

American University of Beirut
Department of Electrical and Computer Engineering

EECE 310 – Electronics

Fall 2011 – 2012

Homework 1

Problem 1

a) $v_o = 12 - 10(v_I - 3)^2$ for $3 < v_I < v_o + 3 V$.

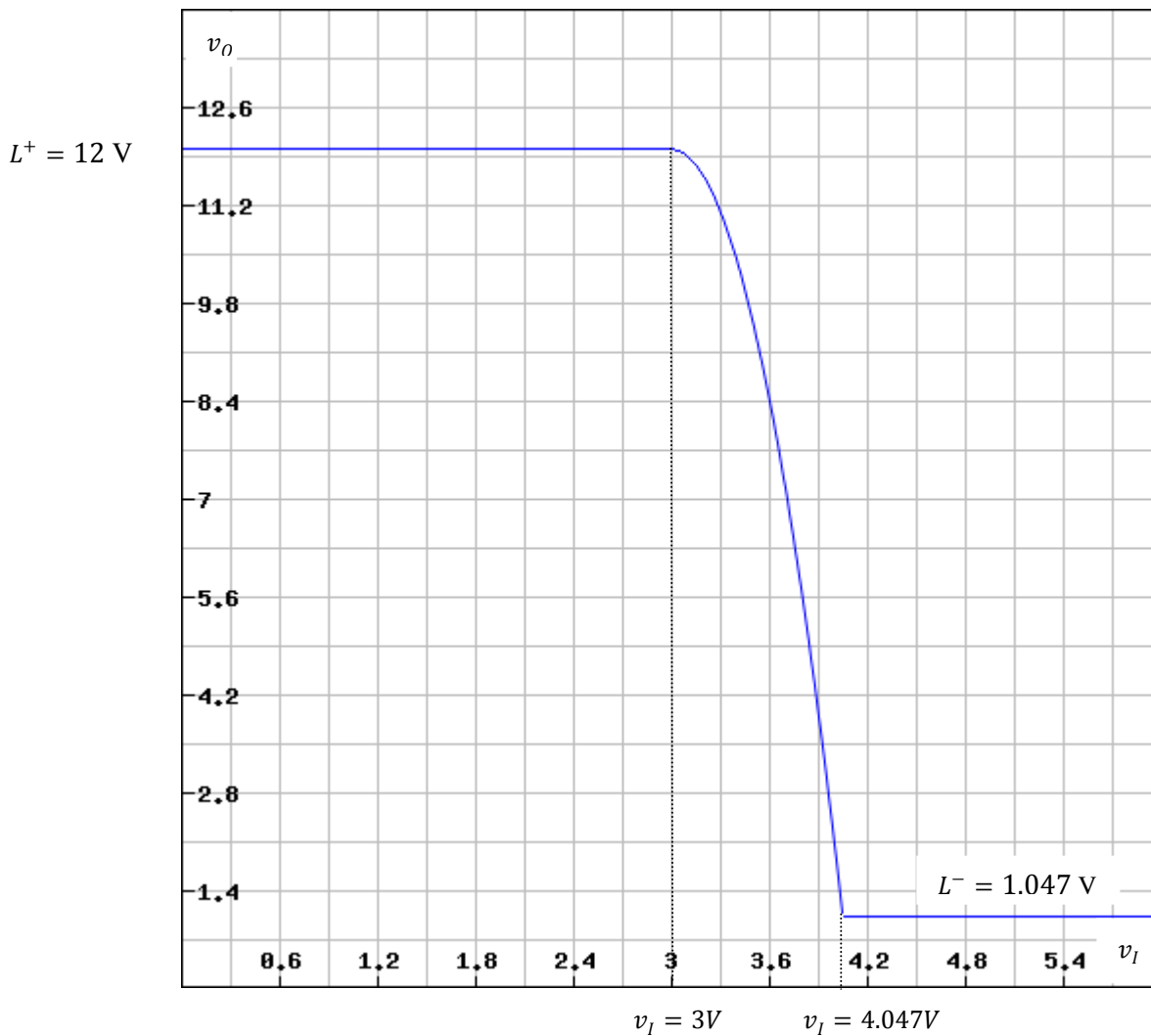
At $v_I = 3 V$, $v_o = 12 V$.

