
Faculty of Engineering
FE
EEE4227: POWER SYSTEM PROTECTION
TERM: FINAL-TERM

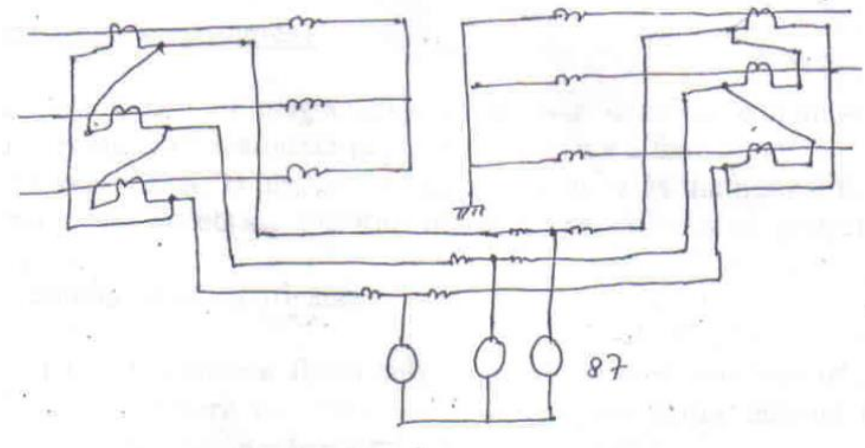

Lecture 12
Transformer protection

Possible faults and protection scheme in transformer

- Phase to phase faults (rare)
  Phase to ground fault (very common)
  - Protection scheme-
    - Primary protection-Percentage differential relay
    - Back up protection- O/C relay
- Magnetizing inrush current
  - Protection scheme- Differential protection scheme with harmonic restrain feature
- Tank earth fault protection
  - Protection scheme- Earth fault relay or core balance relay
- Faults inside the tank below oil level
  - Protection scheme- Buchholz relay or gas actuated relay
- Earth fault near neutral end of Y-connected winding
  - Protection scheme- Restricted earth fault scheme
- High voltage surge due to lightning
  - Protection scheme- Lightning arrestor

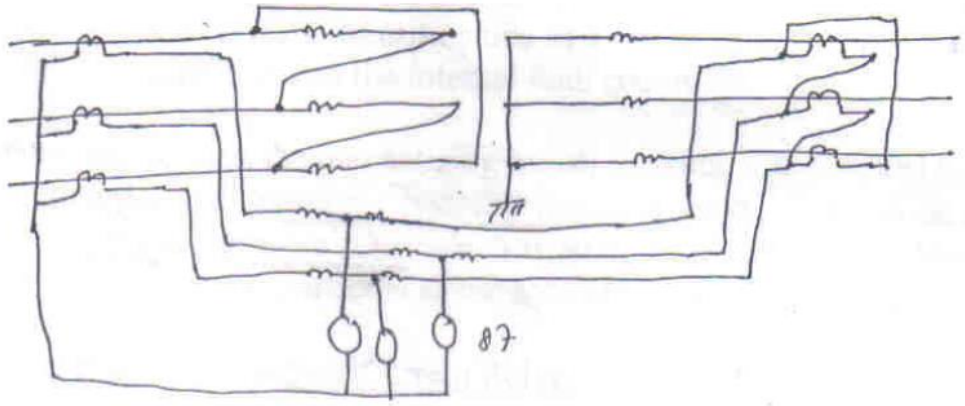
Primary protection against phase-phase and phase-ground fault

- CT connection for biased differential relay of Y-Y transformer



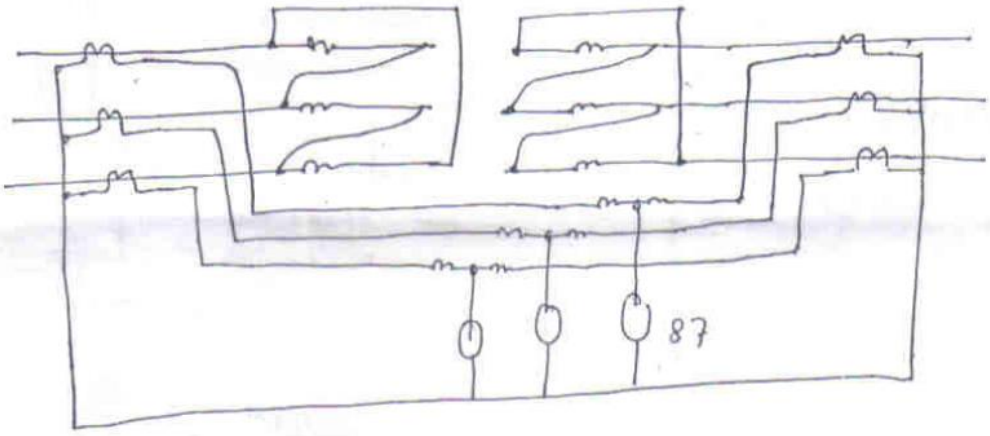
Primary protection against phase-phase and phase-ground fault

