Government Polytechnic West Champaran

Electrical Engineering

POWER ELECTRONICS LABORATORY (2420401(T2420401/P2420401/S2420401))

Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
Electrical Engineering	**2420401**	Power Electronics	03	-	04	02	09	06

Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
Electrical Engineering	**2420401**	Power Electronics	30	70	20	30	20	30	200

CONTENTS: PRACTICAL

Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psycho motor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to

CO-1	Test the performance of Power Electronics devices.
CO-2	Maintain Turn on and turn off circuit for a thyristor.
CO-3	Use relevant Phase Controlled rectifier for a given situations.
CO-4	Select a suitable chopper for a given applications.
CO-5	Test the performance of inverter, Cycloconverter and AC voltage

Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420401

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Identify the terminals of SCR. *LSO 1.2* Test the performance of the given SCR.	1.	V-I Characteristics of SCR.	CO1
LSO 1.3 Test the performance of IGBT.	2.	Characteristics of IGBT.	CO1
LSO 1.4 Test the performance of power MOSFET.	3.	Characteristics of power MOSFET.	CO1
LSO 1.5 Test the performance of the given DIAC and determine the breakover voltage	4.	Characteristics of DIAC.	CO1
LSO 1.6 Test the performance of TRIAC for the given AC load control.	5.	Characteristics of TRIAC.	CO1
LSO 2.1 Design and test the R and RC triggering circuit to trigger the given SCR.	6.	R and RC triggering circuits of SCR.	CO1, CO2
LSO 2.2 Test the performance of UJT triggering circuits of SCR.	7.	UJT triggering circuits of SCR.	CO1, CO2
LSO 2.3 Test the performance of given forced commutation circuit (A, B, C, D and E)	8.	Forced commutation circuit (A, B, C, D and E)	CO1, CO2
LSO 3.1 Test the Performance of a half wave-controlled rectifier comprising of SCR for the given load with freewheeling diode.	9.	Performance of a half wave-controlled rectifier comprising of SCR for R, RL load and RL load with freewheeling diode.	CO2, CO3
LSO 3.2 Test the Performance of a full wave-controlled rectifier comprising of SCR for the given load with freewheeling diode.	10.	Performance of a full wave-controlled rectifier comprising of SCR for R, RL load and RL load with freewheeling diode.	CO2, CO3
LSO 4.1 Test the Performance of buck converter with different values of duty cycle for the given load.	11.	Performance of buck converter with different values of duty cycle for a given R and RL load.	CO2, CO4
LSO 4.2 Test the Performance of a boost converter at different duty cycle for the given load.	12.	Performance of a boost converter at different duty cycle for a given R load.	CO2, CO4
LSO 5.1 Test the performance of single-phase half bridge VSI feeding R load.	13.	Performance of single-phase half bridge VSI feeding R load.	CO5
LSO 5.2 Test the performance of single-phase full bridge VSI feeding RL load.	14.	Performance of single-phase full bridge VSI feeding RL load.	CO5
LSO 5.3 Measure the input to output frequency of a single phase to single phase step down Cycloconverter.	15.	Measurement of frequency of a single phase to single phase step down Cycloconverter.	CO5
LSO 5.4 Measure the input to output frequency of a single phase to single phase step up cyclo-converter.	16.	Measurement of frequency of a single phase to single phase step up cyclo-converter.	CO5
LSO 5.5 Measure the output load voltage of a single-phase AC voltage controller using on- off circuit.	17.	Measurement of output load voltage of a single-phase AC voltage controller using on-off circuit.	CO5
LSO 5.6 Measure the output load voltage of a single-phase AC voltage controller using phase angle control for a Rand RL load.	18.	Measurement of output load voltage of a single-phase AC voltage controller using phase angle control for a R and RL load.	CO5

Experiment No. 01
V-I characteristics of Silicon Controlled Rectifier (SCR)

Aim: - To obtain V-I characteristics and determine the holding current and latching current of given SCR.

Introduction: - An SCR is a unidirectional device as it can conduct from anode to cathode only. SCR is a four-layer, three junction, p-n-p-n semiconductor switching device. It has three terminals anode, cathode & gate. The terminal connected to outer p region is called anode(A), the terminal connected to outer n region is called cathode(K) & that connected to inner p region is called gate (G). Static VI characteristics of a thyristor have three basic modes of operation; namely, reverse blocking mode, forward blocking mode & forward conduction mode.

