Rao Bahadur Y. Mahabaleswarappa Engineering College
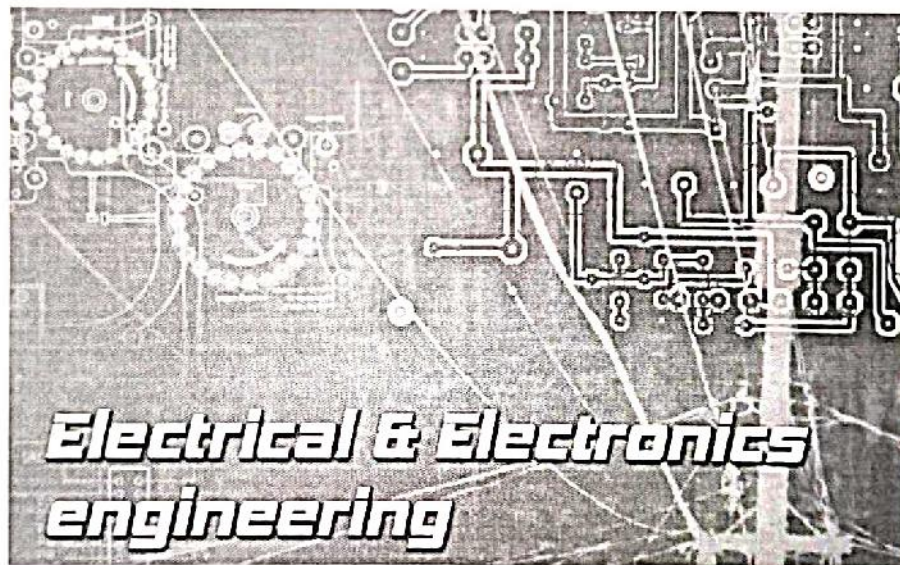

LAB MANUAL

Scheme:2018

Branch: Electrical & Electronics Engineering

Year & Semester: 3rd /5th

18EEL58 Power Electronics Lab

List of Experiments

1. Static Characteristics of SCR.

2. Static Characteristics of MOSFET and IGBT.

3. Characteristics of TRIAC.

4. SCR turn on circuit using synchronized UJT relaxation oscillator.

5. SCR digital triggering circuit for a single phase controlled rectifier and ac voltage regulator.

6. Single phase controlled full wave rectifier with R and R–L loads.

7. AC voltage controller using TRIAC and DIAC combination connected to Rand RL loads.

8. Speed control of dc motor using single semi converter.

9. Speed control of stepper motor.

10. Speed control of universal motor using ac voltage regulator.

11. Speed control of a separately excited D.C. Motor using an IGBT or MOSFET chopper.

PE LAB COURSE OUTCOMES & MAPPING

CONo.	Description At the end of the course, students will be able to ….
C308.1	obtain static characteristics of semiconductor devices to discuss their performance.
C308.2	analyse the different methods to turn on SCR.
C308.3	test the performance of single phase controlled full wave rectifier and AC voltage controller with R and RL loads.
C308.4	examine the speed control of a DC motor, universal motor and stepper motor.

CO	Programme Outcome												Specific Outcome	
	1	2	3	4	5	6	7	8	9	10	11	12	S1	S2
C308.1	3	2		2					2			1	2	
C308.2	3	2		2					2			1	2	
C308.3	3	2		2					2			1	2	
C308.4	3	2		2					2			1	2	
C308	3	2		2					2			1	2	

Note: 1.Slight(low)   2.Moderate(Medium)   3.Substantial(High)

Rubrics for Power Electronics Lab (18EEL58)

Attendance(CIE)	20M
Record	10M
Lab Test	10M
Total CIE Marks	40M

Circuit Diagram:

Ideal Graph:

$I_{G1} > I_{G2}$

I_H

I_{G1}

I_{G2}

V_{BO1} V_{BO2}

$\longrightarrow V_{AK}$ Volts

I_A nA/mA/A

ΔV_{AK}

ΔI_A

$I_0 > I_L$ (F-C.M)

$I_0 < I_L$ (E.B.M)

$I_0 < I_H$ (T_OFF)
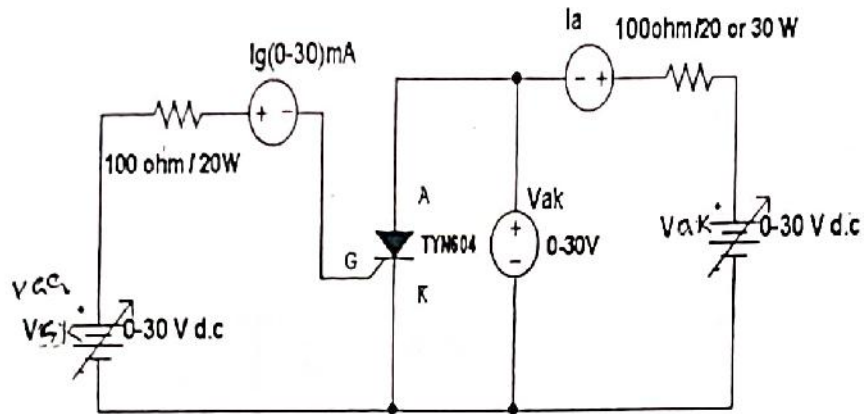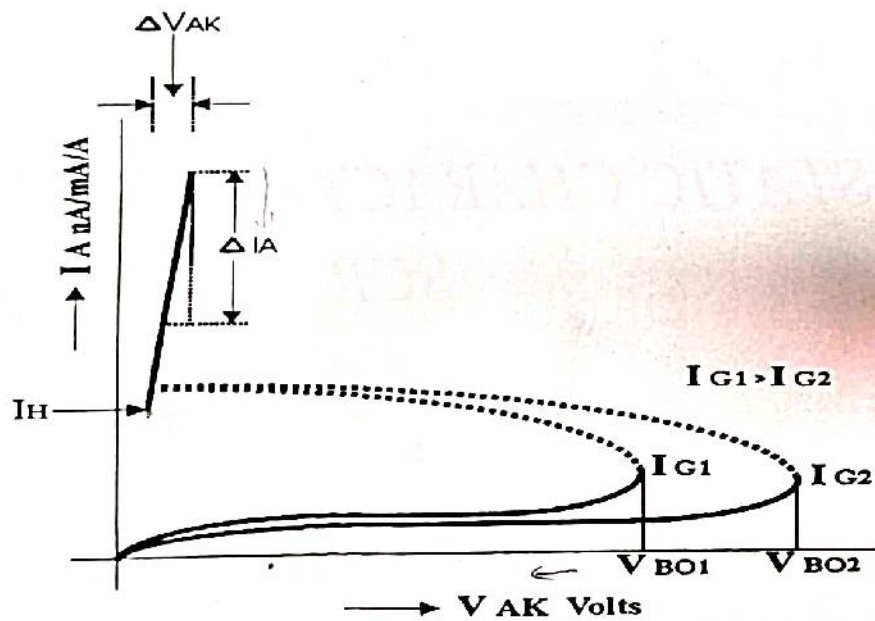
Base Diagrams of 2N3669/70 & TY604: -

K

A —   — A

G

TY604

K A G

g
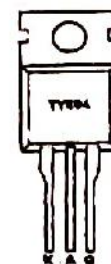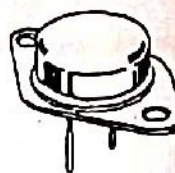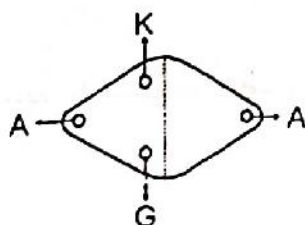
STATIC CHARACTERISTICS OF SCR

Aim: - To study the V-I characteristics of S.C.R. and determine the Break over voltage, on state resistance Holding current. & Latching current.

Apparatus required: -

SCR - TY604, Power Supplies, Wattage Resistors, Ammeter, Voltmeter, etc.

Theory:

SCR belongs to the thyristor family. It's symbol & internal three P-N junction layers is as shown fig (a) & (b). The SCR has three terminals Anode (A), Cathode (K) & Gate (G). It has four layer of PNPN as shown in fig (b).

The working of thyristor can be discussed in 3modes.

1. Reverse blocking mode.

2. Forward blocking mode.

3. .Forward Conduction mode.

When anode voltage is made positive with respect to the cathode, the junction J_1 & J_3 are forward biased. The junction j_2 is reverse biased & the thyristor is then said to be in the forward blocking mode. When anode voltage is made negative with respect to cathode junctions J_1 & J_3 are reverse biased & the thyristor does not conduct & is in reverse blocking mode.

When V_{AK} reaches $V_{BO \, thyristor}$ turn ON, this is called forward conduction mode.

Procedure:

1. Connections are made as shown in the circuit diagram.

2. The value of gate current I_G, is set to convenient value by adjusting V_{GG}.

3. By varying the anode- cathode supply voltage V_{AA} gradually in step-by-Step, note down the corresponding values of V_{AK} & I_A. Note down V_{AK} & I_A at the instant of firing of SCR and after firing (by reducing the voltmeter ranges and increasing the ammeter ranges) then increase the supply voltage V_{AA}. Note down corresponding values of V_{AK} & I_A

4. The point at which SCR fires, gives the value of break over voltage V_{BO}.

5. A graph of V_{AK} V/S I_A is to be plotted.

Experiment No:

Tabular column

:I_g = _____ mA

S.No	V_{AK} (Volts)	I_A (mA)

I_g = _____ mA

| S.No	V_{AK} (Volts)	I_A (mA)

4

6. The on state resistance can be calculated from the graph by using a formula.

7. The gate supply voltage V_{GG} is to be switched off.

8. Observe the ammeter reading by reducing the anode-cathode supply Voltage V_{AA}. The point at which the ammeter reading suddenly goes to Zero gives the value of Holding Current I_H.

9. Steps No.2, 3, 4, 5, 6, 7, 8 are repeated for another value of the gate current I_G.

Procedure (Latching current):

1. Connections one made as shown in the circuit diagram.

2. Set V_{gg} at 7 volts.

3. Set V_{aa} at particular value, observe I_a, by operating the switch (on & off). If it goes to zero after opening of the switch, indicates $I_a < I_L$.

4. Repeat step 3 such that the current I_a should not go to zero after opening of the switch. Then I_a gives the value of I_L.

Circuit Diagram of MOSFET Characteristics
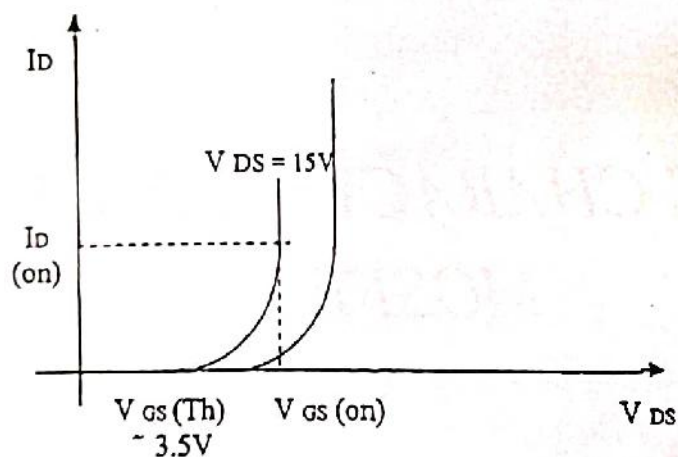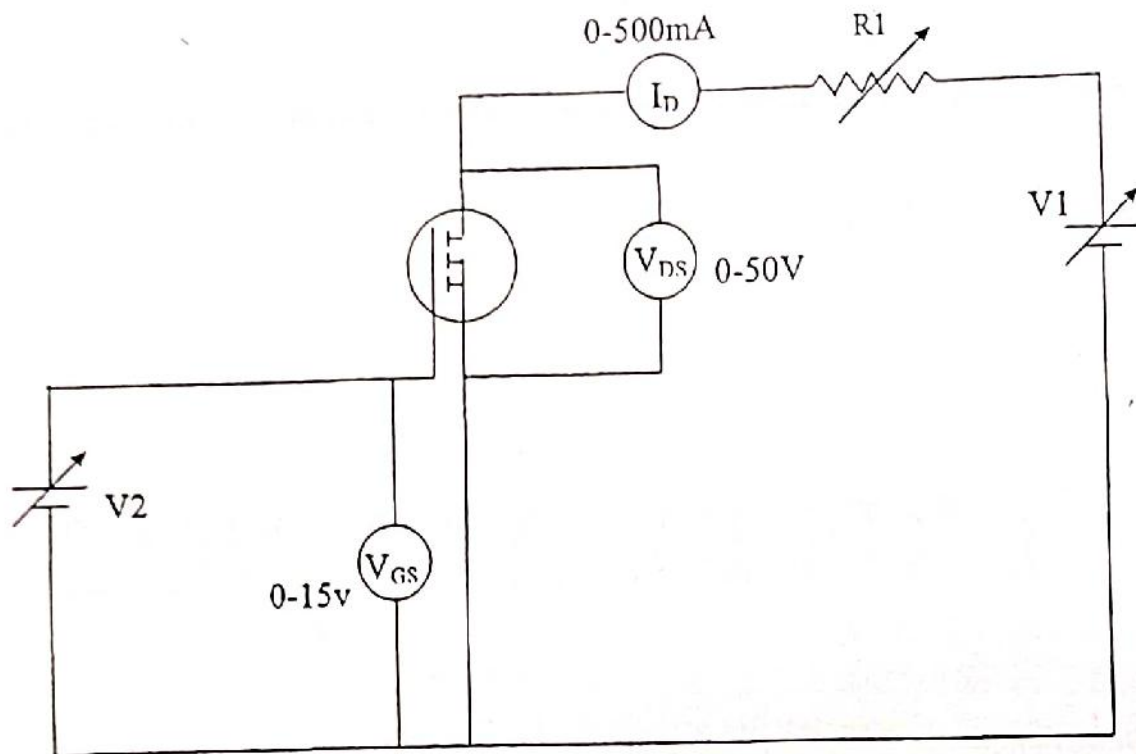
TRANS CONDUCTANCE CHARACTERISTICS

Drain characteristics

7

Experiment No: 2
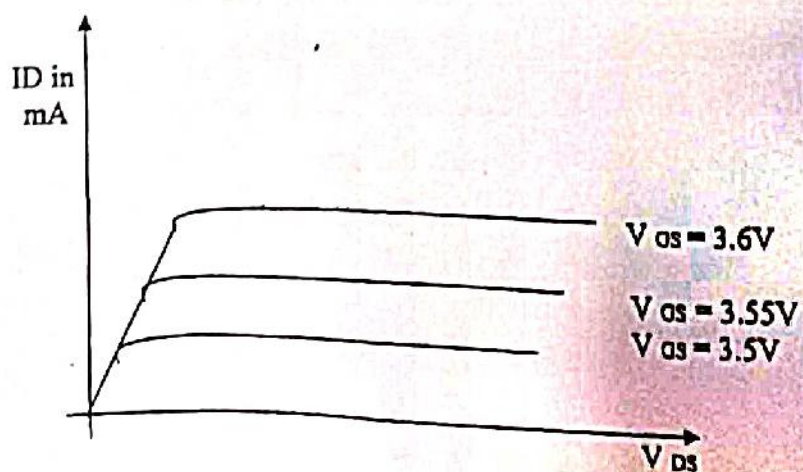
Static Characteristics of MOSFET

Aim: -To study the characteristics of MOSFET

Apparatus required: -

MOSFET-IRF740, Power Supplies, Wattage Resistors, Ammeter, Voltmeter, etc.,

Theory:

A power MOSFET is a Voltage - Controlled device and requires only a small input current. Switching speed is very high and switching times are of order of nano seconds.

MOSFET are of two types:1.Depletion MOSFET and 2.Enhancement MOSFET. An n-channel depletion-type MOSFET is formed on a p-type Si substrate with two heavily doped n-type Si layers for low resistance connections.The gate is isolated from the channel by a thin oxide layer.The three terminals are gate,drain and source.The substrate is normally connected to the source.
There are 3 regions of operation:
Cut-off region
Pinch off or saturation region
Linear region
The drain current I_D varies in proportion to drain-source voltage V_{DS}

Procedure: -

Drain Characteristics

1. Connections are made as shown in the circuit diagram.
2. Adjust the value of V_{GS} slightly more than threshold voltage V_{th}
3. By varying V1, note down I_D & V_{DS} and are tabulated in the tabular column
4. Repeat the experiment for different values of V_{GS} and note down I_D v/s V_{DS}
5. Draw the graph of I_D v/s V_{DS} for different values of V_{GS}.

