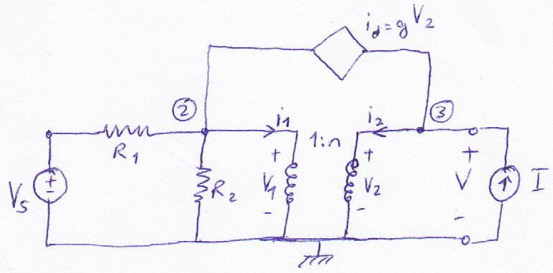
2017-2018 Spring BoEC

Solution of HW7

First find the Thevenin equivalent of the circuit.



② $-G_1 V_s + (G_1 + G_2) e_2 - i_d + i_1 = 0$

$i_d = g V_2 = g V$

$V_2 = n V_1$

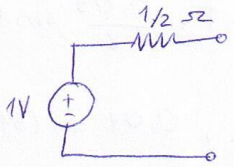
$V = 2 e_2$

$i_1 = -2 i_2$

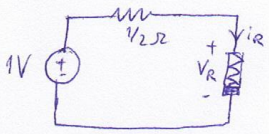
③ $i_d + i_2 - I = 0$

$i_d = g V$

$\Rightarrow V = \frac{1}{2} I + \frac{V_s}{4} = \frac{1}{2} I + 1 \rightarrow$



Now we add the nonlinear resistor to the Thevenin equivalent.



$1 - \frac{1}{2} i_R - (i_R^2 - \frac{7}{2} i_R - 3) = 0$

$i_R^2 - 3 i_R - 4 = 0$

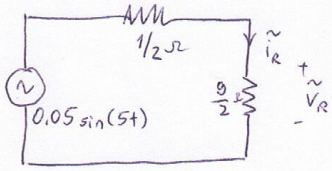
$i_{R_1} = -1 \qquad i_{R_2} = 4$

$\Rightarrow i_{R_Q} = 4A \rightarrow V_{R_Q} = 4^2 - \frac{7}{2} \cdot 4 - 3 = -1V$

small signal analysis:

$$V_{R(i_R)} = i_R^2 - \frac{7}{2} i_R - 3 \quad \rightarrow \quad V_R'(i_R) = 2 i_R - \frac{7}{2}$$

$$V_R'(i_R = i_{RQ} = 4) = 2 \cdot 4 - \frac{7}{2} = \frac{9}{2}$$



$$\tilde{i}_{R(t)} = \frac{0,05 \sin(5t)}{\frac{1}{2} + \frac{9}{2}} = 0,01 \sin(5t)$$

$$\tilde{V}_{R(t)} = \frac{9}{2} \tilde{i}_{R(t)} = \frac{0,09}{2} \sin(5t)$$

$$V_R(t) \cong -1 + \frac{0,09}{2} \sin(5t)$$

$$i_R(t) \cong 4 + 0,01 \sin(5t)$$

2) $V_{1Q} = V_s = 5V$ $\quad i_{2Q} = I_{s1} = 2A$

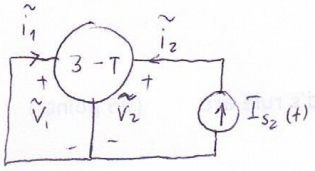
$V_{2Q} = i_{2Q}^2 + i_{1Q} V_{1Q} \rightarrow V_{2Q} = 2^2 + i_{1Q} 5 \searrow V_{2Q} = \frac{11}{8} V$

$i_{1Q} = \frac{V_{1Q}}{2} - V_{2Q} \rightarrow i_{1Q} = \frac{5}{2} - V_{2Q} \nearrow i_{1Q} = \frac{9}{8} A$

$V_2 = i_2^2 + i_1 V_1 \rightarrow \tilde{V}_2 = 2 i_2 \Big|_Q \tilde{i}_2 + V_1 \Big|_Q \tilde{i}_1 + i_1 \Big|_Q \tilde{V}_1$

$\tilde{V}_2 = 4 \tilde{i}_2 + 5 \tilde{i}_1 + \frac{9}{8} \tilde{V}_1$

$i_1 = \frac{V_1}{2} - V_2 \rightarrow \tilde{i}_1 = \frac{1}{2} \tilde{V}_1 - \tilde{V}_2$



$\tilde{V}_1 = 0$

$\tilde{i}_{2(t)} = I_{s2(t)} = 0{,}03 \cos(3t)$

$\tilde{i}_1 = -\tilde{V}_2 \qquad \tilde{V}_2 = 4 \tilde{i}_2 + 5 \tilde{i}_1$

$\tilde{V}_2 = 4 \cdot 0{,}03 \cos(5t) + 5(-\tilde{V}_2) \Rightarrow \tilde{V}_{2(t)} = 0{,}02 \cos(3t)$

$\tilde{i}_1 = -0{,}02 \cos(3t)$