UNIVERSIDAD POLITECNICA DE VALENCIA

Second mid term exam FFI
November 27th 2017
Year 2017/18

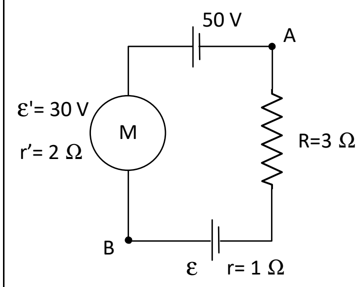
Applied Physics Dept.

1. (**2,5 points**) On circuit on picture, the **ideal generator** with electromotive force **50 V is acting as a generator**, and the **internal resistance** of **the other** generator **consumes** a power of **4 w.**

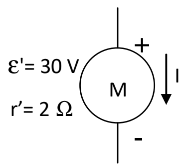
a) State the **polarity** of receptor M.
b) Compute the **intensity** flowing along the circuit.
c) Compute the unknown **electromotive force ε**.
d) Compute the **difference of potential** between points **A and B**.
e) Compute the **generated powers** and the **consumed powers** on circuit, doing a balance of power.
f) Compute the **efficiency** of receptor M.

1. (**2,5 puntos**) En el circuito de la figura, el **generador ideal** de f.e.m. **50 V está actuando como generador**, y la **resistencia interna** del **otro** generador **consume** una potencia de **4 w**.

a) Indica la **polaridad** del receptor M.
b) Calcula la **intensidad** que recorre el circuito.
c) Calcula la **fuerza electromotriz** desconocida **ε**.
d) Calcula la **diferencia de potencial** entre los puntos **A y B** del circuito.
e) Haz un balance de potencias, calculando las **potencias generadas** y las **consumidas** en el circuito.
f) Calcula el **rendimiento** del receptor M.



Solution:



a) If it's said that the 50 V generator acts as a generator, then the intensity must flow on the circuit in counterclockwise direction. So, as the intensity must enter on a receptor through the positive terminal, the upper terminal of motor is the positiev terminal, and the lower terminal, the negative one.

b) As the power consumed on the internal resistor of ε (r=1 Ω) is 4 w: $4 = I^2 1 \Rightarrow I = 2\,A$

c) From the equation of circuit: $2 = \dfrac{50-30-\varepsilon}{2+1+3} \Rightarrow \varepsilon = 50-30-12 = 8\,V$

d) The difference of potential can be calculated by going fom A to B through two different paths:
- Through receptor: $V_A - V_B = 2\cdot 2-(50-30) = 4-20 = -16\,V$
- Through generator ε: $V_A - V_B = -2\cdot 4-(8) = -16\,V$

Obviously, in both cases the result is the same.

e) The only generated power is that of 50 V generator: $P_g = \varepsilon I = 50\cdot 2 = 100\,w$

The consumed powers are:
- On receptor: $P_c = \varepsilon' \cdot I + I^2 r' = 30\cdot 2 + 4\cdot 2 = 68\,w$
- On generator ε: $P_c = \varepsilon\cdot I + I^2 r = 8\cdot 2 + 2^2\cdot 1 = 20\,w$
- On resistor: $P_R = I^2 R = 4\cdot 3 = 12\,w$

Obviously, the generated power equals the consumed powers: 100=68+20+12.

f) $\eta' = \dfrac{P_t}{P_c} = \dfrac{30\cdot 2}{68} = 0{,}88 = 88\,\%$

2. (**3 points**) Given the circuit on picture, compute:

a) Intensity of current flowing along each branch with the shown directions, $\mathbf{I_1}$, $\mathbf{I_2}$ and $\mathbf{I_3}$.

b) **Tehevenin's equivalent generator** between points **A** and **B**, clearly showing its polarity.

c) If the **branch on right** is **connected between points A and B**, say if the 5 V generator of the new branch is acting as a **generator or as a receptor**.

d) **Tehevenin's equivalent generator** between points **B** and **D**, clearly showing its polarity.

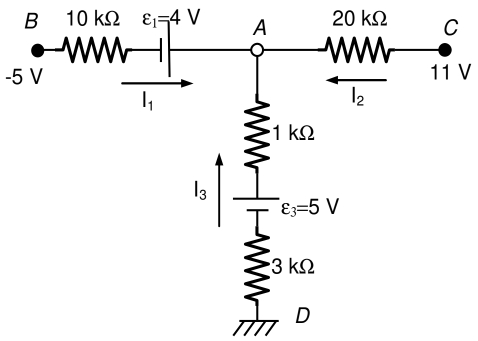
2. (**3 puntos**) Dado el circuito de la figura, calcula:

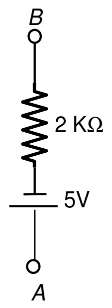
a) La intensidad de corriente en cada rama con los sentidos mostrados, $\mathbf{I_1}$, $\mathbf{I_2}$ y $\mathbf{I_3}$.

b) El **generador equivalente de Thevenin** entre los puntos **A y B**, indicando claramente su polaridad.

c) Si la **rama de la derecha** se **conecta entre los puntos A y B**, di si el generador de 5 V de la nueva rama actúa como **generador o como receptor**.

d) El **generador equivalente de Thevenin** entre los puntos **B** y **D**, indicando claramente su polaridad.



