2 Fundamental Components: Resistors, Capacitors, and Inductors

Resistors, capacitors, and inductors are the fundamental components of electronic circuits. In fact, all electronic circuits can be equivalently represented by circuits of these three components together with voltage and current sources.

2.1 Resistors

Resistors are the most simple and most commonly used electronic component. Resistors have a linear current-voltage relationship as stated by Ohm's law. The unit of resistance is an *ohm*, which is represented by the letter omega (Ω). Common resistor values range from 1 Ω to 22 MΩ.

In the hydrodynamic analogy of electronic circuits, resistors are equivalent to a pipe. As fluid flows through a pipe, frictional drag forces at the walls dissipate energy from the flow and thus reducing the pressure, or equivalently, the potential energy of the fluid in the pipe. A small resistor is equivalent to a large diameter pipe that will allow for a high flow rate, whereas a large resistor is equivalent to a small diameter pipe that greatly constricts the flow rate, as shown in *Figure 2.1*.

Figure 2.1: The hydrodynamic model of a resistor is a pipe

When several resistors are connected in series, the equivalent resistance is the sum of all the resistances. For example, as shown in *Figure 2.2*,

$$R_{eq} = R_1 + R_2$$

When several resistors are connected in parallel, the equivalent resistance is the inverse of the sum of their inverses. For example,

$$R_{eq} = \frac{1}{\frac{1}{R_3} + \frac{1}{R_4}} = \frac{R_3 R_4}{R_3 + R_4}$$

In order to simplify this calculation when analyzing more complex networks, electrical engineers use the ‖ symbol to indicate that two resistances are in parallel such that

$$R_3 \parallel R_4 = \frac{1}{\frac{1}{R_3} + \frac{1}{R_4}} = \frac{R_3 R_4}{R_3 + R_4}$$

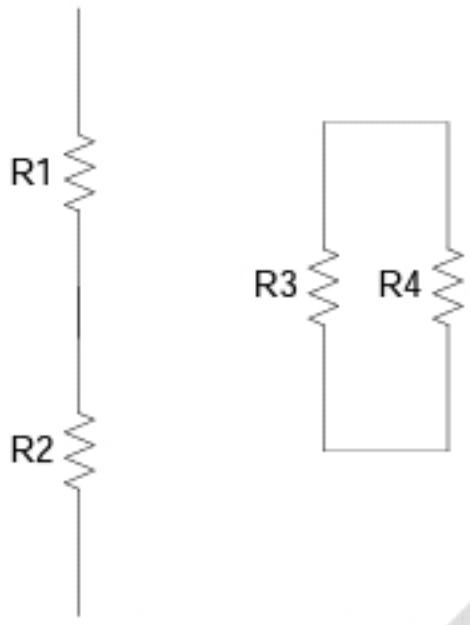

Figure 2.2: Resistors in series and in parallel

A common resistor circuit is the voltage divider used to divide a voltag
fixed value. As shown in *Figure 2.3*, for a voltage V_{in} applied at the input, the r
output voltage is

$$V_{out} = V_{in} \frac{R_1}{R_1 + R_2}$$

Vin