BHARTIYA INSTITUTE OF ENGINEERING & TECHNOLOGY, SIKAR

Lab File

(POWER SYSTEM PROTECTION)

(6EE4-23)

Semester: 6th

Faculty: Mr. Deependra Rolania

(Asst. Professor)

Department of Electrical Engineering

6EE4-23: POWER SYSTEM PROTECTION LAB

Credit: 1 **Max. Marks: 50(IA:30, ETE:20)**
0L+0T+2P **End Term Exam: 2 Hours**

1. To determine fault type, fault impedance and fault location during single line to ground fault.
2. To determine fault type, fault impedance and fault location during single line-to-line fault.
3. To determine fault type, fault impedance and fault location during double line to ground fault.
4. To study the operation of micro-controller based over current relay in DMT type and IDMT type.
5. To analyse the operation of micro-controller based directional over current relay in DMT type and IDMT type.
6. To study the micro-controller based under voltage relay.
7. To study the micro-controller based over voltage relay.
8. To study the operation of micro-controller based un-biased single-phase differential relay.
9. To study the operation of micro-controller based biased single-phase differential relay.
10. To study the operation of micro-controller un-based biased three phase differential relay.
11. To study the operation of micro-controller based biased three phase differential relay.

EXPERIMENT NO. 1

OBJECT: - To determine fault type, fault impedance and fault location during single line to ground fault.

APPARATUS REQUIRED: -

1. Three phase fault analyser kit.
2. Auto Transformer
3. Three phase supply
4. Power Chords
5. Patch Chords

THEORY: -The occurrence of a short- circuit anywhere in the power system is known as fault at that point. Faults on power system basically classified into two types: symmetrical and unsymmetrical faults. Single line to ground fault come under the category of unsymmetrical faults. Any unsymmetrical fault causes unbalanced currents to flow in the system, this type of fault is also known as unbalanced fault.

For a single line to ground fault phase a is connected to ground at the fault point F. The fault impedance is Z_f. The fault current is I_a.

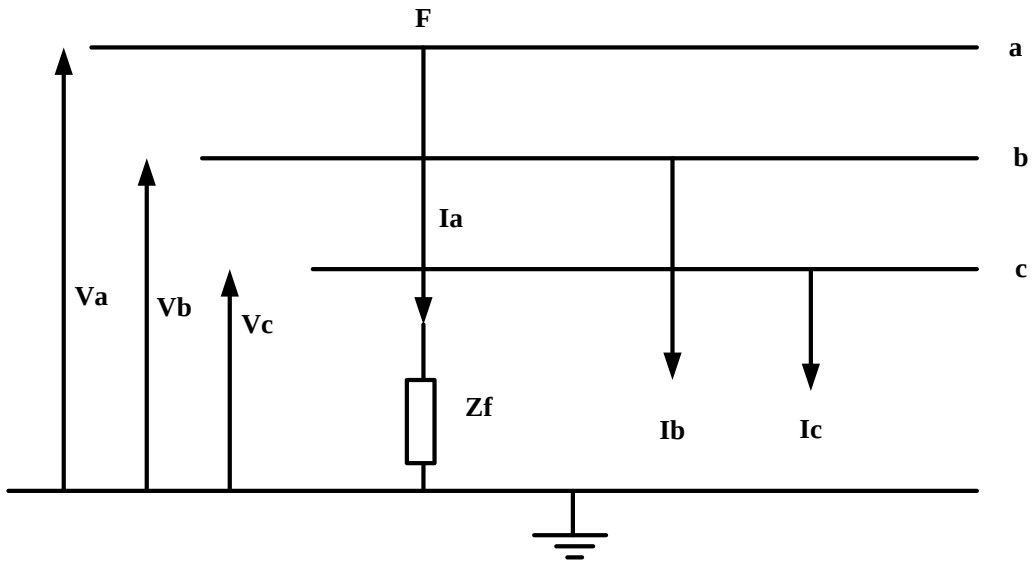


Fig. single line to ground fault

I_a= current fed to the fault by phase a

$I_b = 0$

$I_c = 0$

The symmetrical components of fault currents are

$I_{a1} = I_{a2} = I_{a0} = \frac{1}{3}I_a$

$V_{a1} + V_{a2} + V_{a0} = I_aZ_f = 3I_{a1}Z_f$

$V_a = I_aZ_f$

Fault impedance $Z_f = \frac{Va}{I_a}$

Sequence Network:

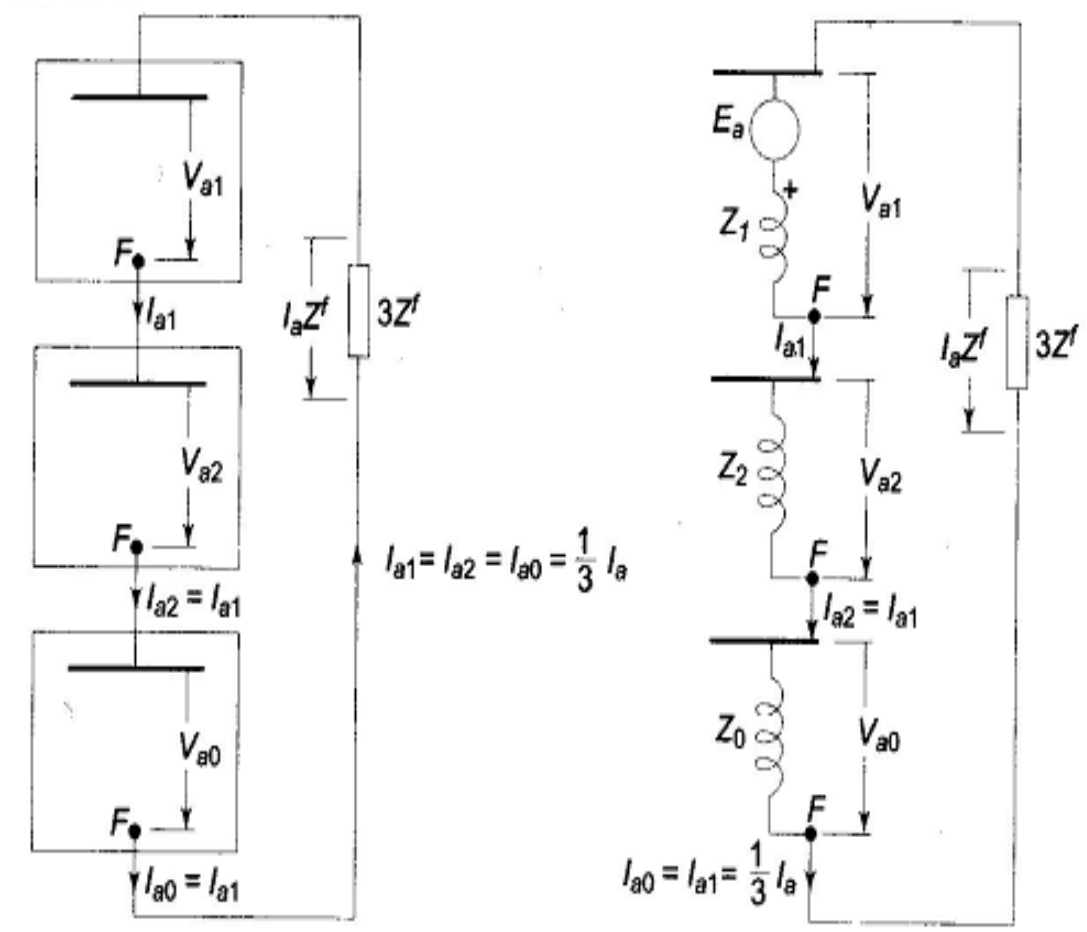


Fig. Interconnection of sequence network of single line to ground fault

OBSERVATION TABLE: -

S. No.	Fault current	Voltage	Fault impedance	Zero sequence current	Positive sequence current	Negative sequence current
1.						
2.						
3.						

RESULT: -

The fault impedance and fault current of a single line to ground fault are ……. ohm and …….. amp. respectively.

EXPERIMENT NO. 2

OBJECT: - To determine fault type, fault impedance and fault location during single line to line fault.

APPARATUS REQUIRED: -

1. Three phase fault analyser kit.
2. Auto Transformer
3. Three phase supply
4. Power Chords
5. Patch Chords

THEORY: -The occurrence of a short- circuit anywhere in the power system is known as fault at that point. Faults on power system basically classified into two types: symmetrical and unsymmetrical faults. Single line to ground fault come under the category of unsymmetrical faults. Any unsymmetrical fault causes unbalanced currents to flow in the system, this type of fault is also known as unbalanced fault.

