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Marks/Grade	

EXPERIMENT # 11

Differential Protection Relay

Objective:

At the end of this lab session students will be able to

- Design of differential protection relay on Simulink /Matlab.

Introduction:

A relay is usually an electromechanical device that is actuated by an electrical current. The current flowing in one circuit causes the opening or closing of another circuit. Relays are like remote control switches and are used in many applications because of their relative simplicity, long life, and proven high reliability. Relays are used in a wide variety of applications throughout industry, such as in telephone exchanges, digital computers and automation systems. Highly sophisticated relays are utilized to protect electric power systems against trouble and power blackouts as well as to regulate and control the generation and distribution of power. In the home, relays are used in refrigerators, washing machines and dishwashers, and heating and air-conditioning controls.

Although relays are generally associated with electrical circuitry, there are many other types, such as pneumatic and hydraulic. Input may be electrical and output directly mechanical. All relays contain a sensing unit, the electric coil, which is powered by AC or DC current. When the applied current or voltage exceeds a threshold value, the coil activates the armature, which operates either to close the open contacts or to open the closed contacts. When a power is supplied to the coil, it generates a magnetic force that actuates the switch mechanism

Tool:

Simulink/Matlab

Differential Protection Relay:

Power systems divided into zones of protection like bus, generator, transformer, transmission line, capacitor, motor, etc. Protection systems applied to these may be broadly classified as unit and non-unit protection systems. Unit systems bounded by CT locations. Major advantage of unit over non-unit is selectivity and speed. Most of the relays operate when any quantity exceeds beyond a predetermined value for example over current relay operates when current through it exceeds predetermined value. But the principle of differential relay is somewhat different. It operates depending upon the difference between two or more similar electrical quantities.

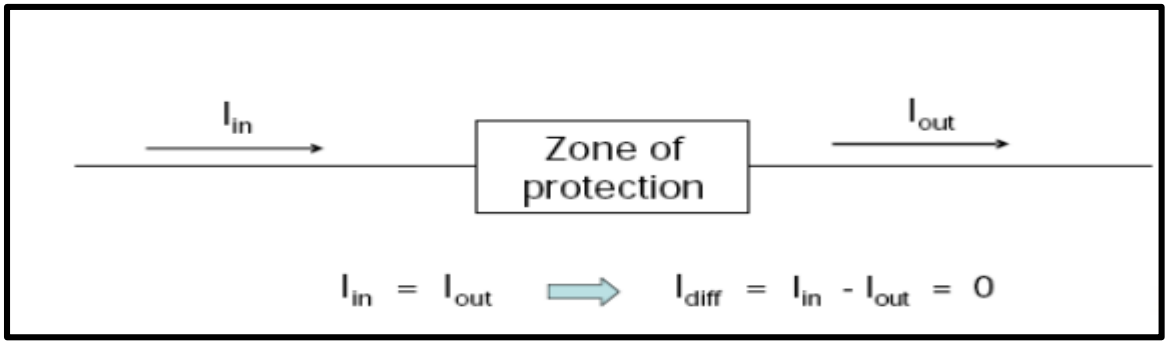

Fig.1 show the zone in and out current for protection of line

In reality provision has to be made for nonzero differential quantities under normal, healthy conditions. These could result due to line charging current, CT mismatching, the transformer tap changer, etc. Provision is thus made for ways to prevent relay operation which could result due to differential current being present under normal system conditions. This is classically done by deriving a restraint quantity from the terminal currents (biased differential protection).

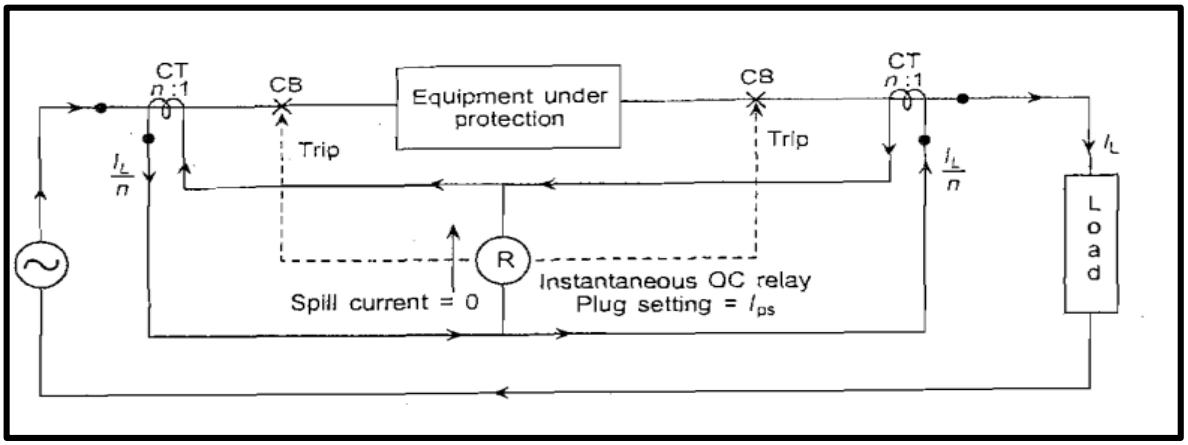

Fig.2 show the general setup for protection

Zone of Protection:

The differential scheme generates a well-defined and closed zone of protection. This zone encompasses everything between the two CTs. Ideally, a differential scheme is supposed to respond only to internal faults, and restrain from tripping on external faults.

