1.8 Problems

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Problem 1.1 CRUMBLE

a. Let two resistors with resistances 1 kΩ and 2 kΩ be connected in series. What is their combined effective resistance?
b. Let two resistors R_1 and R_2 be connected in series. Prove that their combined effective resistance is greater than that of either resistor, individually. Use KVL, KCL, and Ohm's Law.
c. Let two resistors with resistances 1 kΩ and 2 kΩ be connected in parallel. What is their combined effective resistance?
d. Let any two resistors R_1 and R_2 be connected in parallel. Prove that their combined effective resistance is less than that of either resistor, individually. Use KVL, KCL, and Ohm's Law.

Problem 1.2 CORACOMORPH Beginning with the definition of electrical power and the elemental equation of an ideal resistor, find

a. an expression for the power dissipated by a resistor in terms of voltage v_R and resistance R, only; and
b. an expression for the power dissipated by a resistor in terms of current i_R and resistance R, only.

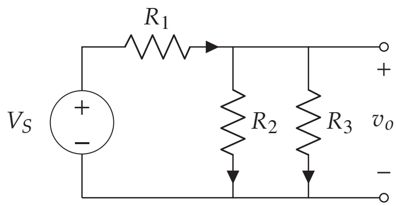
Problem 1.3 MASTICUROUS An unregulated function generator has a 50 Ω output resistance. The front panel displays a nominal voltage amplitude of 10 V, which assumes a matching load of 50 Ω. However, the output is *not* connected to this nominal matching load. Instead, it is connected to an oscilloscope with high input resistance—let's say it's infinite. Respond to the following questions and imperatives about this situation.

a. Draw a circuit diagram.
b. Using the given information about the "nominal" voltage amplitude, determine what the ideal source voltage amplitude V_s should be in your circuit diagram/function generator model.
c. Solve for the actual voltage amplitude v_a at the oscilloscope if the front panel says 5 V amplitude.

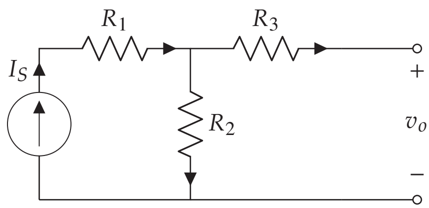
Problem 1.4 CORPORATIONISM Consider two signals with voltage ratios expressed in decibels as follows. What are the corresponding power and voltage amplitude ratios?[5]

a. 0 dB
b. 3 dB
c. 10 dB
d. 20 dB

Problem 1.5 PSEUDOSCARUS For the circuit diagram below with voltage source V_S and output voltage v_o, (a) construct a Thévenin equivalent circuit. Be sure to specify the equivalent source V_e and resistance R_e. Let $R_1 = R_2 = 1$ kΩ and $R_3 = 2$ kΩ. (b) Convert the Thévenin equivalent circuit from (a) to a Norton equivalent.

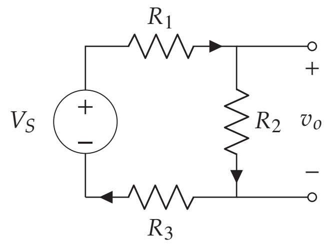


Problem 1.6 BANANA For the circuit diagram below with current source I_S and output voltage v_o, (a) construct a Norton equivalent circuit. Be sure to specify the equivalent source I_e and resistance R_e. Let $R_1 = R_2 = 1$ kΩ and $R_3 = 2$ kΩ. (b) Convert the Norton equivalent circuit from (a) to a Thévenin equivalent.



Problem 1.7 DOORBELL For the circuit diagram below with voltage source V_S and output voltage v_o, (a) construct a Norton equivalent circuit. Be sure to specify the equivalent source I_e and resistance R_e. Let $R_1 = 1$ kΩ, $R_2 = 2$ kΩ, and $R_3 = 3$ kΩ. (b) Convert the Norton equivalent circuit from (a) to a Thévenin equivalent.

5. This exercise was inspired by Horowitz and Hill (2015).


R_1
V_S
+
−
R_2
v_o
+
−
R_3

2 Circuit Analysis

In this chapter, we consider the techniques of analog circuit analysis. We use a time-domain approach in which the dynamics of circuits are expressed as ordinary differential equations (ODEs).

2.1 Sign Convention

We use the **passive sign convention** of electrical engineering, defined below and illustrated in figure 2.1.

Definition 2.1

Power flowing *in* to a component is considered to be *positive* and power flowing *out* of a component is considered *negative*.

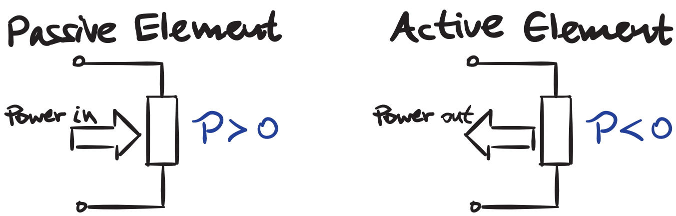


Figure 2.1. passive sign convention in terms of power $\mathcal{P}$.

Because power $\mathcal{P} = vi$, this implies the current and voltage signs are prescribed by the convention. For **passive elements**, the electrical potential must drop in the direction of positive current flow. This means the assumed direction of voltage drop across a passive element must be the same as that of the current flow. For **active elements**, which supply power to the circuit, the converse is true: the voltage drop