EE 42 Introduction to Digital Electronics

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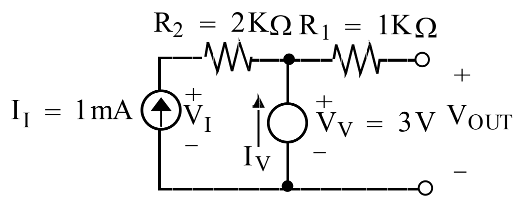
Course Website **www-inst.eecs.Berkeley.edu/~ee42/**

EE42 Midterm #1 – Solutions
2 October 2003

I. (25 points) Basic Circuit Analysis



a) (13 pts.) Find V_{OUT} and voltage on the current source V_{I} when the output is open circuited.

$$I_{R_1} = 0 \Rightarrow V_{\text{OUT}} = V_{\text{V}} = 3\text{V}$$

$$V_{\text{I}} = I_{\text{I}} R_2 + V_{\text{V}} = (1\text{mA})(2K) + 3 = 5\text{V}$$

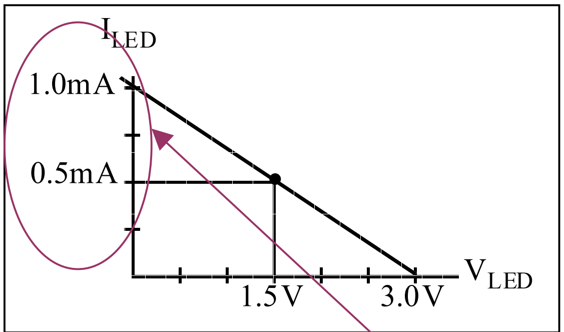
b) (12 pts.) Find the current on the voltage source I_{V} when the output is shorted.

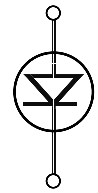
$$\text{Short} \Rightarrow I_{R_1} = \frac{3V}{1K\Omega} = 3\text{mA}.$$

$$I_{\text{I}} + I_{\text{V}} - I_{R_3} = 0$$

$$I_{\text{V}} = I_{R_3} - I_{\text{I}} = 3\text{mA} - 1\text{mA} = 2\text{mA}$$

II. (25 points) Load Lines





LED Device
Desired operating point

$$V_{LED} = 1.5$$
$$I_{LED} = 5\text{mA}$$

a) (15 pts.) Choose a Thévenin voltage in the range from 1 to 4 volts and a Thévenin resistance in the range 400 to 4k ohms to operate the LED device at the desired operating point given above. Values found from a graphical solution are adequate.

$$V_{Th} = 3\text{V}$$
$$R_{Th} = \frac{3\text{V}}{1\text{mA}} = 3k\Omega$$

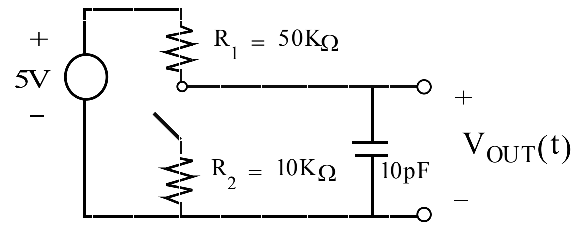
Error in Solution: Point is 5 mA and intercept is 10 mA. This make the resistance 10 times smaller at 300 ohms. A workable solution is 4V and 500 ohms. This problem will be graded on the methodology that you used and the values that you show.

b) (10 pts.) For your choice in a), above, what fraction of the power delivered by the Thévenin voltage source is consumed by the load?

$$\frac{P_{???}}{P_{SUP}} \frac{= I_{LED}V_{LED}}{= I_{LED}V_{SUP}} = \frac{V_{LED}}{V_{SUP}} = 0.50$$

III. (25 points) Transient

This circuit charges when the switch is open and discharges when the switch is closed.



a) (6 pts.) Determine the maximum and minimum voltage on the capacitor.

$$\text{MAX} = 5\text{V} \qquad I_{R_1} = 0$$

$$\text{MIN} = \frac{R_2}{R_1 + R_2} 5\text{V} = \frac{10}{10+50} 5\text{V} = \frac{5}{6}\text{V}$$

b) (13 pts.) Find $V_{\text{OUT}}(t)$ in discharging the capacitor.

$$V_{\text{OUT}}(t) = V_{\text{FINAL}} + (V_{\text{INITIAL}} - V_{\text{FINAL}})e^{-t/\tau}$$

$$V_{\text{FINAL}} = \frac{5}{6}\text{V} \qquad V_{\text{INITIAL}} = 5\text{V}$$

$$\tau = \frac{R_1 R_2}{R_1 + R_2} c = \frac{10 \cdot 50}{10+50} c = \frac{50}{6} K\Omega\, 10\text{pF} = \frac{500}{6}\text{ns}$$

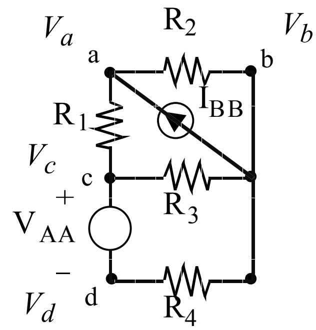
$$V_{\text{OUT}}(t) = \frac{5}{6}V + \left(\frac{25}{6}V\right)e^{-t/833\text{ns}}$$

c) (6 pts.) Find the initial current out of the capacitor when discharging the capacitor.

$$\text{At } t = 0^+ \qquad V_c - 5V, \text{ so } I_{R_1} = 0$$

$$I_{R_2} = \frac{5V}{R_2} = \frac{5V}{10K\Omega} = 0.5\text{mA}$$

IV. (25 points) Node Equations



a) (5 pts.) Six nodes are shown. Determine the nodes that have potentially different voltages and assign only these nodes a label $a, b, c\ldots$ and voltage $V_a, V_b, V_c \ldots$.

b) (5 pts.) Choose one of the remaining nodes as a reference and set its voltage to zero. Which of your remaining nodes have nonzero voltages that cannot be found directly from the voltages of the other nodes? In other words, how many unknown node voltages are there and node equations are you going to need?

$V_b = 0 \qquad V_a, V_c \qquad$ as V_d easy to get

c) (15 pts.) Using the node equation method and your node labeling in a), above, write a sufficient set of equations to solve for the unknown node voltages. [Only V_{AA}, I_{BB}, the resistors and your node voltages from b) should appear.]

$$\frac{V_a - 0}{R_2} - I_{BB} + \frac{V_a - V_c}{R_1} = 0$$

$$\frac{V_c - V_a}{R_1} + \frac{V_c - 0}{R_3} + \frac{V_c - V_{AA}}{R_4} = 0$$