Notes of XII Bifocal (Vocational) Electrical Maintenance

New Syllabus

Electrical Maintenance

12th Electrical Maintenance

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The author welcomes any suggestions, both from the teachers and the students for further improvement of this book, at dsvakola@gmail.com.

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Contents

1 Electrical Symbols

Quick view…

Topics covered

Different types of symbols used in electrical circuits, no description, only symbols expected in this chapter.

Summary of the chapter: important points for the quick preparation of the chapter.

Self examination: objective type questions, short answer questions, long answer questions, conceptual study questions.

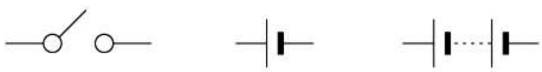
1.1 INTRODUCTION

Electrical engineering is a field of engineering that deals with the study and application of electricity, electronics, electromagnetism, heating and magnetic effects of electric current. Electrical engineering includes electronic engineering also.

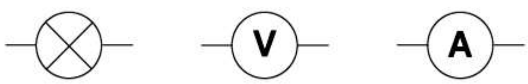
It is a major study in the fields of power generation like in generators, sources of energy, etc. In this chapter, we shall study the basic concepts related to electrical circuits with their related topics like concept of e.m.f., potential difference, Ohm's law, resistance, resistances in series and in parallel, capacitors in series and in parallel, concept of electric power, concept of AC and DC, AC and DC circuits, concept of generators, etc.

1.1.1 General symbols (routine symbols)

These are the routine symbols used in any type of electrical circuit. They are as follows –

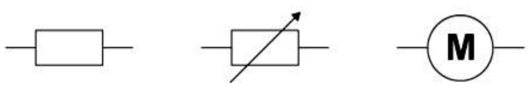


On-off switch, Cell (DC source) and battery (DC source)



Lamp, voltmeter (AC) and ammeter (AC)

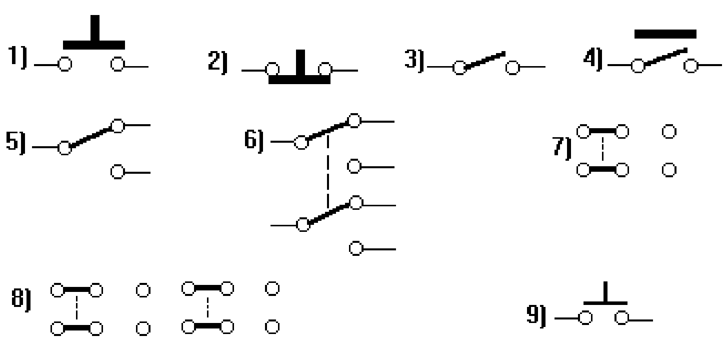
Note: For DC voltmeter and DC ammeter, show only positive and negative signs at its two ends.



Simple or fixed resistor, variable resistor and motor (any type i.e. either AC/DC)

There are two main symbols which are the (+) and (-) signs. They are so common that it is not necessary to show their symbols and need no information.

1.1.2 Symbols of switches and keys



Push-to-on switch: this switch is mainly used to produce a temporary contact. It is used in call bell system, horns and break switches in vehicles.

Push-to-off switch: this switch is mainly used where the contact should be temporarily broken. When pressed, this breaks the contact and when released, the contact is again made. This switch is largely used in fridge and car doors lights for the on-off purpose of the door lights.

Single-pole-single-throw (SPST) switch: it is the most widely used switch for the on-off of different electrical and electronic systems; like tube light, fans, mixer, radio, television, washing machine etc.

Single-pole-single-throw (SPST rocker) switch: it is used especially in domestic wiring for on-off purpose. It is similar to the piano switch. It can be fitted on the wooden board without any nut bolts etc.

Single-pole-double-throw (SPDT toggle) switch: this switch is particularly used in staircase wiring, to produce the OR logic combination. Due to this the lamp in the staircase can be made on-off from two different positions.

Double-pole-double-throw (DPDT toggle) switch: it is widely used in the side indicators of the vehicles.

Double-pole-double-throw (DPDT slide) switch: it is used in the on-off control of both phase and neutral wires in a TV and washing machines etc.

Four-pole-double-throw (FPDT) switch: it is used in the band-switch of the radio to change the band from MW to SW.

Micro push-to-on switch: it is also known as the feather touch switch. It is widely used in the different controls of VCR, TV, washing machines etc.

