NALYSIS OF DIRECT CURRENT NETWORK(Revision)

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Revising the Analysis of Direct Current Networks

Introduction

This study guide builds on your foundational knowledge of electrical circuits—covering key definitions, circuit laws, rules, and more. It’s designed for quick, effective revision, helping you grasp core concepts and a few advanced topics to aid in your exam prep. Use this as a supplement to your recommended materials.

Let’s dive in, starting with DC circuit analysis and essential theorems. Key definitions are included to support your review, but remember to cover any terms not listed here.

1.2 Resistivity and Temperature Coefficient of Resistance

Definition. Resistivity is a materials property that quantifies how strong a material opposes the flow of electric current.

Factors that affect resistance

The resistance of any material is due primarily to four factors:

1. Material
2. Length
3. Cross-sectional area
4. Temperature of the material

Remember This!!!

Law of resistance states: the resistance is directly proportional to the length of the conductor l, and varies inversely to the cross-sectional area of the conductor A. That is, $\boldsymbol{R} \propto \frac{\boldsymbol{l}}{\boldsymbol{A}}$

The constant of proportionality ρ(rho) is specific resistance or resistivity. Therefore, $\boldsymbol{R} = \boldsymbol{\rho}\frac{\boldsymbol{l}}{\boldsymbol{a}}$ The reciprocal of resistivity of a conductor is called its **conductivity.**

Temperature greatly impacts the resistance of conductors, semiconductors, and insulators. For a conductor with initial resistance R_θ at θ°C and final resistance R_T at T°C:

1. The resistance change $(R_T - R_\theta)$ is:
   - Directly proportional to the initial resistance, R_θ.
   - Directly proportional to the temperature increase $(T - \theta)$.
   - Dependent on the material's temperature coefficient of resistance, α_θ.

Combining these, we find:

$$R_T = R_\theta\{1 + \alpha_\theta(T - \theta)\}$$

Resistivity, or specific resistance, also varies with temperature.

The rate of change in resistivity per °C is known as the temperature coefficient of resistivity. For metals, resistivity increases as temperature rises.

This relationship is given by: $\rho t = \rho\theta(1 + a\theta(\mathrm{T} - \theta))$

- where $\rho\theta$ = resistivity of metallic conductor at θ°C
- ρt = resistivity of metallic conductor at temperature T °C
- Note that temperature coefficient of resistivity is equal to temperature coefficient of resistance αθ

Worked out examples

REMEMBER

THIS PLEASE

QT1. A wire sample (1 mm in diameter by 1 m in length) of an aluminium alloy (containing 1.2% Mn) is placed in an electrical circuit. A voltage drop of 0.432 V is measured across the length of the wire as it carries 10 A current. Calculate the conductivity of this wire.

Q2 When a potential difference of 10 V is applied to a coil of copper wire of mean temperature 20 °C, a current of 1.0 A flows in the coil. After some time the current falls to 0.95 A yet the supply voltage remains unaltered. Given that the temperature coefficient of resistance of copper is $\alpha_{0°C} = 4.28 \times 10^{-3}$ /°C referred to 0 °C. Determine the

i. mean temperature of the coil with the new stated conditions.

ii. current though and resistance of the coil at 0 °C

Parallel and Series Connection, of circuit elements

In circuit theory, parallel and series connections refer to how circuit elements (like resistors, capacitors, and inductors) are arranged to impact the total resistance, capacitance, or inductance in the circuit.

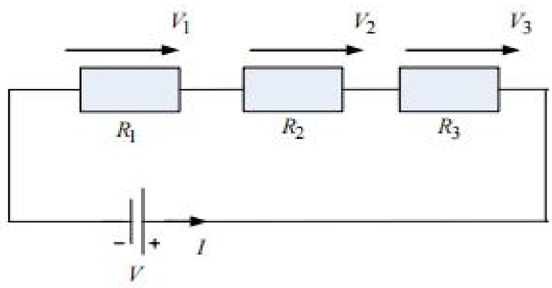
1. Series Connection:

Circuit elements are connected end-to-end in a single path for current flow.

- **Current** is the same across all elements in series.

- **Voltage** across each element adds up to give the total voltage.

- **For resistors**: the total resistance $\mathbf{R_{total}}$ is the sum of individual resistances:



Series

$R_{total} = R_1 + R_2 + R_3$

$V = V_1 + V_2 + V_3$

I = the same across all elements in series

2. Parallel Connection:

Circuit elements are connected with their ends joining to form branches, creating multiple paths for current.

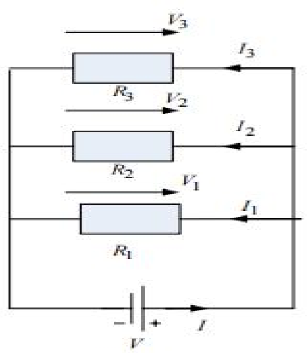
Voltage is the same across each element in parallel.

Current through each branch adds up to give the total current.

