SSM INSTITUTE OF ENGINEERING AND TECHNOLOGY

DINDIGUL – PALANI HIGH WAY, SINTHALAGUNDU POST

DINDIGUL – 624002

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

LABORATORY MANUAL

CLASS : IIIrd YEAR EEE

SEMESTER : VI th (DEC 2017 – MAY 2018)

SUBJECT CODE : EE 6611

SUBJECT NAME : POWER ELECTRONICS AND DRIVES LABORATORY

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SYLLABUS

EE6611 - POWER ELECTRONICS AND DRIVES LABORATORY

LIST OF EXPERIMENTS:

1. Gate Pulse Generation using R, RC and UJT.
2. Characteristics of SCR and Triac
3. Characteristics of MOSFET and IGBT
4. AC to DC half controlled converter
5. AC to DC fully controlled Converter
6. Step down and step up MOSFET based choppers
7. IGBT based single phase PWM inverter
8. IGBT based three phase PWM inverter
9. AC Voltage controller
10. Switched mode power converter.
11. Simulation of PE circuits (1Φ & 3Φ semiconverter, 1Φ & 3Φ fullconverter, dc-dc converters, ac voltage controllers

LIST OF EXPERIMENTS

FIRST CYCLE

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2. Characteristics of SCR and Triac
3. Characteristics of MOSFET and IGBT
4. AC to DC half controlled converter
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SECOND CYCLE

7. IGBT based single phase PWM inverter
8. IGBT based three phase PWM inverter
9. AC Voltage controller
10. Switched mode power converter.
11. Simulation of PE circuits (1Φ & 3Φ semiconverter, 1Φ & 3Φ fullconverter, dc dc converters, ac voltage controllers).

ALLOTMENT OF MARKS

Internal assessment	: 20 marks
Practical assessment	: 80 marks
TOTAL	**: 100 marks**

SPLIT UP OF INTERNAL MARKS

Observation	: 5 marks
Record note	: 10 marks
Model exam	: 5 marks
TOTAL	**: 20 marks**

UNIVERSITY EXAMINATION

The Exam will be conducted for 100 marks. Then the marks will be converted to 80 marks.

SPLIT UP OF PRACTICAL EXAMINATION MARKS

Aim and Procedure	: 10 marks
Circuit diagram / Program	: 25 marks
Circuit connection	: 15 marks
Tabulation	: 15 marks
Calculation & Simulation	: 15 marks
Graph & Result	: 10 marks
Viva	: 10 marks
TOTAL	**: 100 marks**

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Sl.no	Date	Title of Experiment	Page no.	Marks	Signature

Ex.No: Date:

SCR GATE PULSE GENERATION USING R, RC AND UJT

AIM:

To construct the R, RC &UJT triggering circuit for SCR and plot its output waveforms.

APPARATUS REQUIRED:

i.	CRO (20MHz)	-	1 No
ii.	R.P.S (0-30)V	-	1 No
iii.	Voltmeter (0-15V)MI	-	1 No
iv.	Load (100 Ohms, 2A)	-	1 No
v.	Transformer (230V/24V)	-	1 No

PROCEDURE: (R-TRIGGERING)

- Make the connections as per the circuit diagram.
- Vary the DRB to get maximum resistance value.
- Switch on the power supply.
- Note down the output waveform across the load and the voltage across gate cathode using a CRO.
- Repeat the procedure for various resistor values of potentiometer. Switch off the power and remove the connections

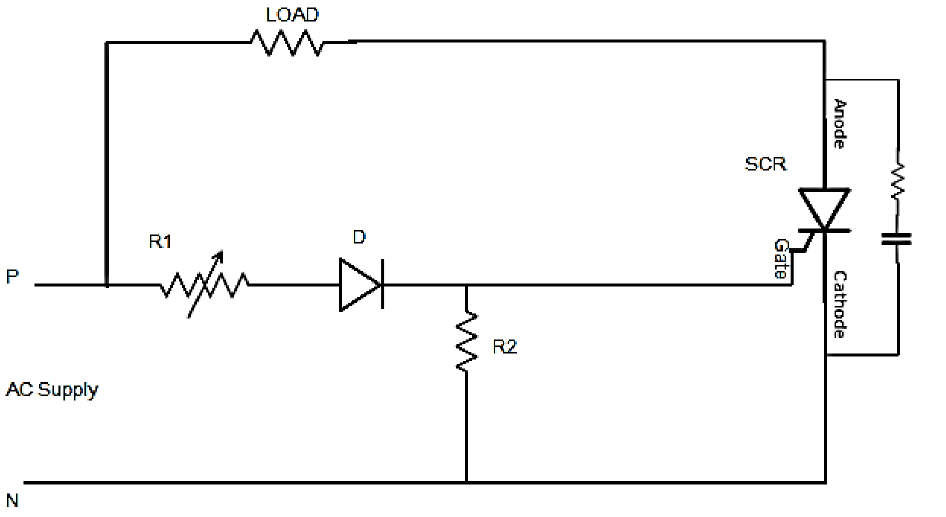
PROCEDURE: (RC-TRIGGERING)

- Make the connections as per the circuit diagram.
- Switch on the power supply.
- Note down the output waveform across the load using a CRO.
- Repeat the procedure for various resistor values of potentiometer.
- Switch off the power and remove the connections.

PROCEDURE: (UJT-TRIGGERING)

- Make the connections as per the circuit diagram.
- Switch on the power supply and set the biasing voltage to 18volts.
- Note down the waveform of voltages (Vc and Vo) using a CRO .
- Repeat the procedure for various resistor values of potentiometer.
- Switch off the power supply and remove the connections.

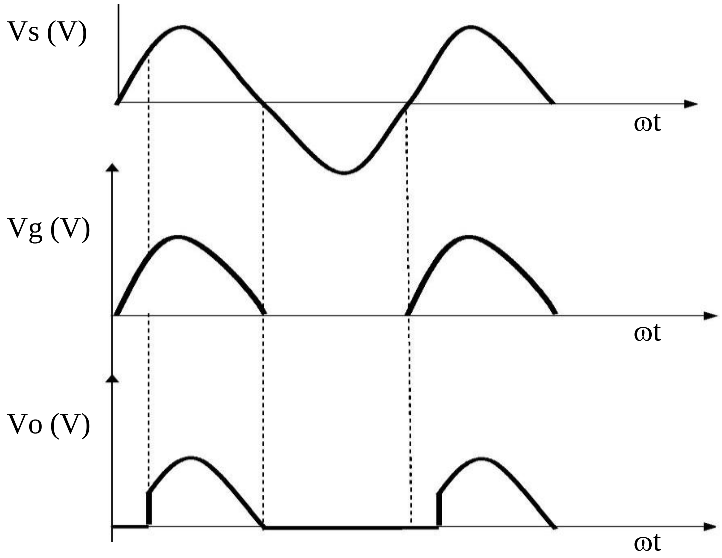
R - Triggering



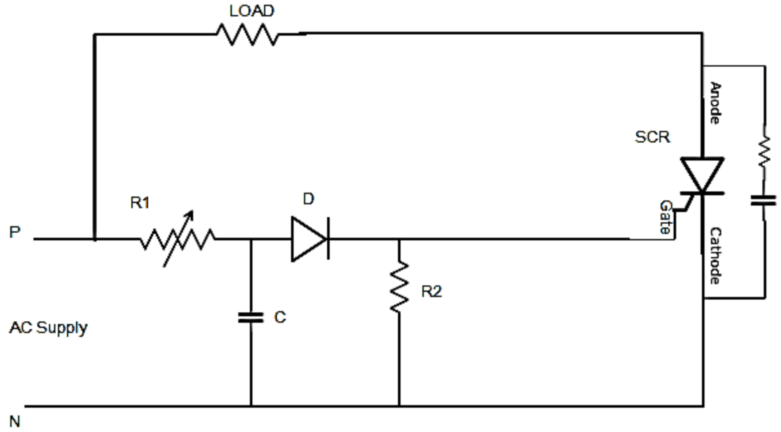
Tabular column (R-Triggering)

Sl.No	α (Degree)	Time in (ms)		I/P Voltage (V_{in}) in Volts	O/P Voltage (V_o) in Volts
		T_{ON}	T_{OFF}		