Transconductance Characteristics

1. Connections are made as shown in the circuit diagram.
2. Initially keep V1 and V2 zero.
3. Set V_{DS} = say 0.6 V
4. Slowly vary V2 (V_{GE}) with a step of 0.5 volts, note down corresponding I_D and V_{DS} readings for every 0.5v and are tabulated in the tabular column
5. Repeat the experiment for different values of V_{DS} & draw the graph of I_D v/s V_{GS}
6. Plot the graph of V_{GS} v/s I_D

Result:

8

Circuit Diagram: -

Ic(0-500mA) RL

IRGBC20

VCE (0-50v)

C

G

E

V1

(10 ohm / 20 W)

(0-30v)

V2

VGE(0-15v)

(0-30v)

Ideal Graphs: -

$V_{GE1} > V_{GE2}$

I_C mA

V_{GE1} Volts

V_{GE2} Volts

V_{GE3} Volts

V_{CE} Volts

Collector Characteristics

I_C mA

V_{CE} Volts

V_{th}

V_{GE} Volts
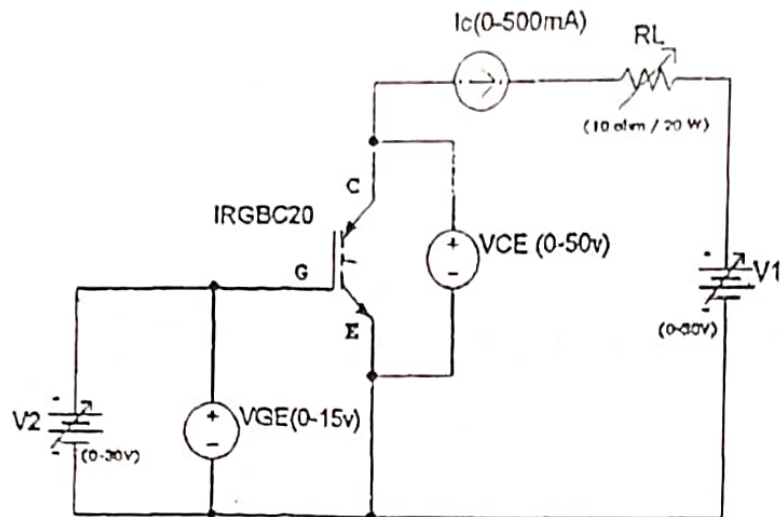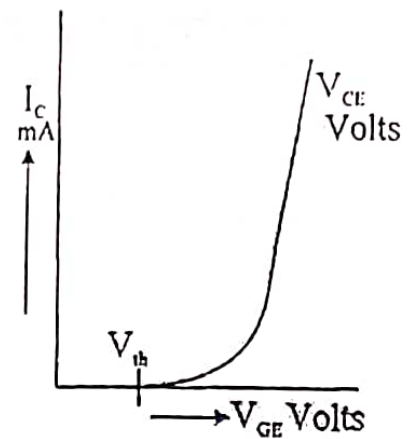
Transconductance Characteristics

Static Characteristics of IGBT

Aim: -To study the characteristics of IGBT

Apparatus required: -

IGBT-IRGBC 20S, Power Supplies, Wattage Resistors, Ammeter, Voltmeter, etc.,

Theory:

Insulated gate bipolar transistor is latest device in power electronics. It is obtained by combining properties of BJT and MOSFET. IGBT has three terminals Gate (G), collector(C) and Emitter (E).Current flows from collector to emitter whenever a voltage between gate and emitter is applied. The IGBT is said to have turned ON when gate has full control over conduction of IGBT. The VI characteristics is as shown in fig

Procedure: -

Collector Characteristics:

1. Connections are mode as shown in the circuit diagram.
2. Initially set V2 to V_{GE1} = 5v (slightly more than threshold voltage)
3. Slowly vary V1 and note down I_c and V_{CE}
4. For particular value of V_{GE} there is pinch off voltage (V_P) between collector and emitter
5. Repeat the experiment for different values of V_{GE} and note down I_c v/s V_{CE}
6. Draw the graph of I_c v/s V_{CE} for different values of V_{GE}.
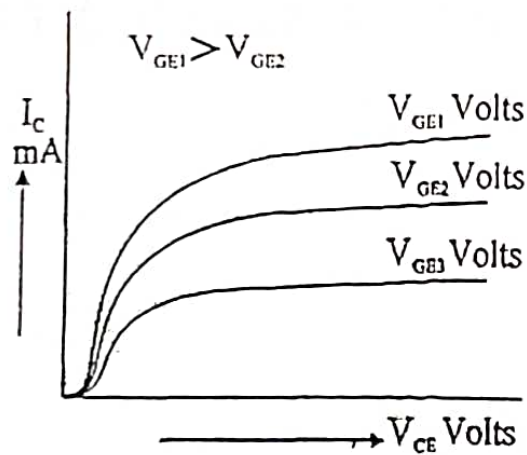
Transconductance Characteristics

1. Connections are mode as shown in the circuit diagram.
2. Initially keep V1 and V2 at zero.
3. Set V_{CE1} = say 0.8 v
4. Slowly vary V2 (V_{GE}) and note down I_c and V_{GE} readings for every 0.5v and enter tabular column
5. Repeat the experiment for different values of V_{CE} and draw the graph of I_c v/s V_{GE}

Tabular Column

$V_{GE} =$	
$V_{CE}(V)$	$I_C(mA)$

$V_{GE} =$	
$V_{CE}(V)$	$I_C(mA)$

$V_{CE} =$	
$V_{GE}(V)$	$I_C(mA)$

$V_{CE} =$	
$V_{GE}(V)$	$I_C(mA)$

UJT FIRING CIRCUIT

RC

Rc

R1

B1

Rz

EMITTER

C

B2

CF

MAINS

AC

A

G

K

R Load

50Ω 2A
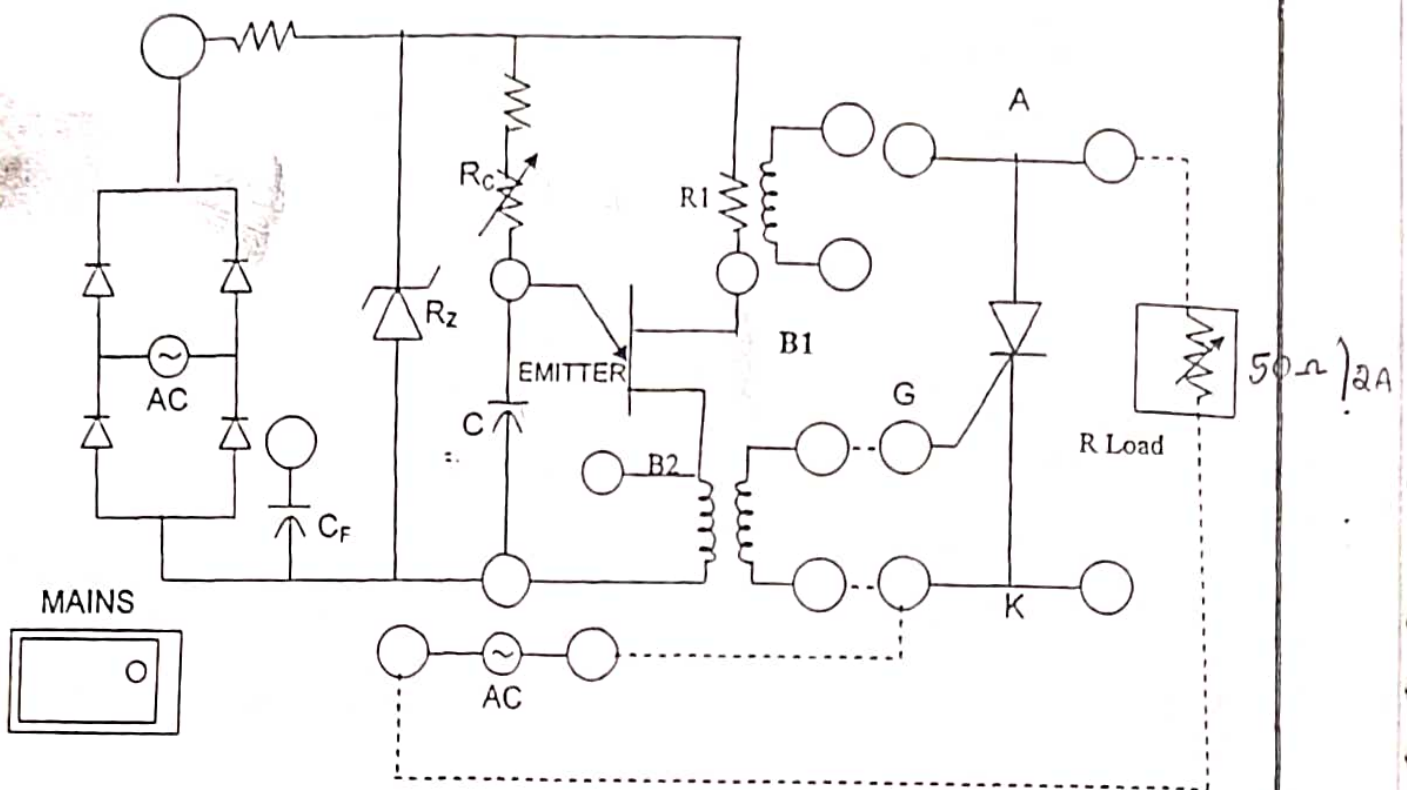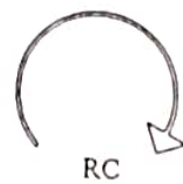
SCR TURN-ON CIRCUIT USING SYNCHRONIZED UJT RELAXATION OSCILLATOR

Aim: To study the SCR synchronized UJT firing circuit.

Apparatus required:

SL.NO	Apparatus	Range	Quantity
1	UJT	2N2646	1
2	Resistor	47Ω,1KΩ	1
3	Capacitor	0.1µF	1
4	DRB	10KΩ	1

Theory:

Firing of SCR using UJT triggering circuit is one of the simplest methods of SCR triggering. It is used in 1 phase converter,1 phase AC regulators to trigger SCR.

Fig (a) shows circuit diagram of UJT triggering circuit. The supply voltage is rectified and given to zener regulator. The voltage of zener diode is V_z. Zener diode clamps rectified voltage to V_z hence voltage V_z is applied to UJT circuit.

Capacitor charges through resistance RC when capacitor voltage becomes equal to V_p of UJT It turns ON. The capacitor discharges through Emitter (E), Base (B) and primary of pulse of transformer. A pulse is generated which is gate triggering pulse. When a capacitor discharges to a voltage called valley voltage (V_v), the UJT turns OFF and capacitor again starts charging. This mode of working of UJT is called relaxation oscillator. The delay angle 'α' is the angle when first triggering pulse is generated in half cycle.

The charging of a capacitor can be varied by resistance Rc. Their delay angle can also be varied. UJT trigger circuit has firing angle from 0-180°.

The Zener voltage acts as supply voltage for UJT relaxation oscillator.

Procedure:
1) Make connection as per given circuit diagram using AC source, UJT relaxation oscillator, SCR and a suitable load.
2) Now switch on the main supply. Observe and note down output waveforms across load.
3) Draw the waveforms at different firing angle 120°,60° etc. This is one of the simplest methods of SCR triggering.

VARIOUS WAVEFORMS FOR HALF WAVE CONVERTER USING UJT

Fixed Freq. Oscillator (ff.) — R

Clock

N –bit Counter-3 stage — Preset ('N'no. of counting bits)

max / min — S

Flip – Flop (F/F) — $\overline{B}$

R — Reset

En

Logic ckt. + Modulator + 74121 monostable oscillator — A, $\overline{A}$

Reset

Load

Sync. Signal (~ 10V)

DC 5V Supply

ZCD — $\overline{C}$

A — $\overline{A}$

Carrier Frequency Oscillator. (~ 5 kHz) — Fc

TM   TA
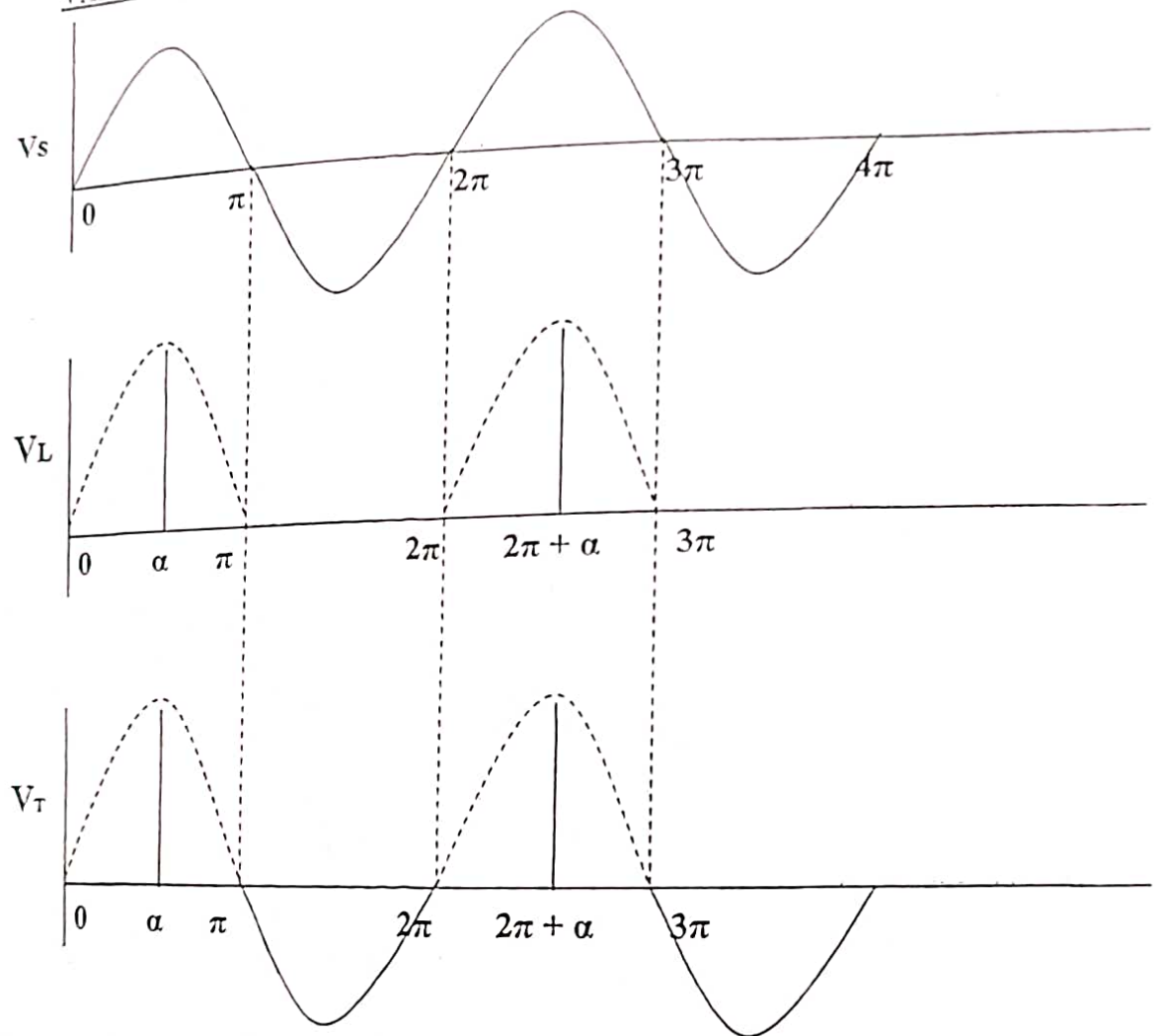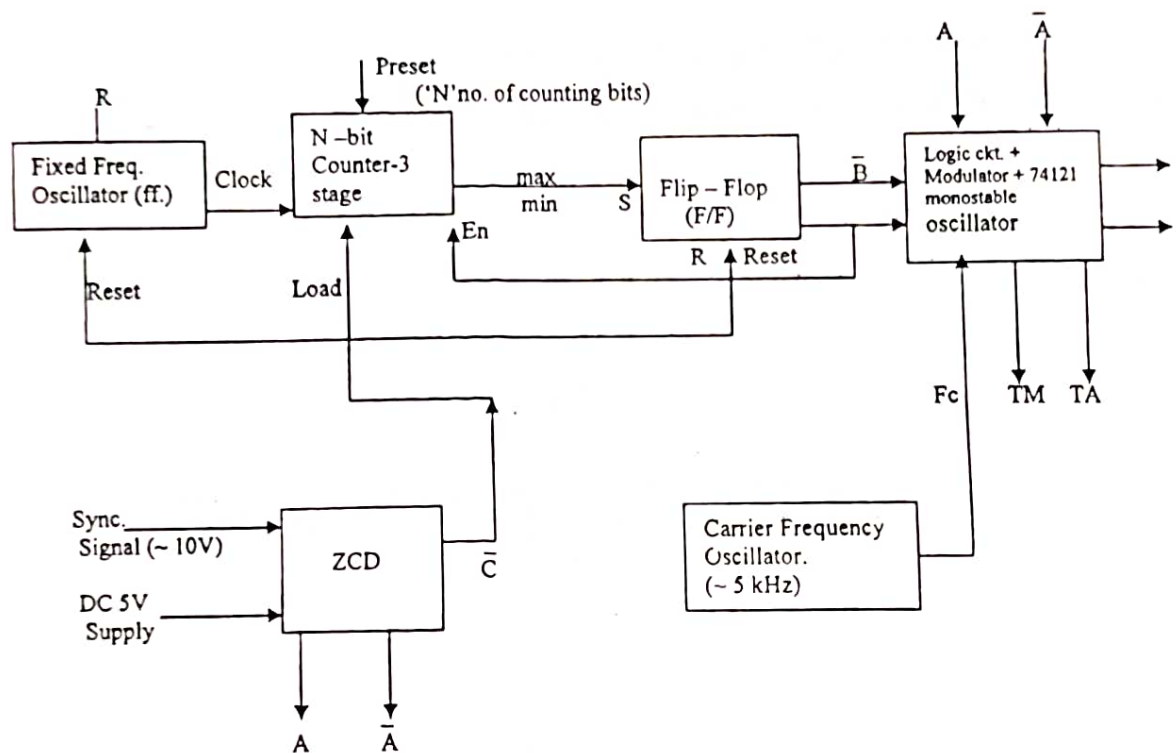
BLOCK DIAGRAM OF THE DIGITAL FIRING CIRCUIT.

25

Experiment No: 4

Digital Firing Circuit

Aim:-

To demonstrate digital firing circuit to turn on SCR (HW) for R-Load and to plot V_{ODC} v/s α.

Apparatus required:-

Digital Firing Module, SCR-TYN604, Resistor, etc.,

Theory:-

DIGITAL FIRING CIRCUIT

1. **Zero Crossing Detector:-**

The AC regulator and converter power circuit are energized by an AC power source. For getting correct pulses at the zero crossing point in each half cycle, a low voltage synchronized signal (10V and of the same frequency and phase as the AC source) is used. LM 393 op-amp is used to get the ZCD output from the 10Volts AC reference signal.

2. **Fixed Oscillator: -**

Astable oscillator using timer IC – 555 is used to generate 180 and 100 pulses per half cycle (using selector switch).

In order to cover the entire range of the firing angle (α) from 0 to 180° and duty Cycle from 0-100%. The n bits counter is required for obtaining 2n rectangular Pulses in half cycle. Connect one channel of the oscilloscope to synchronized Signal and the other channel to the counter and flipflop output. Keep the firing Angle at 179° and adjust the potentiometer R, such that a small pulse of 1° Duration appears at the output.

3. **4 bit programmable counter (74190):-**

Here the counter is being used in 'Down counting mode'. The counter can count From 9 to 0 pulses. Here 3 counters are cascaded. As soon as, the synchronized Signal crosses zero, the load and enable become high and low respectively. And The counter start counting the clock pulses in down mode. The pins PA, PB, PC And PD can be made high or low with the help of thumb wheel switch. The Counter overflow signal (max/min) is processed to trigger the thyristors.

4. **R – S Flip Flop: -**

Make R-S flip flop is isolated using gates. Reset input terminal of the flip Flop is connected with the output pulse C of ZCD and set input of the flip flop is Set according to the max/min output of the counter. The pulse C goes to low at each zero-crossing of the synchronized signal. And a low value of C, which is an input to the flip flop, reset B to 1 and B to 0. A high output of the counter set the flip flop output B to 0 and B to 1. The state of flip flop is latched till the next zero crossing of the synchronized signal. The output B of flip flop is connected with enable pin of counter 74190. A high 'EN' of counter stops counting till the next zero crossing.

5. **Logic Circuit, Modulation and Driver Stage:-**

The o/p pulses of the flip flop and Pulses A and A of ZCD are applied to AND Gate. The output of AND gate is applied to another AND Gate and the other input to this Gate is fc (high frequency carrier generator – 5KHz using op-amp). The output of this 2 AND Gates are Tp and Tn.

6. Chopper pulse Tm and T_N Generation: -

The flip flop output B is connected to Inputs of 74LS123 IC – Dual retriggerable mono stable multivibrator. The outputs of 74LS123 are Tm – Main pulse and TA -auxiliary pulse. The duration of Tm and T_A is approximately 100 ☐ sec. ON/OFF switch is provided for Tm output for commutation purpose.