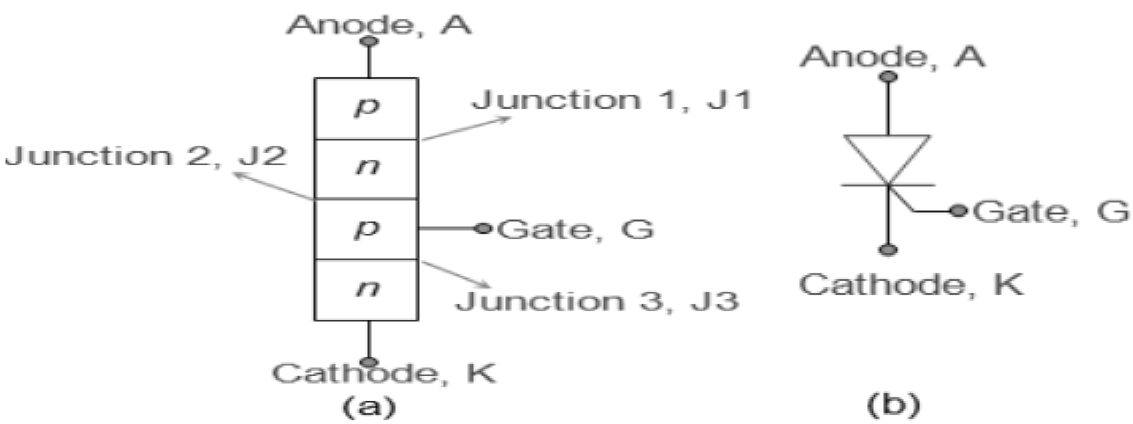


Fig. 1 Silicon controlled rectifier (a) layered structure (b) symbol

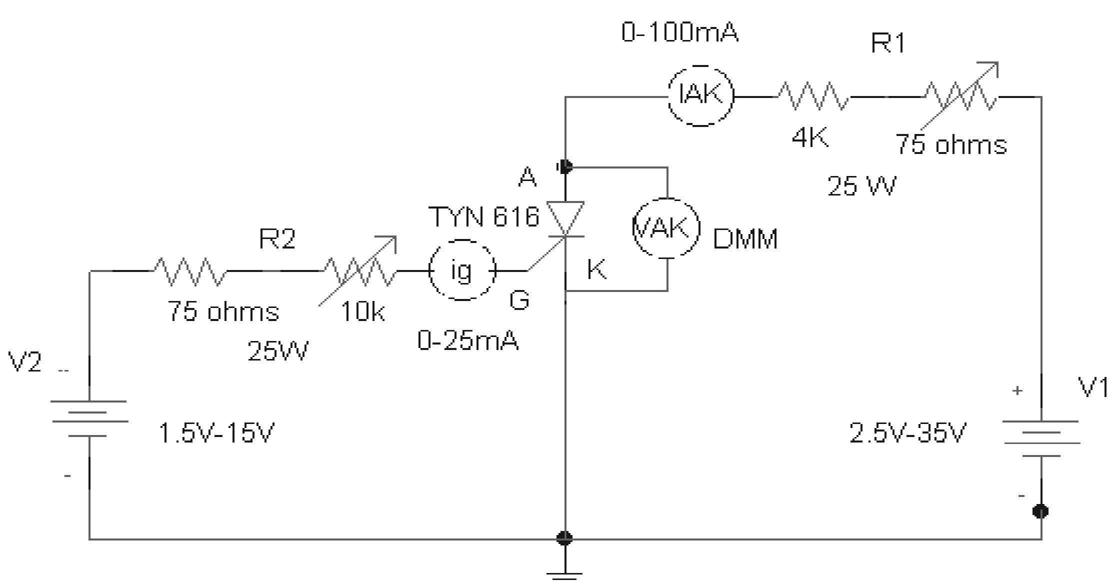


Fig1.1 (a). Circuit diagram for VI characteristics of SCR.

VBO = Forward break over voltage, VBR = Reverse break over voltage, I_g = Gate current

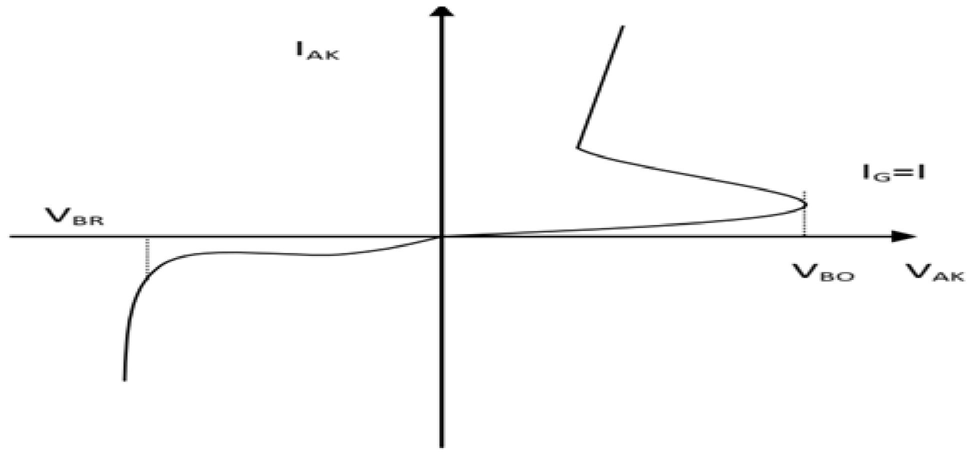


Fig. 1.2 (a) static characteristics of SCR

APPARATUS REQUIRED: Trainer kit, Patch cards, Multimeters.

PROCEDURE:

Forward Characteristics of SCR: -

A. With Open Gate:

1. Make the connections as per the circuit diagram through patch chords.
2. Keep gate power supply control knob (set Gate current) to minimum position so that gate current becomes zero.
3. Select milli ammeter range to 1.2 mA and voltmeter range to 30V.
4. Switch ON the instrument using ON/OFF toggle switch provided on the front panel.
5. Increase Anode(A-K) cathode power supply in small steps and note down corresponding Anode Current. As anode current is small SCR is in ‘OFF’ state.

B. When Gate is positive with respect to Cathode: -

1. Make the connections as per the circuit diagram through patch chords.
2. Keep gate power supply control knob (set Gate current) to minimum position so that gate current becomes zero.
3. Select milli ammeter range to 1.2 mA and voltmeter range to 30V.
4. Switch ON the instrument using ON/OFF toggle switch provided on the front panel
5. Select milli ammeter range to 30 mA.
6. Increase Gate Current (I_g) in small steps and note down corresponding Anode Current. At a particular value of I_g , SCR will turn ON resulting sudden increase in anode current I_A with decrease in anode -cathode voltage (V_{AK}).
7. Change the range of voltmeter to 1.2 V after triggering of SCR record all possible value of I_A (between 10mA to 30mA) and corresponding V_{AK} (range of 0.8V to 1V).
8. Also note down the gate current required for triggering the SCR at a given V_{AK}.
9. Repeat the experiment for different Anode-Cathode voltage (V_{AK}).
10. Plot a graph between V_{AK} & I_A by taking V_{AK} along X-axis & I_A along Y-axis.

