Eastern Mediterranean University
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Faculty of Engineering

ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

INFE221 – Electrical Circuits

Final Exam
Fall 2015-16

16 January 2015
Duration: 120 minutes

Instructor: M. K. Uyguroğlu

STUDENT'S	
NUMBER	
NAME	SOLUTIONS
SURNAME	

Problem		Points
1		25
2		25
3		25
4		25
TOTAL		100

Problem 1

Determine the output voltage V_0 in the circuit of Fig. P1

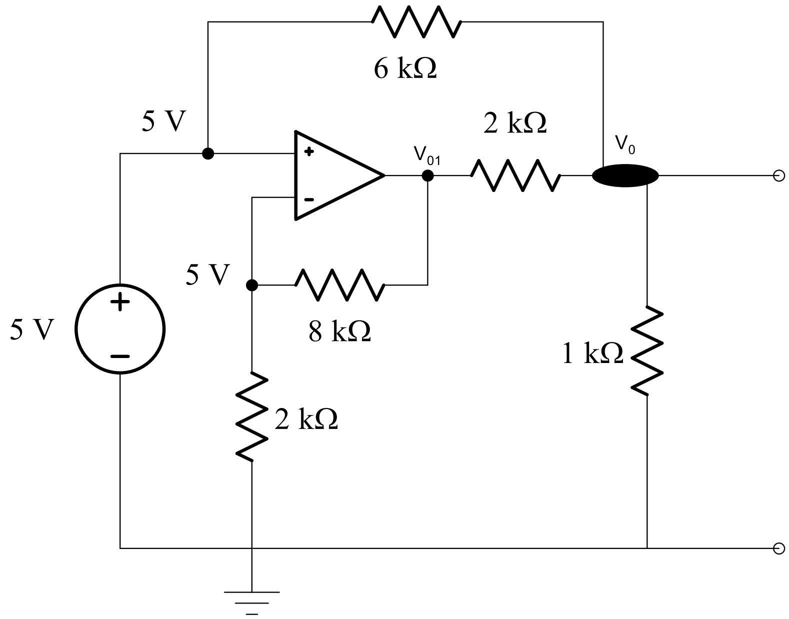


Figure P1

KCL at inverting input terminal yields:

$$\frac{5}{2k}+\frac{5-V_{01}}{8k}=0$$

Multiply both sides by $8k$

$$20+5-V_{01}=0 \Rightarrow \boxed{V_{01}=25\text{ V}}$$

KCL at V_0:

$$\frac{V_0-5}{6k}+\frac{V_0}{1k}+\frac{V_0-V_{01}}{2k}=0$$

Multiply both sides by $6k$ and substitute the value of V_{01}:

$$V_0-5+6V_0+3V_0-75=0$$

$$10V_0=80$$

$$\boxed{V_0=8\text{ V}}$$

Problem 2

Consider the circuit in Fig. P2. Under dc conditions, find:

(a) the power dissipated in 6Ω resistor and

(b) the energy stored in the capacitor and the inductors.

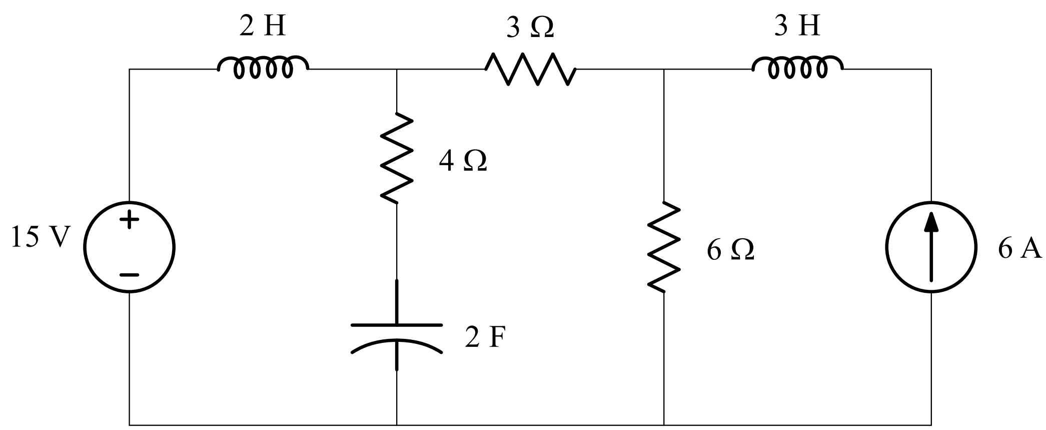
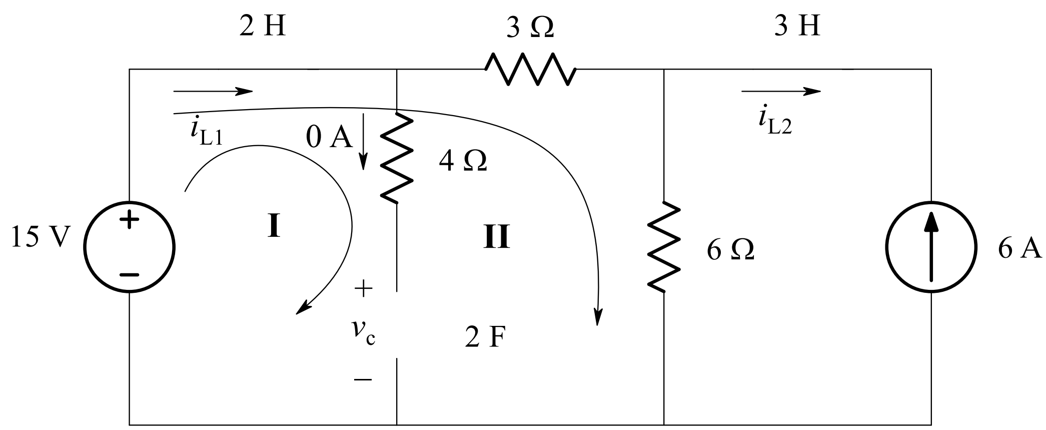