Model graph (R-Triggering)

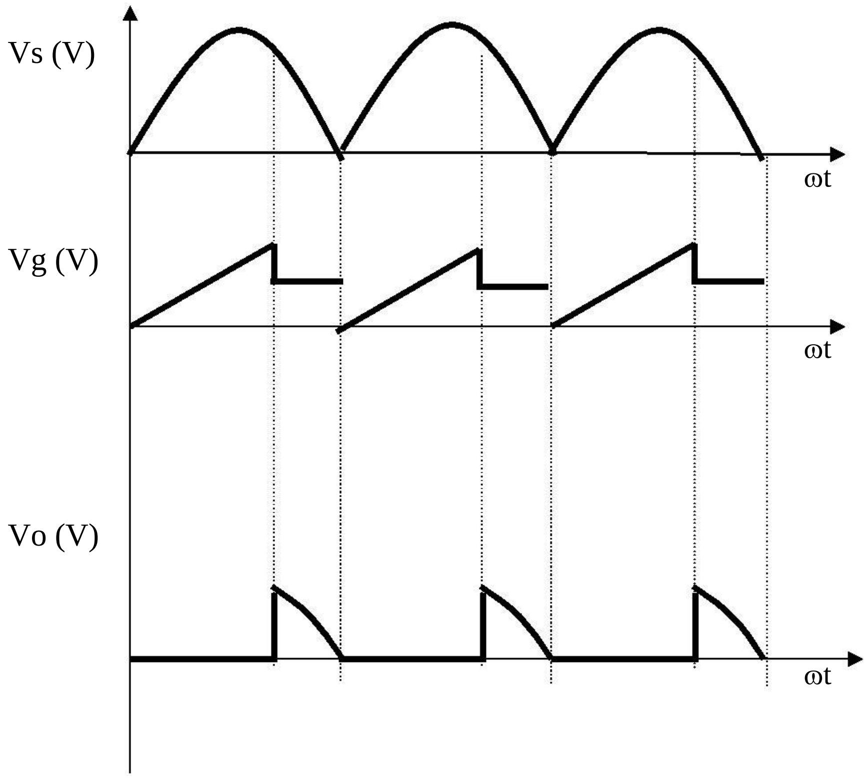


RC-TRIGGERING

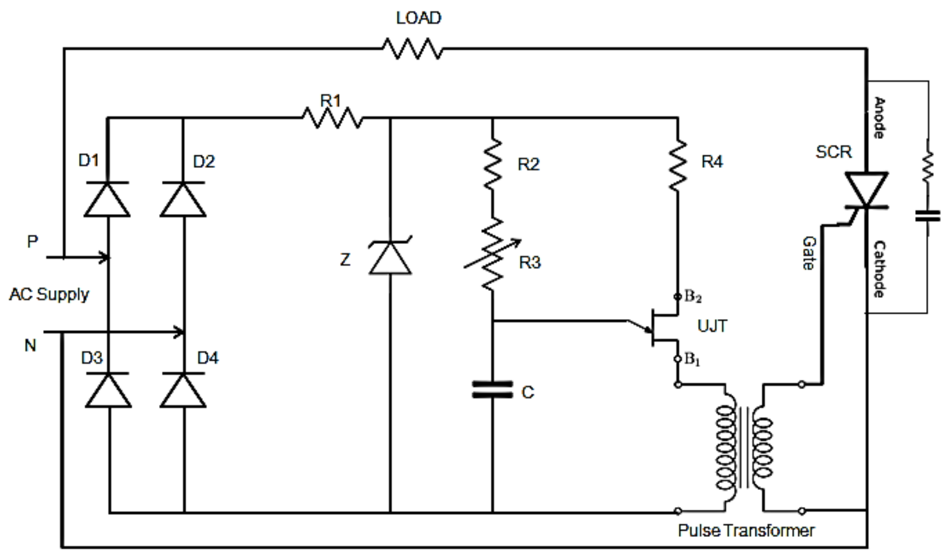


Sl.No	α (Degree)	Time in (ms)		I/P Voltage (V_{in}) in Volts	O/P Voltage (V_o) in Volts
		T_{ON}	T_{OFF}		

RC-TRIGGERING

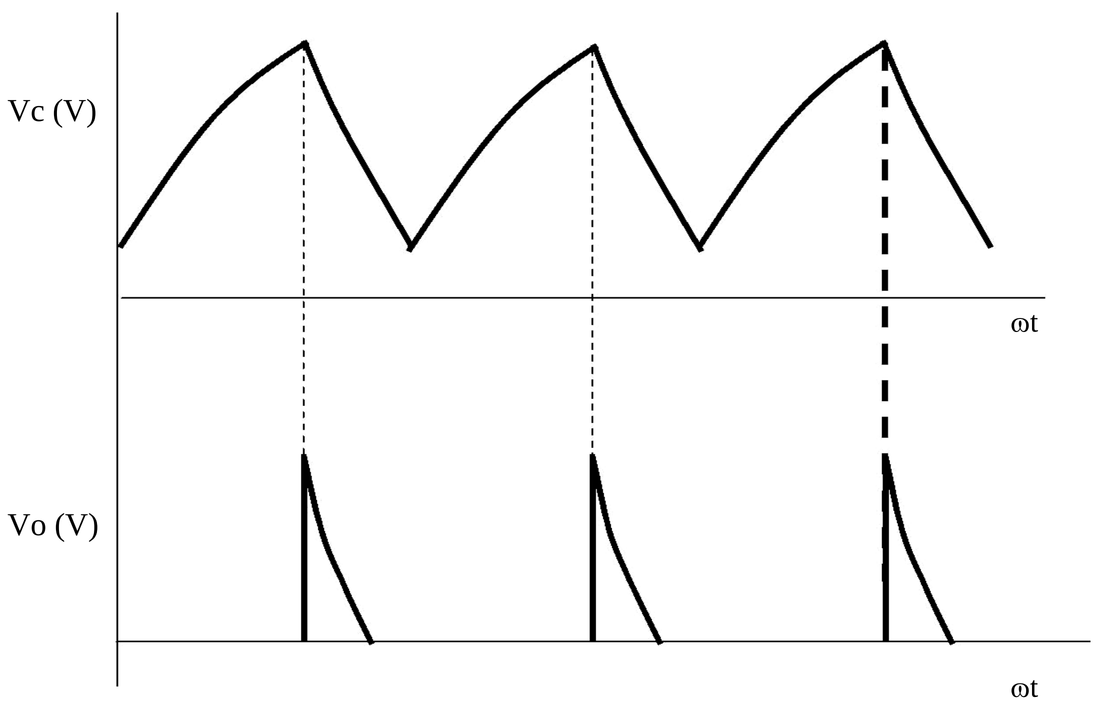


UJT-TRIGGERING



Sl.No	α (Degree)	Time in (ms)		I/P Voltage (V_{in}) in Volts	O/P Voltage (V_o) in Volts
		T_{ON}	T_{OFF}		

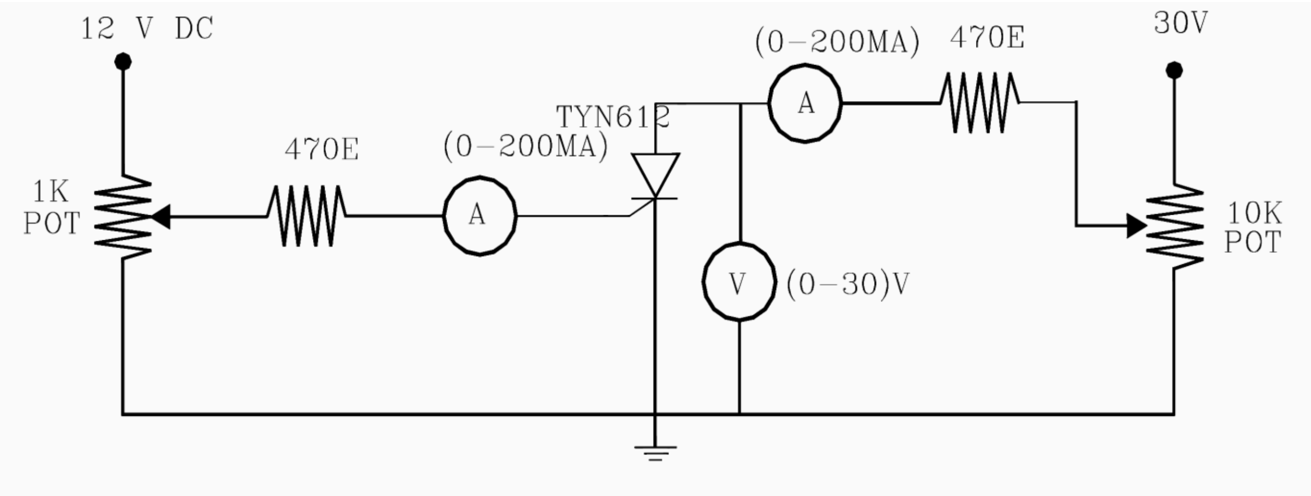
UJT-TRIGGERING



RESULT

Thus the R, RC &UJT triggering circuit for SCR was constructed and its output waveforms were plotted

CIRCUIT DIAGRAM



Ex. No: Date:

CHARACTERISTICS OF SCR

AIM: To Conduct the experiment of the static V-I characteristics of the given SCR.

