

Protective RelaysNeed for protective system:

- An electrical power system consists the generator, transformers, transmission and distribution lines etc. short ckt and other abnormal condition obtain occurs on power system.
- The heavy current associate with s.c. In lightening to cause damage equipment with suitable protective relay and circuit breaker are not provided protection of each section of the power system.

The short circuit are usually called faults by the failure of conducting path due to exist in a conductor is they type of fault. If a fault occurs in an element on a power system and automatic protective device if needed to isolate the faulty element as quickly as possible to clear the healthy section of the system in normal operation.

A protective schemes include circuit breaker and protective relay to isolate faulty section of the system from the healthy section. At C.B can be disconnect the faulty element of the system when it is caused upon to do so by the protective relay.

→ protection is needed not only against the short circuits but also against any other abnormal conditions which may arise on power systems.

A few examples i.e over speed of generators and motors, over voltage under frequency loss of excitation, over heating of stators and rotors.

Nature and cause of faults:

Faults are caused either by insulation failure or by conducting path failures. the failure of insulation results in short circuit which are very harmful as they may damage some equipment of the power system

The most of faults on transmission and distribution lines are called by over voltage due to lightning strike, switching surges or by external conducting objects falling on overhead lines.

→ unbalanced current flowing in rotating machines setup harmonics thereby heating the machines in short period of time.

Types of faults:-

symmetrical faults: A three phase fault is called symmetrical type of fault. In a three phase fault all 3-ph. are short circuited.

Unsymmetrical faults:

1. single line to ground :- A short circuit b/w any one of phase conductors and earth.

It may be due to failure of insulation between phase conductor and earth. ②

2. Double line to ground fault:-

A short circuit b/w any two phases and earth is caused double line to ground fault.

3. phase to phase:-

A short circuit between any two phases.

open circuited phases:-

These type faults is caused by they breaking conducting path faults occurs when one or more type of faults namely the ~~short~~, ~~circuiting~~ ~~terms which on the machine windings~~ please conductors break (or) cable joint the overhead line fails winding faults:-

All type of faults discussed above also occurred in the alternators, motors and transformer winding.

In addition these step of faults there is one more type of faults namely the short circuiting

of terms which on the machine windings.

simultaneous faults:-

Two or more faults occurring simultaneously on a system are known as multiples, and

simultaneously faults for example two different

type of faults occurring at the same point is

a single line-ground faults one phase and

breaking of the conductor of another phase.

Effect of faults:-

- Heavy short circuit current may cause damage to equipment.
- arcs associated with short circuits may cause fire hazards.
- There may be reduction in the supply voltage of healthy feeders resulting in the loss of industrial loads.

→ short voltage and currents there by heating rotating machines.

→ There may be a loss of system stability. Individual generators in a power station may lose synchronizing resulting in a complete shutdown of the system.

→ The above faults may cause the interruption of the supply to the consumers, thereby causing a loss of revenue.

Faults statics (with no damage) out of total faults

Aim

percentage of total faults

Overhead lines about 50%.

Underground cables about 9%.

transformers more or less 10%.

Generators 4 to 5%.

Switch case 12

CT's, PT's, relays, control 12

equipments etc.

Type of faults ... % of total faults. (3)

Line to ground

85

Line to line

08

double line to ground

05

3 phase

02

In case of cables 50% of the faults occurring
cables on 50% at and Junction.

evolution of protective relays:-

In the very earlier days of power industry
power generators are used in supply loads and
fuses but the only automatic device to isolate
the faulty equipment.

They suffered from the disadvantages of
requiring replacement before the supply can be restored.

These inconveniences were overcome with the
introduction of circuit breakers and protective relays

