Switchgear & Protection Laboratory

MANUAL

Part – A

Hardware

Compiled by: Md Aftab Alam, EEN, AU. Sourced from documents provided by equipment suppliers.

Instructions regarding lab report

1. First of all, please note that this lab manual is not exactly your lab report; so, **don't** simply take the printout of this manual and submit it as your lab file. Now, please follow the guidelines for preparing the lab report as under:
2. The title and aim of the experiments will of course remain same as given here. The list of apparatus can be modified by you as per your actual experience during the practical. (You may also write the aim in your own words if it can convey the purpose of the experiment properly.)
3. Write few lines of the relevant theory (brief significant theoretical concepts of the experiment).
4. Draw the **equivalent electrical circuit diagram** of the experiment. Don't draw/print the connection diagram given here (actually, you can draw the connection diagram too, but as additional feature; electrical circuit diagram must be drawn first).
5. Then write 10-20 sentences (bullet points form, not paragraph) that should include how did you **perform the experiment** and what did you **learn from the experiment**.
6. Attach the observation sheets signed by the teacher on respective experiment days. If the observation sheet is not on good page/paper, then it may be copied on a fair page but the signed sheet must be attached in any case.
7. Needless to mention, the files must obviously be prepared individually. Please **don't copy** the theory/observation/circuit diagram of each other.

EXPERIMENT–1 (A): MICROCONTROLLER BASED OVER CURRENT RELAY (DMT TYPE)

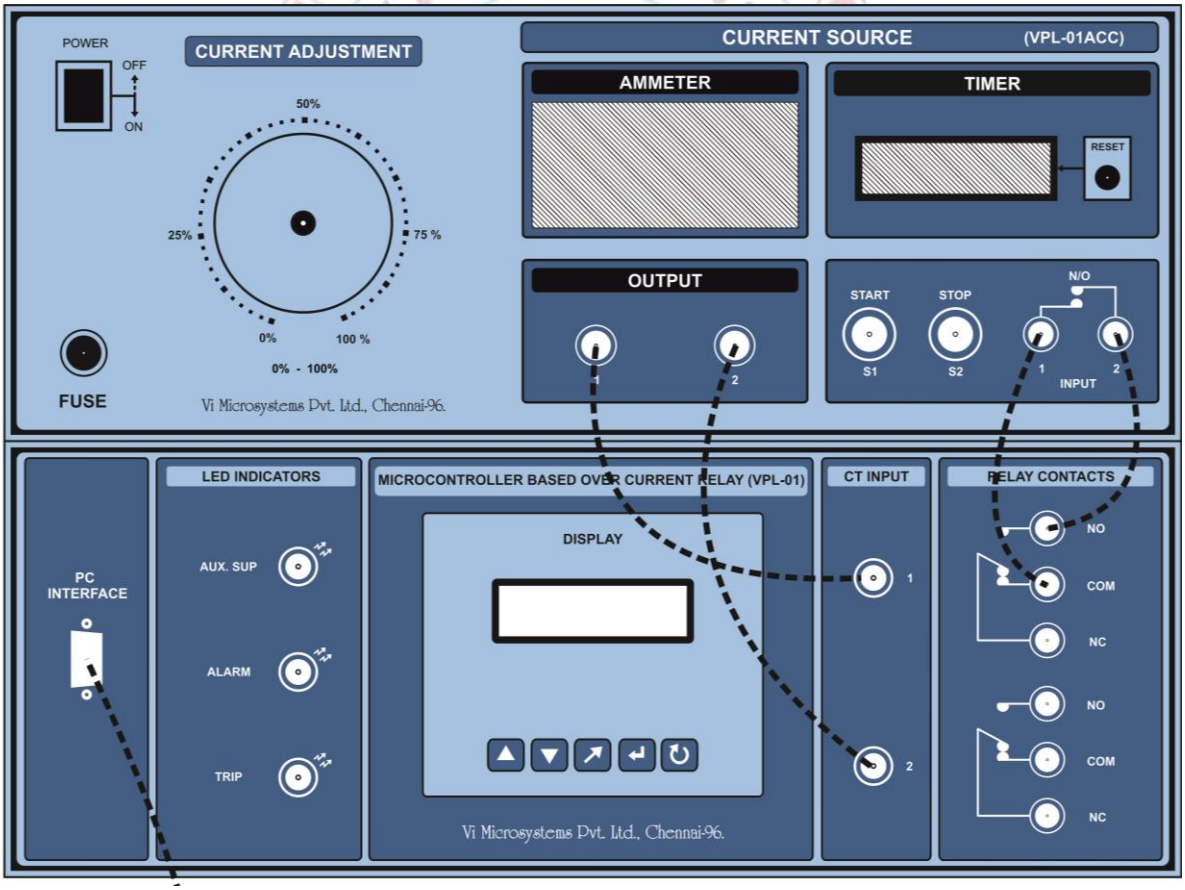
AIM: - To study the operation of Microcontroller based Over Current Relay in DMT mode.

Apparatus Used: - VPL-01 Study trainer module by Vi Microsystems (Current source module and Relay module combination), Power cords, Patch cords (Banana connectors),

Theory:

(Write brief theory of DMT characteristics and microcontroller-based relays)

Connection Diagram:



Procedure:

1. Connect the terminals of the modules with the help of patch cords, as shown in connection diagram (the top module shown in the figure is the current source module and the bottom one is the relay module).
2. Keep the current source variac at zero position.

3. Switch ON the power supply to both the modules; the auxiliary supply LED will glow.
4. Keeping the current source knob at zero position, press the RESET button and START button in current source module.
5. The display of Microcontroller Based Over Current Relay shows

OVER CURRENT RELAY

6. Press ↵, now the display shows,

PC MODE
CONTROLLER MODE

7. Select 'Controller' mode by pressing ▼, now the display shows,

DMT TYPE
IDMT TYPE

8. To select DMT press ▲.
9. The display shows,

SET CURRRENT	**00.00A**
ACTUAL CURRENT	**00.00A**

10. To set current value, use the ↗ for cursor movement and ▲ & ▼ for increasing and decreasing the current value.
11. For example, if you set the current value as 1A, now the display shows,

SET CURRRENT	**01.00A**
ACTUAL CURRENT	**00.00A**

12. After setting the current value, press ↵ now the display shows

SET TIME	**00.00sec**
(0-50.00 sec)	

To set time in sec, use the ↗ for cursor movement and ▲ & ▼ for increasing and decreasing the time in sec.

