



**COLLEGE OF ENGINEERING & TECHNOLOGY**

**LABORATORY MANUAL**

**SWITCH GEAR AND PROTECTION**

**SUBJECT CODE: 2170908**

**ELECTRICAL ENGINEERING DEPARTMENT**

**B.E. 7<sup>th</sup> SEMESTER**

**NAME:** \_\_\_\_\_

**ENROLLMENT NO:** \_\_\_\_\_

**BATCH NO:** \_\_\_\_\_

**YEAR:** \_\_\_\_\_

**Amiraj College of Engineering and Technology,  
Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.**



**COLLEGE OF ENGINEERING & TECHNOLOGY**

**Amiraj College of Engineering and Technology,**  
Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

**CERTIFICATE**

*This is to certify that Mr. / Ms. \_\_\_\_\_*  
*Of class \_\_\_\_\_ Enrolment No \_\_\_\_\_ has*  
*Satisfactorily completed the course in \_\_\_\_\_ as by*  
*the Gujarat Technological University for \_\_\_\_ Year (B.E.) semester \_\_\_\_ of Electrical*  
*Engineering in the Academic year \_\_\_\_\_.*

***Date of Submission:-***

Faculty Name and Signature  
(Subject Teacher)

**Head of Department**  
**(Electrical)**



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List Of Experiments

Sr. No.	Title	Date of Performance	Date of submission	Sign	Remark
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# EXPERIMENT:

Date:

**Aim: To Study about Different Types of Relays.**

▪ **Specific Objectives:**

After performing the experiment, one should be able to know:

- About brief idea of Different Types of Relays.

▪ **Rationale:**

The power engineer can have a large number of relays from the market for various protection purposes, but it is one's vision which would restrict one from buying all the types of them and working satisfactorily with a few of them, but as a matter of study one should have studied all the types of them and hence this practical focuses on the types, construction and working of different relaying philosophy.

The major types of relays are:

- Over current relay
- Definite time over current relay
- Inverse definite time over current relay
- Directional relay
- Differential and biased differential relay
- Thermal over load relay
- Earth fault relay
- Under voltage and under frequency relays.
- Static relays

The working principle of operation of many of the relays is Comparison principle in which the quantity measured is compared with the reference quantity and on that basis the relay will decide its mode of function. The universal torque equation for any type of relay is given by the following formula:

$$\text{Torque} = K_1 I^2 + K_2 V^2 + K_3 VI \cos\Phi - K_4$$

➤ **The Over Current Relaying Philosophy:**

Depending upon the operating current the relays are categorized as:

- Instantaneous over current relays
- Inverse time current relay
- Inverse definite minimum time over current relay
- Very inverse relay
- Extremely inverse relay
- Definite minimum time relay
- Earth fault relay
- Thermal over load relay

Out of the above mentioned relays, except the last relay, the construction and operation is quite similar in which they consist of one disc and a relay coil in which the current passes and hence the torque is produced due to induction principle. Note that in such types of relays, except the current factor and the damping factor, all the other factors are

zero in the universal torque equation. The attracted armature principle is adopted for the instantaneous tripping in most relays with the help of a shading ring. We know that the "drag" principle requires some constant amount of ampere turns and if we keep turns fix, the current required for that many number of turns is also fixed and now if we change the number of turns, accordingly the operating current requirement will also change. Hence one relay can be set for several current ratings and thus obtained ampere turns are compared with the minimum ampere turns requirement and the relays determines its status of function. The damping that is designed will decide its characteristics. Normally a spiral spring and a pair of electromagnets will provide damping torque as well as they will maintain a constant disc velocity if the disc is spital shaped. In thermal over load relays, a bi – metallic stripe is used. The material of the stripe and that of the winding to be protected should ideally have the same thermal expansion factor and as a result as the current starts flowing, the bi – metallic stripe will undergo expansion and in this way the temperature of the winding will be sensed. Because both the stripes will not have same expansion for a given temperature rise, they will trip the system when the temperature and hence expansion is beyond certain limit. Like all over current relays, these relays can also be set for a range of current and they are normally set for 125 per cent of the normal operating current.

➤ **The Directional Relaying Philosophy:**

In such types of relays, induction cup principle is hired in addition to disc operation. First the induction cup will decide whether the relay has to operate or not and if it operates, the disc will operate on the basis of current and then only the final tripping will be done. It is to be noted that in such relays, we also require polarizing quantity for the induction cup unit. These relays are not self powered relays like over current relays. These relays are used for the protection of parallel feeders, protection against reverse power in conjunction with the under voltage relays.

➤ **The Differential And Biased Differential Relaying Philosophy:**

As the name suggests, this relay operates when the differential (subtracted) current exceeds certain value. This type of relaying may also hire opposed voltage principle if supplied with juice from the potential transformers. Due to un even characteristics of current and potential transformers, magnetic inrush currents of transformers, saturation effects, the relay may not remain stable in normal condition even and hence a better philosophy called biased differential is hired to make the relay immune against mal – functioning. This philosophy is hired for large power transformer protection, protection of stator winding of generators of rating 10 MW and above. The protection is instantaneous in nature.

➤ **Under Voltage Relaying Philosophy:**

To sense the "voltage collapse" or "voltage instability" phenomena in power system, this relaying philosophy is hired. The relay is supplied

from the juice of potential transformer connected to the bus bar and it is continuously compared with the reference value and if the error signal exceeds certain value, the relay will operate. Generally these relays are installed at sub stations feeding bulk and continuous load in addition to at generating stations.

➤ **Under Frequency Relaying Philosophy:**

The "cascade tripping" is a effect of "power system instability" phenomena and to sense the power system instability, under frequency relays are used. They are located at the Load Dispatch Centre and on the basis of the readings of the system frequency, load shedding is carried out. This relays also serve other function of preventing over fluxing of a transformer as we know all the electrical machines operate on the constant V/f ratio. If the frequency collapses, flux in the core will increase leading to over fluxing and saturation. If such situation prevails for short time but repeated in the system, the magnetizing current will increase and thus it will lead to more iron losses in the system.

➤ **Static Relaying Philosophy:**

In such relays, transistor – transistor logic is used to make the relays compact in nature and multi functions. These relays requires less power for operation, immune to mechanical vibration, less wear and tear as no rotating part, fast acting as absence of mechanical parts but suffers from the effect of temperature and system voltage variations. The primary principle of operation remains the same.

➤ **Microprocessor Based Relaying Philosophy:**

They are an advanced version of relaying philosophy and far superior that their counter parts known as static relays. They are multi functions and compact and possess all the advantages of static relays. Besides, they are programmable and communicable. They possess a very unique feature of self diagnosis which no other relays possess. They have an embedded chip which functions as the heart of the system.

➤ **Distance Relaying Philosophy:**

In protection practice, the current based or the time based or the current - time based relaying scheme suffers from several disadvantages and hence the protection philosophy based on the constants measurements is hired which is known as distance relaying schemes. In this, the distance of the fault location is measured and then on the basis of selectivity, the relays will operate. The relays are classified as:

- Impedance relays (Plain)
- Reactance relays (Plain)
- Mho relays (Plain)
- Offset mho relay (Hybrid)

▪ **Conclusion:**

▪ **Questions:**

1. Draw the characteristics of IDMT – Normal Inverse / Very Inverse / Extremely Inverse relays.
2. Explain the Construction & working of Induction disc type relay.
3. Enlist only the applications of distance relaying schemes.
4. Is mho relay directional? Justify.
5. Draw and explain the zone protection.



# EXPERIMENT:

**Date:**

**Aim: To Obtain The Characteristics Of Over Current Relays.**

▪ **Specific Objectives:**

After performing the experiment, one should be able to know:

- The effect of T.S.M & magnitude of fault current on the relay operation time.
- The applications of over current relay.

▪ **Rationale:**

Over current protection is that protection in which the relay picks up when the magnitude of current exceeds the pickup level. The basic element in over current protection is an over current relays are connected to the system, normally by means of CT's. over current protection includes the protection from over loads. This is most widely used protection. Over loading of machine or equipment means the machine is taking more current than its rated current. Over current relay are used for the protection of motor, transformer, generator line etc. there is a wide variety of relay units. These are classify accordingly to their type and characteristics. The major characteristics include:

- Define characteristics.
- Inverse characteristics.
- Extremely Inverse characteristics.
- Very Inverse characteristics.

The characteristics with definite minimum time and of inverse type are also called Inverse Definite minimum time characteristics.