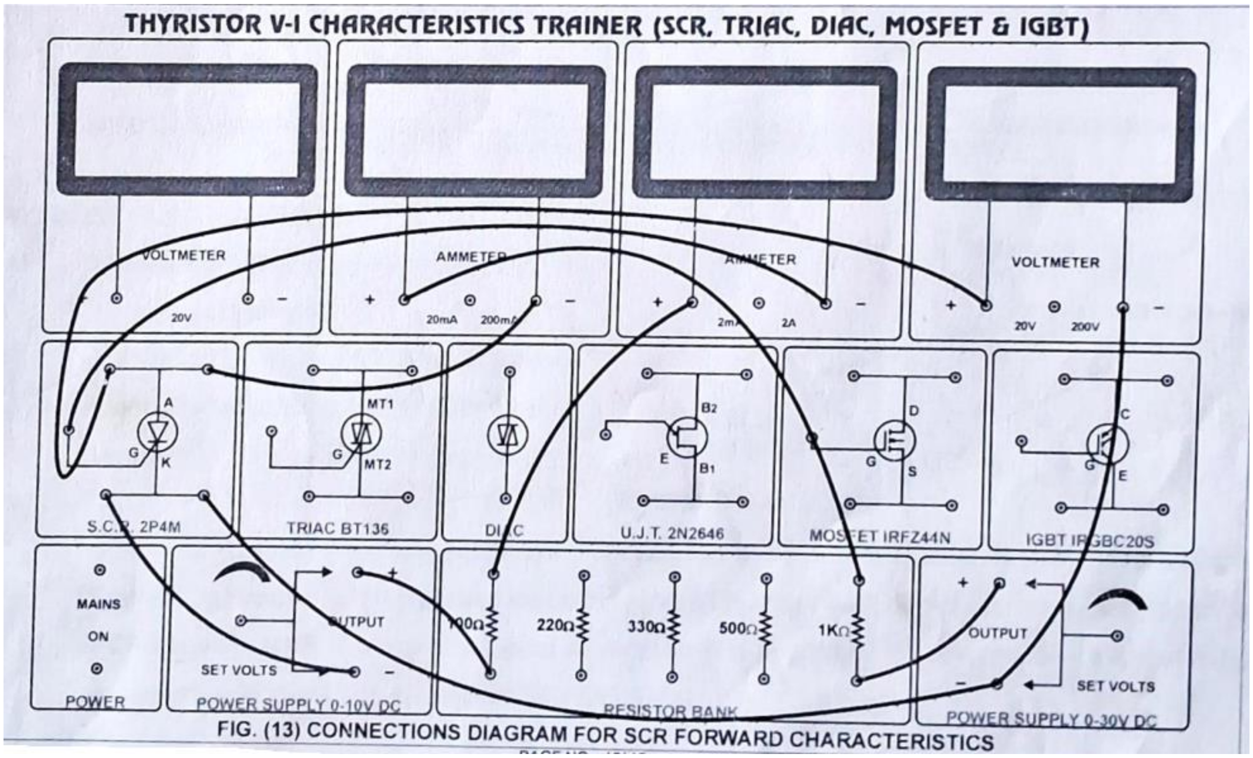


FIG. (13) CONNECTIONS DIAGRAM FOR SCR FORWARD CHARACTERISTICS

Reverse Characteristics of SCR: -

1. Connect the circuit as shown below through the patch chords.
2. Repeat all the steps as in case of forward characteristics procedure and plot a graph between V_{AK} & I_{A}.

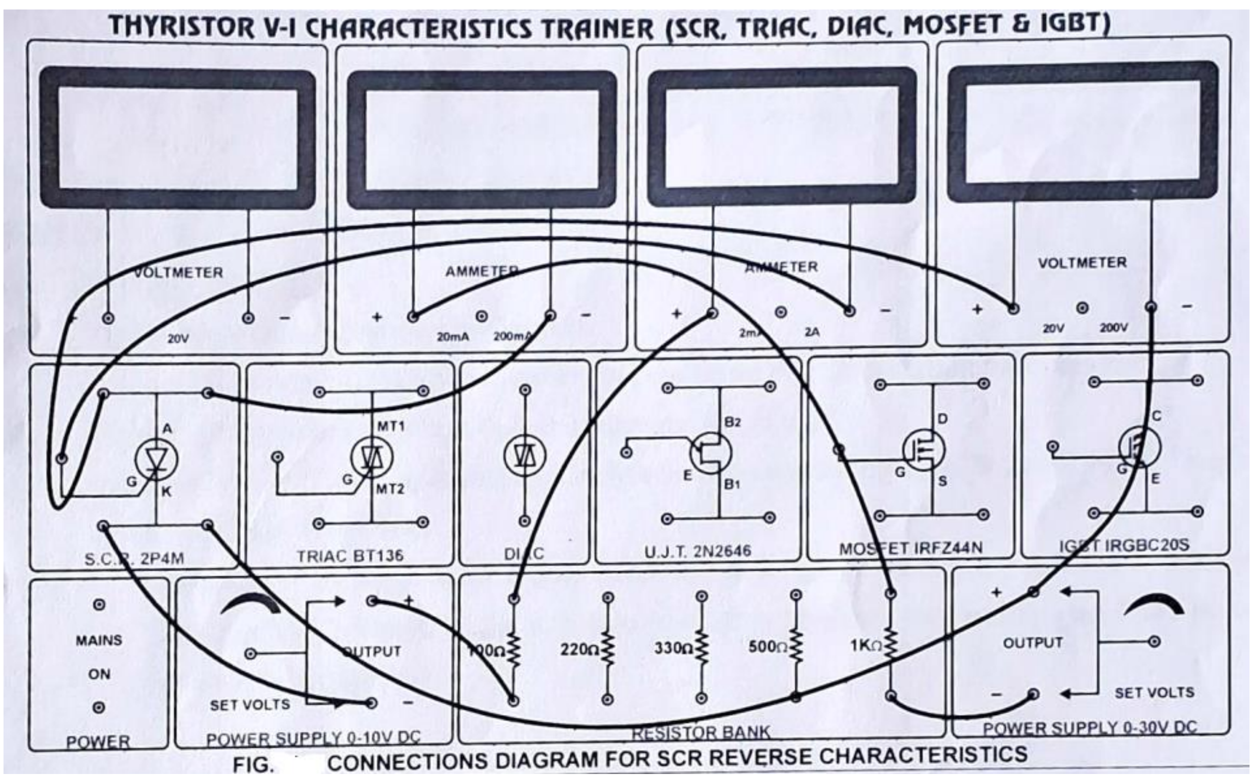


FIG. CONNECTIONS DIAGRAM FOR SCR REVERSE CHARACTERISTICS

FINDING LATCHING CURRENT:

- Ensure that the SCR is in the state of conduction.
- Start reducing (V_{AK}) anode voltage in steps of 2V; simultaneously check the state of SCR by switching off gate supply V_2. If SCR switches off just by removing gate terminal, and switches on by connecting gate supply, then the corresponding anode current I_A is the latching current (I_L) for the SCR.

