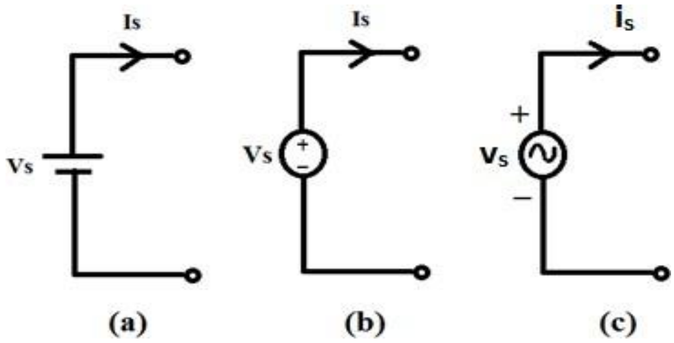
NOTES – CLASS 2

Ideal Voltage & Current Sources:

Ideal Voltage Source:

An ideal voltage source is a source of EMF in which terminal voltage is independent of the current flowing through it.

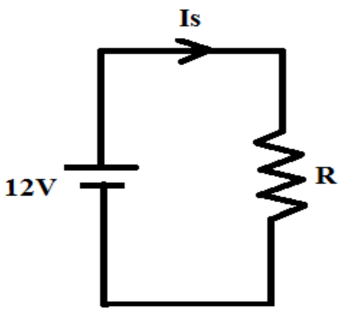
It is represented by one of the following symbols:



Figures (a) & (b) represent a DC Voltage source whereas figure (c) represents an AC voltage source.

However, the current delivered by it can be any finite value & depends on the circuit to which it is connected.

Consider the following example in which an ideal voltage source of EMF 12V is connected across a resistor R.



When R = 10Ω, I_S = 1.2A

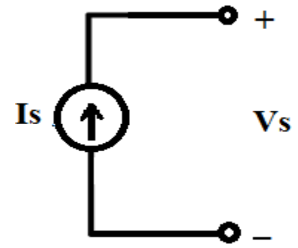
When R = 1Ω, I_S = 12A

As the value of R varies, current delivered by it varies whereas the terminal voltage is fixed at 12V.

Ideal Current Source:

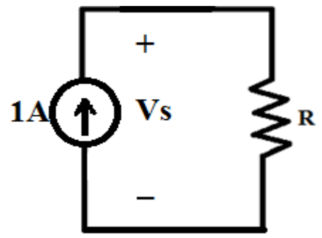
An ideal current source is a source in which terminal current is independent of the voltage across its terminals.

It is represented by the following symbol.



However, the voltage across it can be any finite value & depends on the circuit to which it is connected.

Consider the following example in which an ideal current source of current 1A is connected across a resistor R.



When R = 1Ω, V_S = 1V

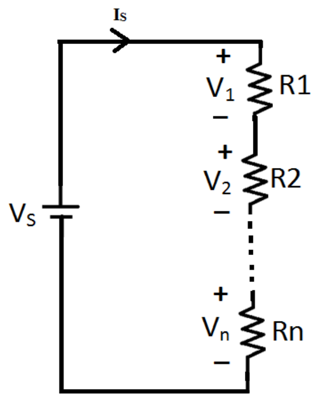
When R = 10Ω, V_S = 10V

As the value of R varies, voltage across it varies whereas the terminal current is fixed at 1A.

Voltage & Current Division Rules:

Voltage Division Rule:

Voltage Division Rule is applicable to series networks. Consider the network shown below:



By Ohm's Law across each resistor,

$V_1 = I_S*R_1$

$V_2 = I_S*R_2$

.

.

$V_n = I_S*R_n$

By KVL around the network,

$V_S = V_1+V_2+...+V_n$

Hence, $I_S = \frac{V_S}{(R_1+R_2+\cdots+R_n)}$

Therefore,

$$V_1 = \frac{V_S * R_1}{(R_1+R_2+\cdots+R_n)} \qquad \text{- ------ (1)}$$

.

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.

.

$$V_n = \frac{V_S * R_n}{(R_1+R_2+\cdots+R_n)} \qquad \text{-----------(N)}$$

Equations (1) to (N) above represent Voltage division rule.

According to it,

“Voltage across any one of the resistors connected in series is equal to the total voltage multiplied by the ratio of that resistance to the sum of all the resistances in series.”

Equivalent series resistance:

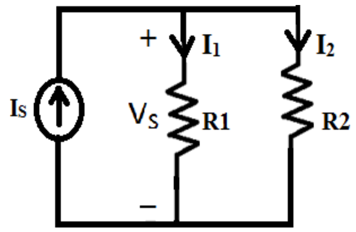
Equivalent resistance of ‘n’ resistors in series is given by

$$\mathbf{R_{eq} = R_1+R_2+\ldots+R_n}$$

Current Division Rule:

Current Division Rule is applicable to parallel networks.

