

* Wire pilot protection :-

In this case the auxiliary pilot-wires are provided to carry the information signals from one end to the other protective systems requiring the use of pilot wires on transmission lines operate on the principle of differential protection. There are basically two forms of differential protection schemes used for transmission line protection :

* longitudinal

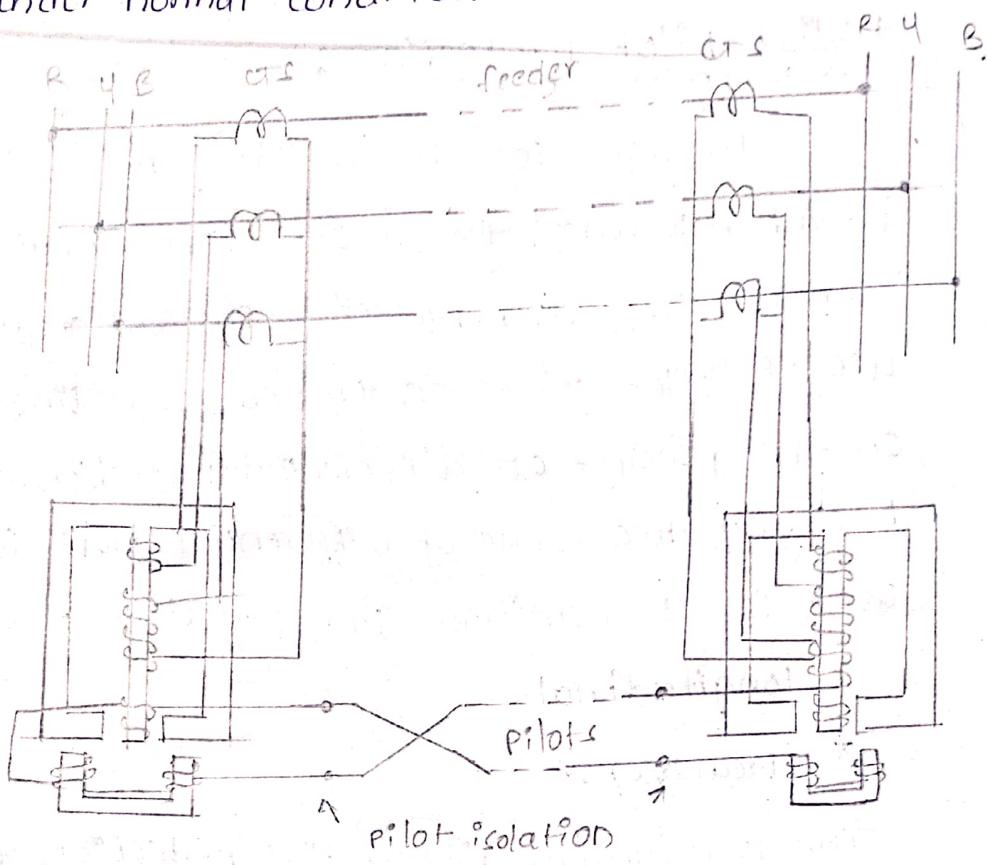
* transverse

The longitudinal differential protection operation principle is based on the comparison of the magnitude and phase of the currents at the two ends of the protected section.

Some of the commonly used longitudinal differential schemes are described below.

a) The translay scheme (AEI) :- The scheme is shown in fig. 21 is of the balanced voltage type and is suitable for pilot circuits up to a loop resistance of 800 ohms. Associated with the CT's at each end is an induction disc type relay whose secondary circuits are connected in opposite by pilot wires. The upper electromagnet system acts as a quadrature transformer and produces at the pick terminal a voltage which varies with the primary

current. No current will flow in the circuit under normal conditions.



translay feeder protection

Compensation for pilot capacitance current is made by providing a copper loop fitted to the centre limb of the upper Electromagnet - the flux from this magnet leads the pilot voltage and produces a flux in the lower magnet in phase with the upper coil flux thus producing no torque in the disc.