Tabular Data:

S.No.	I_G = (mA)	
	V_{AK} (V)	V_{AK} (V) I_A (mA)

FINDING HOLDING CURRENT:

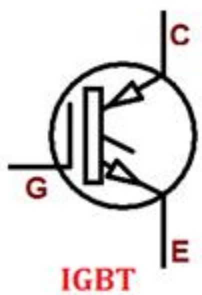
- Ensure that the SCR is in the state of conduction.
- Switch off the gate supply permanently.
- Start reducing (V_{AK}) anode voltage in steps of 2V; simultaneously check the state of SCR. If SCR switches off. Note down the anode current (I_A) just before it drops to zero, which will be I_H.
- Reverse the anode voltage polarity.
- Vary V_{AK} in steps of 5V till 25V and note down V_{AK} and I_A values at each step.
- Plot forward and reverse characteristics using the above-tabulated values. Find the SCR forward resistance using the graph.
- Repeat the above procedure for the forward and reverse characteristics of SCR for a gate current $I_g = I_{g2}$.

Experiment No.-02

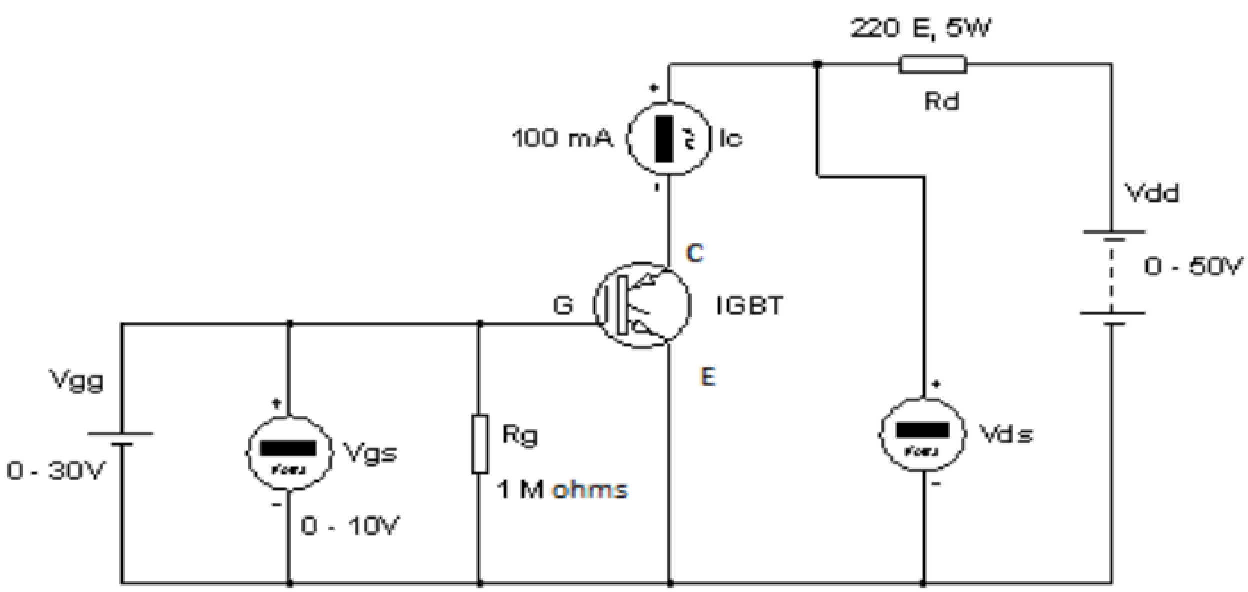
Characteristics of Insulated Gate Bi-polar Transistor (IGBT)

Aim- To determine the output & transfer characteristics of IGBT using PEC16MIA

Introduction: - Insulated Gate Bipolar Transistor (IGBT), combines the advantages of both BJT & MOSFET. So, an IGBT has high input impedance like MOSFET & low on state power loss as in a BJT. IGBT is free from second breakdown problem. A IGBT has three terminals called collector(C), emitter (E) & Gate(G). The static characteristics of IGBT are output & transfer characteristics. IGBTs are used in medium power applications such as dc & ac drives.



Practical Set-up/Circuit Diagram:-



Circuit Diagram for V/ I characteristics of IGBT

Apparatus Required: -

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1	IGBT Module kit		PEC16MIA	1
2	Voltmeter	(0-30) V	MC	2
3	Ammeter	(0-200)mA	MC	2
4	Patch Chords			As required

Precautions to be Followed: -

1. Ensure that all the knobs of the power supplies are at zero value before switching them on.
2. Identify Gate, Collector, and Emitter terminals of the given IGBT and make the connections as shown in the circuit diagram.
3. The applied voltage and current should not exceed the maximum rating of the given IGBT.
4. If IGBT is getting heated, either use appropriate heat sink or limit the collector current.
5. Reading should be noted without parallax error.

PROCEDURE:

To determine the Output Characteristics of IGBT

1. Make the connections as per the circuit diagram.
2. Switch on the supply.
3. Set the gate-emitter voltage (VGE) at a fixed value by varying POT on the gate side.
4. Now slowly increase the collector-emitter voltage (VCE) by varying the POT on collector-emitter side from zero till the IGBT gets turn ON.
5. Note down the VCE& IC.
6. Further increase the collector-emitter voltage (VCE) & note down IC.
7. Draw the characteristics between collector-emitter voltage (VCE) and collector current IC.

To determine the transfer Characteristics of IGBT

1. Make the connections as per the circuit diagram.
2. Switch on the supply
3. Set the collector-emitter voltage (V_{CE}) at a fixed value by varying POT on the collector-emitter side.
4. Now slowly increase the gate-emitter voltage (V_{GE}) by varying the POT on gate side from zero till the IGBT gets turn ON.
5. Note down the V_{GE}& I_C.
6. Further increase the gate-emitter voltage (V_{GE}) & note down I_C.

