Eastern Mediterranean University

"For Your International Career"

Faculty of Engineering

ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

INFE221 – Electrical Circuits

Final Examination
Fall 2016-17

04 January 2017

Duration: <u>120 minutes</u>

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STUDENT'S	
NUMBER	
NAME	SOLUTIONS
SURNAME	

Problem		**Points**
1		30
2		30
3		30
4		30
TOTAL		**120**

Problem 1

The variable resistor in the circuit in Fig.P1 is adjusted for the maximum power transfer to R_0.

a) Find the value of R_0.

b) Find the maximum power that can be delivered to R_0.

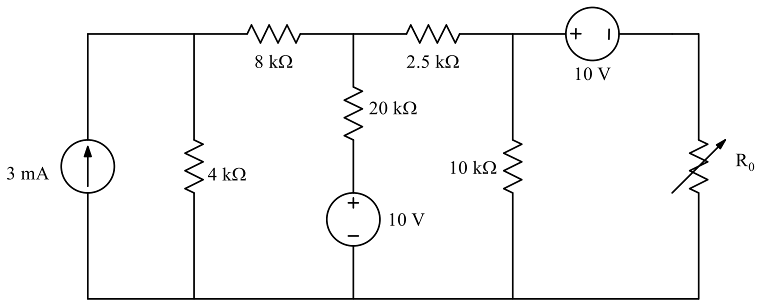
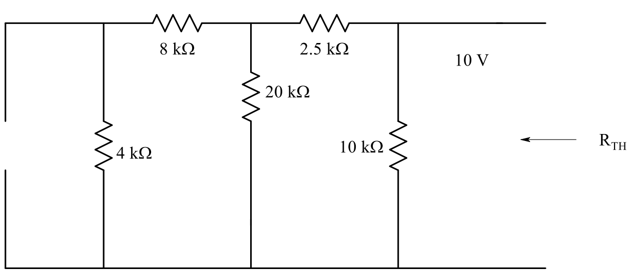


Figure P 1

When $R_0 = R_{TH}$ it will absorb maximum power.

In order to find R_{TH}, set all independent source values to zero.

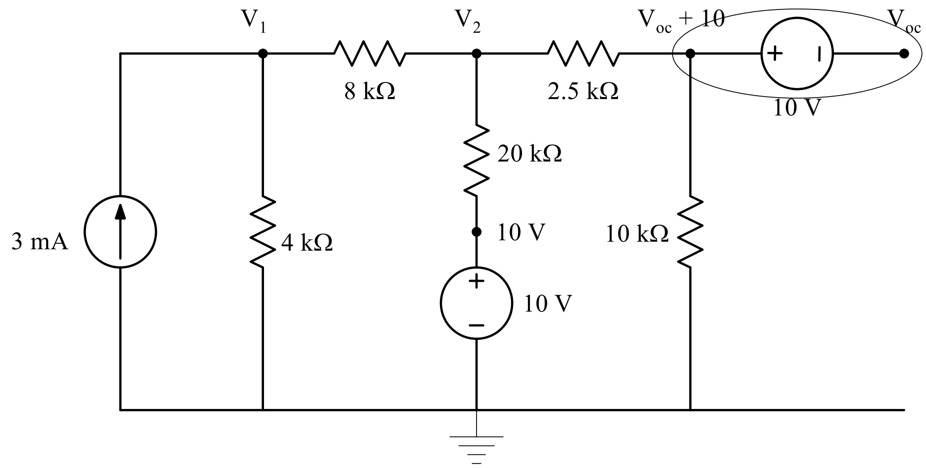


$$R_{TH} = \underbrace{\left(\underbrace{\underbrace{\underbrace{(8k + 4k)}_{12k} // 20k}_{7.5k} + 2.5k}_{10k} \right) // 10k}_{5k} = 5 \text{ k}\Omega$$

Therefore when $R_0 = 5 \text{ k}\Omega$ it will absorb maximum power.

Maximum Power $P_{\max} = \dfrac{V_{TH}^2}{4R_{TH}}$

For V_{TH}, open circuit voltage will be found.



