Name of the teacher— Mrs. Monika Sharma

Department of Physics and Electronics

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

- *Relay and its types (choosing different criteria)*
- *Relay functioning*
- *Relay protection device*
- *Fuse and circuit breakers*
- *Highlighting the difference between fuse and circuit breaker.*

What are relays?

Relays are the switches which aim at closing and opening the circuits electronically as well as electromechanically. It controls the opening and closing of the circuit contacts of an electronic circuit. When the relay contact is open (NO), the relay isn't energize with the open contact. However, if it is closed (NC), the relay isn't energize given the closed contact. However, when energy (electricity or charge) is supplied, the states are prone to change.

Figure: Omron Relay

Relays are normally used in the ***control panels, manufacturing and building automation*** to control the power along with switching the smaller current values in a control circuit. However, the supply of amplifying effect can help control the large amperes and voltages because if low voltage is applied to the relay coil, a large voltage can be switched by the contacts.

If preventive relays are being used, it can detect overcurrent, overload, undercurrent, and reverse current to ensure the protection of electronic equipment. Last but not the least; it is used to heat the elements, switch on audible alarms, switch the starting coils, and pilots the lights.

Relay Types

In addition to the electromechanical and electromagnetic relay, there is a wide variety of relays with different working principles; principles of operation and polarity.

- **Electrothermal Relay** – When two different material gets in contact, bimetallic strip is formed, and when it is energized, it bends. This bending allows the users to make contact connections.
- **Electromechanical Relay** – When different mechanical parts are connected on the basis of the electromagnet, contact connection is established.
- **Solid State Relay** –This relay uses semiconductor devices to make a connection to ensure the effectiveness, efficiency, and easiness of the switching speed. This is commonly used for two reasons; faster-switching process and durability.
- **Hybrid Relay** – It is the name given to the solid-state and electromechanical relays.

Relay Types as Per The Polarity

- **Polarized Relay** – These relays are identical to electromechanical relays except for the presence of electromagnet and a permanent magnet. With this relay, the armature movement is based on the input polarity applied to the coal and is commonly applicable in telegraphical purposes
- **Non-polarized Relay** – There are no polarities in this relay, and it executes no change with the alteration of the input signal

We all are aware of the TV remotes on which we can press one button to make a function, relays work similarly to that. Relays are used to eliminate the direct link of users with electronic equipment to protect them for expected high voltages. If the vast industries are focused, they are using the bigger capacity relays to optimize the motors and pumps operation.

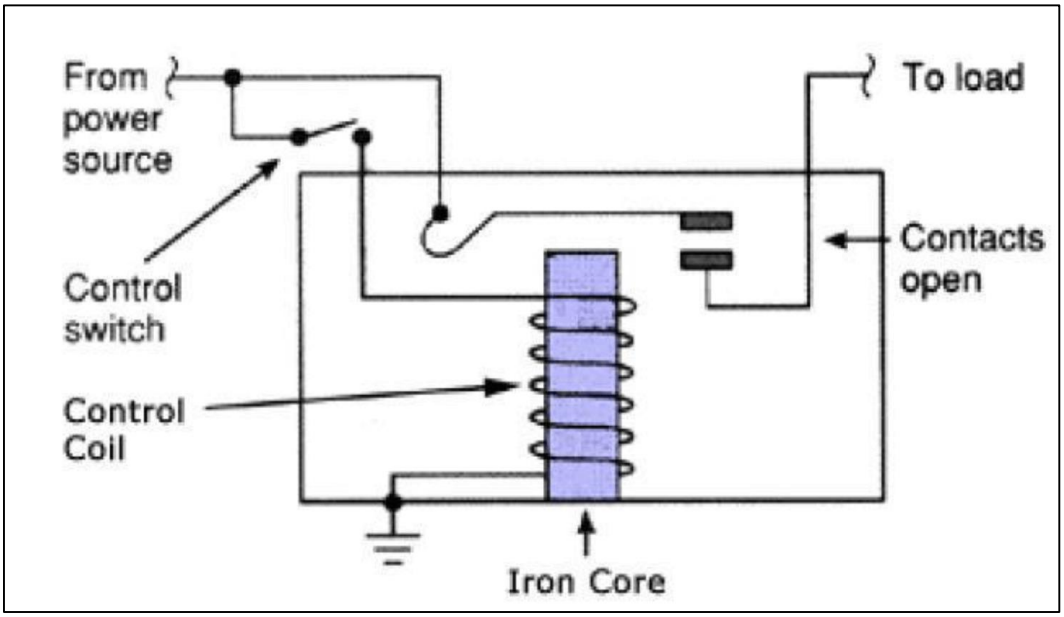
The common purpose of relays can be understood by analyzing the headlight turn on. The headlight switching button can be found on the car dashboard, and if moved, they supply the small value of current to the coil which results in contactor switching on. Then, relay comes into action by controlling the high power load (headlights). There are many other common examples of relays from our daily life.