1.1.3 More symbols & their information

Unit	Abbrev.	Symbol	Description
ampere	A	I	Unit of electrical current (a current of 1A flows in a conductor when a charge of 1C is transported in a time interval of 1s)
coulomb	C	Q	Unit of electric charge or quantity of electricity.
farad	F	C	Unit of capacitance (a capacitor has a capacitance of 1F when a charge of 1C results in a potential difference of 1V across its plates.
henry	H	L	Unit of inductance (an inductor has an inductance of 1H when a current flowing through it is changing uniformly at a rate of 1A/s which produces a potential difference of 1V across its terminals.
hertz	Hz	f	Unit of frequency (a signal has a frequency of 1Hz if one complete cycle occurs in a time interval of 1s)
joule	J	E	Unit of energy

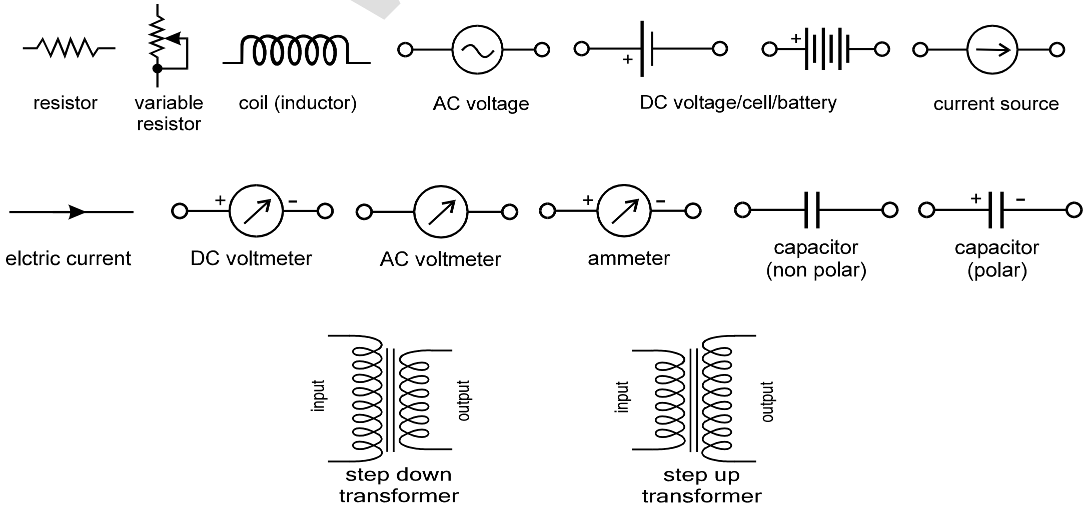
ohm	Ω	R	Unit of resistance (an element has a resistance of 1Ω, if a potential difference of 1V across it results in a current of 1A through it.)
volt	V	V	Unit of electric potential (e.m.f. or p.d.) When a current of 1A flows through an element having resistance of 1Ω, it results in a potential difference of 1V across it.
watt	W	P	Unit of power (it is equal to 1J of energy consumed in a time interval of 1s) When a current of 1A flows through an element at a potential difference of 1V, then 1W of electrical energy is consumed.)
weber	Wb	ϕ	Unit of magnetic flux.
tesla	T	B	Unit of magnetic flux density (a flux density of 1T is produced when a flux of 1Wb is present over an area of 1square meter.)

1.1.4 Relationship of electrical units

Quantity	Symbol	Unit	Relationship
Current	I, i	Ampere (A)	I = E/R, i = E/Z, I = Q/T
Charge	Q, q	Coulomb	Q = I x T, Q = C x E
Resistance	R, r	Ohm (Ω)	R = E/I, required = E/i
Electromotive force (e.m.f.)	E, e	Volt (V)	E = I x R, e = i x r
Capacitance	C	Farad (F) Centimeter	C = Q/E 1cm=1.1x10^{-9}F, 1$\mu\mu$F = 0.9cm
Self inductance	L	Henry (H)	L = XL/2π.f
Mutual inductance	M	Henry (H)	—

Inductive & capacitive reactance	XL Xc	Ohm (Ω) Ohm (Ω)	XL = 2π.*f*.L Xc = 1/2π.*f*.C
Reactance	X	Ohm (Ω)	X = XL – Xc, i.e. X = 2π.*f*.L – (1/2π.*f*.C)
Impedance	Z	Ohm (Ω)	$Z = \sqrt{R^2 + X^2}$
Power	P	Watt (W)	W = E.I, P = E.*i*.cosϕ
Conductance Susceptance Admittance	G, g B Y, *y*	Mho (℧)	G = R/ $(R^2 + X^2)$ B = X/ $(R^2 + X^2)$ Y = 1/Z
Time Frequency	T, t *f*	second Hz, KHz, MHz	T = 1/*f* *f* = 1/T

1.1.5 Advanced method of drawing symbols



Summery

1. Push-to-on switch is mainly used to produce a temporary contact. It is used in call bell system, horns and break switches in vehicles.
2. Push-to-off switch is mainly used where the contact should be temporarily broken. When pressed, this breaks the contact and when released, the contact is again made. This switch is largely used in fridge and car doors lights for the on-off purpose of the door lights.
3. Single-pole-double-throw (SPDT toggle) switch is particularly used in staircase wiring, to produce the OR logic combination. Due to this the lamp in the staircase can be made on-off from two different positions.
4. Double-pole-double-throw (DPDT slide) switch is used in the on-off control of both phase and neutral wires in a TV and washing machines etc.
5. Micro push-to-on switch is also known as the feather touch switch. It is widely used in the different controls of VCR, TV, washing machines etc.
6. Unit of electrical current (a current of 1A flows in a conductor when a charge of 1C is transported in a time interval of 1s).
7. Unit of inductance (an inductor has an inductance of 1H when a current flowing through it is changing uniformly at a rate of 1A/s which produces a potential difference of 1V across its terminals.
8. Unit of capacitance (a capacitor has a capacitance of 1F when a charge of 1C results in a potential difference of 1V across its plates.
9. Unit of resistance (an element has a resistance of 1Ω, if a potential difference of 1V across it results in a current of 1A through it).
10. When a current of 1A flows through an element at a potential difference of 1V, then 1W of electrical energy is consumed).
11. Unit of magnetic flux density (a flux density of 1T is produced when a flux of 1Wb is present over an area of 1square meter).

