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Electric Circuits (ENGR 210)

Assignment 1

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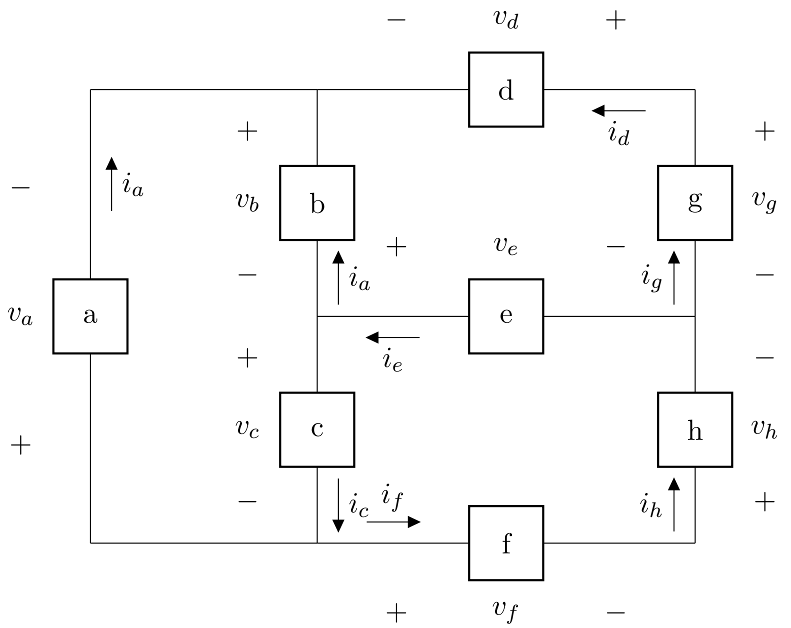
1. The numerical values of the voltages and currents in the interconnection seen in Fig. 1. Does the interconnection satisfy the power check?



Element	Voltage	Current
a	990	-22.5
b	600	-30
c	300	60
d	105	52.5
e	-120	30
f	165	82.5
g	585	52.5
h	-585	82.5

Figure 1

$$
\begin{aligned}
P_a &= v_a i_a && = 990 \times -22.5 && = -22275 \text{ W} && (1)\\
P_b &= v_b i_b && = 600 \times -30 && = -18000 \text{ W} && (2)\\
P_c &= v_c i_c && = 300 \times 60 && = 18000 \text{ W} && (3)\\
P_d &= v_d i_d && = 105 \times 52.5 && = 5512.5 \text{ W} && (4)\\
P_e &= v_e i_e && = -120 \times 30 && = -3600 \text{ W} && (5)\\
P_f &= v_f i_f && = 165 \times 82.5 && = 13612.5 \text{ W} && (6)\\
P_g &= v_g i_g && = 585 \times 52.5 && = 30712.5 \text{ W} && (7)\\
P_h &= v_h i_h && = -585 \times 82.5 && = -48262.5 \text{ W} && (8)\\
&. && && && (9)
\end{aligned}
$$

$$
\begin{aligned}
P_{\text{total}} &= P_a + P_b + P_c + P_d + P_e + P_f + P_g + P_h && (10)\\
&= -22275 - 18000 + 18000 + 5512.5 - 3600 + 13612.5 + 30712.5 - 48262.5 && (11)\\
&= -24300. && (12)
\end{aligned}
$$

$\boxed{\text{The interconnection does not satisfy the power check.}}$

2. The voltage and current at the terminals of the circuit element in Fig. 2 are zero for $t < 0$. For $t \geq 0$ they are:

$$v = 50e^{-1600t} - 50e^{-400t} \text{ V}$$
$$i = 5e^{-1600t} - 5e^{-400t} \text{ mA}$$

(a) Find the power at $t = 625\,\mu$s.

$$P(t) = v(t)i(t) = (50e^{-1600t} - 50e^{-400t})(5e^{-1600t} - 5e^{-400t}) \times 10^{-3} \tag{13}$$
$$P(625 \times 10^{-6}) = \left(50e^{-1600(625\times10^{-6})} - 50e^{-400(625\times10^{-6})}\right) \tag{14}$$
$$\left(5e^{-1600(625\times10^{-6})} - 5e^{-400(625\times10^{-6})}\right) \times 10^{-3} \tag{15}$$
$$= 0.0420W. \tag{16}$$

(b) How much energy is delivered to the circuit element at $t = 625\,\mu$s?

$$E(t) = \int_0^t P(x)\,dx \tag{17}$$
$$= \int_0^{625\times10^{-6}} \left((50e^{-1600x} - 50e^{-400x})(5e^{-1600x} - 5e^{-400x}) \times 10^{-3}\right) dx \tag{18}$$
$$= 1.22 \times 10^{-5} \text{ J}. \tag{19}$$

(c) Find the total energy delivered to the element.

$$E_{\text{total}} = \lim_{t\to\infty} E(t) \tag{20}$$
$$= \lim_{t\to\infty} \int_0^t P(x)\,dx \tag{21}$$
$$= \frac{9}{6400} \approx 1.41 \times 10^{-4} \text{ J}. \tag{22}$$

3. An industrial battery is charged over a period of several hours at a constant voltage of 120 V. Initially, the current is 10 mA and increases linearly to 15 mA in 10 ks. From 10 ks to 20 ks, the current is constant at 15 mA. From 20 ks to 30 ks the current decreases linearly to 10 mA. At 30 ks the power is disconnected from the battery.

