Ahsanullah University of Science and Technology

Department of Electrical and Electronic Engineering

LABORATORY MANUAL

FOR

ELECTRICAL AND ELECTRONIC SESSIONAL COURSE

Student Name :

Student ID :

Course no : EEE4251

Course Title : SWITCHGEAR AND PROTECTION LAB

For the students of

Department of Electrical and Electronic Engineering

4^{th} Year, 2^{nd} Semester

Experiment: 1

Experiment name: Familiarization with different kinds of insulators fuses and miniature circuit breakers.

Objective:

To be familiar with electrical devices like insulators, fuses, MCBs.

Insulators:

Pin Insulators: Pin insulators are used in 11 KV and 33 KV overhead lines.

Fig1.1: Showing the 11 KV and 33 KV pin insulators

Spool / **Shackle Insulators:** These insulators are used in the 0.4 KV overhead service lines.

Fig 1.2: showing the spool/shackle insulators

Disc Insulators: These Insulators are used normally in HV overhead transmission lines. Total Insulation of the string can be increased by increasing the number of disc unit in the string to use in EHV lines.

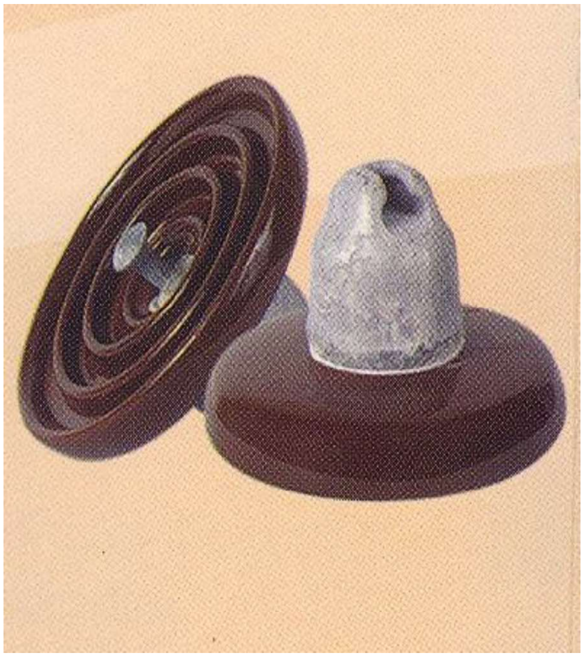


Fig 1.3: Showing the Disc insulators

typical number of disk insulator units for standard line voltages

Line voltage (kV)	Disks
34.5	3
46	4
69	5
92	7
115	8
138	9
161	11
196	13
230	15
287	19
345	22
360	23

Fuse:

Fuse is the simplest and cheapest current interrupting device for protection of the electrical devices from excessive currents. So it can be used for overload and /or short circuit protection.

Semi-enclosed or Re-wire able Fuse:
These types of fuses are used for the protection of appliances at 0.4 KV voltage level and usually called **cut-out.** The Fuse carrier can be pulled out and the blown out fuse element can be replaced.

Fig 1.4: Showing the Re-wire able fuse

Totally Enclosed or cartridge Fuse:

The Fuse Element (the conductor which melts) is enclosed in a totally enclosed container and is provided with metal contact on both side.

Fig 1.5: Showing the totally enclosed Fuse.

Drop out Fuse:

A fuse link in which the fuse carrier drop out after melting the fuse wire thereby providing isolation between the terminals. This type of fuse is normally used in 11 KV side of a 11/0.4 KV distribution transformer.

Fig 1.6: showing the drop out fuse

HRC (High Rupturing capacity) cartridge Fuse:

A cartridge fuse link having breaking capacity higher then certain specified value (e.g. above the 16 KA for medium voltage)

Fig 1.7: Showing the HRC fuse

Lightning Arrestor:

The main function of a Lightning arrestor is to divert any surge over voltage caused by lightning to the ground, so that equipment or devices behind the arrestor are saved from insulation failure and eventually short circuit fault.

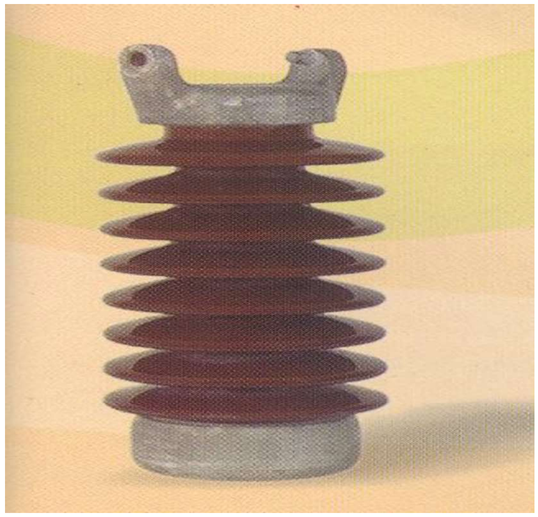


Fig 1.8: showing the Lighting arrestor

Miniature Circuit Breaker (MCB):

A circuit Breaker (CB) is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and by interrupting continuity, to immediately discontinue the high current flow. Unlike a fuse, which operates once and then has to be replaced, a CB can be reset (either manually or automatically) to resume normal operation. CBs are made in varying sizes, from small devices to large switchgears.

MCBs are used to protect electrical appliances in LV system. MCBs use the medium air alone to extinguish the arc, which is produced during high current interruption. Larger units will have metal plates or non metallic arc chutes to divide and cool the arc. Magnetic blow out coils deflect the arc into arc chute.

Fig 1.9: Showing the MCBs

Report:

1. Explain why pin insulators are not used above 33 KV voltages.
2. Explain how a fuse can provide time delayed protection for normal overload and high speed protection for short circuit.
3. What are the differences between a MCB and a CB?

Experiment: 2

Experiment name: Determination of Time Current Characteristics (TCC) curve of a rewire able fuse & MCB.

Objective:

1. To take at least 5 set of reading of current and their corresponding fuse blow out time.
2. To take at least 5 set reading of currents and their corresponding tripping time of MCB.
3. To draw the TCC curve of fuse and MCB from the data

Fuse:

Fuse is essentially a small piece of metal connected in between two terminals mounted on insulated base which forms a series part of the circuit.

The duty of a rewireable fuse wire is to carry the normal working current safely without heating the wire but when the normal operating current is exceeded it should rapidly heat up to the melting point and eventually circuit is opened. It can provide two types of protection.

1. Short circuit protection
2. Over load protection

The melting point follows inverse characteristics between the melting time and the melting current. At normal rated current the fuse element will never be heated to its melting point. At overloaded current the melting will occur after certain time. As the amount of overloading is increased the melting time will be shorter.

Semi-enclosed or Re-wire able Fuse:

These types of fuses are used for the protection of appliances at 0.4 KV voltage level and usually called **cut-out.** The Fuse carrier can be pulled out and the blown out fuse element can be replaced.

Fig 2.1: Showing the Re-wire able fuse

Miniature Circuit Breaker (MCB):

MCBs are used extensively in LV domestic, commercial and industrial applications. They replace conventional fuses and combine the features of a good HRC fuse and a good switch. For normal operation it is used as switch. During overloads or faults, it automatically trips off. The tripping mechanism is actuated by magnetic and thermal sensing devices provided within the MCB. Over current is sensed by over current release which helps to open the contact of the MCB. On the other hand short circuit is sensed by magnetic release which provides the means of opening the contact of MCB

Tripping mechanism and the terminal contacts are assembled in a moulded case, moulded out of thermo setting powders. They ensure high mechanical strength, high dielectric strength and virtually no ageing. The current carrying parts are made of electrolytic copper or silver alloy depending upon the rating of the breaker. All other metal parts are of non ferrous, non rusting type. Sufficient cross section for the current carrying parts is provided to ensure low temperature rise even under high ambient temperature environment. The arc chute has a special construction which increases the length of the arc by the magnetic field created by the arc itself and arc chute is so placed in the breaker that the hot gases may not come in contact with any of the important parts of the breaker.

Fig 2.2: Showing the MCBs

Instrument and Components:

1. Current Injector.
2. Clamp on meter.
3. Rewireable Fuse Wire (2 A).
4. Wooden Board fitted with Fuse Holder.
5. MCB
6. Connecting Wire.