7. Draw the characteristics between gate-emitter voltage (V_{GE}) and collector current I_C

OUTPUT CHARACTERISTICS

S.No	V_{GE} = (V)	
	V_{CE} (V)	I_C (mA)

TRANSFER CHARACTERISTICS

S.No	V_{CE} = (V)	
	V_{GE} (V)	I_C (mA)

Experiment No: - 03
Characteristics of Power MOSFET

Aim: - To determine the output & transfer characteristics of MOSFET using PEC16MIA

Introduction: A metal oxide semiconductor field effect transistor (MOSFET) is a voltage controlled device. As its operation depends upon the flow of majority carriers only, MOSFET is a unipolar device. A power MOSFET has three terminals called drain(D), source(S) & Gate(G). In symbol of MOSFET arrow indicates the direction of electrons flow. The static characteristics of MOSFET are output & transfer characteristics. MOSFETs are widely used for high frequency applications.

APPARATUS REQUIRED

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1	MOSFET Module kit		PEC16MIA	1
2	Voltmeter	(0-30) V	MC	2
3	Ammeter	(0-200)mA	MC	2
4	Patch Chords			As required

CIRCUIT DIAGRAM

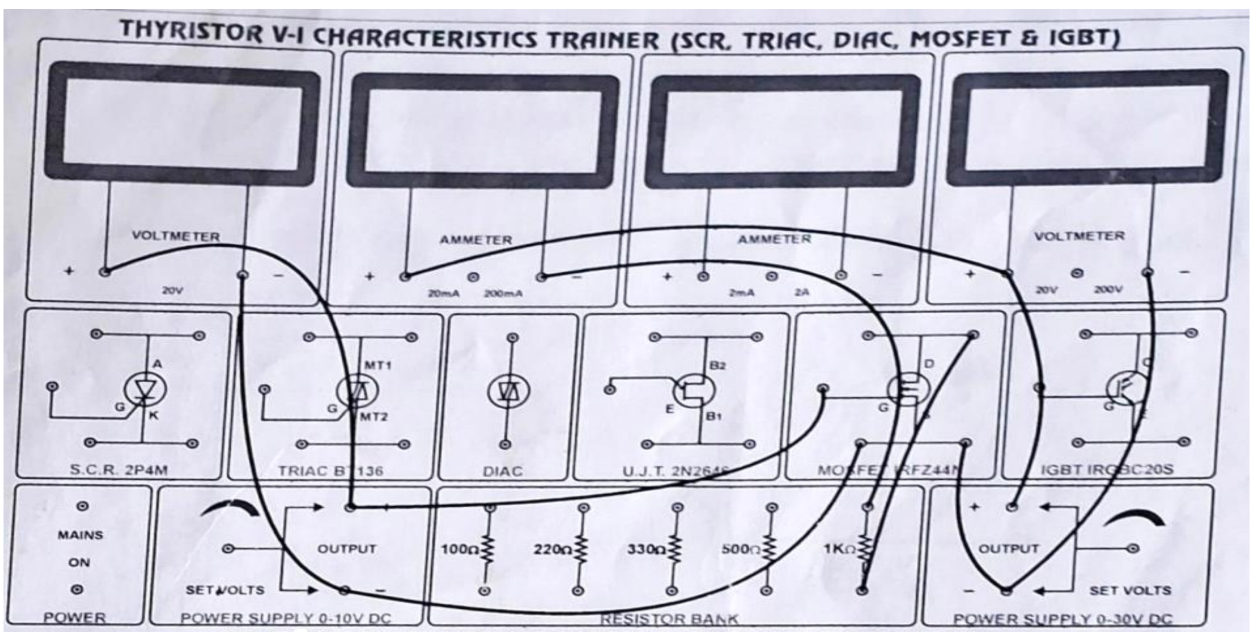


FIG. CONNECTIONS DIAGRAM FOR M.O.S.F.E.T. CHARACTERISTICS

PROCEDURE

To determine the Output (Drain)Characteristics of MOSFET

1. Make the connections as per the circuit diagram.
2. Switch on the supply

3. Set the gate-source voltage (V_{GS}) at a fixed value 2.9V.
4. Keep drain-source voltage (V_{DS}) at 0.5 V and note down the corresponding Drain Current.
5. Now increase the drain-source voltage (V_{DS}) in the steps of 0.5 V and note down the effect of that voltage on the drain current (I_D).
6. Now repeat the steps 4 & 5 for different Gate voltages say 3V, 3.5V, 3.8V. etc and note down the observation in table.
7. Draw the characteristics between drain-source voltage (V_{DS})and drain current $I_{D.}$

To determine the transfer Characteristics of MOSFET

1. Make the connections as per the circuit diagram.
2. Switch on the supply
3. Set the drain-source voltage (V_{DS}) at a fixed value 20V.
4. Now increase the gate-source voltage (V_{GS}) at 05V by varying the POT on gate side from zero and note down the drain current.
5. Further increase the gate-source voltage (V_{GS}) in steps & note down I_D.
6. Draw the characteristics between gate-source voltage (VGS)and drain current ID.