Tm pulse can be used to trigger SCR connected in 1-ph half wave converter.

7. Pulse Transformer Isolation: -

The T_P, T_N and Tm, T_A trigger o/p pulses are fed to pulse transformer isolation circuit. Here the signals are amplified using Transistor and isolated using pulse transformer.

Procedure: -

1. Connections are made as shown in the circuit diagram.
2. Firing angle α is varied in steps gradually, note down corresponding values of V_{ODC} (DC voltmeter reading) and tabulate.
3. A graph of α v/s V_{ODC} is plotted

LIGHT DIMMER CIRCUIT USING TRIAC- DIAC

LAMP

R_1

R_F

50V
AC

R_2

R_F

MT₂

GATE

DIAC

C_1

C_2

MT₁

MAINS
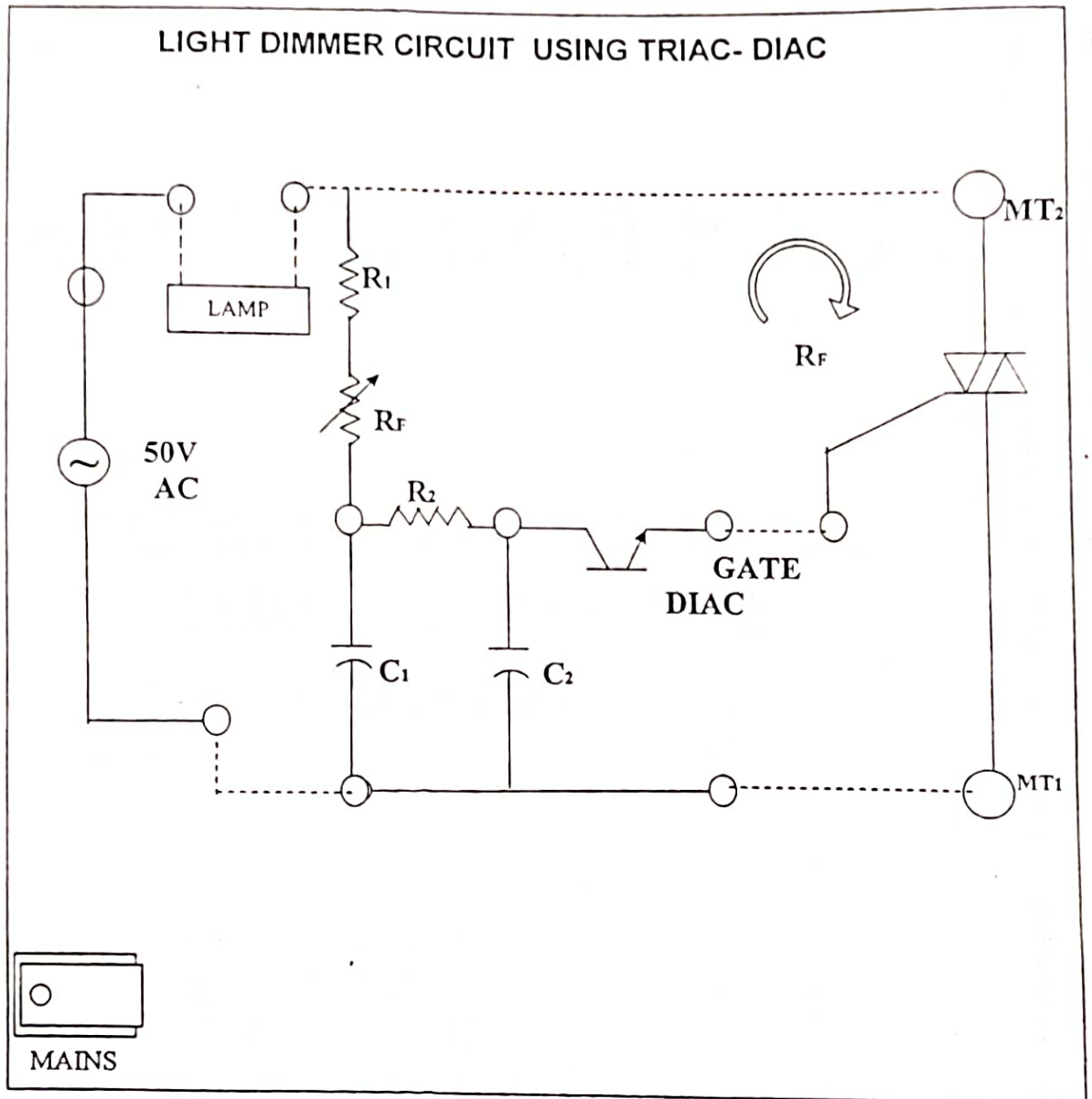
..... dotted lines - connections
must be done

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Experiment No: 5

AC Voltage Controller by using TRIAC-DIAC Combination

AIM: -

To study the AC voltage control by using TRIAC-DIAC combination

APPARATUS REQUIRED: -

TRIAC, DIAC, supply voltage, wattage resistors, Ammeter, Voltmeter, etc

THEORY

Fig 3.1 (a) shows the schematic of a single phase full wave controller using TRIAC. A TRIAC can be considered as two SCR's connected in antiparallel with a common gate connection. Since a Triac is a bi – directional device, its terminals can not be designed as anode and cathode. If terminal MT2 id positive with respect to terminal MT1, the TRIAC can be turned on by applying a positive gate signal between gate 6 and terminal MT1. If terminal MT2 is negative with respect to terminal MT1, it is turned on by applying negative gate signal between gate 6 and terminal MT1. However, it is not necessary to have both polarities of gate signals and a TRIAC can be turned on with either a positive or negative gate signal. In practice, the sensitivities vary from one quadrant to another and the TRIACs are normally operated in quadrant I+(positive gate voltage and gate current).

PROCEDURE:

1) Make the connections as given in the circuit diagram.
2) Connect the lamp (60 Watt) at load terminals.
3) Switch ON the mains supply, vary the firing angle potentiometer and observe the variation in lamp brightness and also note down the voltage variation across the lamp.
4) Observe the waveform across the lamp and RL load.

CIRCUIT DIAGRAM

A MOTOR AA $-$ (A) $+$
                    (O-5A)

IGBT   (O - 270V)

G

E

DRIVER
OUTPUT

$+$ V_{dc}

V_{CE}

NATURE OF GRAPH

SPEED (RPM) →

%, DUTY CYCLE →
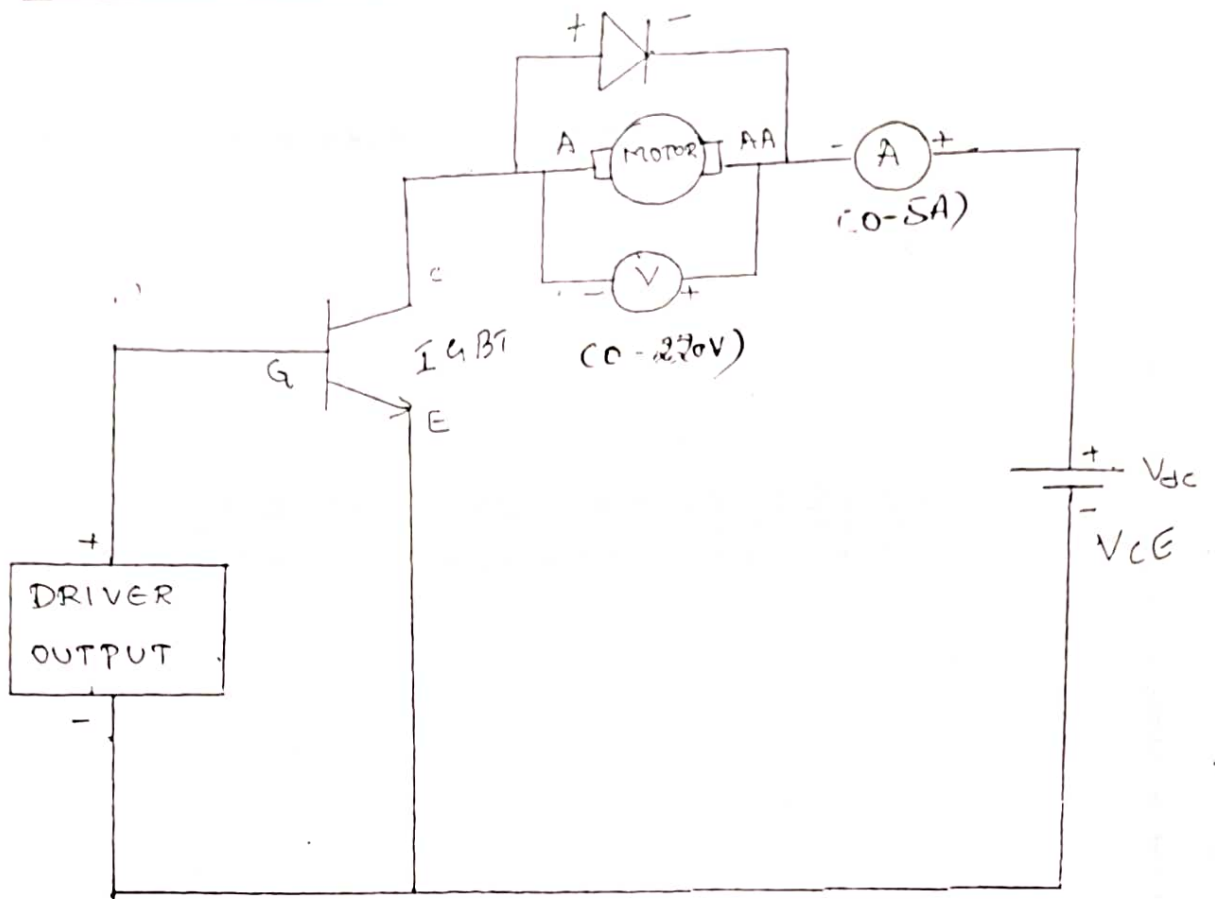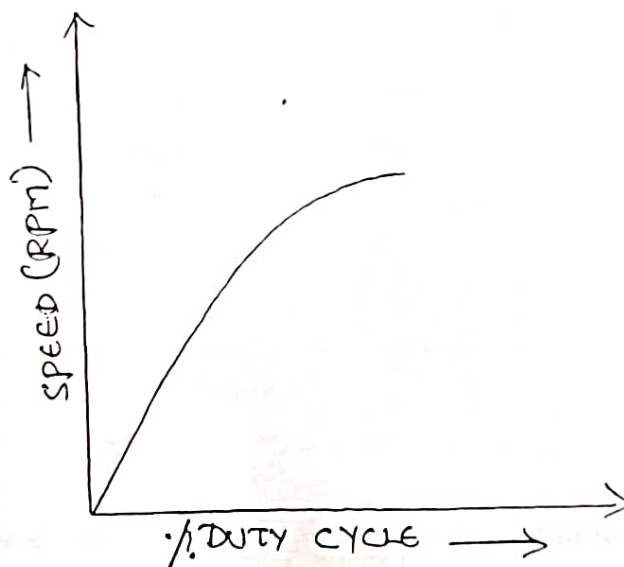
Experiment no:-6
Speed control of separately exited DC motor using MOSFET and IGBT circuits

Aim:-
To control speed of separately exited DC motor.

Apparatus:-
circuit, control circuit

Theory:-
The power circuit mainly consist of power MOSFET,IGBT, a freewheeling diodes built in DC source for the chopper circuits and the digital meters.

A power MOSFET or IGBT and a freewheeling diode are mounted on a suitable heat sink and protected by snubber. Circuit and fuses .All the device terminals are brought out on the front panel.

A built in DC source is provided in the unit for input to the chopper circuit. A main supply of 230v is step down using a transformer with tapping's and different AC output voltage is selected using a rotor switch the selected AC voltage capacitor. A glass fuse is provided filter capacitor a glass fuse is provided in DC supply different DC voltages of 24v, 48v,110v, and 220v can be selected using the rotary switch.

Procedure:-
1) Connections are made as per the circuit diagram.
2) Frequency 'f' is kept constant at particular frequency if f=50hz and by varying duty cycle k. the value of RMS is noted.
3) Corresponding Vdc and Idc is noted down.
4) Ton and Toff time is noted down from CRO and then calculate duty cycle.
5) Output voltage is arranged value of voltage calculated by Vo(avg)=Vin .
6) Thus finally the graph of duty cycle at x-axis Vdc, Idc and RPM on y-axis is plotted.
7) Variable frequency operation the chopping frequency f is varied. Either on time or off time is kept constant this is called frequency modulation.

TABULAR COLUMN

Sl No	Vin VOLTS	FREQUENCY in Hz	DUTY CYCLE	Vout in Volts	Io in Amps	SPEED IN RPM.

Logic circuit :-
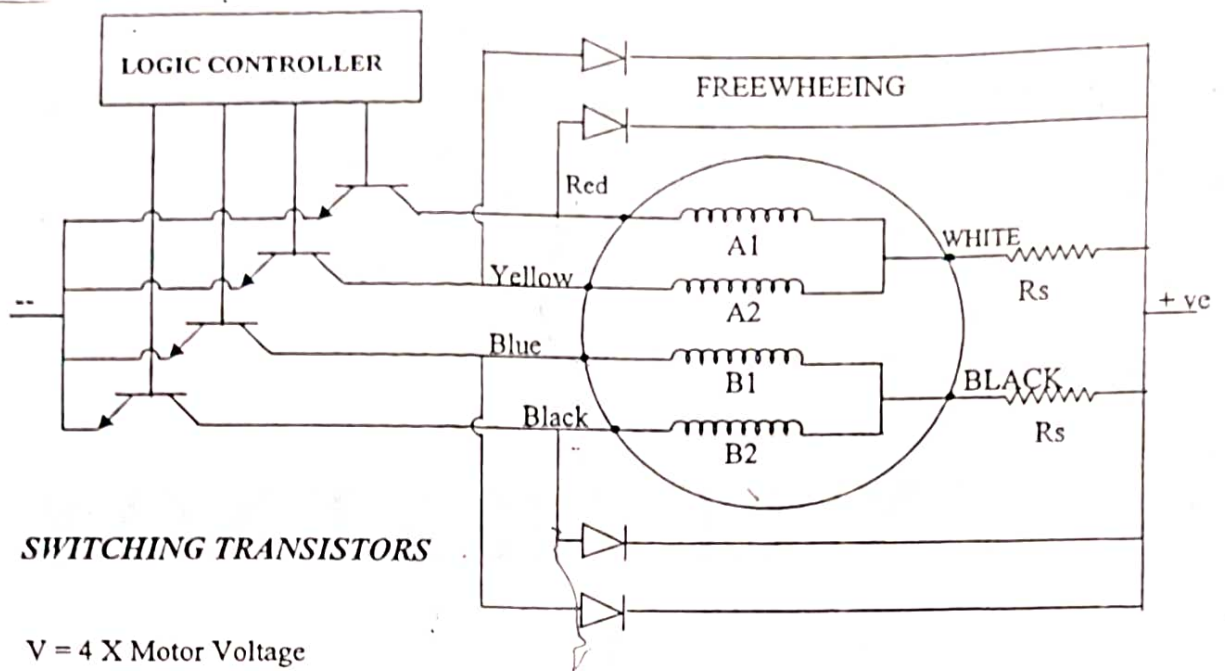
SWITCHING TRANSISTORS

V = 4 X Motor Voltage
Rs = 3 X Rm (Motor resistance/ Phase)
Suitable for slow RPM

SWITCHING LOGIC SEQUENCE
Full step

A1	A2	B1	B2
Red	Black	Blue	Green
0	1	0	1
0	1	1	0
1	0	1	0
1	0	0	1
Q1	Q2	Q3	Q4

Half step

A1	A2	B1	B2
Red	Black	Blue	Green
0	1	0	1
0	0	0	1
1	0	0	1
1	0	0	0
1	0	1	0
0	0	1	0
0	1	1	0
0	1	0	0

To change the direction read sequence from bottom to top.

Specification : -
Permanent Magnet, Bifilar Wound.   Steps per Revolution: 200
Two phase. No. of leads - 6
Step Angle : 1.8* + or – 0.1* non cumulative.
3Kg.cm.= 0.1 N.m = 13.9 Oz
Voltage -5V

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SPEED CONTROL OF STEPPER MOTOR

AIM: -

To control the speed of the stepper motor.

APPARATUS: -

Power supply, LCD display, Leads, LEDs, fuse, keyboards, wires, stepper motor etc

THEORY: -

DC brush motors rotate continuously when voltage is applied to their terminals. Stepper motors, on the other hand, effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external control circuit, such as a microcontroller. To make the motor shaft turn, first, one electromagnet is given power, which makes the gear's teeth magnetically attracted to the electromagnet's teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. So when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one, and from there the process is repeated. Each of those slight rotations is called a "step", with an integer number of steps making a full rotation. In that way, the motor can be turned by a precise angle.

A step motor can be viewed as a synchronous AC motor with the number of poles (on both rotor and stator) increased, taking care that they have no common denominator. Additionally, soft magnetic material with many teeth on the rotor and stator cheaply multiplies the number of poles (reluctance motor). Modern steppers are of hybrid design, having both permanent magnets and soft iron cores.

To achieve full rated torque, the coils in a stepper motor must reach their full rated current during each step. Winding inductance and reverse EMF generated by a moving rotor tend to resist changes in drive current, so that as the motor speeds up, less and less time is spent at full current — thus reducing motor torque. As speeds further increase, the current will not reach the rated value, and eventually the motor will cease to produce torque.

PROCEDURE:-

1) Connect A1, A2, B1, and B2 leads of stepper motor to the corresponding output terminal points, and two common terminals to positive supply.
2) Switch on the main supply to the unit, check the power supplies. The unit displays "WELCOME STEPPER MOTOR".
   After few seconds it displays STOP   S/R   R/F   H/F
                                 RPM 1   FOR   FULL
   STOP- corresponds to RUN/STOP selection.
   S/R- corresponds to STEP/RPM(continuous rotation) selection.
   R/F- corresponds to Reverse/Forward direction selection.
   H/F- corresponds to Half/Full step selection.

   Now RPM blinks, press INC/DEC key to select step or rpm(continuous rotation) mode.

3) After selecting RPM/STEP mode press SET key to select the speed or steps. Now 1 blink- this corresponds to number of rotation or number of steps selected. Press INC/DEC key to select the speed or steps.

4) Press SET key to select the direction of rotation. Now FULL blinks –this corresponds to full step. Press INC/DEC key to select Half step/ Full step mode.

5) Now the setting is over, press RUN/STOP key, the stepper motor rotates at set speed if RPM is selected or it moves the number of steps if step is selected.

6) Check the output status by Led indication for each step and verify with the switching logic sequence as given in the truth table.