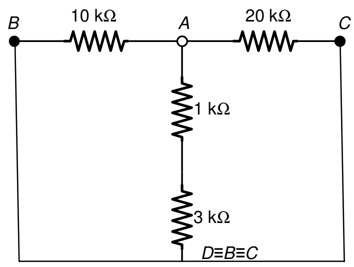


Solution:

This is a network with 2 junctions and two loops, and so we'll need one equation for junctions and two equations for loops:

a) $$\left.\begin{array}{c} I_1+I_2+I_3=0 \\ V_{BD}=-5=10I_1-4-4I_3-(-5) \\ V_{CD}=11=20I_2-4I_3-(-5) \end{array}\right\} \Rightarrow I_1=-\frac{21}{40}=-0{,}525\,mA \quad I_2=\frac{27}{80}=0{,}337\,mA \quad I_3=\frac{3}{16}=0{,}187\,mA$$

b) $$\varepsilon_T=V_{AB}=V_A-V_B=-10I_1-(-4)=\frac{37}{4}=9{,}25\,V$$

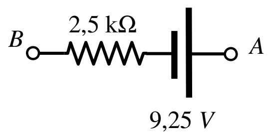


Passive circuit after removing all the generators is

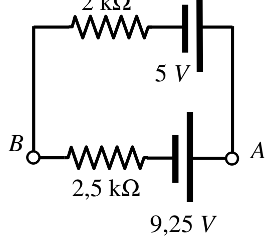
and its equivalent resistance between A and B:

$$\frac{1}{R_{eqAB}}=\frac{1}{10}+\frac{1}{4}+\frac{1}{20}\Rightarrow R_{eqAB}=\frac{5}{2}=2{,}5\,k\Omega$$

So, Thevenin's equivalent generator between A and B is:

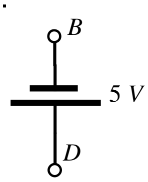


c) If we connect the new branch between points A and B, the resulting circuit is:



In this circuit, the intensity flows in counterclockwise direction, and then, the 5 V generator is acting as a receptor.

d) $\varepsilon_T=V_{BD}=-5\,V \qquad R_{eqBD}=0$

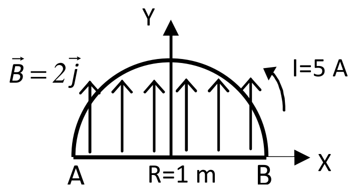


3. (**2 points**) A **loop** is made up by a **semircumference** and a **straight conductor** connecting both endings of semircumference (A and B), as can be seen on picture. The radius of the loop is **R=1 m**, and it's flowed by an intensity of current **I=5 A**. A **uniform magnetic field** $\vec{B}=2\vec{j}$ is acting on the loop.

a) Compute the **force** acting over the **rectilinear** part of the loop, between A and B, giving the **result as a vector**.
b) Write the magnetic moment of the loop, $\vec{\mu}$, writing it **as a vector**.
c) Compute the torque $\vec{\tau}$ acting on the loop.
d) Compute the **force** acting over the **semicumference**, between A and B, giving the **result as a vector**.

3. (**2 puntos**) Una **espira** está formada por una **semircunferencia** y por un **conductor rectilíneo** que une ambos extremos de la semicircunferencia (A y B), como puede verse en la figura. El radio de la espira es **R=1 m**, y está recorrida por una corriente **I=5 A**. Un **campo magnético uniforme** $\vec{B}=2\vec{j}$ actúa sobre la espira.

a) Calcula la **fuerza** que actúa sobre la parte **rectilínea** de la espira, entre A y B, dando el resultado en **forma vectorial**.
b) Escribe el momento magnético de la espira, $\vec{\mu}$, dando el resultado en **forma vectorial**.
c) Calcula el momento $\vec{\tau}$ que actúa sobre la espira.
d) Calcula la **fuerza** que actúa sobre la **semicunferencia**, entre A and B, dando el resultado en **forma vectorial**.