The basic terms of relays:

P.S. = Plug Setting = Relay current setting

P.S.M. = Plug Setting Multiplier = Fault current / Relay current setting

T.M.S. = Time Multiplier Setting

TOP = Time of Operation

Ideal TOP =  $[3/\log (P.S.M.)] * T.M.S.$

▪ **Procedure:**



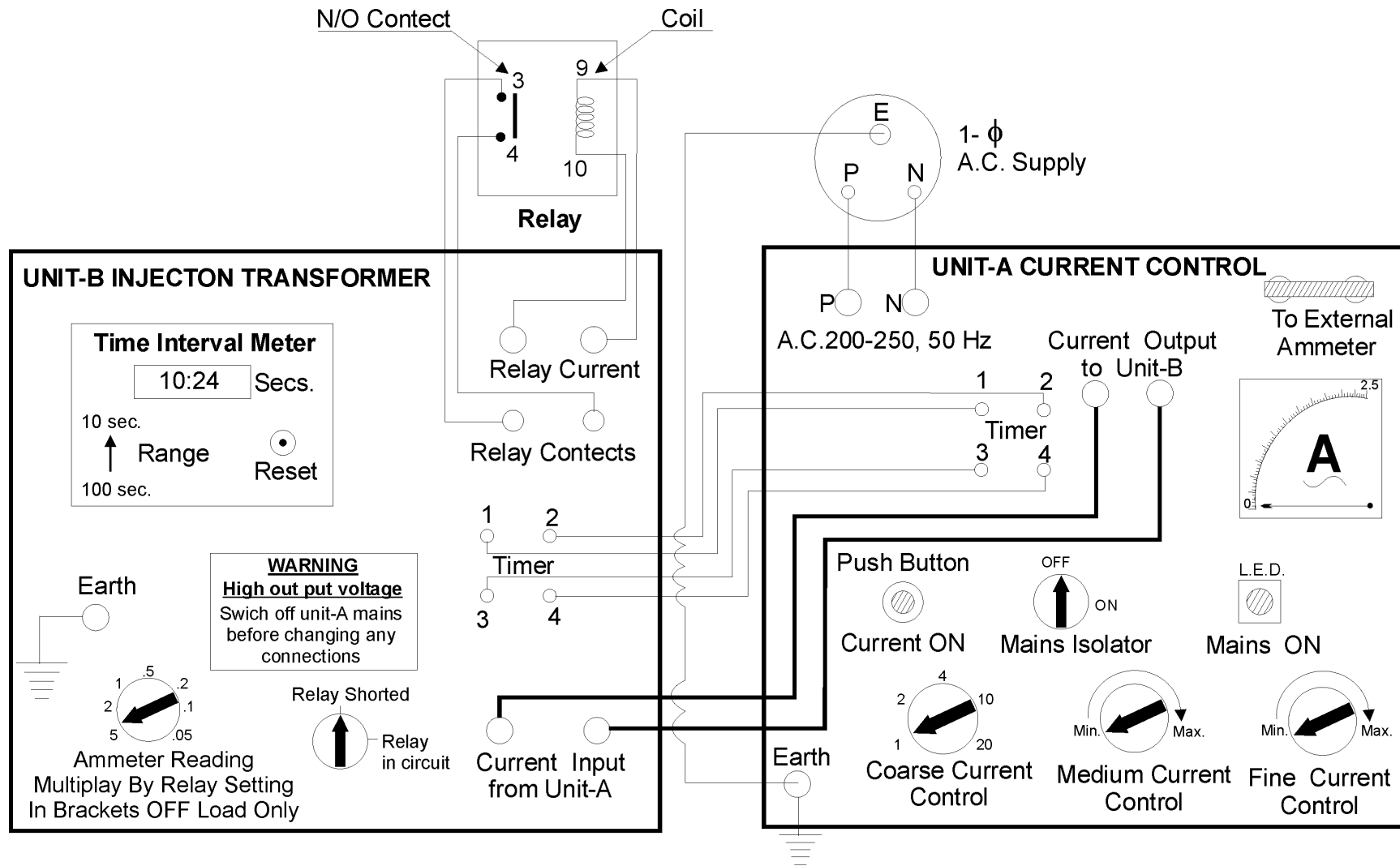
T.S.M. = \_\_\_\_\_

Type of Relay	P.S.	Current $A \times K_1 \times K_2$	P.S.M.	Actual TOP	Ideal TOP

- **Conclusion:**

- **Questions:**

1. What is the difference between plug setting & pick up value of an O/C relay?
2. For grading relays with the fuse or MCB, what setting of TMS, you will make on relay? Relatively lower or higher? Why?
3. State the various applications of O/C relay?
4. Distinguish between an E/F relay & an O/C relay?
5. Define the following terms as applied to protective relays: Reset, Operating time, Reach, Over Reach, Under Reach, and Burden.



Connection Diagram for Obtaining Relay Characteristics

# **EXPERIMENT:**

**Date:**

**Aim: To Obtain The Characteristics Of Earth Fault Relays.**

▪ **Specific Objectives:**

After performing the experiment, one should be able to know:

- The effect of T.S.M & magnitude of fault current on the relay operation time.
- The applications of E/F relay.

▪ **Rationale:**

Earth fault which involves ground is called an earth fault. Examples are single line to ground (L-G) fault and double line to ground (2L-G) fault. Faults which do not involve ground are called phase faults. The protective scheme is used for the protection of an element of a power system of against earth fault is known as earth fault protection. Similarly, scheme used for protection against phase faults is known as phase fault protection. Relay which is used for the protection of a section of the power system against earth faults are called earth fault relays. Similarly, relays used for the protection of a section for the power system against phase faults are called phase fault relays or over current relays. The operating principles and constructional features of earth fault relays and phase fault relays are the same. They differ only in the current in the current levels of their operation. The plug setting for earth fault relays varies from 20% to 80% of the C.T. secondary rating in steps of 10%. Earth fault relays are more sensitive than the relays use for phase faults. The plug setting for phase fault relays varies from 50% to 200% of the C.T. secondary rating in steps of 25%.

▪ **Procedure:-**

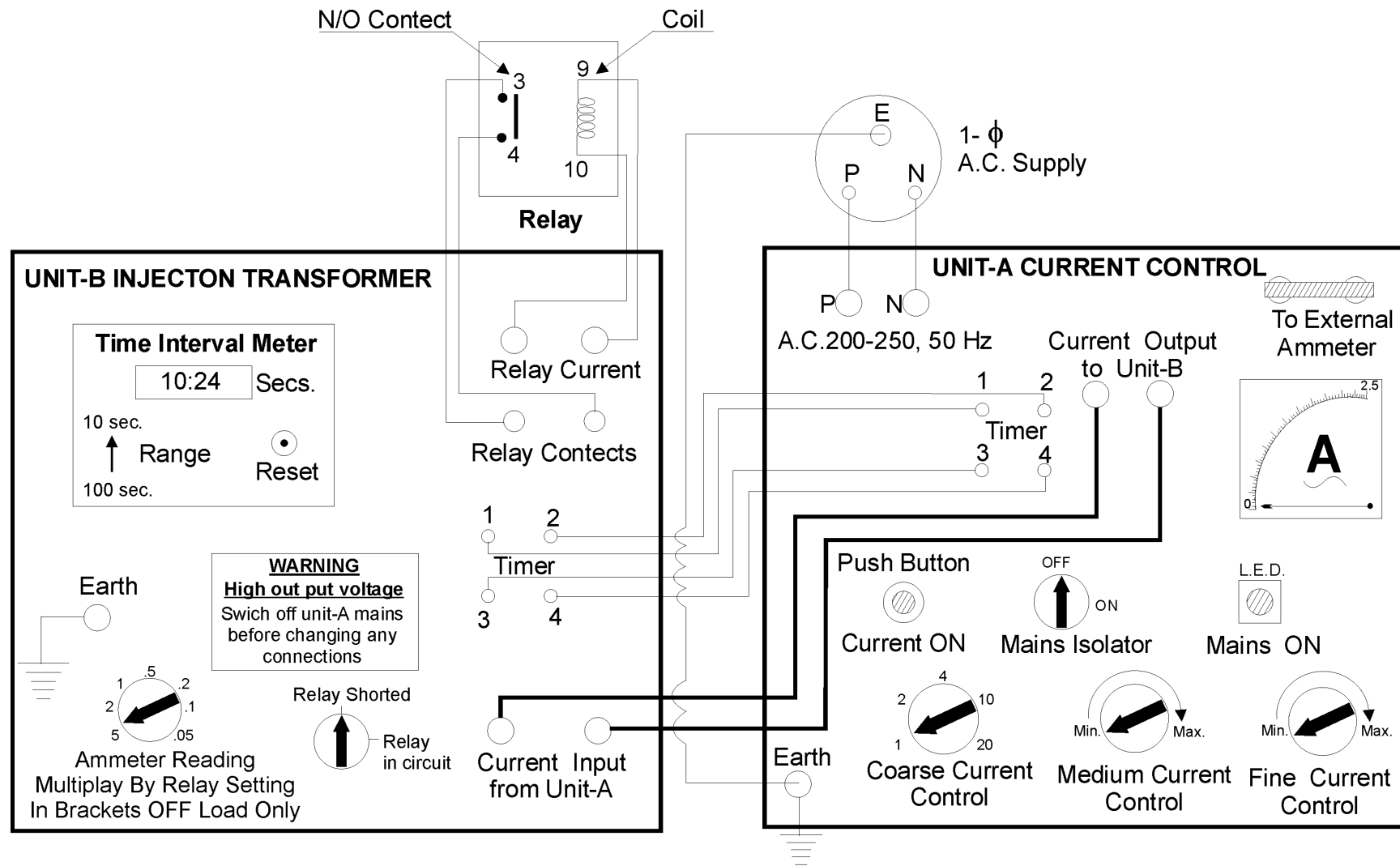
- Connect the circuit properly as per diagram.
- Check relay auxiliary contacts (for normal position)
- Put the position of switch to relay short on unit B
- Select suitable multiplying factor by varying coarse control switch K1 on unit A and coarse unit A and coarse control switch K2 on unit B.
- Set medium and fine current control at minimum position on unit A.
- Switch on main insulator on unit A (check indication also).
- Reset the timer on unit B, it should be zero, also select proper timer range (10 sec or 100 sec).
- Press the push button and keeping it pressed, set the current to a value just slightly higher than that required using the medium and fine control [Current ammeter reading  $\times K \times K2$ ]
- Change the position of switch from relay shorted to relaying in circuit on unit B.
- Allow the relay to operate while doing this check that the current is still
- Set at the required value.
- When relay trips take reading of timer [that is actual TOP] on unit B
- Switch OFF the main isolator



- **Conclusion:**

- **Questions:**

1. Why E/F relay is provided with current setting range of 20% to 80% of rated current compared to current setting range 50% to 200% for O/C relay?
2. Draw the figures for various E/F protective schemes.
3. How a directional E/F relay energized?
4. What is core balance C.T.? Explain its working principle.
5. Explain the term P.S.M. & T.M.S. with reference to IDMT relays.



