Engaged Learning Practice

#1

Application of Voltage Divider (Chap. 4)

Suppose your supervisor has given you a **voltage divider board to evaluate and modify** if necessary.

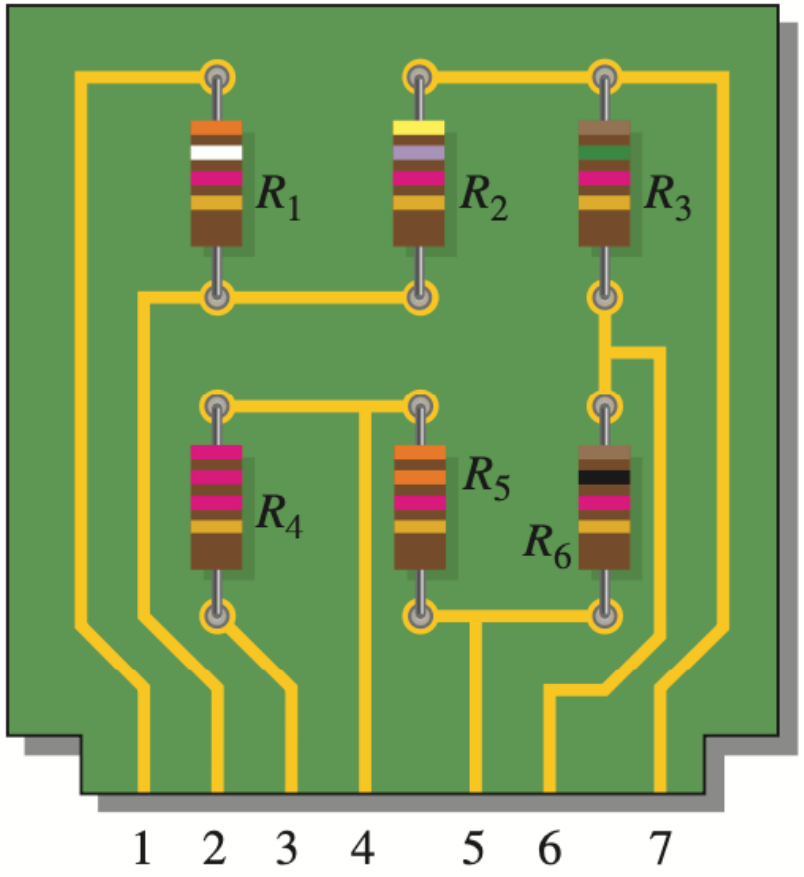
You will use it to obtain **five different voltage levels** from a 12 V battery that has a 6.5 Ah rating. The voltage divider provides positive reference voltages to an electronic circuit in an analog-to-digital converter.

- Your job will be to check the circuit to see if it provides the following voltages within a tolerance of ±5% with respect to the negative side of the battery: 10.4 V, 8.0 V, 7.3 V, 6.0 V, and 2.7 V.
- If the existing circuit does not provide the specified voltages, you will modify it so that it does.
- Also, you must make sure that the power ratings of the resistors are adequate for the application and determine how long the battery will last with the voltage divider connected to it.