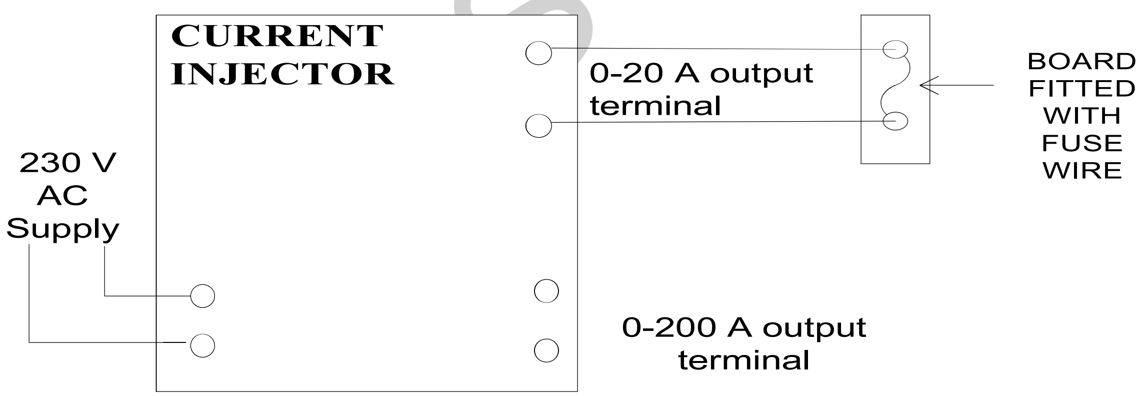
Procedure:

Connect the current injector set to a 230 V supply line. There are two output current terminals, one is of 0-20A and other is 0-200A. Use 0-20A output terminal. Set the output current at a desired value by changing the current varying knob. This can only be achieved by shorting the output terminals by a thick wire. Keeping the knob position at the desired current value, switch off the current injector and connect the fuse holder fitted with fuse wire across the output terminals. Then switch on the injector. The desired current flows through the fuse wire. Measure the blow out time of the fuse wire. As the increased current flows through the fuse wire, the fuse blow out time reduces. Measure and record the currents and the corresponding fuse and blow out time in the table 1.1 and for MCB, connect directly it to the 0-200A output terminals after disconnecting the shorting wire. Then switch on the current injector set. The desired current flows through the MCB. Measure and record the tripping time of the MCB. As the increased current flows through the MCB, the tripping time of the MCB is reduced. Measure and Record the currents and their corresponding tripping time of the MCB in Table 1.1

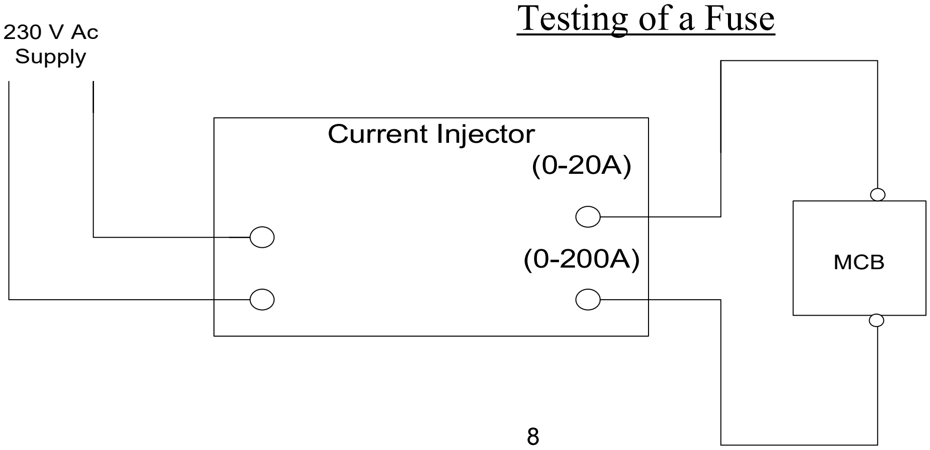
Table 2.1

Sl. No	Current (A)	Fuse blow out time (Sec).	Current (A)	Tripping time of the MCB (sec)
1				
2				
3				
4				
5				

Circuit Diagram:



Testing of a Fuse



Testing of a MCB

Warning:

There are two variable voltage output terminals, one is 110 V dc and other is 230 V ac. Do not touch the terminals of those voltage output.

Report:

1. Explain why pin insulators are not used above 33 KV voltages.
2. Explain how a fuse can provide time delayed protection for normal overload and high speed protection for short circuit.
3. What are the differences between a MCB and a CB?
4. Draw the TCC curve on a graph paper from the data of table 2.1. Use Current in the X-axis and time in Y-axis.
5. Discuss the special feature for selecting the fuse rating for the protection of motor.
6. Discussion the special feature for selecting rating of MCB for the protection of the motor.

Experiment: 3

Experiment name: Study of performance of an electro-mechanical over current relay and thermal overload relay.

Objectives:

1. To observe the performance of IDMT O/C relay and thermal overload relay.
2. To draw TCC curve from the data (over load currents and their corresponding relay tripping times) for different over load currents.

Theory:

Protective relay senses the abnormal conditions in any part of a power system and gives an alarm or isolates the faulty part from the healthy system. The relays are compact, self contained devices which respond to abnormal conditions.

The relays distinguish between normal and abnormal condition. Whenever an abnormal condition develops, the relays close its contacts. Thereby the trip circuit of the CB is closed. Then the contacts of the CB are opened and the faulty part is disconnected from the supply.

The functions of a protective relaying include the following

To sound an alarm or close the trip circuit of the CB so as to disconnect a component during an abnormal condition in the component. The abnormal condition include-overload, under voltage, temperature rise, balanced load, reverse power under frequency, short circuit etc.

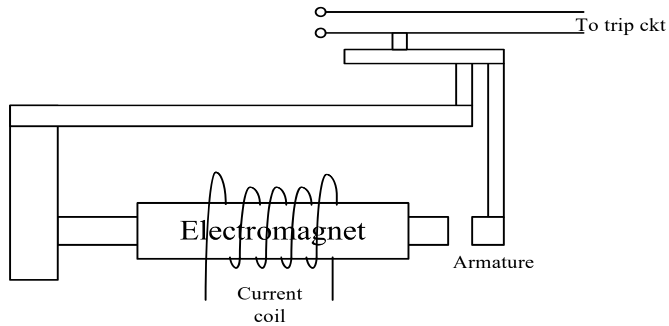
1. To disconnect the abnormal operating part so as to prevent the subsequent fault.
2. To disconnect the faulty part quickly so as to minimize the damage to the faulty part.
3. To localize the effect of fault by disconnecting the faulty part from the healthy part, causing least disturbances to the healthy system.
4. To disconnect the faulty part quickly so as to improve the system stability, service continuity and system performance.

There are two types of electromechanical relays:

- Electromagnetic attraction
- Electromagnetic induction

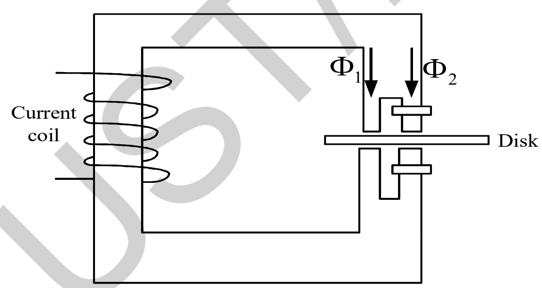
Electromagnetic attraction type:

This is the simplest type of relays. This relay has an electromagnet energized by coil. The coil is energized by the operating quantity which may be proportional to the circuit current or voltage.



Electromagnetic induction type:

It is the most widely used for protective relaying purpose involving ac- quantity. They are not usable with dc quantity. Basically it is like a split phase induction motor. Actuating force is developed in a movable element (either disc or other form of rotor of non magnetic current conducting material) by the interaction of electromagnetic fluxes with eddy currents that are induced in the rotor by these fluxes.



Thermal over load relay:

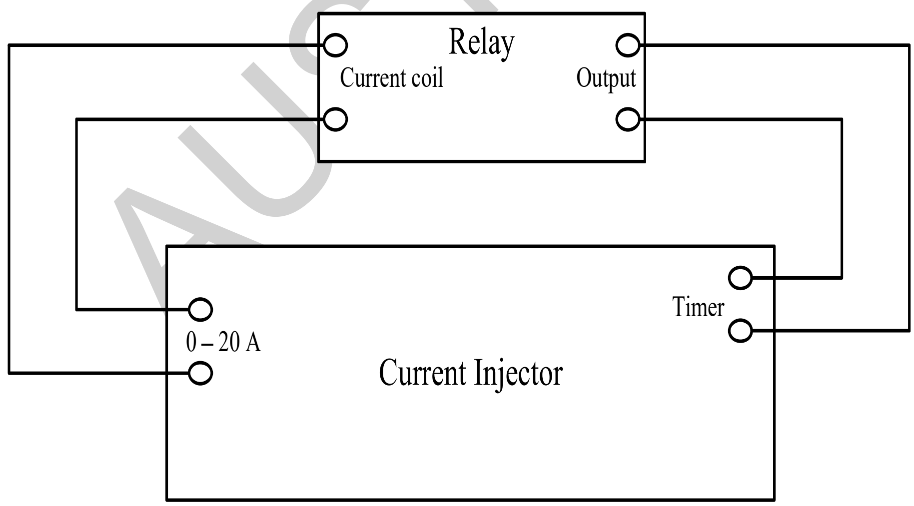
Thermal overload relays are 3 poles. The motor current flows through their bimetals (1 per phase) which are indirectly heated. Under the effect of the heating, the bimetals bend; cause the relay to trip and the position of the auxiliary contacts to change. The relay setting range is graduated in amps. In compliance with international and national standards, the setting current is the motor nominal current and not the tripping current (no tripping at 1.05 x setting current, tripping at 1.2 x setting current. The relays are built to be self protecting in the event of an overload until the short circuit protection device is activated. To make a fine adjustment, change the distance between the heater and the heat-sensitive element. An increase in this distance increases the tripping current. You can make another form of adjustment by changing the distance the bimetal strip has to move before the overload relay contact is opened.