- CT connection for biased differential relay of Δ-Y transformer

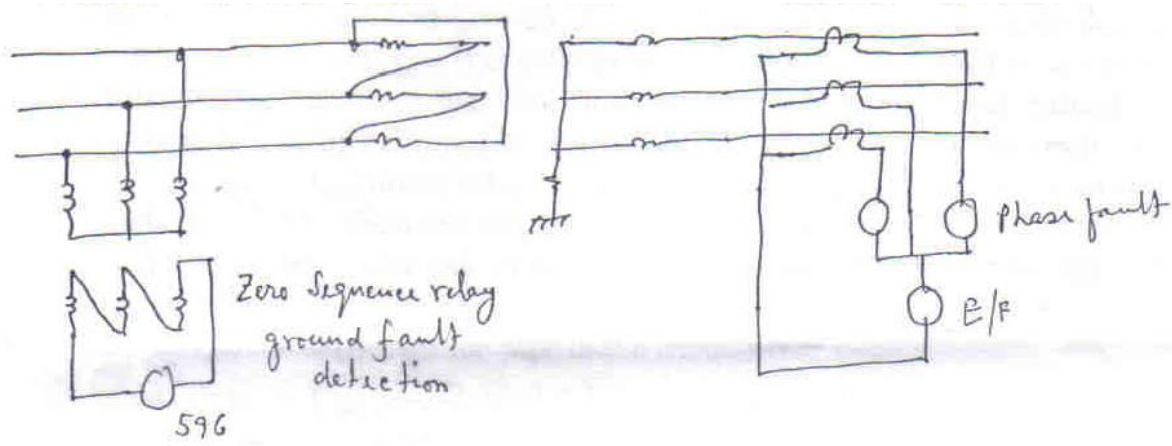


Primary protection against phase-phase and phase-ground fault

- CT connection for biased differential relay of Δ-Δ transformer



Backup protection against phase-phase and phase-ground fault



Mathematical problem

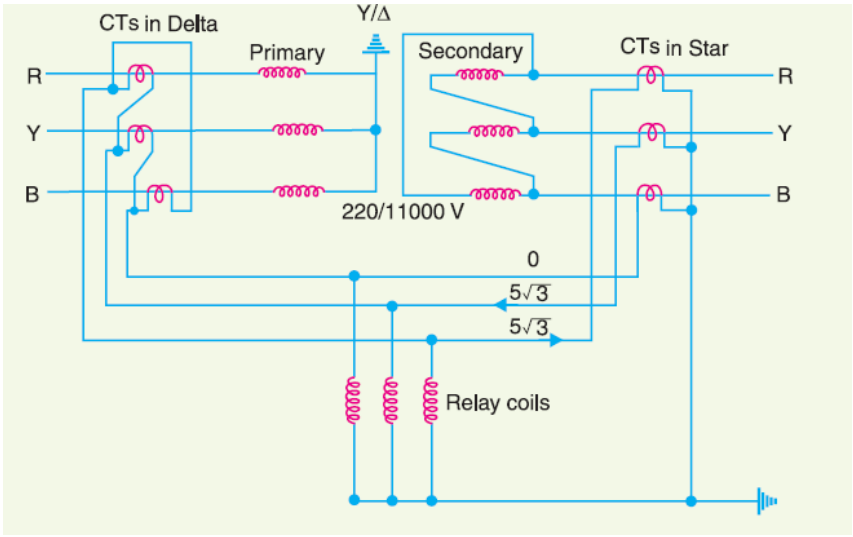
Problem 01-

Example 22.5. *A 3-phase transformer of 220/11,000 line volts is connected in star/delta. The protective transformers on 220 V side have a current ratio of 600/5. What should be the CT ratio on 11,000 V side ?*

Solution:

CT connection of the transformer

Mathematical problem



Mathematical problem

Suppose that line current on 220 V side is 600 A.

∴ Phase current of delta connected *CT*s on 220V side

$= 5$ A

Line current of delta connected *CT*s on 220 V side

$= 5 \times \sqrt{3} = 5\sqrt{3}$ A

This current (*i.e.* $5\sqrt{3}$) will flow through the pilot wires. Obviously, this will be the current which flows through the secondary of *CT*s on the 11,000 V side.

∴ Phase current of star connected *CT*s on 11,000 V side = $5\sqrt{3}$ A

If I is the line current on 11,000 V side, then,

Primary apparent power = Secondary apparent power

Mathematical problem

or $\sqrt{3} \times 220 \times 600 = \sqrt{3} \times 11{,}000 \times I$

or $I = \dfrac{\sqrt{3} \times 220 \times 600}{\sqrt{3} \times 11000} = 12 \text{ A}$

$\therefore$ Turn-ratio of CTs on 11000 V side

$= 12 : 5\sqrt{3} = 1{\cdot}385 : 1$

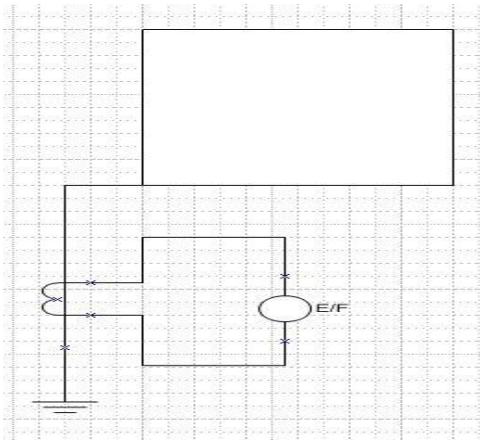
Practice problem- 22.6, tutorial problem-1,2