APPARATUS REQUIRED:

i. PEC16M1A Device module - 1 No.
ii. Ammeters (0-200mA) DC - 2 Nos.
iii. Voltmeter (0-30V) DC - 1 No.
iv. Patch chords.

THEORY:

SCR is a four-layer semiconductor device with three pn junctions. The three terminals are anode, cathode & gate. When anode voltage is made positive with respect to cathode, junctions J_1 & J_2 are forward biased & J_3 is reverse biased. So only leakage current flows through the circuit and the SCR is in the OFF state.

When anode to cathode voltage is increased to a larger value and J_1 & J_2 break down. There will be free movement of carriers across the three junctions and the device is in the conduction state. In the ON state anode an external resistance R limits the current.

The anode current must be more than a value known as latching current in order to maintain required amount of current flow across the junction. However, an SCR is turned off when current is below holding current.

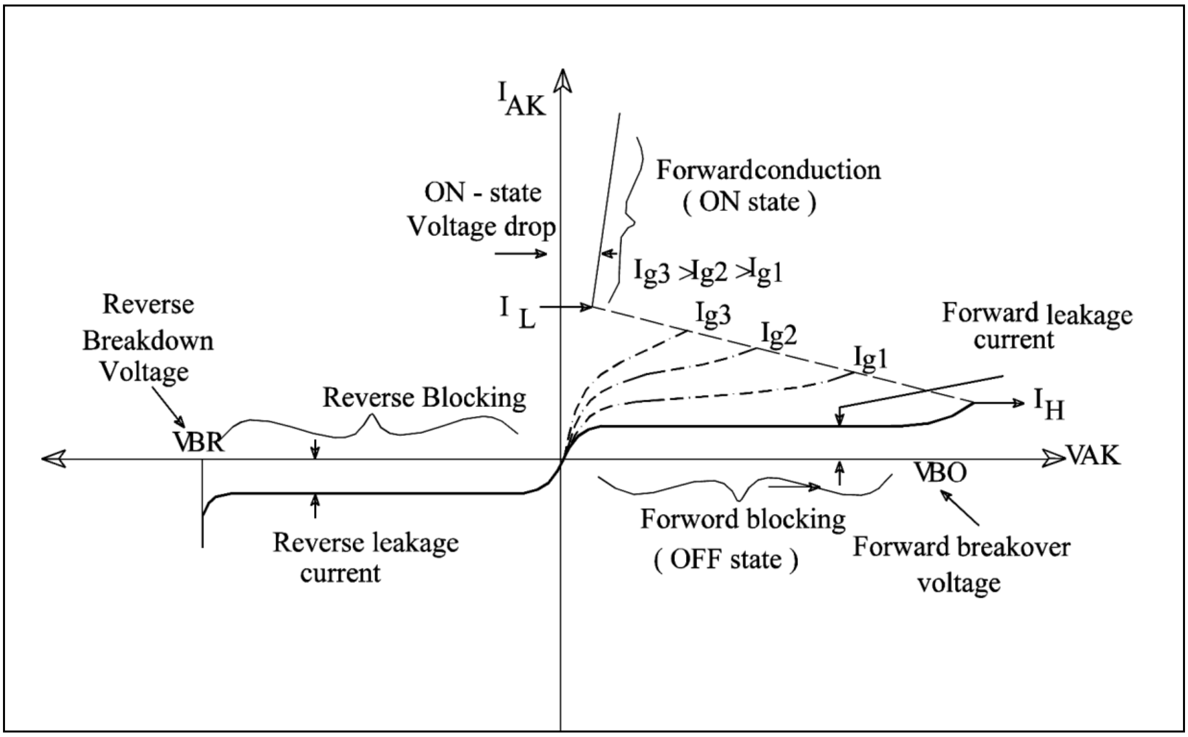
CONNECTION PROCEDURE:

- Connect SCR's anode, cathode & gate terminals to SCR characteristic circuit.
- Connect Ammeter in gate terminal as shown in the front panel.
- Connect Ammeter in anode terminal as indicated in the front terminal.
- Connect Voltmeter across anode and cathode terminal to measured V_{AK}.

TABULATION:

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

MODEL GRAPH:



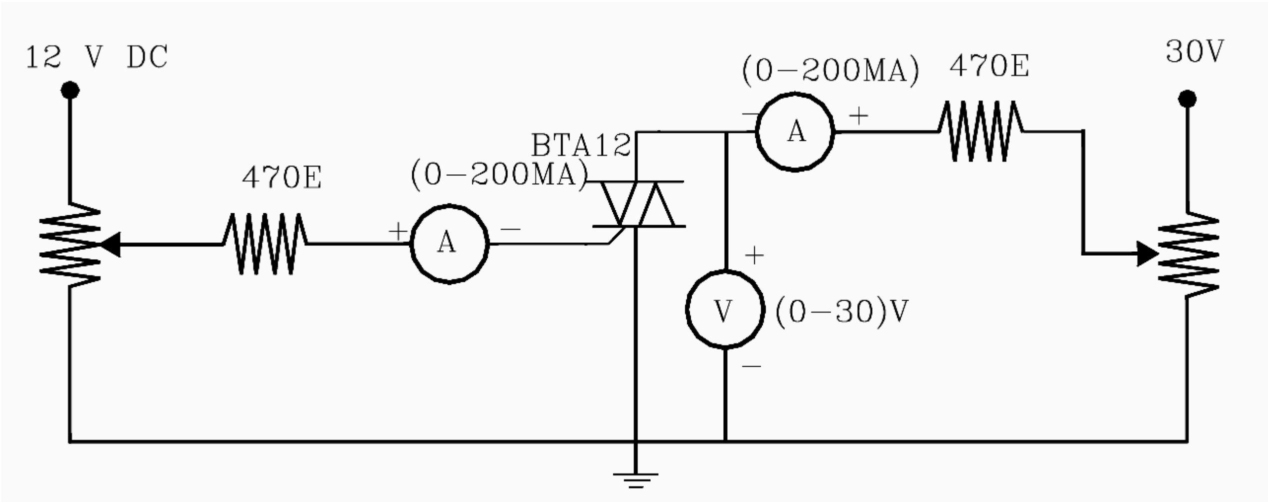
EXPERIMENTAL PROCEDURE:

- Switch on the 230 V AC supply through two-pin power chord.
- Keep the gate current (IG) as certain value like 5mA.
- Now slowly increase the anode-cathode voltage (VAK) by varying the pot till the thyristor get turned on, note down ammeter (IA), Voltmeter (VAK) and note the anode current (IA).
- Now find out the break over voltage (VBR) and note the anode current (IA)
- Further increase the anode-cathode voltage (VAK) till the thyristor turn off and measure the holding current (IH). For various gate current take the reading and tabulate.

RESULT:

Thus the VI characteristics of SCR were drawn.

CIRCUIT DIAGRAM:



Exp. No.: **Date :**

CHARACTERISTICS OF TRIAC

AIM: Conduct the experiment to study the static V-I characteristics of the given TRIAC.