Solution:

a) $\vec{F}_1=I\vec{\ell}\times\vec{B}=5\cdot 2\vec{i}\times 2\vec{j}=20\vec{k}\ N$

b) $\vec{\mu}=I\vec{S}=I\cdot\frac{\pi R^2}{2}\vec{k}=\frac{5\pi}{2}\vec{k}\ Am^2$

c) $\vec{\tau}=\vec{\mu}\times\vec{B}=\frac{5\pi}{2}\vec{k}\times 2\vec{j}=-5\pi\vec{i}\ Nm$

d) As the total force acting over the loop must be null, then the force acting over the semicumference is opposite to that acting over the rectilinear conductor: $\vec{F}_2=-20\vec{k}\ N$

4. (**2,5 points**) Two infinite straight carrying current conductors, with a distance **d** between them, are placed on plane **XY**. They are carrying currents **I_1=2I and I_2=I in oposite directions**. Compute the **magnetic field** created by both currents at points:

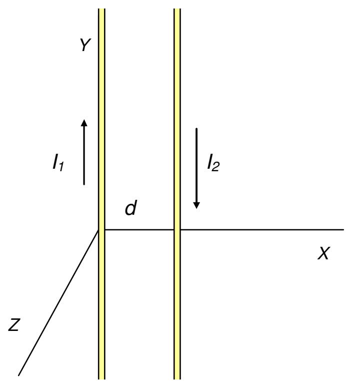
a) A (d/2,0,0).
b) B (2d,0,0).
c) C (0,0,d).

On each case, give the result as **a vector**.

4. (**2,5 puntos**) Dos conductores rectilíneos e indefinidos, separados una distancia **d**, están situados en el plano **XY**, y llevan sendas corrientes **I_1=2I y I_2=I en sentidos contrarios**. Calcula el **campo magnético** creado por ambas corrientes en los puntos:

d) A (d/2,0,0).
e) B (2d,0,0).
f) C (0,0,d).

En cada caso, expresa el **resultado como un vector**.



Solution:

On every case, the magnetic field is the summatory of magnetic fields produced by each conductor:

a) $\vec{B}_A=\vec{B}_1+\vec{B}_2=-\frac{\mu_0 2I}{2\pi\frac{d}{2}}\vec{k}-\frac{\mu_0 I}{2\pi\frac{d}{2}}\vec{k}=-\frac{3\mu_0 I}{\pi d}\vec{k}$

b) $\vec{B}_B = \vec{B}_1 + \vec{B}_2 = -\frac{\mu_0 2I}{2\pi 2d}\vec{k} + \frac{\mu_0 I}{2\pi d}\vec{k} = 0$

c) $\vec{B}_C = \vec{B}_1 + \vec{B}_2 = \frac{\mu_0 2I}{2\pi d}\vec{i} + \frac{\mu_0 I}{2\pi d\sqrt{2}}\frac{-\vec{i}-\vec{k}}{\sqrt{2}} = \frac{\mu_0 I}{\pi d}\vec{i} + \frac{\mu_0 I}{4\pi d}(-\vec{i}-\vec{k}) = \frac{\mu_0 I}{\pi d}\vec{i} - \frac{\mu_0 I}{4\pi d}\vec{i} - \frac{\mu_0 I}{4\pi d}\vec{k} = \frac{\mu_0 I}{4\pi d}(3\vec{i}-\vec{k})$

FORM

Direct current $V_A - V_B = I\sum R - \sum \varepsilon$ $I = \frac{\sum \varepsilon}{\sum R}$ $P = V \cdot I$ $\varepsilon = \frac{dW}{dq}$ $P_R = I^2 \cdot R$

$P_g = \varepsilon \cdot I$ $P_t = \varepsilon' \cdot I$ $P_g - P_r = P_s$ $P_t + P_{r'} = P_c$ $\eta_g = \frac{P_s}{P_g}$ $\eta_r = \frac{P_t}{P_c}$

Magnetic Forces $\vec{F} = q(\vec{v} \times \vec{B})$ $d\vec{F} = Id\vec{l} \times \vec{B}$ $\vec{\mu} = N \cdot I \cdot \vec{S}$ $\vec{\tau} = \vec{\mu} \times \vec{B}$ $V_H = \frac{I \cdot B \cdot d}{n \cdot e \cdot S}$

Sources of magnetic field $d\vec{B} = \frac{\mu_0 I}{4\pi}\frac{d\vec{\ell} \times \vec{r}}{r^3}$ $\mu_0 = 4\pi 10^{-7}\,(I.S.units)$ $B = \frac{\mu_0 I}{2\pi x}$

$B = \frac{\mu_0 I}{2R}$ $\oint_L \vec{B} \cdot d\vec{l} = \mu_0 \sum I$ $B = \frac{\mu_0 N I}{l}$