13. For example, if you set the time value as 5sec, the display shows,

SET TIME 05.00sec
(0-50.00 sec)

14. After setting the time value, press ↵. Now increase the supply current given to the Over Current Relay by varying the knob of Current source. When 80% of set current is reached the Alarm LED glows.
15. Gradually increase the current value above the set value. The display of Over Current Relay module shows,

SET CURRRENT 01.00A
ACTUAL CURRENT 01.50A

16. At this instant the relay timer starts to trip the relay. After the set time (here, 5sec) the relay will trip and the Trip LED glows.
17. After the tripping of relay, the display of Over Current Relay module shows,

RELAY TRIPPED DUE TO
OVER CURRENT

18. Note down the readings from the display.

Observation & Conclusion

Sl. No.	Set Current (A)	Fault Current/Actual Current (A)	Set Time (Sec)	Trip Time (Sec)

(Write your understanding and conclusion from the experiment)

EXPERIMENT– 1 (B): MICROCONTROLLER BASED OVER CURRENT RELAY (IDMT TYPE)

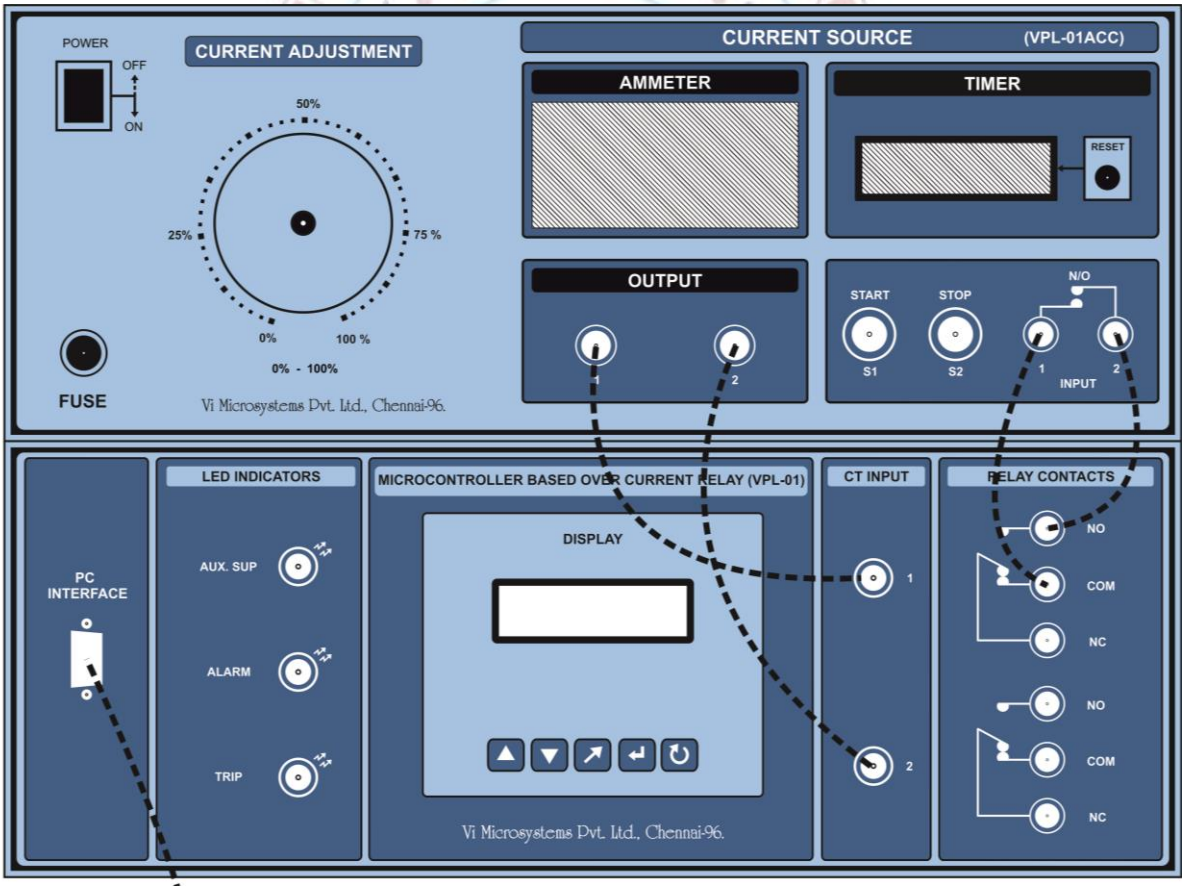
AIM: - To study the operation of Microcontroller based Over Current Relay in IDMT mode.

Apparatus Used: - VPL-01 Study trainer module by Vi Microsystems (Current source module and Relay module combination), Power cords, Patch cords (Banana connectors),

Theory:

(Write brief theory of IDMT characteristics)

Connection Diagram:



Procedure:

1. Connect the terminals of the modules with the help of patch cords, as shown in connection diagram (the top module shown in the figure is the current source module and the bottom one is the relay module).

2. Keep the current source variac at zero position.
3. Switch ON the power supply to both the modules; the auxiliary supply LED will glow.
4. Keeping the current source knob at zero position, press the RESET button and START button in current source module.
5. The display of Microcontroller Based Over Current Relay shows

OVER CURRENT RELAY

6. Press ↵, now the display shows,

PC MODE
CONTROLLER MODE

7. Select 'Controller' mode by pressing ▼, now the display shows,

DMT TYPE
IDMT TYPE

8. To select IDMT press ▼.
9. The display shows,

SET CURRRENT 00.00A
ACTUAL CURRENT 00.00A

To set current value, use the ↗ for cursor movement and ▲ & ▼ for increasing and decreasing the current value.

10. For example, if you set the current value as 1A, now the display shows,

SET CURRRENT 01.00A
ACTUAL CURRENT 00.00A

11. After setting the current value, press ↵ now the display shows

SET TIME 00.00sec
(0.1 - 1.00 sec)

To set time in sec, use the ↗ for cursor movement and ▲ & ▼ for increasing and decreasing the time in sec.

12. For example, if you set the time value as 0.5sec, the display shows,

SET TIME 0.50sec
(0.1 - 1.00 sec)

13. After setting the time value, press  . Now increase the supply current given to the Over Current Relay by increasing the knob of Current source. When 80% of set current is reached the Alarm LED glows.
14. Gradually increase the current value above the set value. The display of Over Current Relay module shows,

SET CURRRENT 01.00A
ACTUAL CURRENT 01.50A

15. When the actual current is increased above the set current then the trip time will be calculated by the processor and after the t seconds the relay trips and the Trip LED glows.

    The calculated time for relay tripping is obtained from the formula:

$$t = TMS \times \left[\frac{k}{\left({}^{I}/_{I_S} \right)^{n} - 1} \right]$$

Where, TMS = Time multiplier setting, 'I' is the Fault Current and 'I_s' is the Set Current of the relay unit.

And for normal inverse type characteristic, used in the module, k = 0.14 & n = 0.02.

