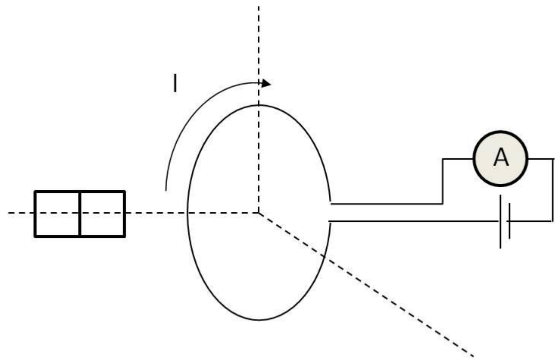
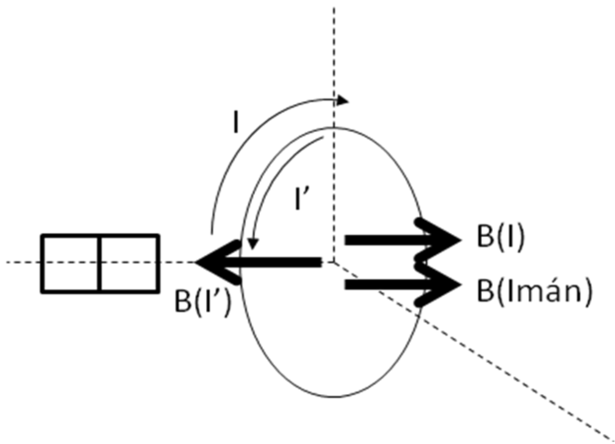
Conceptual Question 1 (1 pt.)

There is a conducting loop (coil) through which a current I flowing in the direction shown in next figure. Moving a magnet oriented along the axis of the loop towards the loop, it is observed that this current I decreases. What pole (N or S) is oriented toward the loop? (Or, what is the same, what is the direction of the magnetic field coming from the pole facing the loop (coil)?). Explain your answer.



Solution:

If the current I (which direction is clockwise) decreases when approaching the magnet, it means that the induced current I' by the variation of the magnetic flux opposes the current I, or that I' flows in counterclockwise direction. Applying the Lenz´s law, there are two possible causes: (a) There is an increasing magnetic field with its North pole faced towards the loop, or (b) There is a decreasing magnetic field with its South pole faced towards the loop. As the magnet is moving towards the loop, then the cause is (a) and the solution is that the North pole is oriented (faced) towards the loop.

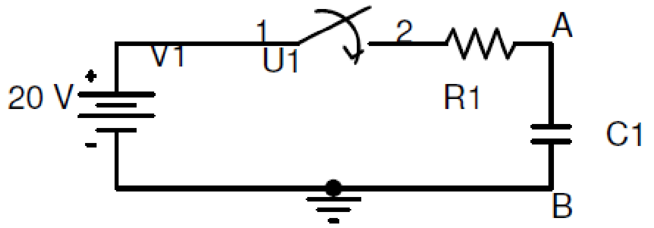


Problem 1 (3 pts.)

Given the circuit in the next figure, where the capacitor is initially uncharged. The switch U1 is initially in the open position and suppose that, at time t = 0, we close the switch, closing the circuit. Calculate:

a) The time constant of the circuit.
b) The instant of time in which the voltage at A will reach one third of its total value and the value itself.
c) The current through the circuit at t = 0 and at t=3 ms.
d) How to simulate this circuit in PSIPCE?. What kind of simulation would be used and what simulation time would be necessary?

Data: V1: 20 V, R1= 2 kΩ, C1= 2 μF.



Solution:

(a) $\tau = RC = 2k\Omega \cdot 2\mu F = 4\,ms$

(b) $V_A(t) = 20(1 - e^{-t/\tau})$

$\frac{1}{3} \cdot 20 = 20(1 - e^{-t_1/\tau}) \rightarrow \frac{2}{3} = e^{-t_1/\tau}$

$t_1 = -\ln(2/3) \cdot 4\,ms = 1.62\,ms$

$V_1 = \frac{20}{3}\,V = 6.67\,V.$

(c) $i(t) \cdot R_1 + 20(1 - e^{-t/\tau}) = 20$

$i(t) = \frac{20}{R_1} e^{-t/\tau} = \frac{20}{2k\Omega} \cdot e^{-t/\tau} = 10^{-2} \cdot e^{-t/\tau}\,A$

