Lab Session 03
Resistance in series and parallel

Objective:

To understand different combinational circuits of resistors

Theory:

Resistors Combinations:

Resistors can be connected in either a series connection, a parallel connection or combinations of both series and parallel together, to produce more complex networks whose overall resistance is a combination of the individual resistors. Whatever the combination, all resistors obey *Ohm's Law* and *Kirchhoff's Circuit Laws.*

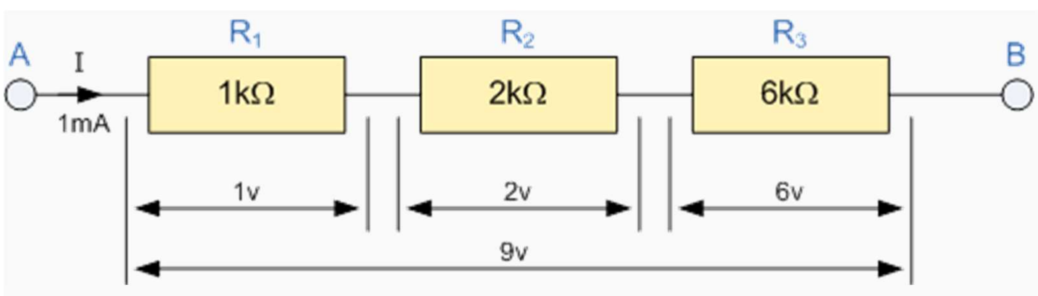
Resistors in Series:

Resistors are said to be connected in "**Series**", when they are daisy chained together in a single line. Since all the current flowing through the first resistor has no other way to go it must also pass through the second resistor and the third and so on. Then, resistors in series have a **Common Current** flowing through them, for example:

$I_{R1} = I_{R2} = I_{R3} = I_{AB} = 1mA$

In the following example the resistors R_1, R_2 and R_3 are all connected in series between points A and B.

Series Resistor Circuit



As the resistors are connected in series the same current passes through each resistor in the chain and the total resistance, R_T of the circuit must be **equal** to the sum of all the individual resistors added together. That is

$$R_T = R_1 + R_2 + R_3$$

By taking the individual values of the resistors in our simple example above, the total resistance is given as:

$$R_T = R_1 + R_2 + R_3 = 1k\Omega + 2k\Omega + 6k\Omega = 9k\Omega$$

Therefore, we can replace all 3 resistors above with just one single resistor with a value of 9kΩ.

Where 4, 5 or even more resistors are all connected in series, the total resistance of the series circuit R_T would still be the sum of all the individual resistors connected. This total resistance is generally known as the **Equivalent Resistance** and can be defined as;" *a single value of resistance that can replace any number of resistors without altering the values of the current or the voltage in the circuit"*. Then the equation given for calculating total resistance of the circuit when resistors are connected in series is given as:

Series Resistor Equation

$$R_{total} = R_1 + R_2 + R_3 + ... R_n \text{ etc.}$$

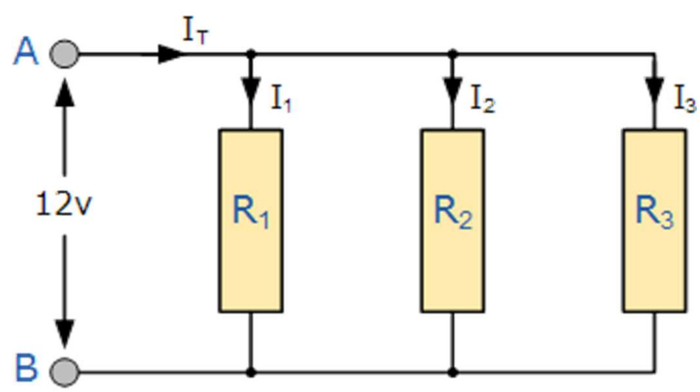
One important point to remember about resistors in series circuits, the total resistance (R_T) of any two or more resistors connected in series will always be **GREATER** than the value of the largest resistor in the chain and in our example above RT = 9kΩ were as the largest value resistor is only 6kΩ.

Resistors in Parallel:

Resistors are said to be connected in "**Parallel**" when both of their terminals are respectively connected to each terminal of the other resistor or resistors. The voltage drop across all the resistors in parallel is the same. In the following circuit the resistors R_1, R_2 and R_3 are all connected in parallel between the two points A and B.