Everyone has a fridge at their home and relays control the equipment responsible for working and production of cold temperature. Traffic lights are another application of relays where they are used as the switching component. The movement and direction of automatic garage doors are also utilizing the relays for optimal switching contacts.

It is safe to state that relays are responsible for energizing the electronic equipment and work on their functioning to ensure the optimal operation. These have eased our lives by bringing in automation factors along with the safe and smooth running of electronic equipment. This means that there are no threats involved regarding the high voltage as there will be no contact at the time of an electronic breakdown.

Relay Function

We have added the relay diagram in the section below to ensure the clear understanding of relay wiring and relay circuits along with their working.



What is relay function?

The diagram sheds focus on the internal section of the relay in the circuit. There is an iron core delimited with the control coin. The power source connects with electromagnet through load contacts and a control switch. When energy is supply to the circuit through the control coil, magnetic fields intensifies given the commencement of energizing. This way, upper contact arms gets attracted by the lower fixed arm which closes the contacts leading to the short circuit. However, if the relay was de-energized, an open circuit is created with the opposite movement of the contact.

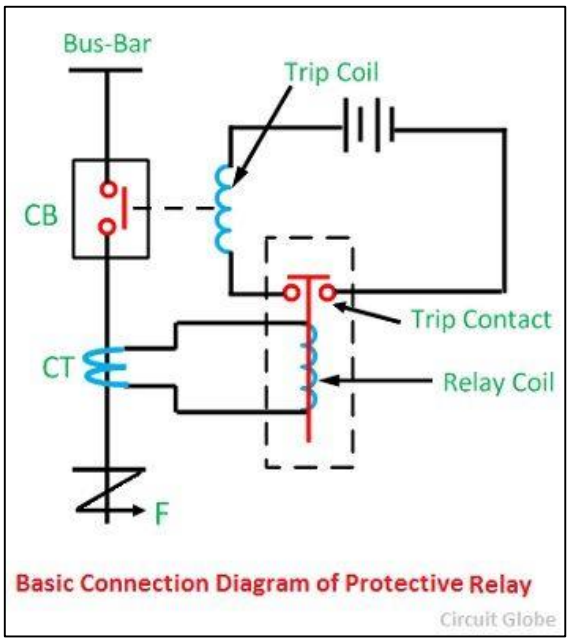
Once the coil current goes off, a movable armature is force back to the initial position, and the force is equal to half of the magnetic force and electric strength. The main reasons behind this force include gravity and spring.

The relays perform two basic functions, such as high voltage application and low voltage application. In the case of high voltage, arcing is reduce while in the low voltage applications, overall circuit noise is reduce to a minimum.

Relay Protection Device

Protective relay work as a sensing device, it senses the fault, then known its position and finally, it gives the tripping command to the circuit breaker. The circuit breaker after taking the command from the protective relay, disconnect the faulted element. By clearing the fault fast with the help of fast-acting protective relay and associated circuit breaker, the damage to the apparatus is reduced, and the resultant hazards like fire, the risk of the life are reduced, by removing the particularly faulted section.