APPARATUS REQUIRED:

i. PEC16M1A Device module. - 1 No.
ii. Ammeters (0-200mA) DC - 2 Nos.
iii. Voltmeter (0-30V) DC - 1 No.
iv. Patch chords.

THEORY:

A device that contains two SCR's back-to-back, but with a single trigger, is called a TRIAC. Switching characteristics of TRIAC is same as SCR, however TRIAC conducts for both cycles of the AC supply. As the TRIAC can control current in both directions, it is widely used to control application of AC power to various types of loads. It gives full-wave AC control with no extra components, and is very convenient. Like SCR, TRIAC is a three terminal device.

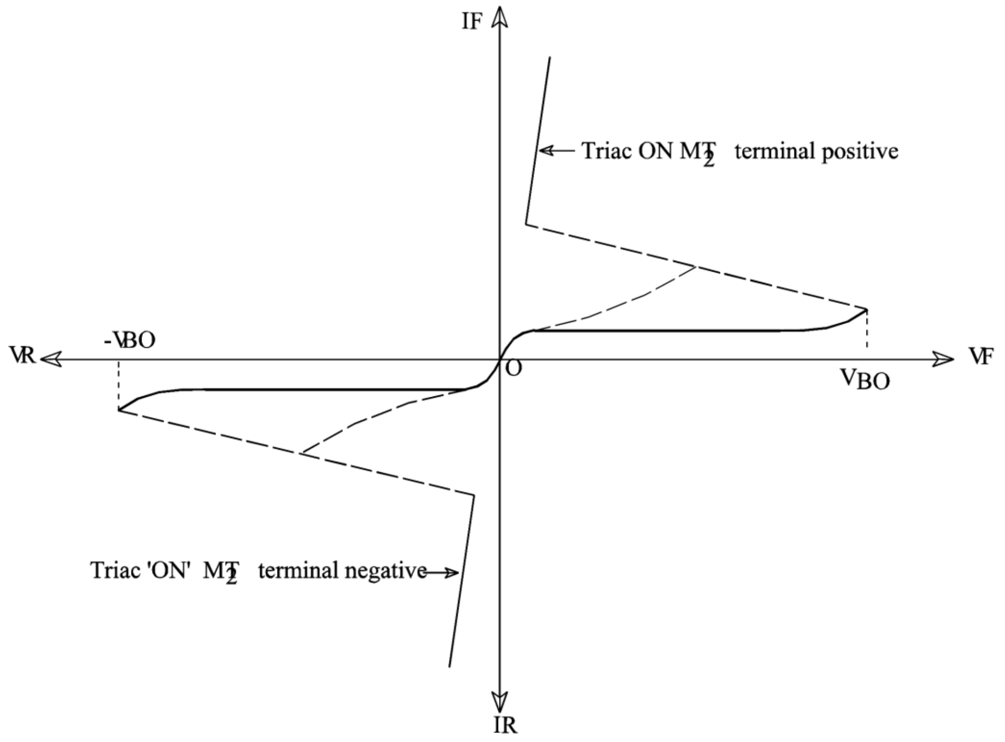
Instead of anode and cathode terminals, here the main terminals are referred as MT_1 and MT_2, since there is no fix polarity at terminals. The terminal MT_1 is the reference point for measurement of voltage and current at the gate terminal. The gate terminal (G) is connected to the PN junction at the same end as MT_1. A TRIAC can be used as an AC switch, It can also be used to control AC power applied to load, but a special triggering device is needed to ensure proper functioning of TRIAC, since the TRIAC is not equally sensitive to the gate current flowing in opposite direction.

A TRIAC operates in the same way as the SCR however it operates in both a forward and reverse direction. To get a quick understanding of its operation refer to its characteristic curve below and compare this to the SCR characteristic curve. It can be triggered into conduction by either a PLUS (+) or MINUS (-) gate signal

TABULATION:

Sl. No.	Forward		Reverse	
	I_G = (mA)		I_G = (mA)	
	V_{AK} (V)	I_A (mA)	V_{AK} (V)	I_A (mA)

MODEL GRAPH:



CONNECTION PROCEDURE:

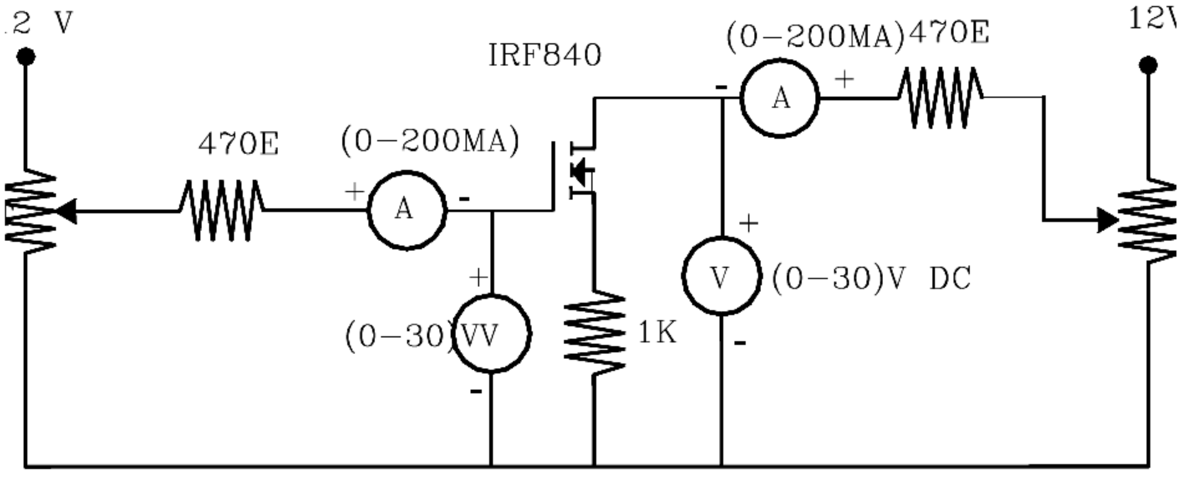
- Connect MT_2 terminal of TRIAC positive with respect to MT_1 and gate current also positive.
- Connect Ammeter to the gate terminal as shown in the front panel.
- Connect Ammeter to the anode terminal as indicated in the front panel.
- Connect the voltmeter across the TRIAC, MT_1 and MT_2 to measure V.

EXPERIMENTAL PROCEDURE:

- Now switch on the 230 V AC supply through the two-pin power chord.
- Vary the pot 3 and set the gate current (I_G).
- Slowly increase the MT_1-MT_2 (V) voltage by varying the POT till the TRIAC is turned on and note down the voltage (V), current (I) and tabulate.
- Now measure the break over voltage V_{BO1}.
- Further increase the voltage and note the current.
- Tabulate the reading in the table and plot the graph.
- To obtain the reverse characteristics of TRIAC interchange the connections of MT_2 and MT_1.

RESULT: Thus the VI characteristics of TRIAC were studied and graph was drawn.

CIRCUIT DIAGRAM:



Exp. No.: **Date :**

CHARACTERISTICS OF MOSFET

AIM: To study and conduct a experiment for the Transfer and output characteristics of the given MOSFET.

APPARATUS REQUIRED:

i. PEC16M1A Device module. - 1 No.
ii. Ammeters (0-200mA) DC - 2 Nos.
iii. Voltmeter (0-30V) DC - 1 No.
iv. Patch chords.

THEORY:

The power MOSFET has three terminals namely drain, source and gate. The drain and source are called as power terminals and the gate is called as control terminals. The control voltage to implement to turn on is applied between the gate & the source terminals. The direction of the direct current flow in an N- channel device is from the drain to the source. This results from the flow of electrons from the source to the drain.

If the drain terminal is made positive with respect to the source without gate voltage, no current flow from the drain to the source because the junction between the N drain region and the P island is reverse biased. Only a small reverse leakage current flows which is negligibly small. This is the off state of the power MOSFET. The power MOSFET is widely used in analog and digital signal processing circuits both in discrete and integrated circuits.