For resistors: the total resistance

R_{total} in parallel is given by:

$$\frac{1}{Rtotal} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$



Parallel

Both arrangements affect how current and voltage behave in the circuit, influencing energy distribution, and are fundamental to circuit design and analysis.

REMEMBER

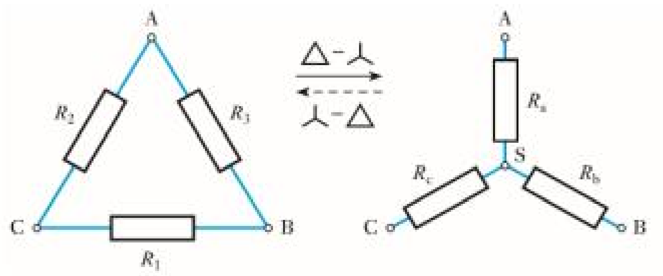
The above circuit configurations are easy to work with.

There are complex circuit configurations that cannot be simplified by series or parallel connections, but for the sake of this course and our own revision will look at two of such configurations.

Star and Delta

Delta

star



Configurations

Please refer to the video on star and delta connections for better insight. Otherwise, the following are the formulas we use to transform from delta to star and star to delta as illustrated.

1. **Delta to star (** use the following formulas when creating a star configuration from a delta configuration)

$$R_a = \frac{R_2 R_3}{R_1 + R_2 + R_3}; \ R_b = \frac{R_1 R_3}{R_1 + R_2 + R_3}; \ R_c = \frac{R_1 R_2}{R_1 + R_2 + R_3}$$

2. **Star to delta (** use the following formulas when creating a delta connection from a star configuration)

$$R_1 = \frac{R_aR_b+R_bR_c+R_aR_c}{R_a} = R_b + R_c + \frac{R_bR_c}{R_a};$$

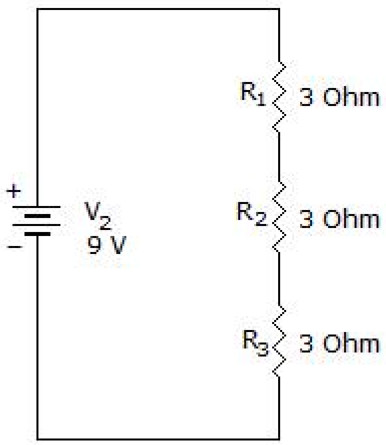
$$R_2 = \frac{R_aR_b+R_bR_c+R_aR_c}{R_b} = R_a + R_c + \frac{R_aR_c}{R_b};$$

$$R_3 = \frac{R_aR_b+R_bR_c+R_aR_c}{R_c} = R_a + R_b + \frac{R_aR_b}{R_c}$$

Worked out Examples

Series connection simple example

1. What is the current flow through R1, R2, and R3?



Ⓐ 1A, 1A, 1A

Ⓑ 1A, 2A, 3A

Ⓒ 3A, 3A, 3A

Ⓓ 3A, 2A, 1A

The Answer is A. are you able to figure out Why?

test your skills.

solution.

Remember, in a series connection the current is the same across each resistor. And there equivalent resistance is the total resistance of the individual resistors connected in series, thus

R_{total} =R1+R2+R3 = 3+3+3 = 9 Ohms

From Ohms law $I = \frac{V}{Rtotal}$

Therefore $I = \frac{9V}{9\ ohm}$ = 1 amp

1 amp is the current moving from the source and since the resisters are connected in series, each resister receives the same current of 1 amp.

Q2

Data given

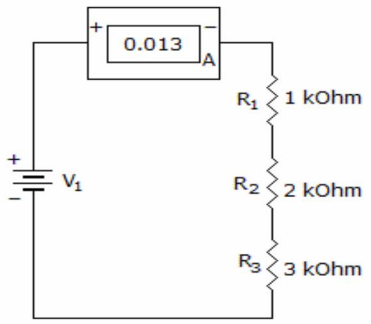
current = 0.013 Amp

R1=1000ohm.R2 = 2000 ohm, R3= 3000ohm

unknowns

Source volage V1.

What is the dc source voltage?



Ⓐ 78 V

Ⓑ 39 V

Ⓒ 13 V

Ⓓ 0 V

Therefore, total source voltage

V = VR1+VR2+VR3

For the network in Figure 27. Calculate the branch currents.

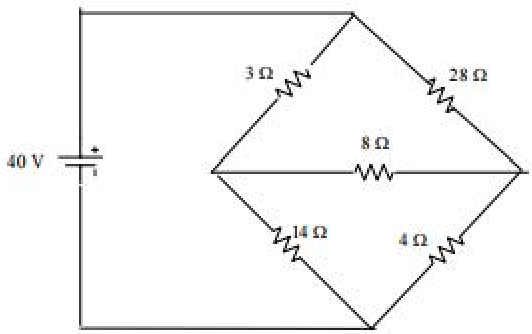


Figure 27