A line to line fault occur when two conductors are short circuited. A three phase system with a line to line fault between phases b and c. the fault impedance is Z_f. The L-L fault is placed between lines b and c. The fault current is I_b.

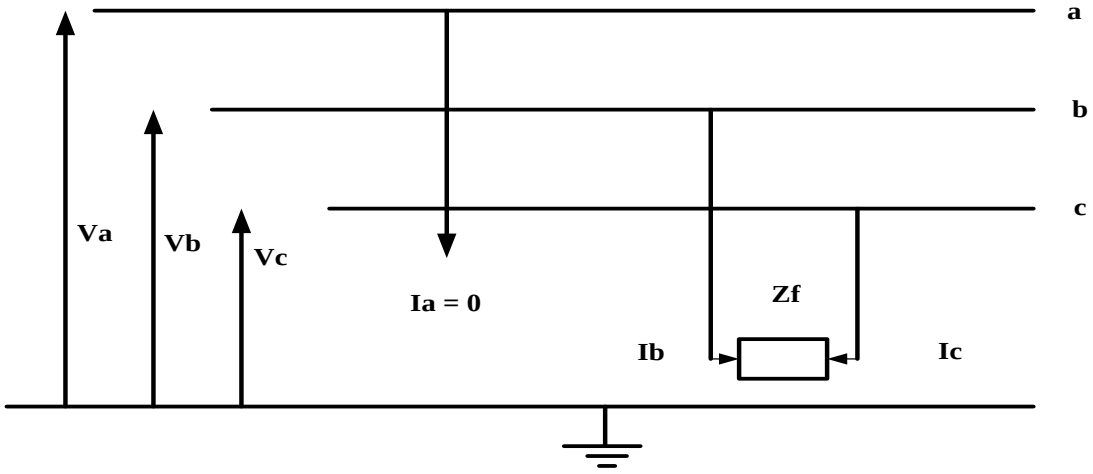


Fig. Line to line fault

$I_a = 0$

$I_b = -I_c$

$V_b - V_c = I_b Z_f$

Fault current $I_f = I_b$

The symmetrical components of fault currents are

$I_{a0} = 0$

$$I_{a1} = \frac{1}{3}(\alpha - \alpha^2) I_b$$

$$I_{a2} = -\frac{1}{3}(\alpha - \alpha^2) I_b$$

$$I_{a1} = -I_{a2}$$

$V_{a1} - V_{a2} = I_{a1} Z_f$

$V_{bc} = V_b - V_c$

Fault impedance $Z_f = \frac{V_{bc}}{I_b}$

Sequence Network:

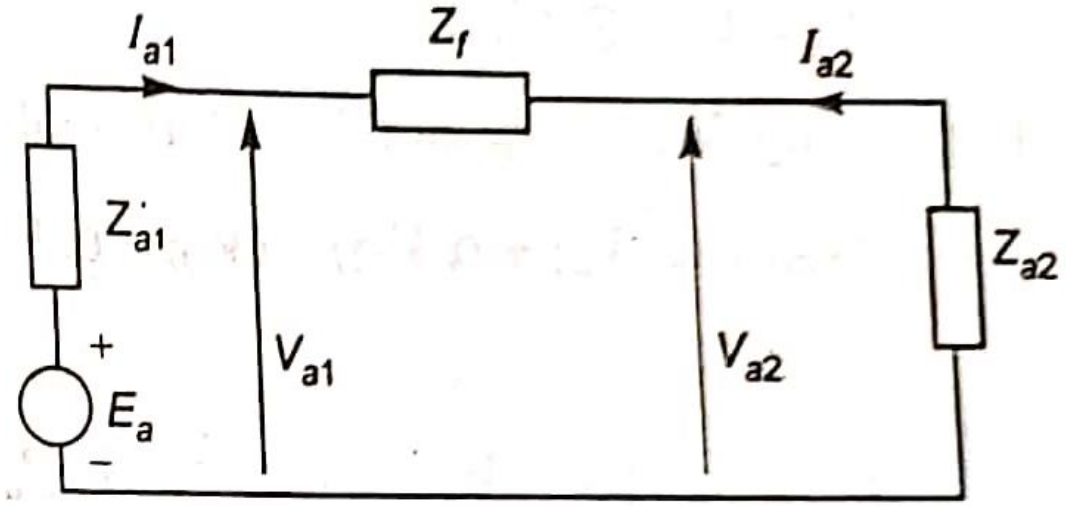


Fig. Interconnection of sequence network of line to line fault

OBSERVATION TABLE: -

S. No.	Fault current	Voltage	Fault impedance	Zero sequence current	Positive sequence current	Negative sequence current
1.						
2.						
3.						

RESULT: -

The fault impedance and fault current of a line to line fault are ……. ohm and …….. amp. respectively.

EXPERIMENT NO. 3

OBJECT: - To determine fault type, fault impedance and fault location during single line to line fault.

APPARATUS REQUIRED: -

1. Three phase fault analyser kit.
2. Auto Transformer
3. Three phase supply
4. Power Chords
5. Patch Chords

THEORY: -The occurrence of a short- circuit anywhere in the power system is known as fault at that point. Faults on power system basically classified into two types: symmetrical and unsymmetrical faults. Single line to ground fault come under the category of unsymmetrical faults. Any unsymmetrical fault causes unbalanced currents to flow in the system, this type of fault is also known as unbalanced fault.

The double line to ground fault occur when two conductors are short circuited with the ground. A three phase system with a phases b and c are faulted. the fault impedance is Z_f. The D-L-L fault is placed between lines b and c. The common line to ground fault impedance is Z_g.

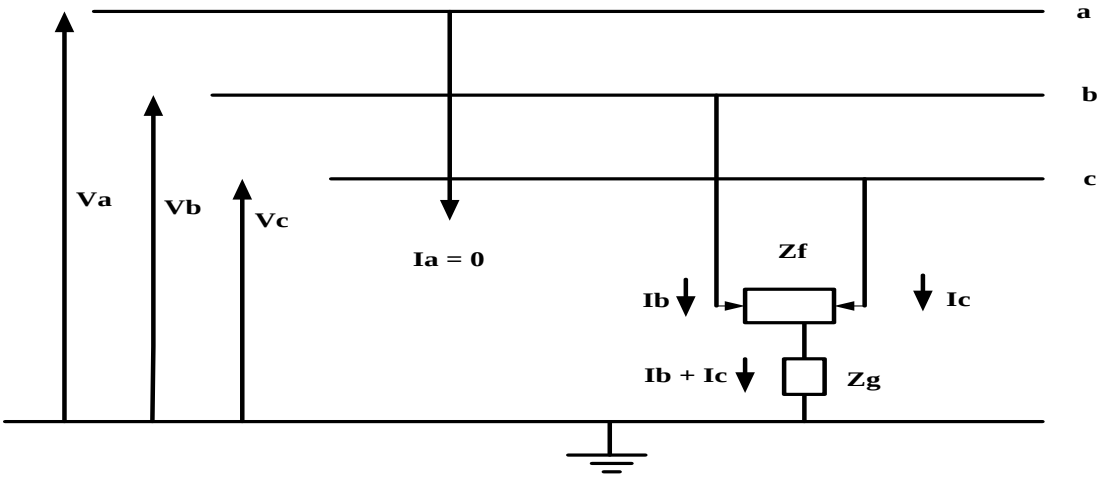


Fig. Double Line to ground fault

$I_a = 0$

$V_b = (Z_f + Z_g)I_b + Z_gI_c$

$V_c = (Z_f + Z_g)I_c + Z_gI_b$

$V_b - V_c = Z_f(I_b - I_c)$

Fault impedance $Z_f = \frac{V_{bc}}{I_b - I_c}$

Sequence Network:

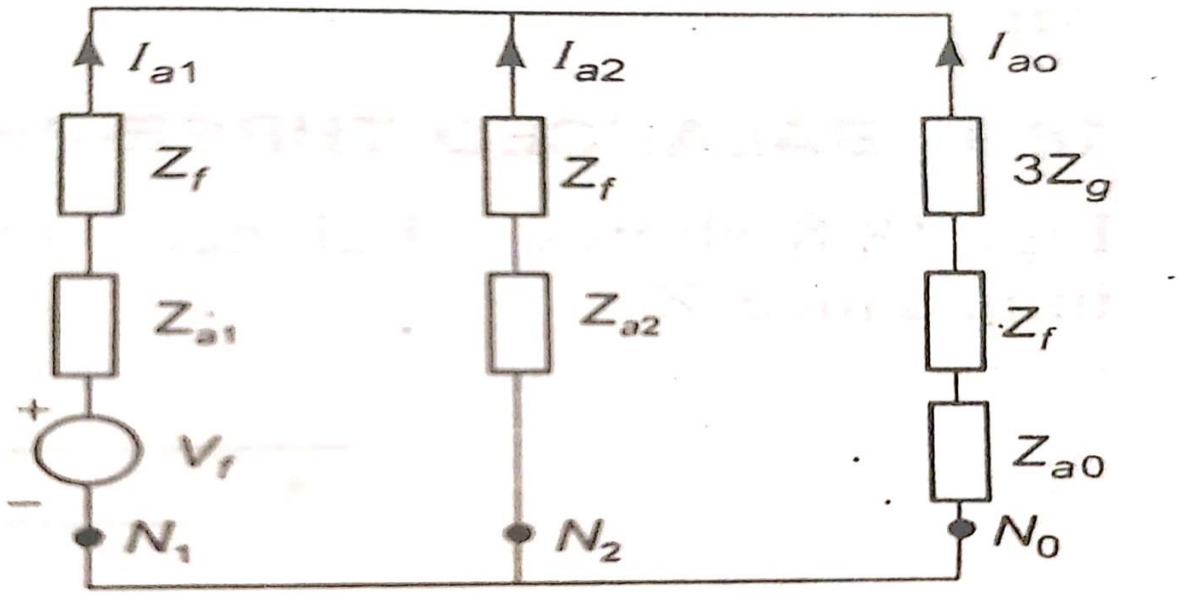


Fig. Interconnection of sequence network of double line to ground fault

OBSERVATION TABLE: -

S. No.	Fault current	Voltage	Fault impedance	Zero sequence current	Positive sequence current	Negative sequence current
1.						
2.						
3.						

RESULT: -

The fault impedance and fault current of a double line to ground fault are ……. ohm and …….. amp. respectively.

EXPERIMENT NO. 4

OBJECT: - To study the operation of micro-controller based over current relay in DMT type and IDMT type.

APPARATUS REQUIRED:-

1. Micro controller based overcurrent relay (VPL-01 module)
2. Variable AC current Source (VPL-01 ACC)
3. Power Chords - 2 no's
4. Patch Chords - 3 no's

THEORY:-

The **overcurrent relay** is defined as the **relay**, which operates only when the value of the current is greater than the **relay** setting time. It protects the equipment of the power system from the fault current. In an **over current relay** or **o/c relay** the actuating quantity is only current. There is only one current operated element in the relay, no voltage coil etc. are required to construct this protective relay.

Depending upon the time of operation, overcurrent relays may be categorized as:

1. Instantaneous Overcurrent Relay

2. Inverse-Time Overcurrent Relay

3. Definite Time Overcurrent Relay

4. Inverse Definite Minimum Time (IDMT) Relays

5. Very Inverse Relay

6. Extremely Inverse Relay.

Instantaneous Time Overcurrent Relay:

The relay pick up in certain shortest time without any intentional time delay. The operating time is less than 0.2 seconds.

Inverse-Time Overcurrent Relay:
An inverse time relay is one in which the operating time is approximately inversely proportional to the magnitude of the actuating quantity.

Inverse Definite Minimum Time type Relay

An inverse definite minimum time relay characteristic is combination of instantaneous and inverse time overcurrent relay.

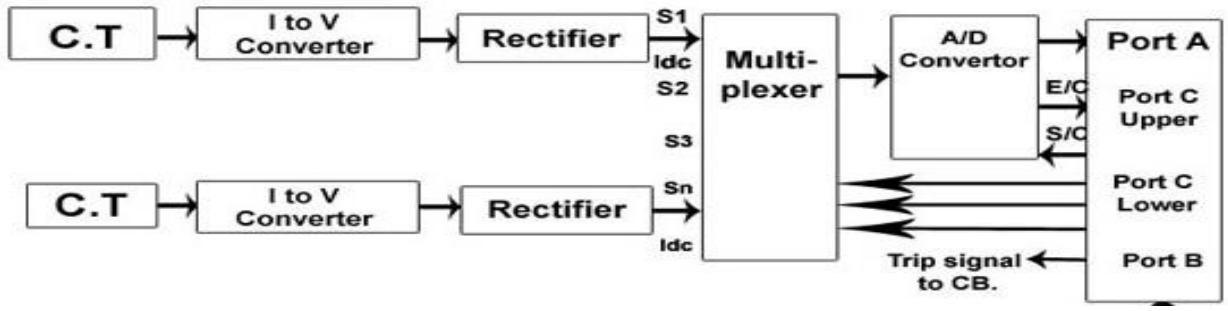


Fig. Block diagram of micro-controller based overcurrent relay

CONNECTION DIAGRAM:-

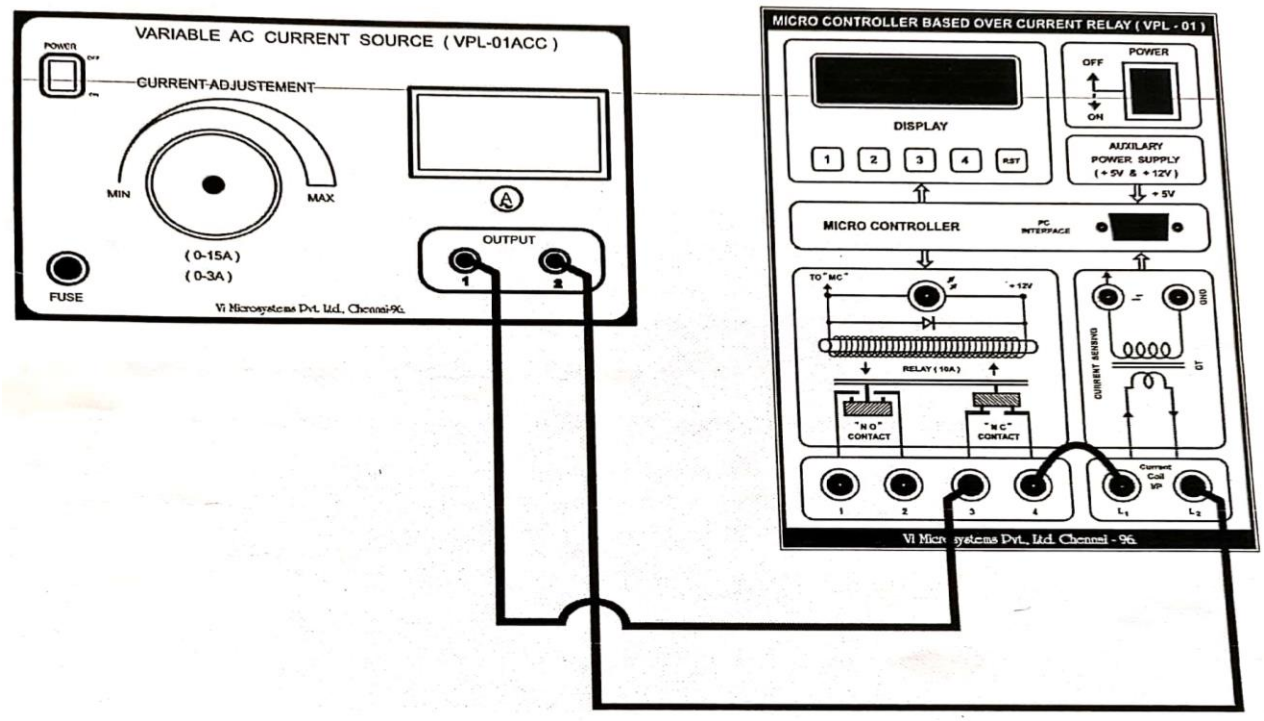


Fig. Connection diagram of microcontroller based overcurrent

CONNECTION PROCEDURE:

1. Connection should be given as shown in figure.
2. Connect output terminal (1) of variable ac current source to ‘NC’ contact (3) of over current relay.
3. Connect output terminal (2) of variable AC current source to current coil input (L2) of over current relay.