TABULATION:

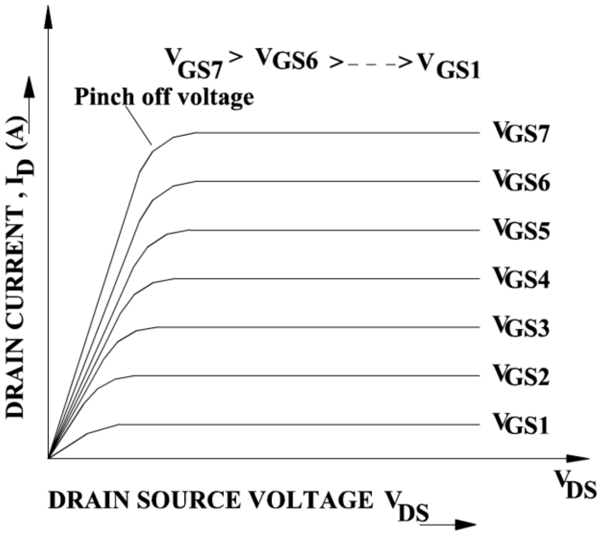
DRAIN CHARACTERISTIC:

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

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

MODEL GRAPH:

DRAIN CHARACTERISTICS



CONNECTION PROCEDURE:

- Connect MOSFET drain, source, and gate terminal to MOSFET characteristic circuit.
- Connect voltmeter across the gate –source terminal.
- Connect Ammeter in drain terminal.
- Connect Voltmeter across the drain and source terminal to measure V_{DS}.

EXPERIMENTAL PROCEDURE:

- Switch on the 230 V supply.
- Keep the gate to source – voltage (V_{GS}) at particular voltage by varying the pot.
- Smoothly vary the drain to source voltage till the MOSFET gets turned on and note down the
- Voltmeter (V_{DS}) and Ammeter (I_D) reading.
- Further increase the V_{DS} voltage and note down the current I_D.
- Repeat the same procedure for different values of V_{gs}.
- From the readings calculate G_M & R_{DS}.
- Draw a graph between V_{DS} & I_D keeping VGS as a constant. Calculate the pinch off voltage

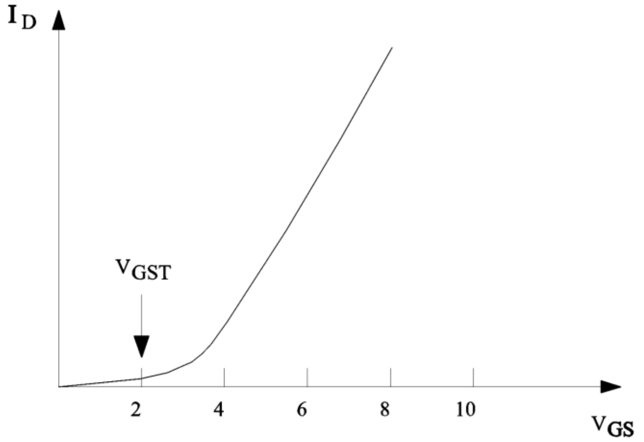
TABULATION:

TRANSFER CHARACTERISTIC

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

MODEL GRAPH:

TRANSFER CHARACTERISTIC



CONNECTION PROCEDURE

- Connect MOSFET drain, source and gate terminal to MOSFET characteristics circuit.
- Connect Volt meter across the gate- source terminal as shown in the connection diagram.
- Connect Ammeter in drain terminal as indicated in the connection diagram.
- Connect Voltmeter across the drain and source terminal.

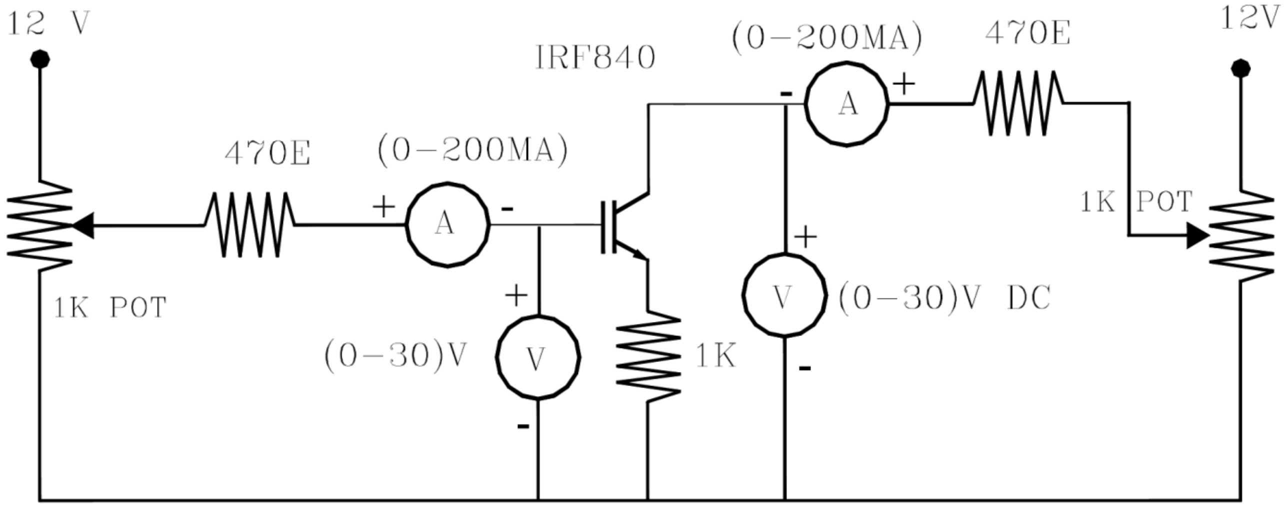
EXPERIMENTAL PROCEDURE

- Now switch on the 230V AC supply.
- Keep the drain -source voltage (V_{DS}) at particular voltage by varying pot2.
- Smoothly vary the gate-source (V_{GS}) voltage by varying pot1 till the MOSFET get turn on and note the voltmeter (V_{GS}) , Ammeter(ID) readings as shown in the table 5.
- Further increase the gate-source (V_{GS}) voltage and note the current ID.
- For different values of drain - source voltage (V_{DS}) note the V_{GS} Vs ID readings as shown in the table.
- Plot the V_{GS} Vs ID in a graph sheet.

RESULT:

Thus the output characteristics of MOSFET were studied and graph was plotted.

CIRCUIT DIAGRAM:



Exp. No.: **Date :**

CHARACTERISTICS OF IGBT

AIM: To Conduct the experiment of Transfer and output characteristics of the given IGBT.

APPARATUS REQUIRED:

i. PEC16M1A Device module. - 1 No.
ii. Ammeters (0-200mA) DC - 2 Nos.
iii. Voltmeter (0-30V) DC - 1 No.
iv. Patch chords.

THEORY:

Insulated Gate Bipolar Transistor (IGBT)

IGBT is a new development in the area of power MOSFET technology. This device combines the advantage of both MOSFET and BJT. So an IGBT has high input impedance like a MOSFET and a low on-state power loss as a BJT. Further IGBT is free from second breakdown problem present in BJT.

IGBT is also known as metal oxide insulated gate transistor conductively modulated field effect transistor (COMFET) or gain modulated FET (GEMFET). It was also initially called insulated gate transistor (IGT).

IGBT Characteristics

Static V-I or output characteristics of an IGBT (n-channel type) shows the plot of collector current IC versus collector emitter voltage V_{CE} for various values of gate emitter voltages. These characteristics are shown in figure. In the forward direction, the shape of the output characteristics is similar to that of BJT. But here the controlling parameter is gate-emitter voltage V_{CE} because IGBT is a voltage controlled device.

