EE 49 Midterm 1 Solutions

March 9, 2019

Q1)

1) 5
2) $101 = 16 * 6 + 5 = 0\text{x}65$
3) True
4) False
5) False
6) 0

Q2)

$$P = \frac{V^2}{R}$$
$$\frac{P_a}{P_b} = \frac{R_{eqb}}{R_{eqa}}$$
$$\frac{P_a}{P_b} = \frac{2R}{R/2}$$
$$\frac{P_a}{P_b} = 4$$

Q3)

$$R_{2||3} = (1/6.25 + 1/25)^{-1}$$
$$R_{2||3} = 5$$

$$I_{R_1} = 10V/10k\Omega$$
$$I_{R_1} = 1mA$$

current divider:

$$I_{R_3} = 1mA \cdot \frac{25}{6.25 + 25}$$
$$I_{R_3} = 0.8mA$$

$$i_x = -0.8mA$$

Q4)

P_{del} is the positive power flowing out of the device, therefore positive current is defined as current leaving the device.
All currents in this calculation are given in mA and all volts in V, resulting in units of mW.

First we solve for the missing current value:

$$5 - 3 + i + 10 - 8 = 0$$
$$i = -4$$

Then, starting at the top left wire leaving the device and summing counter-clockwise:

$$(-6) \cdot (5) + (3) \cdot (-3) + (-4) \cdot (-4) + (0) \cdot (10) + (6) \cdot (7) + (4) \cdot (-15) = -41mW$$

Q5)

a) The plot will be a decreasing exponential, with the $t = 0$ point marked as 5V and the $t = \infty$ point marked as 0V.

b)

$$
\begin{aligned}
v_o &= L_1 \frac{di}{dt} \\
v_o &= L_1 \frac{d}{dt} \frac{(v_i - v_o)}{R} \\
\frac{d}{dt} v_o &= -\frac{R}{L} v_o \\
v_o &= C e^{-\frac{R}{L} t} \\
v_o &= 5 e^{-10^6 t}
\end{aligned}
$$

0s: 5V
2s: ≈ 0
∞: 0V

Q6)

$$
\begin{aligned}
i_1 &= \frac{V_1}{R_1} \\
v_o &= -R_2 \cdot i_1 \\
&= -\frac{R_2 \cdot V_1}{R_1}
\end{aligned}
$$

$$
\begin{aligned}
i_3 &= \frac{v_o}{R_3} \\
&= -\frac{R_2 \cdot V_1}{R_1 \cdot R_3}
\end{aligned}
$$

$$
\begin{aligned}
i_o &= -(i_1 - i_3) \\
&= -(\frac{V_1}{R_1} + \frac{R_2 \cdot V_1}{R_1 \cdot R_3}) \\
&= -(\frac{1}{1000} + \frac{3000 \cdot 1}{1000 \cdot 6000}) \\
&= -1.5mA
\end{aligned}
$$

Q7)

a) Calculations in milliamps:

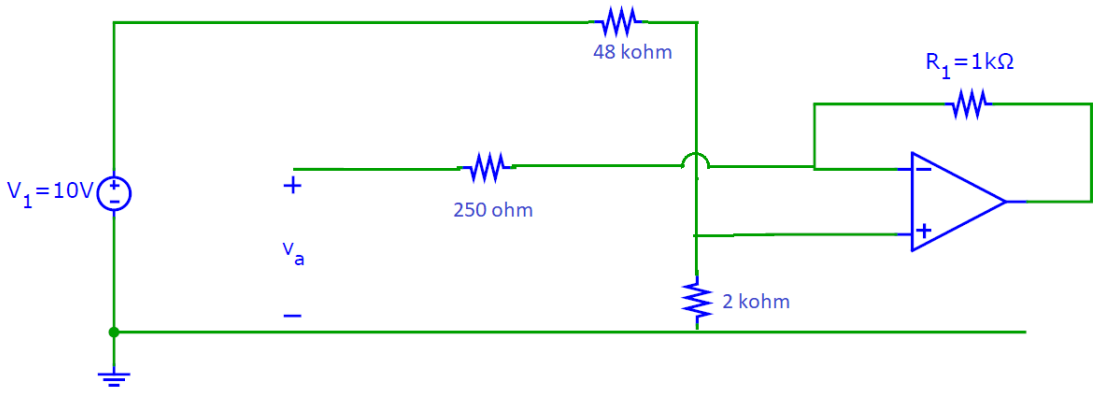
$$\begin{aligned} 10 &= d \cdot 100 + (1-d) \cdot 0.1 \\ 9.9 &= 99.9 \cdot d \\ d &\approx 0.0991 \text{ (9.91\% time on)} \end{aligned}$$

b)

$$\begin{aligned} I_{avg} &= 0.1 \cdot 100 + (1-0.1) \cdot 0.1 \\ &= 10.09mA \end{aligned}$$

$$\begin{aligned} T &= \frac{1Ah}{I_{avg}} \\ &= \frac{1}{.01009} \\ &\approx 99.1h \end{aligned}$$

Q8)



$$v_+ = V_1 \frac{2}{48+2}$$
$$= \frac{2V}{5}$$

$$i_- = \frac{v_a - v_-}{250}$$

$$v_o = v_- - R_1 \cdot i_-$$
$$= \frac{2V}{5} - 4 \cdot (v_a - \frac{2V}{5})$$
$$= 2V - 4v_a$$