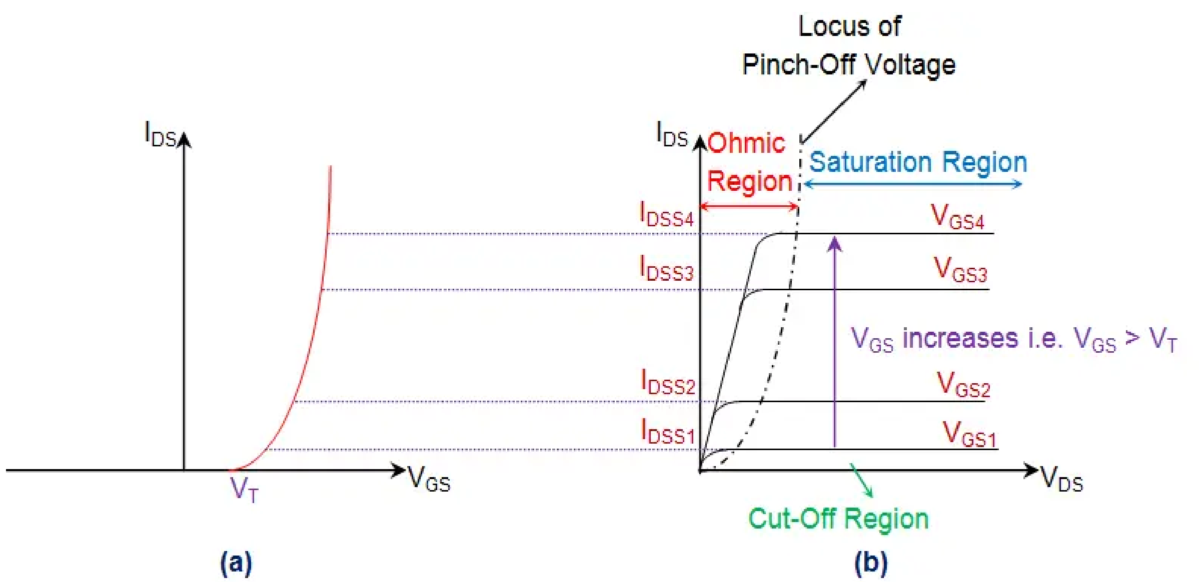


Figure 1 *n*-Channel Enhancement type MOSFET (a) Transfer Characteristics (b) Output Characteristics

OUTPUT CHARACTERISTICS

S.No	V_{GS} = (V)	
	V_{DS} (V)	I_D (mA)

TRANSFER CHARACTERISTICS

S.No	V_{DS} = (V)	
	V_{GS} (V)	I_D (mA)

Experiment No: - 04
Characteristics of DIAC

Aim- To draw V-I Characteristics of DIAC.

Apparatus Required:

S. No.	Apparatus/Accessories	Specifications	Quantity
1	DIAC Kit	As available in lab	1
2	Ammeter	0-50 mA, DC	1
3	Voltmeter	0-50 V, DC	1
4	Connecting Leads		6

Circuit Diagram:

Schematic circuit diagram for V-I characteristics of DIAC is given in Fig.2.1

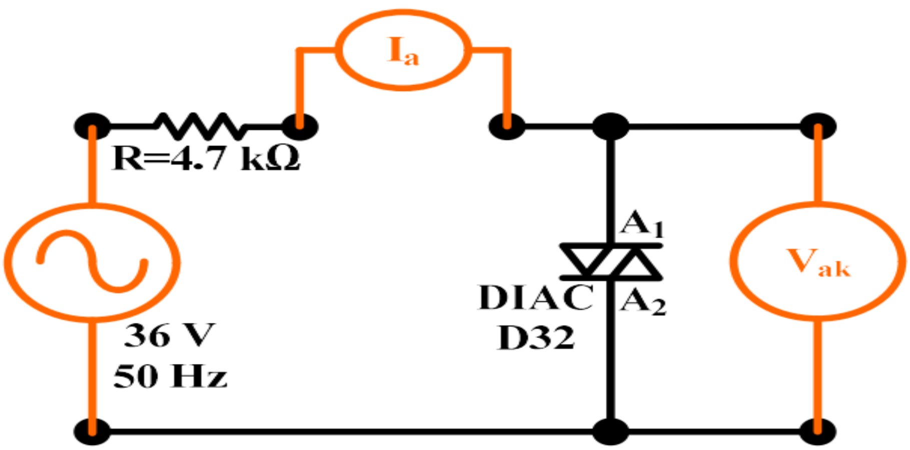


Fig.2.1 Schematic Circuit Diagram for V-I Characteristics of DIAC

Theory: DIAC is two terminal three-layer semiconductor devices. It is a bi-directional diode i.e.; it can be made to conduct in either direction. It has no gate terminal. Switching from off state to on state may done by simply exceeding the avalanche breakdown voltage in either direction. The two p-regions have similar doping characteristics resulting in symmetrical switching characteristic for both positive and negative voltages.

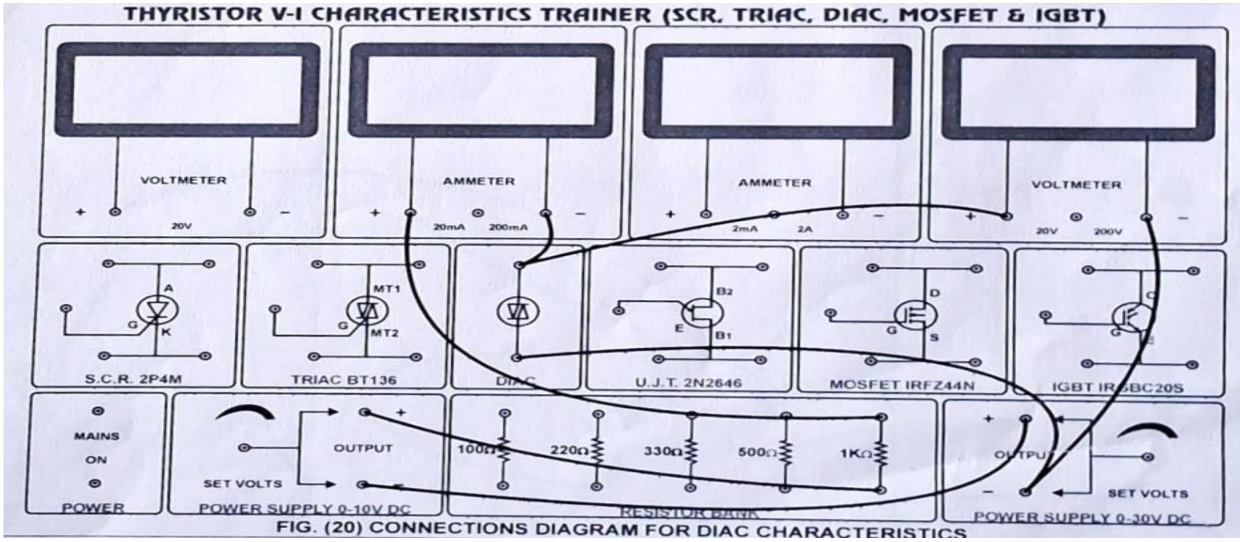
When the applied voltage exceeds the avalanche breakdown voltage, the DIAC current rises sharply. In this ON condition, the voltage across the DIAC decreases with increasing current and the device therefore offers negative resistance. Its turn on voltages is approximately 32V.

