Section 2-5 Independent Sources

P 2.5-1 A current source and a voltage source are connected in parallel with a resistor as shown in Figure P 2.5-1. All of the elements connected in parallel have the same voltage, v_s in this circuit. Suppose that v_s = 15 V, i_s = 3 A, and R = 5 Ω. (a) Calculate the current i in the resistor and the power absorbed by the resistor. (b) Change the current source current to i_s = 5 A and recalculate the current, i, in the resistor and the power absorbed by the resistor.

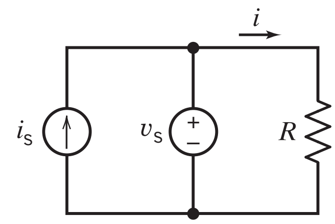


Figure P 2.5-1

Answer: i = 3 A and the resistor absorbs 45 W both when i_s = 3 A and when i_s = 5 A.

Solution:

(a) $i = \frac{v_s}{R} = \frac{15}{5} = \underline{3\text{ A}}$ and $P = R\,i^2 = 5(3)^2 = \underline{45\text{ W}}$

(b) i and P do not depend on i_s.

The values of i and P are 3 A and 45 W, both when i_s = 3 A and when i_s = 5 A.

P 2.5-2 A current source and a voltage source are connected in series with a resistor as shown in Figure P 2.5-2. All of the elements connected in series have the same current, i_s, in this circuit. Suppose that v_s = 10 V, i_s = 2 A, and R = 5 Ω. (a) Calculate the voltage v across the resistor and the power absorbed by the resistor. (b) Change the voltage source voltage to v_s = 5 V and recalculate the voltage, v, across the resistor and the power absorbed by the resistor.

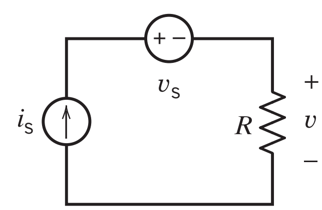


Figure P 2.5-2

Answer: v = 10 V and the resistor absorbs 20 W both when v_s = 10 V and when v_s = 5 V.

Solution:

(a) From Ohm's law $v = R\,i_s = 5(3) = 15\text{ V}$. (The resistor voltage does not depend on the voltage source voltage.) Next $P = \frac{v^2}{R} = \frac{15^2}{5} = \underline{45\text{ W}}$.

(b) Since v and P do not depend on v_s the values of v and P are 15 V and 45 W both when v_s=10V and when v_s=5V.

P 2.5-3 The current source and voltage source in the circuit shown in Figure P 2.5-3 are connected in parallel so that they both have the same voltage, v_s. The current source and voltage source are also connected in series so that they both have the same current, i_s. Suppose that v_s = 12 V and i_s = 3 A. Calculate the power supplied by each source.

Answer: The voltage source supplies –36 W, and the current source supplies 36 W.

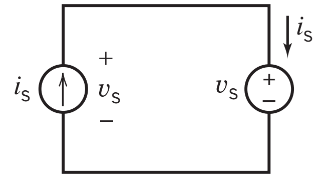


Figure P 2.5-3

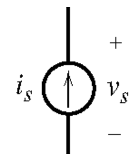
Solution:

Consider the current source:

i_s and v_s do not adhere to the passive convention,

so $P_{cs} = i_s v_s = 3 \cdot 12 = \underline{36\text{ W}}$

is the power supplied by the current source.



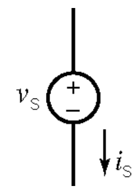
Consider the voltage source:

i_s and v_s do adhere to the passive convention,

so $P_{vs} = i_s\, v_s = 3 \cdot 12 = \underline{36\text{ W}}$

is the power absorbed by the voltage source.

$\therefore$ <u>The voltage source supplies −36 W.</u>



P 2.5-4 The current source and voltage source in the circuit shown in Figure P 2.5-4 are connected in parallel so that they both have the same voltage, v_s. The current source and voltage source are also connected in series so that they both have the same current, i_s. Suppose that v_s = 12 V and i_s = 3 A. Calculate the power supplied by each source.

Answer: The voltage source supplies 36 W, and the current source supplies –36 W.

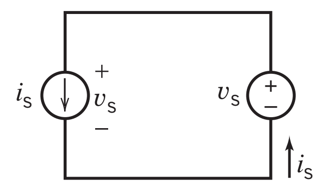
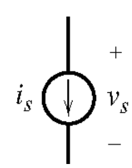


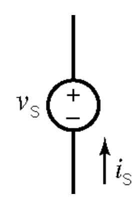
Figure P 2.5-4

Solution:

Consider the current source. i_S and v_S adhere to the passive convention so $P_{CS} = i_S\, v_S = 2(12) = 24$ W is the received by the current source. The current source supplies $\underline{-24\text{ W}}$.



Consider the voltages source. i_S and v_S do not adhere to the passive convention so $P_{CS} = i_S\, v_S = 2(12) = \underline{24\text{ W}}$ is the supplied by the voltage source.



P 2.5-5

(a) Find the power supplied by the voltage source shown in Figure P 2.5-5 when for $t \geq 0$ we have

$$v = 2\cos t \text{ V}$$

and

$$i = 10\cos t \text{ mA}$$

(b) Determine the energy supplied by this voltage source for the period $0 \leq t \leq 1$ s.

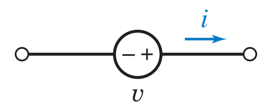


Figure P 2.5-5

Solution:

(a) $P = v\,i = (2\ \cos\ t)\ (10\ \cos\ t) = \underline{20\ \cos^2 t\ \ \text{mW}}$

(b) $w = \int_0^1 P\ dt\ =\ \int_0^1 20\ \cos^2 t\ dt = 20\left(\frac{1}{2}t + \frac{1}{4}\sin 2t\right)\Bigg|_0^1 = \underline{10 + 5\ \sin\ 2\ \text{mJ}}$

P 2.5-6 Figure P 2.5-6 shows a battery connected to a load. The load in Figure P 2.5-6 might represent automobile headlights, a digital camera, or a cell phone. The energy supplied by the battery to load is given by

$$w = \int_{t_1}^{t_2} vi\,dt$$

When the battery voltage is constant and the load resistance is fixed, then the battery current will be constant and

$$w = vi(t_2 - t_1)$$

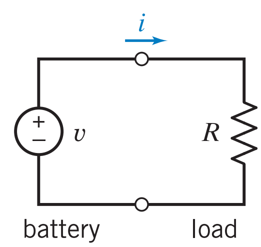


Figure P 2.5-6

The capacity of a battery is the product of the battery current and time required to discharge the battery. Consequently, the energy stored in a battery is equal to the product of the battery voltage and the battery capacity. The capacity is usually given with the units of Ampere-hours (Ah). A new 12-V battery having a capacity of 800 mAh is connected to a load that draws a current of 50 mA. (a) How long will it take for the load to discharge the battery? (b) How much energy will be supplied to the load during the time required to discharge the battery?

Solution:

(a) time to discharge $= \dfrac{\text{capacity}}{\text{current}} = \dfrac{800\ \text{mAh}}{25\ \text{mA}} = 32$ hours

(b) energy = (12 V) (0.025 A) (32 * 60*60 seconds) =34.56 kJ