

ELG 2138 Cheat Sheet

1 Introduction

Power is the rate at which something gives energy. It is the time derivative of work.

We have independant current sources, and independant voltage sources.

Current is the amount of charge per second, and voltage is the potential energy difference.

Anything that consumes energy is a resistor with a resistance in Ohms (Ω).

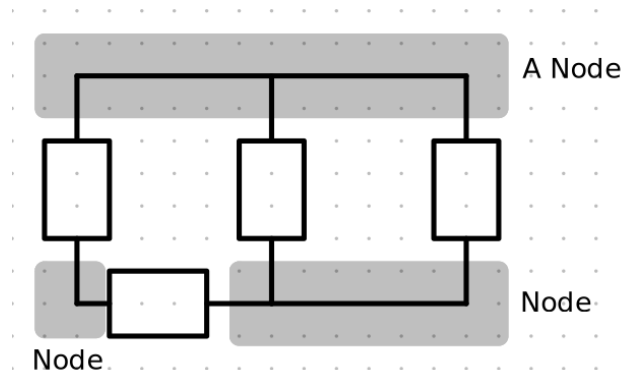
A resistor can be read using the colored bands on the resistor. I will not include a chart here, but it is a simple internet search away.

Electrical sources can be either Direct Current (DC), where the voltage is constant with time, or Alternating Current (AC) where the voltage varies (along a sine wave) with time.

2 Resistive Circuits

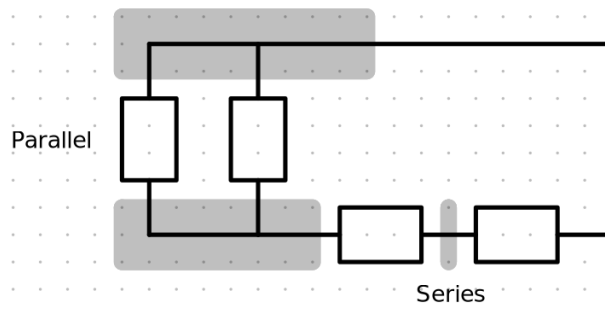
These are circuits with **only** resistors, and independant current/voltage sources.

Circuit elements are directly connected when they share the same terminal. This common terminal is called the node.



A series connection is when 2 elements share a single node. The current is the same.

A parallel connection is when there are 2 terminals shared between 2 or more elements. If 2 elements are in parallel ($//$), then they must both share a node on each side of the elements.

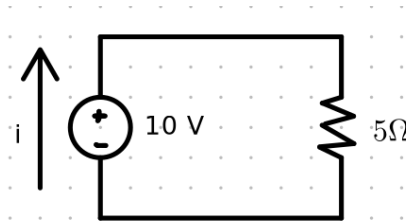


2.1 Ohms Law

Ohms law relates resistance to current and voltage.

$$v = iR$$

Ex. Find the current i through the voltage source.



We cannot use Ohms law directly since we do not know the resistance of the source.

However, we know that the source and resistance are in parallel, so the voltage at the resistor is also 10 V. We know that it is also in series with the 10 V source, so the current everywhere is the same.

$$v = iR \implies i = \frac{v}{R} = \frac{10}{5} = 2A$$

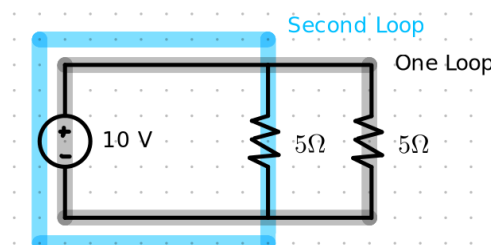
Therefore the current in the resistor is 2A, so the current in the source is 2A.

2.2 KCL (Kirchoffs Current Law)

This states that the sum of all currents at any node is 0.

2.3 KVL (Kirchoffs Voltage Law)

This states that the sum of voltages in any loop is 0.



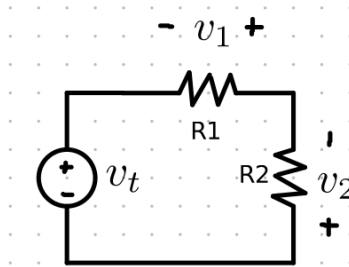
So we go around a loop, getting the voltages of each element (recall $v=iR$) and then solve. We can create multiple KVLs to get a system of equations.