Types :-

1) attracted armature type electromagnetic

relay - 1920

2) auxiliary relay - 1920

3) induction disc type Inverse time current

relays - 1920

4) directional relay - 1939

5) distance relay - 1939

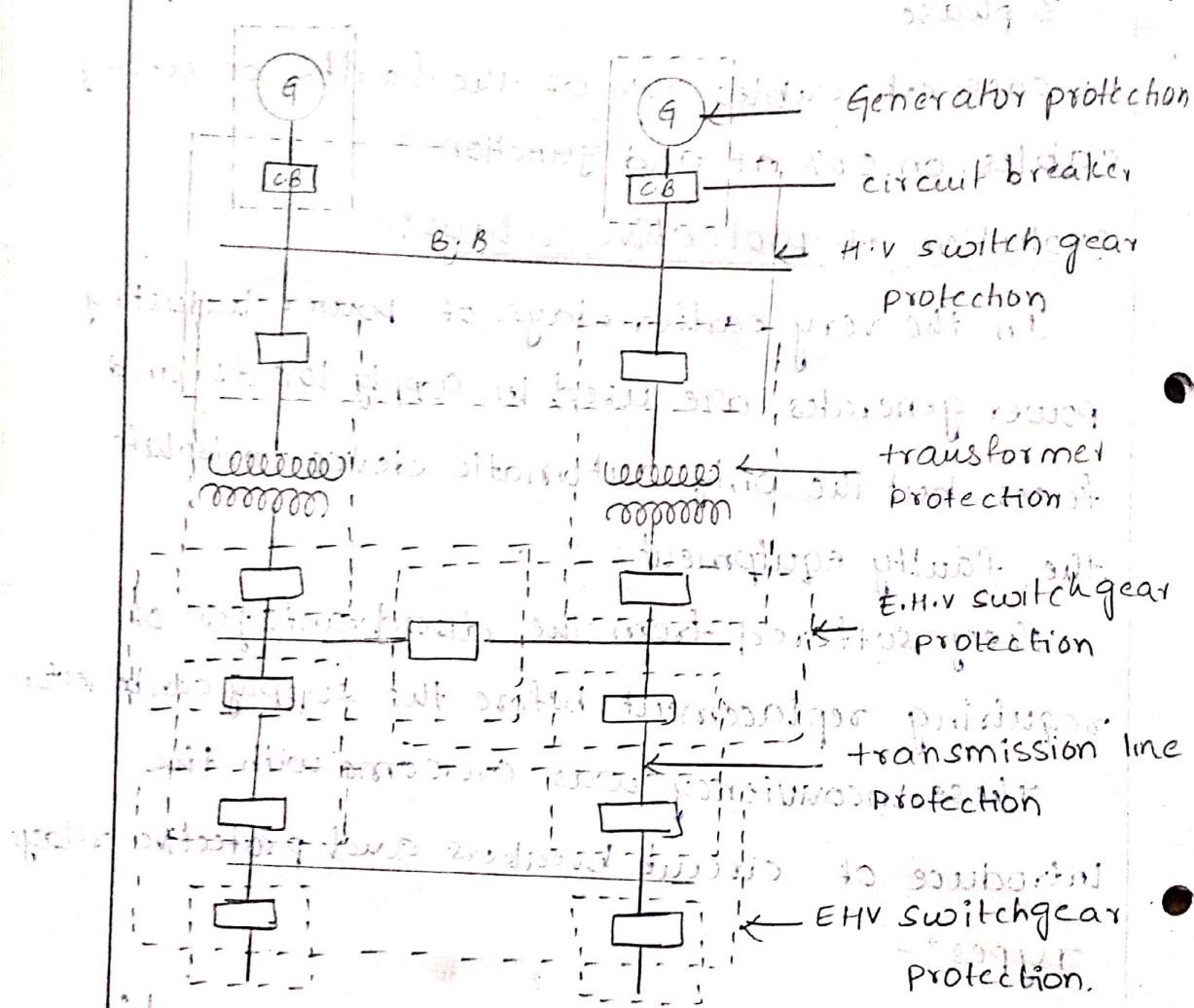
6) Rectifier bridge type relay - 1947

7) vacuum type relay - 1928

8) magnetic Amplifier type

9) cold crystals

zones of protection: along all sides



A power system contains generators, transformers, bus bars, transmission and distribution lines etc.

There is a separate positive scheme for each piece of equipment or element of the power system, such as generator protection, transformer protection, transmission line protection, bus bar protection, etc. Thus a power system is divided into a number of zones for protection.

The protective zone covers one or at the most two adjacent sections.

elements of a power system. The protective zones are planned in such a way that the entire power system is collectively covered by them, and thus, no part of the system is left unprotected. The various protective zones are planned in s of a typical power system are shown in fig. In above.

Primary & Backup protection

There is a suitable protective scheme for each zone, If fault occurs at a particular zone it is duty of primary relay of that zone to isolated the facility element.

If due to any reason primary relay fails to operate there is a backup protective scheme to clear the fault.