But the continuity of supply is maintained, though remaining healthy section, by clearing the fault fast, fault arising time is reduced, and therefore the system can be restored to the normal state sooner. Hence the transient state stability limit of the system is greatly improved, permanent damage to the equipment is avoided, and the possibility of developing most simple fault such as single phase-to-ground into most severe fault such as double phase-to-ground fault is reduced



The fault can only be reduced if the protective relay is reliable, maintainable and sensitive enough to distinguish between normal and abnormal condition. The relay must come into action whenever there is a fault and must not operate if there is no fault. Some relays are used for the protection of the power system. Some of them are primary relay meaning that they are the first line of defence. Such relays sense the fault and send a signal to the proper circuit breaker to trip and clear the fault.

The fault may not be cleared if the circuit breaker fails to open or relay maloperates. The relay failure is because of three reasons such as wrong setting, bad contacts and open circuit in the relay coil. In such cases, the second line of defence is provided by the backup relays. The backup relay has longer operating time, even though they sense the fault along with the primary relays.

To attain the desired reliability, the power system network is divided into two different protection zones. The overall system protection is divided into different protection zones. They are generator protection, transformer protection, bus protection, transmission line protection and feeder protection. The relay employed for protection of the apparatus and transmission lines are as follows

- Overcurrent Relays
- Under-frequency Relays
- Directional Relays
- Thermal Relays
- Phase Sequence Relays
    - Negative phase sequence Relays
    - Positive sequence Relays
- Distance or impedance Relays
    - Phase Impedance Relay
    - Angle Impedance Relay
    - Ohm (or reactance) Relay
    - Angle Impedance Relay

- Mho’s Relay offset or Restricted Relay

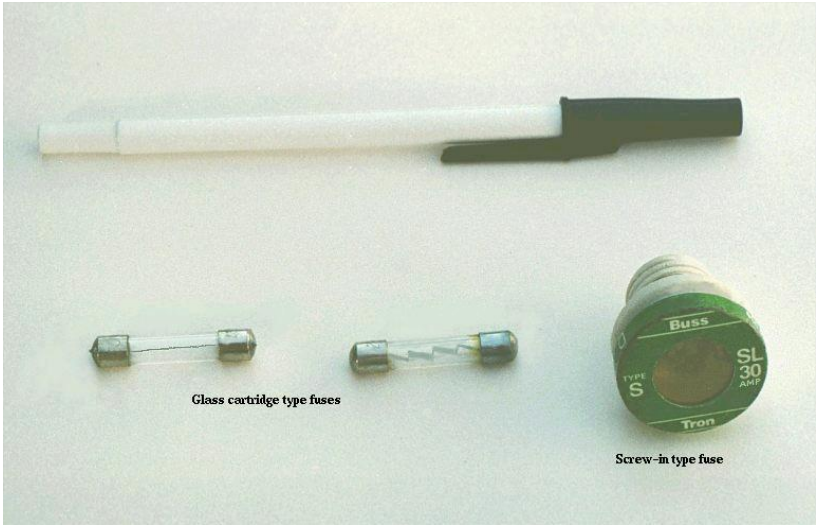
- Pilot Relays
    - Carrier channel pilot or Microwave pilot Relays

The protective relays do not eliminate the possibility of fault occurrence on the power system rather their circuit actions start only after the fault has occurred on the system. The main features of a good protective relaying are its reliability, sensitivity, simplicity, speed, and economy.

What is a Fuse?

A *fuse* is an electrical safety device built around a conductive strip that is designed to melt and separate in the event of excessive current. Fuses are always connected in series with the component(s) to be protected from overcurrent, so that when the fuse *blows* (opens) it will open the entire circuit and stop current through the component(s). A fuse connected in one branch of a parallel circuit, of course, would not affect current through any of the other branches.