2.4 Voltage Divider

If we have a voltage that goes through 2 resistors in series, the voltage gets divided between both of them.

$$v_1 = \frac{R_1}{R_1 + R_2} v_t$$

where v_t is the total voltage going in.

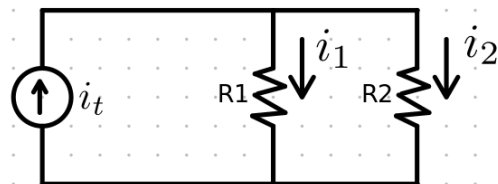


2.5 Current Divider

If we have current that goes through 2 resistors in parallel, the current gets divided between both of them.

$$i_1 = \frac{R_2}{R_2 + R_1} i_t$$

where i_t is the total current going in.



2.6 Power

If the power is **positive**, an element **consumes** power.

If the power is **negative**, an element **produces** power.

We say that:

$$P = vi$$

The net power in a circuit is always 0.

3 Methods to Analyse Resistive Circuits

These methods are ways to easily find all values in a circuit no matter the complexity.

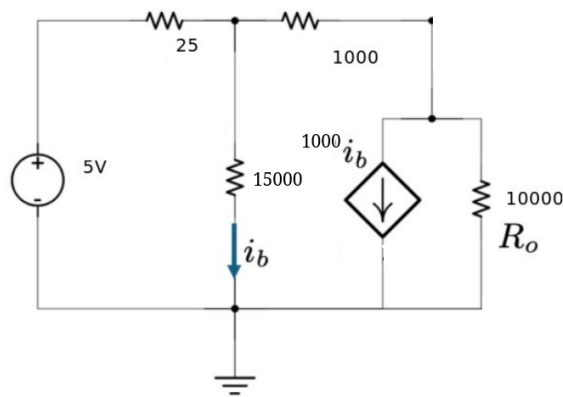
3.1 Node Voltage Analysis (NVA)

With this method, we need a reference node (Ground node). This node can usually be any node.

This method works on using KCL at each node of the circuit, and then we will get all the currents in terms of node voltage, and then solve the system of equations.

1. Identify the number of nodes in the circuit and designate the reference node
2. If there is an independant voltage source that is not connected to ground, make that a supernode and get it an equation.
3. Write the node voltage KCLs for all nodes. Note that if the node is a voltage source connected to ground, we know the voltage.
4. Solve the KCLs to get all voltages.
5. Get the information we need

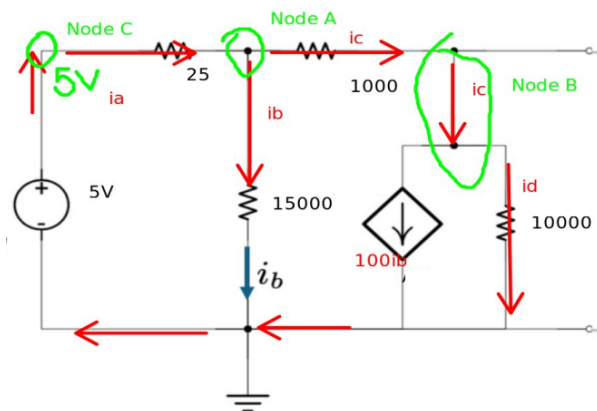
Ex. Find the node voltages in this circuit.



We already have a ground. We notice that there is an independant source in this circuit, as well as 3 nodes.

I will draw in the nodes as well as the current directions I assume (it does not matter what I assume as long as I am consistent).

Note that the leftmost node is 5v.



Now I create equations for nodes A and B. We use the fact that $i = \frac{V}{R}$.

For A:

$$\text{currentIn} = \text{currentOut} \implies \frac{5 - V_A}{25} = \frac{V_A}{15000} + \frac{V_A - V_B}{1000}$$

For B it is a bit harder since we do not know the dependent source, except we actually do since $i_b = \frac{V_A}{15000}$.

$$\text{currentIn} = \text{currentOut} \implies \frac{V_A - V_B}{1000} = 100 \cdot \frac{V_A}{15000} + \frac{V_B}{10000}$$

Now I have 2 equations and 2 unknowns so I solve to get $V_A = 4.33$, $V_B = -22.3$.

3.2 Mesh Current Analysis (MCA)

With this method, we use meshes (loops) in a circuit and do the KVL around those loops. Same idea as the NVA.