Single Phase Half Controlled Bridge Rectifier For Speed Control Of Universal Motor

Sl.No	Input Voltage Vin	Firing angle	output Voltage-Vo	Output Current Io	Speed RPM

Graph

8

Experiment No:8

SPEED CONTROL OF A UNIVERSAL MOTOR

AIM:-

Speed control of the universal motor using control unit 222acide and study characteristics.

APPARTUS REQUIRED:-

Universal motor speed control unit, CRO, connecting wires.

THEORY:-

Universal motor is a device which can be operated by giving dc or ac supply for controlling the speed of motor.

The bi-directional triac used. Triac will conduct both in positive and negative half cycle. The output of the motor can be controlled by triggering the triac at different triggering angle α in both direction.

PROCEDURE:-

1) Connect the motor with the triac unit.
2) Switch ON the main supply & check the triac triggering pulse
3) Connect the triggering pulse to the triac
4) Note down the speed of motor using digital tachometer
5) Vary the firing angle in steps & note down the reading of I_o, V_o, Speed.
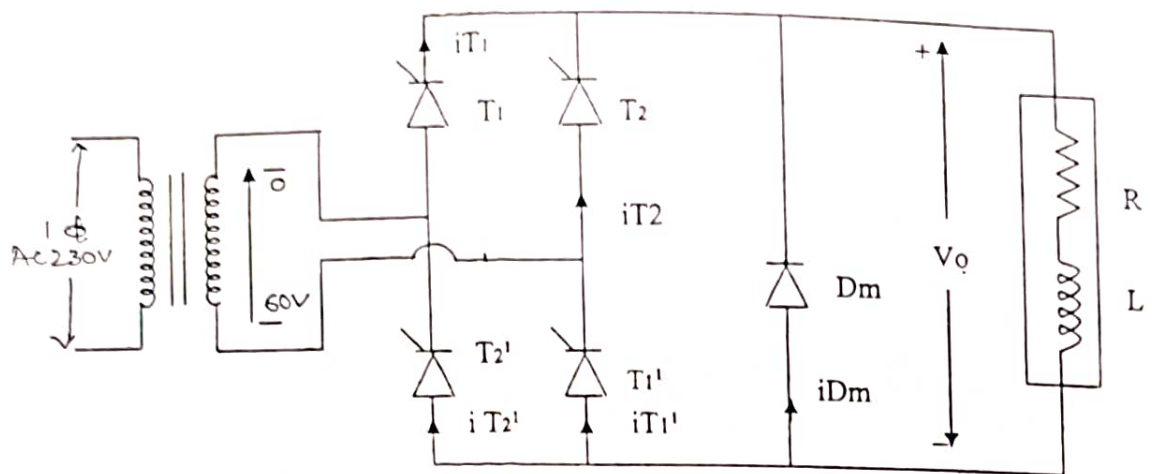
a) Circuit Diagram
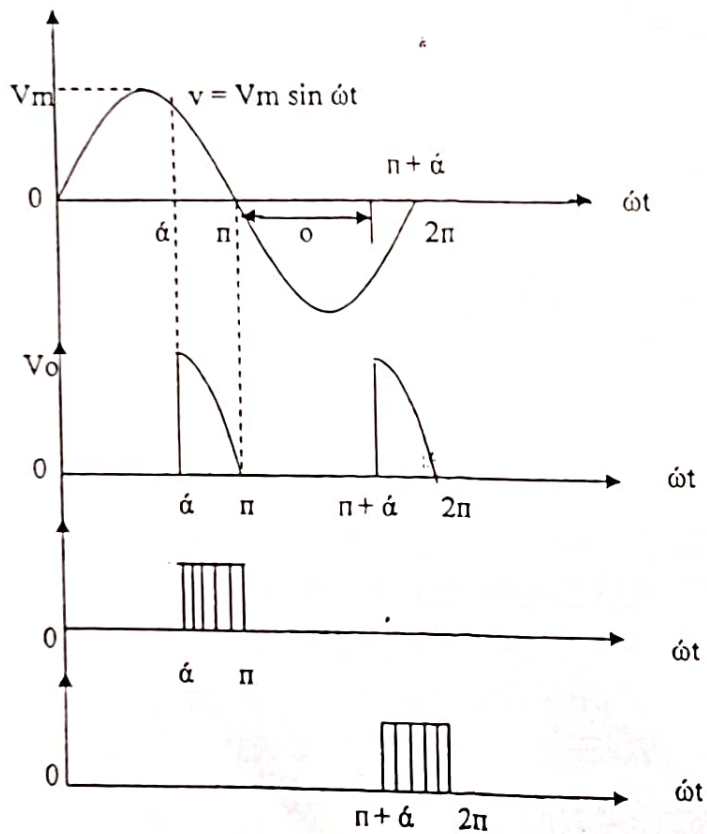
Experiment No: 10

1φ FULL WAVE RECTIFIER WITH R & RL LOAD

AIM:-

To study the single phase fully controlled rectifier.

APPARTUS REQUIRED:-

1) 1-φ converter firing circuit.
2) 1-φ half & full controlled converter power scope with 10:1 probe.
3) Rheostat 50Ω 215A
4) Tachometer
5) Isolation transformer 230/115 at 5A with tapping.

THEORY:-

During positive half cycle thyristor T_1 & $T_1{'}$ are forward biased and when these two thyristors are triggered simultaneously at $\omega t = \alpha$, the load is connected to the input supply through T_1 & $T_1{'}$.

In case of inductive load during the period $r \le \omega t \le (r+a)$, the input voltage is negative and the freewheeling diode D_m is forward biased. D_m conducts to provide the continuity of current. In case of inductive load, the load current is transferred from T_1 & $T_1{'}$ to D_m & thyristors T_1 & $T_1{'}$ are turned OFF due to line.

During the negative half cycle, the input voltage the thyristors T_1 & $T_1{'}$ are forward biased. The firing of thyristor T_2 & T_2' simultaneously at $\omega t = r + a$ will reverse biase D_m. The diode D_m is turned OFF and load is connected to supply through T_2 & T_2'.

PROCEDURE:-

1) Switch on the main supply to the single phase converter circuit.

2) Observe the test points and trigger output . verify the trigger output and their phase sequence.

3) Verify the firing angle , potentiometer and observe the trigger output . the pulse train width will increase as we decrease the firing angle from 180^0 to 0^0.

4) When we press the on or off switch ,the trigger output will start with 180^0 and slowly increase to firing angle set by firing angle potentiometer.

57

5) Vary the firing angle and note down the output voltage, the output current and measure the speed of the DC motor for different values and note down into the tabular column and also observe the voltage waveform we can observe the back emf will increase as the speed increase

6) Next vary the input voltage up to 230v insteps and notedown voltage.

REALY & HIGH VOLTAGE LAB COURSE OUTCOMES & MAPPING

COURSE OUTCOME STATEMENTS

	At the end of the course, students will be able to
C407.1	Demonstrate the characteristics of μP based, electrostatic based, electromechanical based relays, feeder circuits.
C407.2	Analyse the spark over characteristics for both uniform and non uniform configuration using High AC &DC voltages.
C407.3	Inspect breakdown strength of transformer oil, air as insulating medium.
C407.4	Examine the capacitance for different electrode modules using field mapping.

CO	Programme Outcome												Specific Outcome	
	1	2	3	4	5	6	7	8	9	10	11	12	S1	S2
C407.1	3	1	3			2	2		2					2
C407.2	3	1	3			2	2		2					2
C407.3	3	1	3			2	2		2					2
C407.4	3	1	3			2	2		2					2
	3	1	3	2		2	1.75		2					2

Note: 1.Slight(low)   2.Moderate(Medium)   3.Substantial(High)

Rubrics for Power Electronics Lab (18EEL58)

Attendance(CIE)	20M
Record	10M
Lab Test	10M
Total CIE Marks	40M

IDMT CHARACTERISTICS OF ELECTRO-MECHANICAL TYPE

OVER-VOLTAGE RELAY AND UNDER VOLTAGE

IDMT CHARCTERISTICS OF ELECTROMECHANICAL TYPE OVER VOLTAGE & UNDER VOLTAGE RELAY
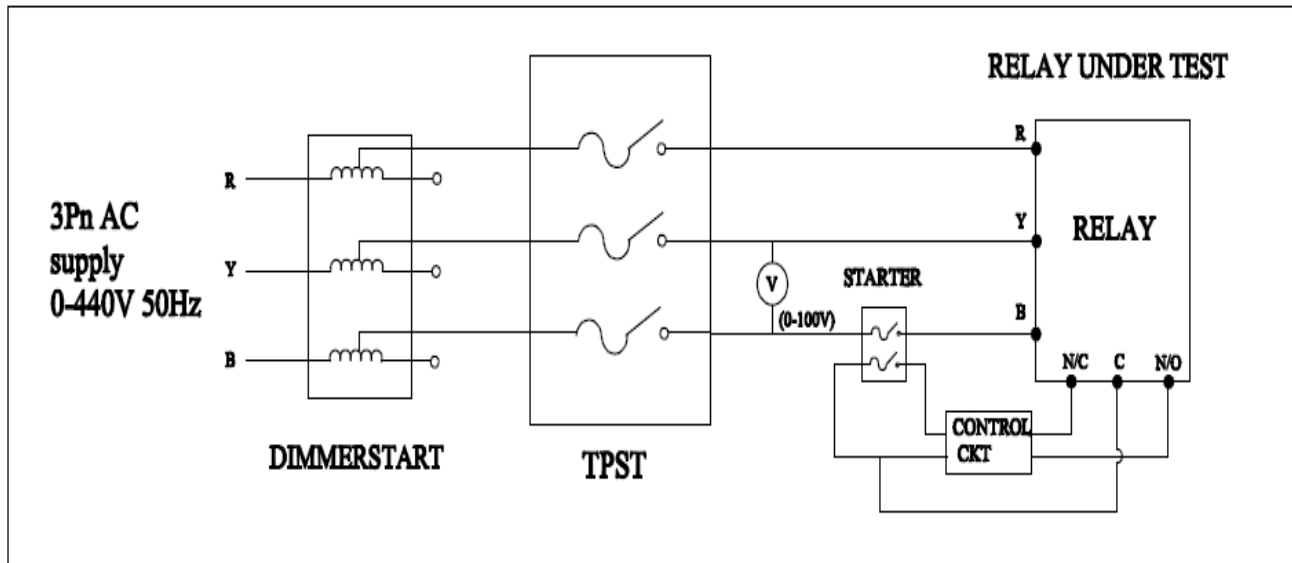
TABULAR COLUMN

SL NO	% VOLTAGE APPLIED	VOLTAGE APPLIED	TIME OF RELAY TRIP				
			3 SEC	6 SEC	9 SEC	12 SEC	15 SEC

EXPERIMENT NO: 01

IDMT CHARACTERISTICS OF ELECTRO-MECHANICAL TYPE

OVER-VOLTAGE RELAY AND UNDER VOLTAGE

AIM: - To study of the operation of electro mechanical type over voltage relay and hence obtain its inverse time/voltage characteristics.

Apparatus required: over-voltage relay, auto-transformer, 110v/440v transformer, (0-600V) AC Voltmeter, stop watch, two way switch, SPST Switch and connecting wires.

Details of the relay:

1. Voltage rating -100V
2. Setting Range-110-170% adjustable in 7 equal steps of 10%.
3. Resetting voltage -The disc will completely reset at 90% of more of the voltage setting.
4. Pickup voltage- Equal to the set taps voltage with maximum error of $\pm$ 5%.
5. Thermal rating- the relay will withstand the voltage setting continuously for 60^0C rise in coil temperature.
6. Auxiliary unit and operation indicator-Auxiliary volts=220V DC.
7. Resetting time-with the T.M.S. =1.0 the relay resetting time 10sec.
8. Accuracy-the operating value confirms to error class index 5.0 as per-S3231/1965 at the voltage setting.
9. Applications-the over-voltage relay is used for the protection of AC circuits, static capacitors and machine such as generators and synchronous motors.

Procedure:

1. The connections are made as shown in the diagram.
2. Auto transformer voltage is adjusted to value greater than set value for under voltage.
3. Adjust the timing levels.
4. Close TPST.
5. Record the voltage as well as time with the help of graduated scales for time.
6. Time of operation is verified for various voltages setting (ie for 80%, 90%, etc.)
7. The experiment is repeated for different time and voltage setting.

NOTE: As the applied voltages are set with switch's' open, they will decrease when the switch's' is closed. Care should be taken to see that the applied voltages given in the tabular column are the voltage when the switch's' is closed.

Graphs: A graph of operating time V/S applied voltage for any one plug setting (say 132v) is drawn as shown in fig (a) below. A common graph of operating time V/S multiplies of plug setting is drawn as shown in fig (b) below. It can be seen that for a given T.M.S. the operating time V/S multiplies of plug setting voltage characteristics is same irrespective of the plug setting.

Result:-

OPERATION OF NEGATIVE SEQUENCE RELAY

OPERATING KIT CIRCUIT DIAGRAM:-
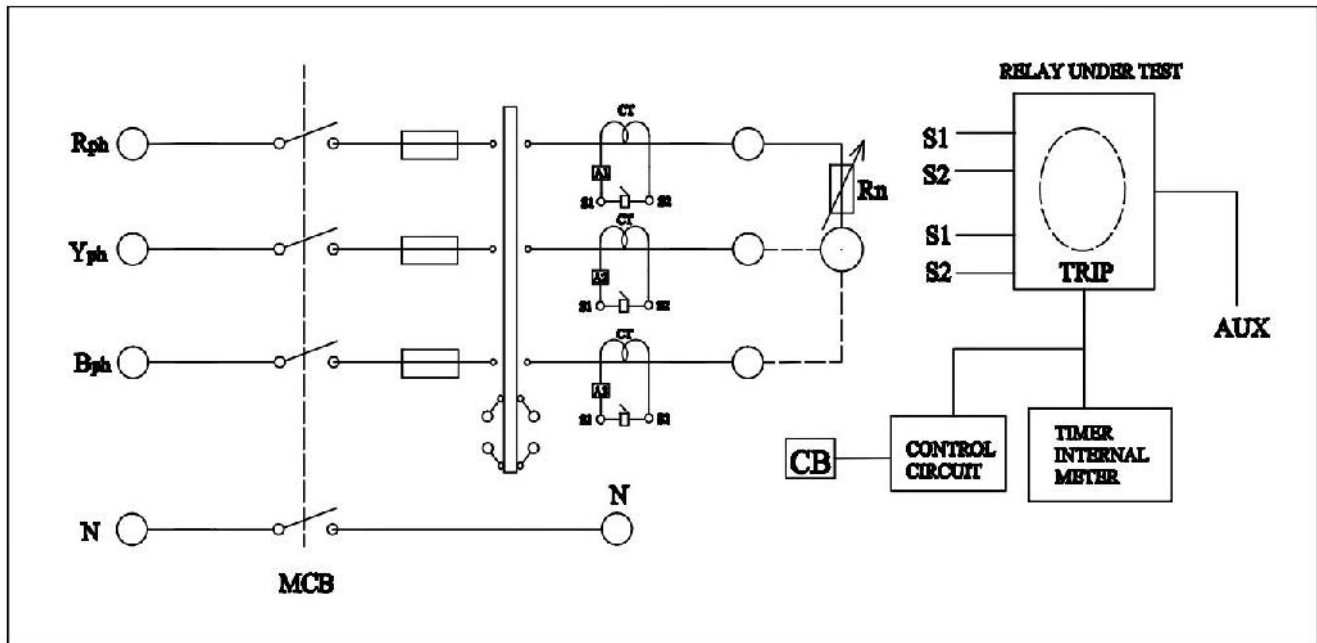
REALY KIT CIRCUIT DIAGRAM:-
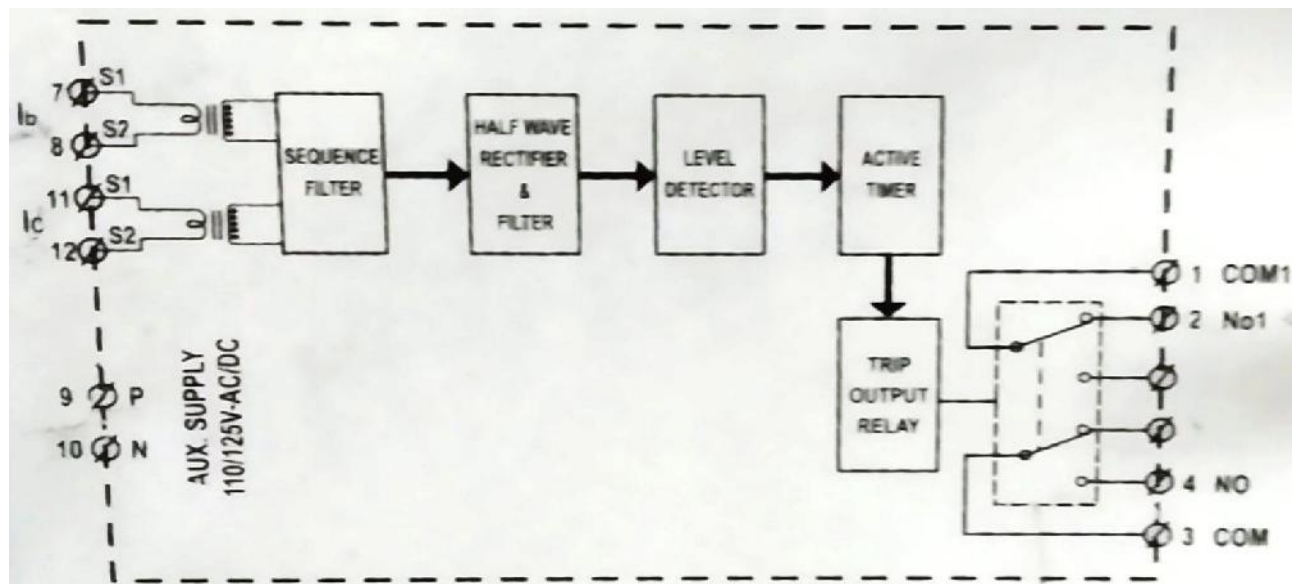
Experiment no: 02

OPERATION OF NEGATIVE SEQUENCE RELAY

AIM: To obtain the operating characteristics of Negative sequence voltage.

TECHNICAL SPECIFICATION OF THE RELAY:

- Current rating:1 Amp
- Rated frequency
- Limits of operating frequency:47-52Hz
- Negative sequence setting(I2S)-A fixed setting for negative phase sequence current of 10%
- Time setting a choice of 3 time setting of 3,6 and 9 second provided using jumper(inside)
- Auxiliary voltage 230v,AC,50Hz
- Thermal withstand.
- Twice the relay current continuously.
- 10 times the relay rated current for the relay operating time

THEORY:

The negative sequence relays are also called phase unbalanced relays because these relays provide protection against negative sequence components of unbalanced currents exciting due to unbalanced load or phase to phase fault. The unbalanced currents are dangerous from generators and motors point of view as these currents cause over rating .Negative sequence relays are generally used to give protection to generator and motor against unbalanced currents

A negative sequence relay has a filter circuit which is operating only for negative sequence components as order of over current also can cause dangerous situations. Hence a negative sequence relay has low current setting. A negative sequence relay provides protection against phase to phase faults which are responsible to produce negative sequence components.

