# EEE4227: POWER SYSTEM PROTECTION
# TERM: FINAL-TERM

## Lecture 08
## Part 01-Differential protection scheme
## Part 02- Earth fault protection scheme
## Part 03- Pilot protection scheme

# Part 01- Differential protection scheme

- What is differential relay?

A differential relay responds to vector difference between two or more similar electrical quantities.

Requirements:

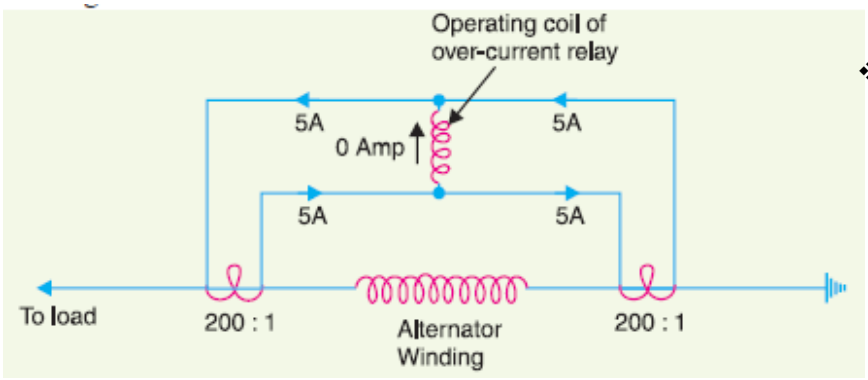
- It must have at least two actuating quantities.
- The actuating quantities should be similar in nature, i.e. current/current or voltage/voltage.
- The relay responds to the vector difference between two quantities, i.e. to (I1-I2), which includes magnitude and/phase angle difference. When this difference exceeds a predetermined value, relay operates.

# Application

- Protection of generator and generator-transformer unit.
- Protection of transformer.
- Protection of transmission line by pilot wire scheme.
- Protection of motor.
- Bus-zone protection.

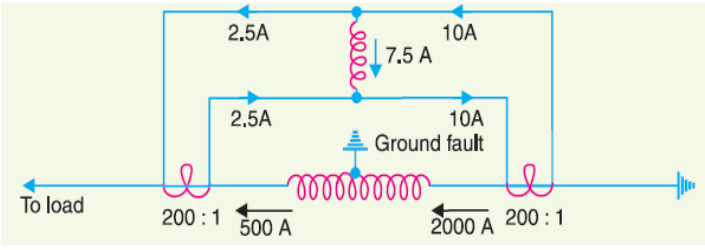
# Simple circulating current differential protection

Simple circulating current differential protection is also known as ***Mertz Price protection***




- No fault has been occurred, so current flowing through operating coil is 0Amp, i.e. relay will not operate

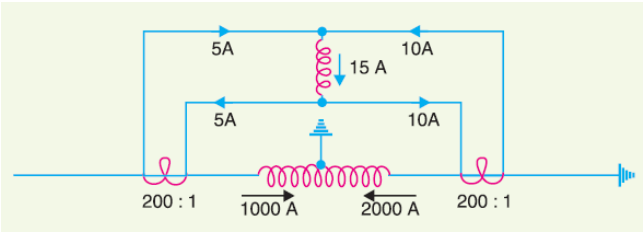
# Simple circulating current differential protection




- First case

If some current(500Amp) flows out of one side while a large current (2000Amp) enters the other side, then the difference of the CT secondary current, i.e. 10-2.5=7.5Amp will flow through the relay, as a result relay will operate.

# Simple circulating current differential protection




Second case:

If current flows to the fault from the both sides then the sum of CT secondary currents, i.e. 10+5=15A will flow through the relay, as a result relay will operate.

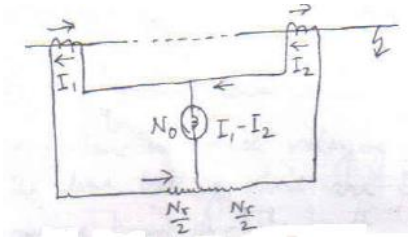
# Disadvantages

Drawbacks of simple circulating differential relay or Mertz price protection scheme-

- Two CTs are not exactly identical.
- Two CTS do not transform their currents very accurately particularly during transient condition because of the presence of DC offset in the fault current.
- Two CTs differ in their magnetic properties slightly in terms of different amount of residual magnetism or in terms of unequal burden on the CTs.