The reliability of protective scheme should at least be 95%. With proper design installation and maintenance of the relays, CB trip mechanism, DC & AC wiring system etc..

Under these conditions the backup can be achieved.

There are three types of relays:

- 1) Remote backup
- 2) Relay backup
- 3) breaker backup

Essential quantities of protection:-

Selectivity or discrimination:-

Selectivity is the quality of protective relay by which it is able to discriminate b/w a fault in the protected section and the normal condition.

It should be able to separate either a fault lies within its zone of protection or outside the zone.

2) Relayability:- Its property to operate at a

A protective system must operate reliable when a fault occurs in its zone of protection. The failure of protective system due to failure of any one more elements of the protective systems. It is important element are protective relays, CB, CT, PT, wire, and battery etc.

3) Sensitivity:-

A protective relay should operate when the magnitude of current excess the present value.

4) stability:-

A protective system should remain stable even when a large current flowing through it due to an external fault which doesn't lie this zone.

5) Fast operation: (6)

A protective system should be fast enough to isolate the faulty elements of the system as quickly as possible to minimize damage to the equipment and to maintain system stability.

Classification of protective relay and schemes:

electromagnetic relay :-

electromagnetic relay has pole attracted armature

Induction disc and induction curv type relay:-

electromagnetic relays contain electro magnet

and a moving part

2) static Relay:-

the static Relay contains electronic circuit which may include Transistor, IC, diode, and other electronic components

there is a comparator circuit in the relay which compares two or more voltages

or currents and gives an output which is applied to either relay or transistor circuit

3) microprocessor based protective Relays:

These are latest developed in this area

with developments in VLSI technology.

sophisticated and fast microprocessor coming up.

- Classification protective relays based on their functions:-
- i) Indirect protection:-
 - ii) The scheme of protection is used for protection of distribution lines, large motors equipments etc..

It includes one or more overcurrent relay can be connected in series with the line. If current exceeds its pickup value.

Distance protection:-

The distance protection is used for the protection of the overhead transmission lines. usually 33kv, 66kv and 132kv lines. the distance relay makes the distinction between the relay location and the point of fault in terms of impedance, reactance etc..

Carrier current protection:-

This scheme of protection is used for protection of EHV & UHV lines. generally 132kv and above. A carrier signal in the range of 50 to 500 kilo cycles/second generated for the purpose. A transmitter and receiver are installed at each end of the line to the protected end. The power rating of the line is very large.

Differential protection:-

This scheme of protection is used for protection of generators, TPS, motors for very large size for bus zones. CT's are placed on both sides of a machine.

Automatic Reclosing

Above 90% of faults on overhead lines are of transient nature. Transient faults are caused by lightning or external faults falling on the lines. Such faults are always located with series arcs. If the lines are disconnected from the supply for a short time the arc is extinguished and fault disappears immediately after these the circuit breaker can be reclosed automatically.

CT'S & PT'S

CT's for the protection:

CT's are used to reduce the heavy current flowing in an element of a power system to low values that are suitable for relay operation.

D Requirement of CT's for protection:

The requirement of CT's used for protective relay are quite different from those of instrument CT's where as where as a CT used for instrument CT's, where as a CT used for protection is required to give a current ratio upto several times of the rated primary current.

2) core material:

i) cold rolled grain oriented silicon steel (CRGO) which has high permeability and high saturation reasonable small exciting current and low errors such core materials are reasonably good accuracy upto 10 to 15 times of the rated current.

2) Hot rolled silicon steel:

It has permeability, low exciting current, low errors and saturation at relatively low flux density; it has good accuracy upto 5 times the rated current.

3) Accuracy:-

The accuracy the CT's is expressed in terms of departure of ratio from its true ratio (2% to 3%).

$$\% \text{ error} = \left[\frac{NFS - IP}{IP} \right] \times 100$$

4) C.T burden:-

The C.T burden is defined as load connected across the secondary, which is generally expressed volt-ampere or I^2R .

Potential transformers:-

Voltage transformers were previously known as potential transformers (PTs). They are used to reduce the power system voltages to lower values and to provide isolation between the high-voltage power network and the relays and other instruments connected to their secondaries. The voltage ratings of the secondary windings of the VT's have been standardized, so that a degree of interchangeability among relays and meters of different manufacturers can be achieved.

The accuracy of voltage transformer (D)

is expressed in terms of the departure of its ratio from its true ratio.