16. After the tripping of relay, the display of Over Current Relay module shows,

RELAY TRIPPED DUE TO
OVER CURRENT

17. Note down the readings from the display.

Observation & Conclusion

Sl. No.	Set Current (A)	Fault Current/Actual Current (A)	TMS/Set Time (Sec)	Calculated relay tripping time (sec)	Actual relay tripping time (sec)

(Write your understanding and conclusion from the experiment)

EXPERIMENT–2: ELECTRO MECHANICAL TYPE OVER VOLTAGE RELAY

AIM: - To study the operation of Electro Mechanical Type Over Voltage Relay

Apparatus Used: - VPST - 103A Study trainer module by Vi Microsystems (Voltage source module and Relay module combination), Power cords, Patch cords (Banana connectors),

Theory:

(Write brief theory of Electromechanical relays)

Connection Diagram:

Procedure:

1. Connect the terminals of the modules with the help of patch cords, as shown in connection diagram (the top module shown in the figure is the voltage source module and the bottom one is the relay module).

2. Keep the voltage source variac at zero position.
3. Select the desired plug setting of the electro-mechanical relay by using plug.
4. Now Switch ON the power supply to both the modules.
5. Keeping the voltage source knob at zero position, press the RESET button in voltage source module and also reset the relay.
6. By using voltage adjustment knob of the Voltage source module, set the actual voltage below the plug setting value. Here, say, plug setting value is 150 V and actual voltage is 80 V.
7. After setting the actual voltage, press the START button. Here, since the actual voltage is below the plug setting value, it means there is no fault. Hence the relay will not trip.
8. Now by using adjustment knob set the actual voltage above the setting value, say 175 V.
9. Now, since the actual voltage is above the plug setting, it means there is fault. So, the disc of the relay rotates and the moving contact touches the fixed contact and the relay proceeds to trip the circuit.
10. After relay is tripped the relay time is stopped in Digital stop clock.

Observation & Conclusion

Sl. No.	Plug Setting Voltage (V)	Actual Voltage (V)	PSM calculated	Trip time from PSM chart (sec)	Relay tripping time (sec)

(Write your understanding and conclusion from the experiment)

EXPERIMENT– 3 (A): MICROCONTROLLER BASED THREE PHASE DIFFERENTIAL RELAY (BIASED-MODE)

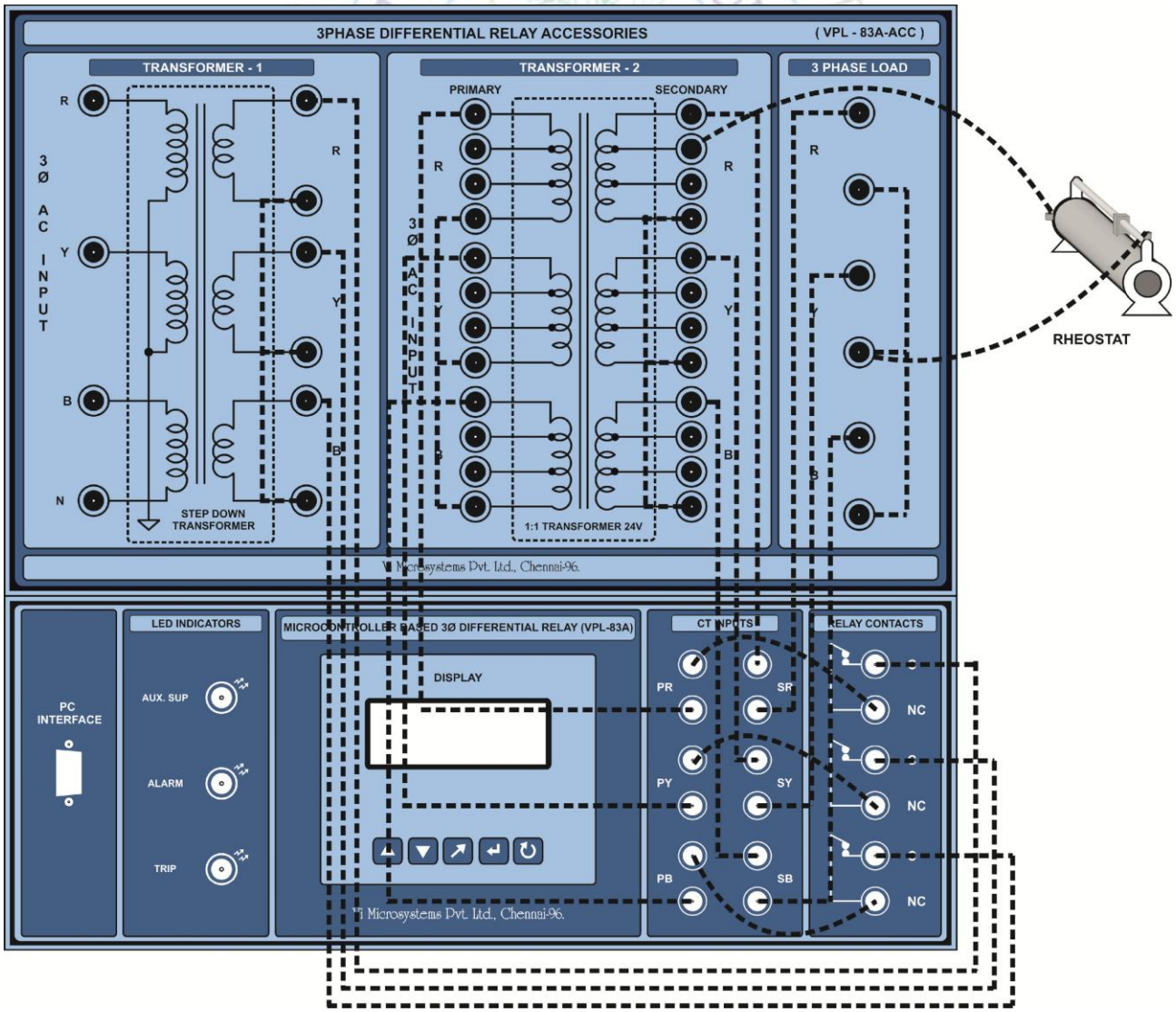
AIM: - To study the operation of Microcontroller Based Three Phase Biased (Percentage) Differential Relay.

Apparatus Used: - VPL-83A Study trainer module by Vi Microsystems (Three-phase transformer module and Relay module combination), Power cords, Patch cords (Banana connectors), 100 Ω/ 5A rheostat.

