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Name of the course— B.Sc. (H) Physics

Semester- IV

Name of the paper—Electrical circuits and Network Skills

Paper code-32223903

Lecture timings: 10:40 to 12:40 AM

Topics to be covered:

Name of the unit: Electrical protection

- *Grounding and related fault*
- *Grounding fault protection*
- *Overload situation and its causes*
- *Overload protection for system and equipment*
- *Phase reversal and its protection*
- *Surge protection device.*

Grounding

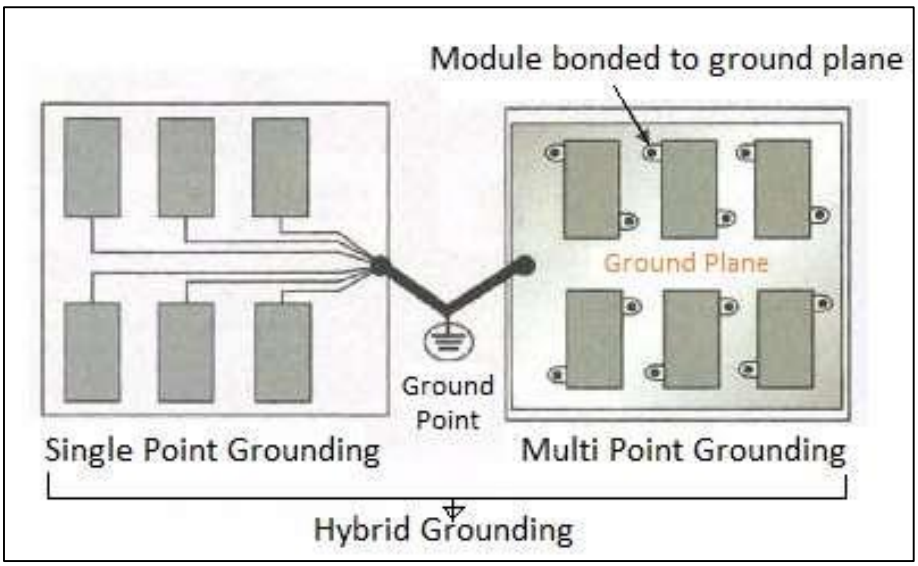
Grounding is done for the safety of the power system or equipment by connecting the live parts of it to the earth. This will provide the return path for the current in case of abnormal conditions. These conditions may include transients and lighting etc.

Return path is the path that current traces to reach back to the source in order to make the complete looping. The whole process is made with the low impedance value path.

Types of grounding

There are two types of grounding:

- Multi point grounding
    - The multi-point system does not trace a singular path back to building.
    - Many existing buildings use multi-point grounding by bonding the same pieces of electrical equipment to ground bars, building steels, cold water pipes or other electrodes.
- Single point grounding
    - Single-point grounding means that only one physical point in the entire circuit system is defined as a ground reference point, and other points that need to be grounded are directly connected to this point. In low frequency circuits, there is not much influence between the wiring and the components. Generally, circuits with a frequency less than 1MHz are grounded at one point.



Best of Two Systems

Single-point grounding should be utilized as the backbone of the building grounding system. Provide a main ground bar to act as a common distribution point for ground risers and connections. Tie the *main electrical ground bar* (MEGB) to the ground bus of the main switchgear and then go to the building from there. Ground bars for power and telecommunications should be utilized in each closet, while providing a single path back to the source (transformers). Also, one should tie telecommunication and IT grounding systems to the power grounding system and final connection at the MEGB.

Multi-point grounding should be used almost as a grounding subsystem for data centers and computer rooms filled with high-frequency electronic equipment, where the benefits of multi-point grounding can be efficiently achieved.

It is crucial, however, that this multi-point subsystem be tied to the single-point building grounding system. It should not be thought of as a separate grounding system. This type of hybrid system will work in most applications.

What is grounding fault?

A ground fault is an unwanted connection **between the system conductors and ground**. Ground faults often go unnoticed and cause havoc on plant production processes. Shutting down power and damaging equipment, ground faults disrupt the flow of products, leading to hours or even days of lost productivity.

Ground fault protection system

A designed, coordinated, functional, and properly installed system that provides protection from electrical faults or short circuit conditions that result from any unintentional, electrically conducting connection between an ungrounded conductor of an electrical circuit and the normally non–current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth.

Further, a system intended to provide protection of equipment from damaging line-to-ground fault currents by operating to cause a disconnecting means to open all ungrounded conductors of the faulted circuit. This protection is provided at current levels less than those required to protect conductors from damage through the operation of a supply circuit overcurrent device.

"An intentionally constructed, [permanent,] low-impedance electrically conductive path designed and intended to carry current under ground-fault conditions from the point of a ground fault on a wiring system to the electrical supply source and that facilitates the operation of the overcurrent protective device or ground fault detectors on high-impedance grounded systems."

There are two (2) types of ground-fault protection.