# Biased differential or percentage differential relay

To overcome the drawbacks of Mertz price protection scheme, the scheme is modified to biased differential or percentage differential relay.




The relay consists of operating coil and restraining coil. Operating coil is connected at the mid point of restraining coil. Under through fault condition, due to dissimilarities in CTs, the differential current in the operating coil is (I1-I2) and restraining coil current is (I1+I2)/2.

Restraining coil will produce a force which will oppose the operating torque of the relay.

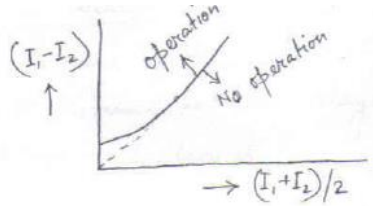
# Torque of percentage differential relay

Torque developed by operating coil, $To \propto (I1 - I2).No$

Torque developed by restraining coil, $Tr \propto \frac{(I1+I2).Nr}{2}$

At balance, $To = Tr$, i.e. $(I1 - I2).No = \frac{(I1+I2).Nr}{2}$

$$\frac{I1 - I2}{(I1 + I2)/2} = \frac{Nr}{No}$$




- From the above equation operating characteristic of biased differential relay can be found.

- From the characteristic it is clear that the ratio of the differential operating current to the average restraining current is a fixed percentage. This is why the relay is called percentage differential relay.

# Relay operation

For the operation of the relay, operating force must be greater than restraining force.

i.e. $Operating\ force \geq restraining\ force$

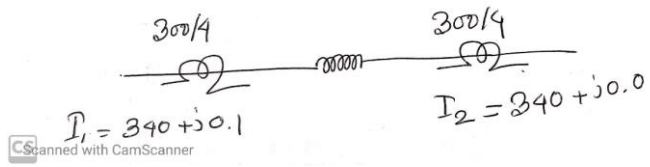
$$\left|\frac{I1 - I2}{K}\right| = \left|\frac{I1 + I2}{2K}\right| . \frac{Nr}{No} + Ipickup$$

Here K= CT ratio, $\frac{Nr}{No}$= bias or slope of the relay

# Mathematical problem

❖ Class work-

The following figure shows the differential relay used for the protection of a synchronous generator winding. Minimum pick up current, percentage slope of the relay are 0.1Amp, 10% respectively. Generator winding neutral is grounded. A high resistance ground fault occurs near the grounded neutral end with the current distribution as shown in the figure. Assume a CT ratio 300/4. What would you conclude here, the relay will operate or not???



End of part 01

## Part 02- Earth fault protection scheme

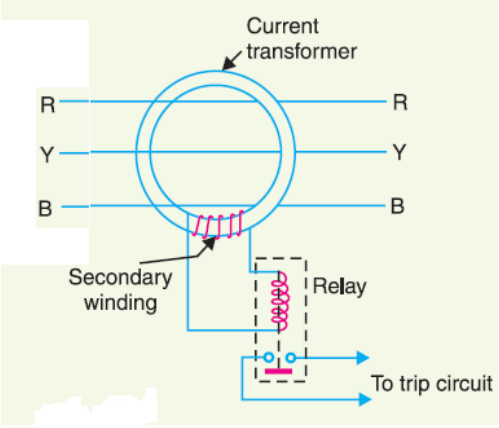
- When the fault current flows through the earth return path, the fault is known as earth fault.
- The resulting leakage current due to earth fault is considerably lesser than the short circuit leakage current but if continued for a longer time then it can gradually turn to short circuit and heavily damage the equipment like alternator, transformer, motor winding.

Here comes the necessity of earth fault relay.

