SRIMAAN COACHING CENTRE-TRICHY-TNMAWS- MUNICIPAL ADMINISTRATION & WATER SUPPLY DEPARTMENT- EEE-(ELECTRICAL) STUDY MATERIAL -TO CONTACT:8072230063.

2024-25 SRIMAAN

# SRIMAAN

# TNMAWS

MUNICIPAL ADMINISTRATION & WATER SUPPLY DEPARTMENT-(MAWS)

## EEE-Assistant Engineer (Electrical)

## TN-MAWS MATERIALS

CIVIL/ MECHANICAL / EEE/ TOWN PLANNING/ ARCHITECTURE / PUBLIC HEALTH & SANITATION AVAILABLE.

UG-TRB-(SGT)-STUDY MATERIAL (TAMIL & ENGLISH MEDIUM) AVAILABLE.

# MUNICIPAL ADMINISTRATION & WATER SUPPLY DEPARTMENT (TN-MAWS)

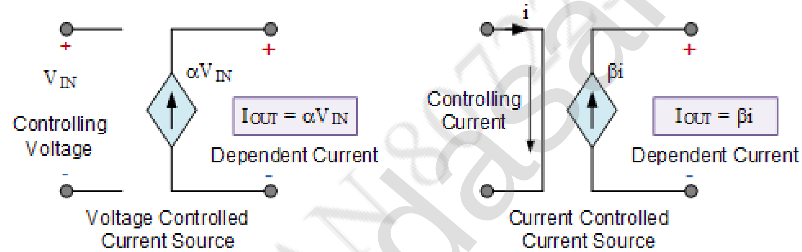
## Paper-I-ELECTRICAL ENGINEERING (Degree Standard)

**UNIT – I: ELECTRICAL CIRCUITS CODE:103**

**Introduction:** We now know that an ideal current source provides a specified amount of current completely independent of the voltage across it and as such will produce whatever voltage is necessary to maintain the required current. This then makes it completely independent of the circuit to which it is connected to resulting in it being called an ideal independent current source.

Generally, an ideal current dependent source, either voltage or current controlled is designated by a diamond-shaped symbol where an arrow indicates the direction of the current.

### Dependent Current Source Symbols:




An ideal dependent voltage-controlled current source, VCCS, maintains an output current, IOUT that is proportional to the controlling input voltage, VIN. In other words, the output current "depends" on the value of input voltage making it a dependent currentsource.

Then the VCCS output current is defined by the following equation: IOUT = αVIN. This multiplying constant $\alpha$ (alpha) has the SI units of mhos, ℧ (an inverted Ohms sign) because α = IOUT/VIN, and its units will therefore beamperes/volt.

An ideal dependent current-controlled current source, CCCS, maintains an output current that is proportional to a controlling input current. Then the output current "depends" on the value of the input current, again making it a dependent current source.

As a controlling current, IIN determines the magnitude of the output current, IOUT times the magnification constant β (beta), the output current for a CCCS element is determined by the following equation: IOUT = βIIN. Note that the multiplying constant β is a dimensionless scaling factor as β = IOUT/IIN, so therefore its units would beamperes/amperes.

# KVL

## Kirchhoff's Voltage Law

Kirchhoff's Voltage Law (KVL) is Kirchhoff's second law that deals with the conservation of energy around a closed circuit path.

**Gustav Kirchhoff's Voltage Law** is the second of his fundamental laws we can use for circuit analysis. His voltage law states that for a closed loop series path **the algebraic sum of all the voltages around any closed loop in a circuit is equal to zero**. This is because a circuit loop is a closed conducting path so no energy islost.

In other words the algebraic sum of ALL the potential differences around the loop must be equal to zero as: $\Sigma V = 0$. Note here that the term "algebraic sum" means to take into account the polarities and signs of the sources and voltage drops around the loop.

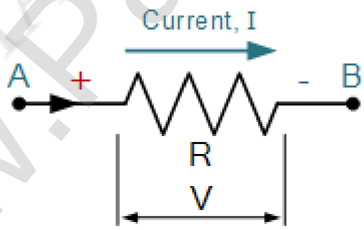
This idea by Kirchhoff is commonly known as the **Conservation of Energy**, as moving around a closed loop, or circuit, you will end up back to where you started in the circuit and therefore back to the same initial potential with no loss of voltage around the loop. Hence any voltage drops around the loop must be equal to any voltage sources met along the way.

So when applying Kirchhoff's voltage law to a specific circuit element, it is important that we pay special attention to the algebraic signs, (+ and -) of the voltage drops across elements and the emf's of sources otherwise our calculations may bewrong.

But before we look more closely at Kirchhoff's voltage law (KVL) lets first understand the voltage drop across a single element such as a resistor.

## Circuit elements

### A Single Circuit Element




For this simple example we will assume that the current, I is in the same direction as the flow of positive charge, that is conventional current flow.

Here the flow of current through the resistor is from point A to point B, that is from positive terminal to a negative terminal. Thus as we are travelling in the same direction as current flow, there will be a *fall* in potential across the resistive element giving rise to a -IR voltage drop across it.

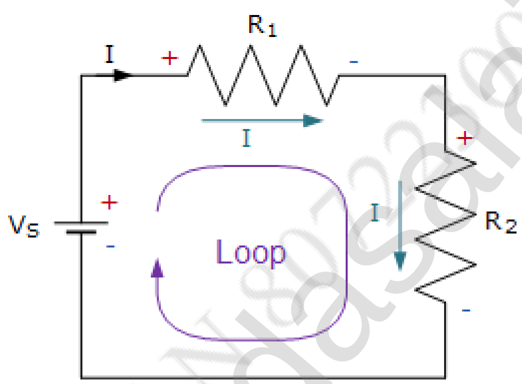
If the flow of current was in the opposite direction from point B to point A, then there would be a *rise* in potential across the resistive element as we are moving from a -potential to a + potential giving us a +I*R voltagedrop.

