**Kirchhoff’s Current Law**

The algebraic sum of currents entering and exiting a node equals zero.

Convention (quite arbitrary): currents going into the nodes are positive, the ones which go out of the node are negative.

**Kirchhoff’s Voltage Law**

The algebraic sum of all voltage changes (aka voltage drops) in a loop equals zero.

Notes:
- chose a direction along which you travel a network. If you go over a resistor and current runs the same way then voltage change is negative, otherwise its positive.
- If you go over a voltage source from negative terminal to positive the voltage change is positive, otherwise negative.

**Example**

Our goal is to find $I_1$, $I_2$, and $I_3$.

We chose $V_A = 0$.

For node $A$:

$$I_1 - I_2 - I_3 = 0 \quad (1)$$

We need 2 more independent equations.

For this we will go over 2 small loops as indicated by arrows.

$$V_{DC} + V_{CA} + V_{AD} = 0 \quad (2)$$

$$V_{AB} + V_{BC} + V_{CA} = 0 \quad (3)$$

Notice:

$$V_{AB} = +E_1, \ V_{BC} = -R_2 \times I_2, \ V_{CA} = +R_3 \times I_3,$$

$$V_{DC} = +R_1 \times I_1, \ V_{AD} = -E_2.$$

**Example (continued)**

$$I_1 - I_2 - I_3 = 0$$

$$V_{DC} + V_{CA} + V_{AD} = 0 \quad \rightarrow \quad R_1 \times I_1 + R_3 \times I_3 + E_2 = 0$$

$$V_{AB} + V_{BC} + V_{CA} = 0 \quad E_1 - R_2 \times I_2 + R_3 \times I_3 = 0$$
Maple as the math aid

\[ \begin{align*}
(I_1 &- R_1)(I_2 - R_2)(I_3 - R_3) = 0, \\
E_1 & R_2 I_2 R_3 I_3 = 0, \\
R_1 I_1 R_3 I_3 & E_2 = 0, \\
I_1, I_2, I_3 & = 0,
\end{align*} \]

Eugeni Mikhailov (W&M)  
Electronics 1  
Lecture 02  
5 / 7

Notes

Maple as the math aid (continued)

Thévenin’s and Norton’s equivalent circuit theorems

Any combination of voltage sources, current sources and resistors with two terminals is electrically equivalent

**Thévenin’s theorem**  
To a single voltage source \( V_{TH} \) and a single series resistor \( R_{TH} \) connected in series.

**Norton’s theorem**  
To a single current source \( I_N \) and a single series resistor \( R_N \) connected in parallel.

Note above circuits are equivalent to each other when

\[ R_{TH} = R_N \text{ and } I_N = V_{TH}/R_{TH} \]

Eugeni Mikhailov (W&M)  
Electronics 1  
Lecture 02  
6 / 7

Notes

Notes