Figure P2

Under dc conditions, Inductors act like short circuits and capacitor acts like open circuit. Therefore the circuit becomes:



KVL around loop I:

$-15 + v_c = 0$

$\boxed{v_c = 15\text{ V}}$

It is obvious that $\boxed{i_{L2} = -6\text{ A}}$

Now, KVL around loop II:

$$-15+3i_{L1}+6(i_{L1}-i_{L2})=0$$

$$9i_{L1}=15+6i_{L2}=15+6(-6)=-21\text{ A}$$

$$\boxed{i_{L1}=\frac{-21}{9}=-\frac{7}{3}\text{ A}}$$

The power dissipated in 6Ω resistor:

$$P_{6\Omega}=i^2R=(i_{L1}-i_{L2})^2 6=\left(-\frac{7}{3}-(-6)\right)^2 6$$

$$P_{6\Omega}=\left(\frac{11}{3}\right)^2 6=\frac{121}{9}6=\frac{121}{3}2=\frac{242}{3}=80.67\text{ W}$$

The energy stored by 2 H inductor:

$$W_{2H}=\frac{1}{2}2\left(\frac{-7}{3}\right)^2=\frac{49}{9}J$$

The energy stored by 3 H inductor:

$$W_{3H}=\frac{1}{2}3\left(-6\right)^2=54J$$

The energy stored by 2F capacitor:

$$W_{2F}=\frac{1}{2}2\left(15\right)^2=225J$$

Problem 3

Consider the circuit in Fig.P3. Assume the switch has been open for a long time and is closed at $t = 0$.

Find

a) $v(0)$
b) $v(\infty)$
c) Time constant τ .
d) $v(t)$ for $t > 0$.

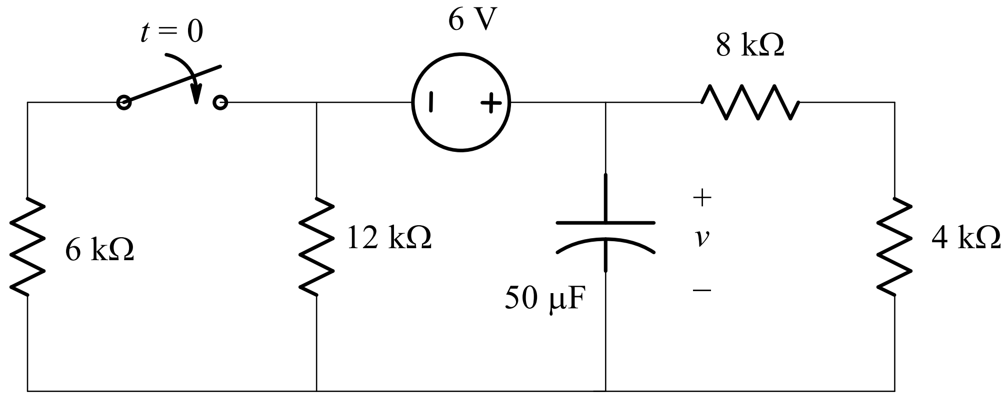
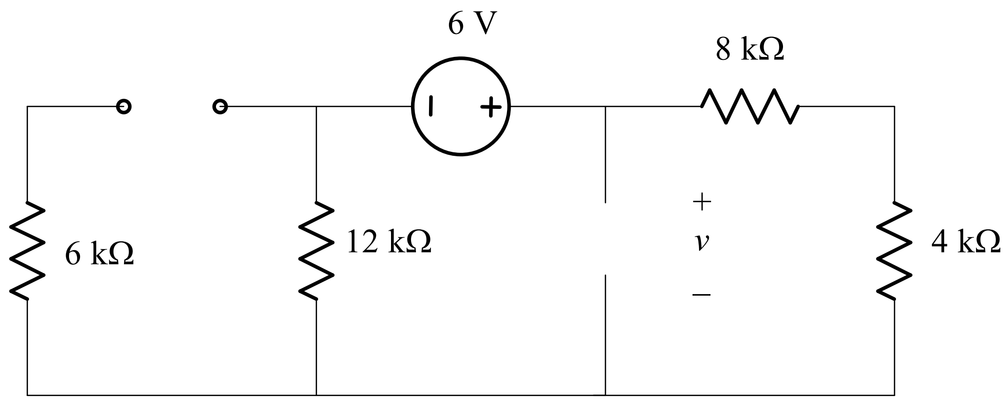