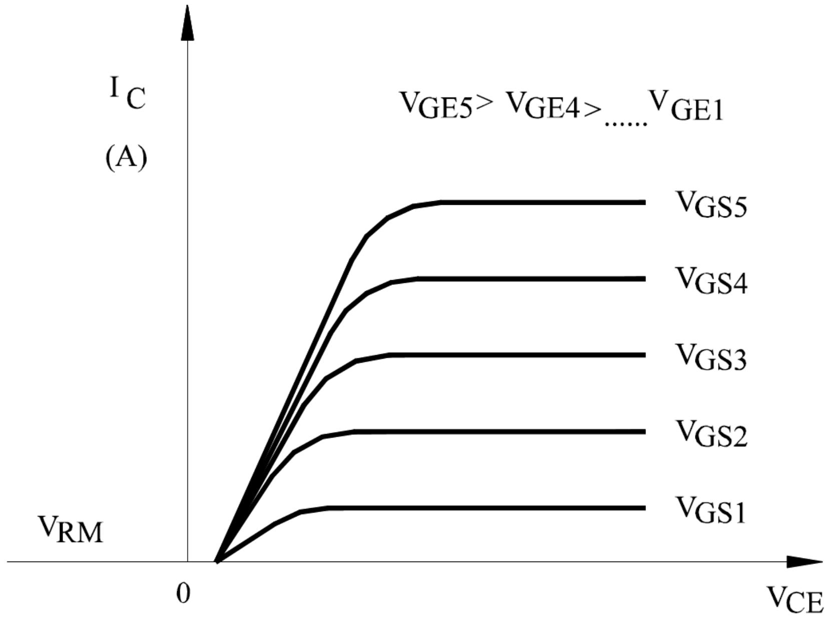
The transfer characteristics of an IGBT is a plot of collector current IC versus gate emitter voltage V_{CE}. This characteristic is identical to the power MOSFET. When V_{GE} is less than the threshold voltage V_{GET} is in the off- state.

TABULATION:

DRAIN CHARACTERISTIC:

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

MODEL GRAPH:



CONNECTION PROCEDURE:

- Connect IGBT Collector, Emitter and Gate terminal to IGBT characteristics circuit.
- Connect Volt meter across Gate-Emitter terminal as shown in the connection diagram.
- Connect Ammeter in Collector terminal as indicated in the connection diagram.
- Connect Voltmeter across the Collector and Emitter terminal.

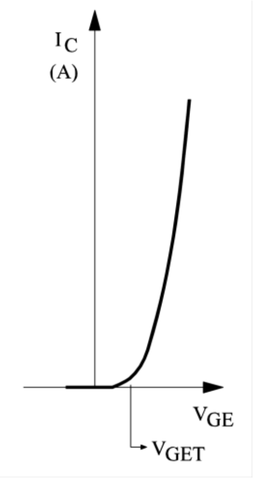
EXPERIMENTAL PROCEDURE

- Now switch on the 230V AC supply.
- Keep the Collector - Emitter (V_{CE}) voltage at particular voltage by varying pot2.
- Smoothly vary the Gate - Emitter (V_{GE}) voltage by varying pot 1 till the IGBT get turn on and note the voltmeter (V_{GE}) , Ammeter(IC) readings as shown in the table 6.
- Further increase the Gate - Emitter (V_{GE}) voltage and note the current IC.
- For different values of Collector- Emitter voltage (V_{CE}), note the readings in the table
- Plot the V_{CE} Vs I_C in a graph sheet.

TRANSFER CHARACTERISTIC

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

MODEL GRAPH:
TRANSFER CHARACTERISTIC



CONNECTION PROCEDURE

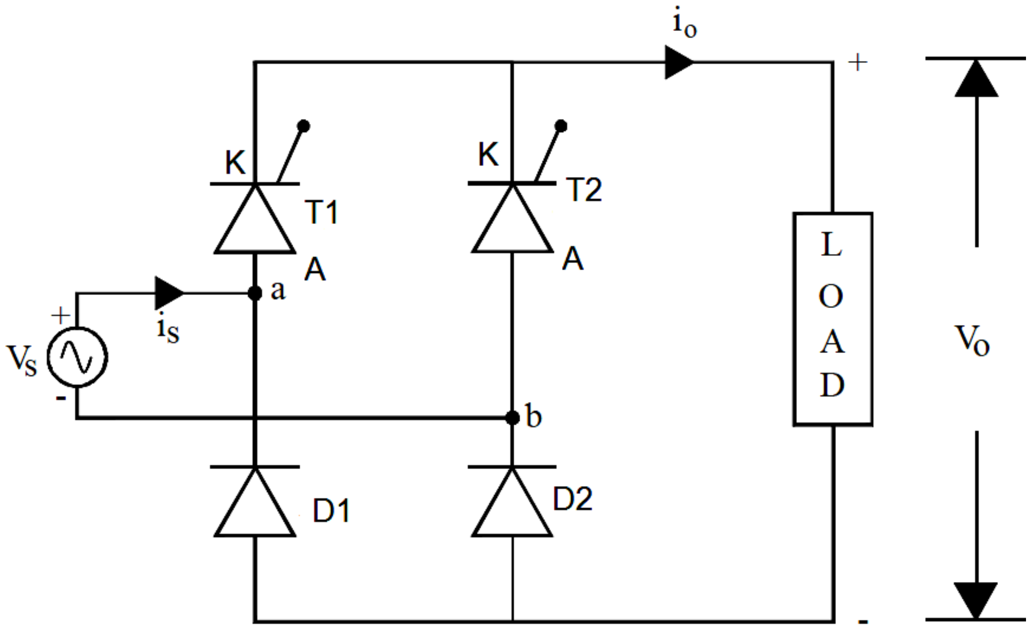
- Connect the IGBT Collector, Emitter and Gate terminal to IGBT characteristics circuit.
- Connect Volt meter across Gate-Emitter terminal as shown in the connection diagram.
- Connect Ammeter in Collector terminal as indicated in the connection diagram.
- Voltmeter is connected to the in between Collector and Emitter terminal.

EXPERIMENTAL PROCEDURE

- Now switch on the 230 V AC supply.
- Keep the Gate - Emitter (V_{GE}) voltage at particular voltage by varying pot1.
- Smoothly vary the Collector - Emitter (V_{CE}) voltage by varying pot2 till the IGBT get turn on and note the voltmeter (V_{CE}) , Ammeter(IC) readings as shown in the table
- Further increase the Collector - Emitter (V_{CE}) voltage and note the current IC.
- For different values of Gate - Emitter voltage (V_{GE}), note the V_{CE} Vs I_C readings as shown in the table
- To calculate GM , RDS values and plot the V_{CE} Vs I_C in a graph sheet.

RESULT: Thus the Transfer and output characteristics of IGBT were studied and graph was plotted.

CIRCUIT DIAGRAM:



TABULATION:

Sl. No.	Firing angle (α)	Measured Voltage (V)	Calculated Value V_s (volt)

Exp. No.: **Date :**

AC –DC HALF CONTROLLED CONVERTER

AIM: With a suitable experiment obtain the output waveform and output voltage for various firing angle for Single Phase Semi-converter using R-L and R-L-E loads

APPARATUS REQUIRED:

i.	Semi controlled converter Power circuit kit	-	1 No.
ii.	Semi controlled converter firing circuit kit	-	1 No.
iii.	Auto Transformer	-	1 No.
iv.	PMDC Motor Load	-	1 No.
v.	Patch Cards		

THEORY:

Controlled rectifiers are those whose output voltage can be controlled by varying the firing angle of the SCR. During the positive half-cycle. SCR_1 & D_2 are forward biased and starts conducting when trigger pulses are given simultaneously. During negative half-cycle SCR_2& D_1 are forward biased and it starts conducting. In the trigger circuit synchronization must be obtained from the supply voltage other than SCR voltage and trigger pulse must be continuous during the conduction period.

CONNECTION PROCEDURE:

- Connect the power circuit.
- Connect the 24V AC input to the bridge circuit.
- Connect the load consisting of L and R across the output terminals of the bridge converter.
- Connect the gating signals to the SCRs.
- Ensure proper connection of the circuit as shown in figure
- Switch ON power supply to CRO and the input power module.
- Connect the CRO probes to observe the waveforms of the input ac voltage, output voltage and voltage across any one of the SCR.