Self Examination

Objective type questions

1. The __________ switch is used in car door lamp circuit.
2. The _____________ switch is used in call bell in our house.
3. When positive/negative signs are not shown on a voltmeter, such voltmeter is called as _________.
4. The symbol of electric current is _________.
5. The symbol of electric voltage is _________.
6. Hz is the symbol used for _________.
7. Wb is the symbol used for __________.
8. The symbol of admittance is _______.
9. ℧ is the symbol used for ______________.
10. The charge Q is the product of _________ and _________.

This chapter covers simple idea of symbols and basic concepts. **No problems will be asked in HSC board examination from this chapter.**

2 Control Panels Wiring

Quick view…

Topics covered

Connection diagram of ammeter, wattmeter, energy level meter, in an electrical circuit.
Concept of starter and its connections with DC motors through power switches.

Scope & Limitations

Connection diagram of ammeter, wattmeter, energy level meter, in an electrical circuit. Simple concepts only and a simple circuit with DPDT switch, and load.

Concept of starter and its connections with DC motors through power switches. Simple wiring diagram of 3-point starter for the DC shunt motor, with variable resistor and multipoint switch. Basic concepts only. No mathematical treatment.

Circuit diagram of starter with NO LOAD RELEASE for DC series motors. No mathematical treatment.

Simple idea of PMMC like moving iron attraction type ammeter/voltmeter,
Moving iron repulsive type meter: both ammeter and voltmeter.
Only diagrams and basic concepts. No mathematical treatment.

Summary of the chapter: important points for the quick preparation of the chapter.

Self examination: objective type questions, short answer questions, long answer questions, conceptual study questions.

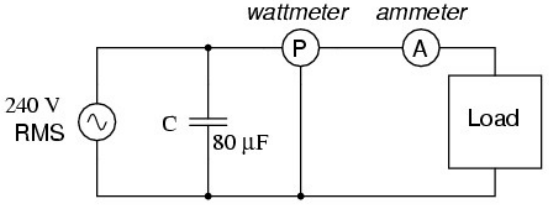
2.1 INTRODUCTION

In this chapter, we have to study the fundamental concepts of connection wiring diagram of a typical control panel used in industries for controlling the heavy motors. These motors may be of two types: the DC shunt motor and the DC series motor. In the following topics first we shall understand how a series and shunt DC motor works.

In next section of the chapter we have to study the simple concepts of PMMC meters. These meters are basically known as analog meters and they work on the principle of Law of Electromagnetic Induction*.

2.2 BASIC IDEA OF MOTOR CONNECTIONS

Any electrical circuit consists of an electric source either AC or DC with an on-off switch, fuse, ammeter, voltmeter, wattmeter and the load, as shown in the following diagram. Such type of connections is done especially in industrial controlling systems.



In this circuit, the ammeter is connected IN SERIES to measure the load current. The voltmeter is connected IN PARALLEL to note down the amount of voltage drop across the load and the wattmeter is in SERIES-PARALLEL combination to measure the amount of electrical power consumed by the load.

Generally it is a routine practice to connect one high voltage capacitor in parallel with the source of the circuit, to suppress any transients or surges, in the circuit. This also protects the inductive load like a motor connected in the circuit.

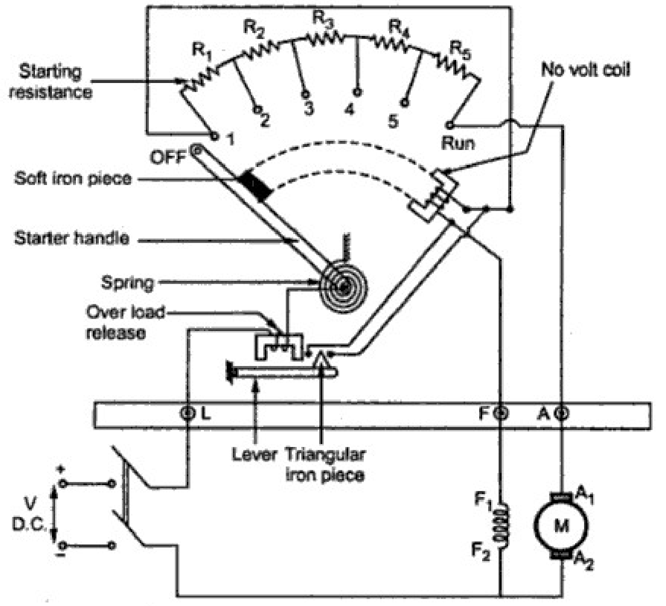
2.2.1 Concept of a 3-point starter

A motor starter is a device used with AC electric motors to reduce the load and torque temporarily in the power-train and electrical current surge of the motor during startup. This reduces the mechanical stress on the motor and shaft, as well as the electrodynamics stresses on the attached power cables. It also reduces loading on electrical distribution network, extending the life of the system.