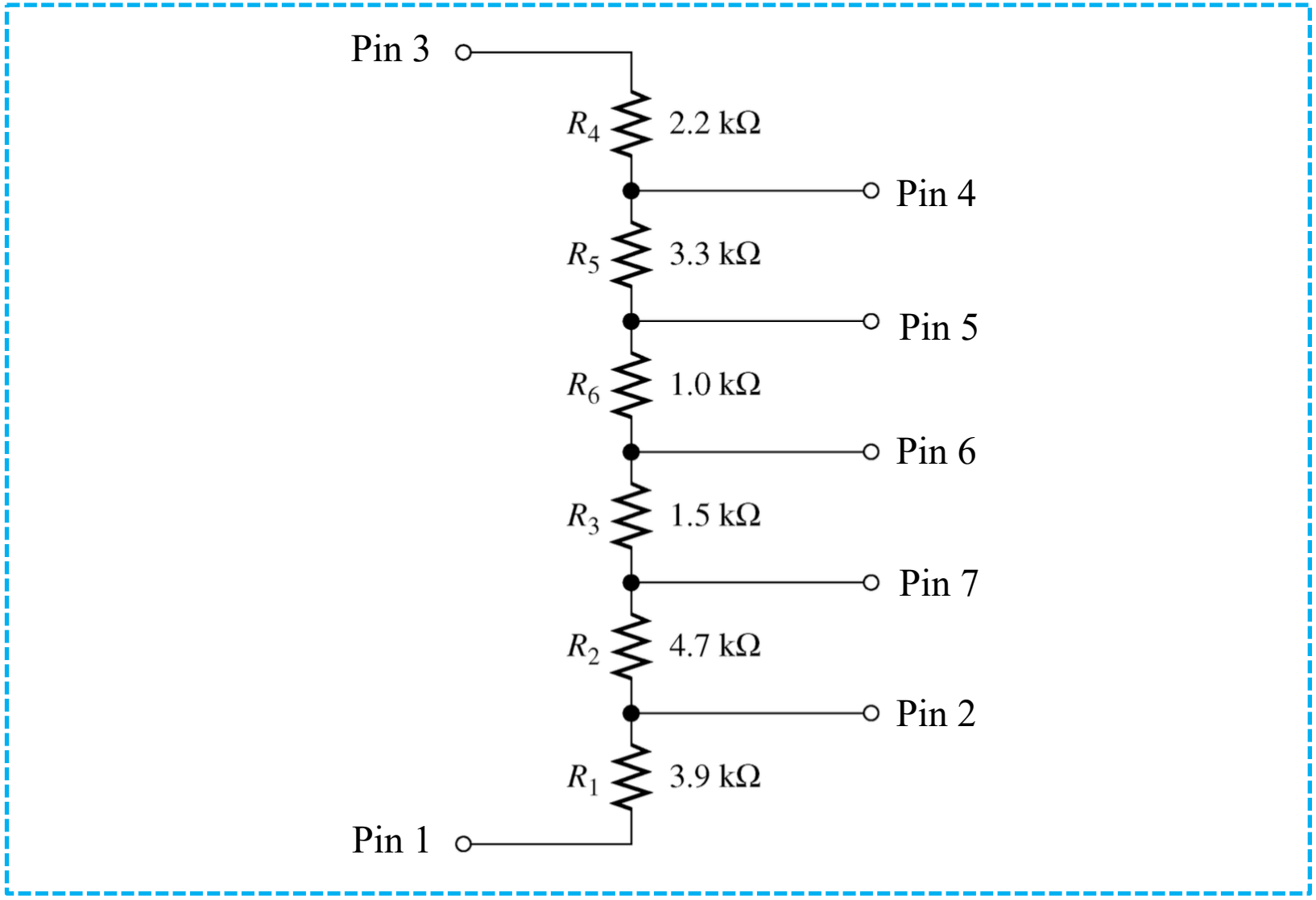
Step 1: Drawing the Schematic of the Circuit

Use the Figure below to determine the resistor values and draw the schematic of the voltage-divider circuit. All the resistors on the board are 0.25 W.

$R_1 = 3.9\ \text{k}\Omega, R_2 = 4.7\ \text{k}\Omega, R_3 = 1.5\ \text{k}\Omega$
$R_4 = 2.2\ \text{k}\Omega, R_5 = 3.3\ \text{k}\Omega, R_6 = 1.0\ \text{k}\Omega$



Solution to Step 1: Drawing the Schematic of the Circuit



Step 2: Determining the Voltages

- Determine each output voltage on the existing circuit board when the positive side of the 12 V battery is connected to ***pin 3*** and the negative side is connected to ***pin 1***.
- Compare the existing output voltages to the following specifications:

Pin 1: Negative terminal of 12 V battery
Pin 2: 2.7 V ± 5%
Pin 3: Positive terminal of 12 V battery
Pin 4: 10.4 V ± 5%
Pin 5: 8.0 V ±5%
Pin 6: 7.3 V ± 5%
Pin 7: 6.0 V ± 5%

Solution to Step 2: Determining the Voltages

- **The total resistance:**

$$R_T = R_1 + R_2 + R_3 + R_4 + R_5 + R_6$$
$$= 3.9\ \text{k}\Omega + 4.7\ \text{k}\Omega + 1.5\ \text{k}\Omega + 1.0\ \text{k}\Omega + 3.3\ \text{k}\Omega + 2.2\ \text{k}\Omega = 16.6\ \text{k}\Omega$$

- **Calculations of output voltages:**

$$V_2 = \left(\frac{R_1}{R_T}\right)V_S = \left(\frac{3.9\ \text{k}\Omega}{16.6\ \text{k}\Omega}\right)12\ \text{V} = \mathbf{2.82\ V}$$

$$V_5 = \left(\frac{R_1 + R_2 + R_3 + R_6}{R_T}\right)V_S = \left(\frac{11.1\ \text{k}\Omega}{16.6\ \text{k}\Omega}\right)12\ \text{V} = \mathbf{8.02\ V}$$

$$V_7 = \left(\frac{R_1 + R_2}{R_T}\right)V_S = \left(\frac{8.6\ \text{k}\Omega}{16.6\ \text{k}\Omega}\right)12\ \text{V} = \mathbf{6.22\ V}$$

$$V_4 = \left(\frac{R_1 + R_2 + R_3 + R_6 + R_5}{R_T}\right)V_S = \left(\frac{14.4\ \text{k}\Omega}{16.6\ \text{k}\Omega}\right)12\ \text{V} = \mathbf{10.4\ V}$$

$$V_6 = \left(\frac{R_1 + R_2 + R_3}{R_T}\right)V_S = \left(\frac{10.1\ \text{k}\Omega}{16.6\ \text{k}\Omega}\right)12\ \text{V} = \mathbf{7.30\ V}$$

- **Are all voltages within 5% of specified values?**

Yes

Step 3: Modifying the Existing Circuit (if necessary)

- If the output voltages of the existing circuit are not the same as those stated in the specifications of Step 2,
  - Make the necessary changes in the circuit to meet the specifications.
  - Draw a schematic of the modified circuit showing resistor values and adequate power ratings.

Solution to Step 3: Modifying the Existing Circuit (if necessary)

- Since the output voltages of the existing circuit **meet the specifications**, no resistor value changes are required.

- The maximum power occurs in R_2 .

$$I = \frac{12\ \text{V}}{R_\text{T}} = \frac{12\ \text{V}}{16.6\ \text{k}\Omega} = 723\ \mu\text{A}$$

$$P_\text{max} = I^2 R_2 = (723\ \mu\text{A})^2\ 4.7\ \text{k}\Omega = \mathbf{2.46\ mW}$$

- The 0.25 W rating of each resistor is more than adequate.

Step 4: Determining the Life of the Battery

- Find the total current drawn from the 12 V battery when the voltage-divider circuit is connected.
- Determine how many days the 6.5 Ah battery will last.

Solution to Step 4: Determining the Life of the Battery

- Find the total current drawn from the 12 V battery when the voltage-divider circuit is connected.

$$I = \frac{12\ \text{V}}{R_\text{T}} = \frac{12\ \text{V}}{16.6\ \text{k}\Omega} = 723\ \mu\text{A}$$

- Determine how many days the 6.5 Ah battery will last.

$$(723\ \mu\text{A})(h) = 6.5\ \text{Ah}$$

$$h = \frac{6.5\ \text{Ah}}{723\ \mu\text{A}} = 8990\ \text{h}$$

$$\text{Number of days} = \frac{8990\ \text{h}}{24\ \text{h/day}} = \mathbf{374.6\ days}$$

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