BIMETAL. In the bimetal relay, the heat-sensitive element is a strip or coil of two different metals fused together along one side. When heated, the strip or coil deflects because one metal expands more than the other. The deflection causes the overload relay contact to open.

Thermal over load relay

Settings of IDMT O/C relay:

The standard IDMT relay has two controls- Plug setting (PS) and Time Setting Multiplier (TSM). The PS is a device used to provide a range of current settings at which the relay starts to operate. The setting ranges from 50% to 200% in the steps of 25% of the relay rated current. The TSM is a means adjusting the moveable backstop which controls the travel of the disc and thereby varies the time at which the relay closes its contact for a given value of fault current.



Circuit diagram

Procedure:

The PS of the relay is set at 5 amps, and the TSM at 0.9 sec (say). The current coil of the relay is connected to (0-20 A) output terminals of the current injector set. Adjust the current output at little over 5 A. Then observe the operation time of the relay. As the current in the operating coil is increased, the relay operation time is reduced. So the operating current and time are recorded in the following table.

Current in the relay coil(A)	Operating time of the Relay (Sec)
5.5	
6.0	
6..5	
7.0	
7.5	

Reports:

1. What is a relay?
2. Draw the TCC of the IDMT relay using the data of the table with current in X axis and time in Y axis.
3. Give Examples where time delayed O/C relay are applied.
4. What is the function of the O/C relay?

Experiment: 4

Experiment name: Performance study of a trip circuit for a protected line.

Introduction:

Power System Protection – Main Functions

1. To safeguard the entire system to maintain continuity of supply.
2. To minimize damage and repair costs.
3. To ensure safety of personnel.

Power System Protection – Basic Requirements

1. *Selectivity*: To detect and isolate the faulty item only.
2. *Stability*: To leave all healthy circuits intact to ensure continuity of supply.
3. *Speed*: To operate as fast as possible when called upon, to minimize damage, production downtime and ensure safety to personnel.
4. *Sensitivity*: To detect even the smallest fault, current or system abnormalities and operate correctly at its setting.

Power System Protection – Basic Components

1. *Voltage transformers and current transformers*: To monitor and give accurate feedback about the healthiness of a system.
2. *Relays*: To convert the signals from the monitoring devices, and give instructions to open a circuit under faulty conditions or to give alarms when the equipment being protected, is approaching towards possible destruction.
3. *Fuses*: Self-destructing to save the downstream equipment being protected.
4. *Circuit breakers*: These are used to make circuits carrying enormous currents, and also to break the circuit carrying the fault currents for a few cycles based on feedback from the relays.
5. *DC batteries*: These give uninterrupted power source to the relays and breakers that is independent of the main power source being protected.

The sequence of operation during abnormal condition:

1. Fault occurs.
2. Relay sense the fault and close the trip circuit.

3. Energize the trip coil unlatch the spring.
4. Contacts start to apart and arc is drawn between the contacts of CB.
5. Arc is extinguished at the instant when fault ac current becomes zero.
6. Fault interruption is completed i.e. fault is cleared.

Apparatus:

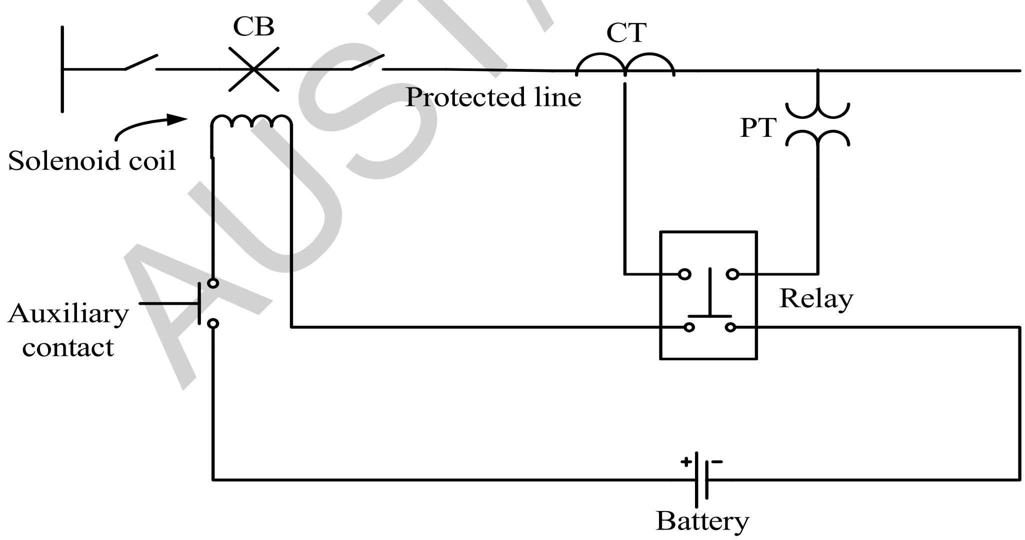
1. Circuit breaker.
2. Protected line.
3. Battery.
4. CT
5. PT
6. Microprocessor based Relay.

    P632: Differential Relay

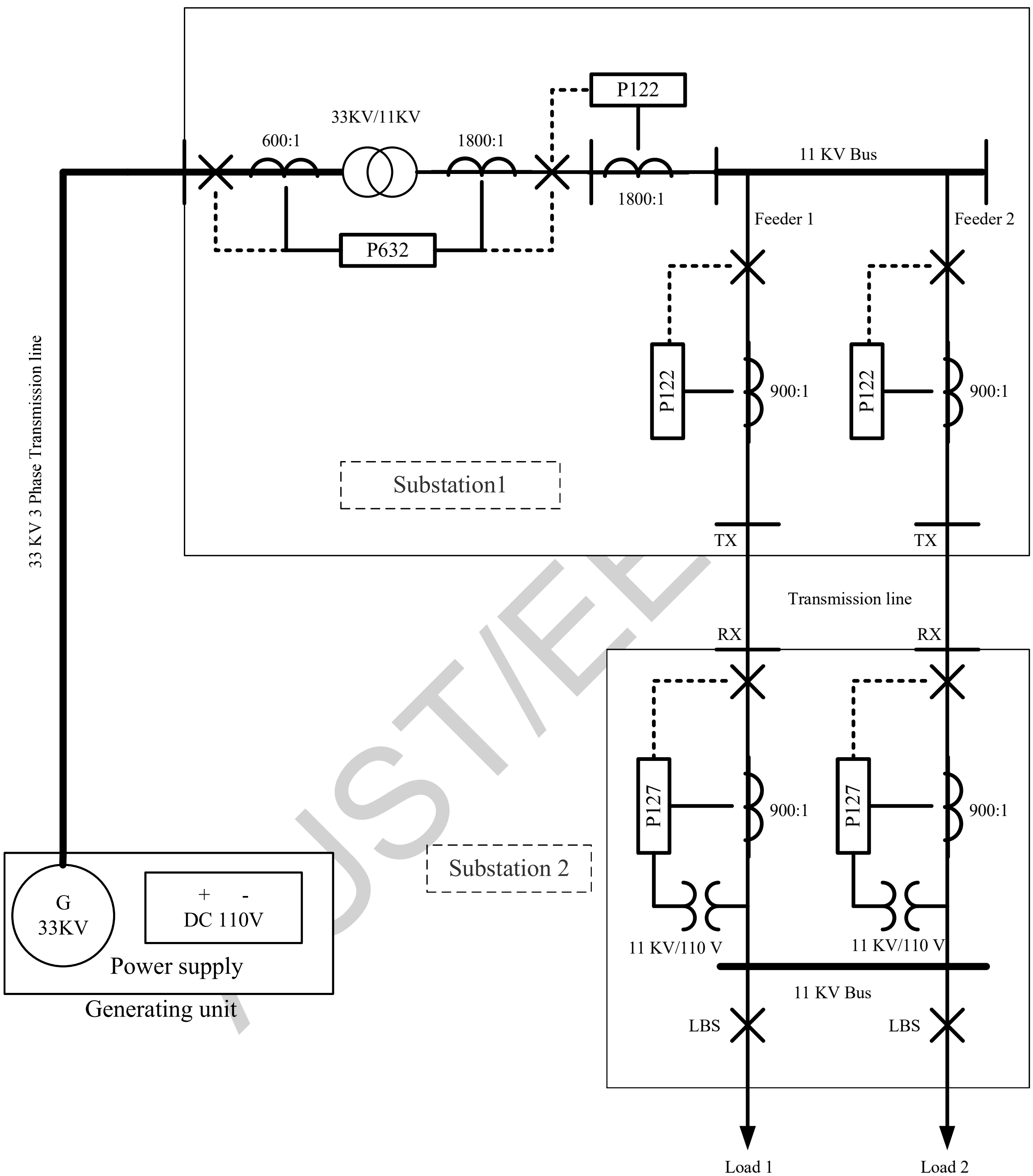
    P122: O/C IDMT Relay

    P127: Directional O/C Relay.

