KCL and KVL in Electrical Networks - GATE Study Material in PDF

In this **free GATE Study Material**, we discuss about **the two Kirchhoff's Laws – KCL and KVL in Electrical Networks**. **Kirchhoff's Law** are the two laws enabling easier analysis of an interconnection of any number of circuit elements.

There are some simple relationships between currents and voltages of different branches of an electrical circuit. These relationships are determined by these basic laws known as **Kirchhoff laws** or more specifically **Kirchhoff Current Law** and **Kirchhoff Voltage Law**. In these **GATE Notes,** you can also learn about the **Sign Conventions** for these laws as well as some common **DC Circuit Theory Terms**.

These laws of KCL and KVL in Electrical Networks are extremely important from the point of view of learning the topics of Network Elements and Network Theorems. Useful for **GATE EC, GATE EE, BARC, IES, DRDO, BSNL** exams.

Download as PDF for reference and revision. Make sure to read up on the recommended articles before you start off.

Recommended Reading –

Basic Network Theory Concepts

Source Transformation

Kirchhoff's Current Law (KCL)

At any instant the algebraic sum of currents leaving any node in a network is zero.

$\sum_n i_n(t) = 0$

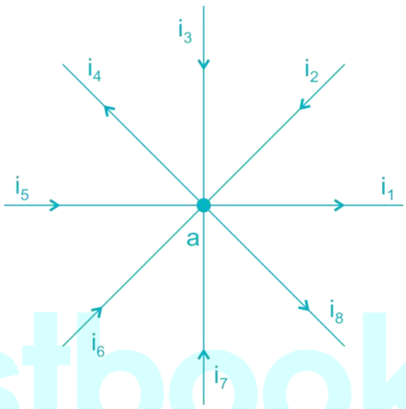
Also we can say that the total current enters, is exactly equal to the total current leaves the point. The point may be considered anywhere in the circuit.

This law is also known as Kirchhoff's first law.

Sign Convention

Depends on the wish of the reader, for an instance choose all the incoming current at a node as positive and outgoing current as negative. You can do vice-versa as well.

Example 1:



At node a

$(i_2 + i_3 + i_5 + i_6 + i_7) - (i_1 + i_4 + i_8) = 0$

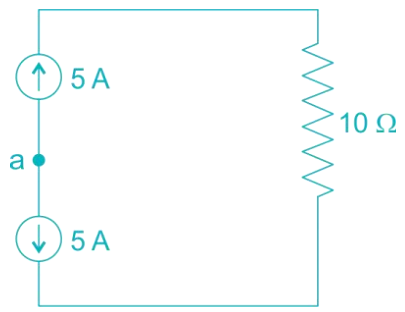
$\sum i_{incoming} = \sum i_{outgoing}$

Note:

i. KCL is applicable to any lumped network irrespective of the nature of the network; whether unilateral or bilateral, active or passive, linear or non-linear.
ii. KCL is not applicable to the distributed networks.
iii. KCL is always gives conservation of charge.
iv. Current always travels in a less resistance path.
v. Maximum amount of current is flowing in a short circuit because of zero resistance
vi. There is no flow of current in an open circuit because of infinite resistance.
vii. Current is constant in a series path and is divided in a parallel path.

Example 2:

Find current in the given circuit



Solution:

At a node only one value of current is possible

So, here violation of KCL

So, no current possible

Kirchhoff's Voltage Law (KVL)

At any instant algebraic sum of the voltage around any closed path within a network is zero.

$\sum_n V_n(t) = 0$

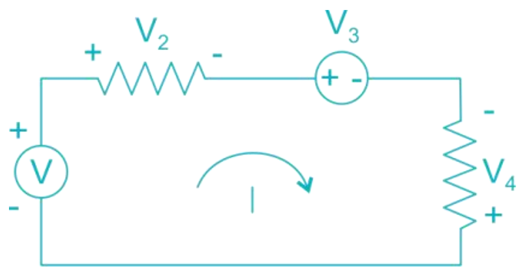
Also we can say that, the algebraic sum of the products of the resistances of the conductors and the currents in them in a closed loop is equal to the total emf available in that loop.

This law is also known as Kirchhoff's second law.

Sign Convention

Positive voltage sign i.e. potential rise if current pass from negative terminal to positive terminal of the element and negative sign i.e. voltage drop if current pass from positive to negative terminal.

Example 3:



$V_1 - V_2 - V_3 + V_4 = 0$

$V_1 + V_4 = V_2 + V_3$

Note:

i. KVL is applicable to any lumped network irrespective of the nature of the network; whether unilateral or bilateral, active or passive, linear or non-linear.

ii. KVL is not applicable to the distributed networks.

iii. KVL is always gives conservation of energy.

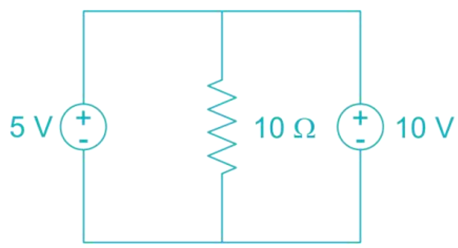
iv. Maximum amount of voltage is appeared across open circuit because of infinite resistance.

v. Voltage drop across a short circuit is zero because of zero resistance.

vi. Voltage is constant in a parallel path and is divided in a series path.

Example 4:

For the given circuit find current in 10Ω.

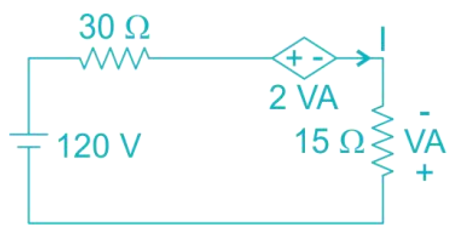


Solution:

In parallel connection voltage should be constant but here it is different which is a violation of KVL .Hence it is not possible to find the current in 10Ω

Example 5:

Find the value of current I in the given circuit



Solution:

Apply KVL in the given loop then we get,

$-120 + 30I + 2V_A - V_A = 0$

$120 = 30I + V_A$ .... (1)

Also from ohms law at the output we can get

$V_A = -15\ I$ .... (2)

On solving equations (1) and (2) we get

I = 8 Ampere.

Common DC Circuit Theory Terms

Circuit – a circuit is a closed loop conducting path in which an electrical current flows.

Path – a single line of connecting elements or sources.

Node – a node is a junction, connection or terminal within a circuit were two or more circuit elements are connected or joined together giving a connection point between two or more branches. A node is indicated by a dot.

Branch – a branch is a single or group of components such as resistors or a source which are connected between two nodes.

Loop – a loop is a simple closed path in a circuit in which no circuit element or node is encountered more than once.

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