Consider the network shown below:



By Ohm's Law,

$I_1 = \frac{V_S}{R_1}$

$I_2 = \frac{V_S}{R_2}$

By KCL,

$I_S = I_1 + I_2$

Hence,

$I_S = V_S * (\frac{1}{R_1} + \frac{1}{R_2})$

Therefore,

$V_S = I_S * \frac{R_1 * R_2}{(R_1 + R_2)}$

$I_1 = I_s * \frac{R_2}{(R_1 + R_2)}$

$I_2 = I_s * \frac{R_1}{(R_1 + R_2)}$

Equations (1) & (2) above represent current division rule.

According to it,

“Current in any one of the two parallel resistors is the total current multiplied by the ratio of parallel resistances.”

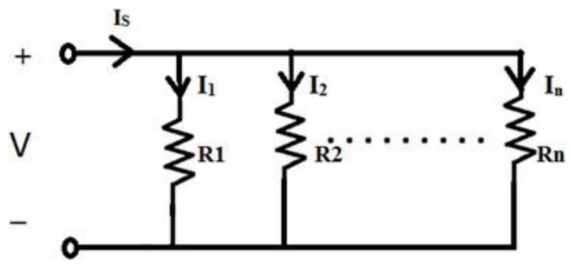
Equivalent parallel resistance (Two resistor case):

Equivalent resistance of two resistors in parallel is given by

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} = \frac{R_1 * R_2}{(R_1 + R_2)}$$

Current Division Rule – More than two resistors in Parallel:

When more than two resistors are in parallel, the following steps need to be followed to apply current division:



Step 1: Obtain R_{eq} using the equation,

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

Step 2: Find V using the equation,

$$V = I_S * R_{eq}.$$

Step 3: Now, use Ohm’s Law to find each branch current.

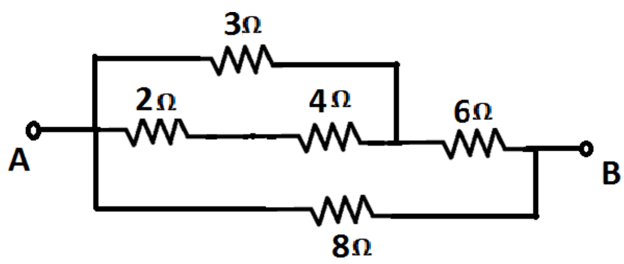
Network Reduction Using Series – Parallel Combinations:

Two elements are said to be in series if they are connected at one terminal and carry the same current through them.

Two elements are said to be in parallel if they are connected at both ends together and have same voltage across them.

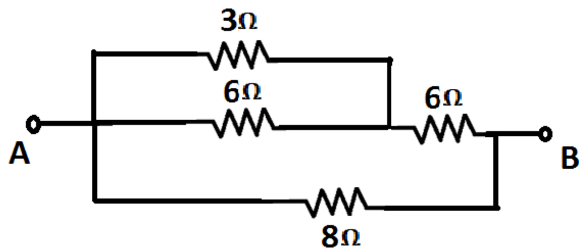
While finding equivalent resistance between two terminals, we usually combine the resistors in series or parallel.

Example: Find the equivalent resistance between A & B in the network shown below



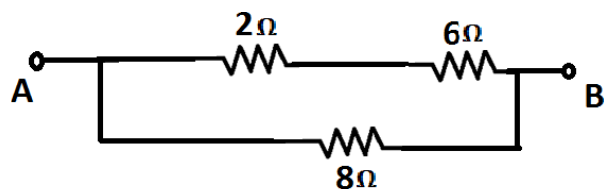
Solution:

2Ω and 4Ω can be combined in series using $R_{eq} = 2\Omega + 4\Omega = 6\Omega$

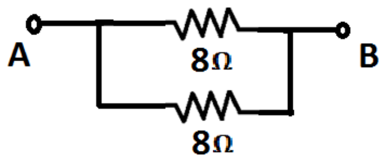


Now, 3Ω and 6Ω can be combined in parallel using R_{eq}

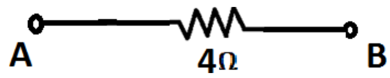
gives 2Ω



Now, combine 2Ω and 6Ω in series, which gives 8Ω



Finally, combine both 8Ω resistors in parallel.



Hence, equivalent resistance between A & B is 4Ω.