Thus to apply Kirchhoff's voltage law correctly to a circuit, we must first understand the direction of the polarity and as we can see, the sign of the voltage drop across the resistive element will depend on the direction of the current flowing through it. As a general rule, you will loose potential in the same direction of current across an element and gain potential as you move in the direction of an emf source.

The direction of current flow around a closed circuit can be assumed to be either clockwise or anticlockwise and either one can be chosen. If the direction chosen is different from the actual direction of current flow, the result will still be correct and valid but will result in the algebraic answer having a minus sign.

To understand this idea a little more, lets look at a single circuit loop to see if Kirchhoff's Voltage Law holds true.

## A Single Circuit Loop




Kirchhoff's voltage law states that the algebraic sum of the potential differences in any loop must be equal to zero as: $\Sigma V = 0$. Since the two resistors, $R_1$ and $R_2$ are wired together in a series connection, they are both part of the same loop so the same current must flow through each resistor.

Thus the voltage drop across resistor, $R_1 = I*R_1$ and the voltage drop across resistor, $R_2 = I*R_2$ giving byKVL:

$$V_S + (-IR_1) + (-IR_2) = 0$$

$$\therefore V_S = IR_1 + IR_2$$

$$V_S = I(R_1 + R_2)$$

$$V_S = IR_T$$

$$\text{Where: } R_T = R_1 + R_2$$

We can see that applying Kirchhoff's Voltage Law to this single closed loop produces the formula for the equivalent or total resistance in the series circuit and we can expand on this to find the values of the voltage drops around the loop.

$$R_T = R_1 + R_2$$

$$I = \frac{V_S}{R_T} = \frac{V_S}{R_1 + R_2}$$

$$V_{R1} = IR_1 = V_S\left(\frac{R_1}{R_1 + R_2}\right)$$

$$V_{R2} = IR_2 = V_S\left(\frac{R_2}{R_1 + R_2}\right)$$

**Kirchhoff's Voltage Law**

Three resistor of values: 10 ohms, 20 ohms and 30 ohms, respectively are connected in series across a 12 volt battery supply. Calculate: a) the total resistance, b) the circuit current, c) the current through each resistor, d) the voltage drop across each resistor, e) verify that Kirchhoff's voltage law, KVL holds true.

### a) Total Resistance($R_T$)

$R_T = R_1 + R_2 + R_3 = 10\Omega + 20\Omega + 30\Omega = 60\Omega$

Then the total circuit resistance $R_T$ is equal to $60\Omega$

### b) Circuit Current(I)

$$I = \frac{V_S}{R_T} = \frac{12}{60} = 0.2A$$

Thus the total circuit current I is equal to 0.2 amperes or 200mA

### c) Current Through EachResistor

The resistors are wired together in series, they are all part of the same loop and therefore each experience the same amount of current. Thus:

$I_{R1} = I_{R2} = I_{R3} = I_{SERIES} = 0.2$ amperes

### d) VoltageDropAcrossEachResistor

$V_{R1} = I \times R_1 = 0.2 \times 10 = 2$ volts

$V_{R2} = I \times R_2 = 0.2 \times 20 = 4$ volts

$V_{R3} = I \times R_3 = 0.2 \times 30 = 6$ volts

### e) Verify Kirchhoff's VoltageLaw

$$V_S + (-IR_1) + (-IR_2) + (-IR_3) = 0$$

$$12 + (-0.2\times10) + (-0.2\times20) + (-0.2\times30) = 0$$

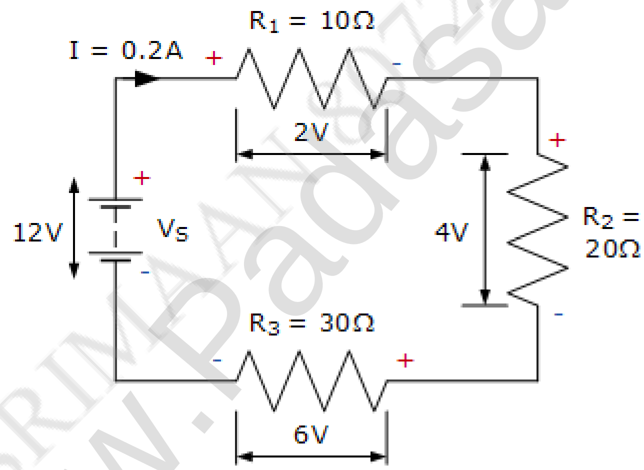
$$12 + (-2) + (-4) + (-6) = 0$$

$$\therefore 12 - 2 - 4 - 6 = 0$$

Thus Kirchhoff's voltage law holds true as the individual voltage drops around the closed loop add up to the total.

## KCL

### Kirchhoff's Circuit Loop

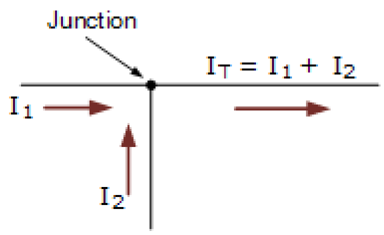



We have seen here that Kirchhoff's voltage law, KVL is Kirchhoff's second law and states that the algebraic sum of all the voltage drops, as you go around a closed circuit from some fixed point and return back to the same point, and taking polarity into account, is always zero. That is $\Sigma V = 0$

The theory behind Kirchhoff's second law is also known as the law of conservation of voltage, and this is particularly useful for us when dealing with series circuits, as series circuits also act as voltage dividers and the voltage divider circuit is an important application of many series circuits.