**Connection Diagram for Obtaining Relay Characteristics**



# **EXPERIMENT:**

**Date:**

**Aim: To Perform the biased differential protection of 1- $\Phi$  transformer.**

▪ **Specific Objectives:**

After performing the experiment, one should be able to know:

- How the biased differential protection used for the protection of power system equipments.

▪ **Rationale:**

"A differential relay responds to vector difference between two or more similar electrical quantities ". From this definition the following aspect are known:

- The differential relay has at least two actuating quantities say  $I_1$  &  $I_2$ .
- The two or more actuating quantities should be similar i.e. current /current.
- The relay respond to the vector difference between the two i.e.  $I_1 - I_2$ , which includes magnitude and/or phase angle difference.

Differential protection is generally a unit protection. The protected zone is exactly determined by location of C.T.s the vector difference is achieved by suitable connections of current transformer or voltage transformer secondary.

➤ **Principle of Biased Differential Protection**

In protection of transformer, CT's are connected at each end of the transformer. The CT secondaries are connected in star or delta and pilot wires are connected between the CT's of each end. The CT connections and CT ratios are such that currents fed into the pilot wires from both the ends are equal during normal conditions and for through faults. During the internal faults such as phase to phase or phase to ground, the balance is disturbed. The out of balance current  $I_1 - I_2$  flows through the relay operating coils. To avoid unwanted operation on through faults restraining bias coil are provided in series with pilot wires. The ampere turns provided by bias coils or restraining coil are proportional to  $(I_1 - I_2) / 2$ .

As a result the restraining torque increases with through current and relay does not operate due to the difference in CT ratios for high values of short circuit currents.

➤ **CT connection:**

There is an inherent phase displacement between the voltage induced in the high voltage winding and low voltage winding. In case of star-delta transformer hence the load current on the high voltage side is displaced in phase with respect to load current on low voltage side. The power transformer are grouped according to the phase displacement e.g,

- Group-1: Star-Star, phase displacement =  $0^{\circ}$
- Group-2: Star-Star, phase displacement =  $180^{\circ}$
- Group-3: Delta-Star, phase displacement =  $-30^{\circ}$
- Group-4: Delta-Star, phase displacement =  $+30^{\circ}$

In the circulating current differential protection, the phase displacement in line current on two sides introduces phase differences in secondary current of C.T.s on two sides.

The CT connection should be such that the resultant current fed into the pilot wires from either side are displaced in phase by an angle equal to the phase shift between the primary and secondary currents.

To get this arrangement, following rules are adopted.

- Secondary of C.T.s on star connected side of power transformer are connected in delta.
- Secondary of C.T.s on delta connected side of power transformer are connected in star.

With this arrangement the phase displacement between currents gets cancelled with the phase displacement due to star/delta connection of CT secondary.

➤ **CT Ratio:**

Current ratio of C.T.s on each side will be different depending upon the line currents of power transformer and connections of C.T.s. the currents fed into the pilots from each side should be the same for normal condition. Suppose current required in the pilot wire is 5Amp. Then secondary rating of the CT which is connected in star side of power transformer must be equal to 5 Amp. And secondary rating of CT which is connected on the delta side of power transformer must be equal to  $5/\sqrt{3}$  Amp. Refer fig. (3) Which gives differential protection scheme for Y/ $\Delta$  power transformer considering CT connection and CT ratio aspect?

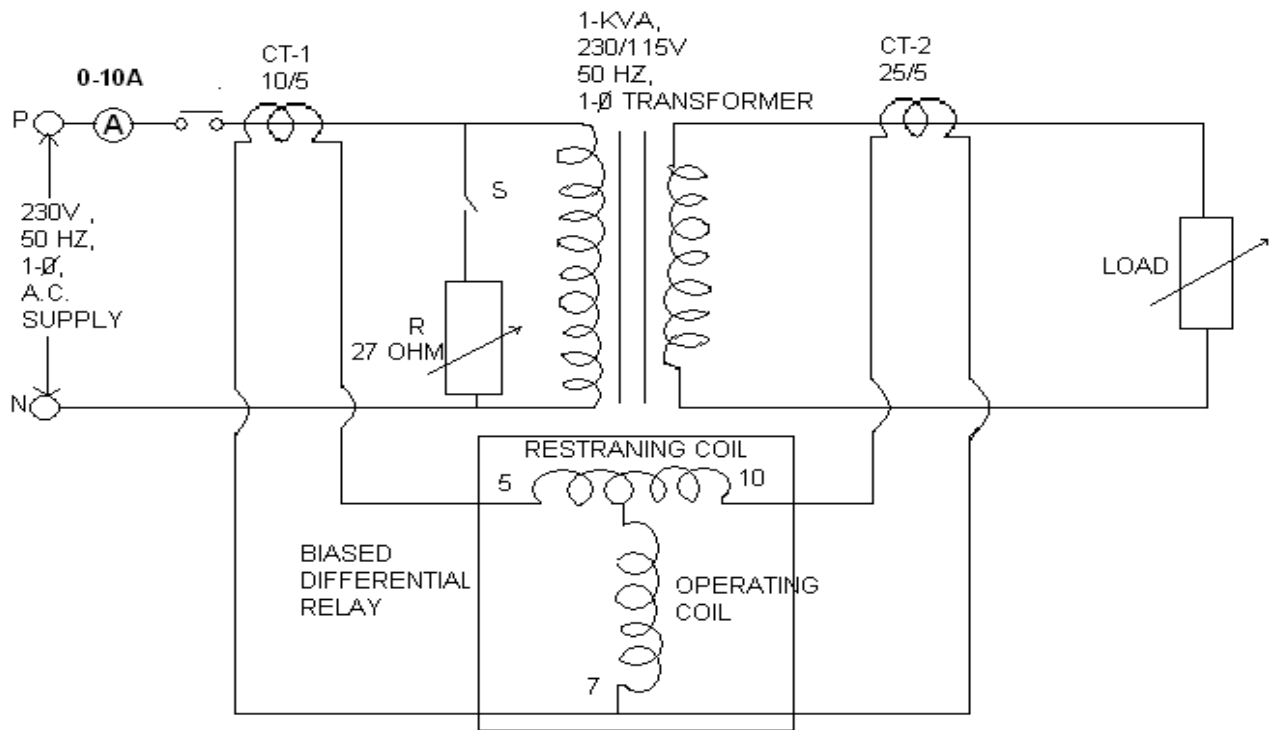
▪ **Procedure:**

- Connect the circuit as shown in figure.
- Apply the rated voltage to the H.V. winding of the transformer.
- Apply the load & create the artificial fault in the circuit.
- Clear the fault & reduce the applied voltage to zero to release the contactor.
- Again apply the rated voltage with increased load.
- Repeat the above procedure for different loads.
- See the fault current in the ammeter connected in the circuit.

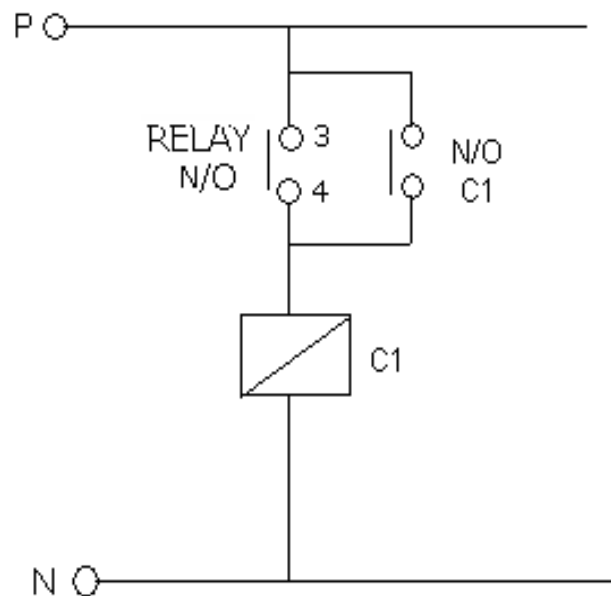
- **Conclusion:**

- **Questions:**

1. What is spill current?
2. Explain the biasing in case of transformer differential protection?
3. Why the C.T.s on the star side of transformer winding is connected in delta and C.T.s on delta side of transformer winding is connected in star?
4. Why high set element is provided in harmonic restraint relay?
5. Draw and explain the restricted earth fault protection of transformer.