# Types of earth fault relay

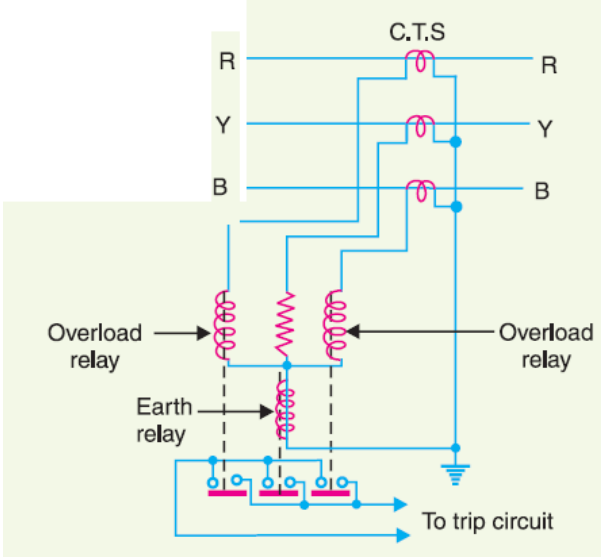
- Earth fault relay/ground fault relay/core balance relay is basically a overcurrent relay of low settings and operate as soon as earth fault occurs.
- Three types of earth fault protection is provided in the system using earth fault relay-
  - Core balance leakage protection
  - Combined leakage and overload protection
  - Restricted earth fault protection

# Core balance leakage protection



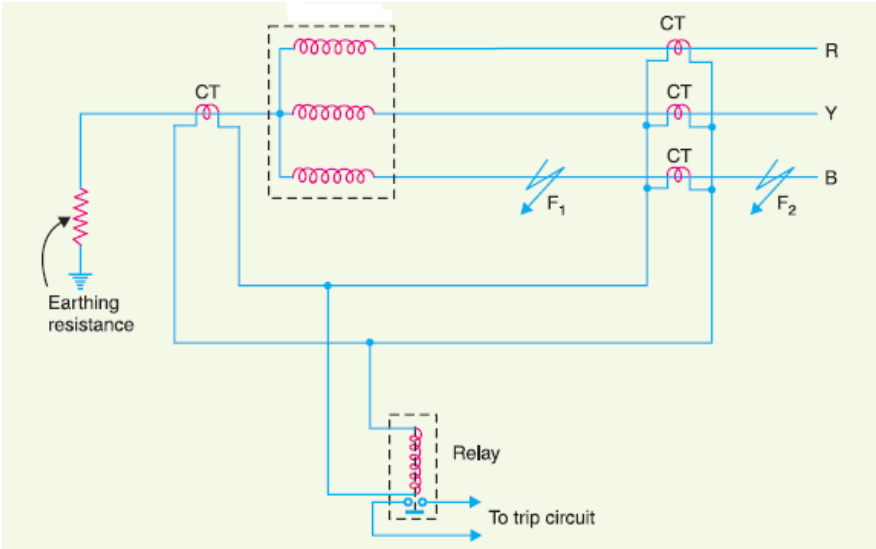

- Under normal operating condition the vector sum of three phase current (known as residual current) is zero, so resultant flux is there in the core of the CT.
- On the occurrence of the earth fault, the vector sum of three phase currents is no longer zero.
- Resultant current sets up in the core of the CT primary which induces an emf in the CT secondary coil.
- Relay is energized, activate the trip circuit and isolate the faulty section.

# Combined leakage and overload protection




- Usual practice is to provide leakage and overload protection together as because if there is any leakage between phases then core balance relay will not be able to provide protection.
- Two overload or o/c relays are sufficient to provide protection against phase-phase fault.
- With the energizing of either overload relay or earth fault relay, circuit breaker will trip because trip control of the both relays are connected in parallel.

# Restricted earth fault protection



## Restricted earth fault protection

- Simple O/C and E/F relay will not give good protection against star connected winding, particularly when the neutral is earthed through an impedance.
- The degree of protection is improved by application of unit differential E/F system.
- The system will be operative only when the fault is within the region between the CTs.
- The system will remain inactive for the faults outside the restricted zone.