Procedure:

1) Connect auxiliary power cord. Connect 3-phase input of 415V.
2) Switch on the main supply.
3) Push circuit breaker:
   a) The circuit breaker ON indicator will glow.
   b) If the motor connected starts running note down the ammeter reading(rheostat should be zero position)
4) Adjust rheostat to create negative sequence(unbalance)
5) The negative sequence relay get tripped
6) Push circuit breaker. OFF/RESET.
7) without disturbing the rheostat ,switch ON the circuit breaker and note down the ammeter reading and trip timing (for unbalance current)
8) Repeat the steps 1 to 5 and create the negative sequence by interchanging any two sequences of R, Y, and B sequence or by opening any phase and observe .Tabulate the meter readings.

NEGATIVE SEQUENCE FILTER-VECTOR DIAGRAM

POSITIVE SEQUENCE

A

$3\angle 60$

120   60
120

C   B

NEGATIVE SEQUENCE
FILTER OUTPUT =K*Ic+Ib $\angle 60$'
'K' is a design constant

NEGATIVE SEQUENCE

A

120   120

60

B   C

$3\angle 60$

RESULTANT OUTPUT

CONNECTION DIAGRAM OF NEGATIVE SEQUENCE
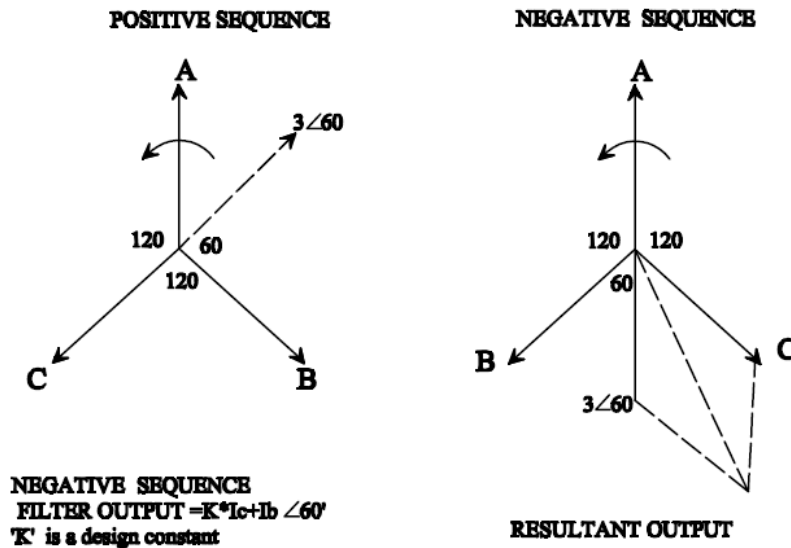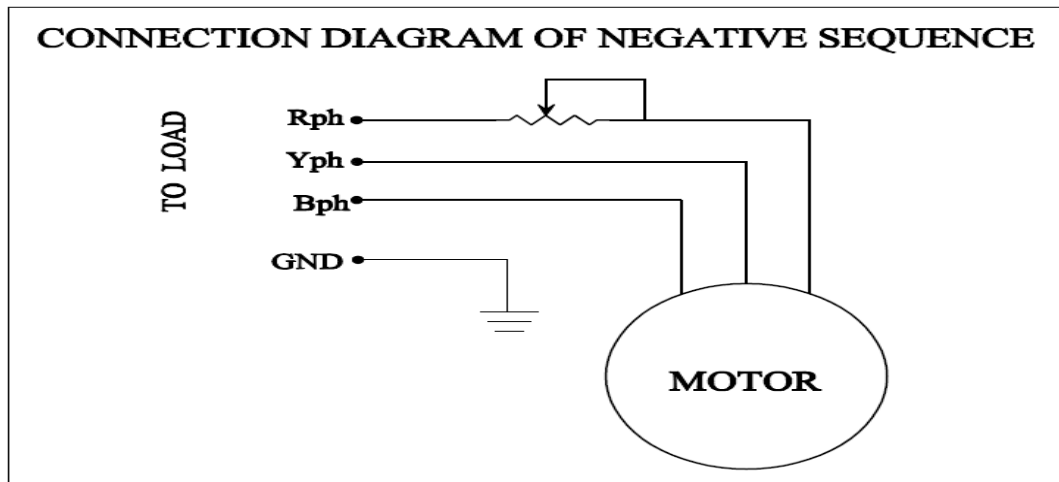
NOTE: 1. Ensure proper earth connections to the relay.
2. Handle the front panel knob very carefully does not over rotate the knob.

TABULAR COLUMN

BALANCED CONDITION

SL NO	CURRENT IN PHASE R	CURRENT IN PHASE Y	CURRENT IN PHASE B	TIME IN SECONDES
01				

UNBALANCED CONDITION

SL NO	CURRENT IN PHASE R	CURRENT IN PHASE Y	CURRENT IN PHASE B	TIME IN SECONDES
1				
2				
3				

Result: The operation of negative sequence relay is realized and tabulated.

SPARK-OVER CHARACTERISTICS OF POINT-POINT ELECTRODES SUBJECTED TO HVAC AND HVDC

CIRCUIT DIAGRAM : MEASUREMENT OF H.V.A.C VOLTAGE

TABULAR COLUMN:

Assume at RTP: P =740 mm of Hg   room temperature=30^0

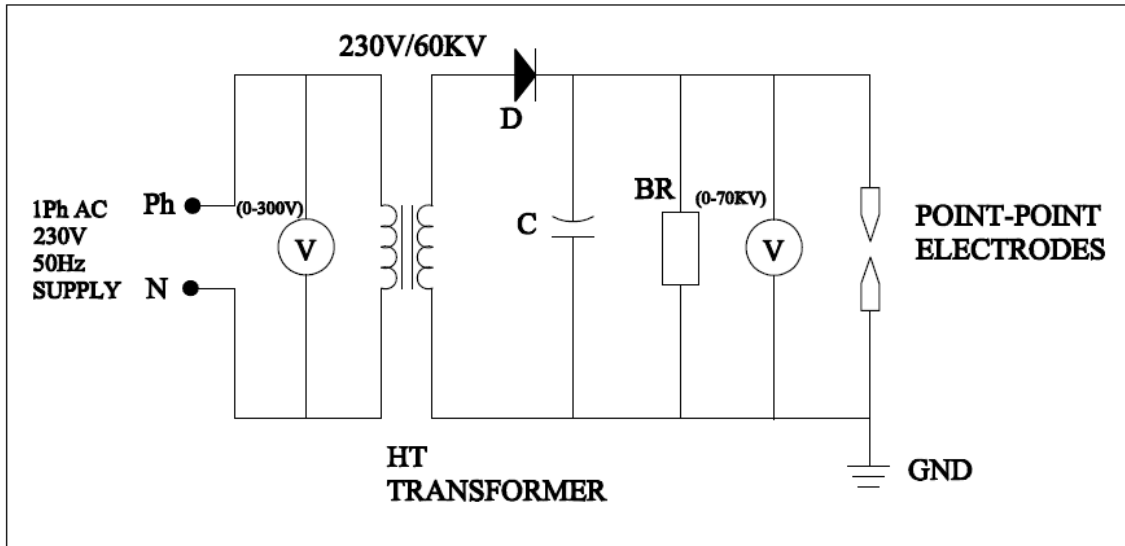| SL no.	Space gap In mm(S)	Break down Voltage=HVAC in KV	V_{act} at STP = peak value(V_A) =$\sqrt{2}$ HVAC in KV	V_{act} at RTP or spark over voltage =KV_A in KV.
1				
2				
3				
4				
5				
6				
7				

Experiment no: 03

POINT-POINT ELECTRODES SUBJECTED TO HVAC AND HVDC

AIM: To study the behaviour of point-point electrodes for measurement of HVAC &HVDC voltages.

MEASUREMENT OF HVAC VOLTAGES:

PROCEDURE:

1. The H.V terminal of the transformer is connected to one of the point electrodes. The other point electrode is grounded.
2. The mains switch in the control unit is switch 'ON'.
3. With the dimmer stat at zero position, the 'H.T ON' button is then pressed. Observe the 'H.T On' indicator lamp glow.
4. By turning the knob of the dimmer stat slowly, the A.C voltage applied to the H.V terminal of the point electrode is increased till the spark over occurs. In the event of spark over, the supply to the sphere in cut off. The fault indicator lamp glow and all the meters indicate zero values.
5. The 'memory' push-button is then pressed and the A.C spark over voltage 'V_{ind}'(RMS) shown by the H.V A.C voltmeter is noted.
6. The dimmer stat is brought to zero position and the 'fault reset' button is pressed.
7. The main switch is then switched "OFF" and all the H.V points in the circuit is grounded using the earthing rod.
8. The procedure given in steps 3 to 8 is then repeated for different gap spacing and the spark over voltage V_{ind} (RMS) is tabulated.

CIRCUIT DIAGRAM : MEASUREMENT OF H.V.D.C VOLTAGE

TABULAR COLUMN:

Assume at RTP: P =740 mm of Hg   room temperature=30^0

SL no.	Space gap In mm(S)	Break down Voltage=HVAC in KV			V_{act} at STP = peak value(V_A) =√2 HVAC in KV	V_{act} at RTP or spark over voltage =KV_A in KV.
		HVAC IN KV	HVDC IN +VE POLARITY IN KV	HVDC IN +VE POLARITY IN KV		
1						
2						
3						
4						
5						
6						
7						

MEASUREMENT OF HVDC VOLTAGES:

PROCEDURE:

1. The connection are made as shown in the diagram taking care to see that the rectifier unit is connected as shown to get +ve polarity D.C voltage. The output from H.V rectifier is connected to the H.V electrode through a current limiting resistor to avoid pitting of the electrodes, which is obtained using a water resistor to obtain resistance of about 1 ohm/volt (about 40 K ohm).
2. Using the operating gear, the gap between the two electrodes is adjusted to 4 mm taking care to see that the axis of the electrodes lie in the same horizontal plane.
3. With the polarity switch in the control unit on +ve side, the main switch in the control unit is switched ON.
4. With the dimmer-stat at zero position, the 'H.T ON' button is then pressed. Observe the 'H.T ON' indicator glow.
5. By turning the knob of the dimmer stat slowly, the D.C voltage applied to the electrode is increased till the spark over occurs. The spark over voltage (V_{ind}) shown by the HVDC voltmeter, connected in the resistance divider circuit, is noted. Care should be taken while noting the voltmeter reading as, in the event of spark over, the supply to the HV transformer is cut-off and all the meters indicate zero values and the fault indicator lamp will glow(no memory for HVDC measurement)
6. The dimmer stat is brought to zero position and the 'fault reset' button is pressed.
7. The main switch is switched off and all the H.V points in the circuit is grounded using the earthing rod. (Touching of the H.V terminals is avoided as there may be residual charges due to smoothing capacitor).
8. The procedure given the steps 3 to 7 is repeated for different electrode gap spacing and the various spark over voltages V_{ind} (RMS) is tabulated.

CALCULATION:

Measurement of HVAC voltage: For a given spacing between the sphere the voltage V_{act} (peak) at the standard temperature and pressure of 20^0 and 760 mm of hg is found from IS-1876-1961.The actual voltage in 'KV' at room temperature and pressure given by v_{act}-actual peak over voltage at RTP=K*V_{act}(STP)/h in KV

Where 'K' is the air density of correction factor& 'h' is the humidity of correction factor.

To find K, the relative air density 'D' is found using D = P (293)/760(273+t)

Where 'P' is the barometric pressure in mm ,740mm Hg & 't' is the room temperature in 30^0C.The value of 'K' for the above value of 'd' is from the table of the value of 'K' for different value of 'd' is given in IS-1876-1961.The value h is taken as 1.
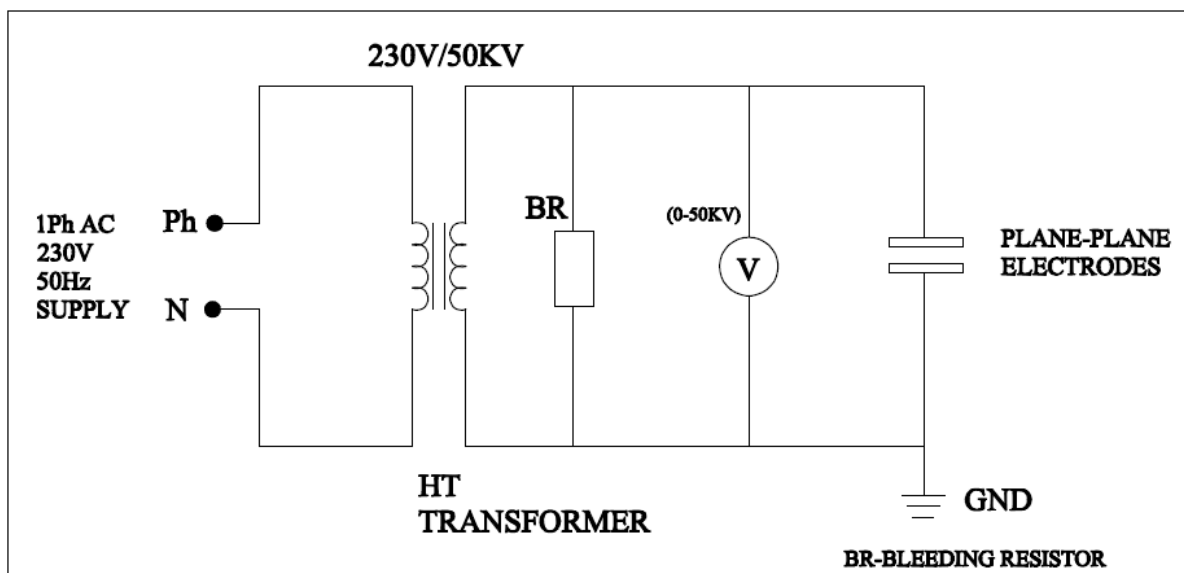
K	0.72	0.77	0.82	0.86	0.91	0.95	1.0	1.05	1.09	1.12
D	0.70	0.75	0.80	0.85	0.90	0.95	1.0	1.05	1.10	1.15

Specimen Calculation:-

Result: -

SPARK-OVER CHARACTERISTICS OF PLANE-PLANE ELECTRODES SUBJECTED TO HVAC AND HVDC

CIRCUIT DIAGRAM : MEASUREMENT OF H.V.A.C VOLTAGE

TABULAR COLUMN:

Assume at RTP: P =740 mm of Hg   room temperature=30^0.

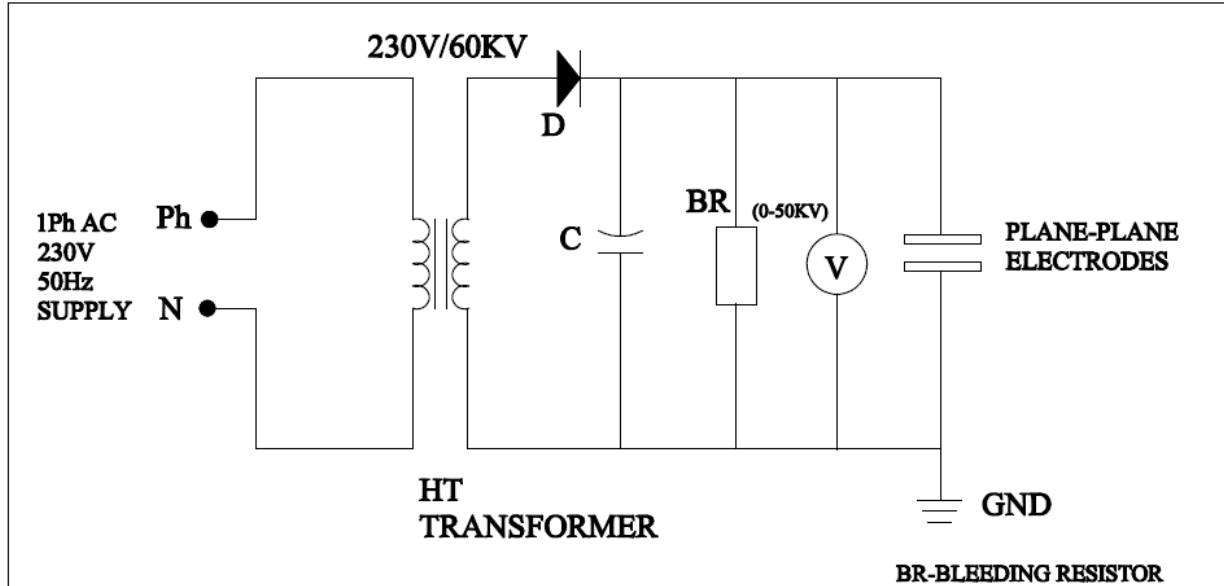| SL no.	Space gap In mm(S)	Break down Voltage=HVAC in KV	V_{act} at STP = peak value(V_A) =$\sqrt{2}$ HVAC in KV	V_{act} at RTP or spark over voltage =KV_A in KV.
1				
2				
3				
4				
5				
6				
7				

Experiment no: 04

PLANE- PLANE ELECTRODES SUBJECTED TO HVAC AND HVDC

AIM: To study the behavior of plane-plane electrodes for measurement of HVAC &HVDC voltages.

MEASUREMENT OF HVAC VOLTAGES:

PROCEDURE:

1. The H.V terminal of the transformer is connected to one terminal of the two plane electrodes. The other plane electrode is grounded.
2. Using the operating gear and the graduated scale provided on the supporting frame, a gap distance 4mm is set between the flat surfaces of plane-plane electrode taking care to see that axis of the both electrode are same.
3. The mains switch in the control unit is switch 'ON'.
4. With the dimmer stat at zero position, the 'H.T ON' button is then pressed. Observe the 'H.T On' indicator lamp glow.
5. By varying the knob of the dimmer stat slowly, the A.C voltage applied to the H.V terminal of the sphere gap is increased till the spark over occurs. In the event of spark over, the supply to the sphere in cut off. The fault indicator lamp glow and all the meters indicate zero values.
6. The 'memory' push-button is then pressed and the A.C spark over voltage 'V_{ind}'(RMS) shown by the HVAC voltmeter.
7. The dimmer stat is brought to zero position and the 'fault reset' button is pressed.
8. The main switch is then switched "OFF" and all the H.V points in the circuit is grounded using the earthing rod.
9. The procedure given in steps 3 to 8 is then repeated for different gap spacing and the spark over voltage V_{ind} (RMS) is tabulated.