Theory:

(Write brief theory of biased differential relay)

Connection Diagram:



Procedure:

1. Connect the terminals of the modules with the help of patch cords, as shown in connection diagram (the top module shown in the figure is the transformer module and the bottom one is the relay module).
2. Initially keep the rheostat at maximum position. Switch ON the power supply.
3. The display of Microcontroller Based Three Phase Differential Relay shows

THREE PHASE DIFFERENTIAL RELAY

1. BIASED 2. UNBIASED

4. To select BIASED press ▲. Now the display shows,

SET BIASED (0-100) %

5. To set biased percentage, use ↗ for cursor movement and ▼ & ▼ for increasing and decreasing the biased percentage.

6. For example, if you set the biased percentage value as 20%, now the display shows,

SET BIASED 20 %

7. Press ↵, now the display shows

DMT TYPE **IDMT TYPE**

8. To select DMT press ▲.
9. Now the display shows,

Set time 00.00 sec (0-50.00 sec)

10. Select the set time by using ▲, ▼ & ↗ keys.

11. For example, if you set the time value as 5 sec, now the display shows

Set time 05.00 sec (0-50.00 sec)

12. Press ↵, now the display shows

IR	0	Ir	0
IY	0	Iy	0
IB	0	Ib	0
Set bias 20%		Trip bias 17%	

13. Gradually vary the Rheostat until the actual bias value reaches the set biased value. Now the relay is tripped. Now the display shows

Set bias 20%	Set time 5.00 sec
Trip bias 25%	

14. Similar procedure is followed for different percentage of bias and for different setting time.

FOR BIASED MODE IDMT:

15. Reset the differential relay by pressing the button RST of VPL-83A module. Repeat the steps 1 to 7.
16. To select IDMT press ▼. Now the display shows,

Set time 00.00 sec
(0.1 to 1.0) Sec

Select the set time by using ▲, ▼ & ↗ keys.

17. For example, if you set the time value as 0.2sec, now the display shows,

Set time 02.00 sec
(0.1 - 1.0) Sec

(Remember, this set time is actually the TMS to be used in calculation of tripping time.)

18. After setting the time value, press ↵, now the display shows

IR	0	Ir	0
IY	0	Iy	0
IB	0	Ib	0
Set bias 20%		Trip bias 17%	

19. Gradually vary the Rheostat until the actual bias value reaches the set biased value. Now the timer starts.
20. The calculated time for relay tripping is obtained from the formula.

$$t = TMS \times \left[\frac{k}{\left({}^{\text{Actual bias}}/_{\text{Set bias}} \right)^{n} - 1} \right]$$

For normal inverse type characteristic, used in the module, k = 0.14 & n = 0.02.

21. Now the display shows

Set biased 20 %	Set time 0.2 sec
Trip biased 25%	Calculated time __

The calculated time shown in the display is actually the actual relay tripping time.

22. Repeat the procedure for various set values & tabulate the readings. Press the reset button to get normal position.

Observation & Conclusion

DMT

Sl. No.	Set bias (%)	Trip Bias (%)	Set time (s)	Actual relay tripping time (sec)

IDMT

Sl. No.	Set bias (%)	Trip bias (%) (Actual bias)	Set time (TMS) (sec)	Calculated relay tripping time (sec)	Actual relay tripping time (sec)

(Write your understanding and conclusion from the experiment)

EXPERIMENT– 3 (B): MICROCONTROLLER BASED THREE PHASE DIFFERENTIAL RELAY (UNBIASED-MODE)

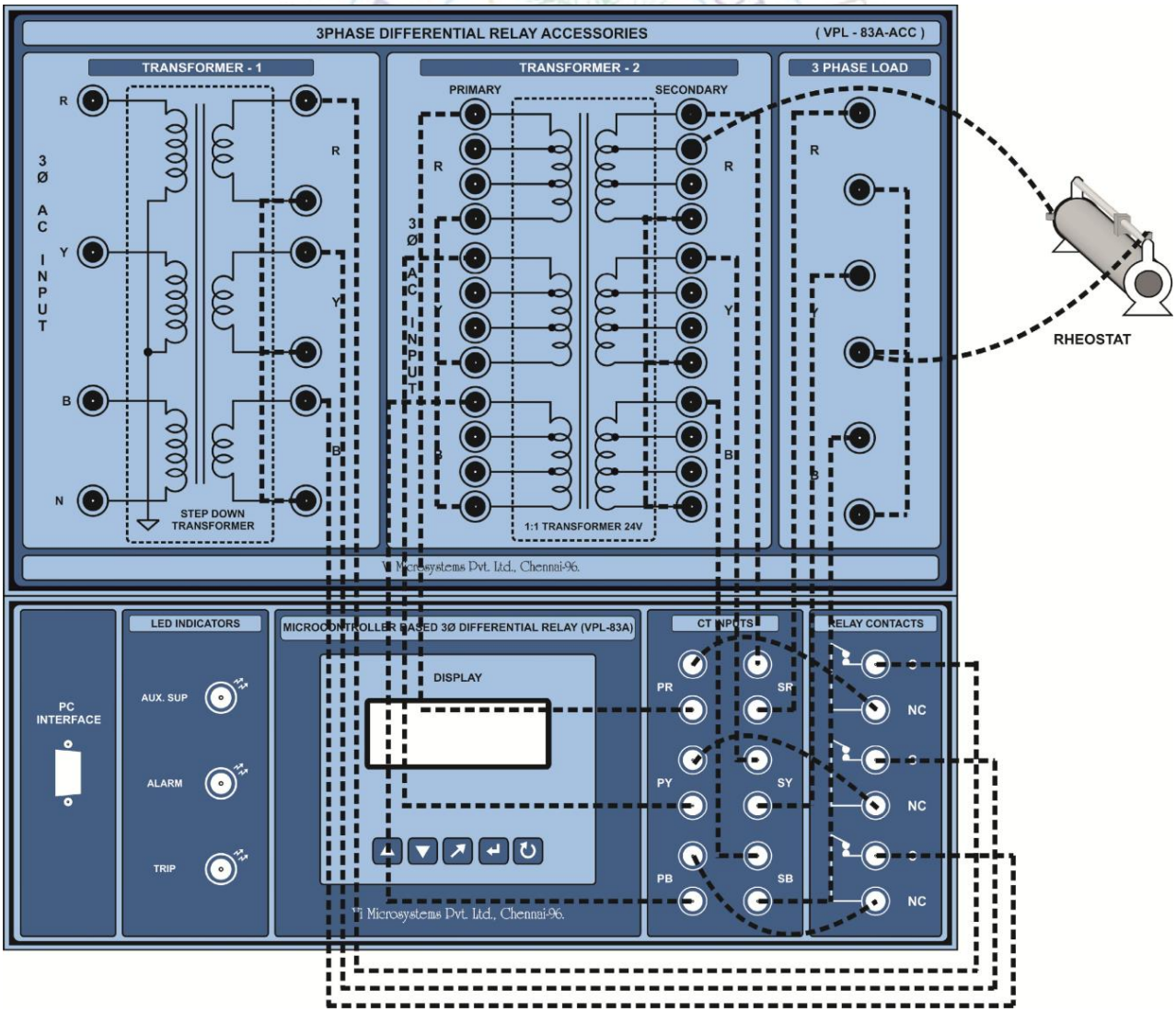
AIM: - To study the operation of Microcontroller Based Three Phase Differential Relay without biasing.