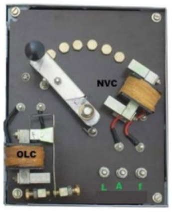
In the following circuit diagram a starter resistor with variable resistance i.e. tapped resistance is shown. Its each tapping is connected to high polished brass contacts to provide high conductivity and low contact resistance. The starter resistance is connected to the armature circuit through the controlling arm. Every time the tapping is to be changed, the NVC *(no volt coil)*, is electro-magnetised and it attracts the SIP *(soft iron piece)*. Due to this the arm moves in right direction and the tapping of the starter resistance changes as per requirement.

Here note that the magnetic attractive force on the SIP is so large that it overcomes the spring tension in the switching action. The motor as a load is connected at the output of the circuit

* Refer our XI standard notes for understanding the concept of Law of electromagnetic induction in details.



Another electro magnet OLC *(overload coil)* is connected in the motor circuit i.e. in series with it. Due to this motor current flows through it also. If the motor current is large enough, then it will



also pass through this coil and it will attract the moving strip near it, towards itself. There is a sufficiently large distance between them. This distance will be overcome, whenever the current through the motor exceeds beyond the overloaded value of the motor. As the strip is attracted towards the OLC, the NVC is short circuited and it is demagnetized.

Now the spring action, the arm is thrown back to OFF condition and the circuit breaks down. Thus the motor stops and protected from overloading.

2.2.2 Working of NVC

The supply to the motor is derived through NVC - No Voltage Coil. So when field current flows, the NVC is magnetized. Now when the handle *(arm)* is in the 'RUN' position, soft iron piece connected to the handle and gets attracted by the magnetic force produced by NVC, because of flow of current through it. The NVC is designed in such a way that it holds the handle in 'RUN' position against the force of the spring as long as supply is given to the motor. Thus NVC holds the handle in the 'RUN' position and hence also called hold on coil.

Now when there is any kind of supply failure, the current flow through NVC is affected and it immediately loses its magnetic property and is unable to keep the soft iron piece on the handle, attracted. At this point under the action of the spring force, the handle comes back to OFF position, opening the circuit and thus switching off the motor. So due to the combination of NVC and the spring, the starter handle always comes back to OFF position whenever there is any supply problems. Thus it protects the motor from any type of abnormal function.

2.2.3 Drawbacks

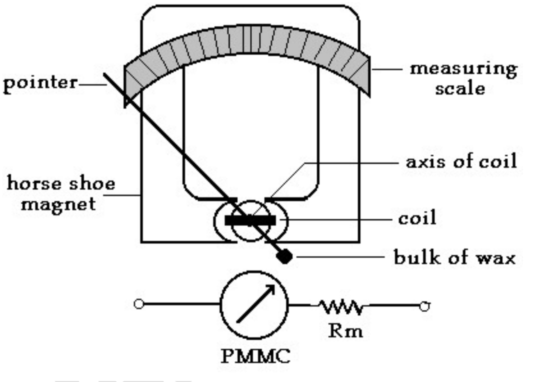
In a three-point starter, the no-volt release coil is connected in series with the shunt field circuit so that it carries the shunt field current. While exercising speed control through field regulator, the field current may be weakened to such an extent that the no-volt release coil may not be able to keep the starter arm in the ON position. This may disconnect the motor from the supply when it is not desired. This drawback is overcome in the four point starter.

2.3 THE MOVING IRON INSTRUMENT

The deflecting torque in any moving-iron instrument is due to forces on a small piece of magnetically 'soft' iron that is magnetized by a coil carrying the operating current. Now we shall see the simple concept of working principle of a basic permanent magnet moving coil meter.

2.3.1 Construction of a basic PMMC

The basic constructional diagram of the meter is given here. In this meter, a permanent magnet is used known as horseshoe magnet.



Between the two poles of this magnet, a coil is suspended. This coil is wound on paper cylinder and its two terminals are taken out for external connection. The coil is suspended on the two supports fixed to the horseshoe magnet. A spring is attached to the cylinder along with the needle or pointer.

In PMMC, the spring is used to restore the resting position of the needle after deflection. A balancing weight is fixed on the other end of the needle.

It is generally a bulk of wax or some sealing material. Now when some electrical quantity is connected across the two terminals of the coil, magnetic field is produced around it.

This magnetic field interacts with the permanent magnet of the horseshoe magnet. Due to this, an angular torque is given to the coil i.e. the cylinder along with the coil rotates on its axis. Therefore, the needle also deflects and the reading of the connected quantity is obtained on the scale of the meter.