CIRCUIT DIAGRAM : MEASUREMENT OF H.V.D.C VOLTAGE

TABULAR COLUMN:

Assume at RTP: P =740 mm of Hg   **room temperature=30^0.**

SL no.	Space gap In mm(S)	Break down Voltage=HVAC in KV			V_{act} at STP = peak value(V_A) =√2 HVAC in KV	V_{act} at RTP or spark over voltage =KV_A in KV.
		HVAC IN KV	HVDC IN +VE POLARITY IN KV	HVDC IN +VE POLARITY IN KV		
1						
2						
3						
4						
5						
6						
7						

MEASUREMENT OF HVDC VOLTAGES:

PROCEDURE:

1. The connection is made as shown in the diagram taking care to see that the rectifier unit is connected to get +ve polarity D.C voltage. The output from H.V rectifier is connected to one of the electrode terminal through a current limiting resistor to avoid pitting of the electrodes, which is obtained using a water resistor to obtain resistance of about 1 ohm/volt (about 40 K ohm).

2. Using the operating gear, the gap between the two electrodes is adjusted to 4 mm taking care to see that the axis of the electrodes lie in the same horizontal plane.

3. With the polarity switch in the control unit on +ve side, the main switch in the control unit is switched ON.

4. With the dimmer stat at zero position, the 'H.T ON' button is then pressed. Observe the 'H.T ON' indicator glow.

5. By turning the knob of the dimmer stat slowly, the D.C voltage applied to the sphere gap is increased till the spark over occurs. The spark over voltage (V_{ind}) shown by the H.V.D.C voltmeter, connected in the resistance divider circuit, is noted. Care should be taken while noting the voltmeter reading as, in the event of spark over, the supply to the H.V transformer is cut-off and all the meters indicate zero values and the fault indicator lamp will glow.

6. The dimmer stat is brought to zero position and the 'fault reset' button is pressed.

7. The' MAINS 'switch is then switched off and all the H.V points in the circuit is grounded using the earthing rod. (Touching of the H.V terminals is avoided as there may be residual charges due to smoothing capacitor).

8. The procedure given the steps 3 to 7 is repeated for different gap spacing and the spark over voltage V_{ind} (RMS) is tabulated.

CALCULATION:

Measurement of HVAC voltage: For a given spacing between the sphere the voltage V_{act} (peak) at the standard temperature and pressure of 20^0 and 760 mm of hg is found from IS-1876-1961.The actual voltage in 'KV' at room temperature and pressure given by

V_{act}(-actual peak over voltage at RTP) $=K*V_{act}$ (STP)/h in KV

Where 'K' is the air density of correction factor& 'h' is the humidity of correction factor.

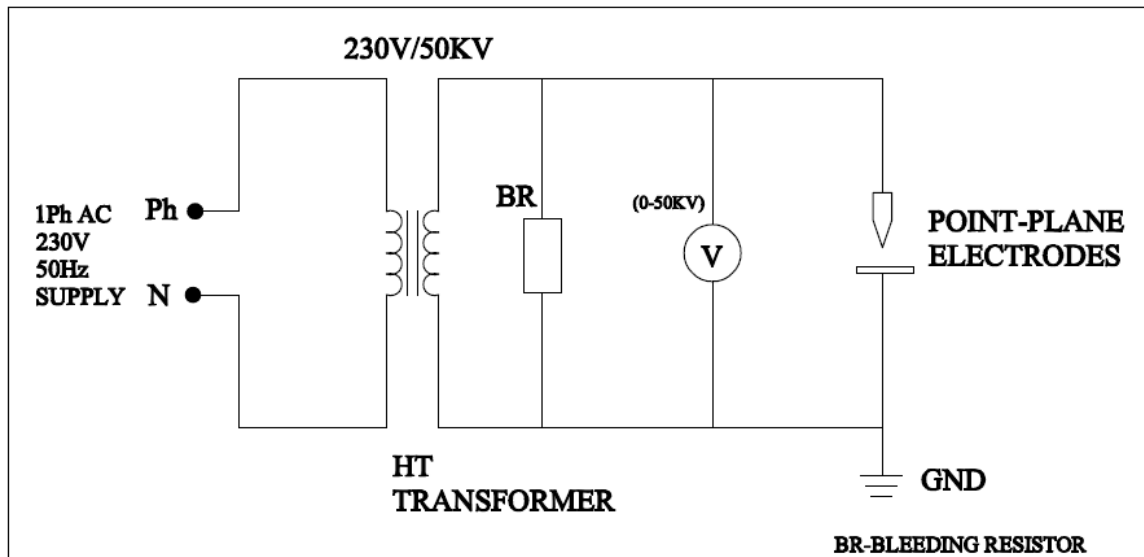To find K, the relative air density 'D' is found using d=P (293)/760(273+t)

Where 'P' is the barometric pressure in mm ,740mm Hg & 't' is the room temperature in 30^0C.The value of 'K' for the above value of 'd' is from the table of the value of 'K' for different value of 'd' is given in IS-1876-1961.The value h is taken as 1.

K	0.72	0.77	0.82	0.86	0.91	0.95	1.0	1.05	1.09	1.12
D	0.70	0.75	0.80	0.85	0.90	0.95	1.0	1.05	1.10	1.15

Specimen Calculation:-

Result:-

SPARK OVER CHARACTERISTICS OF POINT-PLANE ELECTRODES SUBJECTED TO HVAC AND HVDC

CIRCUIT DIAGRAM : MEASUREMENT OF H.V.A.C VOLTAGE

TABULAR COLUMN:

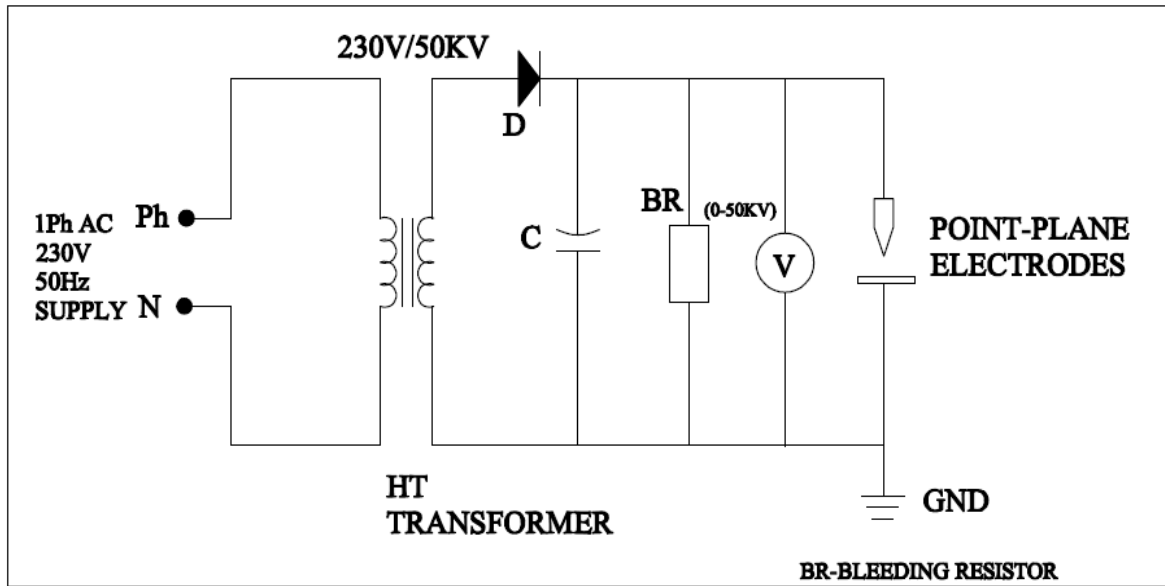**Assume at RTP: P =740 mm of Hg   room temperature=30^0.**

SL no.	Space gap In mm(S)	Break down Voltage=HVAC in KV	V_{act} at STP = peak value(V_A) =$\sqrt{2}$ HVAC in KV	V_{act} at RTP or spark over voltage =KV_A in KV.
1				
2				
3				
4				
5				
6				
7				

Experiment no: 05

SPARK OVER CHARACTERISTICS OF POINT-PLANE ELECTRODES SUBJECTED TO HVAC AND HVDC IN AIR

AIM: To study the behavior of point-plane electrodes for measurement of HVAC & HVDC voltages.

MEASUREMENT OF HVAC VOLTAGES:

PROCEDURE:

1. The H.V terminal of the transformer which is connected to one terminal of the two electrodes. The other electrode is grounded.
2. Using the operating gear and the graduated scale provided on the supporting frame, a gap distance of say 4mm is set between the surfaces of the point-plane electrodes taking care to see that axis of both electrodes are same.
3. The mains switch in the control unit is switched 'ON'.
4. With the dimmer stat at zero position, the 'H.T. O.N' button is then pressed. Observe the 'H.T.O.N' indicator lamp glow.
5. By turning the knob of the dimmer-stat slowly, the A.C voltage applied to the H.V terminal of the sphere gap is increased till the spark over occurs. In the event of spark over, the supply to the sphere in cut off. The fault indicator lamp will glow and all the meters indicate zero values.
6. The 'memory' push-button is pressed and to read the A.C spark over voltage 'V$_{ind}$' (R.M.S) shown by the HVAC voltmeter,
7. The dimmer stat is brought to zero position and the 'fault reset' button is pressed.
8. The procedure given the steps 3 to 7 is repeated for different gap spacing and the spark over voltage V$_{ind}$ (RMS) is tabulated.

CIRCUIT DIAGRAM : MEASUREMENT OF H.V.D.C VOLTAGE

TABULAR COLUMN:

Assume at RTP: P =740 mm of Hg   Room temperature=30^0

SL no.	Space gap In mm(S)	Break down Voltage=HVAC in KV			V_{act} at STP = peak value(V_A) =$\sqrt{2}$ HVAC in KV	V_{act} at RTP or spark over voltage =KV_A in KV.
		HVAC IN KV	HVDC IN +VE POLARITY IN KV	HVDC IN +VE POLARITY IN KV		
1						
2						
3						
4						
5						
6						
7						

MEASUREMENT OF HVDC VOLTAGES:

1. The connection are made as shown in the diagram taking care to see that the rectifier unit is connected as shown to get +ve polarity D.C voltage. The output from H.V rectifier is connected to one of the electrodes through a current limiting resistor to avoid pitting of the spheres, which is obtained using a water resistor to obtain resistance of about 1 ohm/volt (about 40 K ohm).

2. Using the operating gear, the gap between the two electrodes is adjusted to 4mm taking care to see that the axis of the electrodes lie in the same horizontal plane.

3. With the polarity switch in the control unit on +ve side, the mains switch in the control unit is switched ON.

4. With the dimmer stat at zero position, the 'H.T.ON' button is pressed. Observe the 'H.T.ON' indicator glow.

5. By turning the knob of the dimmer stat slowly, the D.C voltage applied to the sphere gap is increased till the spark over occurs. The spark over voltage (Vind) shown by the H.V.D.C voltmeter is noted as in the event of spark over, the supply to the H.V transformer is cut-off and all the meters indicate zero values and the fault indicator lamp will glow.

6. The dimmer stat is brought to zero position and the 'fault reset' button is pressed.

7. The mains switch is then switched 'off and all the H.V points in the circuit is grounded using the earthing rod.(touching of the H.V terminals s avoided as there may be residual charges due to smoothing capacitor).

8. The procedure given the steps 3 to 7 is repeated for different gap spacing and the different spark over voltages V_{ind} (RMS) are tabulated.

CALCULATION:

Measurement of HVAC voltage: For a given spacing between the sphere the voltage V_{act} (peak) at the standard temperature and pressure of 20^0 and 760 mm of hg is found from IS-1876-1961.The actual voltage in 'KV' at room temperature and pressure given by v_{act}-actual peak over voltage at RTP=K*V_{act}(STP)/h in KV

Where 'K' is the air density of correction factor& 'h' is the humidity of correction factor.
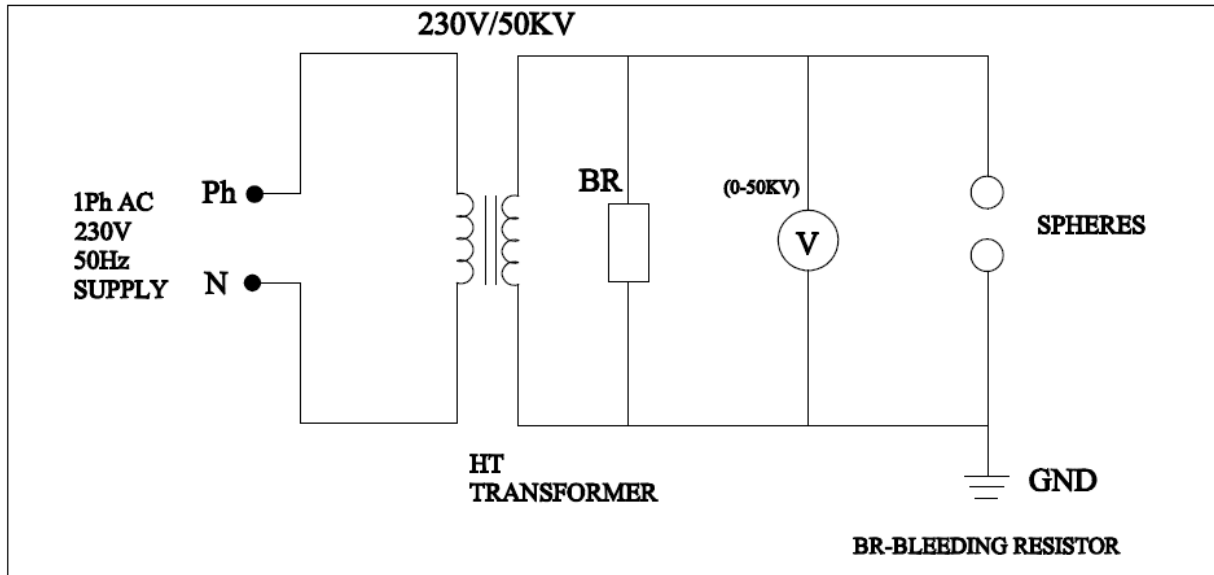
To find K, the relative air density 'D' is found using d=P (293)/760(273+t)

Where 'P' is the barometric pressure in mm ,740mm Hg & 't' is the room temperature in 30^0C.The value of 'K' for the above value of 'd' is from the table of the value of 'K' for different value of 'd' is given in IS-1876-1961.The value h is taken as 1.

K	0.72	0.77	0.82	0.86	0.91	0.95	1.0	1.05	1.09	1.12
D	0.70	0.75	0.80	0.85	0.90	0.95	1.0	1.05	1.10	1.15

Specimen Calculation:-

Result: -

MEASUREMENT OF HVAC AND HVDC USING STANDRED SPHERES

CIRCUIT DIAGRAM : MEASUREMENT OF H.V.A.C VOLTAGE

TABULAR COLUMN:

Assume at RTP: P =740 mm of Hg   room temperature=30^0.

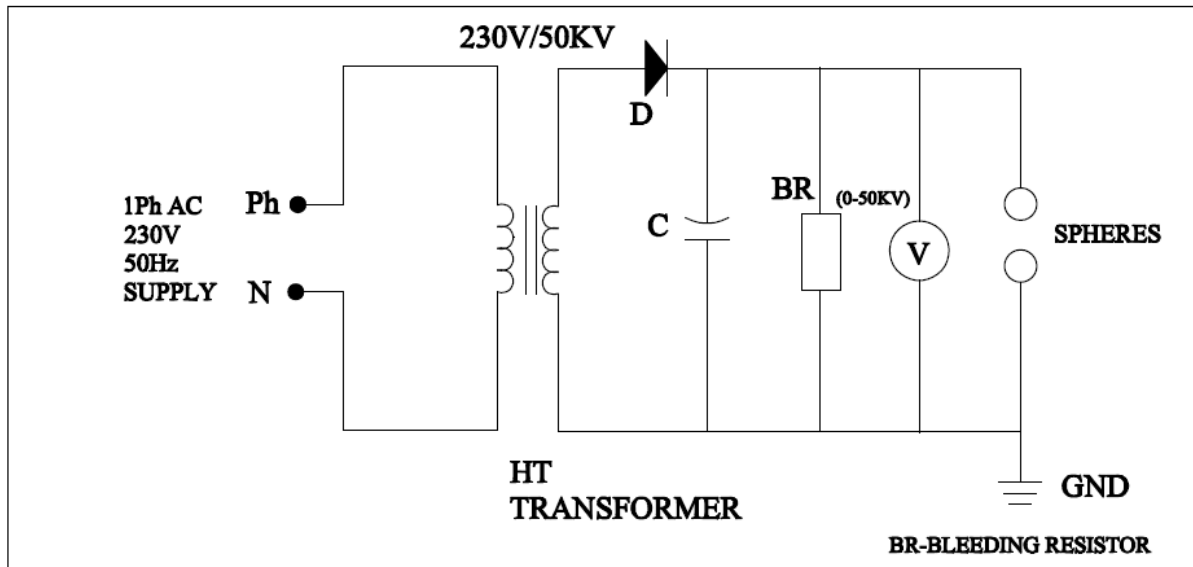| SL no.	Space gap In mm(S)	Break down Voltage=HVAC in KV	V_{act} at STP = peak value(V_A) =$\sqrt{2}$ HVAC in KV	V_{act} at RTP or spark over voltage =KV_A in KV.
1				
2				
3				
4				
5				
6				
7				

Experiment no: 06

MEASUREMENT OF HVAC AND HVDC USING STANDRED SPHERES

AIM: To obtain the sphere-gap calibration curve and hence to determine the given unknown HVAC & HVDC voltage.

MEASUREMENT OF HVAC VOLTAGES

PROCEDURE:

1. The connection are made as shown in circuit diagram by connecting the HV terminal of the transformer to the HV sphere through a current limiting resistor to avoid pitting of the spheres. This is prepared by putting water into the tube such that a resistance of about 1Ω/volt (about 30 KΩ) is obtained which is verified using a multi meter.
2. The surfaces of the spheres are cleaned using a cloth.
3. The barometric pressures in mm of Hg, room temperature are noted.
4. Using the operating gear and graduated scale provided on the supporting frame, the gap between the two spheres (distance between arcing points) is adjusted to 4mm,taking care to see that the axes of the two spheres lie in the same vertical plane.
5. The MAINS switch in the control unit is switched 'ON'.
6. With the dimmer-stat at zero position, the 'H.T ON' button is then pressed. Observe the 'H.T ON' indicator lamp glow.
7. By varying the knob of the dimmer stat slowly, the A.C voltage applied to the H.V terminal of the sphere gap is increased till the spark over occurs. In the event of spark over, the supply to the sphere in cut off. The fault indicator lamp will glow and all the meters indicate zero values.
8. The 'memory' push – button is then pressed and the A.C spark over voltage ' V_{ind}' (RMS) shown by the HVAC voltmeter is noted.
9. The dimmer stat is brought to zero position and the 'fault reset' button is pressed.
10. The mains switch is then switched "OFF" and all the H.V points in the circuit is grounded using the earthing rod.
11. The procedure given in step 5 to 10 is then repeated for different gap spacing and the various spark over voltages V_{ind} (RMS) are tabulated.