**POWER CIRCUIT**



**CONTROL CIRCUIT**

**Biased Differential Protection of Single Phase Transformer**

# EXPERIMENT:

**Date:**

**Aim: To Perform the Radial Feeder Protection.**

▪ **Specific Objectives:**

After performing the experiment, one should be able to know:

- Different protection schemes used for the protection of radial feeder
- Use of time grading, current grading and combine time and current grading systems

▪ **Rationale:**

The radial feeder is the back bone of any large power system and it connects the primary distribution with the generating source and hence an elaborated protective gear is required for them. The usual practice for their protection is to use:

- Current graded system
- Time graded system
- Current – time graded system
- Distance protection

The first two relaying schemes are not used in practice due to their Demerits. The third system is hired for small networks or in large networks, but nearer to the load end. The panel which we are going to study has the third type of protective gears. In such a system, the IDMT relays are used and their coordination is carried out in order to avail the benefits of back – up protections. In such a system, the radial feeder is divided in zones and the individual zone protection takes care of any fault in its zone. Should the zone protection fail to operate due to any reason, the zone in the direction of generating or feeding source will take care of that fault but after a pre determined time lag and will serve as a back up protection. Usually for any main protection, two back up protections are employed. The back up protection coordination does not mean delayed operation for in – zone faults. For such faults, the protection should be fast and without any intentional time lag. Every IDMT relay has an in – built high set unit for instantaneous tripping under very heavy faults. Of course, the used system suffers from several demerits but has proved to be one of the effective ways to protect the radial feeder.

▪ **Procedure:**

- Trace the circuit at the back of the panel before switching the mains.
- Switch on the MCB at the back of the panel.
- Note the status of semaphore indicators on the panel.
- Press three START push buttons  $S_1$ ,  $S_2$  and  $S_3$  in sequence.
- Note the changed status of semaphore indicators which simulate circuit breaker in the system.
- You must have an ON “healthy panel” indication.
- Now close switch  $S_3$
- Start the timer at the instant of closing.

- Note the time of operation of relay R<sub>3</sub> from the timer and fault current from the ammeter on the panel.
- Open the switch S<sub>3</sub> and note the changed status of semaphore indicator on the panel.
- Change the value of T.M.S. of the relay R<sub>3</sub> and press S<sub>3</sub>.
- Repeat the steps.
- Now close switch S<sub>2</sub> and then observe similar readings.
- Now close switch S<sub>1</sub> and then observe similar readings.

▪ **Precaution:**

- After operation of any of the relays, do not forget to open the concerned switch.
- Do not touch any of the metal parts on the relay while changing T.M.S. or P.S. as the main supply is directly available.
- Verify that the relay coil is properly connected across C.T. secondary so that no over voltage results.
- You may connect additional load bank for higher value of current but in doing so the studs on the panels will be having 230 V, and hence keep yourself away from that.

▪ **Observation Table:**

**Case – I: Switch S<sub>3</sub> Closed**

Sr. No.	Relay R <sub>1</sub>			Relay R <sub>2</sub>			Relay R <sub>3</sub>			I Amp
	P.S.	T.M.S.	TOP	P.S.	T.M.S.	TOP	P.S.	T.M.S.	TOP	

**Case – II: Switch S<sub>2</sub> Closed**

Sr. No.	Relay R <sub>1</sub>			Relay R <sub>2</sub>			Relay R <sub>3</sub>			I Amp
	P.S.	T.M.S.	TOP	P.S.	T.M.S.	TOP	P.S.	T.M.S.	TOP	

**Case – III: Switch S<sub>1</sub> Closed**

Sr. No.	Relay R <sub>1</sub>			Relay R <sub>2</sub>			Relay R <sub>3</sub>			I Amp
	P.S.	T.M.S.	TOP	P.S.	T.M.S.	TOP	P.S.	T.M.S.	TOP	

P.S. = Plug Setting

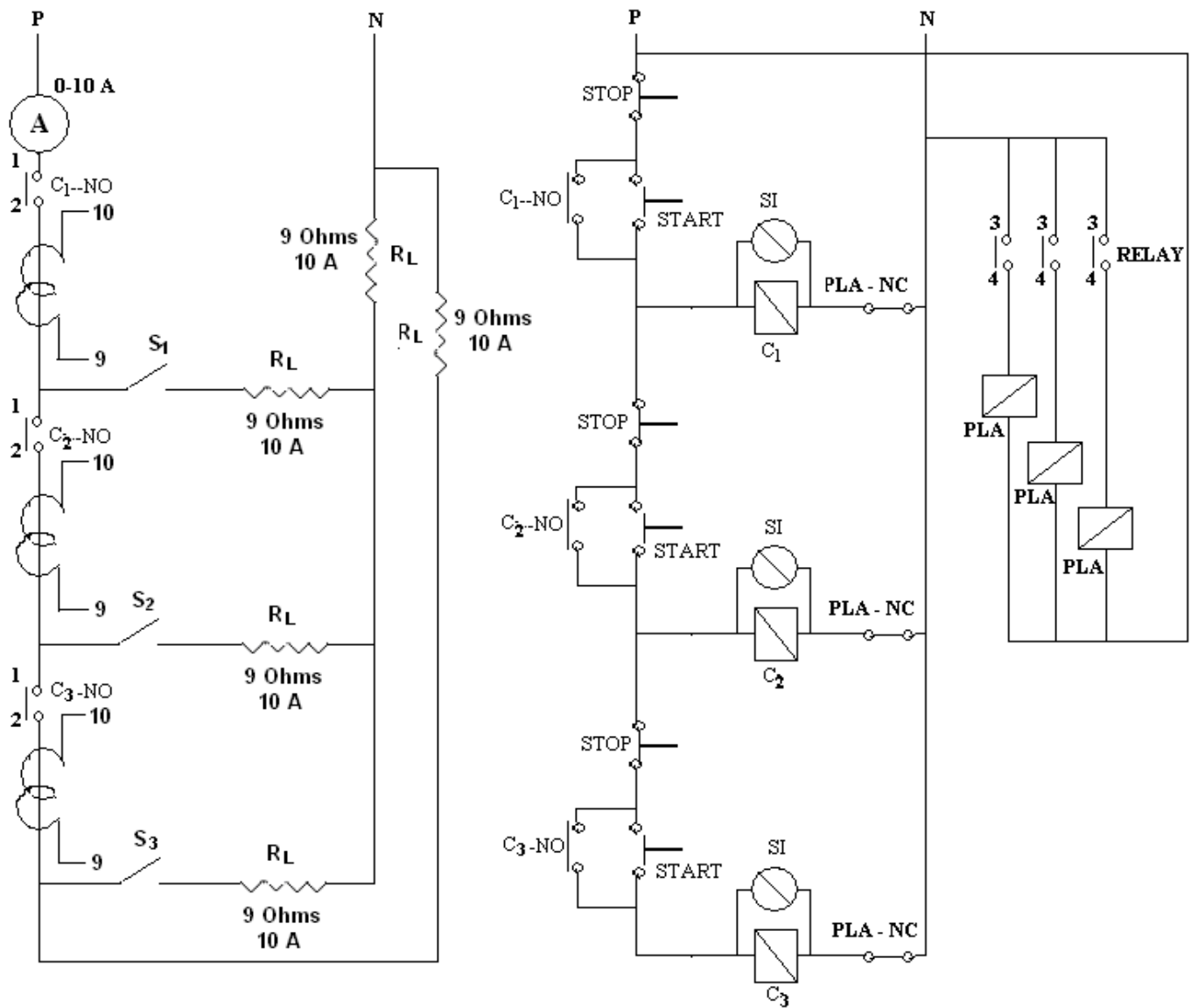
T.M.S. = Time Multiplier Setting

TOP = Time of Operation

▪ **Conclusion:**

▪ **Questions:**

1. Enlist only the demerits of current graded and time graded system.
2. Enlist only the demerits of current time graded system.
3. Explain working of radial feeder protection scheme.
4. Which distance relay you will use for long, medium and short transmission line and why?
5. What is the function of line trap and coupling capacitor in carrier current protection?
6. What is offset mho characteristic and why it is required?



**Power and Control Circuit for Radial Feeder Protection**



# EXPERIMENT:

Date:

**Aim: To Perform the Parallel Feeder Protection.**

▪ **Specific Objectives:**

After performing the experiment, one should be able to know:

- Different protective schemes used for the parallel feeder
- Use of directional relay in parallel feeder protection

▪ **Rationale:**

When the power to be transmitted is bulk in nature and to be transmitted over a long distance, then to reduce the over all reactance and hence improve the maximum power transfer possible, use of parallel feeders is compulsory. The parallel feeder is to be designed for maximum capacity and normally carries half the load and hence the utilization factor for them is very poor. The usual current time graded philosophy fails to provide adequate protection in their case and hence in addition to the IDMT relays, direction relays are to be installed on them. The panel that we have also has the directional relays. It is to be noted that the IDMT and the directional relays are to be crossed coordinated. The directional relay we have is not a self powered relay.

▪ **Procedure:**

- Trace the circuit at the back of the panel before switching the mains
- Provide the auxiliary to the directional relay.
- Switch on the MCB at the back of the panel.
- Note the status of semaphore indicators on the panel.
- Press three START push buttons  $S_1$ ,  $S_2$ .
- Note that unlike radial feeder protection panel, here we can press any push button first and energize any of the parallel feeders.
- Note the changed status of semaphore indicators which simulate circuit breaker in the system.
- You must have an ON "healthy panel" indication.
- Now close switch  $S_1$  and start the timer at the instant of closing.
- Note the time of operation of relays  $R_1$  and  $R_3$  from the timer and fault current from the ammeter on the panel.
- Open the switch  $S_2$  and note the changed status of semaphore indicators on the panel.
- Now close switch  $S_2$  and start the timer at the instant of closing.
- Repeat the steps from 10 and 11 for relays  $R_2$  and  $R_4$ .

