\text{out}} = 1\text{V}$.

b) For $V_{\text{in}} = 3\text{V}$, the diode will be forward biased. Now need to apply KCL across the diode.

$$[V_{\text{out}} - 3]/1\text{K} + [(V_{\text{out}} - 0.7) - 5]/1.5\text{K} + (V_{\text{out}} - 0.7)/1\text{K} = 0$$

Solving this, $V = 2.8\text{V}$

3)

a) Without the zener, $V_{\text{RL}} = 12*60/(60+120) = 4\text{V} < 5\text{V}$
Hence zener is off. $V_{\text{RL}} = 4\text{V}$, $I_{\text{Z}} = 0$, $I_{\text{RL}} = 66.66\text{mA}$.

b) Without the zener, $V_{\text{RL}} = 6\text{V} > 5\text{V}$
Hence zener is on. $V_{\text{RL}} = 5\text{V}$, $I_{\text{RL}} = 41.66\text{mA}$.
 $I_{\text{in}} = (12-5)/120 = 58.33\text{mA}$, Therefore $I_{\text{Z}} = 16.66\text{mA}$.

c) V_{RL} must be minimum of 5V for the zener to be on.
Therefore $12 * R_{\text{L}} / (120 + R_{\text{L}}) \geq 5$
Hence $R_{\text{L}} \geq 85.71\text{Ohms}$

$$P_{\text{Zmax}} = 150\text{mW}. \text{ Therefore } I_{\text{Z}} V_{\text{Z}} \leq 150\text{mW}$$