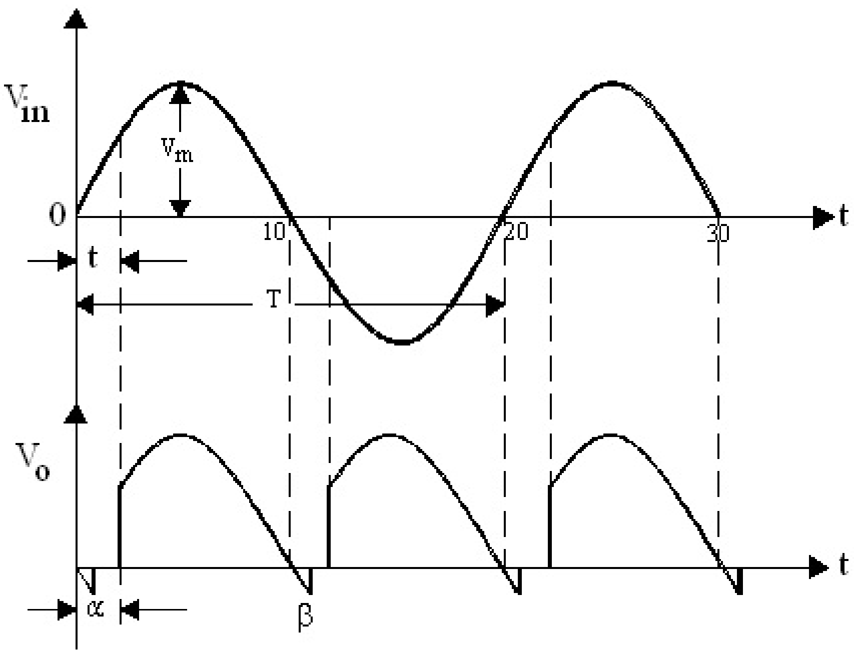
  Average output voltage $V_{dc} = \frac{V_m}{\pi}(1+\cos\alpha)$

  Firing angle $\alpha = \frac{360 * t\,off}{T}$

  V_m = Maximum Voltage in volt

  T = Total time for one angle and t_{off} = Triggering time.

MODEL GRAPH:



CALCULATION:

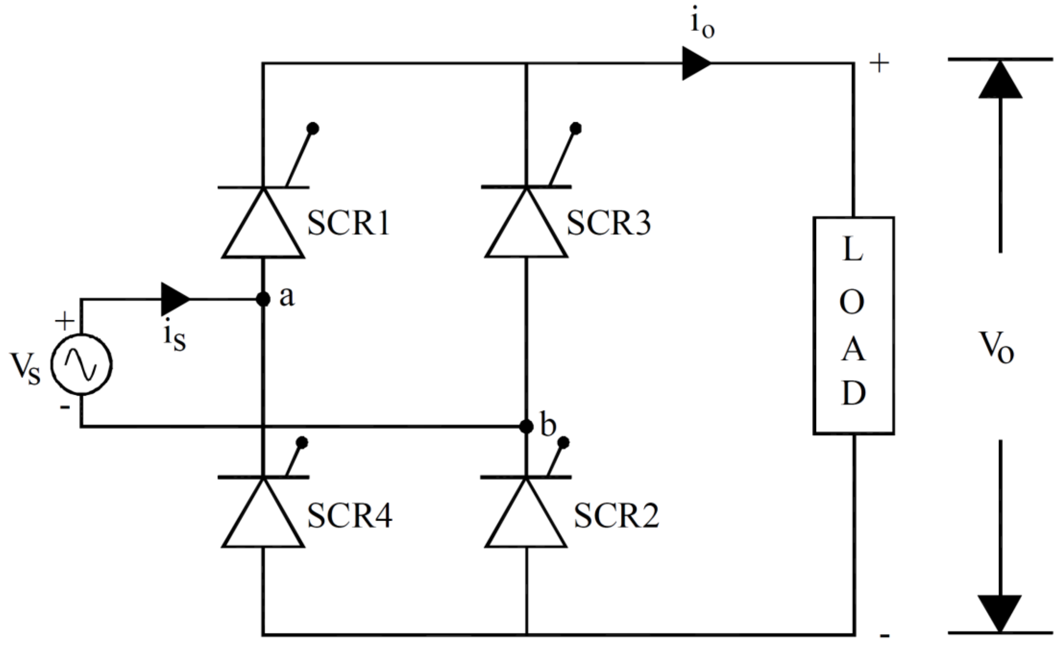
- Output Voltage V_o

$$V_o = \frac{V_m}{\sqrt{2}}\left\{\frac{1}{\pi}(\pi-\alpha)+\frac{1}{2}Sin\,\alpha\right\}^{1/2}$$

- Take the waveforms at different firing angle.
- Plot the input and load voltage waveforms in the graph sheet.
- Measure the average DC output voltage and rms AC input voltage with a digital multimeter. Switch off power supply to the circuit.

RESULT: Thus the output waveform and output voltage for various firing angle was drawn for Single Phase Semi-converter.

CIRCUIT DIAGRAM:



TABULATION:

Sl. No.	Firing angle (α)	Measured Voltage (V)	Calculated Value V_s (volt)

Exp. No.: **Date :**

AC –DC FULLY CONTROLLED CONVERTER

AIM: To obtain the output waveform and output voltage for various firing angle for Single Phase Full -converter using R-L and R-L-E loads

APPARATUS REQUIRED:

i.	Full controlled converter Power circuit kit	-	1 No.
ii.	Full controlled converter firing circuit kit	-	1 No.
iii.	Auto Transformer	-	1 No.
iv.	PMDC Motor Load	-	1 No.
v.	Patch Cards		

THEORY:

The single phase fully controlled rectifier consists of 4 SCRs and load R. During the positive half-cycle SCR1&2 are forward –biased and when this SCR is fired simultaneously at a firing angle w the load is connected to the input supply. During the negative half-cycle the SCRs 3 &4 are forward bi-ased and SCRs 1&2 are turned off due to line or natural commutation.

CONNECTION PROCEDURE:

- Connect the power module and controller to the supply mains.
- Connect PWM output of the controller module to PWM input of the power module using pulse cable.
- Connect the pulse of (K_1, G_1) to gate of SCR_1 (K_1, G_1) using patch chords.
- Connect the pulse of (K_2, G_2) to gate of SCR_2 (K_2, G_2) using patch chords.
- Connect the pulse of (K_3, G_3) to gate of SCR_3 (K_3, G_3) using patch chords.
- Connect the pulse of (K_4, G_4) to gate of SCR_4 (K_4, G_4) using patch chords.
- Connect the cathode of $SCR_1(K_1)$ to cathode of $SCR_3(K_3)$ and anode of $SCR_4(A_4)$ to anode of $SCR_2(A_2)$.

Average output voltage $V_{dc} = \frac{2\,Vm}{\pi}\cos\alpha$

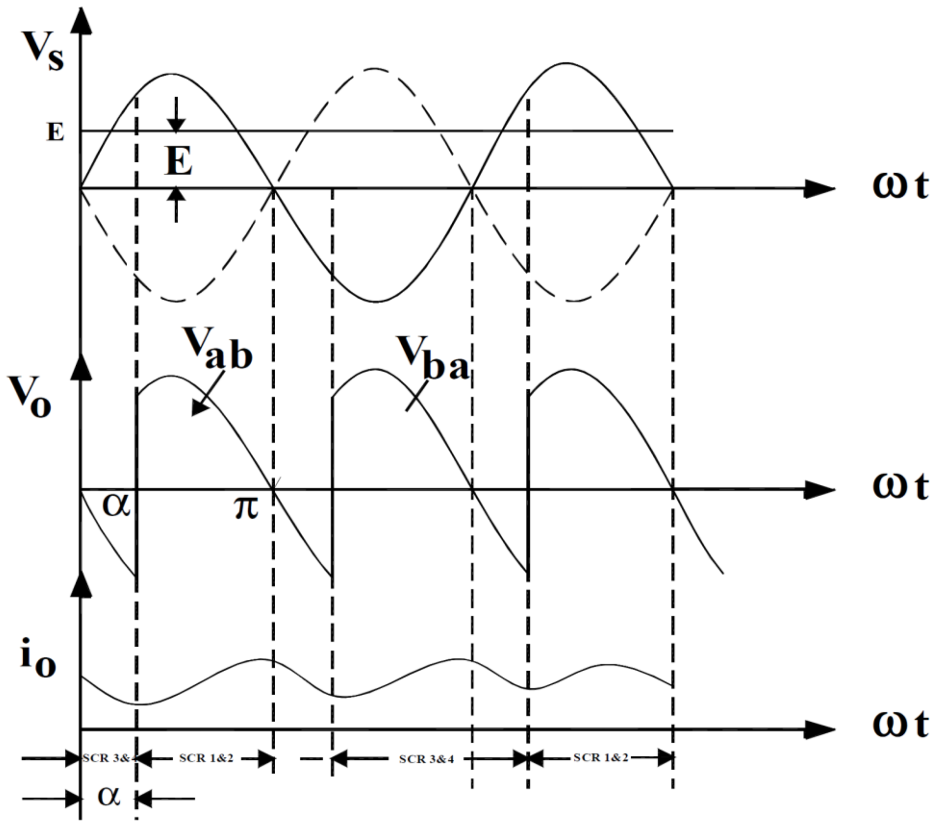
Firing angle $\alpha = \frac{360 * t\,off}{T}$

V_m = Maximum Voltage in volts

T = Total time for one angle

t_{off} = Triggering time.