Procedure:

Steps to perform experiment.

1. Connect the circuit as shown in the figure
2. Switch ON the instrument using ON-OFF toggle switch provided on front panel.
3. Increase the voltage in steps with the voltage control potentiometer and note down the corresponding increase in current.

4. At a particular voltage, when applied voltage approaches the breakover voltage (V_{Bo}) as shown in figure the device exhibits negative resistance i.e. current through the device increases with the decreasing values of applied voltage.
5. Draw a graph between voltage and current, by taking voltage across X-axis and current across Y-axis as shown in figure.



Observations:

S. No.	Voltages across DIAC (Volts)	Current through DIAC (mA)
1		
2		
3		
4		
5		

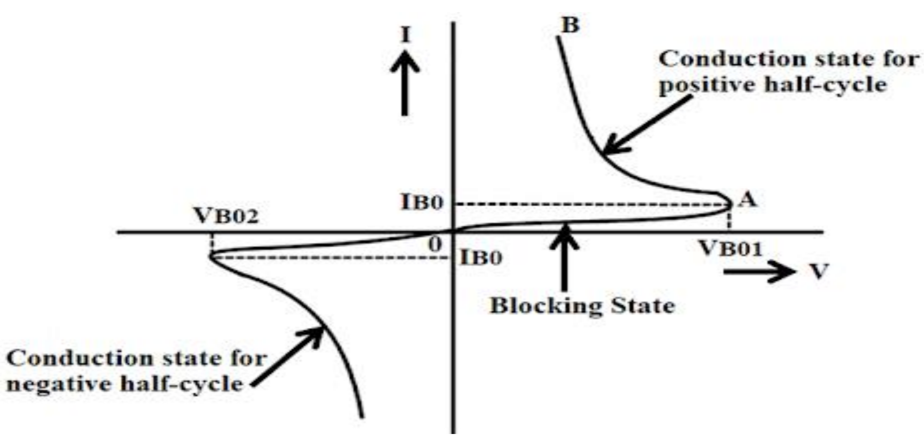


Figure 2**.2 Diac Characteristic Curve**

Experiement-5

Characteristics of TRIAC

Aim: To draw V-I Characteristics of TRIAC.

Apparatus Required:

S. No.	Apparatus/Accessories	Specifications	Quantity
1	TRIAC Kit	As available in lab	1
2	Ammeter	0-10 mA, DC	1
3	Ammeter	0-50 mA, DC	1
4	Voltmeter	0-50 V, DC	1
5	Connecting Leads		10

Theory:

TRIAC has three terminals namely MT1, MT2, and G. The TRIAC can be turned on with positive or negative gate current by keeping the MT2 terminal at positive or negative voltage w.r.t. MT1. It is bilateral device and equivalent to two thyristors connected in anti-parallel. A TRIAC can be triggered in four modes:

Mode-1: MT_2 terminal positive w.r.t. MT_1 and positive gate current

After triggering the TRIAC in this mode, it conducts in I_{st} quadrant. The device is more sensitive in this mode.

Mode-2: MT2 terminal negative w.r.t. MT1 and positive gate current

After triggering the TRIAC in this mode, it conducts in III_{rd} quadrant. The device is less sensitive in this mode.

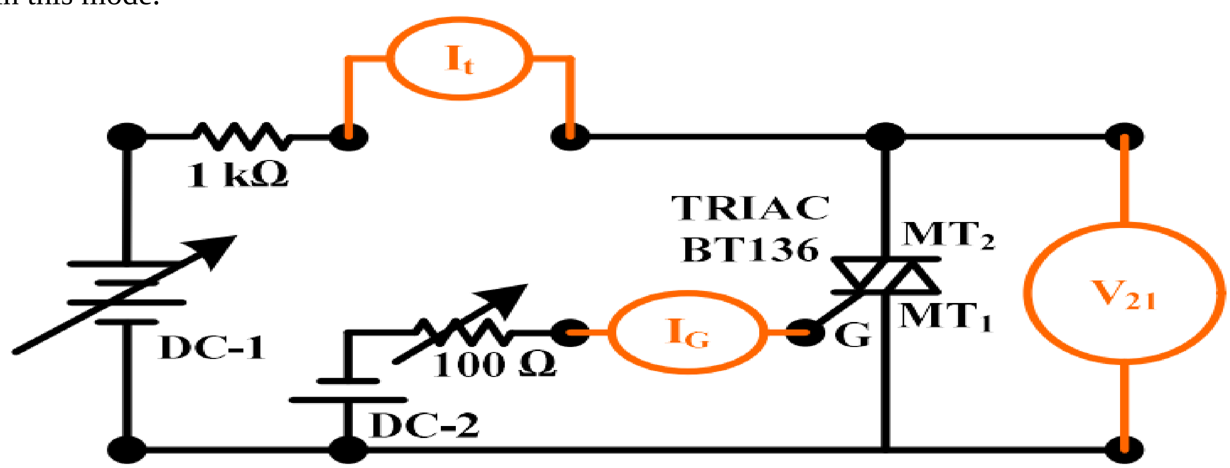


Fig.3.1 Schematic Circuit Diagram for V-I Characteristics of TRIAC.

Mode-3: MT2 terminal negative w.r.t. MT1 and negative gate current

After triggering the TRIAC in this mode, it conducts in III_{rd} quadrant. The device is more sensitive compared to Mode-2 because in this mode less gate current is required for triggering the device with the same supply voltage and same load compared to the positive gate current as in mode-2.

Mode-4: MT_2 terminal positive w.r.t. MT_1 and negative gate current
After triggering the TRIAC in this mode, it conducts in Ist quadrant. The device is less sensitive in this mode compared to the mode-1 of operation because the device requires more gate current in this mode.

