1. Current Differential Relay

Principle Operation of differential relay:

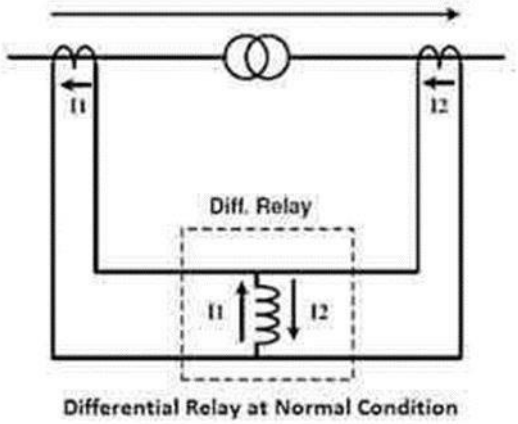


Figure: Current Differential Relay

[Source: "Principles of Powersystem" by V.K.Mehta, Page: 324]

- Let assume a power transformer with transformation magnitude (ratio) relation 1:1 and (Y/Y) connection and therefore the CT1 and CT2 ensure a similar transformation magnitude relation as shown.
- The current flows within the primary side and secondary side of power transformer are equal, presumptuous ideal power transformer. Thesecondary current I1 and I2 are same in magnitude and reverse in direction.
- Therefore, the net current within the differential coil is nil at load situation (without any fault), and therefore the relay won't operate.

External Fault Condition in Differential Relay:

- Assigning the previous one the power transformer with an external fault F is shown in figure.
  - During this case the 2 currents I1, and I2 can increase to terribly high magnitudes values however there's no modification in phase angle.
  - Hence, net current within the differential coil continues to be zero and therefore the relay won't operate.

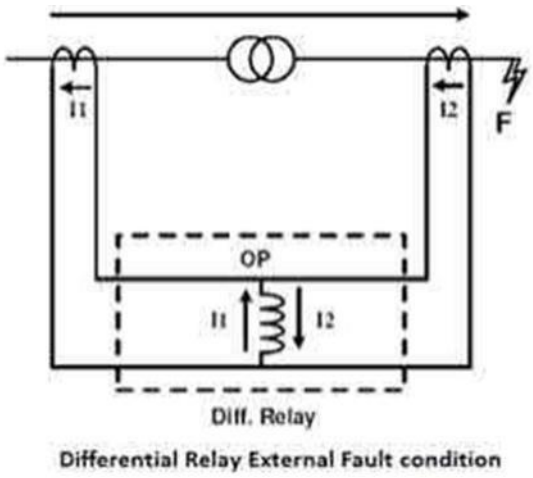


Figure: Current Differential Relay(External fault conditions)

[Source: "Principles of Powersystem" by V.K.Mehta, Page: 326]

Internal Fault Condition in Differential Relay:

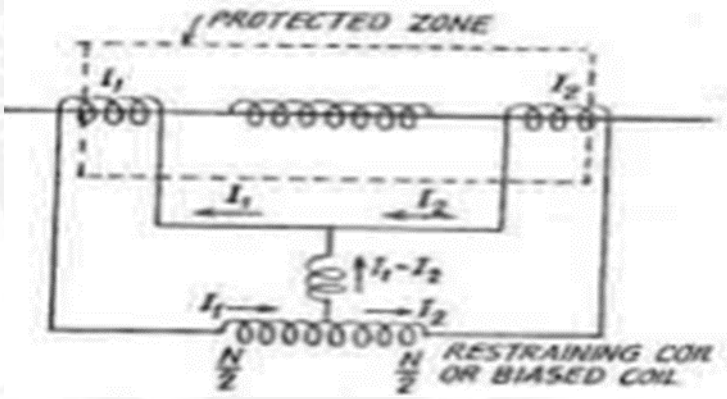


Figure: Current Differential Relay(Internal fault conditions)

[Source: "Principles of Powersystem" by V.K.Mehta, Page: 326]

An internal fault F is shown in this figure. Now, there are 2 anticipated conditions: There's other supply to feed the fault thus I2P includes a nonzero value Idiff = I1S + I2S which can be terribly high and sufficient to function the differential relay. Radial system, I2P = 0. So, Idiff = I1S and additionally the relay can work and disconnect the breaker.