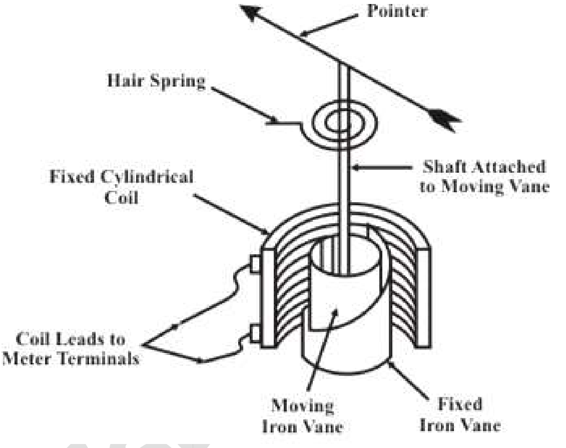
Here note that the deflection of the needle is directly proportional to the electrical quantity applied to the coil. The coil has a DC resistance known as Rm. The scale of the PMMC can be calibrated in terms of the unit of the electrical quantity under measurement.

2.3.2 Repulsion type moving iron meter

In repulsion type moving iron instrument, there are two cylindrical soft iron *vanes* mounted in a fixed current carrying coil. One iron *vane* is held fixed to the coil frame and other is free to rotate, carrying with it the pointer shaft. Two irons lie in the magnetic field produced by the coil that consists of only few turns if the instrument is an ammeter or of many turns if the instrument is a voltmeter.

Current in the coil induces both vanes to become magnetized and repulsion between the similarly magnetized vanes produces a proportional rotation.

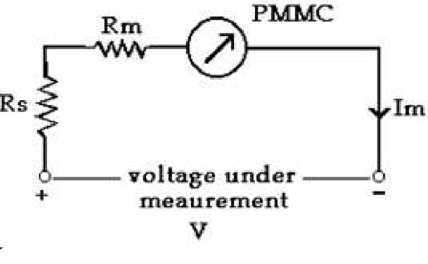
The deflecting torque is proportional to the square of the current in the coil, making the instrument reading is a true 'RMS' quantity. Rotation is opposed by a hairspring that produces the restoring torque. Only the fixed coil carries load current, and it is constructed so as to withstand high transient current. Moving iron instruments have two types of scales: linear and non-linear.



2.4 APPLICATIONS OF MOVING IRON INTRUMENTS

2.4.1 PMMC as Voltmeter

Consider the diagram given here. Here the PMMC is connected in series with a series resistor R_S. The coil's internal resistance is shown as (R_m). Now we are interested to calculate the value of the series resistor R_S when the voltage under measurement is V. Here note that the I_m is known as the full–scale deflection current of the PMMC. When this current flows through the meter, the needle of the meter gives full-scale deflection. Now according to the Ohm's law –

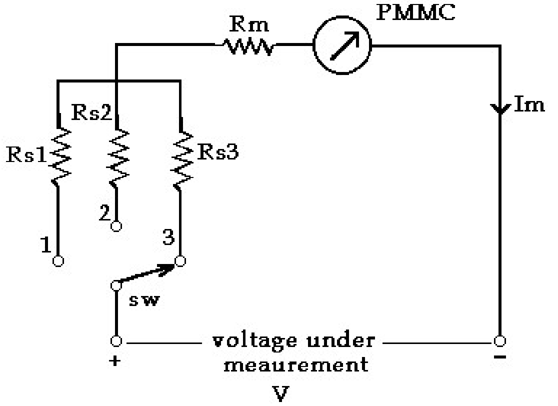


$$I_m = \frac{V}{R_S + R_m} \qquad R_S + R_m = \frac{V}{I_m}$$

$$\therefore R_s = \frac{V}{I_m} - R_m$$

2.4.2 Multirange Voltmeter

When a number of different voltages are to be measured with the help of a voltmeter then a multirange voltmeter is used as shown in the following diagram. Here a number of R_s as series resistors are connected in the circuit i.e. R_{s1}, R_{s2}, R_{s3} … and so on. The values of the resistors are calculated for a different range of the voltage under measurement.

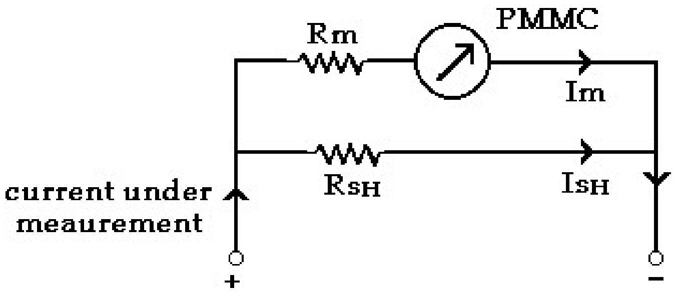


The rotary switch is used to change the selection range of the voltage to be measured. When the rotary switch is rotated the different values of the R_s are selected and the range of the voltage to be measured changes.

The scale of such meter is calibrated in terms of different ranges of voltage. It the same meter is to be used to measure AC voltage, then a rectifier stage can be added to convert the AC voltage into DC and then it can be easily measured. This is because the basic PMMC only operates on DC voltage, so it is necessary to convert the AC voltage under measurement into DC and then measure.

2.4.3 PMMC as Ammeter

Consider the following diagram. Here the PMMC is connected in parallel with a shunt resistor R_{SH}. The internal resistance of the coil is shown as R_m. Now we are interested to calculate the value of R_{SH} in terms of the current under measurement I.