## Kirchhoff's Current Law

Kirchhoff's Current Law (KCL) is Kirchhoff's first law that deals with the conservation of charge entering and leaving a junction.



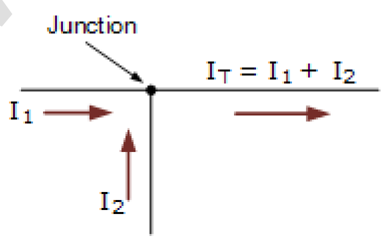

To determine the amount or magnitude of the electrical current flowing around an electrical or electronic circuit, we need to use certain laws or rules that allows us to write down these currents in the form of an equation. The network equations used are those according to Kirchhoff's laws, and as we are dealing with circuit currents, we will be looking at Kirchhoff's current law, (KCL).

**Gustav Kirchhoff's Current Law** is one of the fundamental laws used for circuit analysis. His current law states that for a parallel path **the total current entering a circuits junction is exactly equal to the total current leaving the same junction**. This is because it has no other place to go as no charge is lost.

In other words the algebraic sum of ALL the currents entering and leaving a junction must be equal to zero as: $\Sigma I_{IN} = \Sigma I_{OUT}$.

This idea by Kirchhoff is commonly known as the **Conservation of Charge**, as the current is conserved around the junction with no loss of current. Lets look at a simple example of Kirchhoff's current law (KCL) when applied to a single junction.

## A Single Junction




Here in this simple single junction example, the current $I_T$leaving the junction is the algebraic sum of the two currents, $I_1$and $I_2$ entering the same junction. That is $I_T = I_1 + I_2$.

Note that we could also write this correctly as the algebraic sum of: $I_T - (I_1 + I_2) = 0$.

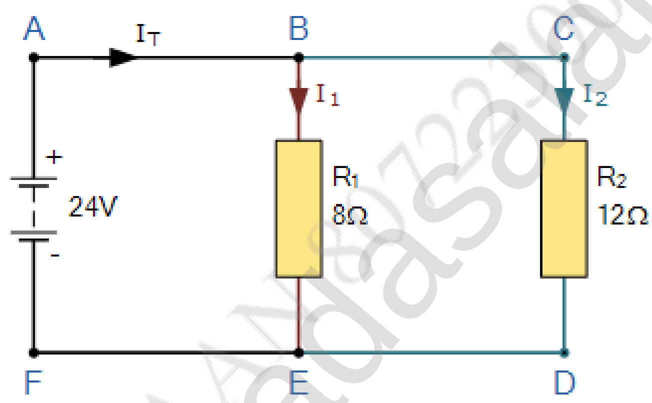
So if $I_1$ equals 3 amperes and $I_2$ is equal to 2 amperes, then the total current, $I_T$ leaving the junction will be 3 + 2 = 5 amperes, and we can use this basic law for any number of junctions or nodes as the sum of the currents both entering and leaving will be the same.

Also, if we reversed the directions of the currents, the resulting equations would still hold true for $I_1$ or $I_2$. As $I_1 = I_T - I_2 = 5 - 2 = 3$ amps, and $I_2 = I_T - I_1 = 5 - 3 = 2$ amps. Thus we can think of the currents entering the junction as being positive (+), while the ones leaving the junction as being negative (-).

Then we can see that the mathematical sum of the currents either entering or leaving the junction and in whatever direction will always be equal to zero, and this forms the basis of Kirchhoff's Junction Rule, more commonly known as *Kirchhoff's Current Law*, or (KCL).

## Resistors in Parallel

Let's look how we could apply Kirchhoff's current law to resistors in parallel, whether the resistances in those branches are equal or unequal. Consider the following circuit diagram:




In this simple parallel resistor example there are two distinct junctions for current. Junction one occurs at node B, and junction two occurs at node E. Thus we can use Kirchhoff's Junction Rule for the electrical currents at both of these two distinct junctions, for those currents entering the junction and for those currents flowing leaving the junction.

To start, all the current, $I_T$ leaves the 24 volt supply and arrives at point A and from there it enters node B. Node B is a junction as the current can now split into two distinct directions, with some of the current flowing downwards and through resistor $R_1$ with the remainder continuing on through resistor $R_2$ via node C. Note that the currents flowing into and out of a node point are commonly called branch currents.

We can use Ohm's Law to determine the individual branch currents through each resistor as: $I = V/R$, thus:

For current branch B to E through resistor $R_1$

$$I_{B-E} = I_1 = \frac{V}{R_1} = \frac{24}{8} = 3A$$

For current branch C to D through resistor $R_2$

$$I_{C-D} = I_2 = \frac{V}{R_2} = \frac{24}{12} = 2A$$

From above we know that Kirchhoff's current law states that the sum of the currents entering a junction must equal the sum of the currents leaving the junction, and in our simple example above, there is one current, $I_T$ going into the junction at node B and two currents leaving the junction, $I_1$ and $I_2$.

Since we now know from calculation that the currents leaving the junction at node B is $I_1$equals 3 amps and $I_2$ equals 2 amps, the sum of the currents entering the junction at node B must equal 3 + 2 = 5 amps. Thus $\Sigma_{IN} = I_T = 5$ amperes.