4. Connect 'NC' contact (4) of over current relay to current coil input (L1) of the over current relay.
5. Connect the power chords at the back side of unit of variable AC current source and microcontroller based over current relay.
6. Keep the current source variac at zero position.
7. Now switch on the power supply of variable AC current source and over current relay.

PROCEDURE TO DO EXPERIMENT BY USING CONTROLLER MODE:

1. Select controller mode by pressing the button 1 of VPL-01 module.

   SET CURRENT (S. C.) …….. A
   ACTUAL CURRENT (A. C.) ……..A

2. By using button 1and 2 of VPL-01 module you change the set current.
3. Adjust actual current above the set current using the variac of VPL-01 ACC.
4. Now press the button 4 of VPL-01 module.

   DMT TYPE
   IDMT TYPE
5. Now select DMT and IDMT type.
6. For DMT Mode select DMT press the button 1 of VPL-01.
7. Select setup time up to 50 seconds.

   SET TIME …… SEC.
   (1-50.00 SEC)
8. Press the button 4 of VPL-01 module.
9. The display of VPL-01 module show,

   SET CURRENT (S. C.) …….. A
   ACTUAL CURRENT (A. C.) ……..A

10. After tripping of relay the display of VPL-01 module show,

    SET TIME……..SEC.
    S.C. =……A, T.C.=……..A
11. Now the LED glow red light of VPL-01 module and note down the readings.
12. For IDMT type reset the over current relay bvy pressing the button RST. Repeat the step 1 to 4.
13. Select IDMT press the button 2 of VPL=01 module. The display of VPL-01 module shows,
14. Now select the set time up to 1 second.
15. Press the button 4 of VPL-01 module.
16. The display of VPL-01module shows,
17. After relay tripped the display of VPL-01 module shows,

18. Now LED glows 'Red'of VPL-01 module.

OBSERVATION TABLE:-

FOR DMT TYPE

S. No.	Set Current (A)	Fault Current (A)	Set Time (Sec.)	Actual relay Tripping Time (sec.)

FOR IDMT TYPE

S. No.	Set Current (A)	Fault Current (A)	Calculated relay tripping time (sec)	Actual relay tripping time

RESULT: -We have successfully studied the operation of micro-controller based over current relay in DMT type and IDMT type.

EXPERIMENT NO. 5

OBJECT: - To study the operation of micro-controller based directional over current relay in DMT type and IDMT type.

APPARATUS REQUIRED: -

1. Micro controller based directional overcurrent relay (VPL-81 module)
2. 1 phase AC VARIAC – 2 Nos.
3. 1 phase transformer (230/60) - 2 no's
4. Patch Chords - 3 no's
5. Connecting wire

THEORY: -Directional overcurrent protection is used when it is necessary to protect the system against fault currents that could circulate in both directions through a system element, and when bi-directional overcurrent protection could produce unnecessary disconnection of circuits. This can happen in ring or mesh-type systems and in systems with a number of infeed points.

Directional overcurrent relay determine the direction of the fault current by measuring the voltage with a voltage transformer as well as the current with a current transformer, and establishing the phase difference.