1. Personnel Protection

- GFCI = Ground Fault Circuit Interruption
- GFCI devices operation is much less than GFP for Equipment
    - ❖ Residences / Hotels – in kitchen / bathroom areas, or on outdoor outlets
    - ❖ On the jobsite – for power tools
    - ❖ For protection of high-value inventory
- Current requires for operation range between 5mA and 15mA
- For branch-circuit applications

2. Equipment Protection •

- Normal Capacitive Charging Current Exceeds 100mA.
- Primarily Employed at Services and on Feeder Circuits
- Employed in some Applications on Sub-Feeder or Branch Circuits
- Is Intended to Protect Equipment (Not Intended to Protect People)

Overload: Low Voltage Release

If the line voltage decreases to an abnormally low value, then the electrical machinery is damaged or unable to start the service. Because of the low voltage, the shunt coil on final contact holding solenoid of the starter disconnects the motor from the line. After the line voltage recovery the motor resumes its service. Low voltage release is unexpected and dangerous. To protect the machines, low voltage protection should be provided.

Low Voltage Over-current Fault

In low voltage condition, the protection against temperature is known as over-current protection. There are three major causes of over-current. The causes are listed below −

By equipment overload

The overload condition occurs when equipment is subjected to more than its rated value. This results in excessive heat production.

By short circuits

If there is any connection between the line to line or line to neutral conductors, it leads to short circuit. This generates temperature above the designated ratings.

By ground faults

If the electrical current flows from a conductor to uninsulated metal, then ground fault occurs.

Overload Protection

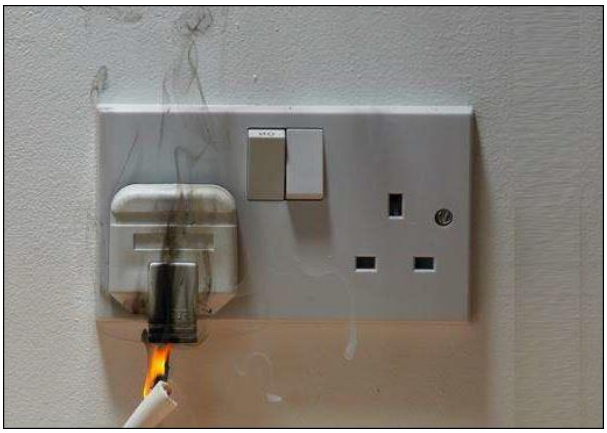
The current flows in the circuit based on the demand of loads. If the amount of current increases and exceeds the rating of the electrical equipment, then the system is overloaded. The wires or cables may not with withstand the higher current. The wires get hot and even melt the insulation. This leads to fire hazards. Therefore, overload protection is necessary to avoid such accidents.

Causes of Overload Condition

Following are the different causes of overload condition −

- Overuse of extension cords and multiple plug adapters on the same circuit.
- Running too many appliances at a time.
- When more electricity is used like electric decoration.

The following image shows the overuse of extension cord and results of an overloading cases:



Signs of Low Voltage Overloading

Let us now see the different signs of low voltage overloading. Following are the different signs

- Flickering of lights
- Sparks from appliances or wall sockets
- Warm switch plates
- Dimming of lights, television sets
- Speed reduction of motors

To avoid such problems, fuse and miniature circuit breakers are used as protecting devices. In fault condition, the fuse should blow and circuit breaker should open the circuit. It is also important to protect the conductors as well as equipment from the higher current.

Conductor Protection

Every cable has a current rating, which is the maximum safe current capacity of the cable. This current carrying capacity depends on the following factors −

- Material − Aluminum or Copper
- A structure − Individual conductor or grouped conductors
- Path medium − Open air, grounded, or near the hot furnace or inside well-ventilated room, etc.

The fuse or breaker should be chosen based on the size of the cable. When the fault current reaches the fuse, it will blow. This gives a temporary overload condition to the cable. The cable must carry momentary overloads for a very short time period. A small amount of overheating cannot build a dangerous level. This is called slow blow protector.

Equipment Protection

The fuse and circuit breaker can protect the cable. However, these are not sensitive to protect a small use device plugged into the circuit. Therefore, these protection devices are built into the appliances to protect from overload. The external fuses are used in the main service panels or sub-panels but the equipment fuse or breakers protect every part of the electrical equipment that secures the system.

Phase Reversal and its protection

When the phase sequence of a three-phase system is incorrect, the connected three-phase motors and other rotating equipment runs in the opposite direction. In many cases, this can cause a hazardous condition that may destroy product, damage machinery, and injure personnel.

Incorrect phase sequence within a three phase system is called phase reversal. Phase reversal usually occurs as a result of mistakes made during equipment installation, maintenance, or modifications to the facility power system.

A three-phase monitor relay with a phase reversal protection should be used in applications where three-phase motors and other rotating equipment must not run in the reverse direction. The relay will not energize if the phase sequence is reversed and it can stop machinery if the phase reversal occurs during operation.

Reason for Phase Reversal

- In home island generator, upon changing the phase sequence of the generator, the connected all motor's phase sequence also changes.
- Drive with VFD we can changes the direction of the motor. VFD has option to change the output voltage to the motor
- Manual errors.