In our example, we have two distinct junctions at node B and node E, thus we can confirm this value for $I_T$ as the two currents recombine again at node E. So, for Kirchhoff's junction rule to hold true, the sum of the currents into point F must equal the sum of the currents flowing out of the junction at node E.

As the two currents entering junction E are 3 amps and 2 amps respectively, the sum of the currents entering point F is therefore: 3 + 2 = 5 amperes. Thus $\Sigma_{IN} = I_T = 5$ amperes and therefore Kirchhoff's current law holds true as this is the same value as the current leaving point A.

**Applying KCL to more complex circuits.**

We can use Kirchhoff's current law to find the currents flowing around more complex circuits. We hopefully know by now that the algebraic sum of all the currents at a node (junction point) is equal tozero and with this idea in mind, it is a simple case of determining the currents entering a node and those leaving the node. Consider the circuitbelow.

Kirchhoff's Current Law Example No1:

In this example there are four distinct junctions for current to either separate or merge together at nodes A, C, E and node F. The supply current IT separates at node A flowing through resistors R1 and R2, recombining at node C before separating again through resistors R3, R4 and R5 and finally recombining once again at node F.

But before we can calculate the individual currents flowing through each resistor branch, we must first calculate the circuits total current, IT. Ohms law tells us that I = V/R and as we know the value of V, 132 volts,

## Circuit Resistance $R_{CF}$

$$\frac{1}{R_{(CF)}} = \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5} = \frac{1}{60} + \frac{1}{20} + \frac{1}{30}$$

$$\frac{1}{R_{(CF)}} = \frac{1}{0.1} \qquad \therefore R_{(CF)} = 10\Omega$$

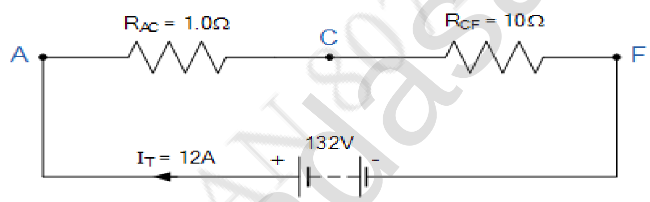
Thus the equivalent circuit resistance between nodes C and F is calculated as 10 Ohms. Then the total circuit current, $I_T$ is given as:

$$R_T = R_{(AC)} + R_{(CF)} = 1 + 10 = 11\Omega$$

$$I_T = \frac{V}{R_T} = \frac{132}{11} = 12\,\text{Amps}$$

Giving us an equivalent circuit of:

## Kirchhoff's Current Law Equivalent Circuit




Therefore, V = 132V, $R_{AC}$ = 1Ω, $R_{CF}$ = 10Ω's and $I_T$ = 12A.

Having established the equivalent parallel resistances and supply current, we can now calculate the individual branch currents and confirm using Kirchhoff's junction rule as follows.

$$V_{AC} = I_T \times R_{AC} = 12 \times 1 = 12\,\text{Volts}$$

$$V_{CF} = I_T \times R_{CF} = 12 \times 10 = 120\,\text{Volts}$$

$$I_1 = \frac{V_{AC}}{R_1} = \frac{12}{2.4} = 5\,\text{Amps}$$

$$I_2 = \frac{V_{AC}}{R_2} = \frac{12}{1.7} = 7\,\text{Amps}$$

$$I_3 = \frac{V_{CF}}{R_3} = \frac{120}{60} = 2\,\text{Amps}$$

$$I_4 = \frac{V_{CF}}{R_4} = \frac{120}{20} = 6\,\text{Amps}$$

$$I_5 = \frac{V_{CF}}{R_5} = \frac{120}{30} = 4\,\text{Amps}$$

Thus, $I_1 = 5A$, $I_2 = 7A$, $I_3 = 2A$, $I_4 = 6A$, and $I_5 = 4A$.

We can confirm that Kirchoff's current law holds true around the circuit by using node C as our reference point to calculate the currents entering and leaving the junction as:

$$\text{At node C} \quad \sum I_{IN} = \sum I_{OUT}$$

$$I_T = I_1 + I_2 = I_3 + I_4 + I_5$$

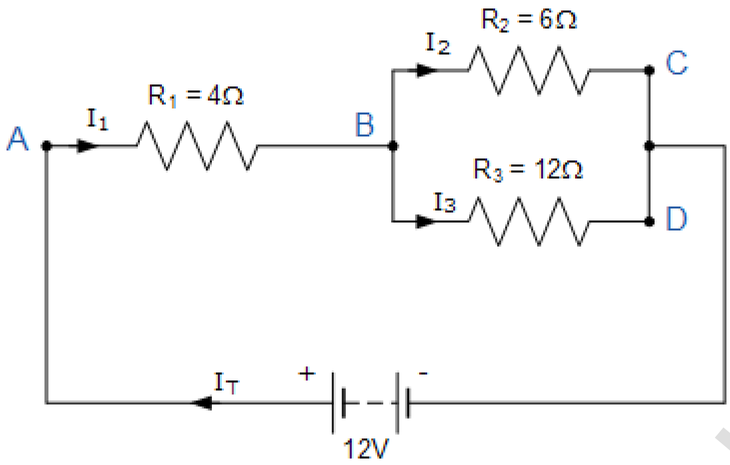
$$\therefore 12 = (5+7) = (2+6+4)$$

We can also double check to see if Kirchhoffs Current Law holds true as the currents entering the junction are positive, while the ones leaving the junction are negative, thus the algebraic sum is: $I_1 + I_2 - I_3 - I_4 - I_5 = 0$ which equals $5 + 7 – 2 – 6 – 4 = 0$.