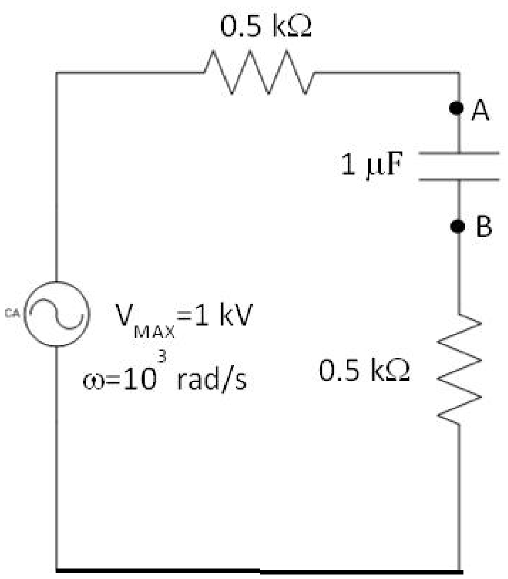
$i(0) = 10^{-2}\,A$

$i(3ms) = 10^{-2} \cdot e^{3\cdot 10^{-3}/4\cdot 10^{-3}}\,A = 0.02\,A$

(d) Transient Analisys

Problem 2 (3 pts.)

Given the AC circuit in the next figure.



Calculate:

a) The total complex impedance of the circuit.

b) The maximum current flowing through the circuit.

c) The effective values of voltage and current.

d) The phasor representation of the current with respect to the voltage.

e) The power factor and average power for the total circuit.

f) The power factor and average power across points A and B. Compare with the result in e) and explain the meaning of them.

Solution:

a) $Z = 1000 + \dfrac{1}{1\mu F \cdot 10^3 \, rad/s \; j} = 1000 - 1000 j =$

$= 1000\sqrt{2} \angle -45° \; \Omega$

b) $V = 1000 \angle 0° \; V$, $I = \dfrac{V}{Z} = \dfrac{1000 \angle 0°}{1000\sqrt{2} \angle -45°} = \dfrac{1}{\sqrt{2}} \angle 45° \; A$

c) $I_{ef} = I_{rms} = \dfrac{I}{\sqrt{2}} = 1 \; A$, $V_{rms} = \dfrac{V}{\sqrt{2}} = \dfrac{1000}{\sqrt{2}} \; V.$

d)

e) $PF = \cos|\theta_i - \theta_v| = \cos 45 \simeq 0.7$

$P_{AV} = \dfrac{1}{2} \, 1000 \cdot \dfrac{1}{\sqrt{2}} \cdot |\cos 45| = \dfrac{1}{2} \, 1000 \cdot \dfrac{1}{\sqrt{2}} \, \dfrac{\sqrt{2}}{2} \; W =$

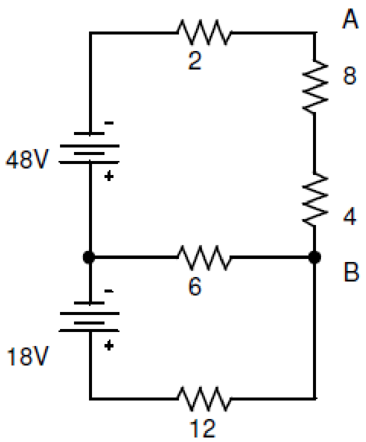
$= 250 \; W$

f) $I_{AB} = \dfrac{1000 \angle 0}{1000 \angle -90} = 1 \angle 90 \; A$, $PF_{AB} = |\cos 90| = 0$

$P_{AV(AB)} = 0$

Problem 3 (3 pts.)

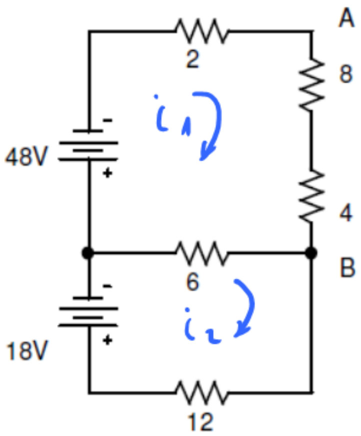
Given the DC circuit in the figure, in which all resistances are given in omhs.



a) Calculate and draw the Thevenin equivalent circuit across its terminals A to B,

b) Calculate and draw the equivalent Norton circuit through terminals A and B.

Solution:



(a) $R_{TH} = R_{AB} = 4\Omega$

$\rightarrow R_{AB} = ((6 \| 12)+2) \| 12 =$
$= (4+2) \| 12 = 4\Omega$

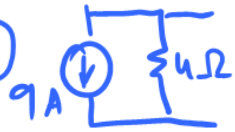
$20i_1 - 6i_2 = -48V$

$-6i_1 + 18i_2 = -18V.$

$$i_1 = \frac{\begin{vmatrix}-48 & -6\\ -18 & 18\end{vmatrix}}{\begin{vmatrix}20 & -6\\ -6 & 18\end{vmatrix}} = -3A$$

$V_{TH} = V_{AB} = -3A \cdot 12\Omega = -36V$

(b)



$I_N = \frac{-36V}{4\Omega} = -9A$