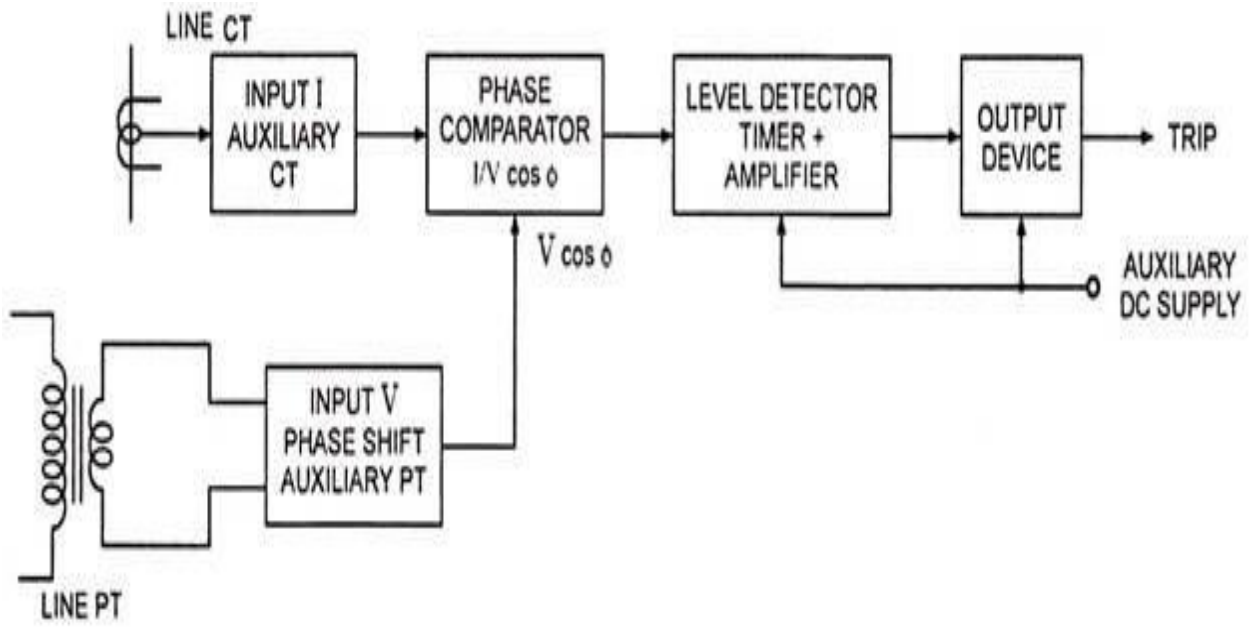


Fig. Block diagram of directional overcurrent relay

CONNECTION DIAGRAM: -

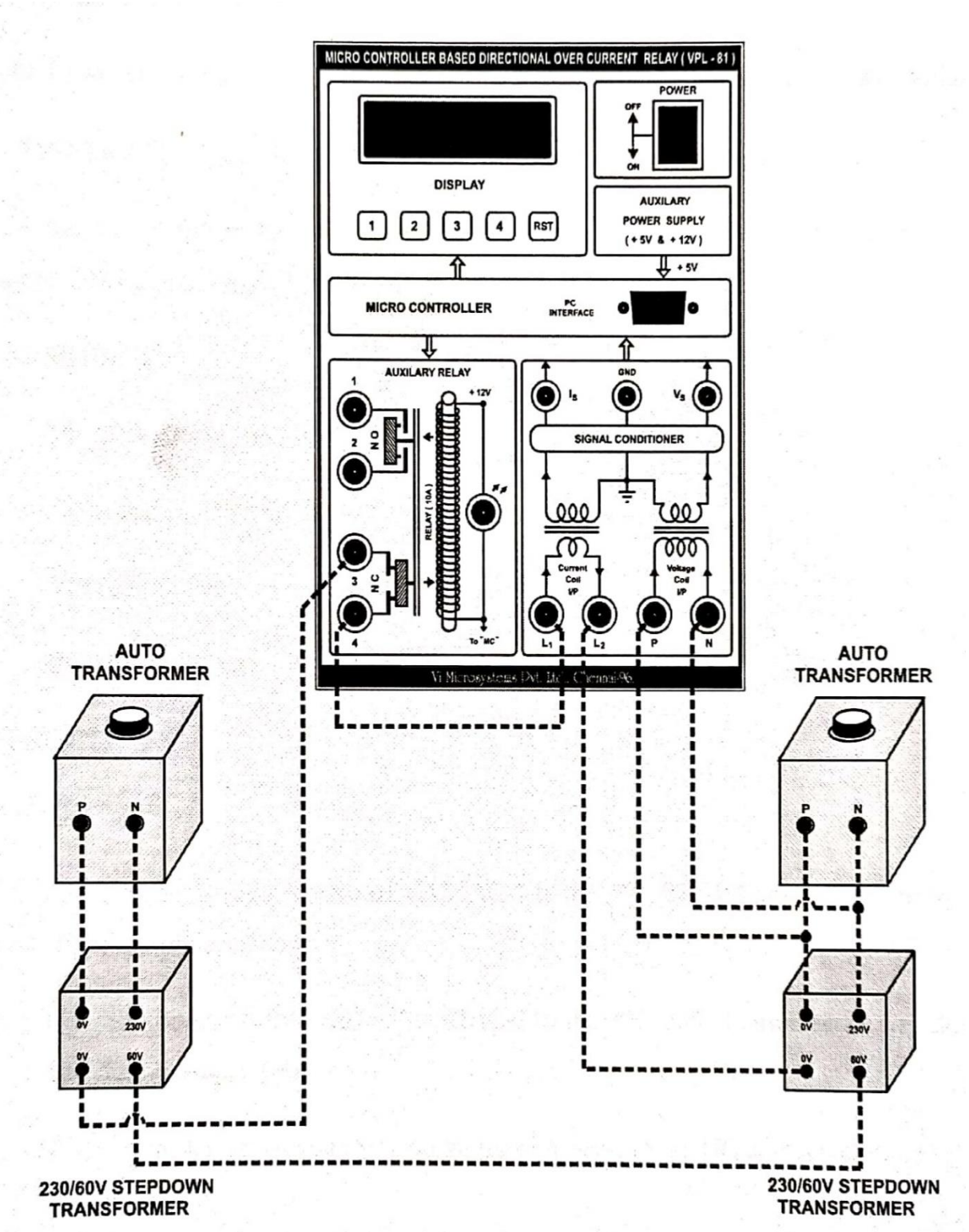


Fig. connection diagram of microcontroller based directional overcurrent relay

OBSERVATION TABLE: -

FOR DMT TYPE

S. No.	Set Current (A)	Fault Current (A)	Set Time (Sec.)	Actual relay Tripping Time (Sec.)

FOR IDMT TYPE

S. No.	Set Current (A)	Fault Current (A)	Calculated relay tripping time (Sec.)	Actual relay tripping time (Sec.)

RESULT: - We have successfully studied the operation of micro-controller based directional over current relay in DMT type and IDMT type.

EXPERIMENT NO. 6

OBJECT: - To study the micro-controller based under voltage relay.

APPARATUS REQUIRED: -

1. Micro controller based under voltage relay (VPL-04 module)
2. Auto transformer- 1 no's
3. Power Chords - 2 no's
4. Patch Chords - 3 no's

THEORY: -Undervoltage occurs when the average voltage of a power system drops below intended levels, and is sometimes referred to as a brown-out. Electromechanical devices, including three phase motors and pumps, are designed to be operated at very specific voltage levels. If these devices are allowed to operate at reduced voltage levelsthey will draw higher currents. The increase in current causes increased heat in the winding and coils of the equipment damaging the critical insulation protecting them. Operating in under-voltage conditions can drastically reduce the life of the electromechanical equipment and lead to premature failure.

Undervoltage conditions are usually be caused by undersized or overloaded utility and facility transformers. During peak demand periods and/or when the utility is experiencing problems, the demand for power exceeds the capability of the transformer and as a result the voltage drops. These conditions can occur without warning and provide no obvious indications. To protect motors and equipment, use an undervoltage protection.

An undervoltage protection, can shutdown equipment when undervoltage occurs preventing damage. A clear indication of the fault present is provided by these relays for rapid troubleshooting and reduced downtime.

CONNECTION PROCEDURE: -

1. Connections are made as per the circuit diagram.
2. Set the rheostat at minimum position.
3. Switch ON the power supply.

CONNECTION DIAGRAM: -

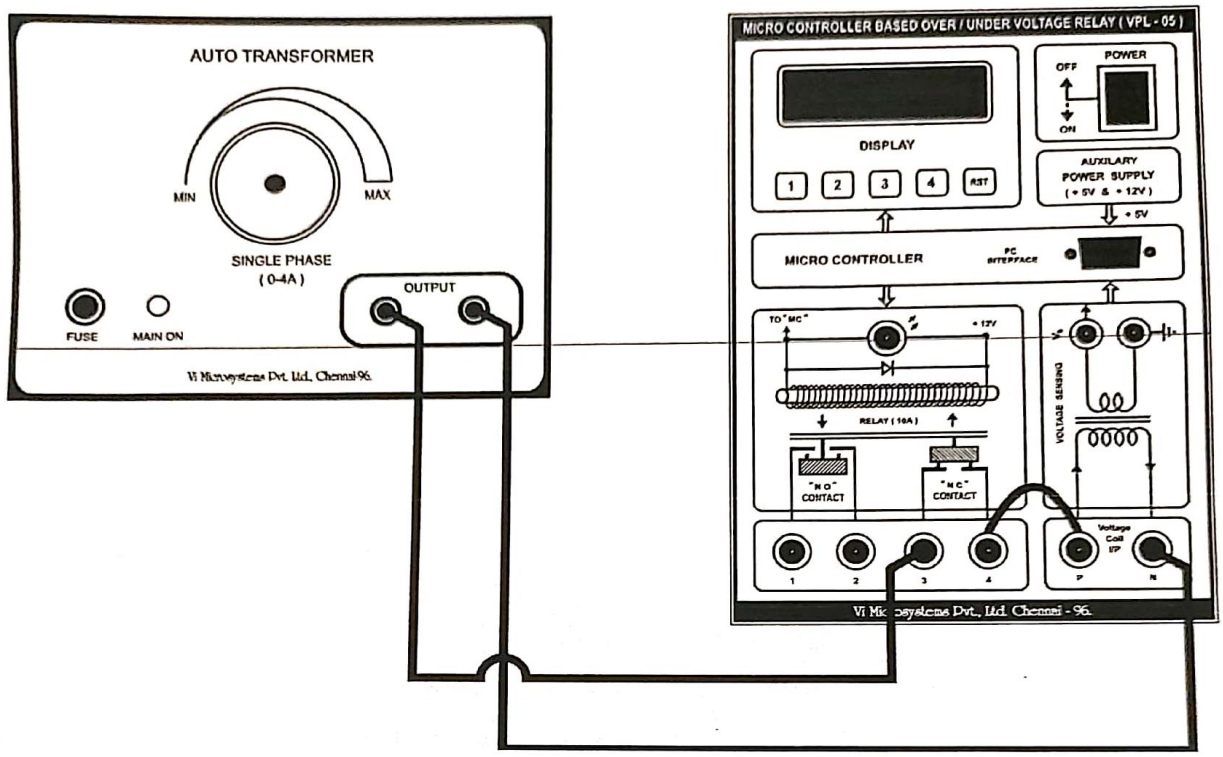


Fig. connection diagram of micro controller based under voltage relay

OBSERVATION TABLE: -

FOR DMT TYPE

S. No.	Set voltage (V)	Fault Voltage (V)	Set Time (Sec.)	Actual relay Tripping Time (Sec.)

FOR IDMT TYPE

S. No.	Set Voltage (V)	Fault Voltage (V)	Calculated relay tripping time (Sec.)	Actual relay tripping time (Sec.)

RESULT: - We have successfully studied the operation of micro-controller based under voltage relay in DMT type and IDMT type.

EXPERIMENT NO. 7

OBJECT: - To study the micro-controller based over voltage relay.

APPARATUS REQUIRED:-

1. Micro controller based overvoltage relay (VPL-04 module)
2. Auto transformer- 1 no's
3. Power Chords - 2 no's
4. Patch Chords - 3 no's

THEORY:-An over-voltage relay operates when the current produced by a load, or device connected to the output of a circuit, exceeds a predetermined value.The over-voltage relay connects to a transformer, or device that transfers electrical energy from one circuit to another. The relay is calibrated to operate at or over a preset voltage level. When the relay is switched on, one or multiple contacts trip, or open a circuit breaker.

Overvoltage relay serves primarily the same purpose as an overcurrent **relay** except that it is connected in the line by a potential transformer which measures the voltage across the line. When an **overvoltage** exists, the **relay** operates and opens the circuit breaker.