Circuit Diagram:

Schematic circuit diagram for V-I characteristics of TRIAC is given in Fig.3.1

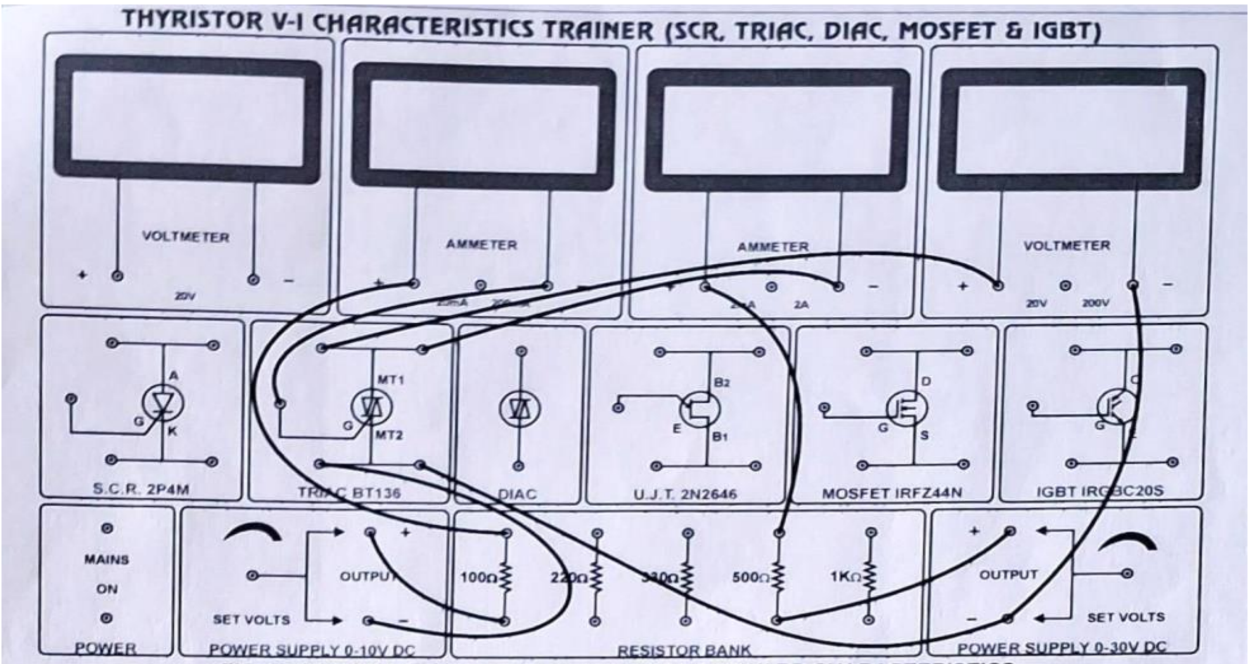


FIG. (16) CONNECTIONS DIAGRAM FOR TRIAC FORWARD CHARACTERISTICS

Procedure:

Step to Perform the Forward Characteristics

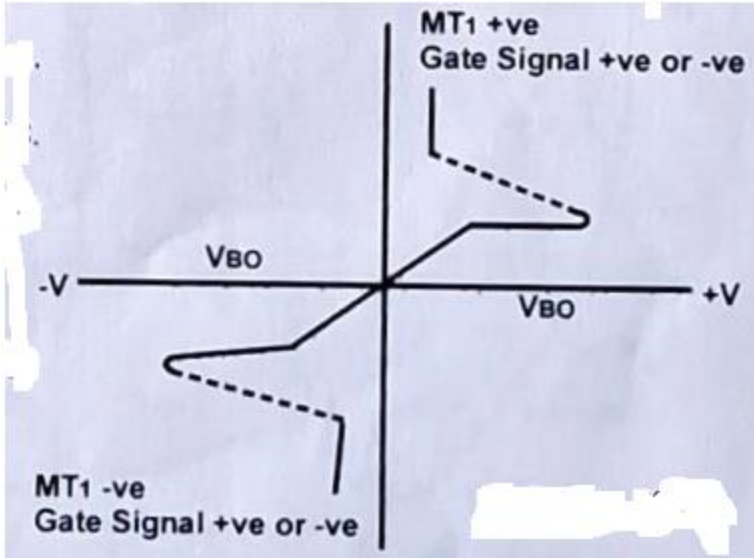
A. With Open Gate

1. Connect the circuit as shown in the above figure.
2. Keep Gate supply control knob to minimum position so that gate current becomes zero.
3. Select milliammeter range to 500µA and voltmeter range to 30V.
4. Increase MT1-MT2 supply in steps and note down the corresponding MT1 current. As MT1 current is small TRIAC is in 'OFF' state.

B. When Gate is Positive.

1. Connect the circuit as shown in the above figure.
2. Repeat step 2 to 4 as given above (in case of open gate circuit).
3. Select milliammeter range to 60mA.
4. Increase gate current (I_g) in small steps, at a particular value of I_g, Triac will turn ON resulting sudden increase in MT1 current and decrease in MT1-MT2 voltage.
5. Change the range of voltmeter to 3V after triggering of Triac.
6. Also note the gate current I_g required for triggering the triac at a given $V_{MT1-MT2}$.

7. Record different breakover voltages and triggering gate currents. Plot the graph as shown in figure.



C. When Gate is negative with respect to MT2:

1. Connect the circuit as shown in the above figure.
2. Repeat step 2 to 4 as given above (in case of open gate circuit).
3. Select milliammeter range to 60mA.
4. Increase gate current (I_g) in small steps, at a particular value of I_g, Triac will turn ON resulting sudden increase in MT1 current and decrease in MT1-MT2 voltage.
5. Change the range of voltmeter to 3V after triggering of Triac.
6. Also note the gate current I_g required for triggering the triac at a given $V_{MT1-MT2}$.
7. Record different breakover voltages and triggering gate currents. Plot the graph as shown in figure.

D. Reverse Characteristics

1. Connect the circuit as shown in the above figure.
2. Repeat all the steps as in case of forward characteristics procedure.
3. Record all the possible results and plot the graph as shown in figure.

Observations:

S. No.	I_G		I_G		I_G	
	V	I	V	I	V	I
1						
2						
3						
4						
5						