The percentage ratio error is given by

$$\text{Percent ratio error} = \left(\frac{K_{\text{true}} - K_{\text{nominal}}}{K_{\text{nominal}}} \right) \times 100$$

K = Nominal voltage ratio

= Rated primary voltage

Rated secondary voltage

Number of primary turns

Number of secondary turns

V_S = Secondary voltage, and

V_P = Primary voltage

the ratio and phase angle errors are introduced.

Three types of voltage transformers:

i) electromagnetic type

ii) capacitor type

iii) Opto-electronic type

The electromagnetic type of VT is similar to a

conventional wound type transformer with

additional feature to minimise error. This type

of VT is conveniently used for voltages up to

132 kV.

at 20000 : 1 - kVA

Basic Relay Terminology

Relay: A relay is an automatic device by means of which an electrical circuit is indirectly controlled and is governed by a change in the same or another electrical circuit.

protective relay:

A protective relay is an automatic device which detects an abnormal condition in an electrical circuit and causes a circuit breaker to isolate the faulty element of the system.

operating force or torque: - A force or torque which tends to close the contacts of the relay.

Restraining force or torque:

A force or torque which opposes the operating force/torque.

Actuating quantity: - An electrical quantity to which relay responds.

Pick-up: - The threshold value of the actuating quantity

above which, the relay operates.

Electromechanical Relays

(8)

Electromechanical relays operate by mechanical forces generated on moving parts due to electromagnetic or electrothermic forces created by the input quantities. The mechanical force results in physical movement of the moving part which closes the contacts of the relay for its operation. The operation of the contact arrangement is used for relaying the operated condition to the desired circuit. In order to achieve the required function, since the mathematical force is generated due to the flow of an electric current, the term 'electromechanical relay' is used.

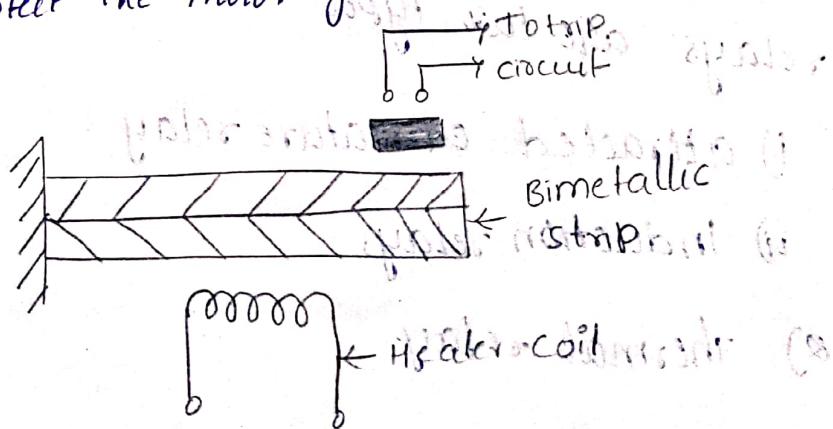
Most electromechanical relays use either electromagnetic attraction or electromagnetic induction principle for their operation. Such relays are called electromagnetic relays. Depending on the principle of operation, the electromagnetic relays are two types