Circuit Diagram:



Observation: Observe different types of relays in substation I and substation II, their configuration & how they operate during fault condition.


P122
33KV/11KV
600:1
1800:1
11 KV Bus
1800:1
P632
Feeder 1
Feeder 2
33 KV 3 Phase Transmission line
P122
900:1
P122
900:1
Substation1
TX
TX
Transmission line
RX
RX
P127
900:1
P127
900:1
Substation 2
11 KV/110 V
11 KV/110 V
11 KV Bus
LBS
LBS
G
33KV
+ -
DC 110V
Power supply
Generating unit
Load 1
Load 2

Power Supply: [33V is for safety precaution]

1. 3 phase 220 V/33 V Transformer
2. 3 Phase rectified DC 110 V for relay biasing.

P632: Differential relay comprising of

1. Primary CT 600:1 [33 KV side]
2. Secondary CT 1800:1 [11 KV side]
3. BT : Bucholz Trip
4. BA : Bucholz Alarm
5. TA : Temperature Alarm
6. TT : Temperature Trip
7. Neutral CT secondary 1800:1 for restricted earth fault protection.
8. 33 KV/ 11 KV 3 Phase DY transformer which is to be protected.

P122-1: IDMT O/C relay for over load protection of transformer & backup protection of relay P122-2 P122-3 comprising of

1. CT 1800:1 [11 KV side]

P122-2: IDMT O/C relay for protection of feeder 1 comprising of

1. CT 900:1 [11 KV side]

P122-3: IDMT O/C relay for protection of feeder 2 comprising of

1. CT 900:1 [11 KV side]

P127-1: Directional O/C relay for protection of feeder 1 of substation -2comprising of

1. CT 900:1 [11 KV side]
2. PT 11 KV/110 V

P127-1: Directional O/C relay for protection of feeder 2 of substation -2comprising of

1. CT 900:1 [11 KV side]
2. PT 11 KV/110 V

Experiment: 5

Experiment name: Performance study of an O/C relay, O/C relay co-ordination & advantage of parallel feeder.

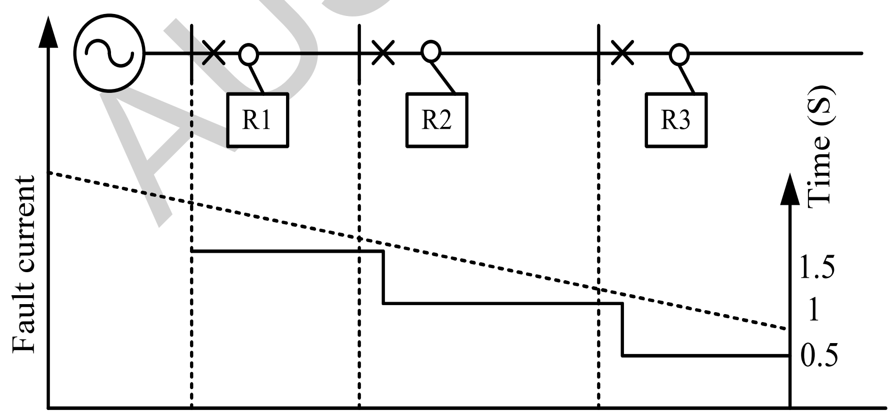
Introduction:

Though it may be possible to grade the relay settings based on the fault currents, it is noted that the fault currents in a series network differs marginally when the sections are connected by cables without any major equipment like transformers in between the two ends. In such types, if networks grading the settings based on current values do not serve the purpose. It is required to go for time grading between successive relays in most of the networks.

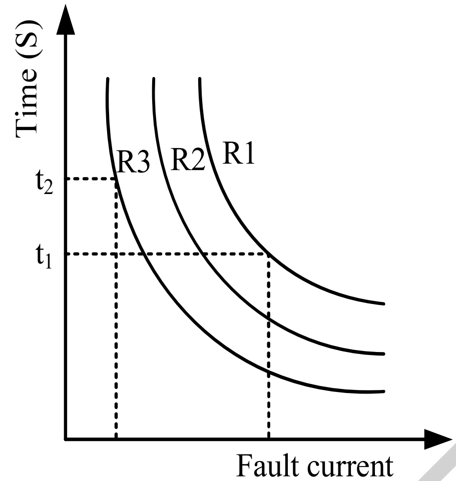
To achieve selectivity and coordination by time grading two philosophies are available, namely:

1. Definite time lag (DTL), or
2. Inverse definite minimum time (IDMT).

For the first option, the relays are graded using a definite time interval of approximately 0.5 s. The relay *R*3 at the extremity of the network is set to operate in the fastest possible time, whilst its upstream relay *R*2 is set 0.5 s higher. Relay operating times increase sequentially at 0.5 s intervals on each section moving back towards the source as shown in Figure 1.



The problem with this philosophy is, the closer the fault to the source the higher the fault current, the slower the clearing time – exactly the opposite of what we should be trying to achieve. On the other hand, inverse curves as shown in Figure 2 operate faster at higher fault currents and slower at the lower fault currents, thereby offering us the features that we desire.



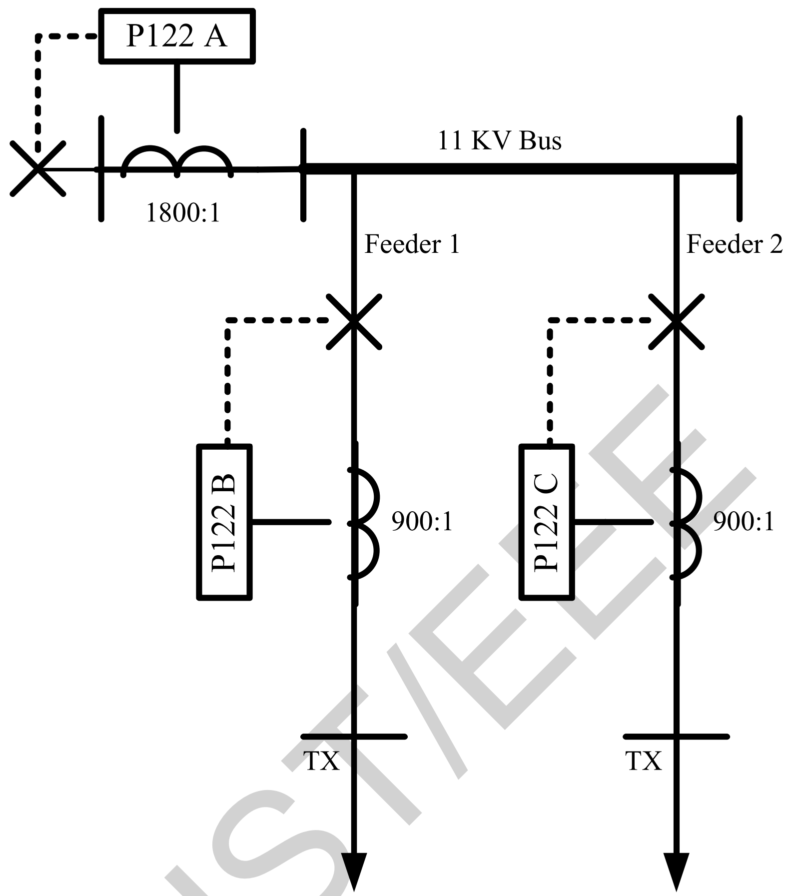
Apparatus:

1. Circuit breaker.
2. Protected line.
3. CT 900:1 – 3+3 no's
4. CT 1800:1 – 3+3 no's
5. Microprocessor based IDMT O/C Relay: P122-3no's

Observation:

- How P122 IDMT, DMT O/C relay operate during fault condition.
- P122-1, P122-2 relay configuration.
- CT/PT ratio
- Phase sequence
- Protection type
- Trip command
- Alarm
- LED configure

Circuit Diagram:



Procedure:

For satisfactory back-up protection the time setting of relay P122 A must be higher than P122 B and P122 C. Now reduce the time setting of relay P122 A then P122 B and observe how the backup protection works.

Report:

1. Discuss the significance of the back up protection.
2. Under what condition back up protection is economically justified?

Experiment: 6
Experiment name: Performance study of directional relay.

Introduction:
Active power flowing through a part of an electric circuit is P = VI cosθ, where θ is the angle between voltage and current.

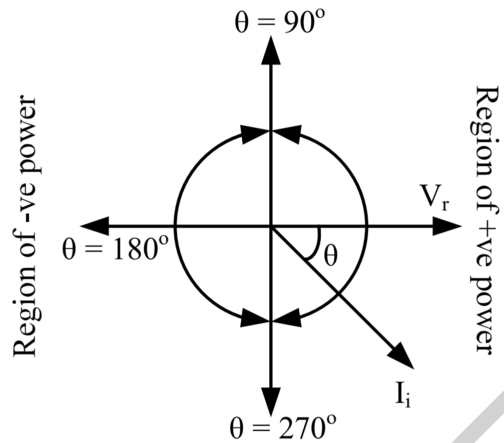


Fig 1: Vector diagram of power.