KCL at V_1:

$\frac{V_1}{4k}+\frac{V_1-V_2}{8k}=3m$ multiply both sides by 8k: $3V_1-V_2=24$.....(1)

KCL at V_2:

$\frac{V_2-V_1}{8k}+\frac{V_2-10}{20k}+\frac{V_2-V_{oc}-10}{2.5k}=0$ multiply both sides by 40k: $23V_2-5V_1-16V_{oc}=180$.......(2)

KCL at $V_{oc}+10$:

$\frac{V_{OC}+10-V_2}{2.5k}+\frac{V_{OC}+10}{10k}=0$ multiply both sides by 10k: $5V_{OC}-4V_2=-50$......(3)

$\boxed{V_2=\frac{5V_{OC}+50}{4}}$...........(4)

Subst. of Eq. (4) into (1) and (2) yields:

$$3V_1-\frac{5}{4}V_{OC}=36.5$$

$$-5V_1+\left(\frac{115}{4}-16\right)V_{OC}=180-\frac{1150}{4}\ \Rightarrow -5V_1+12.75V_{OC}=-107.5$$

or

$$15V_1-6.25V_{OC}=182.5$$
$$-15V_1+38.25V_{OC}=-322.5$$

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$$32V_{OC}=-140$$

$$V_{OC}=-\frac{140}{32}=-4.375V$$

$$P_{\max}=\frac{(-4.375)^2}{4\times 5k}=0.957mW$$

Problem 2

The two op amps in the circuit in Fig. P2 are ideal. Calculate v_{01} and v_{02}.

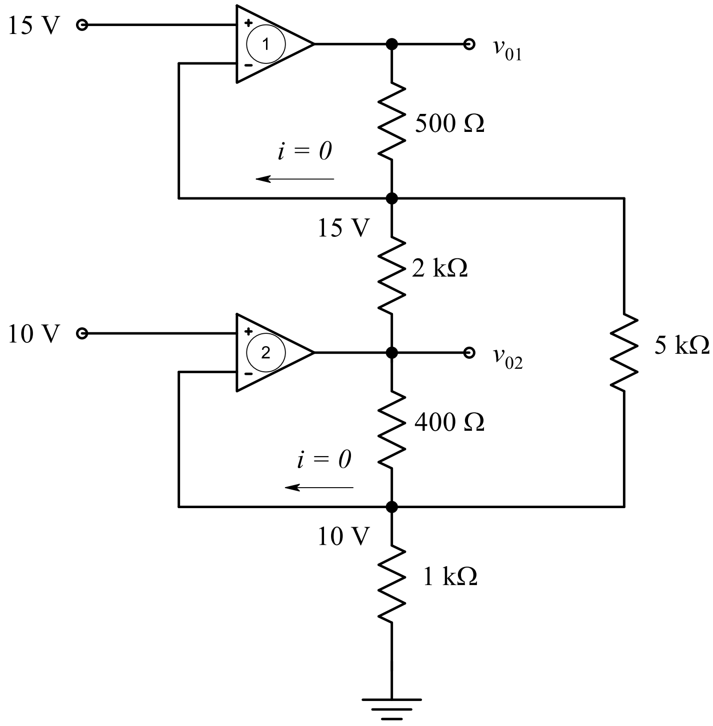


Figure P 2

KCL at inverting input terminal of op amp 2:

$$\frac{10}{1k}+\frac{10-v_{02}}{0.4k}+\frac{10-15}{5k}=0$$

Multiply both sides by 20k gives:

$$200+500-50v_{02}+40-60=0$$

$$50v_{02}=680$$

$$v_{02}=13.6\text{ V}$$

KCL at the inverting input terminal of op amp 1:

$$\frac{15-13.6}{2k}+\frac{15-10}{5k}+\frac{15-v_{01}}{0.5k}=0$$

Multiply both sides by 10k gives:

$$7+10+300-20v_{01}=0$$

$$v_{01}=\frac{317}{20}=15.85\text{ V}$$

Problem 3

The switch in the circuit shown in Fig. P3 has been open for a long time. The initial charge on the capacitor is zero. At $t=0$, the switch is closed. Find

a) $i(t)$ for $t>0$.

b) $v(t)$ for $t>0$.