Figure P3

At $t = 0^-$ (just before the switching action, the circuit is under dc conditions.)



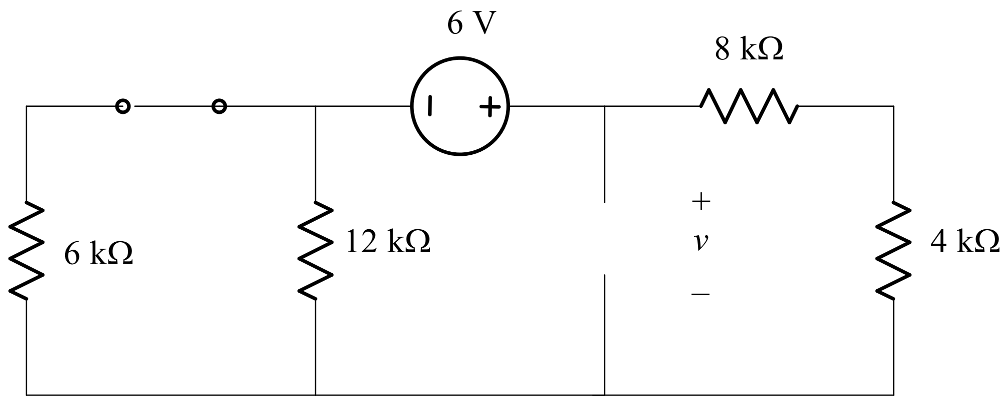
It is obvious that $v(0^-)$ is the voltage across $8k\Omega$ and $4k\Omega$ resistors. Therefore using voltage division principle:

$$v(0^-) = 6 \times \frac{(8k + 4k)}{8k + 4k + 12k} = 3 \text{ V}$$

Since the capacitor voltage cannot change instantaneously,

$v(0^+) = v(0^-) = v(0)$

At $t = \infty$ the circuit is under dc conditions as well.



$6k\Omega$ and $12k\Omega$ resistors are in parallel.

$$6k//12k = \frac{6k \times 12k}{6k + 12k} = 4k$$

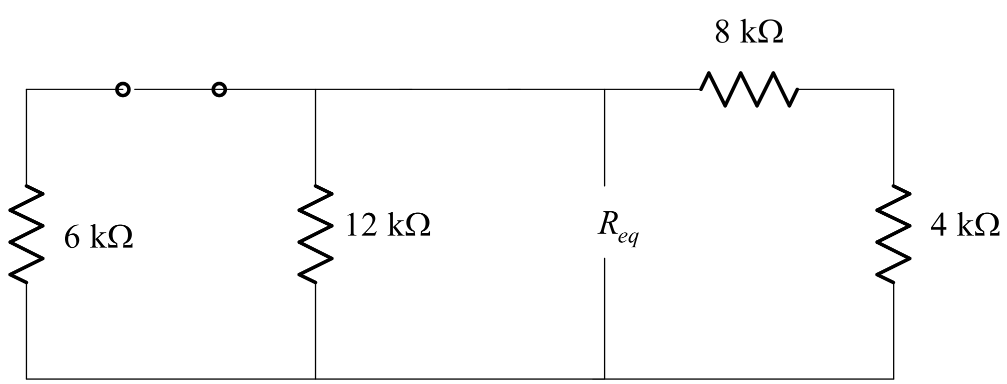
Therefore

$$v(\infty) = 6 \times \frac{8k + 4k}{8k + 4k + 4k} = 6 \times \frac{12}{16} = \frac{72}{16} = 4.5 \text{ V}$$

Time constant τ is:

$\tau = R_{eq} C$

In order to find R_{eq} all independent sources are set to zero.