So we can confirm by analysis that Kirchhoff's current law (KCL) which states that the algebraic sum of the currents at a junction point in a circuit network is always zero is true and correct in this example.

## Kirchhoff's Current Law

Find the currents flowing around the following circuit using Kirchhoff's Current Law only.




$I_T$ is the total current flowing around the circuit driven by the 12V supply voltage. At point A, $I_1$ is equal to $I_T$, thus there will be an $I_1$*R voltage drop across resistor $R_1$.

The circuit has 2 branches, 3 nodes (B, C and D) and 2 independent loops, thus the I*R voltage drops around the two loops will be:

- Loop ABC ⇒12 = $4I_1$ +$6I_2$
- Loop ABD ⇒12 = $4I_1$ +$12I_3$

Since Kirchhoff's current law states that at node B, $I_1 = I_2 + I_3$, we can therefore substitute current $I_1$ for $(I_2 + I_3)$ in both of the following loop equations and then simplify.

## Kirchhoff's Loop Equations

| Loop (ABC) | Loop (ABD) |
|---|---|
| $12 = 4I_1 + 6I_2$ | $12 = 4I_1 + 12I_3$ |
| $12 = 4(I_2 + I_3) + 6I_2$ | $12 = 4(I_2 + I_3) + 12I_3$ |
| $12 = 4I_2 + 4I_3 + 6I_2$ | $12 = 4I_2 + 4I_3 + 12I_3$ |
| $12 = 10I_2 + 4I_3$ | $12 = 4I_2 + 16I_3$ |

We now have two simultaneous equations that relate to the currents flowing around the circuit.

Eq. No 1 : $12 = 10I_2 +$

$4I_3$Eq. No 2 :$12 = 4I_2 + 16I_3$

By multiplying the first equation (Loop ABC) by 4 and subtracting Loop ABD from Loop ABC, we can be reduced both equations to give us the values of $I_2$ and $I_3$

Eq. No 1 : $12 = 10I_2 + 4I_3$ (x4) $\Rightarrow 48 = 40I_2 +$
$16I_3$Eq. No 2 : $12 = 4I_2 + 16I_3$ (x1)
$\Rightarrow 12 = 4I_2 + 16I_3$ Eq. No 1 – Eq. No 2 $\Rightarrow 36$
$= 36I_2 + 0$

Substitution of $I_2$ in terms of $I_3$ gives us the value of $I_2$ as 1.0 Amps

Now we can do the same procedure to find the value of $I_3$ by multiplying the first equation (Loop ABC) by 4 and the second equation (Loop ABD) by 10. Again by subtracting Loop ABC from Loop ABD, we can be reduced both equations to give us the values of $I_2$ and $I_3$

Eq. No 1 : $12 = 10I_2 + 4I_3$ (x4) $\Rightarrow 48 = 40I_2 + 16I_3$ Eq.
No 2 : $12 = 4I_2 + 16I_3$ (x10) $\Rightarrow 120 = 40I_2 +$
$160I_3$Eq. No 2 – Eq. No 1 $\Rightarrow 72 = 0 + 144I_3$

Thus substitution of $I_3$ in terms of $I_2$ gives us the value of $I_3$ as 0.5 Amps

As Kirchhoff's junction rule states that : $I_1 = I_2 + I_3$

The supply current flowing through resistor $R_1$ is given as : 1.0 + 0.5 = 1.5 Amps

Thus $I_1 = I_T = 1.5$ Amps, $I_2 = 1.0$ Amps and $I_3 = 0.5$ Amps and from that information we couldcalculate the I*R voltage drops across the devices and at the various points (nodes) around thecircuit.

We could have solved the circuit of example two simply and easily just using Ohm's Law, but we have used Kirchhoff's Current Law here to show how it is possible to solve more complex circuits when we cannot just simply apply Ohm's Law.

# INTRODUCTION TO ELECTRICAL CIRCUITS

**Circuit concept:**. Basic definitions, Ohm‟s law at constant temperature, classifications of elements, R, L, C parameters, independent and dependent sources, Kirchhoff‟s laws, equivalent resistance of series, parallel and series parallel networks. Star to delta and delta to star transformation, mesh analysis and nodal analysis by Kirchhoff‟s laws, inspection method, super mesh and super node analysis.

## Introduction

The interconnection of various electric elements in a prescribed manner comprises as an electric circuit in order to perform a desired function. The electric elements include controlled and uncontrolled source of energy, resistors, capacitors, inductors, etc. Analysis of electric circuits refers to computations required to determine the unknown quantities such as voltage, current and power associated with one or more elements in the circuit. To contribute to the solution of engineering problems one must acquire the basic knowledge of electric circuit analysis and laws. Many other systems, like mechanical, hydraulic, thermal, magnetic and power system are easy to analyze and model by a circuit. To learn how to analyze the models of these systems, first one needs to learn the techniques of circuit analysis. We shall discuss briefly some of the basic circuit elements and the laws that will help us to develop the background of subject.

**Basic electrical circuits use standard symbols for the components in the circuit. Understanding electrical circuits is of great importance nowadays.**

As we all know that modern life is overwhelmingly dependent on electricity, it is quite important for people to understand simple electrical circuits. Simple electrical circuits introduction is a good assistant for you to better know electrical circuits.