Here also note that the I_m is known as full scale deflection current of the PMMC. When this flows through the meter it shows full scale deflection.

Now according to the Ohm's law, we can have –

$$R_{SH} \cdot I_{SH} = R_m \cdot I_m$$

i.e.
$$R_{SH} = \frac{I_m \cdot R_m}{I_{SH}}$$

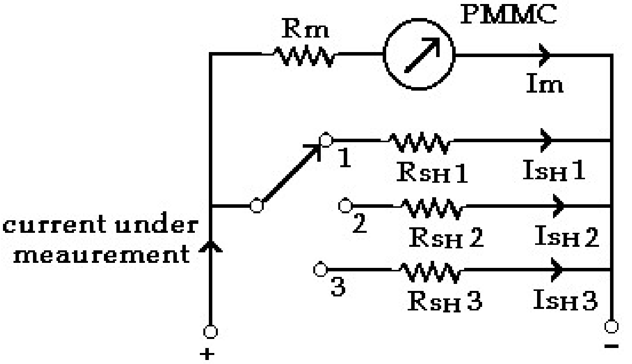
But since R_{SH} is unknown we cannot know the I_{SH}. However according to KCL we have –

$$I_{SH} = I - I_m$$ putting this value in the equation.

$$R_{SH} = \frac{I_m \cdot R_m}{I - I_m}$$

2.4.4 Multirange ammeter

When a number of different currents are to be measured with the help of an ammeter then a multirange ammeter is used as shown in the following diagram -



Here note that the rotary switch should be make-before-break type so that the meter is not damaged. In this above diagram there is one disadvantage. When the position of the switch is changed for a fraction of second the total current under measurement flows through the PMMC which may damage it since the meter's full scale deflection current is very small. To avoid this problem the Ayrton Shunt Method is used.

Summery

1. Any electrical circuit consists of an electric source either AC or DC with an on-off switch, fuse, ammeter, voltmeter, wattmeter and the load.
2. The ammeter is connected IN SERIES to measure the load current. The voltmeter is connected IN PARALLEL.
3. The wattmeter is in SERIES-PARALLEL combination to measure the amount of electrical power consumed by the load.
4. The NVC *(no volt coil)*, is electro-magnetised and it attracts the SIP *(soft iron piece)*.
5. The electro magnet OLC *(overload coil)* is connected in the motor circuit.
6. The supply to the motor is derived through NVC - No Voltage Coil.
7. Due to the combination of NVC and the spring, the starter handle always comes back to OFF position whenever there is any supply problems.
8. In a three-point starter, the no-volt release coil is connected in series with the shunt field circuit so that it carries the shunt field current.
9. In PMMC, the spring is used to restore the resting position of the needle after deflection.
10. Balancing weight is fixed on the other end of the needle, in PMMC.
11. In repulsion type moving iron instrument, there are two cylindrical soft iron *vanes* mounted in a fixed current carrying coil.
12. The deflecting torque is proportional to the square of the current in the coil, making the instrument reading is a true 'RMS' quantity.
13. When a number of different voltages are to be measured with the help of a voltmeter then a multirange voltmeter is used.
14. The PMMC is connected in parallel with a shunt resistor R_{SH} in ammeter.
15. When a number of different currents are to be measured with the help of an ammeter then a multirange ammeter is used.

Self Examination

Objective type questions

1. The voltmeter is always connected in ________.
2. The series connection is used for an ________ measuring instrument.
3. The wattmeter is connected in ______ as well as ________ combination.
4. NVC stands for _________________.
5. SIP stands for _______________.
6. The OLC stands for _______________.
7. A high input resistance voltmeter has ________ loading effect.
8. The ammeter is connected in ______ with the circuit and the voltmeter is connected in _______ with the circuit.
9. To convert PMMC into voltmeter a ________ resistance is connected in _______ with PMMC.
10. To convert the PMMC into ammeter a _______ resistance is connected in _______ with the PMMC movement.

Short answer questions

1. Draw the circuit of block diagram of a motor starter and explain its connections in brief, showing the voltmeter, ammeter and wattmeter.
2. Draw a neat circuit diagram of 3-point starter and explain the working in details. Explain the function of OLC in it.
3. Draw the constructional diagram of moving iron attraction type instrument and explain its working in short.
4. What is the basic concept of PMMC?
5. How a PMMC can be used as simple voltmeter and multi-range voltmeter. Explain both in brief with relevant circuit diagrams.
6. How a PMMC can be used as simple ammeter and multi-range ammeter. Explain both in brief with relevant circuit diagrams.
7. Why Ayrton Shunt Method is used? Explain its importance in short.
8. What will happen if a voltmeter is connected in series with load? Explain with proper reasons.
9. Why an ammeter is not connected in parallel with the load? Give proper reason to support this problem.
10. Calculate the value of the required series resistance for the conversion of a (0 – 100V) voltmeter from PMMC movement if: meter resistance = 150Ω, full scale deflection current = 50µA.

3

Fuses

Quick view...

Topics covered

Concept of fuse and its importance.
Fuse rating with basic formula, concept of fusing.
Explanation to the materials used in fuse wires.
Different types of fuses.