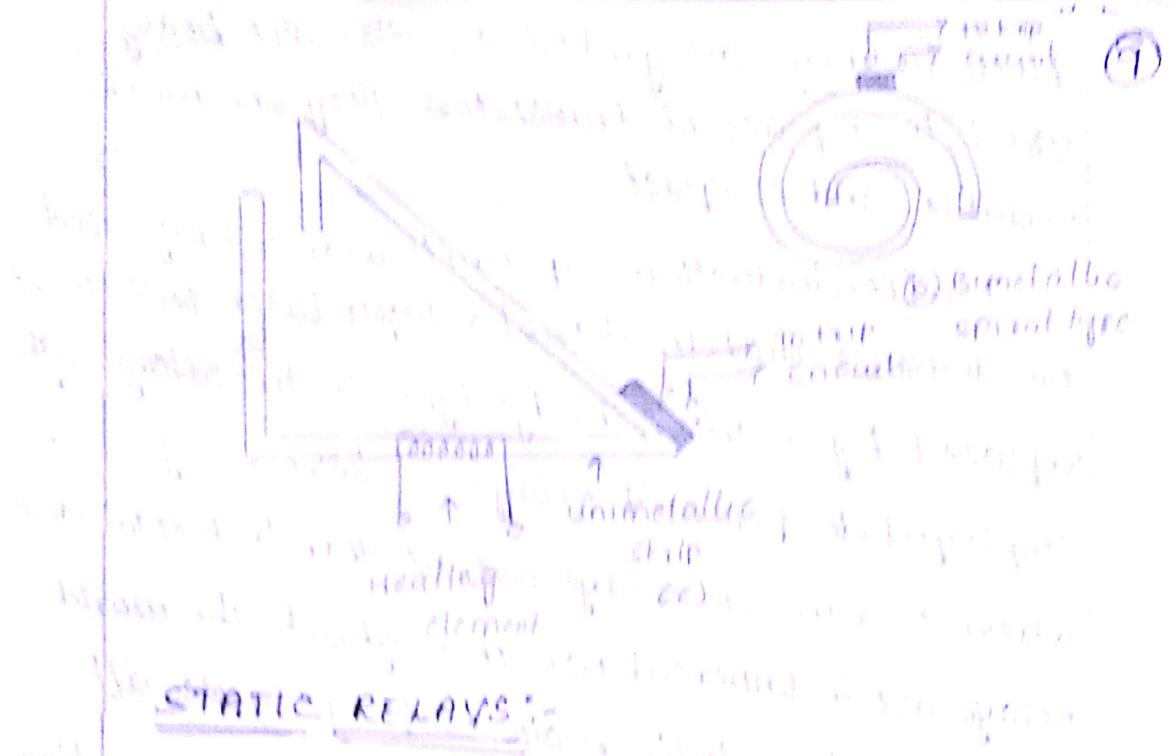
- i) Attracted armature relay
- ii) Induction relays
- iii) Thermal relay.

Thermal Relays:-

These 'relays' utilise the electro-thermal effect of the actuating current for their operation. They are widely used for the protection of small motors against overloading and unbalanced currents. The thermal element is a bimetallic strip, usually wound into a spiral to obtain a greater length, resulting in a greater sensitivity. A bimetallic element consists of two metal strips of different coefficients of thermal expansion, joined together.

For the protection of 3 phase motors, three bimetallic strips are used. They are energised by currents from the three phases. Their contacts are arranged in such a way that if any one of them moves differently from the other, due to an unbalance exceeding 12%, their contacts meet and cause the circuit breaker to trip. These relays also protect the motor against overloading.





- In a static relay, the comparison of measurement of electrical quantities is performed by a static circuit which gives an output signal for the tripping of a circuit breaker. Most of the present day static relays include a dc polarised relay as a slave relay. The slave relay is an output device and does not perform the function of comparison or measurement. It simply closes contacts. It is used because of its low cost. In a fully static relay, a thyristor is used as a slave relay provides a number of output contacts at low cost.
- Electromagnetic multicontact tripping arrangements are much simpler than an equivalent group of thyristor circuits.

A static relay employs semiconductor diodes, transistors, zener diodes, thyristors, logic gates etc as its components.

Now-a-days, Integrated circuits are being used in place of transistors. They are more reliable and compact.

Earlier, induction cup units were widely used for distance and directional relays; later these were replaced by rectifier bridge type static relays with

employed dc polarised relays as above relays. where overcurrent relays are needed, Induction disc

relays are in universal use throughout the world.

But ultimately static relays will supersede all

electromagnetic relays, except the extracted core malice

relays and dc polarised relays as these relays can

control many circuit at low cost.

microprocessor based protective relays:-

A microprocessor-based relay system is used to

combination with relay contactors and a control

circuit therefore to protect an electric motor from

overload currents. In addition to phase faults,

ground faults, load losses, and load jams. The

microprocessor is provided with a database comprising

thermal characteristics of the motor during heating

and cooling. The heating data comprise current

versus time curves stored as a look-up table for

which each data point represents a thermal limit,

neglect the maximum time the motor is permitted to operate at a particular current level, the cooling data comprise motor cooling rates. These currents were sampled at preselected fixed time intervals during a predetermined period. Then and an average motor current value relative to a predetermined overload current value. The average motor current value is used as an index to the heating curve look-up table. If the thermal sum exceeds the corresponding thermal limit in the look-up table, if the I_{th} for a predetermined time interval, then an overload condition is indicated, and the relay is tripped.