CIRCUIT DIAGRAM : MEASUREMENT OF H.V.D.C VOLTAGE

TABULAR COLUMN:

Assume at RTP: P =740 mm of Hg   Room temperature=30^0.

SL no.	Space gap In mm(S)	Break down Voltage=HVAC in KV			V_{act} at STP = peak value(V_A) =$\sqrt{2}$ HVAC in KV	V_{act} at RTP or spark over voltage =KV_A in KV.
		HVAC IN KV	HVDC IN +VE POLARITY IN KV	HVDC IN +VE POLARITY IN KV		
1						
2						
3						
4						
5						
6						
7						

MEASUREMENT OF HVDC VOLTAGES:

PROCEDURE:

1. The connections are made as shown in the diagram taking and the rectifier unit is connected as to get +ve polarity D.C voltage. The output from H.V rectifier is connected to the H.V sphere through a current limiting resistor to avoid pitting of the spheres, which is obtained using a water resistor to obtain resistance of about 1 ohm/volt (about 40 K ohm).

2. Using the operating gear, the gap between the two sphere is adjusted to 4 mm taking care to see that the axis of the sphere lie in the same vertical plane.

3. With the polarity switch in the control unit on +ve side, the main switch in the control unit is switched ON.

4. With the dimmer stat at zero position, the 'H.T ON' botton is then pressed. Observe the 'H.T ON' indicator glow.

5. By turning the knob of the dimmer stat slowly, the DC voltage applied to the sphere gap is increased till the spark over occurs. The spark over voltage (V_{ind}) shown by the H.V.D.C voltmeter is noted, as in the event of spark over, the supply to the H.V transformer is cut-off and all the meters indicate zero values and the fault indicator lamp will glow.

6. The dimmer stat is brought to zero position and the 'fault reset' button is pressed.

7. The MAINS switch is switched off and all the H.V points in the circuit is grounded using the earthing rod. (Touching of the H.V terminals is avoided as there may be residual charges due to smoothing capacitor).

8. The procedure given the steps 3 to 7 is repeated for different gap spacing and the spark over voltages are noted in each case and tabulated.

CALCULATION:

Measurement of HVAC voltage: For a given spacing between the sphere the voltage V_{act} (peak) at the standard temperature and pressure of 20^0 and 760 mm of hg is found from IS-1876-1961.The actual voltage in 'KV' at room temperature and pressure given by v_{act}-actual peak over voltage at RTP=K*V_{act}(STP)/h in KV

Where 'K' is the air density of correction factor& 'h' is the humidity of correction factor.

To find K, the relative air density 'D' is found using **d=P (293)/760(273+t)**

Where 'P' is the barometric pressure in mm ,740mm Hg & 't' is the room temperature in 30^0C.The value of 'K' for the above value of 'd' is from the table of the value of 'K' for different value of 'd' is given in IS-1876-1961.The value h is taken as 1.

K	0.72	0.77	0.82	0.86	0.91	0.95	1.0	1.05	1.09	1.12
D	0.70	0.75	0.80	0.85	0.90	0.95	1.0	1.05	1.10	1.15

Specimen calculation:

Result:-

OPERATING CHARACTERISTICS OF MICROPROCESSOR BASED OVER/UNDER VOLTAGE RELAY

CIRCUIT DIAGRAM:-

CONNECTION DIAGRAM OF RELAY MV-12

CONNECTION DIAGRAM OF PSOV-UV-MICRO PROCESSOR

Experiment no: 07

OPERATING CHARACTERISTICS OF MICROPROCESSOR BASED
OVER/UNDER VOLTAGE RELAY

Aim: To obtain characteristics of microprocessor based over/under voltage relay.

THEORY:

For the satisfactory working of all electrical and electronic devices, it is recommended to allow voltages at prescribed limits. Voltage fluctuations in electric power supply certainly have advance affects on countered loads. These fluctuations can be of over voltage and under voltages which are caused by several reasons like voltage surges, lightening, overload etc. Over voltages are the voltages that exceed the normal or rated values which cause insulation damage to electrical appliances leading to short circuits. Similarly, under voltage causes overloading of the equipment leading to lamp flickers and inefficient performance of the equipment. Thus this experiment is intended to give under and over voltage protection circuit schemes with different control structures.

TECHNICAL SPECIFICATION RATING

1. Voltage Vn110/240/415v, AC
2. Frequency 50Hz (+2.5 or -2.5).
3. Under voltage mode 95%-20% of V_n in steps of 5%.
4. Time multiplier setting 0.1%-1.6% in steps of 0.1.

OPERATING CHARACTERISTICS

Trip time characteristics normal inverse 3.5 seconds O/V mode

Normal inverse 5.7 seconds in U/V mode.

Definite time 1, 10,100 seconds same as set voltage.

PICK UP VOLTAGE

Reset voltage (90%-95% of set voltage Vs) for over voltage.

Under voltage 105%-110% of set value

ACCURACY: + 5% OF Vs

OPERATING TIME

1. Normal inverse as per IS3231:1987 refer fig 7 for details the curve is given for Vn=100v, 240v, 415v.It is limited by overload capacity.
2. Definite time: This range 1s,10s,100s   TIME=TMS*Range
   Given a delay from 0.1s-160s
3. Accuracy: As per error class 5 IS3231:1987
4. Reset time: LESS THAN 50 Ms.

OVERLOAD CAPACITY: UPTO 800V

Contacts configuration two pair of C/O contacts (self reset)

MAX S/W voltage: 440v AC/300V DC.

Rated current: 8amps

Rated breaking capacity: 2000Va/240w (resistive).

INSULATIONAs per IS3231:1987/IEC 60255-5 2kv AC RMS, 50Hz for 1 minute across independent circuits .1kv AC RMS, 50Hz for 1 minute across open circuits.

2. OPERATING INSTRUCTIONS –μp BASED OVER VOLTAGE RELAY TEST KIT.

1. Connect as per inter connection diagram-Fig 2.5.
2. Set the relay over voltage – (setting procedure-refer Table 1).
3. Set TMS(refer Table 2)
4. Ensure Time interval meter selection switch in TIM position.
5. Ensure protection time switch is ON position.
6. Ensure s2 switch is ON position
7. Bring both dimmers to zero position.
8. Connect the power card
9. Put on the mains using mains on switch (ROCKER). Results (Mains on indicator, ammeter display, relay power and Timer display will glow).
10. Bring toggle switch 'SET' mode.
11. Push TEST START BUTTON, CB ON indicator will glow.
12. Adjust the dimmer 2 set the approximate injection voltage (within 30 seconds otherwise protection timer will activate and circuit breaker will be off.
13. 13. Push test stop/reset button.
14. Don't disturb dimmer 1 &2.
15. Bring toggle switch 'TEST' mode.
16. Push TEST START BUTTON, note down the voltage. (circuit breaker ON,CB ON on indicator will glow ,time interval meter starts up[counting ,protection timer starts down counting ,over voltage relay trip occurs TRIP indicator will glow at relay and injector unit also. if buzzer switch is on it gives the beep sound.
17. Note down the Time interval METER reading (Pick up time)

18. Press the RESET button.
19. Repeat operation (10-18) by adjusting different voltage & TMS settings.
20. Draw the graph trip time v/s PSM (plug setting Multiplier).

NOTE: FOR FINDING UP THE PICK UP VOLTAGE, PROTECTION TIMER SWITCH IN BY PASS POSITION, AND MODE SWITCH KEPT AT TEST POSITION.

AFTER TEST START GRADUALLY INCREASE THE DIMMER-2 FROM ZERO TO YOUR VOLTAGE SET VALUE AND WHEN THE TRIP INDICATOR LED STARTS BLINKING NOTE DOWN THE PICKUP VOLATGE.

2. OPERATING INSTRUCTIONS-µP BASED UNDER VOLTAGE RELAY TEST KIT.

1. Connect as per inter-connection diagram
2. Set the relay UNDER voltage- (Setting procedure-refer Table 1).
3. Set TMS.(refer Table 3)
4. Ensure Time interval meter selection switch in TIM position.
5. Ensure protection time switch is ON position.
6. Ensure S2 switch is ON position.
7. Bring both dimmers to zero position.
8. Bring toggle switch 'SET' mode.
9. Connect the power card.
10. Put on the mains using (ROCKER). Results (Mains on indicator, ammeter display, relay power and timer display will glow).
11. Adjust the voltage level above the threshold level of under voltage relay setting using dimmer1.
12. PUSH TEST START BUTTON, CB ON indicator will glow.
13. Adjust the under voltage level (i.e. Less than relay set voltage) using dimmer2. Within 30 seconds otherwise protection timer will activate and circuit breaker will be off.(to avoid activation of protection timer use by pass switch of that timer)
14. PUSH TEST STOP/REST BUTTON.
15. Don't disturb the dimmer 1 & 2.
16. Bring Toggle switch 'TEST' mode.
17. PUSH TEST START BUTTON Note down the voltage. (circuit breaker ON, CB ON indicator will glow , time interval meter starts up counting, protection timer starts down counting ,over voltage relay trip occurs TRIP indicator will glow at relay and injector unit also. if buzzer switch is on it gives the beep sound.
18. Note down the time interval meter reading.(drop off time)
19. Press the RESET button.
20. Repeat operation (11-19) by adjusting different voltage & TMS settings.
21. Draw the graph Trip time Vs PSM (plug setting multiplier)

NOTE: FOR FINDING UP THE DROP OFF VOLTAGE, PROTECTION TIMER SWITCH IN BY PASS POSITION, AND MODE SWITCH KEPT AT TEST SET POSITION.DIMMER2 VOLTAGE BEYOND THE THERHOLD LEVEL

AFTER TEST START GRADUALLTY DECREASEV THE DIMMER-2 FROM ZERO TO YOUR CURRENT SET VALUE AND WHEN THE TRIP INDIACTOR LED STARTS BLINKING NOTE DOWN THE DROP OFF VOLTAGE.

Table1: Gives the DIP switch SW1 position

Sl.NO	1	2	3	4
OVERVOLTAGE	OFF	0FF	OFF	OFF
UNDERVOLTAGE	ON	0FF	0FF	0FF

Table2: Gives the DIP POSITION of SW2 for various trip time characteristic curves for Over-Voltage mode.

TRIP TIME CHARACTERISTICS	S/W **1**	S/W 2	S/W 3	S/W 4
NORMAL Inverse(3.5)	ON	OFF	OFF	OFF
Definite time(1sec)	ON	OFF	ON	OFF
Definite time(10sec)	ON	ON	OFF	OFF
Definite time(100sec)	ON	ON	ON	OFF

Table3: Gives the DIP POSITION of SW2 for various trip time characteristic curves for under voltage mode.

TRIP TIME CHARACTERISTICS	S/W **1**	S/W 2	S/W 3	S/W 4
NORMAL Inverse(5.7sec)	OFF	OFF	OFF	OFF
Definite time(1sec)	OFF	OFF	ON	OFF
Definite time(10sec)	OFF	ON	OFF	OFF
Definite time(100sec)	OFF	ON	ON	OFF

TIME MULTIPLIER SETTING (TMS):

This feature offers various options of trip time for a selected trip time characteristic.
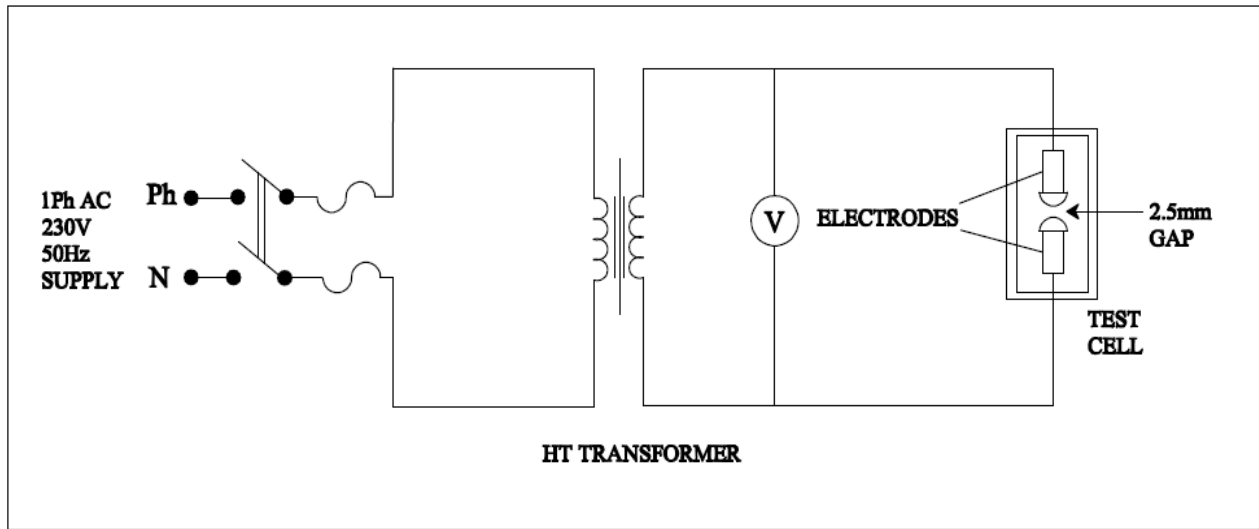
Trip time T is given by formula

$$T = k (0.1 + \sum t)$$

Where, T=Trip time in seconds

k=constant depending on trip time characteristic selected. **<u>Using table 2 and 3 for over and under voltage</u>**

t=weight of switch in ON position

Result: The operating characteristics of microprocessor based over/under voltage relay are realized.

BREAK DOWN STRENGTH OF TRANSFORMER OIL

CIRCUIT DIAGRAM

HT TRANSFORMER

TABULAR COLUMN

TYPE OF INSULATING OIL	BDV IN KV	AVERAGE BDV IN KV	GAP IN MM
TRANSFORMER OIL			
ENGINE OIL			

Experiment no: 08

BREAK DOWN STRENGTH OF TRANSFORMER OIL USING OIL TESTING UNIT

Aim:-To determine the breakdown strength of transformer oil as per Indian Standards specifications

APPARATUS:-One transformer oil kit, one oil cell, two 500ml glass containers, one glass rod, about 500ml of transformer oil.

DESCRIPTION OF BREAKDOWN STRENGTH OF TRANSFORMER OIL USING OF THE TEST SET:

The test set, which operates on 230V, 50 Hz supply has mainly two transformers. One is a torpidly wound auto transformer used to apply steeples continuously variable voltage to the other HT transformer. The HT transformer operates as low flux density ensuring distortion free output voltage .It is a 60 KV, 0.5 KVA capacity transformers. It is so designed that the short circuit current of the secondary is more than 20MA at voltages about 10KV. The max short circuit current does not exceed 200 MA thus preventing the unnecessary pitting of the electrodes. The test set consists of an over-load relay which trips and disconnects the HT transformer when the breakdown occurs across the gaps. The oil or the insulating material to be tested has to be put in the cells only after removing a plastic enclosure provided. When the enclosure is removed, it actuates a micro-switch shutting off the supply to the unit. A zero return interlock arrangement makes it obligatory to bring the HT voltage to zero after every breakdown test. The panel board of the test

Set consist of a voltage control knob, a moving iron ,meter to indicated the voltage applied in KV ,three indicator ,mains 'ON', HT,'ON' and HT 'OFF'. it also consists of mains switch, a HT 'ON' switch and a HT'OFF' switch.

PRECAUTION DURING SAMPLING: BS -148/1972 suggests the following precautions necessary for sampling

1) Utmost care should be taken to avoid contamination of the samples with traces of external impurities such as dust and moisture
2) The hands of the samples should not come into contact with the sample
3) Test should not be carried out on the samples until it is at least as warm as the surrounding air,
4) Only glass sample containers should be used cotton waste or other fibrous materials should not be used to wipe containers

PROCEDURE:

1. The gap between the two spheres in the oil test cell is 2.5 mm or 4mm
2. The test cell is cleaned and the transformer oil to be tested is poured inside the cell taking all the precautions outline earlier
3. The enclosure is removed and the oil test cell is placed inside the fiber glass chamber
4. The leads from the HT transformer are connected to the electrodes.
5. The mains cord is then connected to the 230V AC supply and the toggle switch on the panel is put in 'ON' position .The 'MAINS ON' as well as 'HT OFF' indicator lamps glows.
6. The 'HT START' Button is then pressed and the voltage control knob is turned in clock-wise direction .This will result in the excitation of the primary of the HT transformer.
7. The voltage knob is advanced till the breakdown occurs, watching the voltmeter throughout. Immediately after the breakdown, the 'HT ON' lamp goes off and 'HT OFF' lamp glows..Do not advance the voltage control any further .The breakdown voltage is the voltage reached during the test at the time of breakdown and is noted down .If the spark is an established one (not transient) the 'HT ON' lamp goes off and 'HT OFF' lamp light up.
8. The above test is carried out again three times on the same cell filling. The first application of the voltage is made as quickly as possible after the cell has been filled provided there are no longer any air bubbles in the oil. After each breakdown, the oil is gently stirred between the electrodes by means of a clean dry glass rod, avoiding as far as possible the production of air bubbles. For the subsequent three tests, it is necessary to wait for five minutes before a new breakdown test is started. The electric strength of the oil is in the arithmetic mean of the three results which are obtained and tabulated.
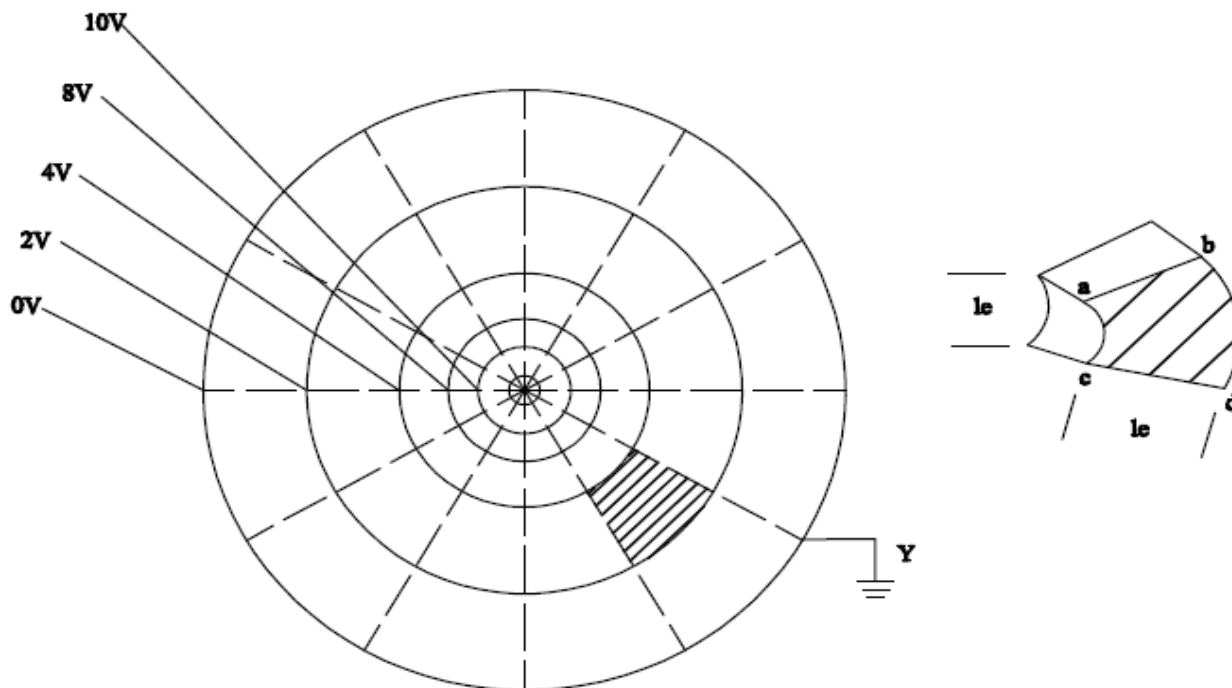
RESULT: The breakdown strength of the different insulating oils is experimentally determined and tabulated.