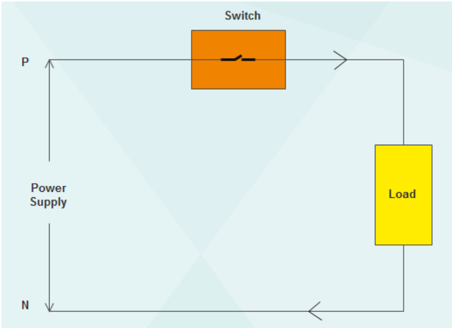
## The Definition of Electrical Circuits

An electrical circuit is a closed loop of conductive material that allows electrons to flow through continuously without beginning or end. There is continuous electrical current goes from the supply to the load in an electrical circuit. People also say that a complete path, typically through conductors such as wires and through circuit elements, is called an electric circuit.

An electrical circuit is an electrical device that provides a path for electrical current to flow. After you get the definition of the electrical circuit, now we are going to show you three simple electrical circuits.

## Switch Circuit

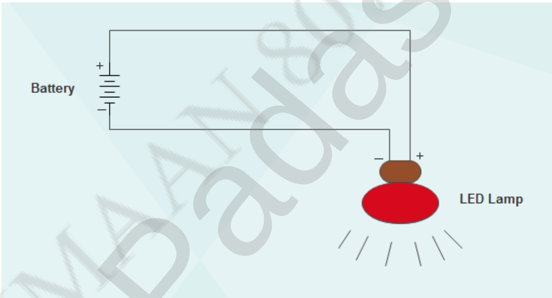
A switch is a device for making and breaking the connection in an electric circuit. We operate switches for lights, fans, electric hair drier and more many times a day but we seldom try to see the connection made inside the switch circuit. The function of the switch is to connect or complete the circuit going to the load from the supply. It has moving contacts which are normally open.




With a switch you can turn the device on or off, therefore, it is a very important component in an electrical circuit.

## DC Lighting Circuit

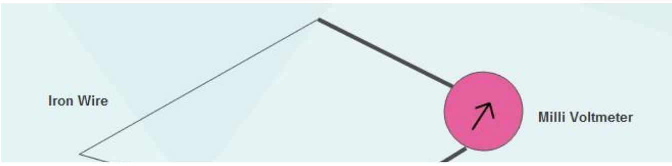
As you can see from the picture below that the LED lamp uses DC supply battery. The battery is bipolar, one is anode and the other is cathode. Moreover, the anode is positive and the cathode is negative. Also, the lamp itself has two ends, one positive and the other is negative. Therefore, the anode of the battery is battery is connected to positive terminal of the lamp, meanwhile the cathode of the battery is connected to the negative terminal of the lamp.




Once the above connection is complete, the LED lamp will light. Although it is simple electrical circuit, many people have no idea how to deal with the connection correctly.

## Thermocouple Circuit

If you are looking to build a temperature-sensing device or you need to add sensing capabilities to a large system, you will have to familiarize yourself with thermocouples circuits and understand how to design them. A thermocouple is a device consisting of two dissimilar conductors that contact each other at one or more spots, and it is used to measure temperature. As you can see from the picture below that a thermocouple is made of two wires - iron and constantan, with a voltmeter. If the cold junction temperature is kept constant, then the EMF is proportional to the temperature of the hot junction.



Voltmeter will measure the EMF generated and this can be calibrated to measure the temperature. The temperature difference between the hot and cold junction will produce an EMF proportional to it. Because thermocouple junctions produce such low voltages, it is imperative that wire connections be very clean and tight for accurate and reliable operation. Despite these seemingly restrictive requirements, thermocouples remain one of the most robust and popular methods of industrial temperature measurement in modern use.

A circuit diagram is like a map that shows electricity flows. This tutorial will show you a few of the common symbols and some of the professional terms to help you read circuit diagrams.

Learning to read electrical schematics is like learning to read maps. Electrical schematics show which electrical components used and how they are connected together. The electronic symbols consisted represent each of the components used. The symbols are connected with lines.

**Recognizing Electrical Schematic Terms**

**Here are some of the standard and basic terms of circuit diagrams:**

- Voltage: Voltage is the "pressure" or "force" of electricity, it is usually measured in volts (V) and the outlets in common house operate at 120V. Outlets of voltage may differ in othercountries.
- Resistance: Resistance represents how easily electrons can flow through a certain material, and it is measured in Ohms (R or Ω). Current flow can move faster in conductors such as gold or copper, in this case we say the resistance is low. The movement of electrons is relatively slow in insulators such as plastic, wood, and air, in this case we say the resistance ishigh.
- Current: Current is the flow of electricity, or to be more specific, the flow of electrons. Current is measured in Amperes (Amps). The flow of current is only possible when a voltage supply is connected.
- DC (Direct Current): DC is the continuous current flow in one direction. DC can flow not just through conductors, but semi-conductors and insulatorstoo.
- AC (Alternating Current): In AC, the current flow alternates between two directions according to a certain period, it often forms a sine wave. The frequency of AC is measured in Hertz (Hz), and it is usually 60Hz.

**Basic Elements & Introductory Concepts**

- **Electrical Network:** A combination of various electric elements (Resistor, Inductor, Capacitor, Voltage source, Current source) connected in any manner what so ever is called an electrical network. We may classify circuit elements in two categories, passive and activeelements.
- Passive Element: The element which receives energy (or absorbs energy) and then either converts it into heat (R) or stored it in an electric (C) or magnetic (L ) field is called passiveelement.
- Active Element: The elements that supply energy to the circuit is called active element. Examples of active elements include voltage and current sources, generators, and electronic devices that require power supplies. A transistor is an active circuit element, meaning that it can amplify power of a signal. On the other hand, transformer is not an active element because it does not amplify the power level and power remains same both in primary and secondary sides. Transformer is an example of passiveelement.