▪ **Precaution:**

- After operation of any of the relays, do not forget to open the concerned switch.
- Do not touch any of the metal parts on the relay while changing T.M.S. or P.S. as the main supply is directly available.

- Verify that the relay coil is properly connected across C.T. secondary so that no over voltage results.
- You may connect additional load bank for higher value of current but in doing so the studs on the panels will be having 230 V, and hence keep yourself away from that.

▪ **Observation Table:**

**Case – I: Switch S<sub>1</sub> Closed**

Sr. No.	Relay R <sub>1</sub>			Relay R <sub>2</sub>			Relay R <sub>3</sub>			Relay R <sub>4</sub>			I Amp.
	PS	TMS	TOP	PS	TMS	TOP	PS	TMS	TOP	PS	TMS	TOP	

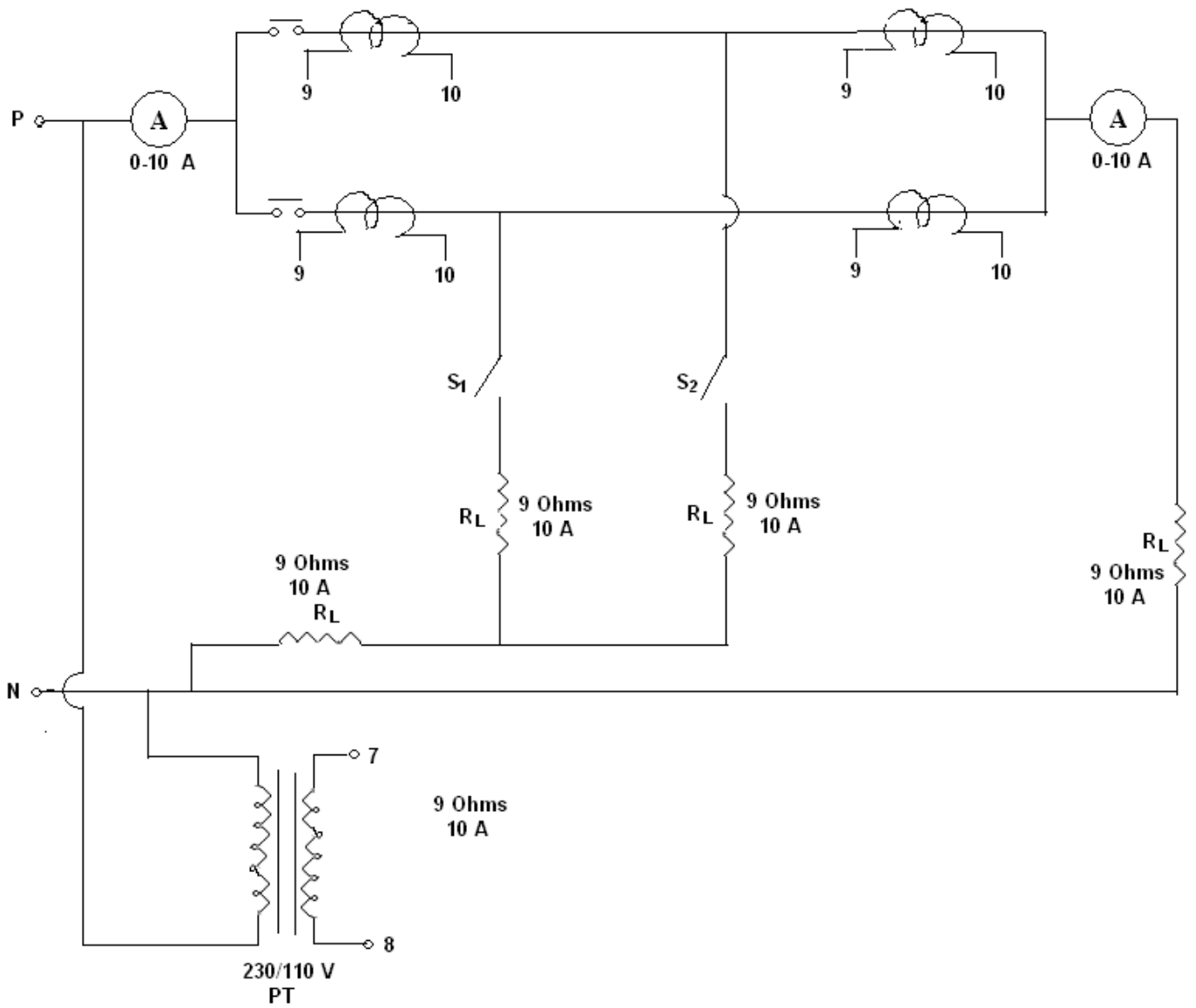
**Case – II: Switch S<sub>2</sub> Closed**

Sr. No.	Relay R <sub>1</sub>			Relay R <sub>2</sub>			Relay R <sub>3</sub>			Relay R <sub>4</sub>			I Amp.
	PS	TMS	TOP	PS	TMS	TOP	PS	TMS	TOP	PS	TMS	TOP	

▪ **Conclusion:**

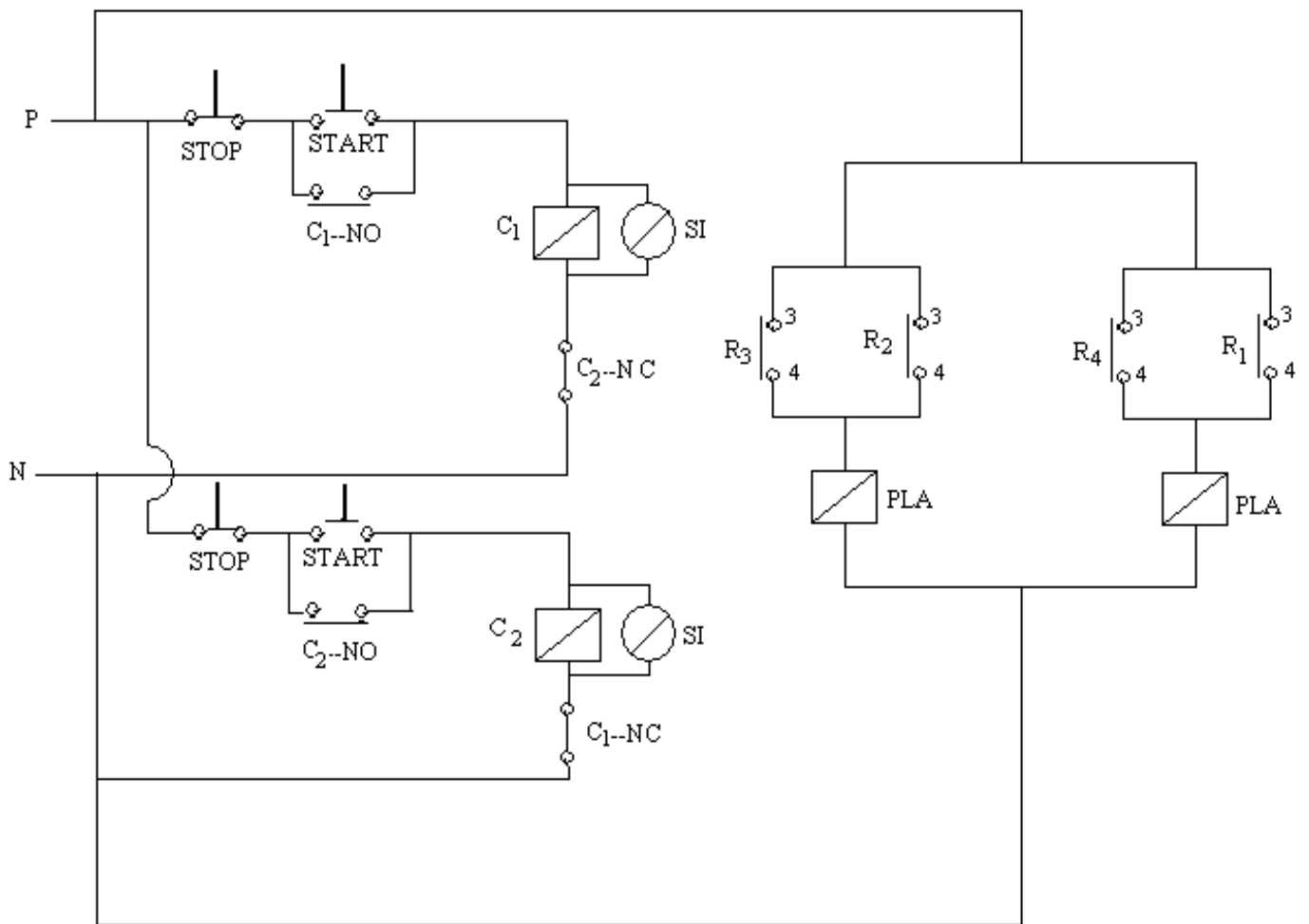
▪ **Questions:**

1. Explain 30<sup>0</sup>, 60<sup>0</sup> and 90<sup>0</sup> connections for directional relay.
2. Draw the directional relay characteristics for an MTA of 45 degree and label different zones on it.
3. Justify, "For the parallel feeder protection, the relays nearer to the generating station are non directional in nature while those away from it are directional in nature."
4. What do you understand by cross coordination of relays in parallel feeder protection?