From the above vector diagram,

For $\theta < \pm 90^o$, cosθ is positive, hence the real power is positive.

For $\theta > \pm 90^o$, cosθ is negative, hence the real power is negative.

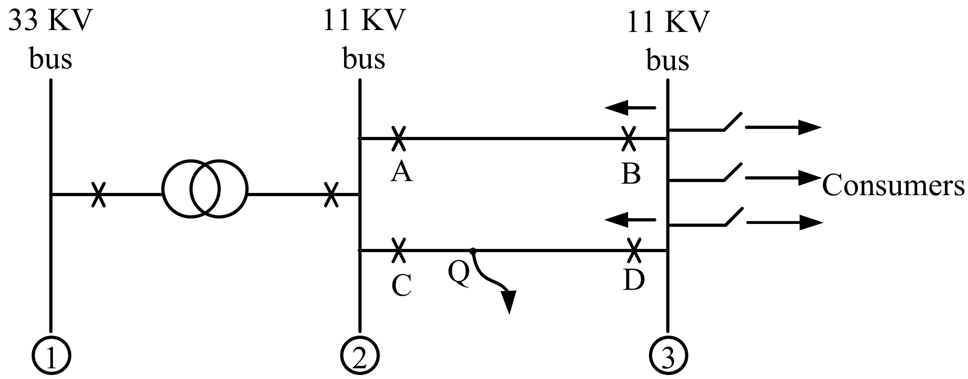
For $\theta = 90^o$ & $\theta = 270^o$, cosθ is zero, hence the real power is zero.

The direction of power flow can be sensed by sensing the magnitude and sign of power. Here we used microprocessor based P127 for directional relay. Directional protection responds to the flow of power in a definite direction with reference to the location of CT's and PT's. Directional relay senses direction of power flow by means of phase angle between V and I. When this angle exceeds certain predetermined value, the directional relay operates if, of course, the current in the relay current coil is above pick up value. A directional relay is a double actuating quantity relay with one input as current I from CT and the other input as voltage, V from PT.
With the electromagnetic directional O/C relays, discrimination is affected when the voltage drops down to a low value due to faults close to the location of PT. With static or digital directional O/C relay, the static relay can function well up to 1% of the system voltage.

Description of the set up

The following figure shows the single line diagram of a power system which feeds 11 KV consumers of bus 3. The bus 3 is fed from bus 2 at 11 KV through two circuits in parallel. There are two breakers and associated relays at the two ends of each circuit.

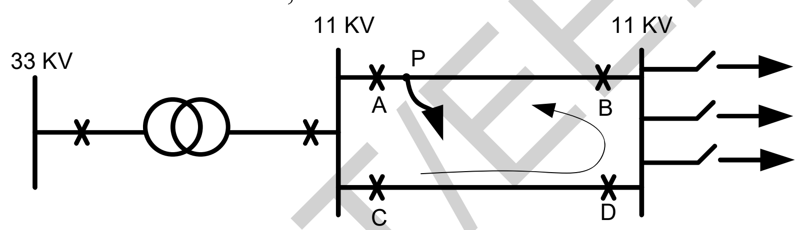
These relays are A & B and C & D as shown in the figure. Of these, A&C are non directional O/C relays whereas B and D are directional O/C relays.



When the fault current flows through the relays B and D in the direction of arrow as shown in the figure, the relays operate and trip associated breakers.

Case I

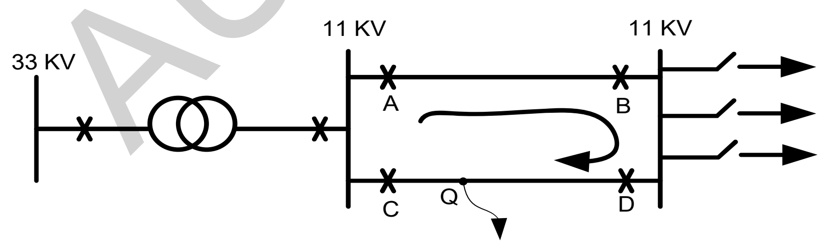
For a fault at P on one of the circuits, the direction current flow is as shown.



Under this fault condition, the non directional relay A and directional relay B operate and trip the associated breakers to isolate the fault.

Case II

For a fault at Q in the other circuit, the direction of current flow is as shown.



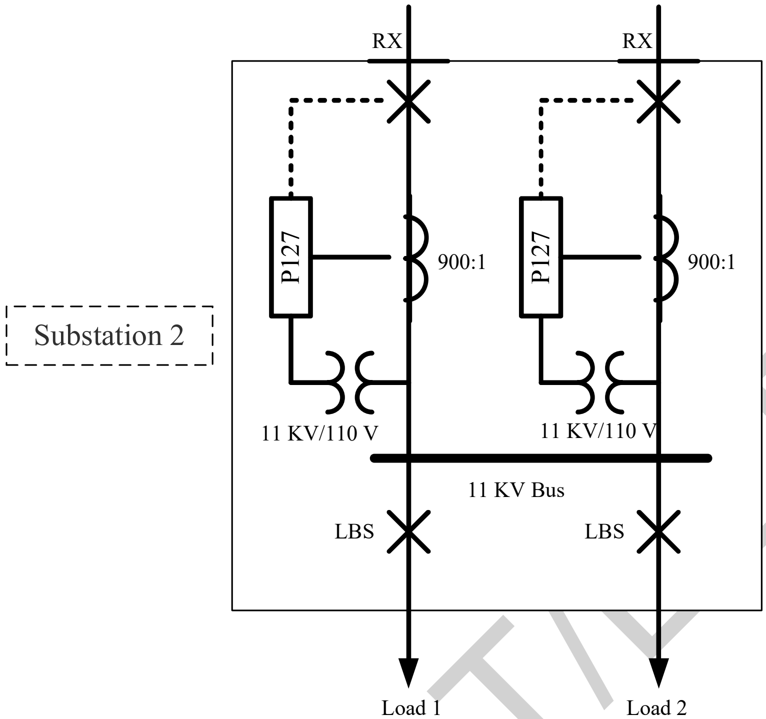
Under the fault condition, the non directional relay C and the directional relay D operate and trip the associated breakers to isolate the faulty circuit.

Apparatus:

1. Circuit breaker.
2. Protected line.
3. CT 900:1 – 3+3 no's

4. PT 11KV/110V – 2 no's
5. Microprocessor based directional O/C Relay: P127

Circuit Diagram:



Observation:

- How P127 relay operate during fault condition.
- P127 relay configuration.
- CT/PT ratio
- Phase sequence
- Angle
- Protection type
- Trip command
- Alarm
- LED configure

Reports:

1. Explain your observation about the performance of the relay.
2. Explain how close up faults affects the relay operation.
3. If one of the terminals of the PT supplying relay Voltage coil, is open what will happen?
4. Explain why there are two actuating quantity in a directional relay.

Experiment: 7

Experiment name: Performance study of a differential relay for the protection of generator and transformer.

Objectives:

The objectives of this experiment are to observe the performance of the following schemes of a power transformer

1. Buchholz alarm
2. Buchholz trip
3. Temperature alarm
4. Temperature trip
5. Differential relay trip due to phase to phase and ground fault
6. Restricted E/F relay trip

Introduction:

The choice of the protection for any power transformer depends upon a number of factors such as its size, importance and cost.

Buchholz relay (Gas relay / Gas actuated relay):

All faults below oil in a transformer result is the localized heating and break down of the oil; some degree of arcing will always take place in a winding fault and resulting decomposition of the oil will release gas such as hydrogen, Carbon monoxide and light hydro carbons. When the fault is of a very minor type, such as a hot joint, gas is released slowly, but a major fault involving severe arcing cause's rapid release of large volumes of gas as well as oil vapour. The action is so violent that the gas and oil vapour do not have time to escape but instead build up pressure and bodily displace the oil.

When such faults occur in transformers having oil conservators, the faults causes a blast of oil to pass up the relief pipe to the conservator.

(a)Buchholz Alarm:

The incipient faults (gradually developing faults in the winding below oil level) produce the gas and it gets collected in the upper portion of the relay, thereby the oil level in the relay drops down. The float, floating in the oil in the relay tilts down with lowering the oil level. While doing so the mercury switch attached to the float is closed on to the alarm circuit.

(b)Buchholz trip :

The short circuit fault causes a blast of oil rushes towards the conservator through Buchholz relay. The baffles (plate) in the Buchholz relay get pressed by the rushing oil. Thereby it closes another switch which in turn closes the trip circuit of the circuit breaker.

(c) & (d) Overheating Protection:

The rating of the transformer is based on the temperature rise above an assumed maximum ambient temperature; under this condition no sustained overload is usually permissible. At lower ambient temperature some degree of overload can be safely applied. Short time overloading are also permissible to an extent dependent on the previous loading conditions. No precise ruling applicable to all conditions can be given concerning the magnitude and direction of safe overload.

Thermocouples or resistor temperature detectors are kept near each winding. These are connected to a bridge circuit. When temperature increases above safe value, an alarm is given. If measures are not taken, the circuit breaker is tripped after a certain temperature. Some typical settings for oil temperature are as follows-

At 60^0C, Switch on fans

At 95^0C, give an alarm

At 120^0C, give a trip signal to trip the CB.