FIELD MAPING USING ELECTROLYTIC TANK FOR CO-AXIAL CABLE AND PARALLEL PLATE CAPACITOR

CIRCUIT DIAGRAM
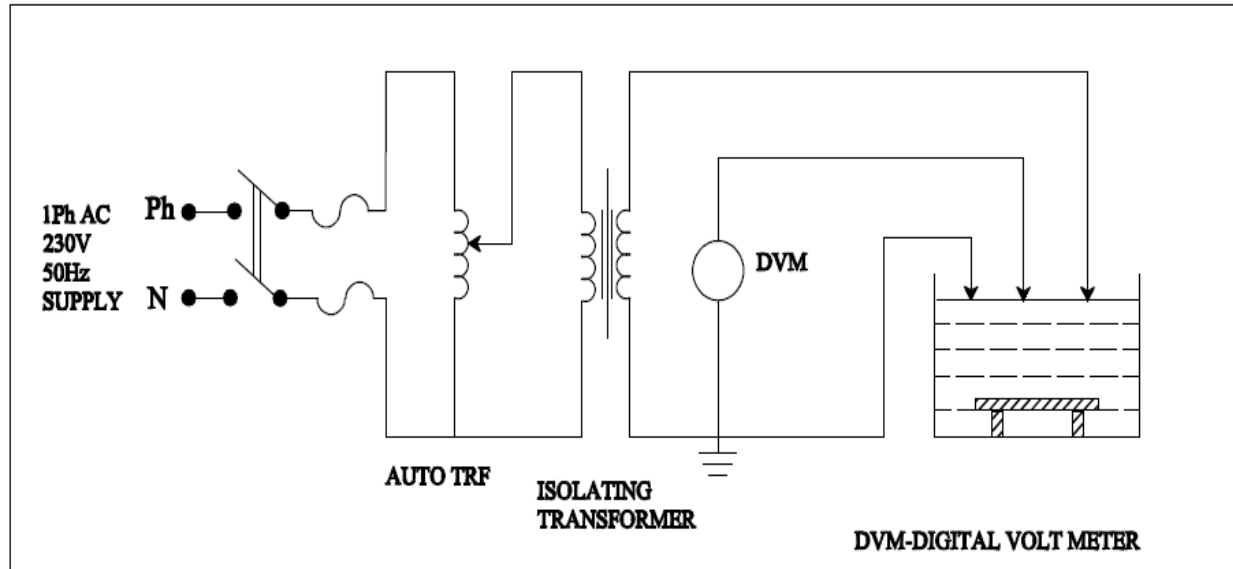
CO-AXAIL CABLE MODLE

Experiment no: 09

FIELD MAPING USING ELECTROLYTIC TANK

FOR CO-AXIAL CABLE AND PARALLEL PLATE CAPACITOR

AIM:

1) To plot the equipotential points and hence field lines for the given co-axial cable and parallel plate model

2) To determine the capacitance of the given co-axial cable and parallel plate model

3) To determine the voltage gradient

APPARATUS REQUIRED:

Electrolytic tank with pantograph arrangement, isolating transformer, one digital voltmeter, an auto-transformer, drawing sheet, pencil and eraser and the given co-axial cable and parallel plate model

INTRODUCTION:

A measure of the electric stress of a dielectric is the electric field strength, the determination of which is therefore an important task in high voltage technology .A mathematical solution is possible only in cases of simple arrangements, but for more complicated arrangements with in practice, a solution can be obtained by plotting the potential distribution in an electrolytic tank. Conduction of current in an electrolytic tank is used as an analog in high voltage dielectrics .The electrolytic tank is used for plotting the equipotential lines and forms this electric strength at any points can be determined.

For equipotential plots, the model is so constructed that they have the same shape and position as those in the original structure the most convenient electrolyte used in the electrolytic tank is the ordinary tap water for most of the problems. For the two-dimensional field model (one in which conductor configuration can be shown by single cross section, all cross section parallel to it being same) with more than one dielectric shallow tanks are used where different dielectric constants are simulated by different heights of electrolyte. Three dimensional fields with circular symmetry can be readily simulated in wedge shape tank(slopping bottom).To obtain the equipotent lines a low AC voltage(10volts) at 50Hz is applied across the electrodes DC voltage gives rise to much polarizing at the electrodes, which is the source of error. Polarisation is greatly reduced when AC is used.

While plotting the field lines the following points must be remembered.

1. The field lines leave and enter the electrodes at right angles, because there cannot be voltage drop and therefore no current flow, along an electrode. Near a corner in an electrode surface a field line bisects the included angle.

2. Field lines are perpendicular to the equipotential lines (because there is no voltage drop along an equipotential and therefore there can be no component of field line along it).

3. In a uniform field the potential varies linearly with distance.

4. All meshes (called a field cell) formed by two field lines and two equipotentials have the same shape or ratio of length to width equal to the mesh factor "a" and are all squares or curvilinear squares (refer fig A).By curvilinear square is meant an area that tend to yield true squares as it is subdivided into smaller and smaller areas by successive halving of the equipotential internal and the flux per tube.

Fig A

5. The field cells are obtained in the uniform field region.

6. It can be shown that 2D field with one dielectric if, I_f=distance along field lines, I_e=distance along equipotential lines, N_t=number of flux tube corresponding to cells in parallel, N_e=number of equipotential space corresponding to cells in series, C_o=capacitance per unit depth of the field cell, D=depth (into the page) of the field cell, A=mesh factor (i_f/i_e)
The total capacitance per unit length (into the plane of the diagram) is given by formula

7. The capacitance of any field cell is same.

PROCEDURE:

a) coaxial cable model

1) The given coaxial cable model mounted on the non conducting base is placed inside the electrolytic tank taking care to see that model as well as the surface inside the tank are clean and free of dust .If the water in the tank is not clean then this water is drained out using the tap provided in the tank and inside surface of the tank is cleaned.

2) Clean water is then added into the tank upto the tip of the given coaxial cable model.

3) Using the pantograph arrangement the probe is moved along the surface of the water to ensure that the water surface is perfectly horizontal. The leveling screw at the base of the tan can be used to obtain perfectly horizontal position of the tank.

4) The drawing sheet is now placed on the glass plate of the tank. Care must be taken in doing this and ensuring that the sheet is well anchored. A small undetected slide of the sheet during the plot will give an incorrect plot.

5) The electrical connections are then made as shown in the circuit diagram and a small voltage of 10V (with the probe touching the electrode"X") is applied to the electrode using the autotransformer.

6)The trace of the electrodes "X" and "Y" (shown in fig B) is then obtained on the sheet placed above the glass plate by moving the probe along the electrode surface.

7) Guiding the probe along a circle corresponding to 2V from the reference electrode "Y" and using the DVM. The equipotential line corresponding to 2V.Alternatively various points which are at 2V with respect to the reference electrode "Y" are the first marked using the probe and the DVM. The equipotential line is then obtained by joining smoothly all these points.

8) The equipotential lines corresponding to voltages of 4V,6V and 8V with respect to the reference electrode "Y" are similarly plotted.

b) Parallel plate capacitance model

1) The equipotential lines corresponding to potentials of 1V, 2V, 3V……10V with respect to the reference electrode "Y" (shown in fig C) is obtained in the same way as explained above.

PARALLEL PLATE MODEL
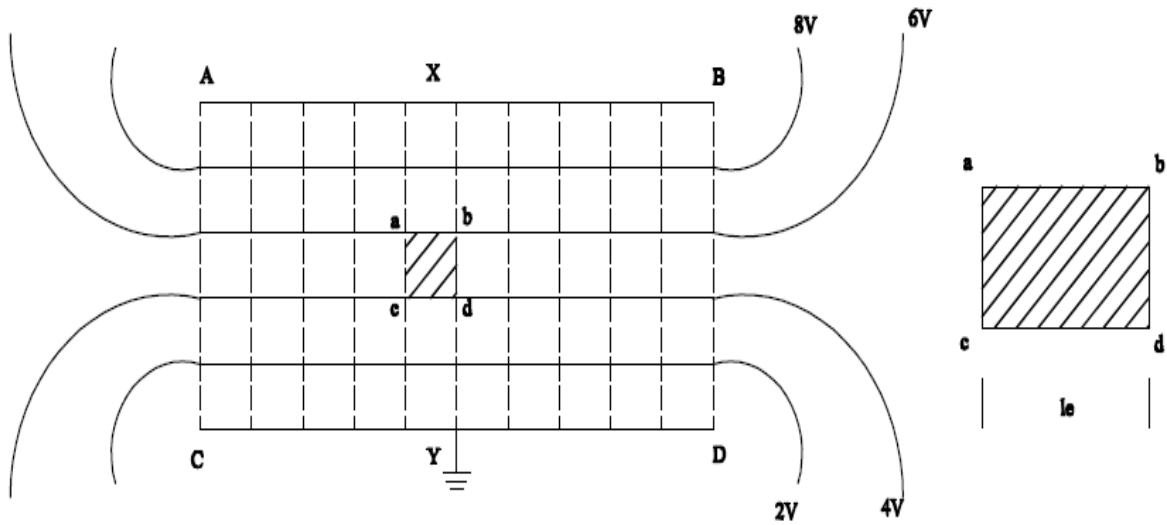
CALCULATIONS:-

RESULT: - The equipotential points and the field lines for given parallel plate and coaxial cable model is obtained and hence the capacitance is determined.

ELECTROMECHANICAL OVER CURRENT REALY

Experiment no: 10

ELECTROMECHANICAL OVER CURRENT REALY

Aims: - To study the operating characteristics of a electromechanical over current relay

Apparatus: - Electromechanical over current relay test kit, connecting wires

Theory: - The over current relay operates when the current in the circuit exceeds the pre determined of two electromagnets, the upper one it consists of E-shaped, while the lower in U-shaped. The aluminum disc rotates fully between the two magnets. The spindle of the disc carries moving contacts with fixed contacts which on the terminals of trip circuit the upper magnet has two windings the primary is connected to secondary of current transformer on the line to line protected the secondary winding is in series with winding of the lower magnet.

The winding is energized by contacts, by these arrangements of magnets are sufficiently displaced in space and time to produce a rotational torque on aluminum disc the controlled torque is provided by a spiral spring when current exceeds its peak value disc rotates and moving contacts make connection with trip circuit terminal angle this disc rotates between 0 to 360 degree.

OPERATING PROCEDURE:-

1. Connect as per interconnection diagram.
2. Set the relay current setting (Trip current value)
3. Set TMS.
4. Ensure Time interval meter selection switch in TIM position.
5. Connect the power cord.
6. Bring dimmer to zero position.
7. Put on the mains using Mains on switch. Results (Mains on indicter, ammeter display, relay power and Timer display grow)
8. Put the SHORT/INJECT switch to SHORT position.
9. Press TEST START push button, CB ON indicator will glow.
10. For different range of current values, select using the selector switch provided on the side of the kit.

Position-1: 1A	Position-4: 10A
Position-2: 2A	Position-5: 20A
Position-3: 5A	Position-6: 50A.

11. By adjusting the variac set the approximate injection current.
12. Push TEST STOP/RESET push button.
13. Without disturbing the position of variac, put the SHORT/INJECT switch to INJECT position.

14. Press TEST START push button, Note down the current. (Circuit breaker on, CB ON indicator will glow ,time interval meter starts up counting, over current relay trip occurs TRIP indicator will glow at relay and injector unit also.
15. Note down the Time interval meter reading. (pick up time)
16. Press the RESET button.
17. Repeat operation (6 – 16) by adjusting different current & TMS settings.
18. Draw the graph of Trip time v/s PSM (pick setting multiplier.)

Actual current =Meter reading * range selector position

FOR FINDING THE PICK UP CURRENT

1. Bring the variac zero; select the current range as required.
2. Put the SHORT/INJECT switch to INJECT position.
3. Press TEST START push button; gradually increase the variac from zero to the current setting value till the disc starts its rotation.
4. The reading on ammeter multiplied by current range selector gives the actual pickup current value.

Calculation

PSM = Fault current/ plug setting

If CT IS USED

**PSM (pulg setting multiplier) = fault current (primary current)/ plug setting (primary setting current)*ct ratio**

TSM (time setting multiplier) = actual operating time (ta) in sec/ calibrated operated time for tsm =1.0(t_c) in sec

Tabular column:-

SL NO	TSM (time setting Multiplier)	Plug setting	Fault current	PSM=fault current/plug setting	Operating time in seconds
1					
2					
3					
4					
5					

RESULT:-

SINGLE PHASE RADIAL FEEDEE PROTECTION SIMULATION STUDY

FEEDER PROTECTION CIRCUIT DIAGRAM
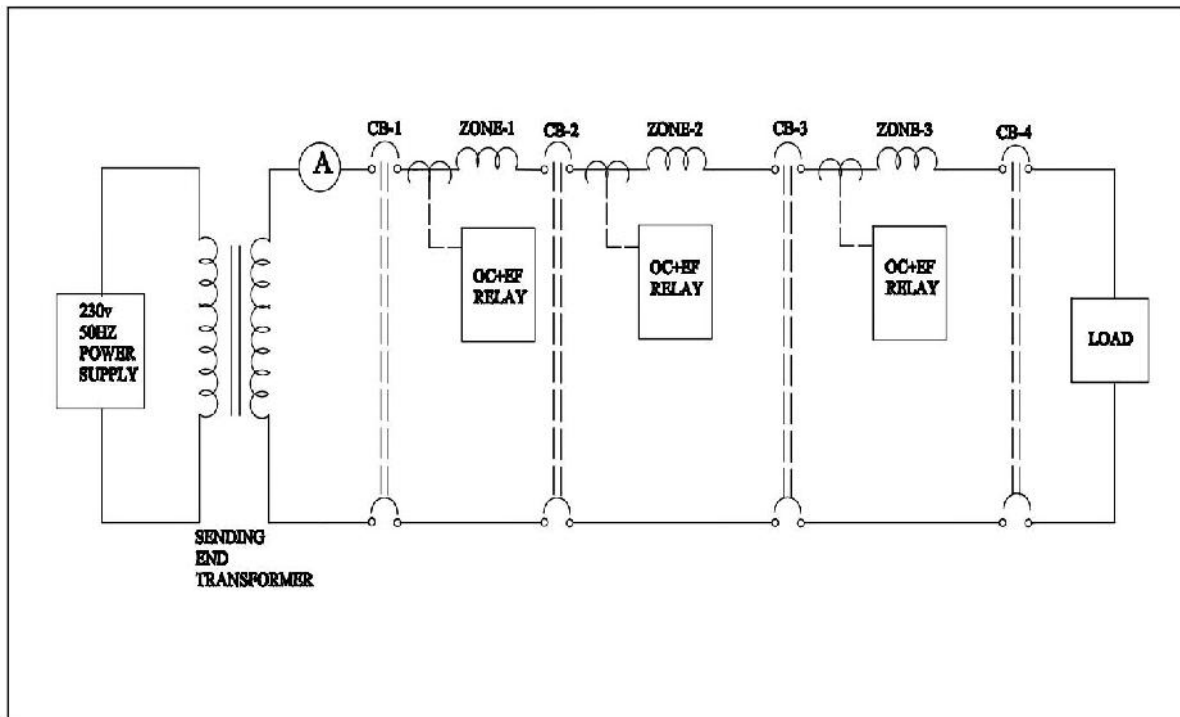
Experiment no: 11

SINGLE PHASE RADIAL FEEDEE PROTECTION SIMULATION STUDY UNIT

Aims: - To study the single phase radial feeder protection simulation study unit

Apparatus: - Single phase radial feeder protection test kit, connecting wires

INTRODUCTION

The word feeder here means the connecting link between two circuits. The feeder could be in the form of a transmission line, medium of long, or this could be a distribution circuit. The various methods of protecting the feeders are:

1. Over current protection.
2. Distance protection
3. Pilot relaying protection

Of these over current protection is simplest and cheapest form of protection. It is most difficult to apply and needs readjustment, should a change in the circuit occur. This have to be replaced depending upon the circuit conditions. Over current relay for distribution circuits besides being simple and cheap provides the following advantages:

- Very often the relays need not to be directional and hence no A.C. voltage source is required.
- Two phase and one earth fault relay or three element, earth relay fault can be used.

The over current protection is normally used as back up protection where the primary protection is provided with distance schemes. The discrimination using over current protection is achieved in the following ways.

- Time graded system.
- Current graded system.
- Time current graded system

TIME GRADED SYSTEM

The selectivity is achieved based on the time of operation of the relays. Consider a radial feeder in fig.1 the feeder is being fed form one force and has four substations indicated by vertical lines. The crosses represent the location of the relay. The relays used are simple over current protection relays. The time of operation the relays at various locations is so adjusted that the relay farthest from the source will have minimum time of operation and as it is approached towards the source the operating time increases. This is the main drawback of grading the relays in this way because it is required that the more servers a fault is

lesser should be the operating time of the relays where as in the scheme of operating time increases. The main application of such a grading is done on systems where the fault current does not vary much with the location of the fault and hence the inverse characteristic is not used.

CURRENT GRADED SYSTEM

This type of grading is done on a system where the fault current varies appreciably with the location of the fault. This means as we go towards the source the fault current increases. With this if the relays are set to pick at progressively higher current towards source, then the disadvantages of the long-time delay that occurs in cars of time graded systems can be partially overcome. This is known as current grading. Since it is difficult to determine the magnitude of the current accurately and also the accuracy of the relays under transient conditions is likely to suffer,

1. Put on the main's MCB. Results (Mains on indicator, ammeter display, relay power and timer display will glow.)
2. Turn on the relays & circuit breakers of the respective zones.
3. Now gradually reduce the rheostat which leads to increase of current in the respective zone creating the fault.
4. Once the fault is created & relay of corresponding zone operates leading the respective zone circuit breaker to open indicating us the fault zone.
5. To get the trip times & safe operation fault simulation switch is to be used.

CALCULATION:-

RESULT:-