Parallel Resistor Circuit

In the previous series resistor circuit we saw that the total resistance, R_T of the circuit was equal to the sum of all the individual resistors added together. For resistors in parallel the equivalent circuit resistance R_T is calculated differently.



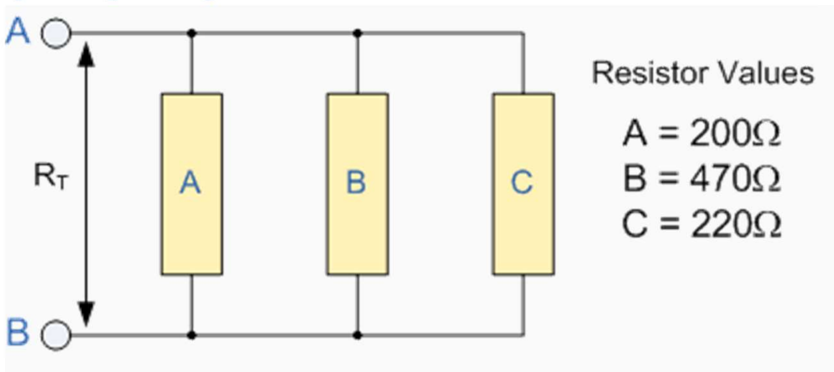
Parallel Resistor Equation

Here, the reciprocal (1/Rn) value of the individual resistances are all added together instead of the resistances themselves. This gives us a value known as **Conductance**, symbol **G** with the units of conductance being the **Siemens**, symbol **S**. Conductance is therefore the reciprocal or the inverse of resistance, (G = 1/R). To convert this conductance sum back into a resistance value we need to take the reciprocal of the conductance giving us then the total resistance, R_T of the resistors in parallel.

Example No1:

For example, find the total resistance of the following parallel network

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots\ldots\ldots + \frac{1}{R_n} \text{ etc}$$



Then the total resistance R_T across the two terminals A and B is calculated as:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

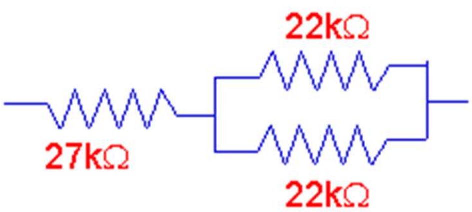
$$\frac{1}{R_T} = \frac{1}{200} + \frac{1}{470} + \frac{1}{220} = 0.0117$$

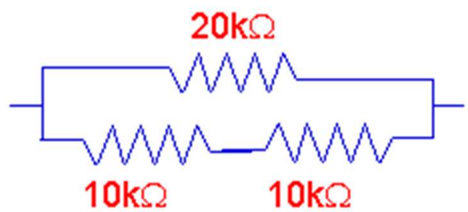
$$\text{therefore, } R_T = \frac{1}{0.0117} = 85.67\Omega$$

This method of calculation can be used for calculating any number of individuals

Exercises:

What is the equivalent resistance of these resistance combinations?





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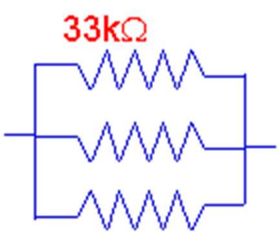

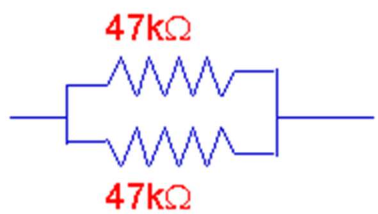

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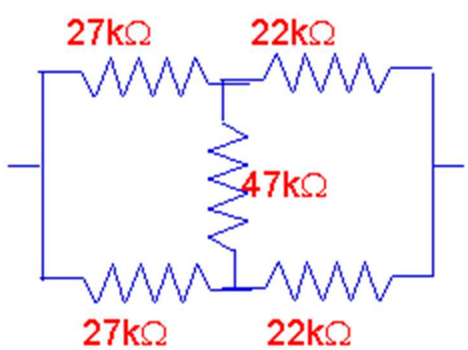

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