POWER CIRCUIT

### Parallel Feeder Protection



CONTROL CIRCUIT

### Parallel Feeder Protection

# **EXPERIMENT:**

**Date:**

**Aim: To Perform The Protection of Three Phase Induction Motor.**

▪ **Specific Objectives:**

After performing the experiment, one should be able to know:

- Different protective schemes used for three phase induction motor
- Necessity of protection of three phase induction motor

▪ **Rationale:**

The induction motor is widely used in industries and hence its protection attains at most priority in any firm. Here first the control of induction motor is done and then its protection is applied. The major of the protection that we find in an induction motor are:

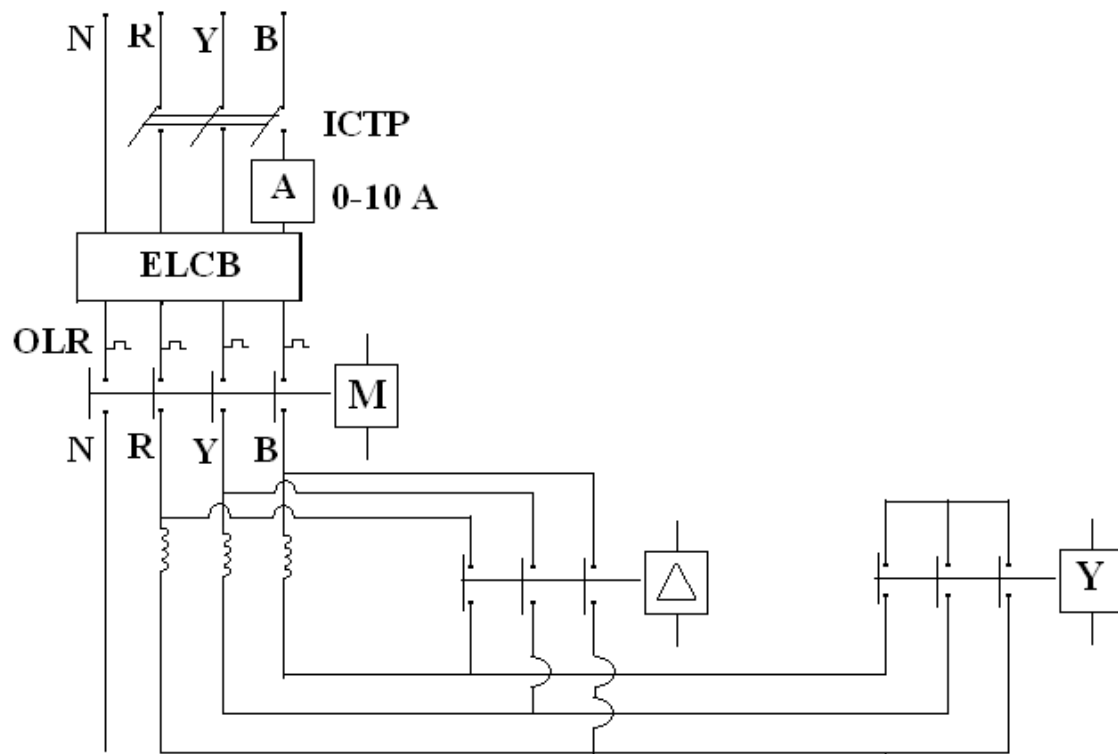
- Overload protection
- Single phasing protection
- Under voltage protection
- Negative phase sequence protection

The motor is to be protected against the thermal overload or the Motor will burn out due to its thermal insulation breakdown. While running, if the motor suffer a single phasing problem, it will start drawing more current and in certain cases, it will burn also. Under the condition of under voltage while working for the same power demand, the motor will start taking high current and hence it will once again suffer from its thermal breakdown of insulation. When the motor is supplied with the negative phase sequence current, the rotor will have a double frequency current flowing in it and hence it will overheat the motor.

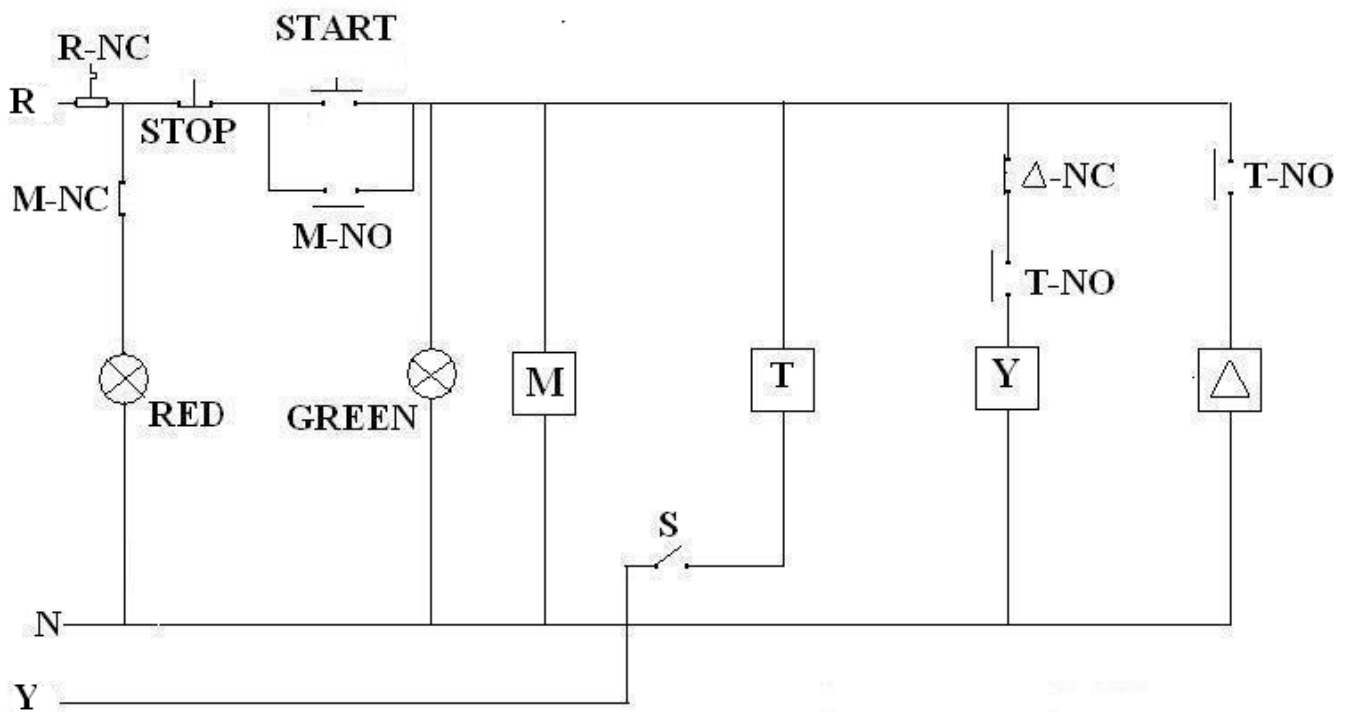
To protect the motor in such cases, the motor is supplied with the over load relay or bi-metallic relay to take care of any gradual or sudden overload. For protection against single phasing, the single phasing preventor is used.

▪ **Procedure:**

- Switch on the supply
- Press the start push button
- Let the motor run in STAR and then in DELTA.
- Draw your conclusion.



**POWER CIRCUIT OF STAR-DELTA STATER**



**CONTROL CIRCUIT OF STAR-DELTA STARTER**

- **Conclusion:**

- **Questions:**

- 1.** How will you select the rating of the bi-metallic relay for a given capacity of motor?
- 2.** Explain the working of Single Phasing Preventer.
- 3.** What modifications do you suggest to include the remaining protections of induction motor in the panel studied by you?
- 4.** Should you go for over voltage protection of motor as normally done for a generator? Why?
- 5.** Enlist the effects of negative phase sequence protection failure on the performance of motor?

## **EXPERIMENT:**

**Date:**

**Aim: To Perform C.T. Saturation Characteristics.**

▪ **Specific Objectives:**

After performing the experiment, one should be able to know:

- Effect of saturation on the operation of C.T.
- Difference between measuring C.T. and operating C.T.

▪ **Apparatus:**

- Voltmeter                      One (0-15V)
- Voltmeter                      One (0-30 V)
- Ammeter                        One (0-5A)
- C.T. 10/5 Amp
- Single phase auto transformer

▪ **Rationale:**

A saturation characteristic is a plot of open circuit voltage  $V/S$  excitation current of C.T. This curve is very important tool for deciding whether a C.T. is suitable for given application. The ratio error can also be checked using this curve. The curve can be experimentally obtained using a test set-up. The voltage should be gradually increased and ample number of reading for excitation current  $I_e$  and corresponding value of O.C. voltage  $E_s$  should be taken. Care should be taken to see that  $I_e$  time  $E_s$  does not exceed the rated burden of C.T.

The initial non-linear region is due to the fact that a small ampere turns supplied used in exciting the core. Hence C.T. does not reproduce the primary current the secondary side faithfully when it operates in this region. Thus at very small percentage of primary rated current the C.T. ratio error is large.

The excitation characteristic of a C.T. depends upon the cross-sectional area and length magnetic path of the core, the numbers of turns in the windings and the magnetic characteristics of the core material.