$R_{eq} = 12k//6k//(8k + 4k) = 3k$

$\tau = 3k \times 50\mu = 150ms$

$$v(t) = v(\infty) + \left[v(0) - v(\infty)\right] e^{-\frac{t}{\tau}} = 4.5 + \left[3 - 4.5\right] e^{-\frac{t}{150m}} = 4.5 - 1.5e^{-\frac{t}{150m}} = 1.5\left(3 - e^{-\frac{t}{150m}}\right)$$

Problem 4

Determine i_x in the circuit of Fig. P4 using the phasor approach and superposition principle.

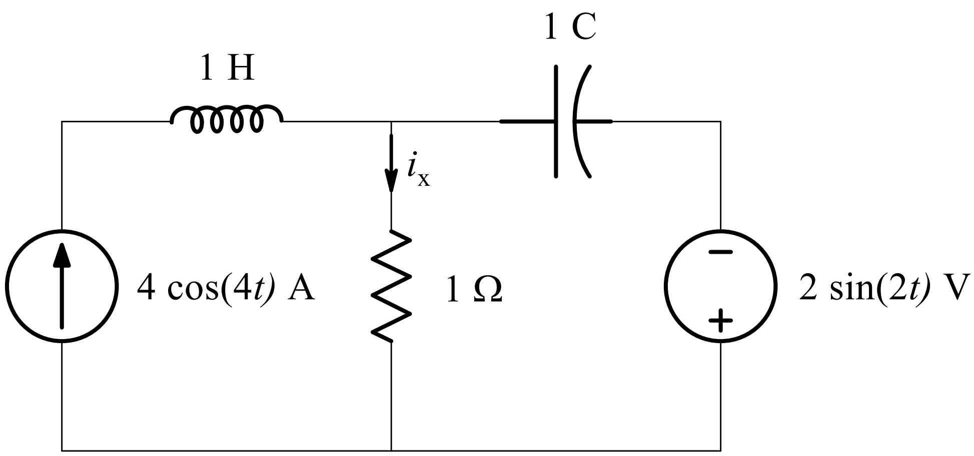
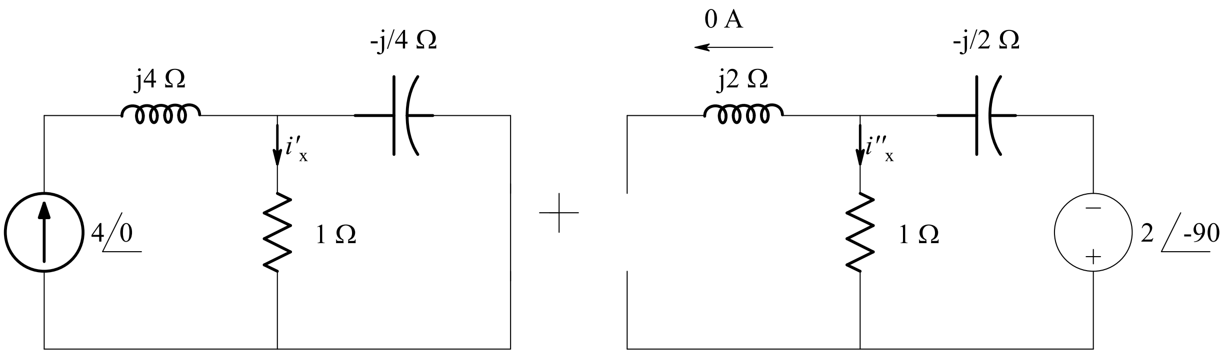


Figure P4



Using current division principle:

$$I'_x = \frac{4\angle 0\left(-\frac{j}{4}\right)}{1-\frac{j}{4}} = \frac{4\angle 0 \times \frac{1}{4}\angle -90}{1.0308\angle -14.036} = \frac{1\angle -90}{1.0308\angle -14.036} = 0.97\angle -75.96$$

$$i'_x = 0.96\cos\left(4t-75.96\right)$$

In order to find i''_x :

$$I''_x = -\frac{2\angle -90}{1-\frac{j}{2}} = -\frac{2\angle -90}{1.118\angle -26.565} = -1.79\angle -63.435 = 1.79\angle 116.565$$

$$i''_x = 1.79\cos\left(2t+116.565\right)$$

$$i''_x = 1.79\sin\left(2t+116.565+90\right) = 1.79\sin\left(2t+206.565\right)$$

Therefore

$$i_x = i'_x + i''_x = 0.96\cos\left(4t - 75.96\right) + 1.79\sin\left(2t + 206.565\right)$$