Faculty of Engineering

ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

EENG223 Circuit Theory I

Fall 2006-07

Instructor:

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Midterm EXAMINATION

Nov 24, 2006

Duration: 100 minutes

Number of Problems: 4

Good Luck

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1. (a) The current that enters an element is shown in Fig. P1(a).
   a) Write the current expression between $0 < t < 20s$ (5 pts.)
   b) Find the charge that enters the element in the time interval $0 < t < 20s$ (5 pts.)

   Figure P1(a)

   \[
   i(t) = \begin{cases} 
   10 \times 10^{-3} \text{ A} & 0 < t < 10s \\
   (-t + 20) \times 10^{-3} & 10 < t < 20s 
   \end{cases} 
   \]

   \[
   q(t) = \int_0^{10} idt + \int_{10}^{20} ((-t + 20) \times 10^{-3}) dt 
   \]

   \[
   q(t) = 100 \times 10^{-3} + 50 \times 10^{-3} = 150 mC 
   \]
1. (b) Find $R_{AB}$ in the circuit in Fig. P1(b). (5 pts.)

$$R_{AB} = 6k \|(6k + 9k \| 18k) \| 12k$$

$$R_{AB} = 3k\Omega$$
1. (c) Combine sources and use the voltage division principle to find $V_{ab}$ in the circuit in Fig.P1(c). (5 pts.)

$$V_{ab} = -15 \frac{4}{15} = -4V$$

Figure P 1(c)
1. (d) Use current division principle to find $I_0$ in the circuit in Fig. P1(d) and the power supplied by 12-mA current source. (5 pts.)

![Figure P 1(d)](image)

$I_0 = 12m \frac{12k}{16k} = 9mA$

$V = V1 + V2 = 2k (12m) + 4k (9m) = 60V$

$P_{12mA} = -12 \times 10^{-3} (60) = -720mW$ supplied
2. Use nodal analysis to find $I_o$ in the circuit in Fig. P2.

![Figure P 2](image)

KCL at the supernode:

$$\frac{v_i - 12}{2k} + \frac{v_i - 12}{1k} - 3m + \frac{v_i}{2k} + \frac{v_i}{2k} + 4 = 0$$

Multiply both sides by 2k yields:

$$v_i - 12 + 2v_i - 24 - 6 + v_i + v_i + 4 = 0$$

$$5v_i = 38$$

$$v_i = \frac{38}{5} = 7.6V$$

$$I_o = \frac{v_i}{2k} = 3.8mA$$
3. Use mesh analysis to find the power dissipated in the 1Ω resistor in the circuit in Fig.P3.

![Figure P 3](image)

**KVL around the supermesh:**

\[-10 + 2i_1 + 2(i_1 - i_2) + 2(i_2 - i_3) = 0\]
\[4i_1 + 2i_2 - 4i_3 = 10\]

\[\text{(1)}\]
KVL around $i_3$:

\[-2(i_2 - i_3) - 2(i_1 - i_3) - 6 + 4i_3 = 0\]
\[-2i_1 - 2i_2 + 5i_3 = 6 \ldots \ldots \ldots \ldots (2)\]

KCL at node $a$:

\[-i_2 + i_1 + 2 = 0\]
\[\text{or}\]

\[i_2 = i_1 + 2 \ldots \ldots \ldots \ldots (3)\]

Subst. of Eq.(3) into (1) and (2) and solving for $i_3$ yields:

\[i_3 = 6 \text{A}\]

\[\therefore P_\Omega = (i_3)^2 \cdot 1 = 36 \text{W}\]
4. Find the value of $I_0$ in the circuit in Fig. P4 using
   
   a) Superposition
   b) Source transformation

![Figure P 4]

**a) Superposition**

6 V voltage source is active:

$$R_T = 6k + 6k \parallel (6k + 6k) = 10k\Omega$$

$$I_T = \frac{6}{10k} = 0.6mA$$

$$I_0' = \frac{6 \times 10^{-3}}{6k + 12k} = 0.2mA$$

1 mA current source is active:

$$R_{EQ} = 6k + 6k \parallel 6k = 9k\Omega$$

$$I_0'' = -1 \times 10^{-3} \times \frac{R_{EQ}}{R_{EQ} + 6k} = -1 \times 10^{-3} \times \frac{9k}{15k} = -0.6mA$$

$$\therefore I_0 = I_0' + I_0'' = 0.2m - 0.6m = -0.4mA$$
B) Source transformation

\[ I_0 = -\frac{2}{3} \times 10^{-3} \frac{9k}{9k + 6k} = -0.4mA \]