A temperature of about 95^0C is considered to be the normal maximum working value. Any further rise of 8^0-10^0C beyond this 95^0C will make the life of the transformer half if this rise is sustained.

(e) Protections of transformer against internal fault by differential relay:

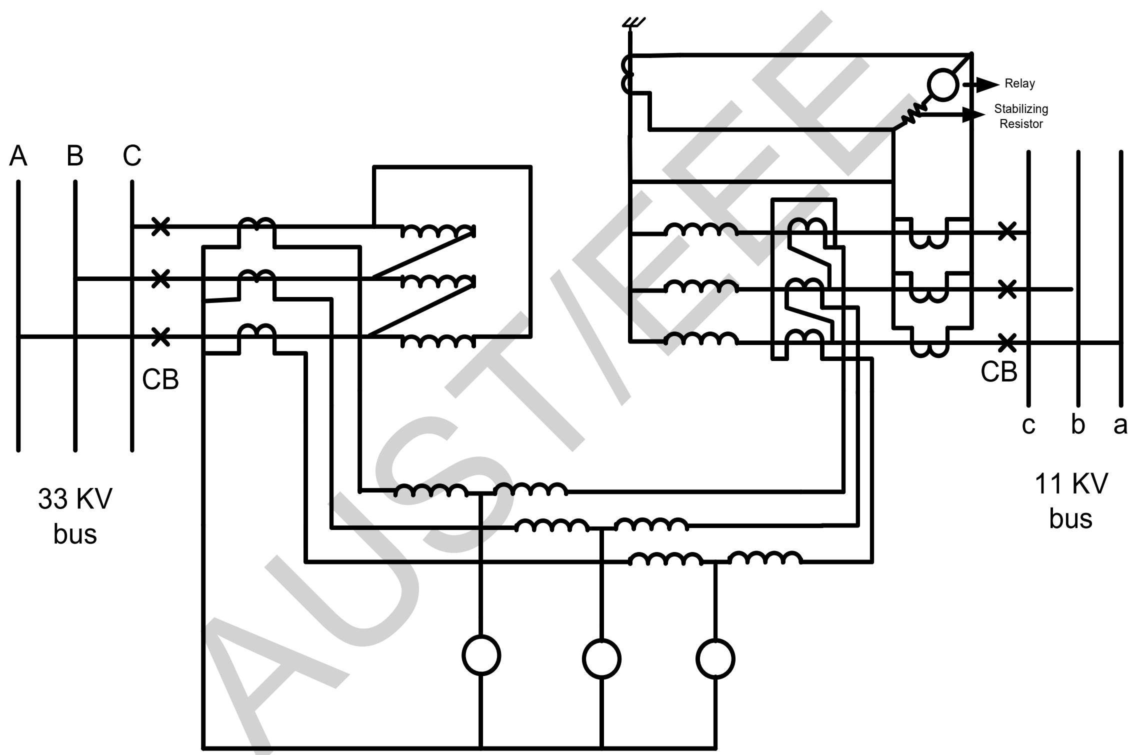
In protection of a transformer, CTs are connected at both sides of the transformer. The CT secondaries are connected in star or delta and pilot wires are connected between the CTs of each end. The CT connections and CT ratios are such that current fed into the pilot wires fron both the ends are equal during normal and for through fault conditions. During any kind of internal fault, like phase to phase faults or phase to ground faults, the balanced is disturbed. The out of balance current (I_1-I_2) flows through the relay operating coils. To avoid unwanted relay operation on through faults, restraining coils are provided in series with the pilot wires. The average current through the restraining coil is (I_1+I_2)/2. As a result the restraining current increases with the increase of (I_1-I_2) in the operating coil for a through fault condition.

(f) Restricted Earth Fault Protection of Y-winding

When E/F occurs very near to the neutral point of Y-winding of the transformer, the voltage available for driving earth fault current is small. Hence the fault current is low. If the normal biased different relay is to sense such faults, it has to be too sensitive and would therefore operate for spurious signal like, external faults and switching surges, under this condition restricted earth fault protection scheme has evolved. Here the practice is to set the relay such that it operates for earth fault current of the order of 15% of rated winding current, such setting protects restricted portion of the winding.

Procedure:

A 3φ, 38 MVA, 33/11KV, Δ-Y connected power transformer feeds power to an 11 KV bus from a 33 KV bus as shown in the figure below-



Temperature Alarm:

For pushing the temperature alarm switch, which represents the closing of a contact due to rise in winding temperature, an alarm signal will be displayed on the relay display board.

Temperature trip:

If the winding temperature goes to a very high level, the transformer should be isolated from the system. By pushing the temperature trip switch, the temperature relay essentially closes the trip circuit and fault is cleared by two breaker on the two sides of the transformer.

Buchholz Alarm:

Pushing this button means closing the contact of Buchholz relay as an indication of incipient fault in the winding inside the oil, so an alarm indication is displaced on the relay.

Buchholz trip:

Pushing this button means closing the contact of Buchholz rely as an indication of internal short circuit fault. So the breakers on both sides of the transformer are tripped.

Internal Fault:

A short circuit fault in the winding is created by shorting the two phase of any side. This fault is detected by the differential relay and the breakers on both sides of the transformer are tripped to isolate the fault.

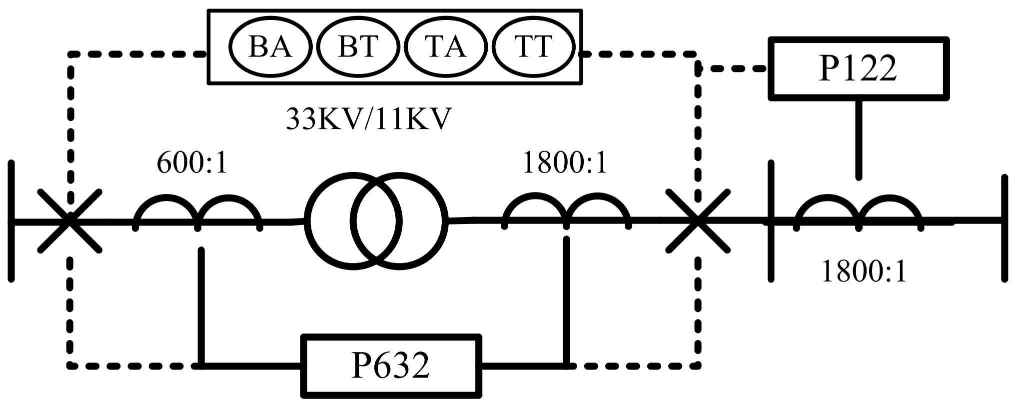
Restricted E/F Protection:

An earth fault close to the neutral end of the Y- winding of the transformer is created by shorting the phase terminal and neutral terminal. This fault is detected by the concerned relay and the breakers on both sides of transformer are tripped to isolate the fault.

Apparatus:

1. Circuit breaker: 2 no's
2. 3 Phase 38.1 MVA Δ-Y 33KV/11KV transformer.
3. CT 600:1 – 3 no's
4. CT 1800:1 – 3 no's
5. Microprocessor based differential Relay: P632
6. Microprocessor based O/C Relay: P122

Circuit Diagram:



Observation:

- How P632 relay operate during fault condition.
- P632 relay configuration.
- Transformer voltage.
- Power
- REF
- CT/PT ratio
- Differential protection
- Vector group.
- BA, BT, TA, TT
- LED configures.

Report:

1. What do you mean by incipient faults in the transformer winding? What are the possible causes if this fault?

2. Is the earth fault close to neutral end of a wye connected winding very common? Why?

3. Explain why percentage differential relay is not suitable for detecting the E/F near neutral end of an wye connected winding whose neutral is grounded through high resistance.