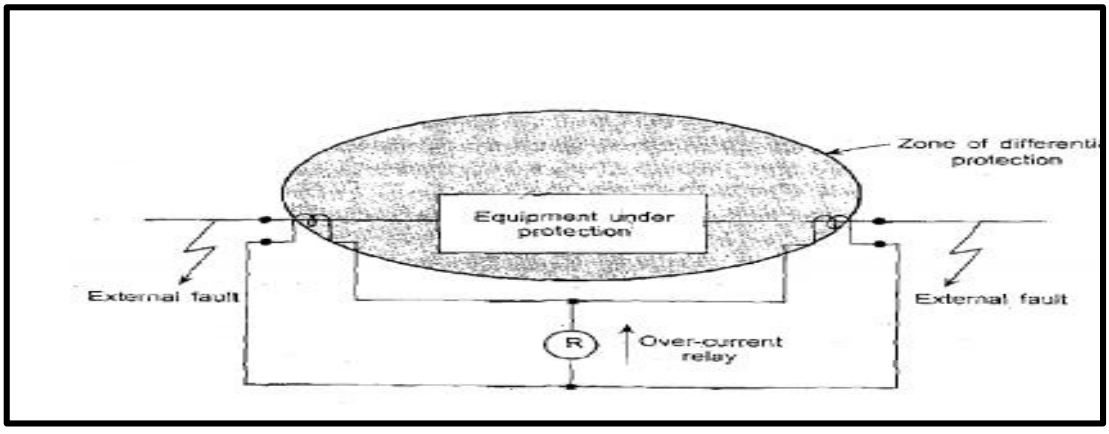

Fig.3 show the general setup under external fault

Protection of Transformer using Differential Relay in Simulink:

The power system is designed in Simulink. The zone which is protected using differential protection scheme includes transformer. The two CTs is in this zone which senses the voltage and current and send the information to relay. The relay takes information and send trip signal to breaker to isolate the faulty zone. The fault is generated in zone in which transformer is protected and outside the zone and result is concluded. The relay should only isolate the zone which is protected and should not trip the breakers when fault occurs outside the zone.

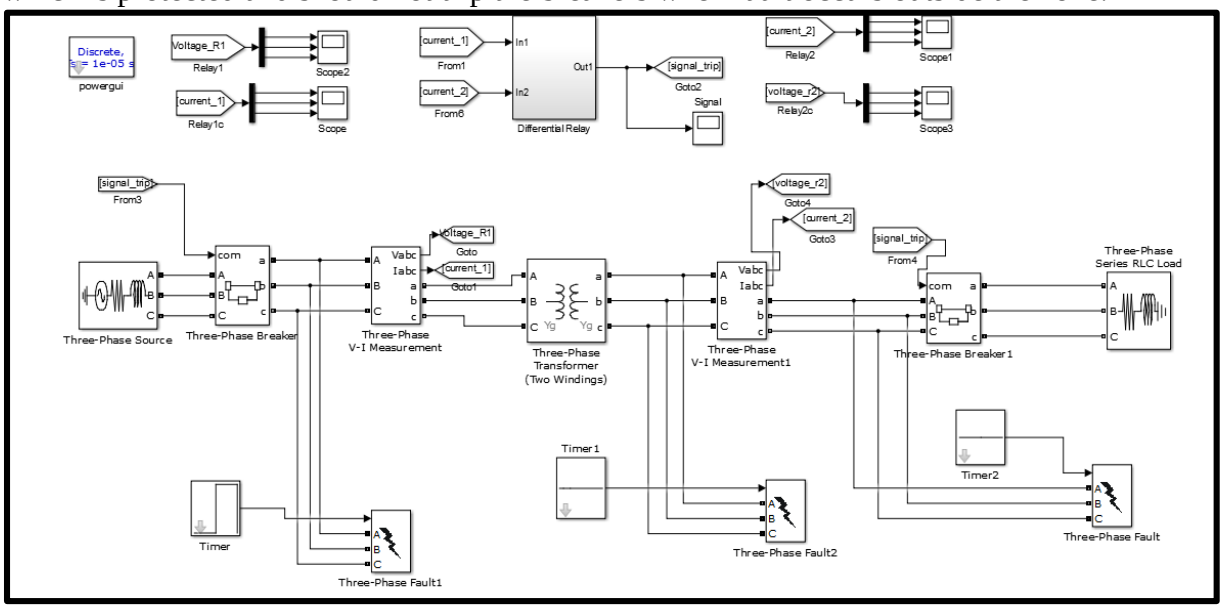

Fig.4 show the protection of Transformer using differential relay

Design of Relay:

The numerical differential relay is designed in Simulink. The values from CTs is taken through communication system and logic is designed to isolate only faulty zone. The difference of two CTs values is taken and compare with some threshold value if the value is greater than it will send trip signal to breaker to operate.