(a) Sketch the voltage, current and power from $t = 0$ to $t = 30$ ks.

(b) Using the sketch of the power, find the total energy delivered to the battery.

$$E_{\text{total}} = \int_0^{30k} P(t)\,dt \tag{23}$$
$$= (30k \times 1200) \tag{24}$$
$$+ (10k \times 600) \tag{25}$$
$$+ (10k \times 600 \times \frac{1}{2}) \tag{26}$$
$$+ (10k \times 600 \times \frac{1}{2}) \tag{27}$$
$$= 4.8 \times 10^7 \text{ J}. \tag{28}$$

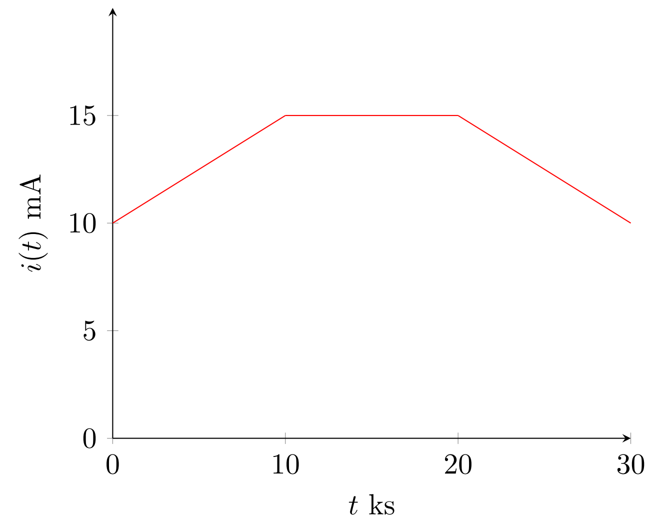


Figure 2

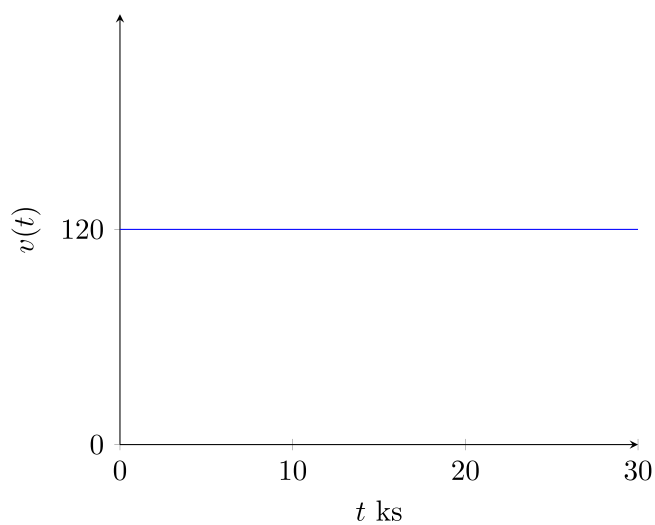


Figure 3

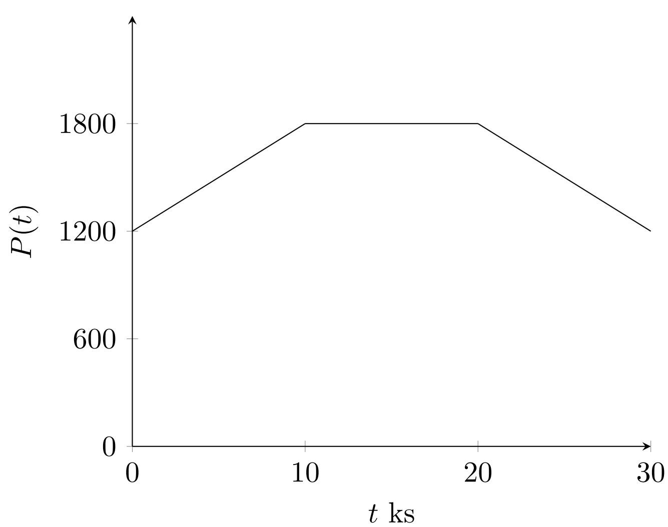


Figure 4