Scope & Limitations

Concept of fuse, its importance and simple applications, no calculations or mathematical treatment.

Fuse rating, fuse current handled by the fuse wire, concept of fusing current, basic formula.

Types of materials used in fuses, specific resistance and melting point value, etc., comparison table (maximum 5 materials)

Types of fuses, round type (cut-out), kit-kat type, cartridge type, HRC type. Introduction to more fuse types like plug type, liquid fuse, expulsion type, automatic cut-out type, DO fuse type, horn gap type, tubular type, etc.

Summary of the chapter: important points for the quick preparation of the chapter.

Problems on the chapter: board examination based problems on different topics.

Self examination: objective type questions, short answer questions, long answer questions, conceptual study questions.

3.1 INTRODUCTION

This chapter is simple to understand and easy for preparation. It includes the basic concepts of fuse, its different types and important applications.

The fuse is an important element in the protection of any device working on electric supply. It generally consists of simple fuse wire made up of special material, which has low melting point w.r.t. temperature.

3.2 CONCEPT OF FUSE

Definition: *In electronics and electrical engineering, a fuse is a type of low resistance resistor that acts as a sacrificial device to provide over-current protection, of either the load or source circuit.*

In simple language, a fuse is a current limiting element. It is always used in series. It is generally connected between load and electric supply. It may be a thin copper wire or a thin wire of any particular material, which blows out *(i.e. melts and breaks down the circuit)* when electric current flows beyond its rated value.

3.2.1 Important point about a fuse

1) Every electric supply either AC or DC consists of two wires. In AC supply, one wire is called PHASE and the other is called NEUTRAL. In DC supply, one wire is POSITIVE and other wire is NEGATIVE.
2) Remember that the fuse is ALWAYS inserted between PHASE wire of AC supply or POSITIVE wire of DC supply.
3) So when the fuse is blown out, it cuts off the phase terminal or positive terminal of the supply completely from the load.
4) Due to this, the load is also protected from electric shock hazard and thus there is no danger of electric shock, while handling the load like an appliance.
5) The rating of the fuse must be according to the type of load used in the circuit so that the maximum load current will not be exceeded.
6) Always remember that any fuse is always connected in series with the load.

3.3 HOW TO CALCULATE FUSE RATING?

It is a simple concept of calculating the rated current value of a fuse that can pass through it safely. When this rated value of current exceeds, then the fuse wire should melt so that the circuit will be broken.

Thus the fuse rating is defined as the maximum value of electric current that can flow through it safely without destroying it. Remember that the rated value of electric current flowing through it is generally the half of the fusing current of the fuse. This is calculated as follows –

$$fusing\ factor = \frac{min.fusin\quad current}{rated\ current\ of\ the\ element}$$

For circular wires, the current I is given as: $I = k.\sqrt{d^3}$, where, d is the diameter of wire.

3.4 COMPARISON OF FUSE MATERIALS

The comparison of different types of materials used in the fuse wires and elements are given below. The values given here are typical values and may change depending on the ambient conditions, etc.

Type of fuse material	Specific resistance ($\mu\Omega/cm^3$)	Melting point of material (°C)
Copper	1.78	1083.27
Silver	1.56	960.5
Aluminium	2.782	655.0
Tin	11.43	232.27
Lead	22	327.33
Zinc	6.628	421.52

Fuse materials form the active part of a circuit fuse and are required to melt in under specific conditions to break down the circuit i.e. open circuit condition. The reliability of these materials is very important for the protective function of a fuse. Fuse materials are supplied in wire and strip form, to obtain specific melting and switch-off characteristics. To obtain time-lag melt characteristics, generally an active agent, like ***Sn-based*** soft solder is also used.

Conventionally, the fuse manufacturer use the active agent to the individual finished fuse materials, however it is now becoming more common to purchase semi-finished fuses which include the active agent.

3.4.1 Characteristics of a fuse

A fuse must have following characteristics –

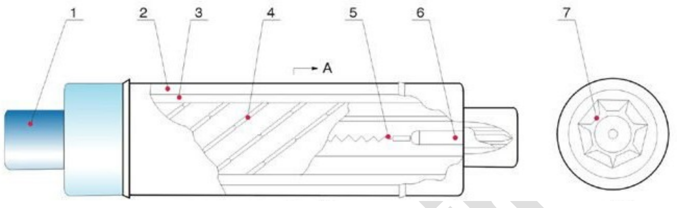
1) It must have easy installation.
2) It must provide complete isolation between electric supply and the load, when fused.
3) The body of the fuse must be fully insulated so that it should not make any electrical contact with other parts of the load or appliance.
4) It must provide with simple and easy replacement, which can be done by a layman, who may not have good technical knowledge.

3.5 TYPES OF FUSES

According to the working of a particular fuse, the fuses are classified into following types –

Round type (cut-out): This type of fuse is used to provide protection for electric system and the various apparatus on these lines, such as transformers and capacitor banks. It has a similar shape of a ceiling rose *(see following picture)*, to understand its shape. It is generally made up of bakelite or porcelain material. Its base fixed on insulated material with screws or nut bolts. The two terminals of the fuse are taken out for external connections.