End of part 02

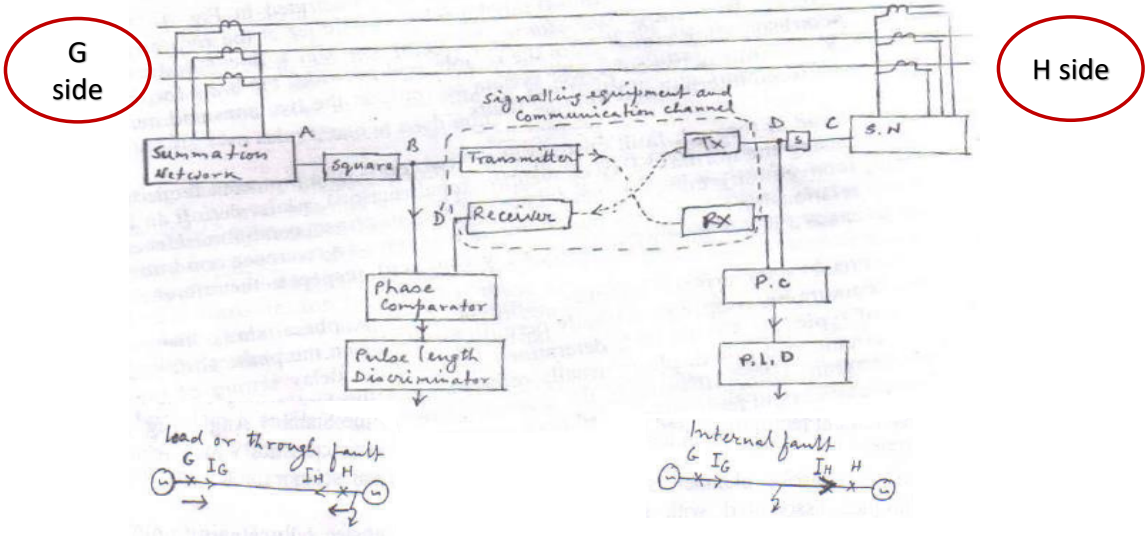
# Part 03- Pilot protection scheme

Unit form of protection scheme which compares two electrical quantities at the two ends of the protected scheme.

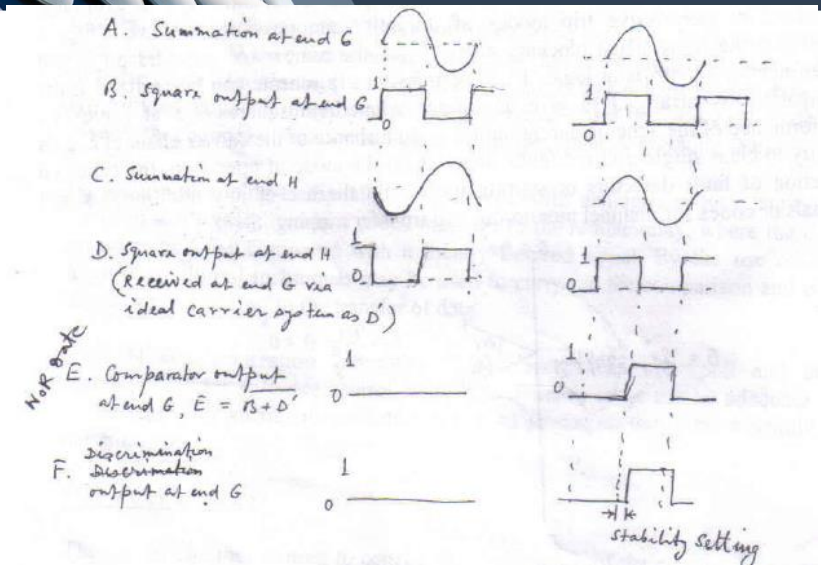
Three types-

- ❖Wire pilot protection
- ❖Carrier pilot protection
- ❖Microwave pilot protection

# Operation of pilot protection scheme



# Operation of pilot protection scheme




## End of part 03

- Reference-
- Topic 21.18/22.2/22.9/22.10/ Chapter 21 & 22/ Principles of power systems/ V.K.Mehta & Rohit Mehta.

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