Minimum earth-fault settings 22-40%

Minimum phase-fault setting 45-90%

Minimum three-phase fault setting 52%

operating time at 5 times the fault 0.12 s

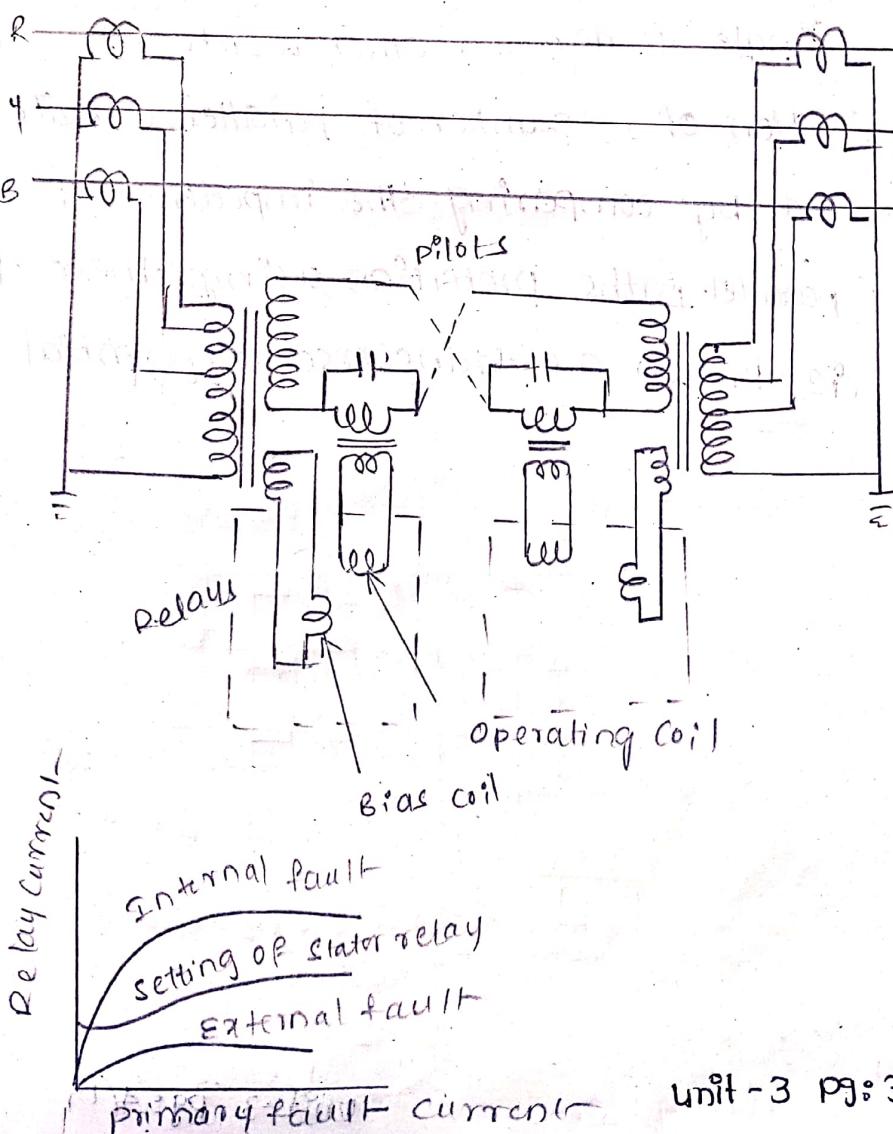
(b) solkar scheme (Rayrolle) :-

The scheme and the characteristics of the relay are shown in fig. This is also essentially a balanced voltage feeder protection scheme. separate saturable summation transformers are provided which are designed to saturate at about 1.5 times the CT Secondary rating for an earth fault energizing the whole summation transformer primary winding.

Earth-fault setting 40-60%

Phase-fault setting 120-240%

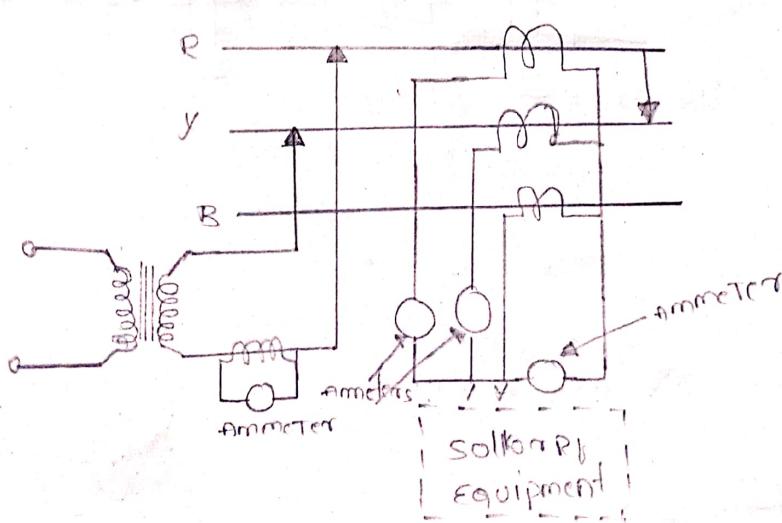
Three-phase-fault setting 140%



(C) Soltor R scheme :-

This is also known as half wave comparison scheme. Fig shows the circuit of this scheme. It can be seen the basic connections are similar to the circulating current scheme.