2. Merz –price protection:

The reason for using this modification is circulating current current

differential relay is to overcome the trouble arising out of differences in CT ratios for high values of external short circuit currents.

- The percentage differential relay has an additional restraining coil connected in the pilot wire as shown. In this relay the operating coil is connected to the mid-point of the restraining coil becomes the sum of ampere turns in its two halves, i.e $(I_1N/2) + (I_2N/2)$ which gives the average restraining current of $(I_1 + I_2)/2$ in N turns.

  For external faults both I_1 and I_2 increase and thereby the restraining torque increases
- which prevents the mal- operation In this relay the operating coil is connected to the mid-point of the restraining coil becomes the sum of ampere turnsin its two halves, i.e $(I_1N/2) + (I_2N/2)$ which gives the average restraining current of $(I_1 + I_2)/2$ in N turns.

  For external faults both I_1 and I_2 increase and thereby the restraining torque
- increases which prevents the mal-operation.

✓ The ratio of differential operating current to average restraining current is fixed percentage. Hence the relay is called 'percentage differential relay'.

✓ The relay is so called 'Based differential relay' because the restraining coil is also called a biased coil as it provides additional flux.

✓ The percentage of biased differential relay has a rising single pick up characteristic. As the magnitude of through current increases, the restraining current decreases.

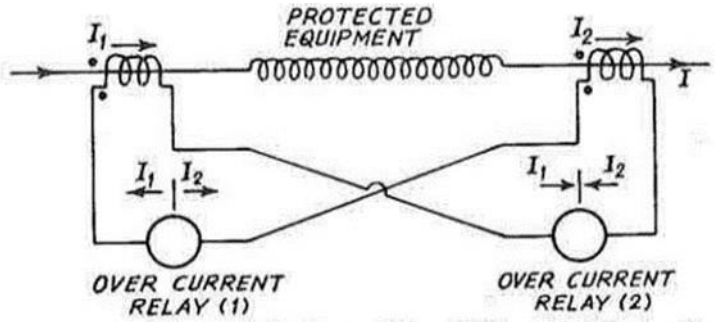
3. Voltage Balance Differential Relay:

➔ The relays are connected in series with the pilot wires, one at each end. The relative polarity of the current transformers is such that there is no current through the relay under normal operating conditions and under fault conditions

➔ In this the secondary of CT's are connected such that for normal conditions and through fault conditions, the secondary current of CT's on two sides opposes

each other and their voltage are balanced During internal fault, the condition changes as an equivalent current $(I_1 + I_2)/2$ flows through relay coils at each end.

➔ The current transformer used in such protection is with air gap core so that the core does not get saturated and over voltages are not produced during zero secondary current under working normal condition.



Through fault condition Differential Protection based on balanced voltage principle.

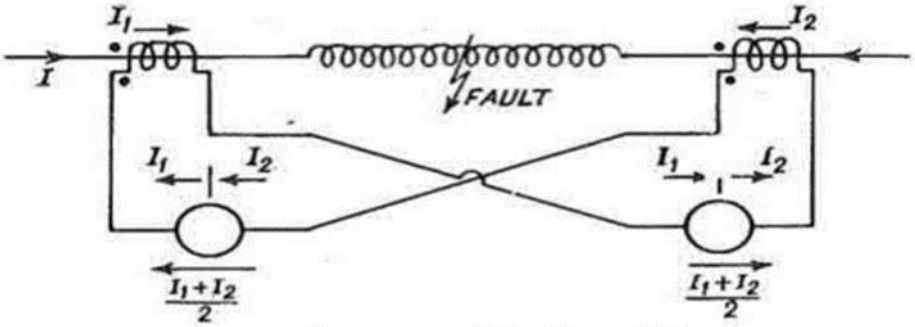


Figure: Voltage Balance Differential Relay

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