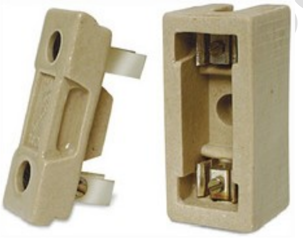
This fuse is easy to replace due to its round shape and it is therefore easy to hold for taking it out of the circuit or fixing it. It has small holes on both sides to enter the air inside. This helps to burn the fuse properly, otherwise if air is not present inside the body of the fuse, it will not burn out, when a current through it flows beyond the rated value of the fuse.



1. terminal cap, 2. porcelain tube, 3. ARC-perished filler, 4. melting body,
5. coil resistance, 6. striker device, 7. star-shaped framework

Kit-kat type: This type of fuse is not completely enclosed like the Round type cut-out fuse. It finds large number of applications in domestic wiring and appliances. However, this fuse has insulated cover due to which it can be replaced without switching off the power supply.

It is made up of China clay or porcelain



Kit-kat type: This type of fuse is made up of china clay or porcelain material. It is very safe as it is completely covered and therefore there is no danger of any electric shock. It is airy from inside as it has small windows on both sides. It is general purpose fuse used in domestic wiring.

When the upper lid is taken out, it can be rewired without actual electrical contact. It is generally fitted on wooden panel or tin box with screws.

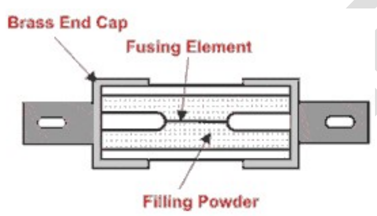
This fuse is available in different ratings from 5A to 300A. The basic terminologies used for this type of fuse are as follows –

Fuse link: it is the small piece of wire used as the fuse wire.

Fuse base: the two terminals of the fuse, where the fuse wire or fuse link is connected. It is molded into the china clay or porcelain material.

Cartridge fuse unit: The cartridge fuse unit is totally enclosed unit. It consists of a glass or porcelain tube having two end caps between which the fuse element is placed. Sometimes the container is filled with quartz powder and many fuse units are only evacuated. There is one 'peep' hole which is clear in normal condition and blackens when the fuse blows out. The fuse elements blow at accurate current and to be replaced by a new one when it blows out. It is a costly fuse unit and used industries for controlling the current in costly machineries.

H.R.C. fuse unit: The HRC fuse unit, also known as high rupturing capacity, is totally enclosed type of fuse unit. It consists of a glass or porcelain tube having two end gaps made of brass. The fuse element is placed between the two caps and the tube is completely filled with filling powder like quartz. The fuse element has a bimetal thermal control. And the element is completely air tight.



The HRC fuse unit has a special characteristic that it does not blow as soon as short circuit occurs but allows a predetermined period to remove that short circuit. If within this time the short circuit is not removed, then the fuse blows out. The fuse unit is replaced one when the fuse blows out. It is advised that in any circuit or installation of new wiring, all types of fuses should be either HRC type of kit-kat type. This fuse unit is available from 2A to 800A current rating.

3.5.1 Important Points to note

A fuse should always be connected in live i.e. phase line. It should never be connected in neutral wire or neutral line.

The material which can be used a fuse wires are tin, lead, zinc, antimony, copper, silver, alluminium, etc. Experimentally, it is found that no other materials are suitable as fusing elements.

For general purpose loads like tube lights, fans, etc. the fuse wire or fusing element's current rating should never exceed 5A. Same rule is effective for power wiring with a minimum current rating of fuse element from 10A onwards.

Summery

1. In electronics and electrical engineering, a fuse is a type of low resistance resistor that acts as a sacrificial device to provide over-current protection, of either the load or source circuit.
2. Every electric supply either AC or DC consists of two wires. In AC supply, one wire is called PHASE and the other is called NEUTRAL.
3. In DC supply, one wire is POSITIVE and other wire is NEGATIV.
4. Remember that the fuse is ALWAYS inserted between PHASE wire of AC supply or POSITIVE wire of DC supply.
5. When this rated value of current exceeds, then the fuse wire should melt so that the circuit will be broken.
6. For circular wires, the current I is given as: $I = k.\sqrt{d^3}$, where, d is the diameter of wire.
7. A fuse must have following characteristics:
8. It must have easy installation.
9. It must provide complete isolation between electric supply and the load, when fused.
10. The body of the fuse must be fully insulated so that it should not make any electrical contact with other parts of the load or appliance.
11. It must provide with simple and easy replacement, which can be done by a layman, who may not have good technical knowledge.
12. A fuse should always be connected in live i.e. phase line. It should never be connected in neutral wire or neutral line.
13. The material which can be used a fuse wires are tin, lead, zinc, antimony, copper, silver, alluminium, etc. Experimentally, it is found that no other materials are suitable as fusing elements.
14. For general purpose loads like tube lights, fans, etc. the fuse wire or fusing element's current rating should never exceed 5A. Same rule is effective for power wiring with a minimum current rating of fuse element from 10A onwards.