Apparatus Used: - VPL-83A Study trainer module by Vi Microsystems (Three-phase transformer module and Relay module combination), Power cords, Patch cords (Banana connectors), 100 Ω/ 5A rheostat.

Theory:

(Write brief theory of simple differential relay)

Connection Diagram:



Procedure:

1. Connect the terminals of the modules with the help of patch cords, as shown in connection diagram (the top module shown in the figure is the transformer module and the bottom one is the relay module).
2. Initially keep the rheostat at maximum position. Switch ON the power supply.
3. The display of Microcontroller Based Three Phase Differential Relay shows

THREE PHASE DIFFERENTIAL RELAY

1. BIASED 2. UNBIASED

4. To select UNBIASED press ▼. Now the display shows,

UNBIASED 1. DMT 2. IDMT

5. To select DMT press ▲. Now the display shows,

Set time 00.00 sec (1-50.00 sec)

6. Select the set time by using ▲, ▼ & ↗ keys.
7. If bias is above 0%, then the timer starts and the relay trips after set time.
8. Similar procedure is followed for different percentage of bias and for different setting time. The trip current can be measured and tabulated.

FOR UNBIASED MODE IDMT:

9. Repeat the procedure 1 to 4.
10. To select IDMT press ▼. Now the display shows,

Set time 00.00 sec (0.1 to 1.0) Sec

11. Select the set time by using ▲, ▼ & ↗ keys.

12. If bias is above 0%, then the timer starts and the relay trips after calculated time.

13. The calculated time for relay tripping is obtained from the formula.

$$t = TMS \times \left[\frac{k}{\left({}^{\text{Actual bias}}/_{\text{Set bias}} \right)^{n} - 1} \right]$$

For normal inverse type characteristic, used in the module, k = 0.14 & n = 0.02.

14. Now the display shows

Set time = 1.0 Sec Trip biased 25%

Observation & Conclusion

DMT

Sl. No.	Set bias (%)	Trip Bias (%)	Set time (s)	Actual relay tripping time (sec)

IDMT

Sl. No.	Set bias (%)	Trip bias (%) (Actual bias)	Set time (TMS) (sec)	Calculated relay tripping time (sec)	Relay tripping time (actual) (sec)

(Note: Actually, in unbiased mode, the IDMT cannot be observed. Discuss this in your understanding and conclusion from the experiment.)

EXPERIMENT– 4: MICROPROCESSOR BASED OVER FREQUENCY AND UNDER FREQUENCY RELAY

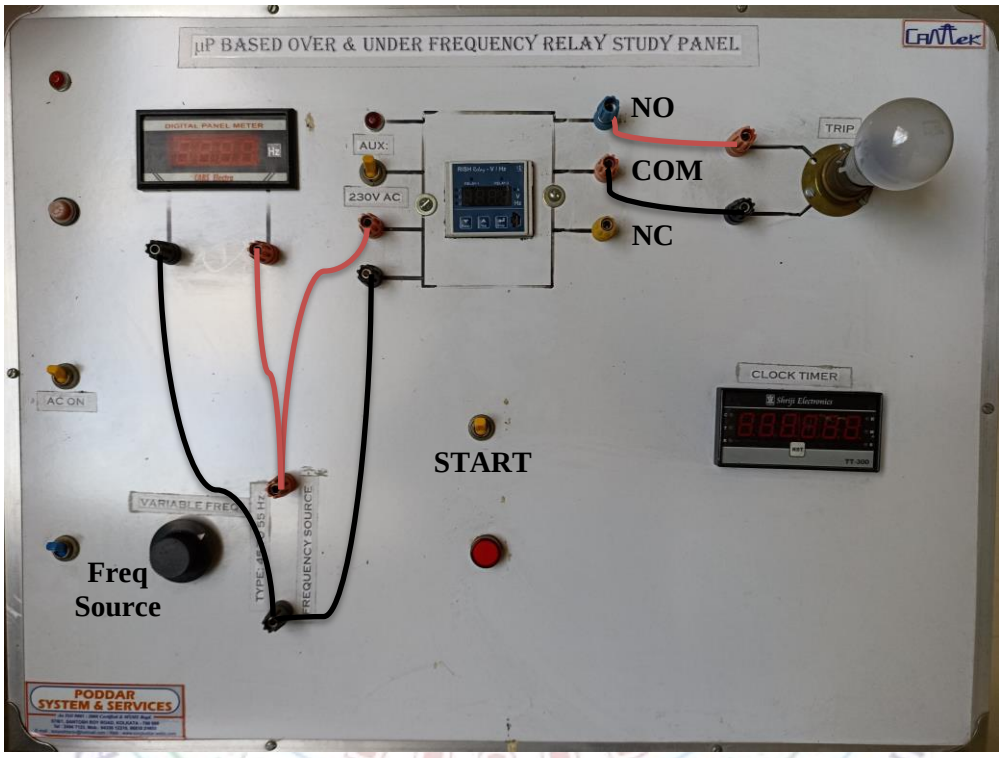
AIM: - To study the operation of microprocessor based over frequency and under frequency relay.

Apparatus Used: - Cantek brand over and under frequency relay study panel by Poddar System & Services, Power cords, Patch cords (Banana connectors).

Theory:

(Write brief theory about significance of over and under frequency protection)

Connection Diagram:



Procedure:

1. Make the connections as per the above figure.
2. Keep Frequency source and Start switches in OFF condition. Make AC (supply) switch ON and Auxiliary (supply) switch to relay ON.
3. The relay will start displaying the parameters like voltage and frequency. It may be observed from the picture here that the relay module has actually two relay elements inside. Both the relays can be used in the experiment.

Caution: Proceed very carefully; any wrong setting may change the entire behavior of the training module. Wait for minimum 1-2 sec after pressing any key - don't press key(s) in quick successions.