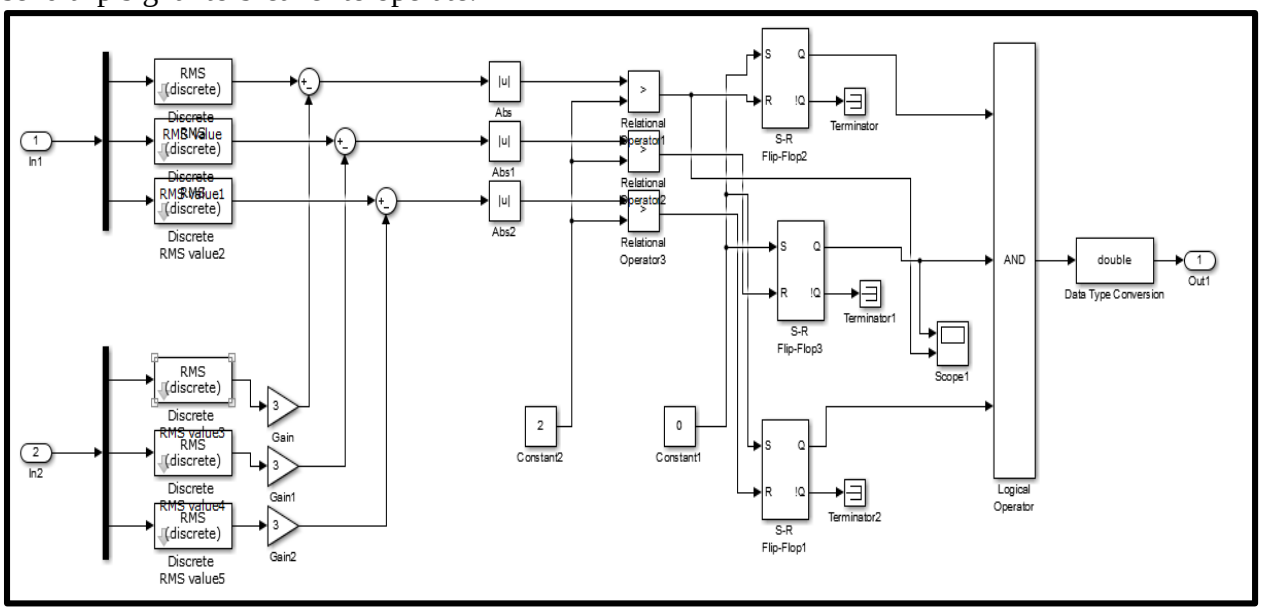

Fig.5 show the design of differential relay

Results:

i- Under normal Condition:

Simulink model:

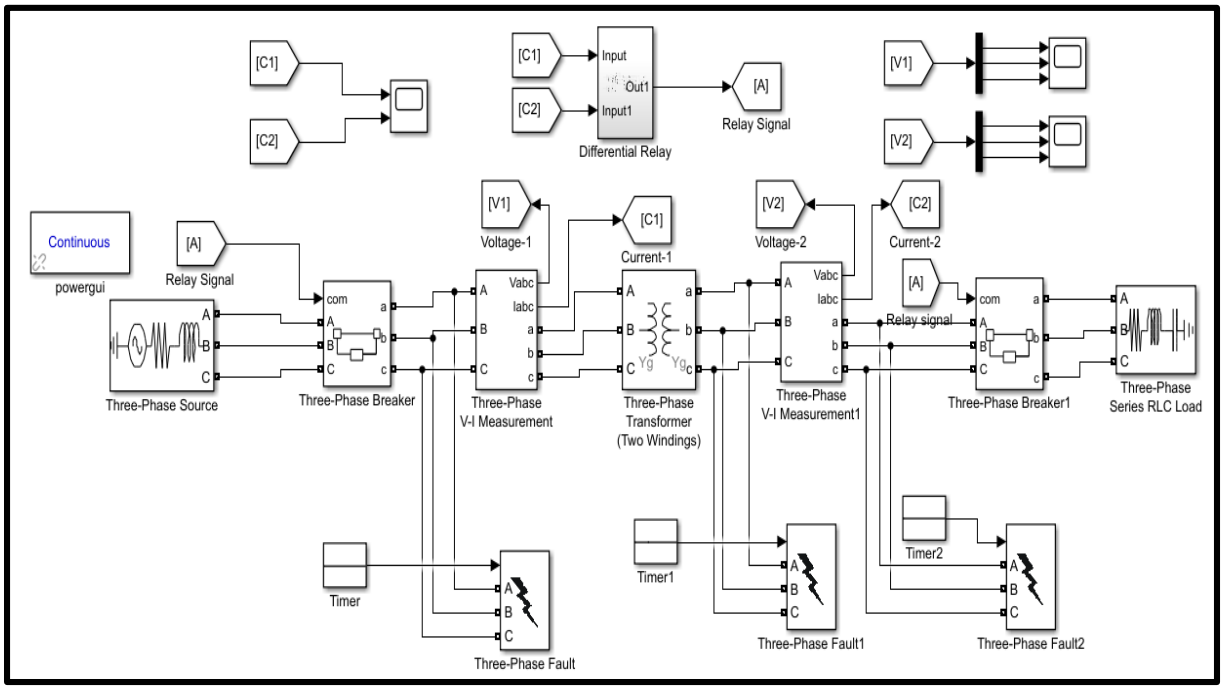

Fig.6 show the protection of power transformer using differential relay

Relay design:

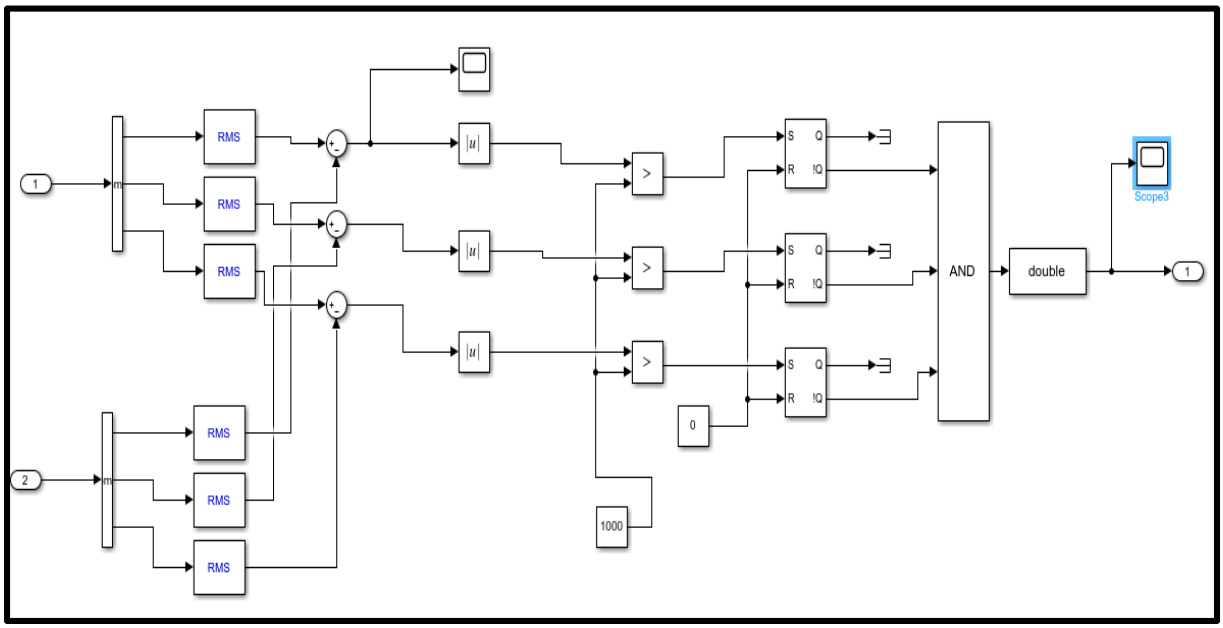

Fig.7 show the design of differential relay

Current Waveform:

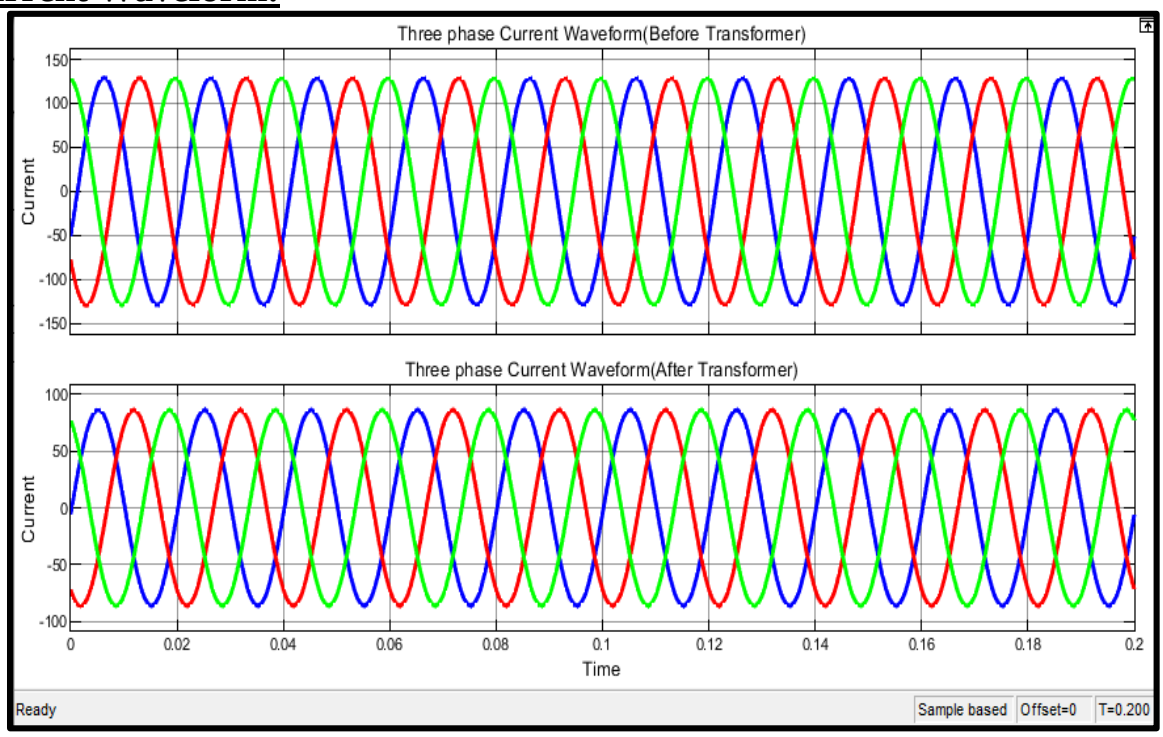

Fig.8 show the three phase current waveform

Relay Signal:

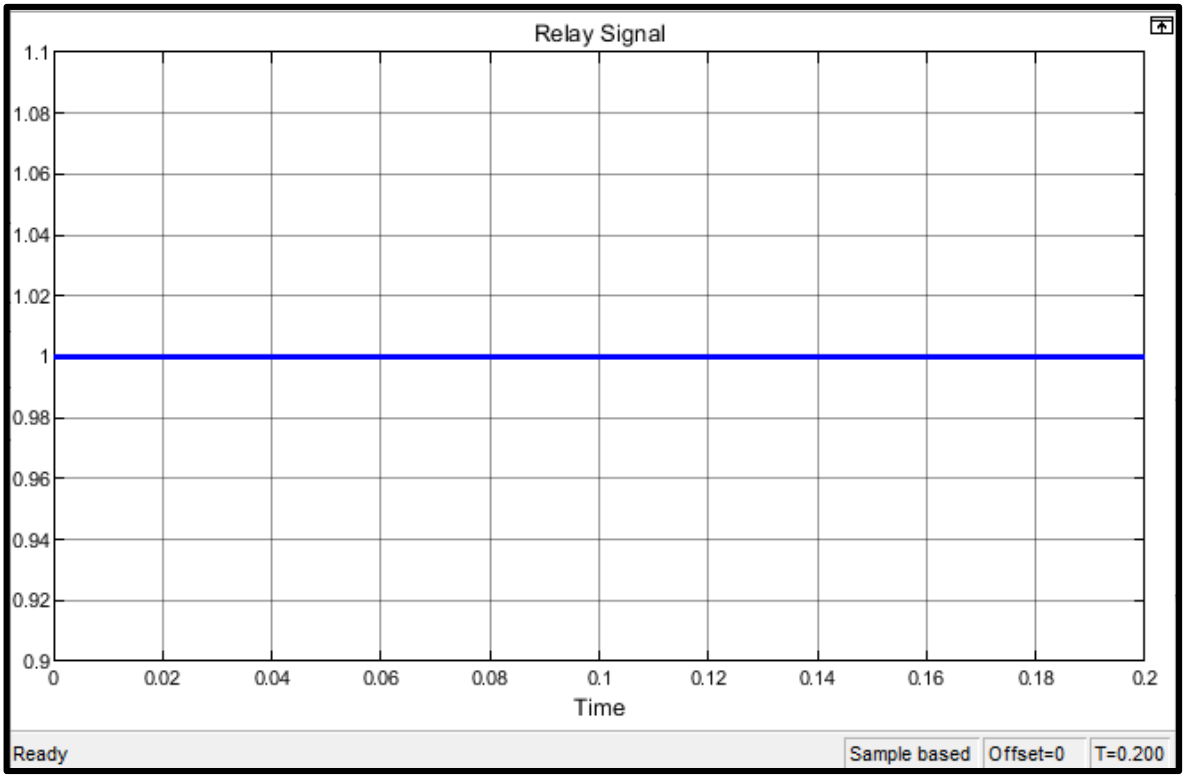

Fig.9 show the relay signal under normal condition

ii- When fault is generated inside zone:

Simulink model:

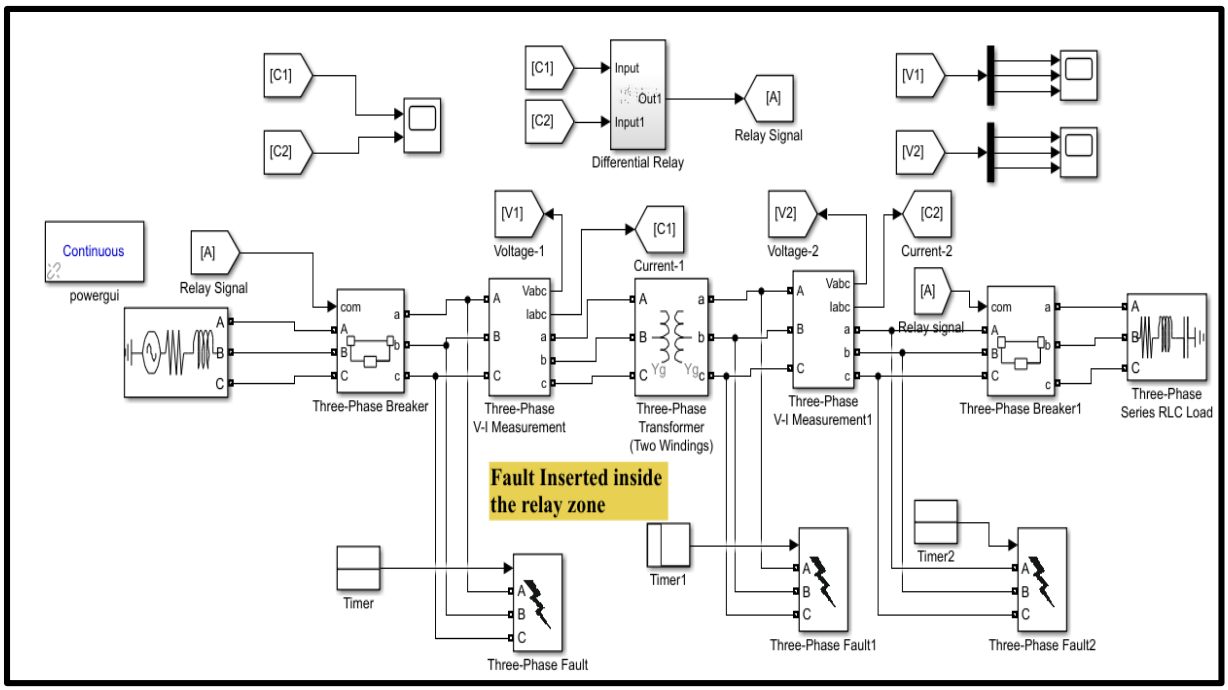

Fig.10 show the fault condition inside zone of differential relay

Current Waveform:

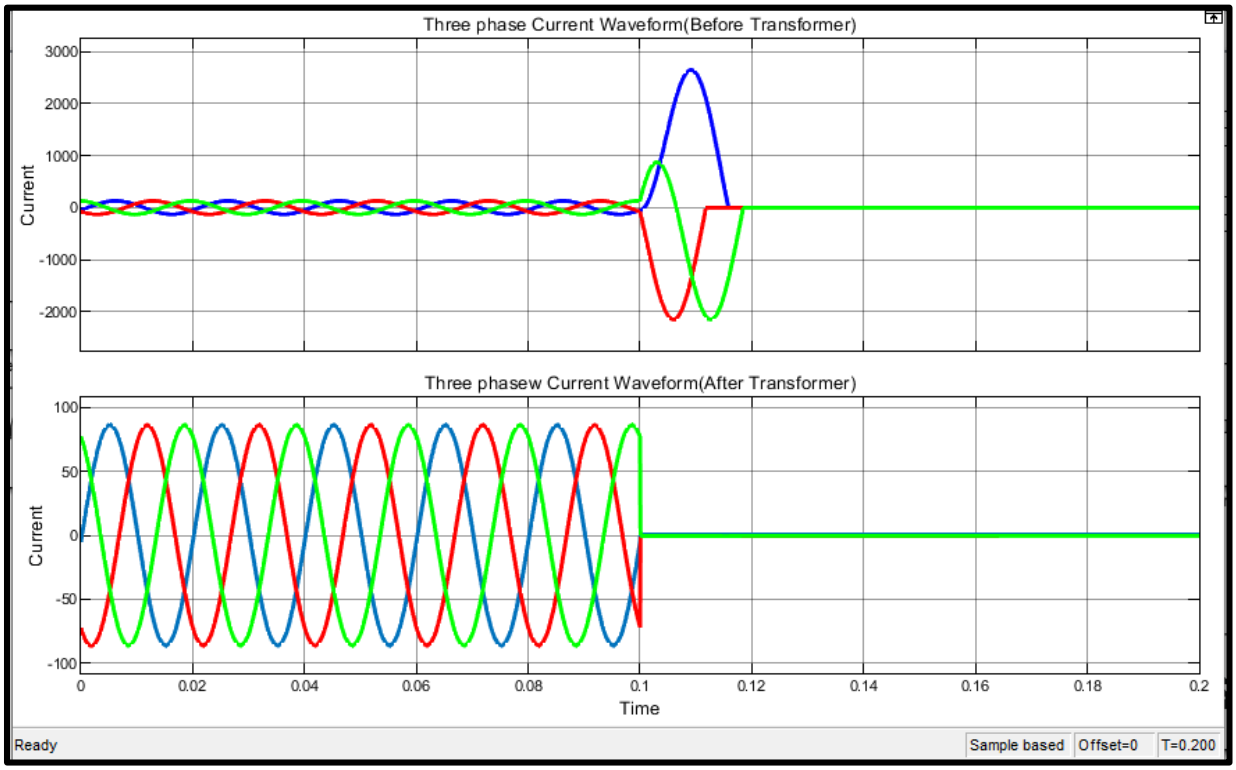

Fig.11 show the current waveform under fault condition inside zone of protection

Relay Signal:

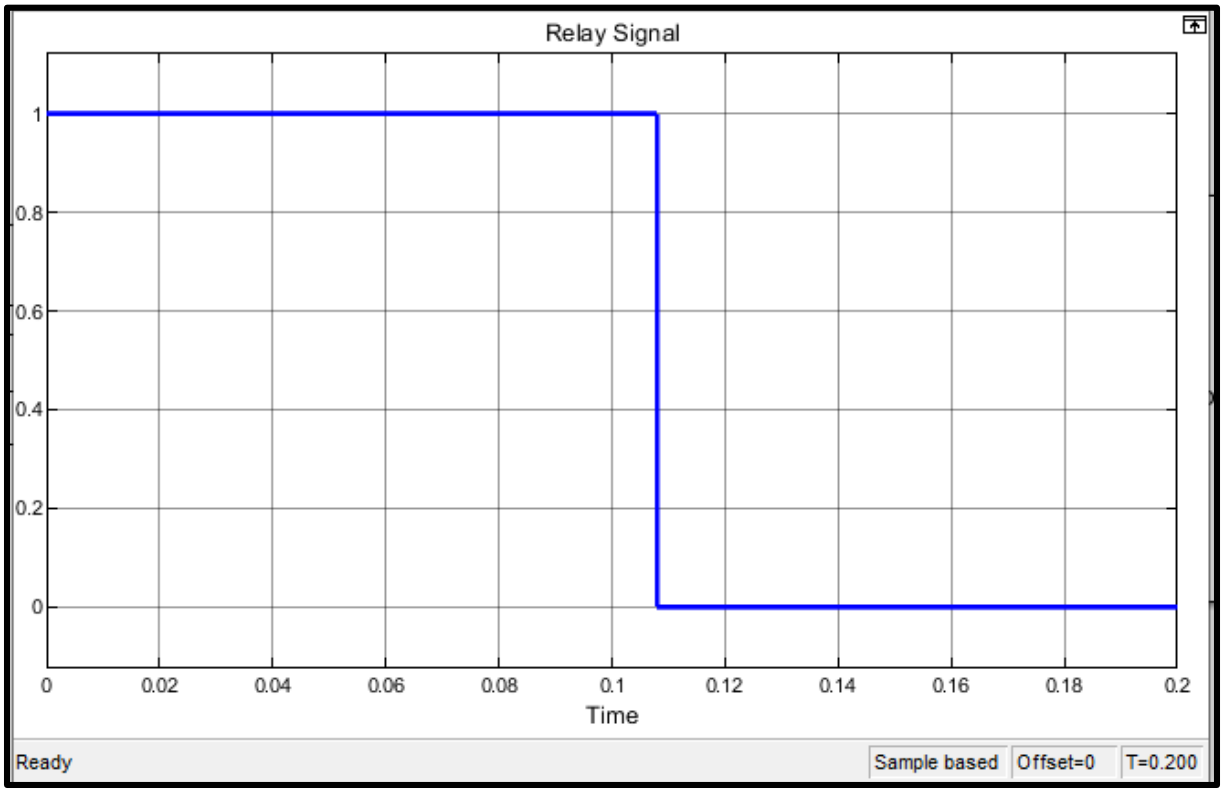

Fig.12 show the relay signal when fault is inside the zone of protection

Observation:

From above waveform, we observe that when fault occur inside the zone of protection of differential relay, suddenly current rises to maximum value e.g. 2500A. Relay detect this fault and send tripping signal to breaker. As shown in above waveform of current. At 0.1sec, relay send signal to breaker and trip the line to protect the transformer. This is done by comparing fault current value with the relay pickup value of current.

iii- When fault is generated outside the zone:

Simulink model:

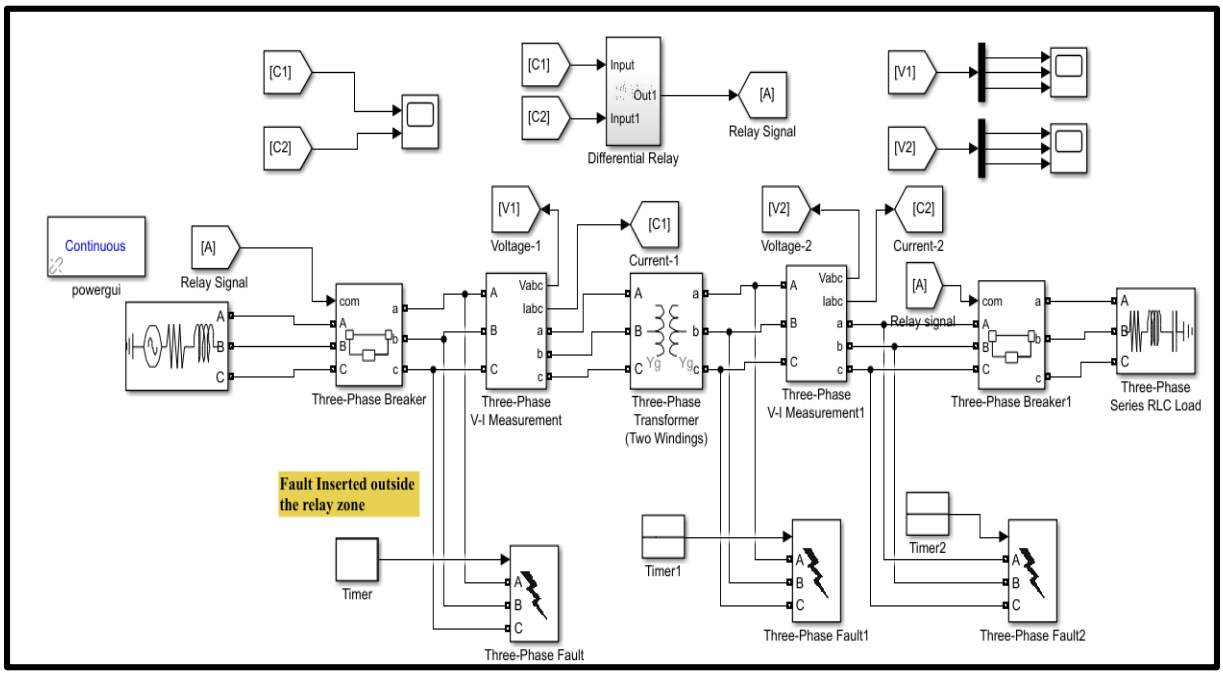

Fig.13 show the fault condition outside zone of differential relay

Current Waveform:

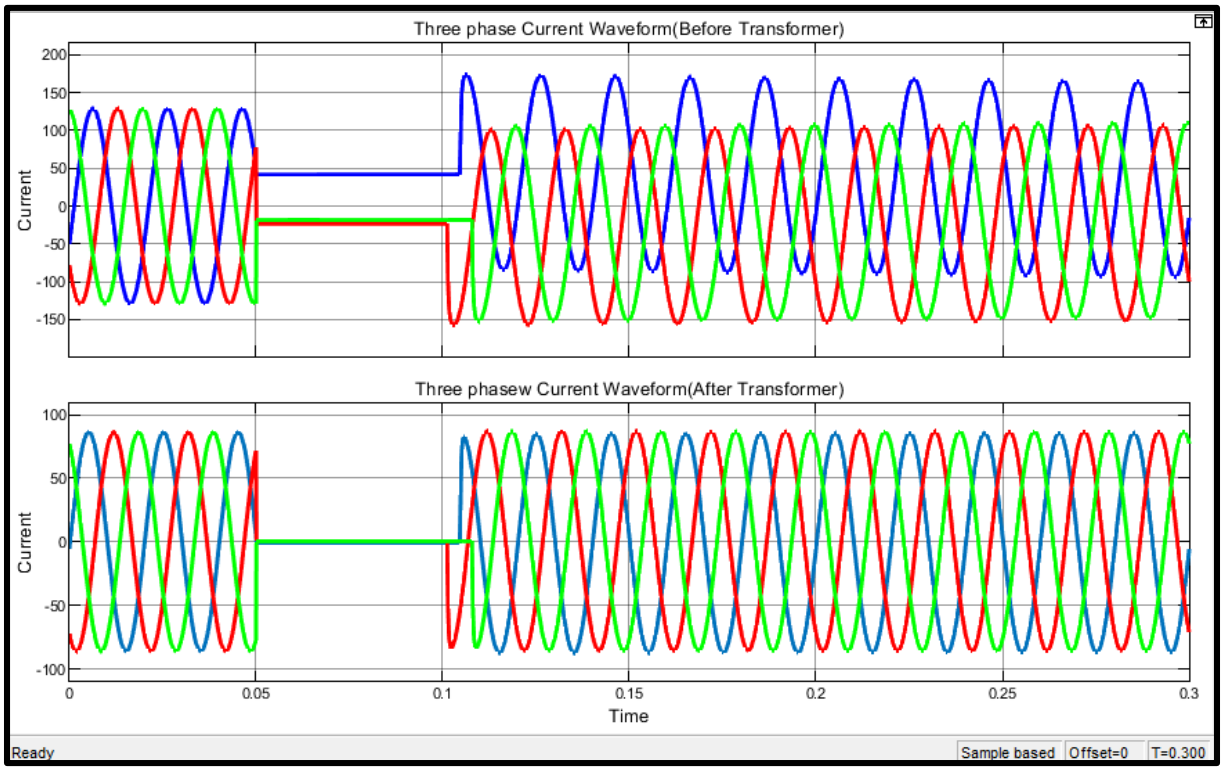

Fig.14 show the current waveform under fault condition outside zone of protection

Relay Signal:

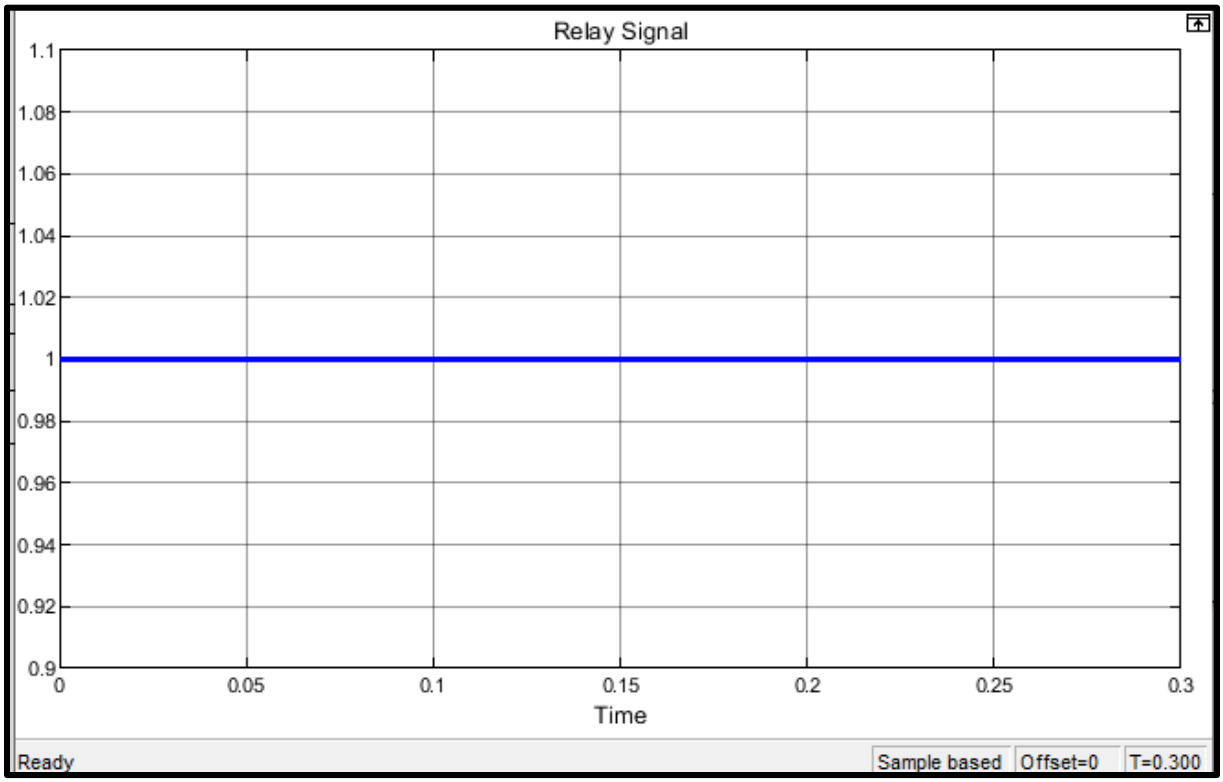

Fig.15 show the relay signal when fault is outside the zone of protection

Conclusion:

In this lab, we learn about the design and implementation of differential relay by using MATLAB (Simulink). First of all, we design the power system model for that we have to operate differential relay. Then we define the zone of protection for differential relay. After that, we inserted the fault inside and outside the zone. We conclude that:

- When fault is inserted inside the zone of protection of differential relay. Current rises to maximum value. Relay detects this fault (as shown in graph of relay signal) when current cross the threshold or pickup value which is 1000A we set. Differential Relay compare the fault current value with pickup value. If this difference is above the set value differential relay sends tripping signal to breaker and break the line in 0.1sec So, 0.1sec is the operating time of relay.
- When fault inserted outside the zone of protection of differential relay for 0.05sec to 0.1sec as shown in above waveform. Relay didn't detect this fault as it is outside the zone of protection and remain open in this fault condition.

We conclude that if use differential relay for protection of equipment. It can precisely detect the fault in its own zone of protection and can't detect the fault which is outside the zone. So, there is no chances for the loss of security because this relay operates only in its own zone of protection.