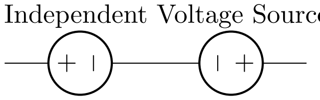
Foundations of Electrical and Computer Engineering

Conrad A. Mearns

March 9, 2017

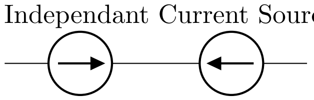
1 Elements

1. Independent Voltage Source

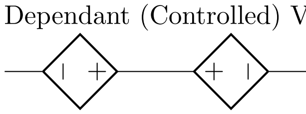
   Provides a fixed voltage independent of what is already attached to the circuit.

2. Independant Current Source

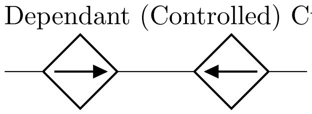
   Provides a fixed current independent of what is already attached to the circuit as long as there is a closed path.

3. Dependant (Controlled) Voltage Source

   Provides a voltage dependant on some other voltage or current.

4. Dependant (Controlled) Current Source

   Provides a current dependant on some other voltage or current.

5. Resistor

   Unit: Ohm (Ω)
   Absorbs power and follows Ohm's Law. $V = Ri$

2 Analog Circuit Fundementals

1. Current $\equiv$ the flow of charge around a closed path in a circuit.

Symbol $\equiv i(t)$ or i
Unit $\equiv$ Amperes, Amps or (A)
Current is a vector of Amperes and direction. It may be defined at any one point along a circuit with either positive or negative values. A negative value current is equivalent to a positive value but opposite direction current.

2. Voltage $\equiv$ the measure of potential difference between two points in a circuit.
   Symbol $\equiv v(t)$ or v
   Unit $\equiv$ Volts or (V)
   Voltage is a vector of of voltage and polarity. The point with postive polarity is the point where the potential difference is greatest. Voltage may also be either positive or negative, and a negative voltage is equivalent to a positive voltage with reversed polarity.

3. Power $\equiv$ a measure of useful output of a circuit.
   Symbol $\equiv p(t)$ or p
   Unit $\equiv$ Watts or (W)
   Relationship $\equiv p(t) = v(t) * i(t)$ or $p = vi$
   Conservation of Power $\equiv$ in a valid circuit, the total power supplied is equivalent to the total power absorbed. Power can be absorbed or supplied by a given element. Circuit validity, as used in the of Conservation of Power is true as a consequence of the law. That is to say, a circuit that does not satisfy the Conservation of Power is not a valid circuit.

To determine if an element absorbs or supplies power:

1. Take measurements of current and voltage before and after the element, in terms of positive values.

2. If current flows into the positive side $\rightarrow$ the element absorbs power.
   If current flows into the negative side $\rightarrow$ the element supplies power.

3 Kirchhoff's Laws

1. Node $\equiv$ a node is a point in a circuit where two or more elements are connected. All points along a wire are the same node.

2. Loop $\equiv$ a loop in a circuit is a closed path that begins and ends at the same node and goes through at least one element.

3.1 Kirchhoff's Current Law (KCL)

The total current into a node is equal to the total current out of the node.

3.2 Kirchhoff's Voltage Law (KCL)

The sum of the voltages around a loop in the circuit is zero.
When tracing the loop, if voltage goes from negative to positive through an element, the voltage is positive. If voltage goes from positive to negative, the voltage is negative.

Both laws must be true in order to have a valid circuit.

4 Parallel Elements and Elements in Series

Series $\equiv$ two elements are in series if they share 1 node and no other element is attached to that node. Elements in series always have the same current.
Parallel $\equiv$ two elements are parallel if they share 2 nodes. Parallel elements have the same voltage.

5 Analyzing All-Series / Single Loop Circuits with Resistors

1. Label all elements with same current
2. Label Voltage across each element as variables
3. Calculate KVL for the loop
4. Calculate Ohm's Law for each resistor
5. Substitute Ohm's Law equation back into KVL equation
6. Modify the equation to solve for a single unknown (which is often the current)
7. Solve for the unknown
8. Use Ohm's Law to get voltages
9. Calculate power

6 Analyzing All-Parallel Circuits with Resistors

1. Label voltage across each element, be mindful that resistors always absorb power
2. Label current across each element
3. Calculate a single KCL equation for the top node
4. Calculate Ohm's Law for each resistor

5. Substitute Ohm's Law equation back into KCL equation
6. Modify the equation to solve for a single unknown
7. Use Ohm's Law to find the current
8. Calculate power

7 Solving Circuits with at Least Two Loops

1. Label current across each element
2. Label voltage across each element
3. Calculate KVL for each loop as long as it isn't parallel
4. Calculate a KCL equation for each node shared between loops
5. Calculate Ohm's Law for each resistor
6. Substitute Ohm's Law equation into everything you can, keep reducing variables to solve everything

8 Solving Circuits Sequentially

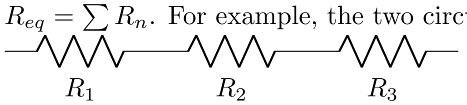
When given a resistor with voltage, resistance and current, etc...

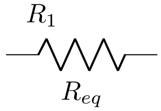
- Alternate Ohm's equations with either KVL or KCL
- Get one unknown after every step
- Use one the solved unknown for the next step

9 Series and Parallel Resistors

9.1 Series

Resistors that are in series can be redrawn into a single new resistor R_{eq} where $R_{eq} = \sum R_n$. For example, the two circuits are equivalent.

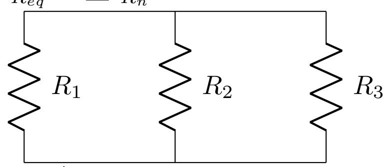


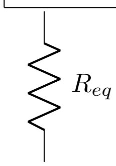


where $R_{eq} = R_1 + R_2 + R_3$.

9.2 Parallel

Resistors that are parallel can be redrawn into a single new resistor R_{eq} where $\frac{1}{R_{eq}} = \sum \frac{1}{R_n}$. For example, the two circuits are equivalent.





where $R_{eq} = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}}$.