4. Press and hold ↵ key for 3 seconds. The relay will enter in set-up mode and display ‘SetP’.
5. Press ↵; relay will ask for code (password) and - - - - will be displayed. Press ↵ again 0000 will be displayed then press ↵ again. (0000 password can also be entered by using ‘UP’, ‘DOWN’ and ‘ENTER’ keys.)
6. Now display will show ‘SYS’. Don’t enter into this (unless guided by the teacher) - it is for changing system setting.
7. Press ▲ key, display will show ‘PArA’ (parameter setting). Press ↵. It will show ‘OV’ (over voltage setting). Ignore that and press ▲. Now it will show ‘uV’ (under voltage setting). Ignore that too and press ▲.
8. Now the display will show ‘OF’ (over frequency setting). Press ↵, it will then show ‘YES’ (means over frequency relay active), press ↵ to confirm. ‘trIP’ (means trip percentage setting) will flash on the display for 1-2 seconds and then display will show digits with cursor blinking.
9. Use ▲ and ▼ keys to change the digits and ↵ key to confirm the digit. Accordingly, set some value between 101 and 110 – the over frequency percentage for relay to trip. If the setting is modified, the relay will ask for ‘set’; press ↵ and continue. If last setting is not edited, continue to the next step.
10. After pressing the ↵ key after final digit, the display will then flash ‘tr_d’ (means trip delay time). Set some value between 0 – 50 sec, as explained in above step.
11. After final ↵, the display will now flash ‘HYS’ (for hysteresis – it is used here to mean allowable error margin). Leave it at ‘0.1’ and press ↵.
12. The next step is to select relay(s) for this ‘OF’ setting. Use ▲ and ▼ keys to select from any of the three options that are ‘rL1’, ‘rL2’ & ‘rL12’, that means relay-1, relay-2 or both the relays should actuate on the violation of over frequency limit.
13. After selecting the relay, press ↵; this will bring the display to one level up in the menu i.e., to the step 8.
14. Now press ▲ key and it will show ‘uF’ (under frequency setting). Repeat the same procedure as described in steps 8 to 13 above to set under frequency relay. Remember, both the relays can have simultaneous over and under frequency settings. (Under frequency range: 98 - 99)

15. After completing the under-frequency settings, when the display is back to the menu showing 'uF', now press  . It will show 'Ph.F' (phase fault setting) – ignore that and press  again. Now display will show 'quit' – press  , it will come to the one level up in the menu and show 'PArA' (step 7).
16. Press  , it will show 'rELY' (relay setting), ignore that and press  again. It will show 'rEST' (reset setting), ignore that too and press  again. Now it will show 'quit' – press  , it will come out of the setup mode and start displaying the system parameters. Over frequency and under frequency relay settings are now ready.
17. Now make frequency source switch ON and vary the knob to set some value of frequency above over frequency limit.
18. Ensure the clock timer is reset and then switch ON the test (START) switch. The L1 LED (red) in the relay will start blinking immediately and the timer will start.
19. After the set time (plus minus the error), the relay will trip and the corresponding relay LED(s) will turn to red from green.
20. Switch OFF the test switch and repeat the steps 17 – 18, for frequency below under frequency limit.
21. Repeat the experiment for different frequency settings and tabulate your readings.

Observation & Conclusion

Sl. No.	Over frequency (OF)/ under frequency (UF)	Set frequency		Actual frequency (Hz)	Set time (sec)	Actual Tripping time (sec)
		(%)	(Hz)			
1.						
2.						
3.						
4.						
5.						

Task/Activity: During different readings, change the selection of relays 'rL1', 'rL2' & 'rL12'. Find out how does it affects the performance of test panel. Similarly change the connection of trip indicating lamp to 'NC' from 'NO' and vice-versa. Note down your observations and share with the teacher.

EXPERIMENT– 5: THREE PHASE UNDER VOLTAGE RELAY

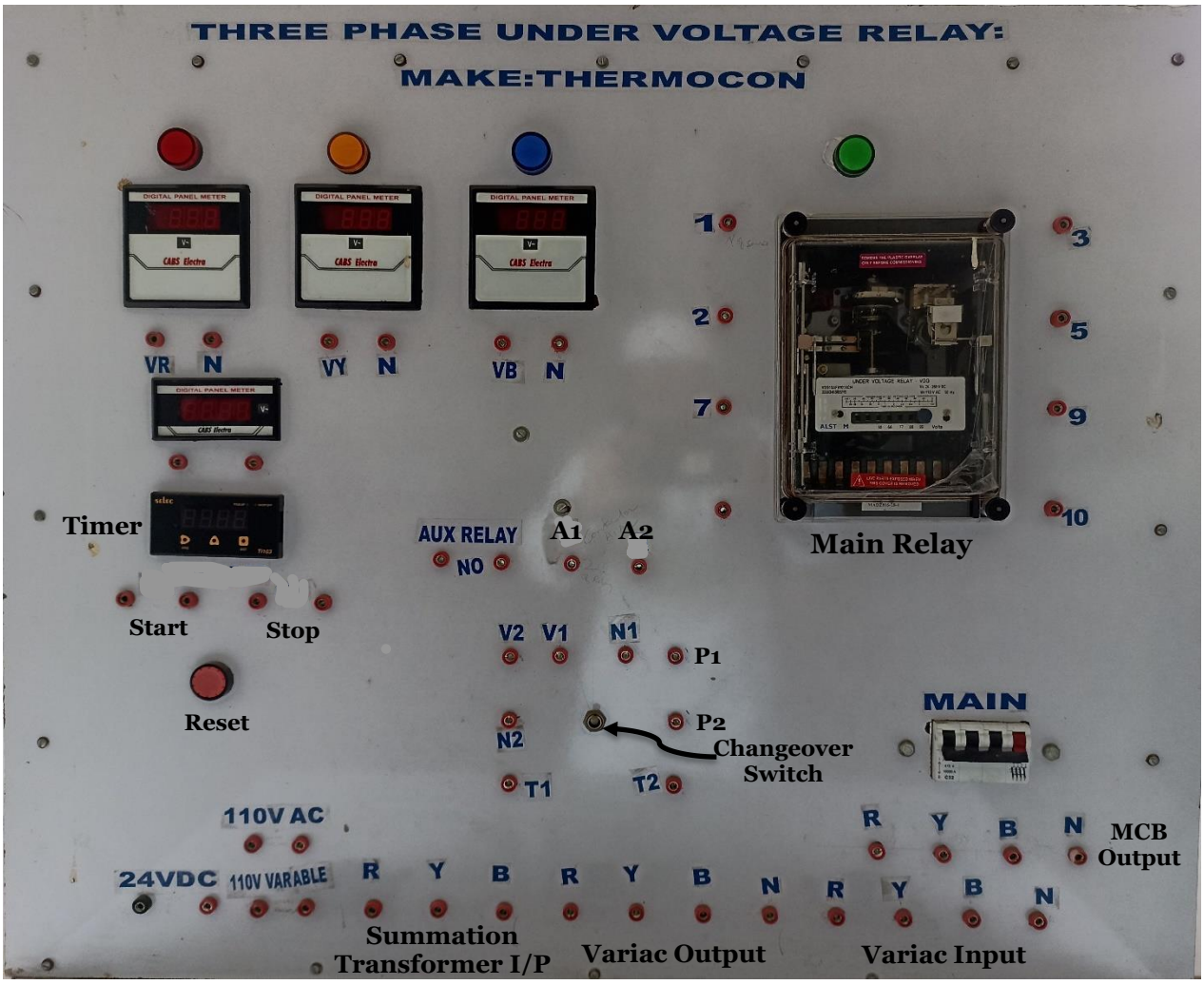
AIM: - To study the operation of ALSTOM VDG-13 three phase under voltage disc relay.