▪ **Procedure:**

- Connect the circuit.
- Gradually increase the voltage and take respective readings.
- Repeat step-2 until the knee point is obtained.
- Plot the graph.

▪ **Observation Table:**



Sr. No.	V primary Volt	I <sub>sec</sub> Amp	V <sub>sec</sub> Volt	VA
1.				
2.				
3.				
4.				
5.				

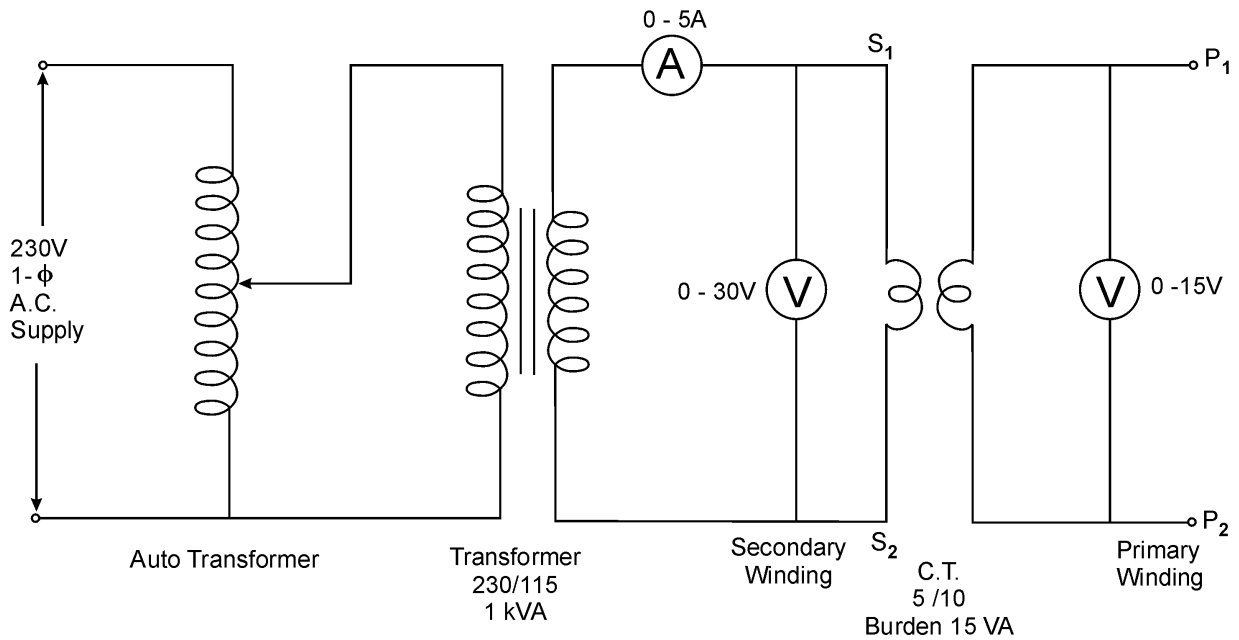
▪ **Precautions:**

While performing this experiment, Give supply through the auto transformer to the C.T. secondary and primary should be open. Increase supply voltage slowly.

▪ **Conclusion:**

▪ **Questions:**

1. Explain the term burden.
2. Why C.T. secondary is never kept open?
3. For same rating can measuring C.T. replaces protective C.T. and for the same rating can protective C.T. replaces measuring C.T.? Justify.
4. Explain the 0.1 accuracy class.
5. Explain the meaning of each term in 5P10 C.T. rating.



**Circuit Diagram to Obtain Saturation Characteristics of Current Transformer**

# **EXPERIMENT:**

**Date:**

**Aim: To Obtain The Characteristic of Miniature Circuit Breaker (MCB).**

▪ **Specific Objectives:**

After having performed the experiment, one should be able to:

- Know the Characteristics and selection of MCB for over load protection and short circuit protection for low power circuits.

▪ **Apparatus:**

- MCB (2 A)
- Ammeter (0-10 A)
- Lamp load
- Stop Watch
- Single Auto Transformer

▪ **Rationale:**

Miniature circuit breakers have evolved in the latest development of circuit breakers, particularly for low power circuits, 440 V applications. For high current rating, molded case circuit breakers (MCCBS) are used. The MCBS can replace fuses in many applications like house wiring, commercial and industrial applications.

Fuse, when fuses, has to be replaced; while in case of MCB, one has just to make it on when it becomes off due to fault current or overload. Also for fuses there are chances of a person replacing higher capacity of a fuse wire which will endanger the equipment which the fuse is protecting. In case of MCB, such difficulty is not there because MCB is a sealed unit and there is nothing to be replaced when it becomes off on fault. MCB has comparatively better defined characteristics with reference to fuses. MCB can be well coordinated with fuses, induction motors and characteristics of circuit breaker which fuses, induction motors and characteristics of circuit breaker which is breaking up the MCB for protection of a feeder.

MCB cover is molded using thermo seating powder having high dielectric strength. Inside the cover, MCB contains current carrying, arc chute, tripping mechanism, instantaneous electromagnetic tripling arrangement etc.

The conductor is made of copper and takes different forms like a coil for instantaneous electromagnetic tripling arrangement. The bimetal also carries the current and if the current crosses the rated value, bimetal, because of temperature developed by heating, bends and actuates the tripling mechanism. Therefore MCB trips. Tripping mechanism is trip-free.

The contacts are of silver, silver-tungsten or copper tungsten depending on short circuit capacity. Arc chute is used for splitting the arc, so that arc is cooled, split, lengthened and quenched fast.

Instantaneous tripping arrangement is so adjusted that the electromagnetic attracting force generated by a coil of conductor is not enough to attract an armature (which is responsible for actuating the tripping mechanism) at lower current at which thermal bimetallic tripping action works. E.g. bimetallic will actuate the tripping mechanism up to say 40 A for a 5-A MCB. Beyond this current, electromagnetic attracting force increases to a value which attracts the armature, which in turn actuates the tripping mechanism and hence MCB trips instantaneously (i.e. within 3 cycles).

MCBs are available in single-pole, double-pole, three-pole or four-pole versions.

▪ **Procedure:**

- Connect the circuit as per diagram.
- Make MCB off and keep the shorting switch 'on'.
- Make the connector 'on' by a 5 amp. Switch.
- Adjust the load current to about the 2 amp.
- Make the MCB 'on' and shorting switch 'off'.
- Observe that the MCB does not operate.
- Now make the shorting switch 'on' and MCB 'off'.
- Adjust the load current at about 4 amp.
- Make the shorting switch 'off' and MCB 'on'.
- Be ready with the stop watch.
- MCB will trip as per its characteristics and stop.
- Note down the current and time of operation of MCB.
- Repeat the procedure (sr. No. 7 to 12) for currents 6,8,10, amp.
- Tabulate the readings as shown in observation table.
- Observe the graph of tripping time v/s current. Draw your own conclusion.

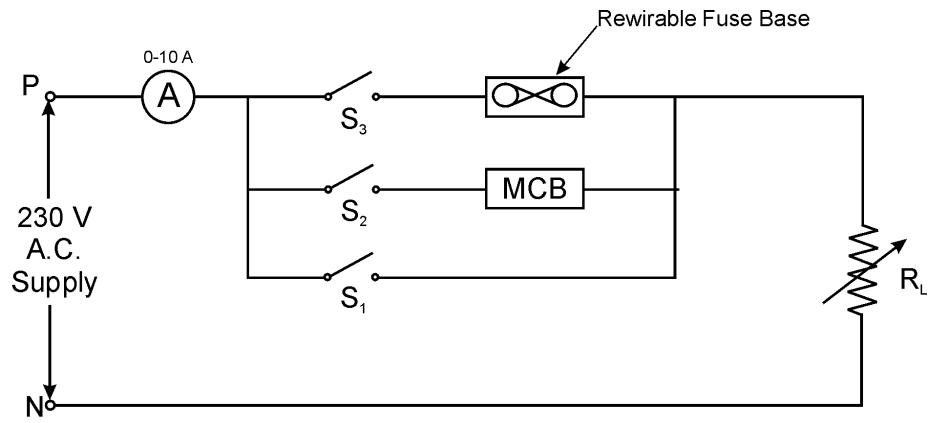
▪ **Observation:**

Sr. No.	Current through MCB(amp)	Operating Time(Sec.)
1.		
2.		
3.		
4.		
5.		

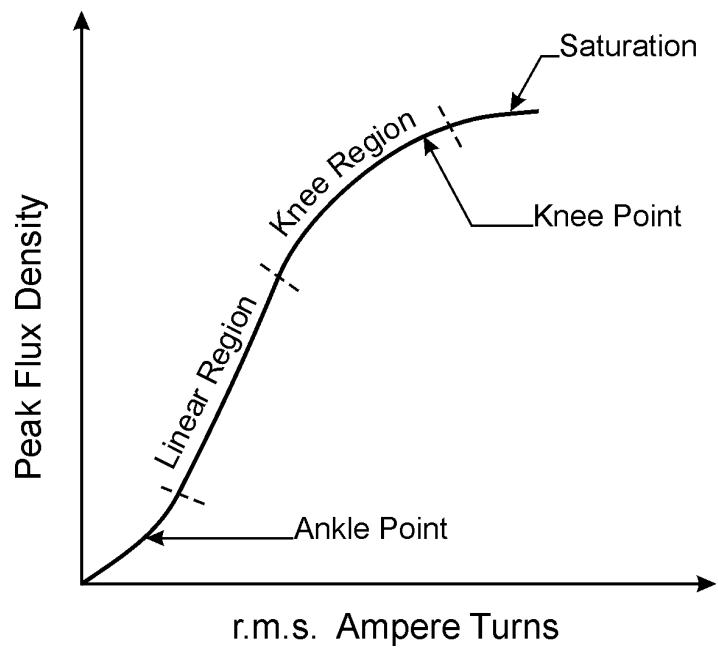
▪ **Conclusion:**

▪ **Questions:**

1. What is the difference between the fuse and MCB?
2. How is the arc extinguished in MCB?
3. What do you understand by trip-free tripping mechanism of an MCB?
4. What is the difference between MCB & ELCB?
5. Give the different ratings of MCBs available in market?