The resistance R_A and R_B are made slightly greater than that of the pilot loop resistance R_p . Under through fault condition either R_A or R_B is short circuited by its rectifier depending on the particular half cycle. Protection of Teed's feeders. Pilot wire protection for teed's feeders is more difficult than for a single feeder. In other words, the unit protection of a number of parallel circuits is achieved by comparing the impedance of the several parallel paths. Protection using these principles is known as transverse differential protection.



* carrier current protection :-

The different methods of current carrier protection and the basic form of the carrier current protection are:-

1. Directional comparison protection

2. Phase comparison protection

1. Directional comparison protection :-

In this protection schemes, the protection can be done by the comparison of a fault of the power flow direction at the two ends of the line. The operation takes place only when the power at power at both the end of the line is on the bus to the line direction. After the direction comparison, the carrier pilot relay informs the equipment how a directional relay behaves at the other to a short circuit.

If the relay at both the end removes the fault from the bus If the fault is in protection section the power flows in the protective direction and the external fault power will flow in the direction. The pilot protection relay schemes used for the protection of transmission are mainly classified into two types

They are:-

* carrier blocking protection scheme :-

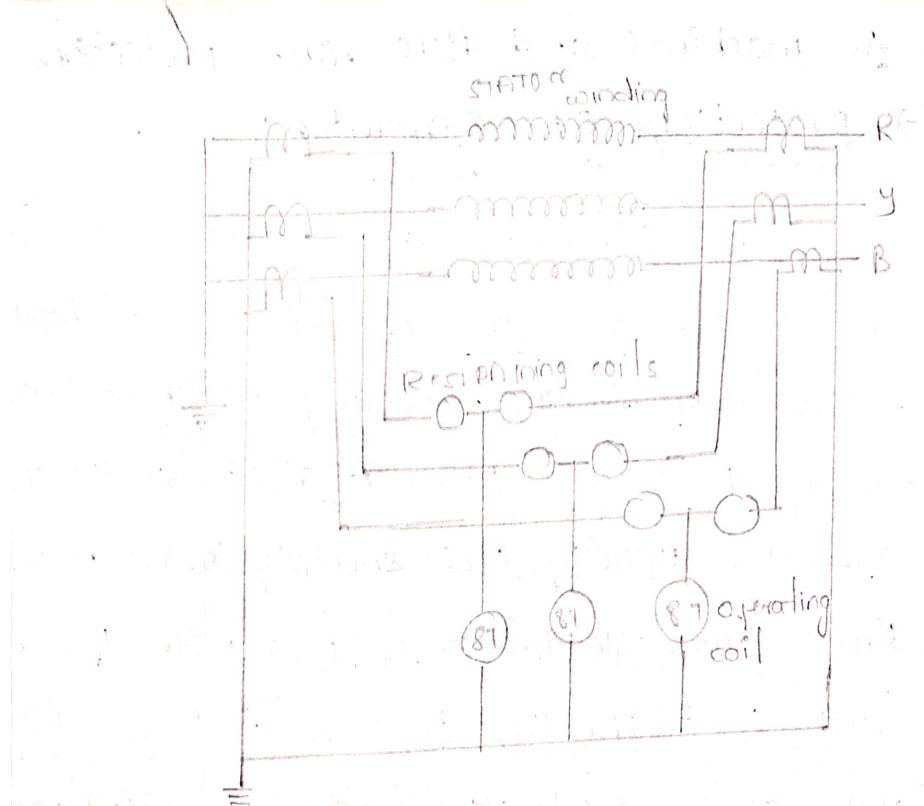
The carrier blocking protection schemes restricts the operation of the relay. It blocks the fault before entering into the protected section of the system. It is one of the most reliable protecting schemes because it protects the system equipment from damage.

* carrier permitting blocking scheme :-

The carrier, protective schemes allows the fault current to enter into the protected section of the system.

* phase comparison carrier protection :-

This system compares the phase relation between the current enter into the pilot zone and the current leaving the protective zone. The current magnitudes are not compared. If provided only main or primary protection and backup protection must be provided also. The circuit diagram of the phase comparison carrier protection scheme is shown in the figure below.



The transmission line CTS feeds a network that transforms the CTC output current into a single phase sinusoidal output voltage. This voltage is applied to the carrier current transmitter and the comparer. The output of the carrier current receiver is also applied to the comparer. The comparer regulates the working of an auxiliary relay for tripping the transmission line circuit breaker.