Apparatus Used: - Thermocon make three phase under voltage relay study panel, Power cables, Patch cords (Banana connectors).

Theory:

(Write brief theory about significance of under voltage protection)

Connection:



1. Connect the mains supply (MCB output) to the variac input.
2. Connect the variac output to the input of the summation transformer. Also connect R, Y & B voltmeters to the corresponding variac output terminals.
3. Connect the 110 V constant AC terminals to the V1-N1 terminals of the changeover switch. Similarly connect the 110 V AC variable points (the output of the summation transformer) to the V2-N2 terminals of the changeover switch.
4. Connect the T1-T2 terminals of the changeover switch to the 'START' terminals of the timer. The 'STOP' terminals of the timer are to be connected to the 'NO' contacts of the auxiliary relay.

5. Connect P1-P2 terminals of changeover switch to the PT terminals (9-10) of main relay. Also connect 24 V DC terminals to the auxiliary supply terminals (3-5) of the main relay (3 to +ve and 5 to -ve).
6. Give connection from any one phase (mains) to the A1 terminal of auxiliary relay. Connect A2 terminal of the auxiliary relay to terminal 1 of the main relay. Also connect terminal 2 of the main relay to neutral point N of the mains.
7. Connect the fourth voltmeter (the smaller one) to the 110 V AC variable output of the summation transformer.

Procedure:

1. Ensuring changeover switch in UP position and all the variac knobs in zero position, switch ON the mains supply MCB.
2. Now vary all the three variac knobs and set some voltage of the summation transformer that is less than the plug setting in the main relay.
3. Find the approximate trip time for the given plug setting and the set voltage with the help of PSM chart available in the main relay.
4. Ensure the main relay flag reset and timer reset and then pull the changeover switch DOWN. The disc will start rotating and the timer will start.
5. After few seconds, the main relay will trip causing the timer to stop and green LED indicator will also stop glowing.
6. Fill in the observation table below and switch OFF the main MCB.
7. Now change the plug setting in the relay and repeat the experiment.

Observation & Conclusion

Sl. No.	Plug setting (V)	Set voltage (V)	PSM (in %)	Tripping time from PSM chart (sec)	Actual tripping time (sec)
1.					
2.					
3.					
4.					
5.					

Task/Activity: Draw the complete electrical circuit diagram of the training module (experiment panel).

EXPERIMENT– 6: THREE PHASE FAULT ANALYZER

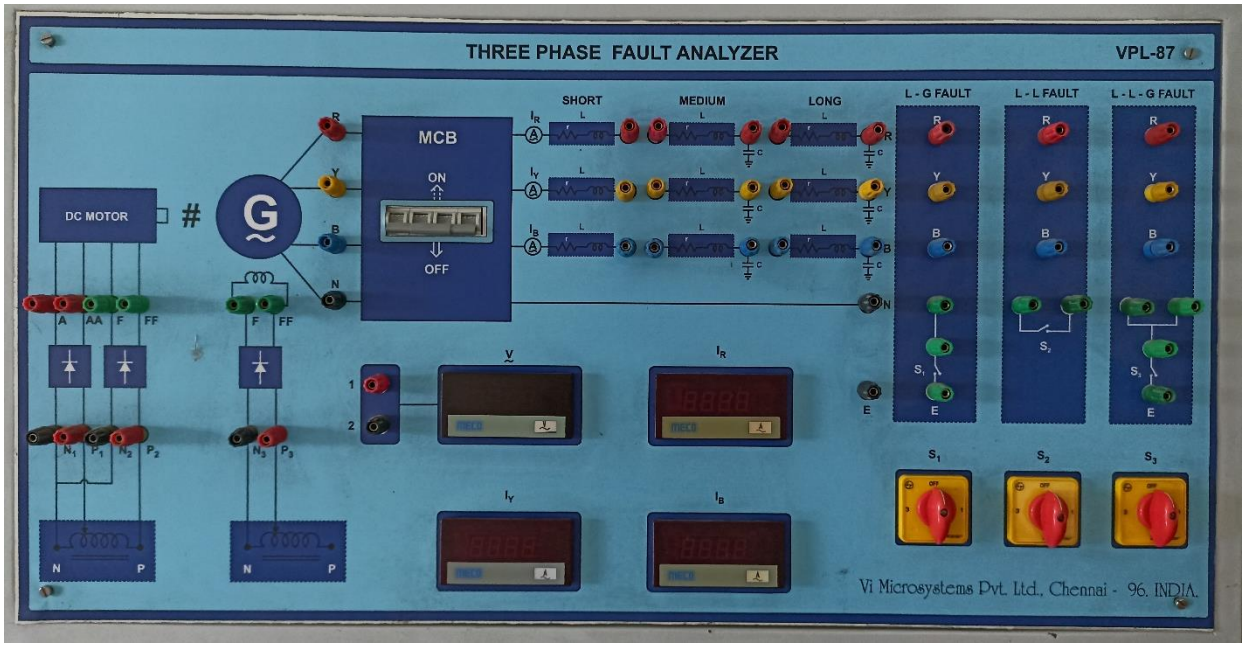
AIM: - To simulate the various shunt faults in transmission line using three-phase fault simulator.

Apparatus Used: - Vi Microsystems make three-phase fault analyzer study panel, Three-phase variac, Power cables, Patch cords (Banana connectors).

Theory:

(Write brief theory about faults)

Connection and procedure:



1. Connect three-phase variac output directly to the R-Y-B-N input of MCB (ignore Motor-Generator assembly; it just for illustration purpose).
2. Connect the corresponding points so as to make the three-phase long transmission line.
3. Connect the voltmeter to measure any one phase voltage. Ammeters are internally connected.
4. Now connect the last end(s) of the transmission line to the fault column(s) on the right side so as to create the desired fault via switch(es) S1/S2/S3.
5. Ensuring the variac at zero position, switch ON the MCB.
6. Gradually vary the variac so as to raise the voltage to 20 V.

> **Caution: Remember, this is fault simulation. Creating short-circuit at higher voltage may damage the equipment. So be careful with voltage application.**

7. Note down the pre-fault voltages and currents. Since the supply is balanced, pre-fault voltage will remain the same in all the three phases. Still, it can be verified by carefully changing the connection of voltmeter to other phases. (As the voltage applied is very low, there is no such danger in

changing the voltmeter connection of live panel but do it carefully so that the patch cords do not touch other points in the panel.)