Circuit Diagram for Obtain Characteristics of Fuse & MCB



# **EXPERIMENT:**

**Date:**

**Aim: To Study Static Relay SPAJ 140C.**

▪ **Specific Objectives:**

- After performing the experiment, one should be able to know:
- Construction and working of Static Relay SPAJ 140C.

▪ **Rationale:**

The combined over current & earth fault relay SPAJ140C is intended to be used for the selective short circuit and earth fault protection of radial feeder in solidly earthed, resistance or impedance earthed power system.

The integrated protection relay includes a phase over current & earth fault unit with tripping & signaling facilities. The over current & earth fault relay can also be used for applications requiring single, two or three phase over current & earth fault features. The relay also features circuit breaker failure protection (CBFP)

**Features:**

1. Three phase low set over current unit with definite & IDMT characteristics
2. Three phase high set over current unit with instantaneous & definite time characteristics.
3. Low set earth fault unit with definite time & IDMT characteristics.
4. High set earth fault unit with instantaneous characteristics.
5. Breaker failure protection.
6. Numerical display of setting values, measuring values and memorized fault values.
7. Enhanced system reliability and availability due to software self-supervision with auto diagnosis.
8. Software support for setting & recording of relay parameters with portable PC.

**Description of characteristics:**

Low set unit of over current and earth fault gives seven curves:

1. Definite time
2. Extremely inverse
3. Very inverse
4. Normal inverse
5. Long time inverse
6. RI type
7. RXIDG type

**Description of operation:**

There are six output relays inside the relay module.

1. Output relay A is a heavy-duty trip relay capable of controlling main circuit breaker.
2. Output relay B and C can be used for signaling on operation of relay module. Normally relay B is used for signaling over current unit and relay C is used for earth fault unit.
3. The start signals of relay of protection stages of the relay are routed to output relay D.

4. The output relay E is a heavy-duty relay as output relay A. It can be controlled by start and operate signal of protection stages. This relay can also be used as trip relay for circuit breaker failure protection.

The functions of blocking and start signals are selected with the switches of switch groups SGF, SGB and SGR. The checksum of the switch groups are found in the setting menu of the protection relay module.

SGF switch groups for functions

SGB switch groups for blocking

SGR switch groups for relay configuration.

These switch groups are not to be found physically in hardware of relay but they are software based. Programming (0 or 1) of different switch groups is explained in relevant table for SGF, SGB & SGR.

O/P relay	Signal received from o/p relay
A	TS2
B	SS3
C	SS2
D	SS1
E	TS1
F	IRF

- The operate signals of different protection stages which are issued by O/P relay are routed to trip relay with switches 2,4,6,and 8 of switch group SGR 1.
- The signals to be routed to O/P relay B and C are selected with switches 1...8 of switch group SGR2.
- The signals to be routed to O/P relay D are selected by means of switches 1,3,5 and 7 of switch group SGR1.

e.g.

To select normal inverse characteristics for low set over current unit the position for SGF1 should be

SGF1/1=1

SGF1/2=1

SGF1/3=0

To activate breaker failure protection

SGF1/4=1

For automatic doubling of high set over current setting

SGF1/5=1

To select normal inverse characteristics for low set earth fault unit

SGF1/6=1

SGF1/7=1

SGF1/8=0

Switch No	Pos.	\weight	Value
SGF1/1	1	* 1	1
2	1	* 2	2
3	0	* 4	0
4	1	* 8	8
5	1	* 16	16



6	1	*	32	32
7	1	*	64	64
8	0	*	128	0
Check sum $\Sigma = 123$				

When check sum calculated according to example equals to checksum displayed by relay module the switches in concerned switch group are properly set.

#### Automatic doubling of high set o\c setting

Automatic doubling of high set start current of high set over current  $I >>$  is obtained when the protected object is energized.

This facility avoids mal-operation of relay during magnetizing inrush of transformer, capacitive inrush current, starting of I.M.

#### Circuit breaker failure protection:

This relay provides circuit breaker failure protection (CBFP). The CBFP unit generates a trip signal via ts1 of relay after a time set 0.1...1s, following the main trip signal ts2. If the fault has not been cleared before the set operate time has elapsed, the CBFP unit can be used for tripping via redundant trip circuit of same circuit breaker if circuit breaker provided with two trip coils.

Circuit breaker failure protection is enable\disable by switch SGF1/4.

#### **Memorized fault data:**

This relay memorizes last five fault data, which gives current of each phase during the fault. Relay does not contain battery back-up so if aux. supply is disconnected, the data of memory will be destroyed.

Relay is having inbuilt ammeter so it shows current of each phase during healthy condition.

#### **IRF (Internal Relay Failure):**

This is the facility, which indicates whether the relay is properly working or not. The facility can be checked by following procedure explained in next experiment.

#### **Technical data:**

##### 1. Low set o\c stage I>

Start current  $I >$

Definite time 0.5.... 5.0\*In

Inverse time 0.5.... 2.5\*In

Operate time  $t >$

Definite time 0.05...300sec

Inverse time characteristics Extremely inverse

Very inverse

Normal inverse

Long time inverse

RI inverse

RXIDG inverse

TMS (k) 0.05...1.00

##### 2. High set o\c stage I>>

Start current  $I >>$  0.5....40\*40 In and  $\infty$

Operating time  $t >>$  0.04...300 sec

### 3. Low set earth fault stage I0>

Start current I0>

Definite time

Inverse time 0.1...0.8\*In

Operate time to>

Definite time 0.05...300sec

Inverse time characteristics

- Extremely inverse
- Very inverse
- Normal inverse
- Long time inverse
- RI inverse
- RXIDG inverse

TMS (k) 0.05...1.00

### 4. High set earth fault I0>>

Start current I0>> 0.1...10.00\*In and ∞

Operating time to>> 0.04...300 sec

### 5. Auxiliary supply = 230 v a.c

### 6. Relay terminals:

C.T secondary quantity:

For 1A:

R	1-3
Y	4-6
B	7-9
N	25-27

For 5A:

R	1-2
Y	4-5
B	7-8
N	25-26

Trip signal: 65-66 (TS2)

Uaux: 61-62

CBFP : 74-75(TS1)

### Time/current characteristic:

#### 1. IDMT characteristic:

<b>Slope of the Time/current</b>	$\alpha$	$\beta$
Extremely inverse	2.0	80.0
Very inverse	1.0	13.5
Normal inverse	0.02	0.14
Long time inverse	1.0	120.0

$$t(s) = \frac{k \times \beta}{\left(\frac{I}{I >}\right)^\alpha - 1}$$

Where,

t = time of operation

k = TMS

I = measured current value

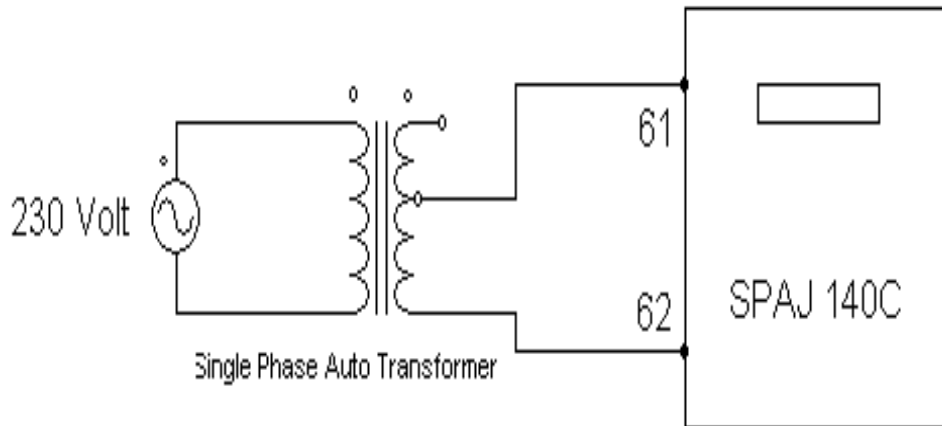
I> = pick-up current

#### 2. RI type

$$t(s) = \frac{k}{0.339 - 0.236 \frac{I >}{I}}$$

3. RXIDG type

$$t(s) = 5.8 - 1.35 * \log_e \left( \frac{I}{I > \times k} \right)$$



**Basic Connection of SPAJ 140C**

▪ **Conclusion:**

▪ **Questions:**

1. Write merits and demerits of static relays.
2. What is two over current one earth fault protection?
3. How are the logic gates applied in static relays?
4. Which are the basic elements of static relays?