Ac machines and Bus zone protection:-

* protection of Generator :-

The increased size of generator and even greater increases in their outputs by more efficient methods of cooling make it imperative to protect them against faults. The generator capacity has sharply risen in recent times from 30MW to 500MW with the result that the loss of even a single unit may cause overloading of associated machines and eventual system instability.

All large modern generator units are invariably transformer connected owing to interconnections. Before considering the types of protection fitted to generator it is desirable to consider the origin and effects of faults.

Generator faults :-

Generator faults can be considered under the following heads

a) Stator faults :- these include the

following :

* Phase -to -earth faults

* Phase to phase faults

* Inter-turn faults

Most faults occur in the stator winding and their connections and majority of these are earth phase faults and inter-turn faults are less common these usually develop into an earth fault.

1. Arcing to core which welds laminations together, causing eddy current hotspots on subsequent use. Repair to this condition involve considerable expenditure of time and money.

2. Severe heating in the conductors damaging them and the insulation, with possible fire risks.

b) Rotor faults :-

Faults in the rotor circuit may be either earth faults or between turns, which result from mechanical and thermal stresses acting on the winding insulation. Modern practice is to operate a generator with its field winding isolated from earth and therefore a single fault between field winding and rotor body due to insulation breakdown can be tolerated.

c) Abnormal running conditions :-

The abnormal running conditions which are likely to occur in a generator are

- i) loss of excitation ii) unbalanced loading
- iii) overloading iv) failure of prime mover
- v) overspeeding and vi) over-voltage

field failure may occur due to a faulty field breaker or failure of the exciter. When a generator losses its field excitation it speed up slightly and acts as an induction generator deriving excitation from the system and supplying power at a leading power factor.

unbalance may occur due to single phase faults, unbalanced loading, open circuits due to broken lines, or due to the failure of one pole of a circuit breaker to close. Although short circuit will normally be cleared by circuit protection uncleaned faults and cases of unbalanced loading arising from one of the foregoing, occasionally cause the unbalanced current condition.

In the event of generator being over-loaded it will overheat the stator which can further damage the insulation and thus complicate matters.

A sudden loss of load may cause the machine to overspeed which is more likely to occur with hydraulic generator because the water flow cannot be stopped quickly for reasons of energy and mechanical and hydraulic inertia.

*stator protection :-

The type of stator faults likely to occur have been discussed in the previous section. The earth-fault current is usually limited by resistance in the neutral of the generator. Depending upon the amount of the resistance in the neutral circuit of the generator the fault current may be limited to a value between 200A and 250A or between 4A and 10A.

because the earth-fault loop is restricted to the stator and transformer primary winding no discrimination with other earth-fault relay is necessary. The maximum value of the resistance is given by

$$R_a = \frac{10^6}{6\pi f c} \text{ ohms}$$

If neutral is earthed through the primary winding of a distribution transformer, earth-fault protection is provided by connecting an overvoltage relay across its secondary, then the maximum value of resistance is equal to

$$R_n = \frac{10^6}{6\pi f N^2 c} \text{ ohms}$$

where N is the turn ratio of the transformer. In this case slow acting relays are sufficient to prevent damage.

Generator Differential protection:-

The best form of stator protection from phase-to-phase and phase-to-ground is provided by the longitudinal differential relay. The relay recommended for this application is an instantaneous attracted armature type setting 10 to 40%

which is immune to a.c transients and has the high speed feature is suitable if the CTs are reasonably matched.

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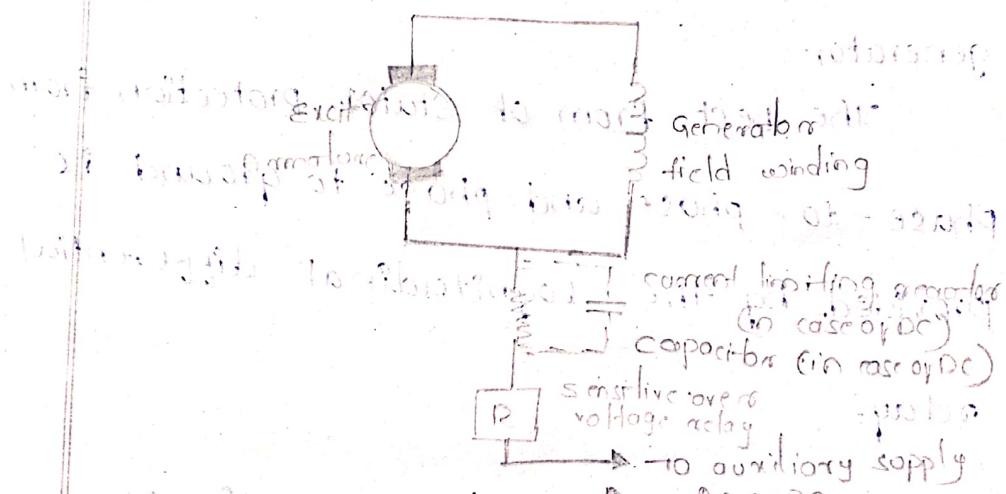
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Stator Inter-turn fault protection:-