Mechanical phase reverse protection:

In old days, before microprocessor relays, this protection is provided using motor driven disc working on electromagnetic principle. The disc rotates parallel with the motor. The auxiliary contact for particular direction from the disc is given to the motor starting circuit. Under normal condition, the disc does not open the auxiliary contact and the motor starts rotating. If the direction of the motor is reversed, then simultaneously the direction of the disc also reversed. Hence the disc contact open the circuit and motor will be isolated.

Solid state phase reversal protection:

Solid state relay sense the phase sequence of the motor. To install these relay, first we should run the motor without relay. By that we should find out the correct direction of the motor. Only the direction or phase sequence finalized, then we have to install the phase reversal relay. The

relay catches the existing sequence. If the sequence is reversed, then the relay de-energize the circuit.

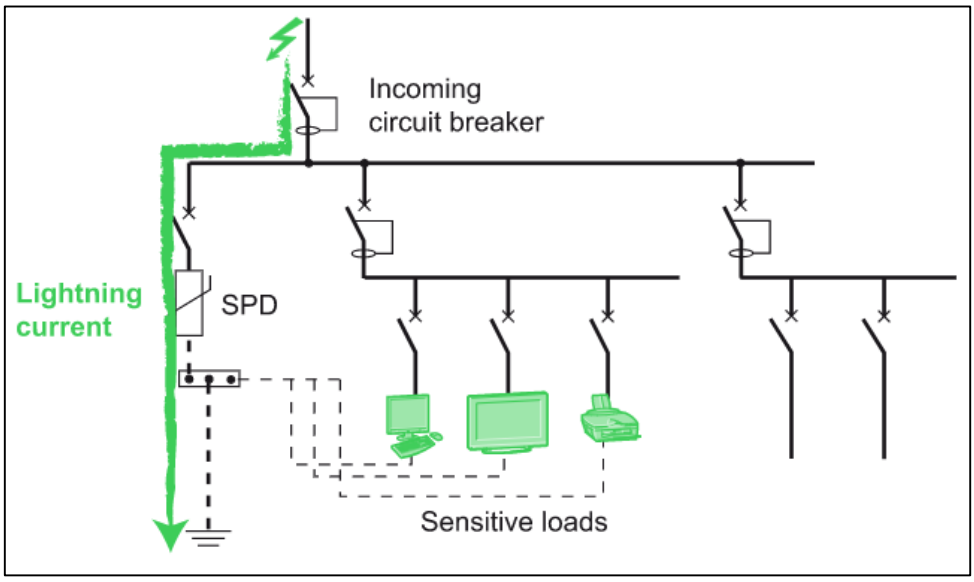
Surge Protection device

Surge Protection Devices (SPD) are used for electric power supply networks, telephone networks, and communication and automatic control buses.

The Surge Protection Device (SPD) is a component of the electrical installation protection system.

This device is connected in parallel on the power supply circuit of the loads that it has to protect (see **Fig. below**). It can also be used at all levels of the power supply network.

This is the most commonly used and most efficient type of overvoltage protection.



SPD connected in parallel has a high impedance. Once the transient overvoltage appears in the system, the impedance of the device decreases so surge current is driven through the SPD, bypassing the sensitive equipment.

Principle

SPD is designed to limit transient overvoltages of atmospheric origin and divert current waves to earth, so as to limit the amplitude of this overvoltage to a value that is not hazardous for the electrical installation and electric switchgear and controlgear.

SPD eliminates over voltages

- in common mode, between phase and neutral or earth;
- in differential mode, between phase and neutral.

In the event of an overvoltage exceeding the operating threshold, the SPD

- conducts the energy to earth, in common mode;
- distributes the energy to the other live conductors, in differential mode.

The three types of SPD

Type 1 SPD

The Type 1 SPD is recommended in the specific case of service-sector and industrial buildings, protected by a lightning protection system or a meshed cage.

It protects electrical installations against direct lightning strokes. It can discharge the back-current from lightning spreading from the earth conductor to the network conductors.

Type 1 SPD is characterized by a 10/350 µs current wave.

Type 2 SPD

The Type 2 SPD is the main protection system for all low voltage electrical installations. Installed in each electrical switchboard, it prevents the spread of overvoltages in the electrical installations and protects the loads.

Type 2 SPD is characterized by an 8/20 µs current wave.

Type 3 SPD

These SPDs have a low discharge capacity. They must therefore mandatorily be installed as a supplement to Type 2 SPD and in the vicinity of sensitive loads.

Type 3 SPD is characterized by a combination of voltage waves (1.2/50 µs) and current waves (8/20 µs).

Main applications

- Low Voltage SPD

Very different devices, from both a technological and usage viewpoint, are designated by this term. Low voltage SPDs are modular to be easily installed inside LV switchboards.

There are also SPDs adaptable to power sockets, but these devices have a low discharge capacity.

- SPD for communication networks

These devices protect telephon networks, switched networks and automatic control networks (bus) against overvoltages coming from outside (lightning) and those internal to the power supply network (polluting equipment, switchgear operation, etc.).

Such SPDs are also installed in RJ11, RJ45, ... connectors or integrated into loads.