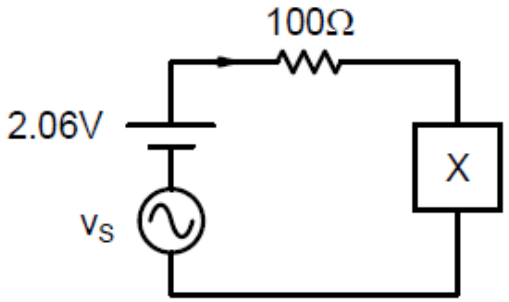
EE210: HW-2

Date: 16.01.2019

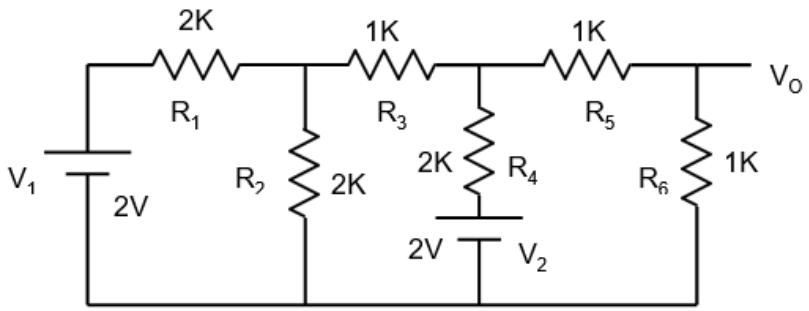
Q.1 (a) A two terminal element X has I-V characteristics given by the relation $I_x = V_x{}^6$. A simple model for this device is a constant voltage of V_α. Determine this voltage, if the model is to be used in the current range 10mA-100mA. Determine the % error in the use of such a model over the specified current range. Will the error reduce if the non-linearity in the device became stronger (a higher order polynomial)?
(b) A battery of 5V is in series with a resistor and the element X. Determine an approximate value for the maximum % error in current, when the above model is used. (Note that error would increase as supply voltage gets closer to the voltage V_α.)
(c) What would be a new suitable value of V_α, if the current range is changed to 1µA-10µA? (Note that a model is a representation for a purpose).

Q.2 An improved model for the element X is a constant voltage source V_α in series with a resistor R_α. Determine values of these elements for the current range 10mA-100mA.

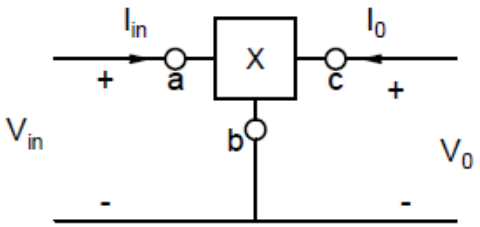
Q.3 (a) Determine the small signal model for element X, when it is biased at a voltage of 0.5V. Show that the small signal voltage across X has to be less than or equal to 21mV for error in small signal current to be less than or equal to 10%.
(b) How large can the ac voltage in the circuit be for the small signal model to be valid (with error < 10%) in the following circuit? (Note that X has a dc bias of 0.5V).

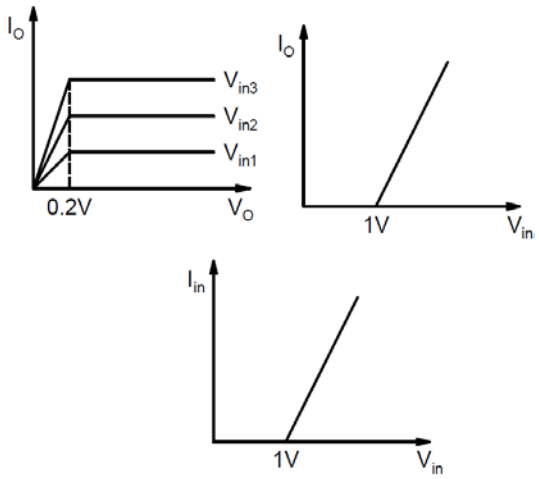


Q.4 For the circuit shown below, V_o = 0.5V and I_{R1} = 0.5mA for the given values of components. Using the small signal analysis technique, determine the approximate change in output voltage, if R_1 changes by 10%.



Q.5 A hypothetical 3-terminal (a, b & c) unilateral device (shown below) has the following characteristics.





$I_O = 0$ for $V_{in} \le 1$ for all values of V_O

$= 0.05 \times (V_{in} - 1)$ for $V_{in} > 1V, V_O \ge 0.2V$

$= 0.05 \times (V_{in} - 1) \times \frac{V_o}{0.2}$ for $V_{in} > 1V, 0 \le V_O \le 0.2V$

$= 0$ for $V_O \le 0$

$I_{in} = 0.001 \times (V_{in} - 1)$ for $V_{in} > 1V$ and 0 for $V_{in} \le 0$

Determine the small signal model of the device around the bias point V_{in} = 1.5V and two values of output voltage V_o = 0.1V and V_o = 2V.