* Bilateral Element: Conduction of current in both directions in an element (example: Resistance;Inductance; Capacitance) with same magnitude is termed as bilateral element.

- **Unilateral Element:** Conduction of current in one direction is termed as unilateral (example: Diode, Transistor)element.
- 

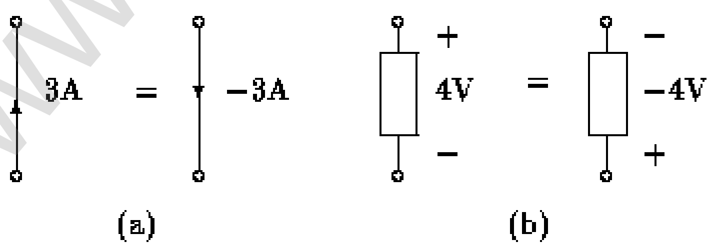

- **Meaning of Response:** An application of input signal to the system will produce an output signal, the behavior of output signal with time is known as the response of thesystem**.**

**BASIC CIRCUIT CONCEPTS**

An electric circuit is formed by interconnecting components having different electric properties. It is therefore important, in the analysis of electric circuits, to know the properties of the involved components as well as the way the components are connected to form the circuit. In this introductory chapter some ideal electric components and simple connection styles are introduced. Without resort to advanced analysis techniques, we will attempt to solve simple problems involving circuits that contain a relatively small number of components connected in some relatively simple fashions. In particular we will derive a set of useful formulae for dealing with circuits that involve such simple connections as ``series", ``parallel", ``ladder", ``star" and ``delta". This chapter serves as a review of the basic properties of electric circuits. In addition we will briefly introduce the PSPICE analysis programme and how it can be used to help analyze electric circuits.

**Direction and Polarity**

Current direction indicates the direction of flow of positive charge, and voltage polarity indicates the relative potential between two points. Usually, ``+" is assigned to a higher potential point and ``-" to a lower potential point. However, during analysis, direction and polarity can be *arbitrarily* assigned on circuit diagrams. Actual direction and polarity will be governed by the sign of the value. Figure 1.1 shows some examples.




Equivalent assignments of (a) current direction; (b) voltage polarity

**Ohm's Law | Equation Formula and Limitation of Ohm's Law**

The most basic quantities of electricity are voltage,current and resistance or impedance. **Ohm's law** shows a simple relationship between these three quantities. This law is one of the most basic laws of electricity.

This law helps to calculate the power, efficiency, current, voltage and resistance or impedance of any element of electrical circuit.

## Statement of Ohm's Law:

Whenever, we apply a potential difference i.e. voltage across a resistor of a closed electric circuit, current starts flowing through it. The statement of Ohm's law says that The current (I) is directly proportional to the applied voltage (V), provided temperature and all other factors remain constant.

Mathematically, $I \propto V \;\; i.e. \;\; V \propto I \Rightarrow V = RI$

Where, R is constant of proportionality.

This equation presents the statement of Ohm's law. Here, we measure current in Ampere (or amps), voltage in unit of volt. The constant of proportionality R is the property of the conductor; we know it as resistance and measure it in ohm (Ω). Theoretically, the resistance has no dependence on the applied voltage, or on the flow of current. The value of R changes only if the conditions (like temperature, diameter and length etc.) of the resistor are changed by any means.

**History of Ohm's Law**

In the month of May 1827, Georg Simon Ohm published a book "Die GalvanischeKette, MathematischBearbeitet". "Die GalvanischeKette, MathematischBearbeitet" means "The Galvanic Circuit Investigated Mathematically". He presented the relationship between voltage (V), current (I), and resistance (R) based on his experimental data, in this book. Georg Simon Ohm had defined the fundamental interrelationship between current, voltage and resistance of a circuit which was later named Ohm's law. Because of this law and his excellence in the field of science and academics, he got the Copley Medal award in 1841. In 1872 the unit of electrical resistance was named 'OHM" in hishonor.

Ohm's Law Physics

We can understand the physics behind Ohm's law well if we examine it from atomic level of a metal. A metal conductor contains plenty of free electrons. These free electrons randomly move in the conductor. When, we apply a voltage, across the conductor, the free electrons keep being accelerated towards higher potential end due to electrostatic force of the applied voltage. This means they acquire some kinetic energy as they move towards the + Ve end of the conductor. However, before they get very far they collide with an atom or ion, lose some of their kinetic energy and may bounce back. Again due to presence of static electric field the free electrons again being accelerated. This keeps happening. That means, even after application of external electric field, there will be still random motion in the free electrons of the conductor. Each free electron drifts towards +Ve end with its inherent random motion. As a result, the free electrons tend to "drift" towards the + Ve end, bouncing around from atom to atom on the way. This is how the materials resist a current. If we apply more voltage across the conductor, the more free electrons will move with more acceleration which causes more drift velocity of the electrons. The drift velocity of the electrons is proportional to the applied static electric field. That more electrons pass through a cross section per unit time, which means more charge transfer per unit time. The rate of charge transfer per unit time iscurrent.