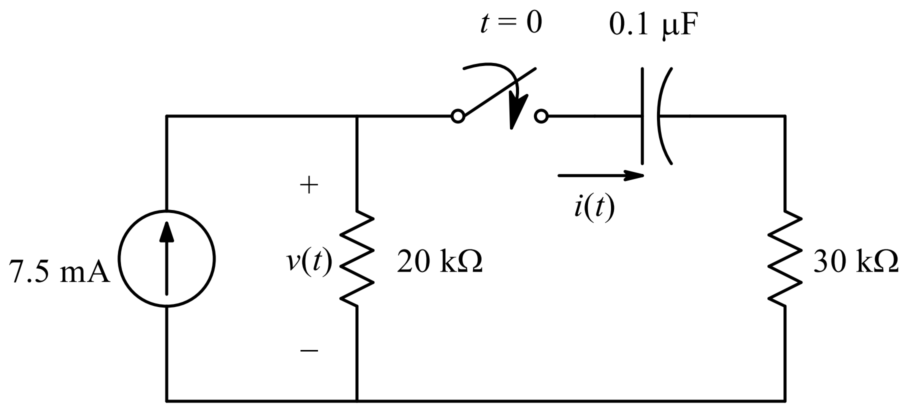
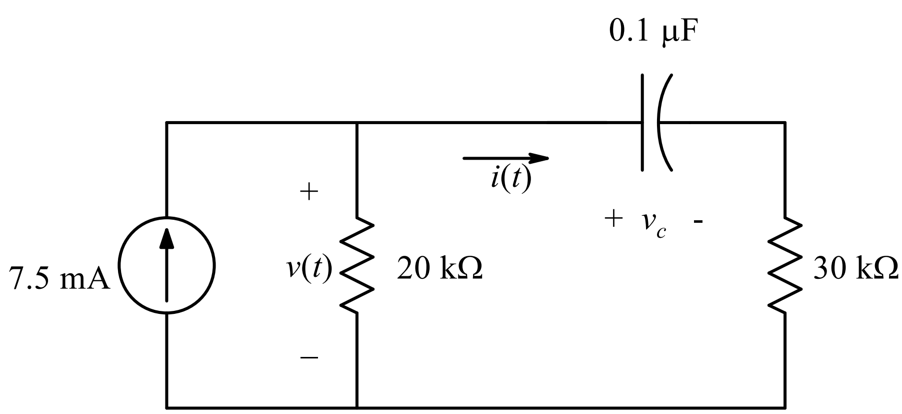


Figure P 3

For $t>0$:



Since there is a DC source in the circuit for t > 0, the voltage across the capacitor will be

$$v_c(t)=v_c(\infty)+\left[v_c(0)-v_c(\infty)\right]e^{-\frac{t}{\tau}}$$

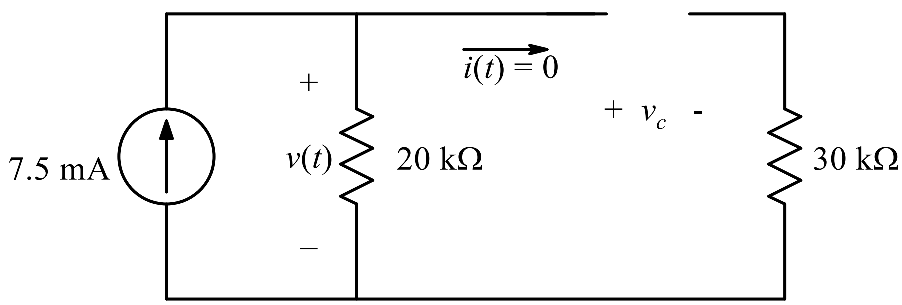
Where $v_c(0)=0$ (capacitor is initially uncharged) and $\tau=R_{eq}C$

Equivalent resistance seen by the capacitor is

$R_{eq}=20k+30k=50k\Omega$

$\tau=R_{eq}C=50k\times 0.1\mu=5ms.$

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

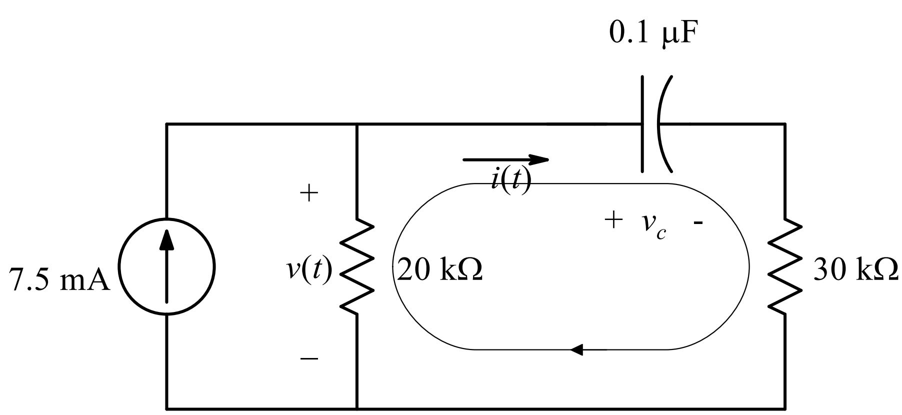


$v(\infty) = v_c(\infty) = 7.5m \times 20k = 150 \;\; V$

Therefore

$$v_c(t) = 150 + [0 - 150]e^{-200t} \;\; V$$

$$i(t) = C\frac{dv_c}{dt} = 0.1 \times 10^{-6} \times 30 \times 10^3 e^{-200t} \; = 3e^{-200t} \; mA.$$



KVL around the loop:

$v(t) = v_c(t) + i(t)30k = 150 - 150e^{-200t} + 90e^{-200t}$

$v(t) = 150 - 60e^{-200t}\, V$

Problem 4

The circuit in Fig. P4 is operating in the sinusoidal steady state. Find $v_0(t)$ if $i_s = 3\cos 200t$ mA.

