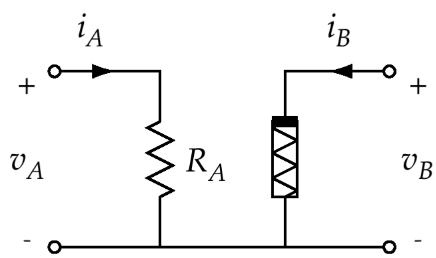
Inter American University of Puerto Rico
Bayamón Campus
School of Engineering
Department of Electrical Engineering

ELEN 3311 – Electronics I

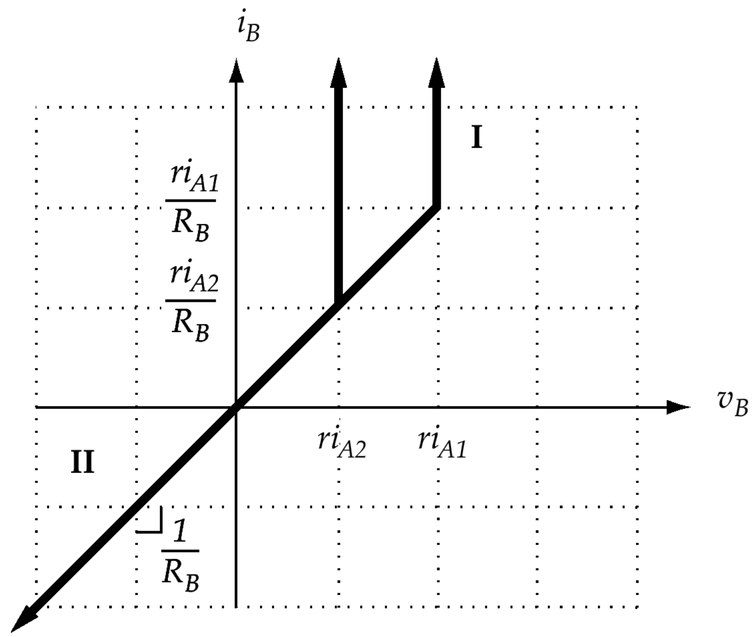
Final Exam Review Problems

Problem 1: The nonlinear resistor inside the three-terminal device shown below is characterized by the equations:

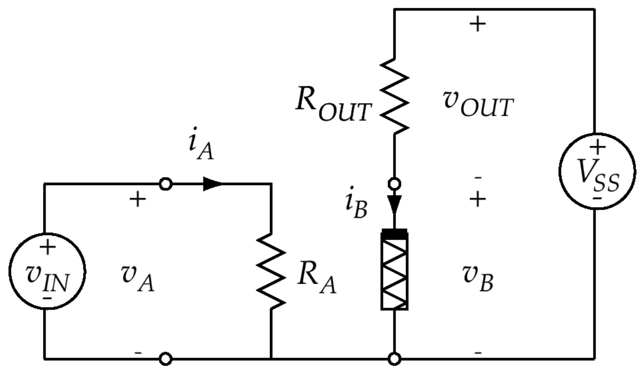
$v_B = ri_A$	$i_B \geq \dfrac{r}{R_B} i_A$	Region I
$i_B = \dfrac{v_B}{R_B}$	$v_B \leq ri_A$	Region II



These equations trace the following curves in the v_B-i_B plane for $i_{A1} > i_{A2} > 0$:



The three-terminal resistor is placed inside the circuit shown below:



(A) Find an algebraic equation for the v_B-i_B constraint imposed by the external circuit and graph this load line in the v_B-i_B plane. Mark the points corresponding to solutions of the circuit.

(B) Find an algebraic expression for the v_{IN}-v_{OUT} relation in each region. Find the small-signal gain $\frac{v_{out}}{v_{in}}$ for each region using these expressions.

(C) Find the range of v_{IN} for which the circuit is operating in each region independently and verify that the regions complement each other.

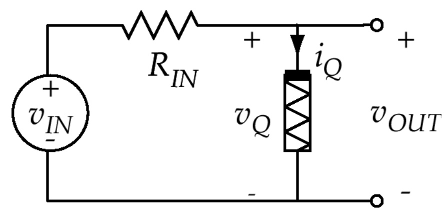
(D) Find the value of v_{OUT} at each transition between regions of operation independently and verify that the values of v_{OUT} are the same.

(E) Plot the v_{IN}-v_{OUT} relation showing clearly all transition values, any intercepts and/or any asymptotes.

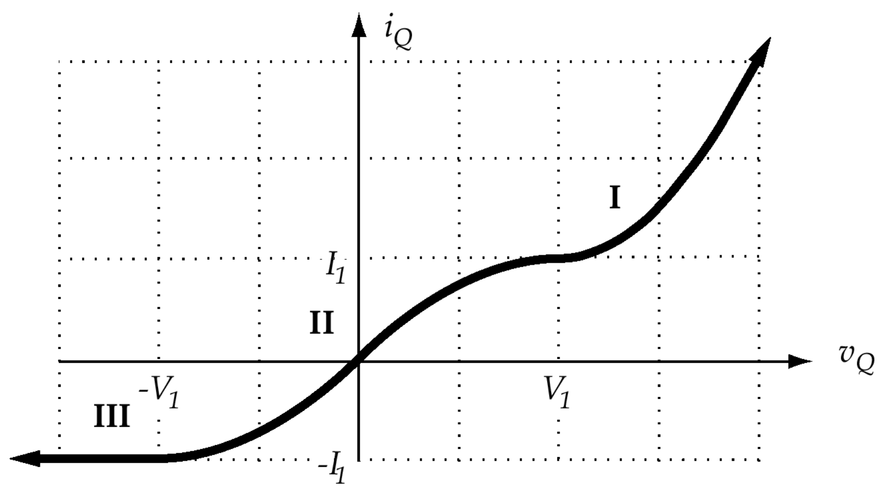
(F) Draw the small-signal circuit diagram for each region and find the small-signal gain. Verify that each gain is the same as the one found before. Remember that all elements in the small-signal circuit must be linear.

Problem 2: The nonlinear resistor inside the circuit shown below is characterized by the equations:

$$
\begin{array}{lll}
i_Q = \alpha(v_Q - V_1)^2 + I_1 & v_Q \geq V_1 & \text{Region I} \\
i_Q = I_1 \sin\left(\dfrac{\pi}{2}\dfrac{v_Q}{V_1}\right) & -V_1 \leq v_Q \leq V_1 & \text{Region II} \\
i_Q = -I_1 & v_Q \leq -V_1 & \text{Region III}
\end{array}
$$



These equations trace the following curve in the v_Q-i_Q plane:



(A) Find an algebraic equation for the v_Q-i_Q constraint imposed by the external circuit and graph these load lines in the v_Q-i_Q plane for $v_{IN} > 0$ and $v_{IN} < 0$. Mark the points corresponding to solutions of the circuit.

(B) Find an algebraic expression for the v_{IN}-v_{OUT} relation in each region. Do not solve the equations for v_{OUT} (for some regions, you can't!). Find the small-signal gain $\frac{v_{out}}{v_{in}}$ for each region using these expressions. Remember that $\frac{v_{out}}{v_{in}} = \left[\frac{v_{in}}{v_{out}}\right]^{-1}$, but $\frac{dv_{OUT}}{dv_{IN}} \neq \left[\frac{dv_{IN}}{dv_{OUT}}\right]^{-1}$!

(C) Draw the small-signal circuit diagram for each region and find the small-signal gain. Verify that each gain is the same as the one found before. Remember that all elements in the small-signal circuit must be linear.