8. Now change the switch(es) S1/S2/S3 position(s) to simulate the fault condition.
9. Note down the post-fault readings of voltmeter and ammeters (carefully change the voltmeter connection to other phases and note down all the phase voltages) and bring back the switches S1/S2/S3 to their original (OFF) position. (The voltages may not be much affected by the faults, as they are being measured at the source end while the faults are created at the receiving end of transmission line.)
10. Reduce the voltage to zero, switch OFF the MCB and repeat the experiment for other faults.

Observation & Conclusion

Fault		**V_{RN} (V)**	**V_{YN} (V)**	**V_{BN} (V)**	**I_R (V)**	**I_Y (V)**	**I_B (V)**
L-G	Pre-fault						
	Post-fault						
L-L	Pre-fault						
	Post-fault						
L-L-G	Pre-fault						
	Post-fault						
L-L-L	Pre-fault						
	Post-fault						
L-L-L-G	Pre-fault						
	Post-fault						

(Write your understanding and conclusion from the experiment)

Part – B

Simulation

EXPERIMENT– 7: Microcontroller based DMT/instantaneous Overcurrent Relay

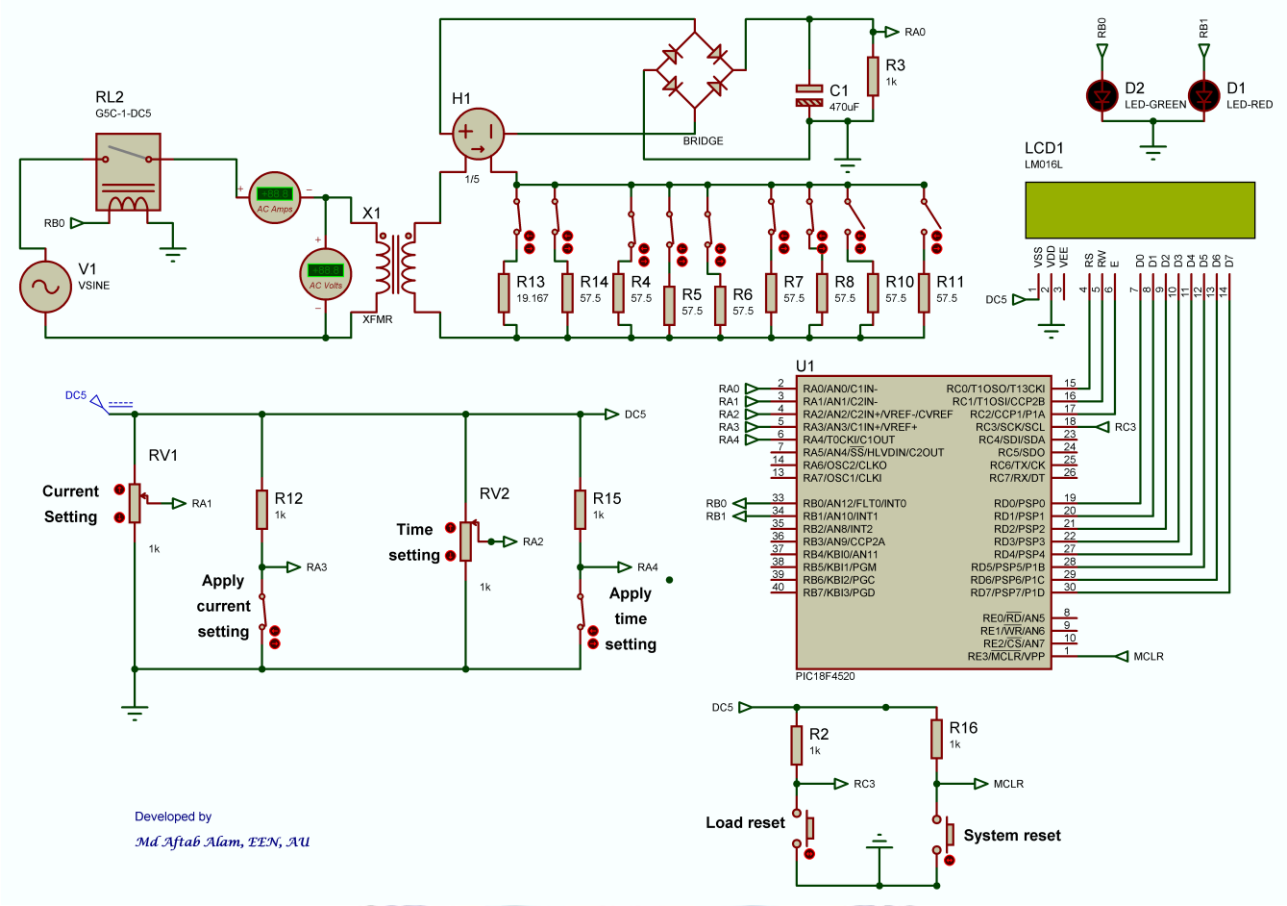
AIM: - To simulate the DMT and instantaneous overcurrent relay in Proteus software.

Apparatus Used: - Proteus software in Personal Computer.

Theory:

(Write brief theory about digital relays)

Connection and procedure:



1. Create the circuit, as shown above, in the Proteus software. Some important parameters to take care are:
    a. AC source (VSINE): Amplitude = 230*1.414, Frequency = 50
    b. Vcc (DC5) = 5
    c. Transformer (XFMR): Turns ratio = 230/115
    d. CCVS (H1): Transresistance = 1/5
    e. Microcontroller: Clock frequency = 8 MHz
    f. All resistance, capacitance values as indicated in the figure. All input, output connectors correct string value (label name) as indicated.
2. Load the .hex file, provided by the teacher, in the microcontroller.
3. Ensure that 'apply current setting' and 'apply time setting' switches are in open position.

4. Start the simulation.
5. After the ‘welcome’ screen, display will ask to ‘set current’.
6. Adjust the ‘current setting’ pot to set the overcurrent limit (4 A to 10 A).
7. After setting the desired current limit, close the ‘apply current setting’ switch.
8. Then display will ask to ‘set time’.
9. Repeat steps 6 and 7 for time setting pot and switch (time range is 0 to 50 sec). Setting time limit as zero will make this relay ‘Instantaneous Overcurrent Relay’. Else, the relay will behave as DMT relay (for time limits other than zero).
10. After both the settings are done, the relay will start displaying the load current. If the current is less than 3 A, it will show as ‘under current’.
11. Increase the load current in steps by closing the load bank switches one by one.
12. As soon as the load current crosses the set limit, relay timer will start. After the set time, the relay will trip the circuit.
13. Reduce the load by opening some of the load bank switches, then press the ‘load reset’ button; display will again start showing the load current.
14. If you want to change the setting, press ‘system reset’ button after ensuring that ‘apply current setting’ and ‘apply time setting’ switches are in open position.

Task/Activity: Draw the flowchart of the relay operation as per your observation and understanding.