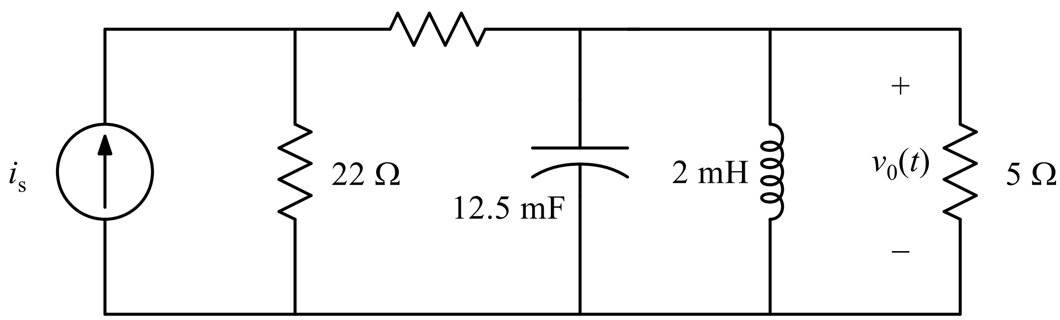


Figure P 4

Given:

Time domain representation	Phasor domain representation
$V_m \cos(\omega t + \phi)$	$V_m \underline{\vert \phi}$
$\frac{dv}{dt}$	$j\omega \mathbf{V}$
$\int v dt$	$\frac{\mathbf{V}}{j\omega}$

In phasor domain:

$\omega = 200 rad/s$

$i_s(t) = 3\cos 200t\, mA \to \mathbf{I}_s = 3\underline{\vert 0}\, mA$

$6\Omega \to 6\Omega$

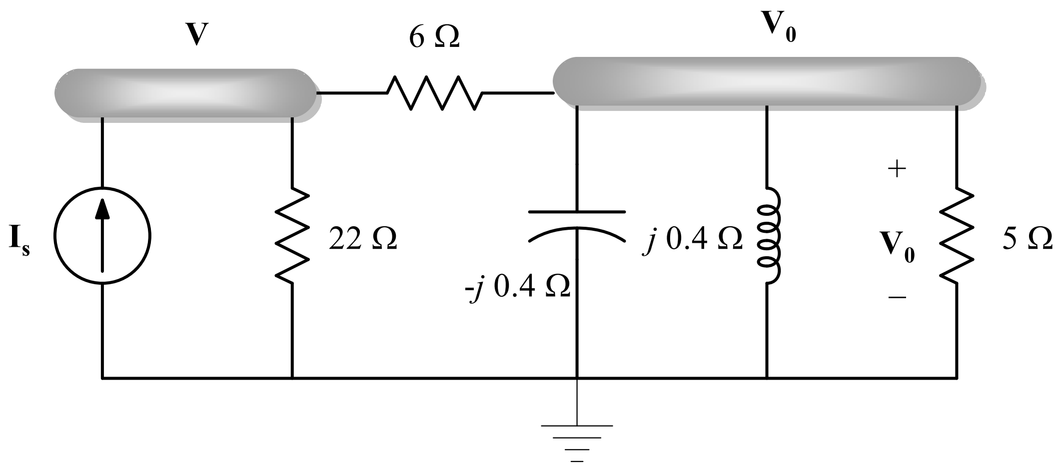
$22\Omega \to 22\Omega$

$5\Omega \to 5\Omega$

$$12.5mF \to \frac{1}{j200 \times 12.5 \times 10^{-3}} = -j0.4\Omega$$

$2mH \to j200 \times 2 \times 10^{-3} = j0.4\Omega$

Therefore, in phasor domain, the circuit will be



KCL at **V:**

$$\frac{\mathbf{V}}{22}+\frac{\mathbf{V}-\mathbf{V}_0}{6}=3\angle 0=3m$$

Multiply both sides by 66:

$$14\mathbf{V}-11\mathbf{V_0}=198m.......(1)$$

KCL at $\mathbf{V_0}$:

$$\cancel{\frac{\mathbf{V_0}}{-j0.4}}+\cancel{\frac{\mathbf{V_0}}{j0.4}}+\frac{\mathbf{V_0}}{5}+\frac{\mathbf{V}_0-\mathbf{V}}{6}=0$$

Multiply both sides by 30:

$$-5\mathbf{V}+11\mathbf{V_0}=0.........(2)$$

The addition of Eqns.(1) and (2) yields:

$$9\mathbf{V}=198m$$

$$\mathbf{V}=22mV$$

Using Equation (2)

$$\mathbf{V}_0=\frac{5}{11}\mathbf{V}=10mV\Rightarrow v_0\left(t\right)=10\cos\left(200t\right)\ mV.$$