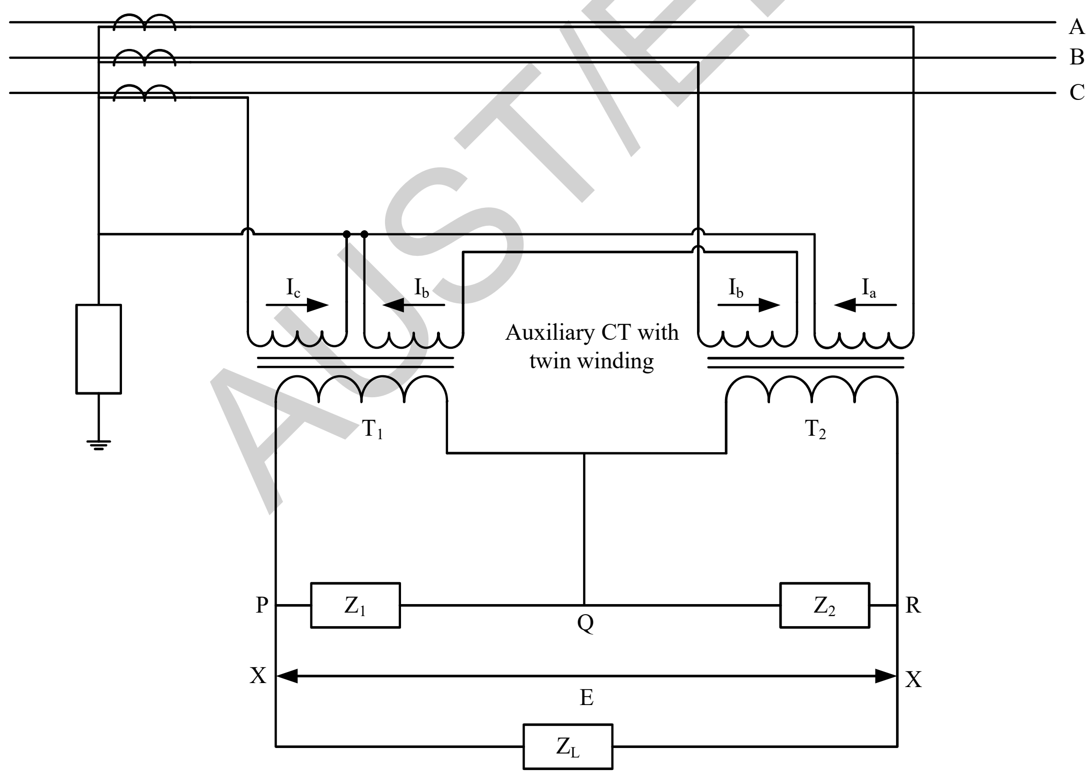
Experiment: 8

Experiment name: Performance study of a negative phase sequence relay.

Objective:
Observation of the performance of NPS relay for the protection of a power system against unbalanced loading or unsymmetrical faults.

Introduction:
When a three phase rotating electric machine, including an alternator is connected to the perfectly balanced three phase power system, no negative sequence current is developed in the rotor winding. If, however, the power system is unbalanced, as usually in the case, a negative sequence current double the system frequency is induces in the rotor winding. This naturally causes motor rotor overheating that in the absence of this current. Flow of large amount of negative phase sequence current in the rotor winding for long period can cause damage to the rotor winding. Under this situation, a necessary measure must be taken to save the machine. So, the negative phase sequence current can be used as a parameter in the design of negative sequence protection scheme of large and expensive rotating electric machines including generator.

Negative phase sequence scheme



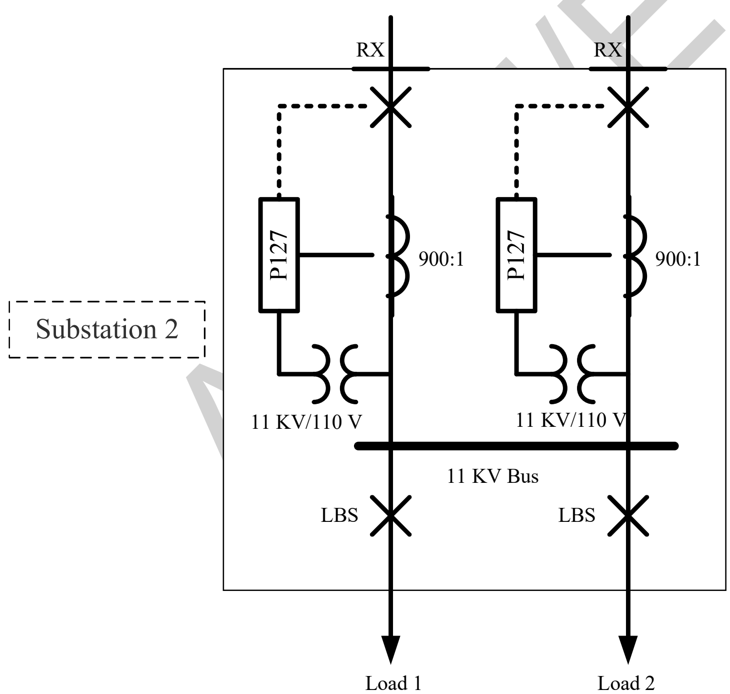
The twin windings of the two auxiliary CT's (T_1 and T_2) are so connected to the line CT's that under normal balances load condition, I_a, I_b, I_c flows in the direction shown. Impedance Z_1 and Z_2 are connected across the T_1 and T_2. A load impedance Z_L is connected across the terminal XX. When primary load current flows, the current through

T_1 will be (I_b-I_c) and that through T_2 will be (I_a-I_b). For a given value of load impedance Z_L (over current relay) the impedance Z_1 and Z_2 are chosen such that point P and R remain at the same potential. So voltage across QR and QP are equal and opposite. Under unbalanced conditions, this voltage differs and an output voltage, proportional to the negative phase sequence, is produced across XX (voltage E) so as to operate the relay.

Apparatus:

1. Circuit breaker.
2. Protected line.
3. CT 900:1 – 3+3 no's
4. PT 11KV/110V – 2 no's
5. Microprocessor based directional O/C Relay: P127

Circuit Diagram:



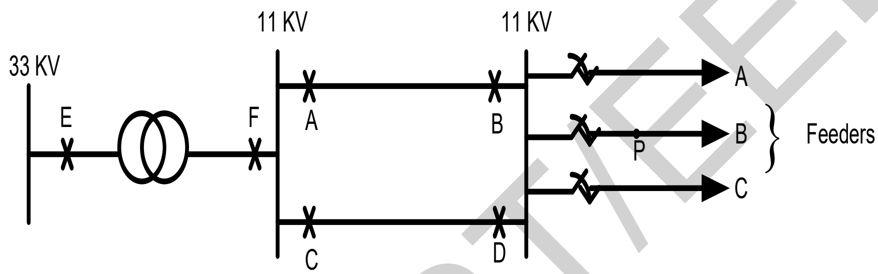
Observation:

- How P127 negative phase sequence relay operate during unbalanced condition.
- P127 relay configuration.

- CT/PT ratio
- Phase sequence
- Angle
- Protection type
- Trip command
- Alarm
- LED configuration.

Procedure:

The following power system is used to observe the performance of the NPS relay.



The relays at locations B and D are directional O/C numerical relays. Only the relay at B is also set to function as NPS relay. Now one of the three phases of feeder B is opened while the feeder B is on load. Negative Sequence Current is generated in the system due to creation of unbalance in the system. The NPS relay at B picks up and trips the breaker.

Questions:

1. What are the causes of generation of negative phase sequence current in a power?
2. Can you run a power system with perfectively balanced condition all the time? Give reasons.
3. What are the electrical devices that are affected due to the presence of negative phase sequence current? Also explain the type of effect on these devices.

Experiment: 9

Experiment name: Study of different components and their functions of an Air Circuit Breaker (ACB)

Objectives:

- To observe the contact closing operation manually
- To observe the contact closing operation automatically
- To observe the tripping mechanism
- To observe the under voltage shunt tripping mechanism

Theory:

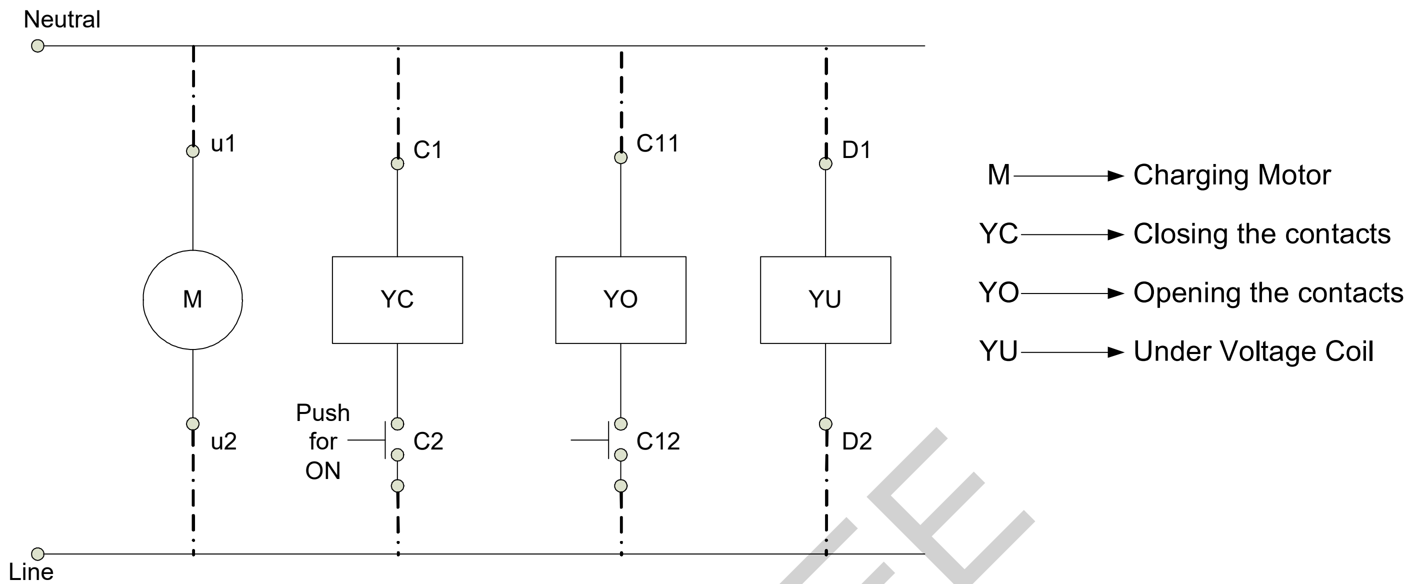
In the ACB under discussion the over current relays and their corresponding CTs in three lines are built inside the ACB. The under voltage relay coils are also built inside the ACB.