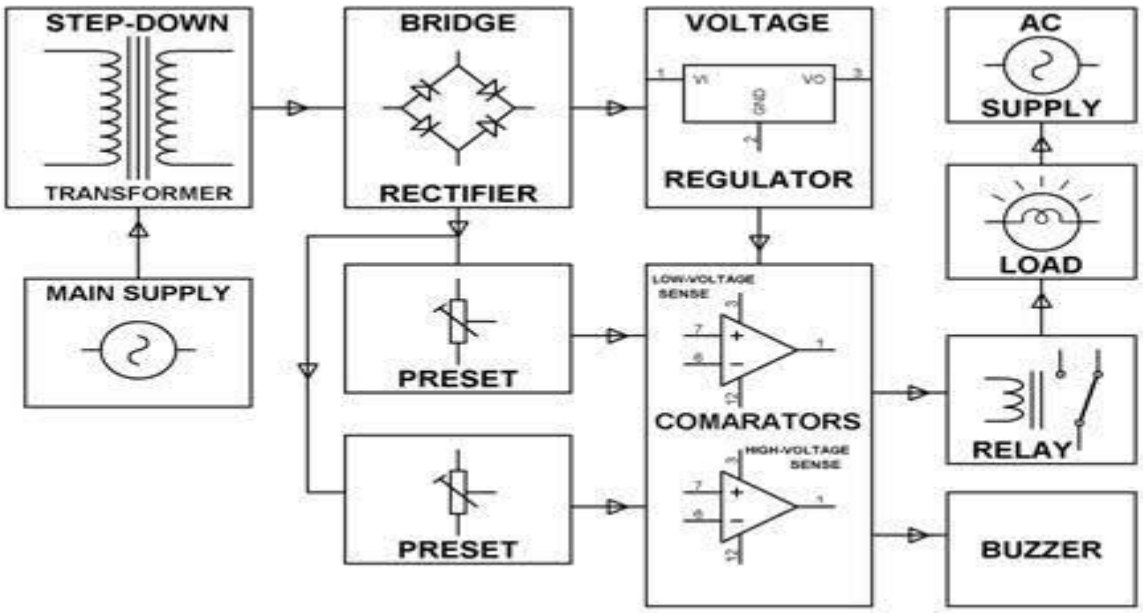


Fig. block diagram of over voltage relay

CONNECTION DIAGRAM:-

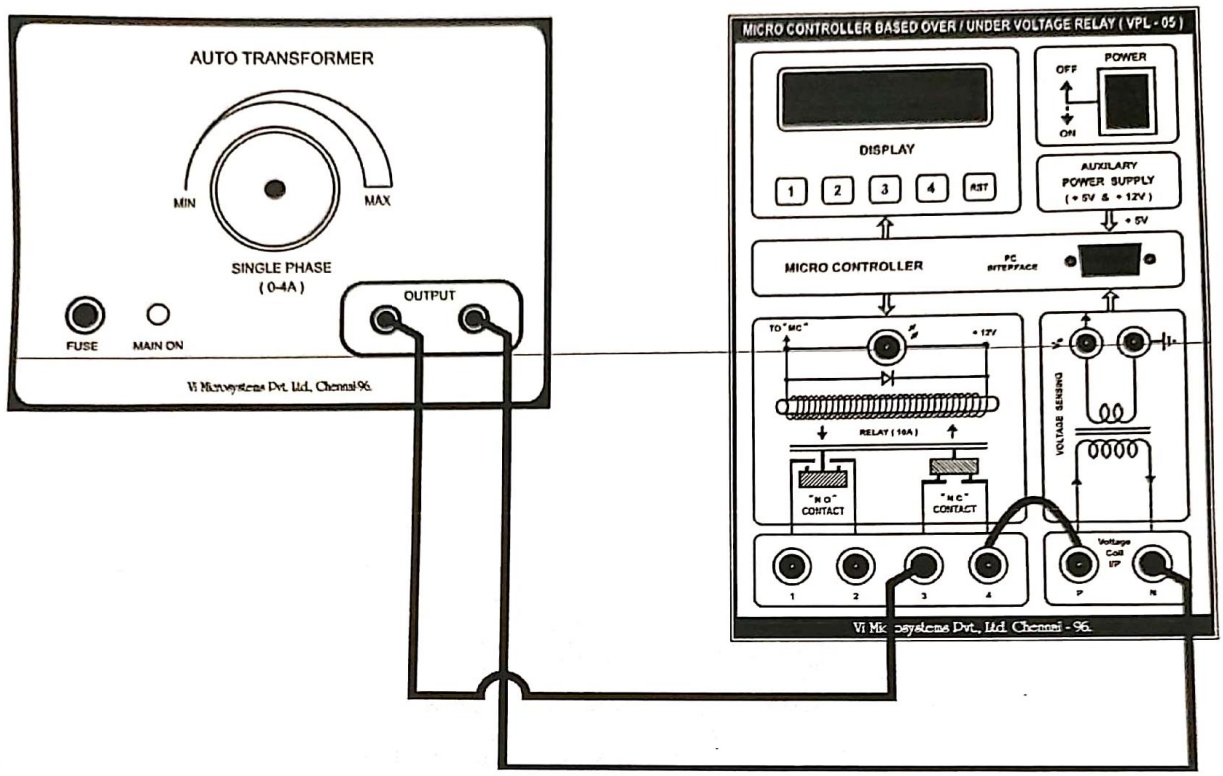


Fig. connection diagram of micro controller based overvoltage relay.

OBSERVATION TABLE: -

FOR DMT TYPE

S. No.	Set voltage (V)	Fault Voltage (V)	Set Time (Sec.)	Actual relay Tripping Time (Sec.)

FOR IDMT TYPE

S. No.	Set Voltage (V)	Fault Voltage (V)	Calculated relay tripping time (Sec.)	Actual relay tripping time (Sec.)

RESULT: - We have successfully studied the operation of micro-controller based over voltage relay in DMT type and IDMT type.

EXPERIMENT NO. 8

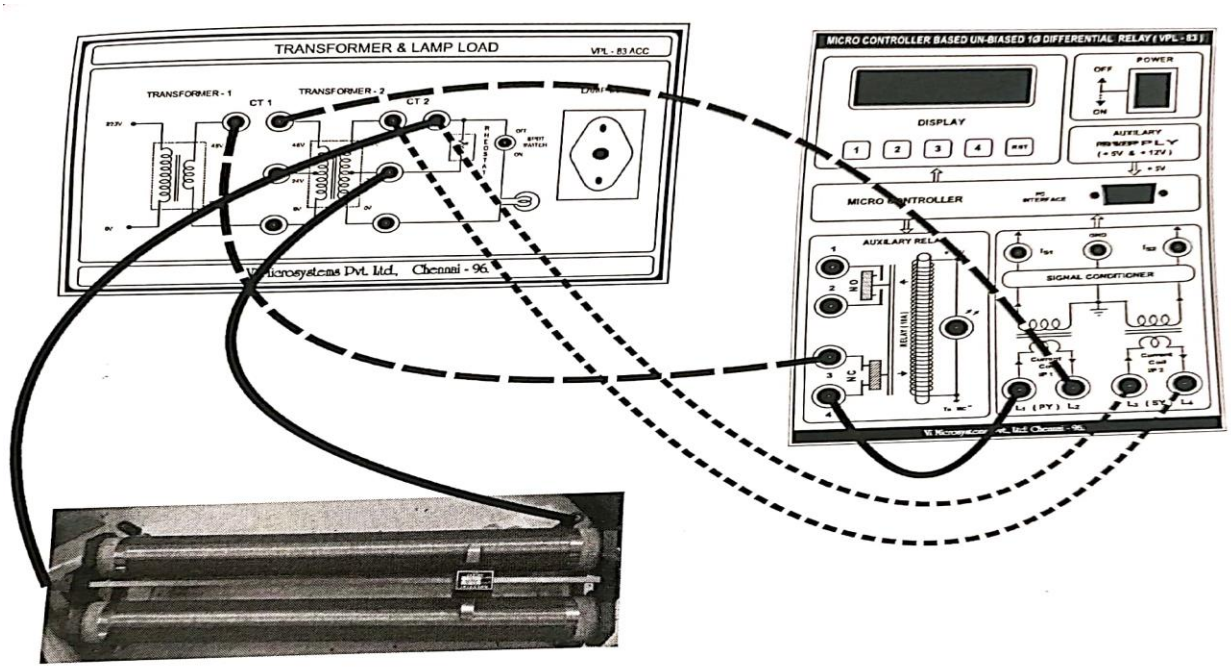
OBJECT: - To study the operation of micro-controller based un-biased single phase differential relay.

APPARATUS REQUIRED: -

1. Micro-controller based differential relay (VPL-83)
2. Transformer and Lamp load (VPL- 83 ACC)
3. Rheostat 100Ω/ 5A
4. Power chords
5. Patch chords

THEORY: - The differential relay is one that operates when there is a difference between two or more similar electrical quantities exceeds a predetermined value. In the differential relay scheme circuit, there are two currents come from two parts of an electrical power circuit. These two currents meet at a junction point where a relay coil is connected. According to Kirchhoff Current Law, the resultant current flowing through the relay coil is nothing but the summation of two currents, coming from two different parts of the electrical power circuit. If the polarity and amplitude of both the currents are so adjusted that the phasor sum of these two currents, is zero at normal operating condition. Thereby there will be no current flowing through the relay coil at normal operating conditions. But due to any abnormality in the power circuit, if this balance is broken, that means the phasor sum of these two currents no longer remains zero and there will be non-zero current flowing through the relay coil thereby relay being operated.