Normally, the thin piece of fuse wire is contained within a safety sheath to minimize hazards of arc blast if the wire burns open with violent force, as can happen in the case of severe over currents. In the case of small automotive fuses, the sheath is transparent so that the fusible element can be visually inspected. Residential wiring used to commonly employ screw-in fuses with glass bodies and a thin, narrow metal foil strip in the middle. A photograph showing both types of fuses is shown here:



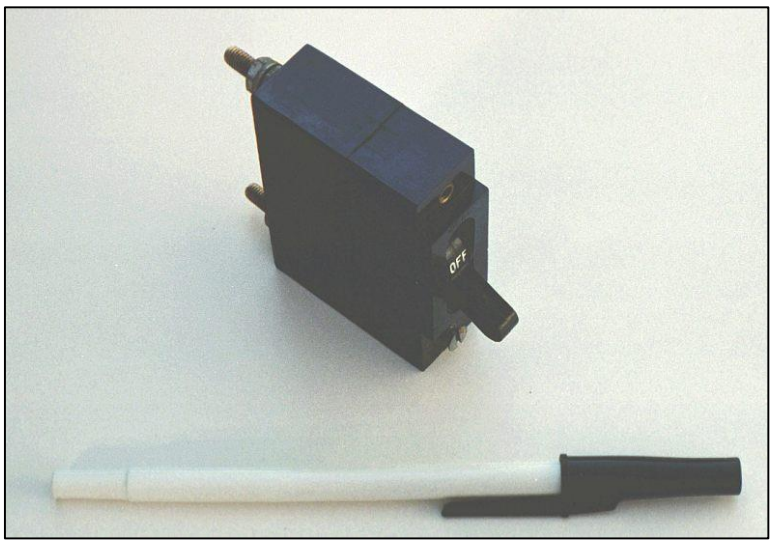
Cartridge type fuses are popular in automotive applications, and in industrial applications when constructed with sheath materials other than glass. Because fuses are designed to “fail” open

when their current rating is exceeded, they are typically designed to be replaced easily in a circuit. This means they will be inserted into some type of holder rather than being directly soldered or bolted to the circuit conductors.

What is a Circuit Breaker?

Circuit breakers are specially designed switches that automatically open to stop current in the event of an overcurrent condition. Small circuit breakers, such as those used in residential, commercial and light industrial service are thermally operated. They contain a ***bimetallic strip*** (a thin strip of two metals bonded back-to-back) carrying circuit current, which bends when heated. When enough force is generated by the bimetallic strip (due to overcurrent heating of the strip), the trip mechanism is actuated and the breaker will open. Larger circuit breakers are automatically actuated by the strength of the magnetic field produced by current-carrying conductors within the breaker, or can be triggered to trip by external devices monitoring the circuit current (those devices being called *protective relays*).

Because circuit breakers don't fail when subjected to overcurrent conditions—rather, they merely open and can be re-closed by moving a lever—they are more likely to be found connected to a circuit in a more permanent manner than fuses. A photograph of a small circuit breaker is shown here:



From outside appearances, it looks like nothing more than a switch. Indeed, it could be used as such. However, its true function is to operate as an overcurrent protection device.

The Difference between Fuse and Circuit Breaker is given below in the tabulated form

BASIS	FUSE	CIRCUIT BREAKER
Working Principle	Fuse works on the electrical and thermal properties of the conducting materials.	Circuit breaker works on the Electromagnetism and switching principle.
Reusability	Fuses can be used only once.	Circuit breakers can be used a number of times.
Status indication	It does not give any indication.	It gives an indication of the status
Auxiliary contact	No auxiliary contact is required.	They are available with auxiliary contact.
Switching Action	Fuse cannot be used as as an ON/OFF switch.	The Circuit breaker is used as an ON/OFF switches.
Temperature	They are independent of ambient temperature	Circuit breaker Depends on ambient temperature
Characteristic Curve	The Characteristic curve shifts because of the ageing effect.	The characteristic curve does not shift.
Protection	The Fuse provides protection against only power overloads	Circuit breaker provides protection against power overloads and short circuits.

BASIS	FUSE	CIRCUIT BREAKER
Function	It provides both detection and interruption process.	Circuit breaker performs only interruption. Faults are detected by relay system.
Breaking capacity	Breaking capacity of the fuse is low as compared to the circuit breaker.	Breaking capacity is high.
Operating time	Operating time of fuse is very less (0.002 seconds)	Operating time is comparatively more than that of the fuse. (0.02 – 0.05 seconds)
Version	Only single pole version is available.	Single and multiple version are available.
Mode of operation	Completely automatically.	Manually as well as automatically operated.
Cost	Cost of fuse is low.	Cost of circuit breaker is high.