Inter turn fault on the same phase of the stator winding does not disturb the balance between the current in the neutral and the high voltage CTs with the result that such a fault cannot be detected by longitudinal differential protection. Transverse differential protection can detect the unbalance between normally identical windings caused by an inter-turn fault when the generator has two winding per phase.

* Rotor protection:-

As pointed earlier rotor winding may be damaged by earth faults or open circuit. The field is biased by a d.c voltage which causes current to flow through the relay R for an earth fault anywhere on the field system.



Detection of rotor open circuit is the same as that used for detecting loss of excitation described.

* Loss of excitation protection :-

Two distinct effects of loss of excitation are that the machine starts drawing magnetizing current of large magnitude from the system, and the slip frequency emf's induced in the rotor circuit both of them cause over heating of the rotor.

* over load protection :-

→ continuous balanced overloading of a machine causes overheating in the stator winding.
 ⇒ The most reliable method of detecting such a condition is by means of temperature detector coils embedded at various points in the stator winding arranged to provide an indication of the temperature conditions which exist over the stator winding.

* prime-mover protection :-

In the event of prime mover failure the machine starts motoring meaning thereby that it draws electrical power from the system and drives the prime mover. This condition imposes a balanced load on the system, which can be detected by a power relay with a directional characteristic, as illustrated.

The load coming on the machine

under such condition are very low of the order of 1% of the machine rating in case of steam sets and 25% in case of

An alternative solution is to supply an offset impedance or mho measuring relay at the generator terminals.

* Unbalanced Loading protection :-

In case of high-speed turbo-generators, the continuous current which can be carried is usually between 10 and 15% of the positive sequence continuous rating. The heating time constant of the machine is largely a function of the cooling system employed. This is expressed by a rating equation

$$P_2^r t = b$$

The problem of protection against this condition lies in obtaining a relay characteristic which will accurately match this heating characteristic.

* Over voltage protection

Over voltage protection is provided on machines which are subjected to overspeed or loss of load. The relay is energized from a single-phase voltage transformer and uses unity of the induction pattern with an RDMT characteristic.

* Transformer protection :-

* Nature of Transformer faults :-

- power transformer, being static, totally enclosed and oil immersed develop faults only rarely but the consequences of even a rare fault may be serious unless the transformer is quickly disconnected from the system.

→ faults in the auxiliary equipment which is part of the transformer.

→ faults in the transformer windings and connections

→ overloads and external short circuit

* Faults in Auxiliary Equipment:-

The detection of faults in auxiliary equipment is necessary to prevent ultimate failure of the main transformer winding.

i) Transformer oil: low oil is a dangerous condition in a transformer because live parts and the leads to bushings etc.

ii) Gas cushion: deterioration of transformer oil and insulation is minimized if O_2 and moisture are excluded from the gas space.

iii) oil pumps and forced Air fans :-

The top oil temperature normally gives indication of load on the transformer. Increased oil temperature might be an indication of an overloaded.

iv) core and winding Insulations :-

Incipient faults may occur initially which may develop into major faults if not taken care of at the initial stages.

a) The insulation of the laminations and core bolts may be of poor quality or have been damaged accidentally during erection.

* Winding faults :-

Electrical faults which cause immediate serious damage and are detected by unbalance in current or voltage may be divided into the following classes:

* faults between adjacent turns or parts of coils such as phase-to-phase faults on the HV and LV external terminals or on the winding itself or short circuits between turns of HV and LV windings.

(ii) Faults to ground or across complete winding such as Phase-to-earth faults on the HV and LV external terminals.

* overloads and external short circuits :-

overloads can be sustained for long periods, being limited only by the permitted temperature rise in the winding and cooling medium. Excessive overloading will result in deterioration of insulation and subsequent failure.

* Differential protection of Transformers

Differential protection is the most important types of protection used for internal phase-to-phase and phase-to-earth faults and is generally applied to transformers having ratings of 5 MVA and above.

* Star winding with neutral solidly earthed
The earth-fault current is limited solely by the winding impedance and the fault current is no longer proportional to the position of the fault, the leakage reactance of the faulted winding in terms of the reactance per turns increases the nearer the fault is to the star point.