At $v_I = v_o + 3$, $v_o = 12 - 10v_o^2$.

Solving $10v_o^2 + v_o - 12 = 0$ gives $v_o = 1.047 V$ or $v_o = -1.147 V$.

Since $v_o > 0 V$, $v_o = 1.047 V$ at $v_I = 4.047 V$.

Thus the saturation levels are $L^+ = 12 V$ at $v_I = 3 V$, and $L^- = 1.047 V$ at $v_I = 4.047 V$.



b) $v_o = 12 - 10(v_I - 3)^2$

To obtain $v_o = 6 V$, the required input voltage is:

$$6 = 12 - 10(v_I - 3)^2$$

$$(v_I - 3)^2 = 0.6$$

Since $v_I > 3 V$, $v_I = 3 + \sqrt{0.6} = 3.77 V$.

c) $A_v = (dv_o/dv_I)|_{v_I=3.77}$
 $dv_o/dv_I = -20(v_I - 3)$;
 $A_v = -20(3.77 - 3) = -15.4 V/V$.
 In dB $A_v = 20 \log(15.4) = 23.75 \text{ dB}$.

d) $v_I = V_I + V_i \cos(\omega t)$

$$v_o = 12 - 10(v_I - 3)^2 = 12 - 10(V_I + V_i \cos(\omega t) - 3)^2$$

$$v_o = 12 - 10((V_I - 3)^2 + (V_i \cos(\omega t))^2 + 2(V_I - 3)V_i \cos(\omega t))$$

$$v_o = 12 - 10\left((V_I - 3)^2 + (V_i)^2 \left(\frac{1+\cos(2\omega t)}{2}\right) + 2(V_I - 3)V_i \cos(\omega t)\right)$$

$$v_o = 12 - 10(V_I - 3)^2 - 5(V_i)^2 - 5(V_i)^2 \cos(2\omega t) - 20(V_I - 3)V_i \cos(\omega t)$$

DC component = $12 - 10(V_I - 3)^2 - 5(V_i)^2$; where $V_I = 3.77 V$.

$$A_2 = -5(V_i)^2$$

$$A_1 = -20(V_I - 3)V_i$$

$$\left| \frac{A_2}{A_1} \right| = \frac{V_i}{4(V_I - 3)} < 0.01; \text{ so that } V_i < 0.04(V_I - 3) = 0.04(3.77 - 3) = 0.0308 V.$$

Problem 2

a) The output saturation is $\pm 11V$. The *peak-to-peak* value of the largest sinusoidal wave is $0.5V$. Since the amplifier has linear transfer function

$$A_v = \frac{11 - (-11)}{0.5} = 44 \text{ V/V}, \text{ in dB } A_v = 20 \log(44) = 32.87 \text{ dB}.$$

b) The output power is $P_o = \frac{V_{orms}^2}{R} = \frac{\left(\frac{11}{\sqrt{2}}\right)^2}{32} = 1.89 \text{ W}$.

c) The power gain is $A_p = \frac{P_o}{P_{in}} = 189 \text{ W/W}$.

In dB, $A_p = 10 \log(189) = 22.76 \text{ dB}$.

$$A_i = \frac{A_p}{A_v} = \frac{189}{44} = 4.295 \text{ A/A. In dB, } A_i = 20 \log(4.295) = 12.66 \text{ dB.}$$

$$\text{d) } \eta = \frac{P_L}{P_{dc}} \times 100$$

$$P_{dc} = 12.7 * 200 + 12.7 * 200 = 5080 \text{ mW.}$$

$$\eta = \frac{1.89}{5.08} \times 100 = 37.2\%.$$