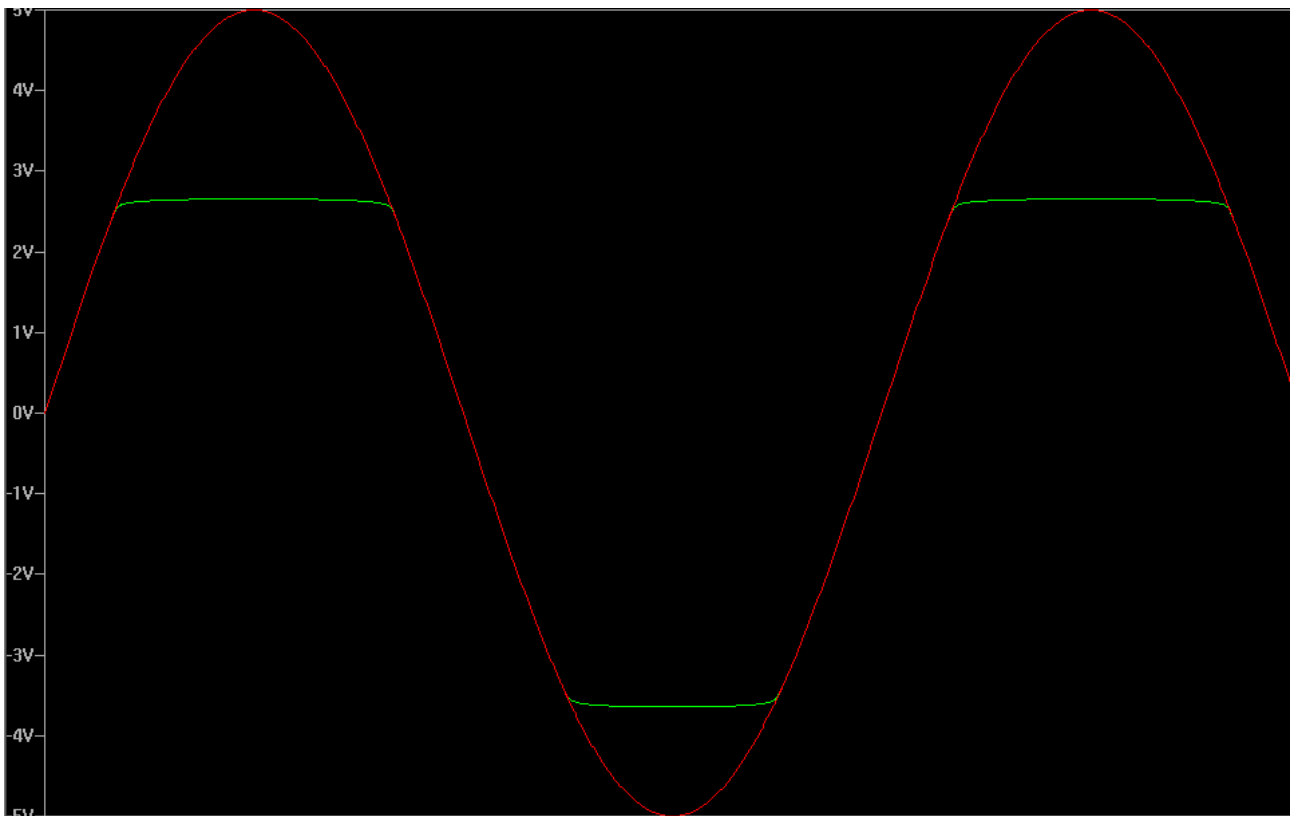
$$I_{\text{Z}} \leq 30\text{mA}$$

$$I_{\text{in}} - I_{\text{RL}} \leq 30\text{mA}$$

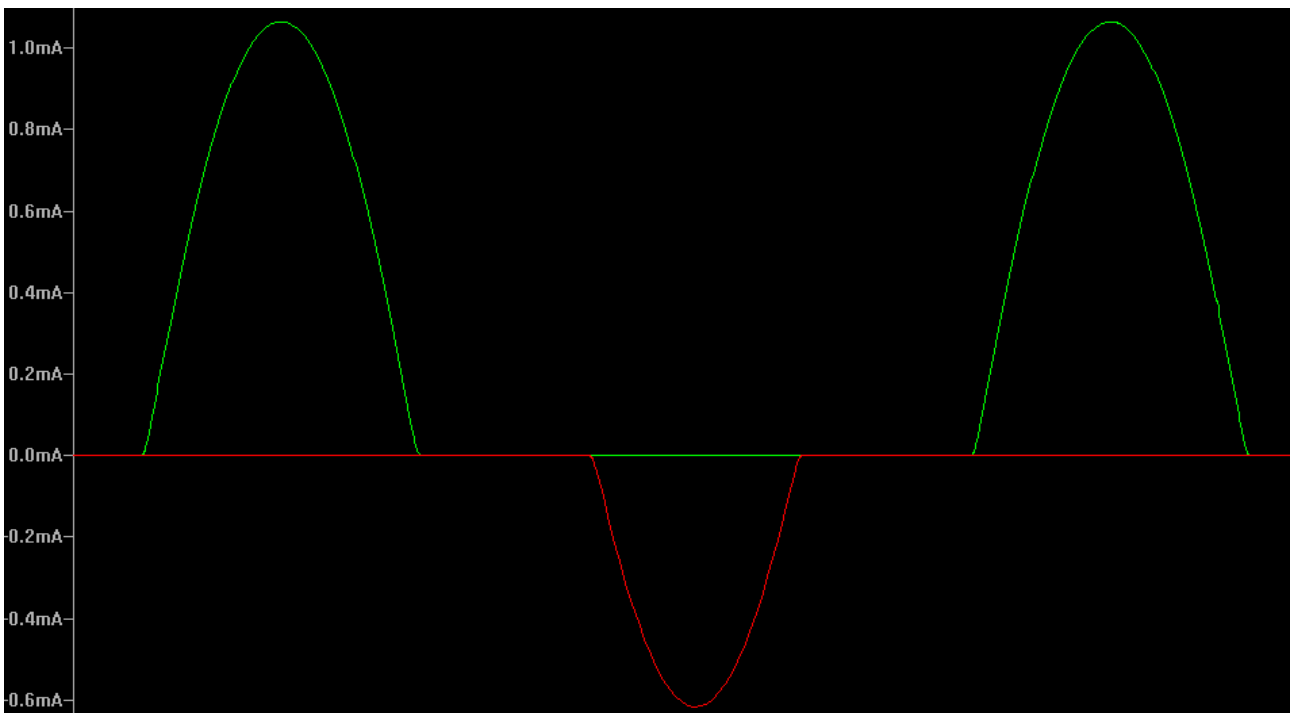
$$(12-5)/120 - 5/R_{\text{L}} \leq 30\text{mA}$$

$$R_{\text{L}} \leq 176.47\text{Ohms}.$$

4) During positive half cycle D1 will be forward biased at a voltage of 2.7V and so the output clips at this voltage. During negative half cycle D2 will be forward biased at -3.7V and the output clips at -3.7V .



D1 will be ON when input voltage is more than 2.7 and D2 will be ON when input voltage is less than -3.7V. The peak current in D1 = $(5-2.7)/2.2K = 1.045mA$. Peak current in D2 = $(-5+3.7)/2.2K = -0.59mA$



5) During the initial negative half cycle the diode is forward biased and capacitor will be charged to 4.3V. In steady state during positive half cycle the input rides on this 4.3V and

hence the output starts at 4.3V and peaks at 9.3V . During the negative half cycle in steady state, the negative peak will be -0.7V.