CONNECTION DIAGRAM: -



CONNECTION PROCEDURE: -

1. Connection should be given as shown in Fig.
2. Connect patch chord between NC-3 terminal of auxiliary relay in VPL-83 module and secondary voltage terminal (48 V) of transformer1 (CT1) of VPL-83 ACC module -big dash lines.
3. Connect patch chord between NC-4 terminal of auxiliary relay in of VPL -83 module and primary of current coil input 1 (L1) of VPL-83 module -continuous line.
4. Connect patch chord between primary of current coil input 1 (L2) of VPL-83 module and primary voltage terminal (48 V) of transformer 2 (CT1) of VPL- 83 ACC Module big dash lines.
5. Connect patch chord between coil input 2 (L3 & L4) of VPL -83 module and secondary voltage terminal (48 V) of transformer 2 (CT2) of VPL- 83 ACC module small dash lines.
6. Connect the rheostat between midpoint terminal and neutral of secondary side in transformer 2 (CT1) of VPL-83 ACC module continuous line
7. Connect power chords at the back side of module VPL-83 & VPL-83 ACC.

OBSERVATION TABLE: -

S. No.	DMT TYPE		IDMT TYPE	
	SET TIME	TRIP TIME	SET TIME	TRIP TIME
1.				
2.				
3.				

RESULT: - We have successfully studied the micro-controller based single phase unbiased differential relay.

The trip time of the relay is……..

EXPERIMENT NO. 9

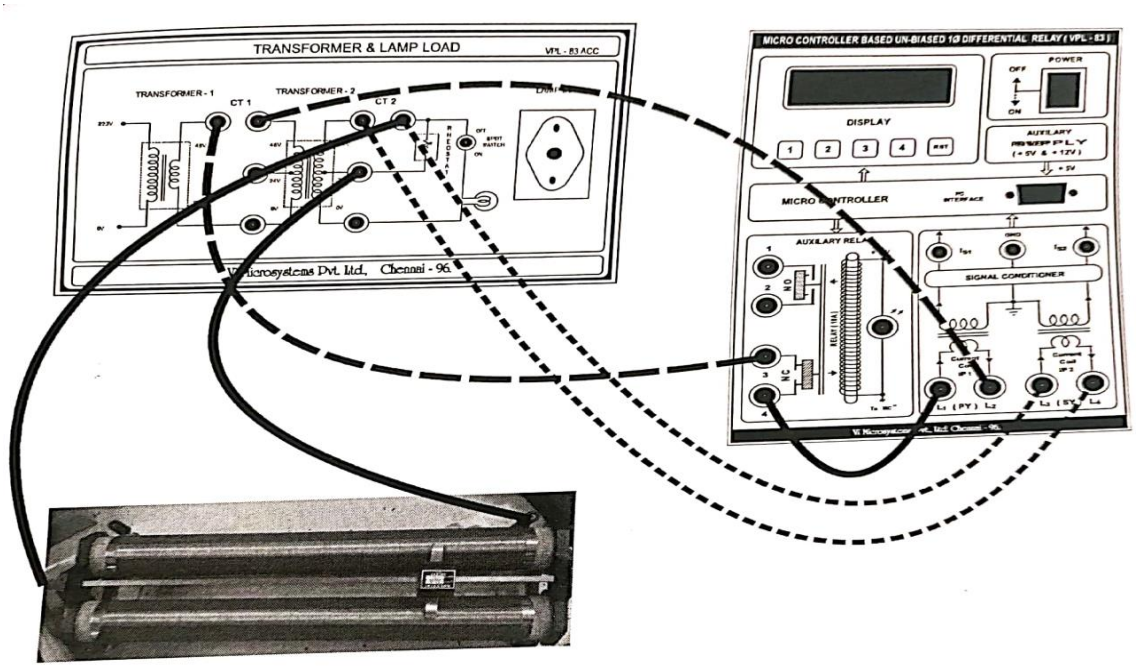
OBJECT: - To study the operation of micro-controller based biased single-phase differential relay.

APPARATUS REQUIRED: -

1. Micro-controller based differential relay (VPL-83)
2. Transformer and Lamp load (VPL- 83 ACC)
3. Rheostat 100Ω/ 5A
4. Power chords
5. Patch chords

THEORY: -The differential relay is one that operates when there is a difference between two or more similar electrical quantities exceeds a predetermined value. In the differential relay scheme circuit, there are two currents come from two parts of an electrical power circuit. These two currents meet at a junction point where a relay coil is connected. According to Kirchhoff Current Law, the resultant current flowing through the relay coil is nothing but the summation of two currents, coming from two different parts of the electrical power circuit. If the polarity and amplitude of both the currents are so adjusted that the phasor sum of these two currents, is zero at normal operating condition. Thereby there will be no current flowing through the relay coil at normal operating conditions. But due to any abnormality in the power circuit, if this balance is broken, that means the phasor sum of these two currents no longer remains zero and there will be non-zero current flowing through the relay coil thereby relay being operated.

CONNECTION DIAGRAM: -



CONNECTION PROCEDURE: -

1. Connection should be given as shown in Fig.
2. Connect patch chord between NC-3 terminal of auxiliary relay in VPL-83 module and secondary voltage terminal (48 V) of transformer1 (CT1) of VPL-83 ACC module - big dash lines.
3. Connect patch chord between NC-4 terminal of auxiliary relay in of VPL -83 module and primary of current coil input 1 (L1) of VPL-83 module -continuous line.
4. Connect patch chord between primary of current coil input 1 (L2) of VPL-83 module and primary voltage terminal (48 V) of transformer 2 (CT1) of VPL- 83 ACC Module big dash lines.
5. Connect patch chord between coil input 2 (L3 & L4) of VPL -83 module and secondary voltage terminal (48 V) of transformer 2 (CT2) of VPL- 83 ACC module small dash lines.
6. Connect the rheostat between midpoint terminal and neutral of secondary side in transformer 2 (CT1) of VPL-83 ACC module continuous line
7. Connect power chords at the back side of module VPL-83 & VPL-83 ACC.

OBSERVATION TABLE: -

S. No.	DMT TYPE			IDMT TYPE		
	SET %	SET TIME	TRIP TIME	SET %	SET TIME	TRIP TIME
1.						
2.						
3.						

RESULT: - We have successfully studied the micro-controller based single phase unbiased differential relay.

The trip time of the relay for DMT type is……..

The trip time of the relay for IDMT type is……..

EXPERIMENT NO. 10

OBJECT: To study the operation of micro-controller based un-biased three phase differential relay.

APPARATUS REQUIRED: -

1. Micro controller based 3phase differential relay.
2. Transformer MP1
3. Transformer MP2
4. Rheostat 100Ω/ 2 A
5. Power Chords
6. Patch Chords

THEORY: -A differential relay is a suitably connected overcurrent relay which operate when the phasor difference of currents at the two ends of protected elements exceeds a predetermine value. The three phase differential protection of three phase circuits. Under normal conditions the three secondary currents of CTs are balanced and their phasor sum is zero. Therefore, no current flows the operating coil of the relay. If the differential current is more than the pick-up value, the relay operates.