Protection against magnetizing inrush current

- Magnetizing inrush current is a transient condition which occurs primarily when a transformer is energized. It is not a fault condition. Inrush current affect the operation of differential protection system. The value is 6-8times the normal load current.
- This inrush current flows in the primary winding only. It contains a high percentage of second harmonic components (above 63%) of the fundamental.
- A high speed biased differential relay incorporating harmonic restraint feature is used for the protection against magnetizing inrush current which can be achieved by using a second harmonic filter.

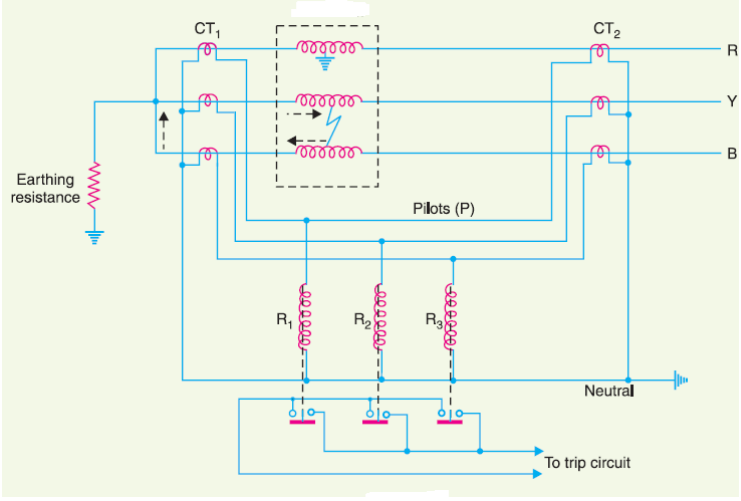
Protection against tank earth fault protection

- The connection configuration of a tank earth fault protection is shown in the figure below:



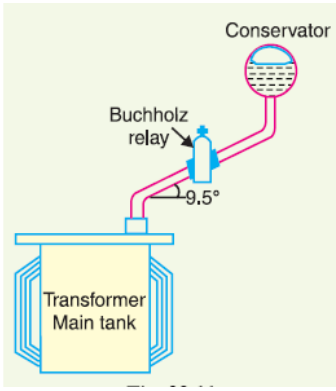
Protection against Earth fault near neutral end of Y-connected winding

- Restricted earth fault relay is being used for protection

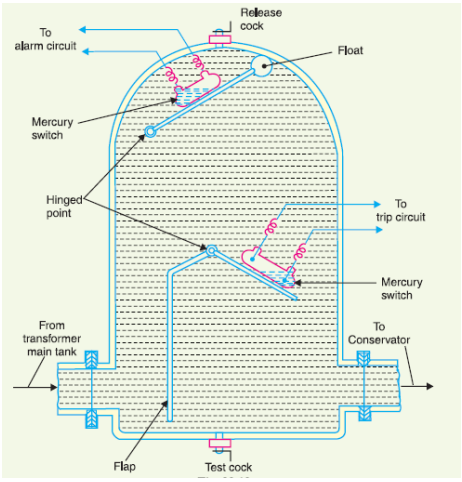


Protection against Faults inside the tank below oil level

- Buchholz relay is used for the protection against any fault below oil level of transformer



Protection against Faults inside the tank below oil level



- Operation of Buchholz relay

In case of incipient faults within the transformer, the heat due to fault causes the decomposition of some transformer oil in the main tank. The products of decomposition contain more than 70% of hydrogen gas. The hydrogen gas being light tries to go into the conservator and in the process gets entrapped in the upper part of relay chamber. When a predetermined amount of gas gets accumulated, it exerts sufficient pressure on the float to cause it to tilt and close the contacts of mercury switch attached to it. This completes the alarm circuit to sound an *alarm.

If a serious fault occurs in the transformer, an enormous amount of gas is generated in the main tank. The oil in the main tank rushes towards the conservator *via* the Buchholz relay and in doing so tilts the flap to close the contacts of mercury switch. This completes the trip circuit to open the circuit breaker controlling the transformer.

Protection against Faults inside the tank below oil level

❖Advantages of Buchholz relay

(*i*) It is the simplest form of transformer protection.
(*ii*) It detects the incipient faults at a stage much earlier than is possible with other forms of protection.

❖Disadvantages of Buchholz relay

(*i*) It can only be used with oil immersed transformers equipped with conservator tanks.
(*ii*) The device can detect only faults below oil level in the transformer. Therefore, separate protection is needed for connecting cables.

- Reference-
- Topic 22.7-22.12/ Chapter 22/ Principles of power systems/V.K.Mehta & Rohit Mehta

Prepared by
Susmita Ghosh
Assistant Professor
American International University-Bangladesh(AIUB)
Dept-EEE/Faculty of Engineering