## Applications of Ohm's Law

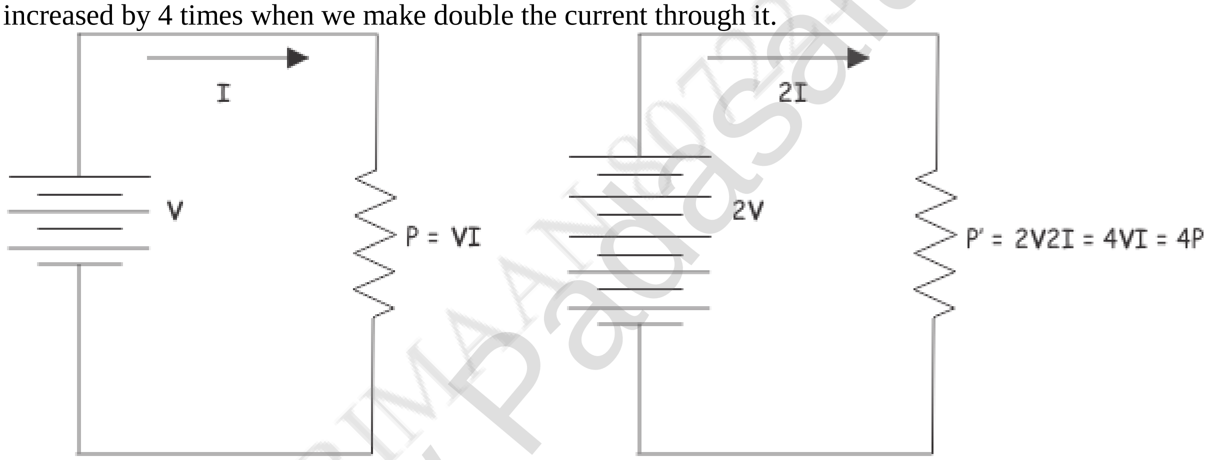
The **applications of ohm's law** are that it helps us in determining either voltage, current or impedance or resistance of a linear electric circuit when the other two quantities are known to us. Apart from that, it makes power calculation a lot simpler, like when we know the value of the resistance for a particular circuit element, we need not know both the current and the voltage to calculate the power dissipation since, P = VI.

$$V = RI \Rightarrow \quad I = \frac{V}{R}$$

To replace either the voltage or current in the above expression to produce the result

$$Thus,\ P = VI = \frac{V^2}{R} = I^2R \quad (Since\, V = IR)$$

We can see from the results, that the rate of energy loss varies with the square of the voltage or current. When we double the voltage applied to a circuit, obeying Ohm's law, the rate at which energy is supplied (or power) gets four times bigger. Similarly, the power dissipation at a circuit element is increased by 4 times when we make double the current through it.




## Limitation of Ohm's Law

The **limitations of Ohm's law** are explained as follows:

1. This law cannot be applied to unilateral networks. A unilateral network has unilateral elements like diode, transistors, etc., which do not have same voltage current relation for both directions of current.
2. **Ohm's law** is also not applicable for non – linearelements.

Non-linear elements are those which do not have current exactly proportional to the applied voltage, that means the resistance value of those elements changes for different values of voltage and current. Examples of non – linear elements are thyristor, electric arc,etc.

# Mesh and Nodal Analysis

## MESH ANALYSIS

Mesh analysis is an technique used to solve the complex networks consisting of more number of meshes.

Mesh analysis is nothing but applying KVL to each and every loop in circuit and solving for mesh currents. By finding the mesh currents we can solve any require data of the network.

Let V1 = 30v, V2 = 40v, R1 =4 ohms, R2 = 2 ohms and R3 = 4 ohms

i1, i2 are the mesh currents, here positive direction of currents are assumed , but in general we can assume current directions in any fashion and can solve.

Applying KVL to first loop we get, V1 – i1R1 – (i1+i2)R2.

V1 = (R1+R2)i1+ i2.R2. -------- 1

Applying KVL to second loop we get, V2 – i2R3 – (i1+i2)R2.

V2 = (R1+R2)i1+i2.R3. ---------2

Hence by solving eq. 1 and 2 we can get mesh currents i1 and i2.

**Mesh analysis by inspection method:**

Inspection method is direct method using mesh currents can be find directly without applying KVL. Let us take same network as above , representing eq 1 and 2 in matrix form.

**To be continued……**

SRIMAAN COACHING CENTRE-TRICHY-TET/PG-TRB / UG-TRB
BEO/ DEO/TRB-POLY/ASST.PROF/COM.INS/TNEB/SCERT/JSO
STUDY MATERIALS AVAILABLE- CONTACT:8072230063.

**2024-25**
**SRIMAAN**

# UG-TRB MATERIALS

**GRADUATE TEACHERS / BLOCK RESOURCE TEACHER EDUCATORS (BRTE) & SGT**

- **UG TRB: TAMIL MATERIAL WITH QUESTION BANK.**
- **UG TRB: ENGLISH STUDY MATERIAL +Q. BANK.**
- **UG-TRB: MATHEMATICS MATERIAL WITH Q. BANK (E/M)**
- **UG TRB: PHYSICS MATERIAL WITH QUESTION BANK (E/M)**
- **UG TRB: CHEMISTRY MATERIAL + QUESTION BANK (E/M)**
- **UG TRB: HISTORY MATERIAL + Q.BANK (E/M)**
- **UG TRB: ZOOLOGY MATERIAL + QUESTION BANK (E/M)**
- **UG TRB: BOTANY MATERIAL +QUESTION BANK (T/M& E/M)**
- **UG TRB: GEOGRAPHY STUDY MATERIAL (E/M)**

**SCERT/DIET/GTTI (LECTURER) STUDY MATERIAL AVAILABLE.**

## TRB-POLYTECHNIC LECTURER-(NEW SYLLABUS) STUDY MATERIALS AVAILABLE

- **MATHEMATICS STUDY MATERIAL with Question Bank.**
- **ENGLISH STUDY MATERIAL with Question Bank.**
- **PHYSICS STUDY MATERIAL with Question Bank.**