There is a spring charging motor in the ACB. When the motor is supplied from a single phase 230 V, the motor is started and the contact of the ACB are closed keeping the spring fully charged and latched. When there is any over current in all the phases or in any of the phases, the built in over current relay closes its trip circuit and the trip coil unlatch the fully charged spring, then the contacts are opened by the mechanical energy charged in the spring. The arc is extinguished in the medium of normal atmospheric air.

If the voltage in any of the three phases or in all three phases, supplied to the load through the ACB, are reduced below a preset level, the under voltage relay will be picked up and closes the trip circuit; consequently the trip coil will unlatch the fully charged spring and the contacts will be opened.

The closed contacts of the ACB can be manually opened by pushing the OFF button, which closes the trip circuit, then trip coil is energized and unlatch the spring to open the contacts.

Circuit diagram for motor operating mechanism, opening closing and under voltage release are shown in the figure.



Procedure:

For energizing the charging motor, closing the contacts, opening the contacts and under voltage tripping, the terminals of control circuits for the motor are connected as shown in the diagram. One incandescent lamp is connected across one of the three phases of the contacts and the neutral. When the 'ON' switch is pushed the contacts will be closed and the lamp will glow and when the "OFF" switch is pushed the contacts will be opened and the lamp will stop glowing. It is important to keep in mind that the voltage across the under voltage coil (i.e D1 and D2) should be maintained at about 220 V (ac) otherwise contacts cannot be closed by pushing the 'ON' switch. If the voltage across the under voltage coil is reduced below 200 V (approax.) the breaker will automatically be tripped.

Report:

1. What are the difference between a MCB and the ACB used in this experiment?
2. What are the means of arc extinction in ACB?

Experiment: 10

Experiment name: Study of different types of motor protection system

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Objectives:

- To observe the connection diagram of DOL protection system and its operation.
- To observe the connection diagram of MMS protection system and its operation.
- To observe the connection diagram of Inverter protection system and its operation & control.

Theory:

The following two basic protections are provided for every motor:

1. Thermal over load protection
2. Short circuit protection.

The switchgear used for the motor protection can also be classified into the following two groups depending on the size of the motor:

1. For small motor (up to 150 hp), fuse and thermal over current protection are used
2. For large motors, circuit breakers and associated relays are used.

For small motors:

Short circuit protection:

Fuse will provide the short circuit protection of stator winding. The operating time current characteristics of the fuse should be such that the fuse should not blow during the motor starting which could be 5 to 7 times the motor full load current. The fuse should blow at current more than those which can be interrupted by the contactors. Here we used magnetic contactor for short circuit protection.

Over load protection:

Thermal relay should provide the overload protection. Thermal relay should not operate during starting period of the motor. Starting period is generally considered to be 5 to 10 seconds.

For large motor:

Overload and short circuit protection:

Over current relay and earth fault relay (either instantaneous or inverse time or both depending on the importance of the motor) are used to protect against phase fault and earth fault on stator winding. If the motor is very large and expensive, it is essential to provide differential protection for the winding. The short circuit protection characteristic is set just above the maximum starting current of the motor.

Here we used three different protection systems:

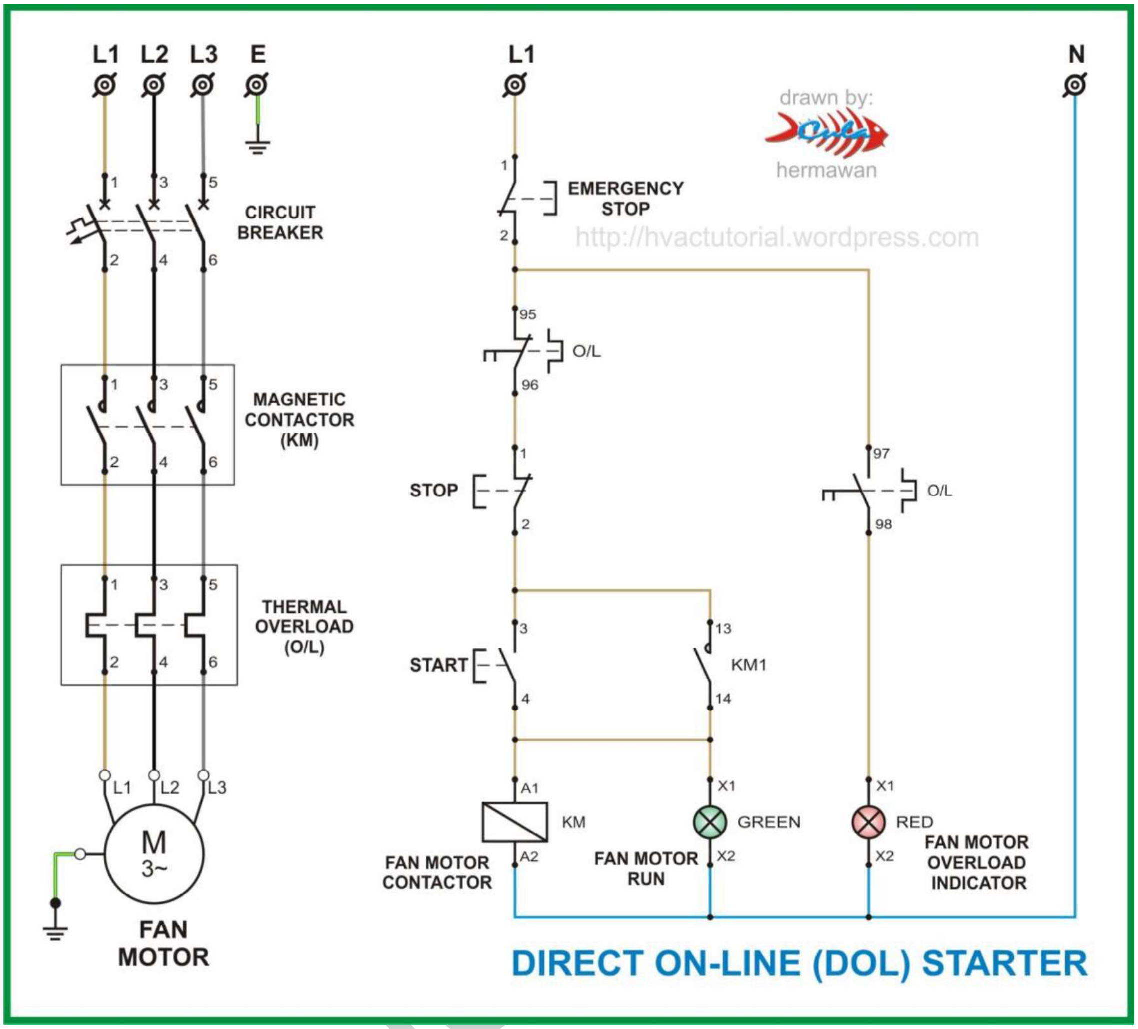
- DOL (Direct on line)
- MMS (Manual motor starter)
- Inverter

DOL protection system:

In electrical engineering, a **direct on line** (DOL) or **across the line** starter starts electric motors by applying the full line voltage to the motor terminals. This is the simplest type of motor starter. A DOL motor starter also contain protection devices, and in some cases, condition monitoring. Smaller sizes of direct on-line starters are manually operated; larger sizes use an electromechanical contactor (relay) to switch the motor circuit. Solid-state direct on line starters also exist.

A direct on line starter can be used if the high inrush current of the motor does not cause excessive voltage drop in the supply circuit. The maximum size of a motor allowed on a direct on line starter may be limited by the supply utility for this reason. For example, a utility may require rural customers to use reduced-voltage starters for motors larger than 10 kW.

DOL starting is sometimes used to start small water pumps, compressors, fans and conveyor belts. In the case of an asynchronous motor, such as the 3-phase squirrel-cage motor, the motor will draw a high starting current until it has run up to full speed. This starting current is commonly around six times the full load current, but may be as high as 6 to 7 times the full load current. To reduce the inrush current, larger motors will have reduced-voltage starters or variable speed drives in order to minimize voltage dips to the power supply.



MMS protection system:

MMS is the integrated form of magnetic contactor, overload relay and a switch. You can use an extra magnetic contactor for remote control. The characteristics of manual motor starter are:

- Overload protection
- Phase failure sensitiveness
- Disconnect function for safety isolation of the installation and the supply
- Temperature compensation from -25 … +60 °C
- Adjustable current setting for overload protection
- Suitable for three- and single-phase application
- Trip-free mechanism
- Lockable handle.

Inverter protection system:

You can control and protect the motor using inverter.

Report:

1. What kind of protections is given in small and large motor?
2. How can you control the speed of a motor?
3. Why thermal over load relay is used in motor protection system?