1. Divide the circuit into meshes and assign each mesh a name.
2. If there is an independent current source common to 2 meshes, form a supermesh and get it an equation.
3. Write the mesh current KVLs for all meshes. Note that if there is an independent current source only common to 1 mesh, we know that mesh's current.
4. Solve the KVLs to get all currents.
5. Get the information we need.

Ex. put mca ex here

4 Circuit Theorems

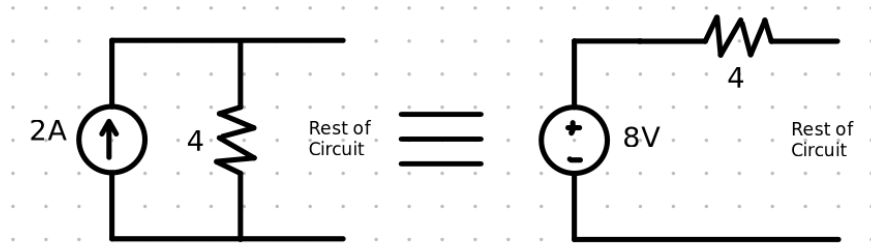
These are things that help make a circuit simpler.

4.1 Source Transformations

We can turn a voltage source and resistor in series into a current source and resistor in parallel.

We can turn a current source and resistor in parallel to a voltage source and resistor in series.

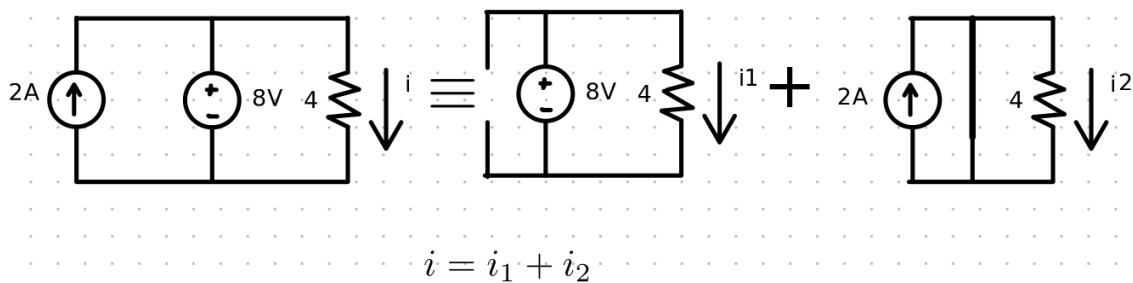
For both of these we just use Ohms law.



4.2 Superposition

This states that if we have 2 circuits with current and voltage sources only, then the value of any current or voltage can be gotten by adding the values obtained from each individual source with other sources deactivated.

Deactivating means replace a voltage source with a short circuit (SC), and a current source with an open circuit (OC).



4.3 Thevanin

Any circuit **connected between 2 terminals** can be simplified down to an independant voltage source in series with a resistor.

This voltage source is called the Open Circuit Voltage (V_{OC}) and the resistance is called the Thevanin resistance (R_t)

To find V_{OC} between 2 terminals, we create an open circuit between those 2 terminals and solve for the voltage across them. This is the V_{OC} .

To find R_t , we can deactivate all independant sources (Voltage becomes SC, Current becomes OC), then if there are no dependant sources, combine resistors until we have one left. If there are still dependant sources, then we connect a dependant current source with 1A to

the terminals, then find the voltage across the terminals, then find R_t knowing 1A current, and voltage.

4.4 Norton

Any circuit **connected between 2 terminals** can be simplified down to an independant current source in parallel with a resistor.

This current source is called the Short Circuit Current (I_{SC}) and same as the Thevanin circuit, the resistance is R_t .

To find I_{SC} between 2 terminals, we create a short circuit between the terminals and find the current flowing through that wire. This is the I_{SC} .

If we know both I_{SC} and V_{OC} , then we can find $R_t = \frac{V_{OC}}{I_{SC}}$

5 Energy Storage Elements

5.1 Capacitors and Inductors

5.2 Switches and Initial Conditions

6 Complete Responce of RL and RC

6.1 RC Circuits (Resistance and Capacitor)

6.2 RL Circuits (Resistor and Inductor)

7 AC Analysis of RLC Circuits using Phasors

8 Power Calculations in AC Circuits