CONNECTION DIAGRAM: -

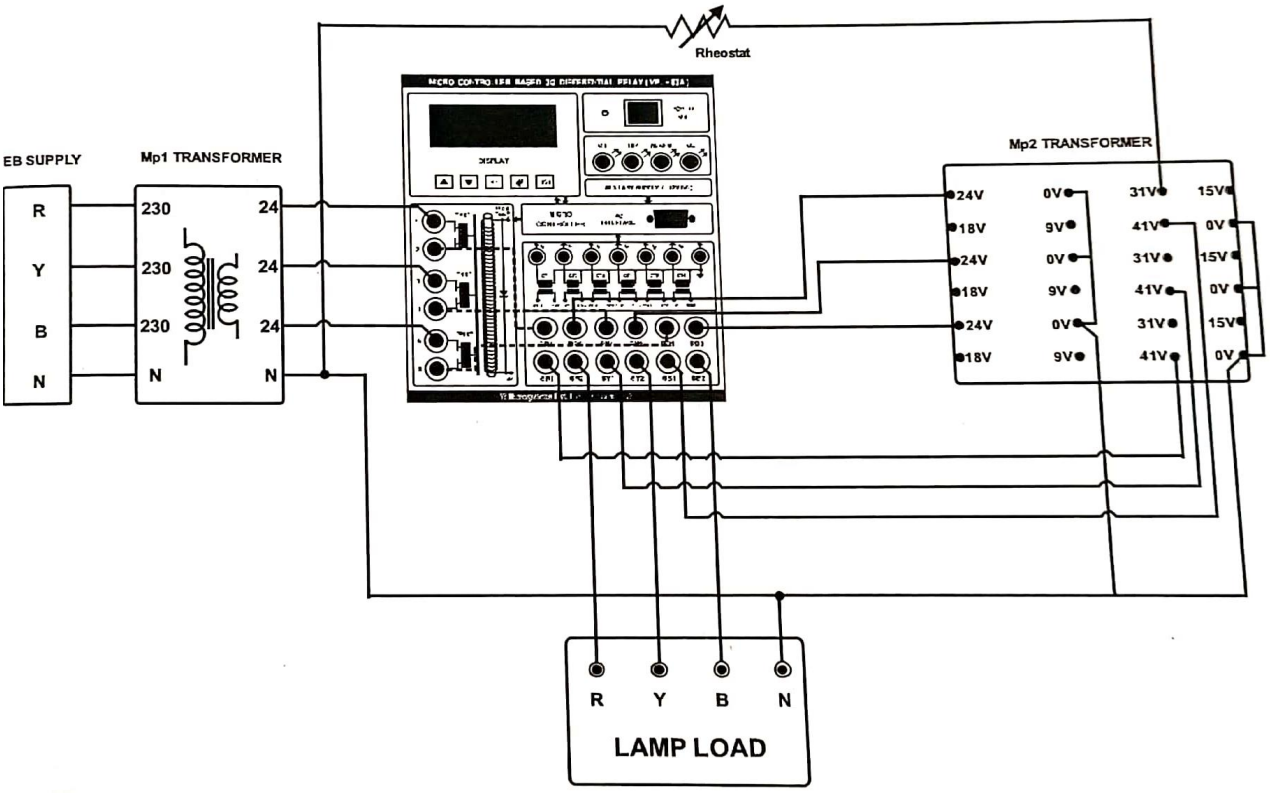


Fig. connection diagram of micro controller based 3 phase unbiased differential relay

CONNECTION PROCEDURE: -

1. Connections are made as per the circuit diagram.
2. Set the rheostat at minimum position.
3. Switch ON the power supply.

OBSERVATION TABLE: -

FOR DMT TYPE

S. NO.	SET BIASED %	SET TIME	TRIP BIASED

FOR IDMT TYPE

S. No.	SET BIASED %	SET TIME	TRIP BIASED	CALCULATED TIME

RESULT: - We have successfully studied the micro-controller based un-biased three phase differential relay.

The trip time of relay for DMT type is…….

The trip time of relay for IDMT type is…….

EXPERIMENT NO. 11

OBJECT: - To study the operation of micro-controller based biased three phase differential relay.

APPARATUS REQUIRED: -

1. Micro controller based 3phase differential relay.
2. Transformer MP1
3. Transformer MP2
4. Rheostat 100Ω/ 2 A
5. Power Chords
6. Patch Chords

THEORY: -Due to the maloperation of the unbiased differential relay due to CTerrors during heavy external faults occurred. This disadvantage of unbiased differential relay is overcome by using percentage differential relay which is also called as biased differential relay.

Biased differential relay provides high sensitivity to light internal faults and make differential protection schemes more stable. In biased three phase differential relay have three operating coil and three restraining connected in each phase respectively. The operating coil is connected to the midpoint of the restraining coil.

The relay operates if the operating torque produced by the operating coil is more than the restraining torque produced by the restraining coil.

The relay operates when,

$$(AT)_o > (AT)_r$$

$$I_d > KI_r$$

$$I_d = I_1 - I_2$$

Where K is the bias, $K = N_r/N_o$

I_d is the differential current through the operating coil

CONNECTION DIAGRAM: -

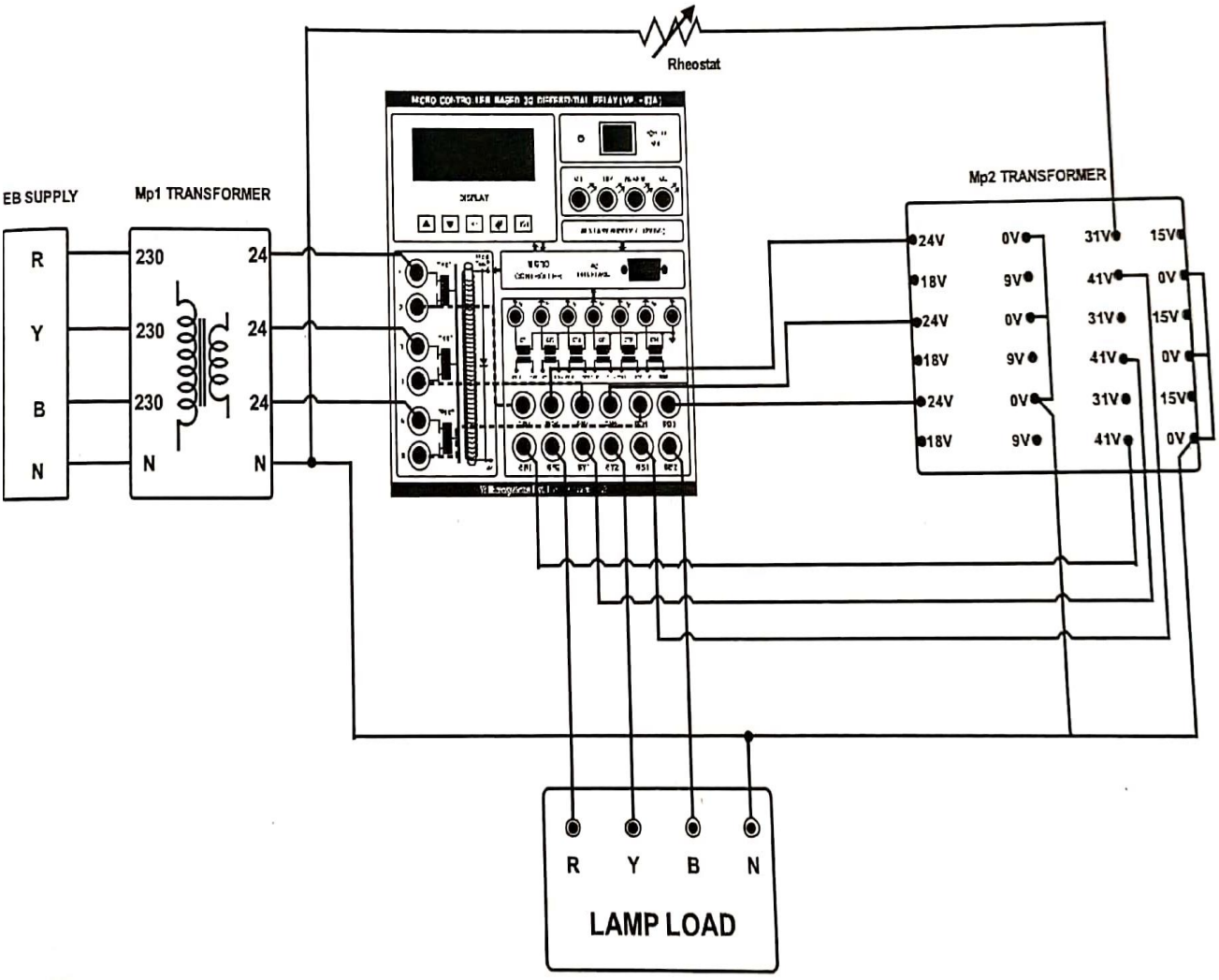


Fig. connection diagram of micro controller based 3 phase biased differential relay

CONNECTION PROCEDURE: -

1. Connections are made as per the circuit diagram.
2. Set the rheostat at minimum position.
3. Switch ON the power supply.

OBSERVATION TABLE: -

FOR DMT TYPE

S. NO.	SET BIASED %	SET TIME	TRIP BIASED

FOR IDMT TYPE

S. No.	SET BIASED %	SET TIME	TRIP BIASED	CALCULATED TIME

RESULT: - We have successfully studied the micro-controller based biased three phase differential relay.

The trip time of relay for DMT type is…….

The trip time of relay for IDMT type is…….