MODEL GRAPH:



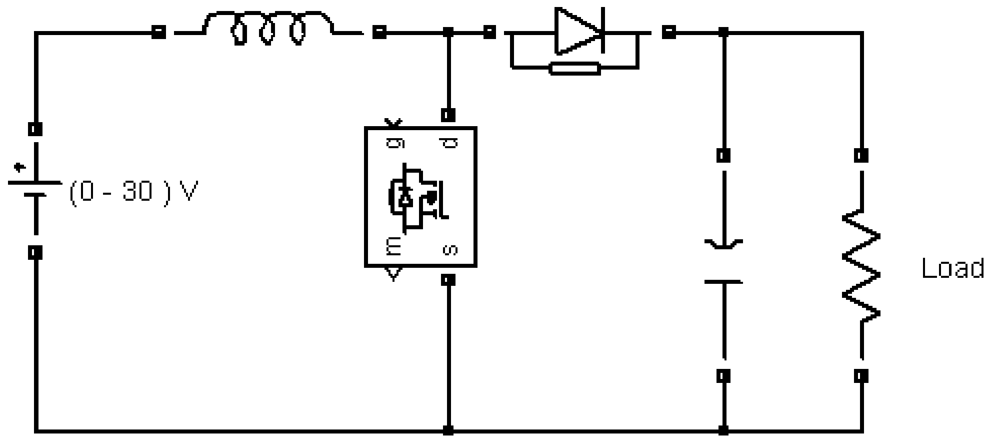
CALCULATION:

- Connect the 24 V terminals of 16 Ext transformer to P,N terminals of SCR power module
- Connect the cathode of $SCR_1(K_1)$ to R load (24 V lamp)one end and another to the anode of $SCR_4(A_4)$.
- Connect the PEC 16 Ext transformer input to 230V AC supply using power chord.
- Connect the CRO terminals across the load.

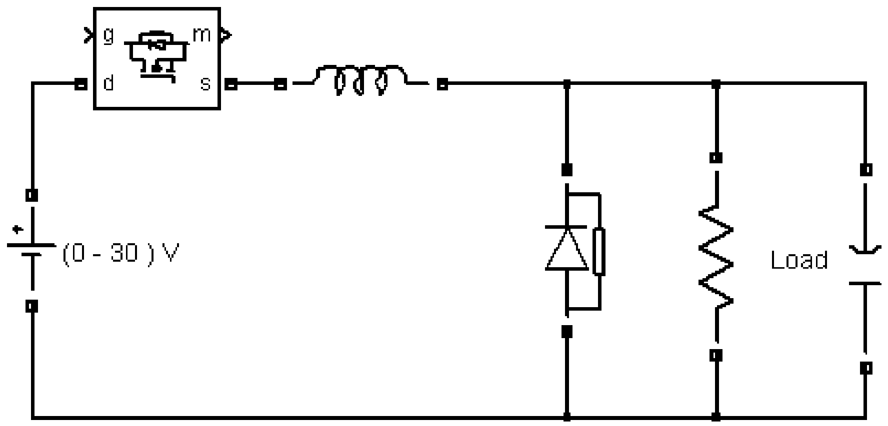
RESULT: Thus the output waveform and output voltage for various firing angle was drawn for Single Phase full-converter.

CIRCUIT DIAGRAM:

STEP UP CHOPPER



STEP DOWN CHOPPER



Exp. No.: **Date :**

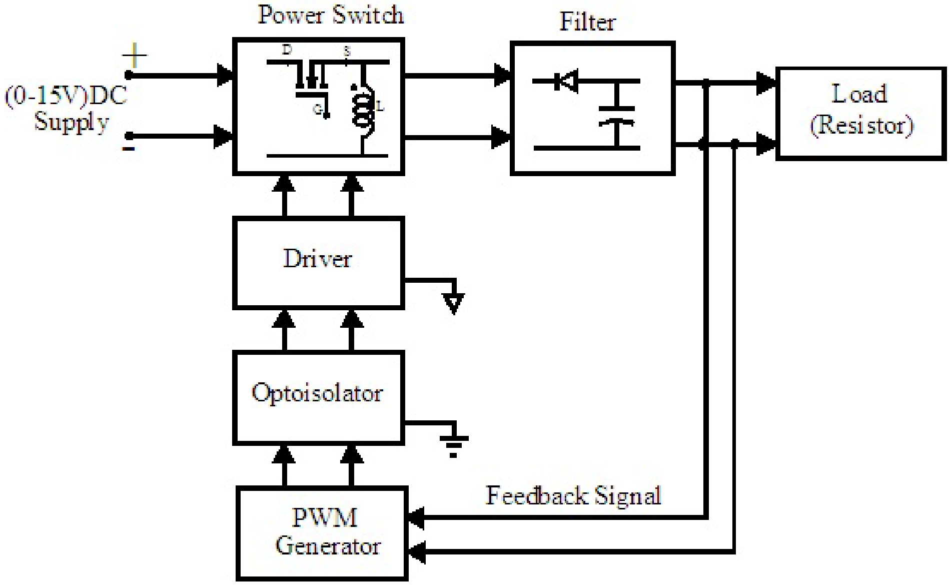
STEP DOWN AND STEP UP MOSFET BASED CHOPPERS

AIM: To construct Step down & Step up MOSFET based choppers and to draw its output response.

APPARATUS REQUIRED:

i. VSMPS-07A - 1 No
ii. Pulse patch chord
iii. Power chord

THEORY **:**



The block diagram of Buck Boost Converter consists of

i. PWM Generator
ii. Optoisolator
iii. Driver
iv. MOSFET switch
v. Filter

i. PWM Generator (TL494)

PWM signal is generated from the **TL 494 IC.** PWM generation is done by the comparison of the saw tooth waveform and the reference voltage signal. Sawtooth wave generator, a comparator and other auxiliary circuits are integrated on the chip.

ii. Optoisolator (6N137 or 4506)

The function of Optoisolator is to isolate the control circuit from power circuit. PWM signalfrom TL494IC is not directly fed to the power circuit In order to protect the PWM signal it is essential to provide isolation circuit between power circuit and control circuit.

TABULATION:

STEP UP CHOPPER

Sl.No.	T_{ON}	T_{off}	T	Input Voltage V_{in} (V)	Measured Output Voltage V_o (V)	Calculated Output Voltage V_o (V)

STEP DOWN CHOPPER

Sl.No.	T_{ON}	T_{off}	T	Input Voltage V_{in} (V)	Measured Output Voltage V_o (V)	Calculated Output Voltage V_o (V)

iii. Driver (IR2110)

A MOSFET drive circuit is designed **to connect the gate directly to a voltage bus** with no intervening resistance other than the impedance of the drive circuit switch. Gate driver acts as a **high-power buffer stage** between the PWM output of the control device and gates of the primary power switching MOSFET.

iv. MOSFET switch (IRF250)

MOSFET switch is used as a **switching device** in the Buck-Boost converter circuit. The PWM signal from the driver IC is fed to the gate of the switch. The drain of the switch is connected to the primary of the isolation transformer.

v. Filter

This switched voltage signal undergoes rectification in the filter circuit. Finally rectified pure DC signal is seen at the output terminal. Filter capacitor is used to eliminate unwanted ripples in the DC output.

PROCEDURE:

- Switch on the power supply 24 V and MOSFET Module.
- Vary the control voltage min to max for step by step
- For each step ,note down the T_{on} and T_{off}

STEP UP CHOPPER

$$V_o = \left[\frac{1}{1 - \frac{T_{ON}}{T}}\right] V_S$$

STEP DOWN CHOPPER

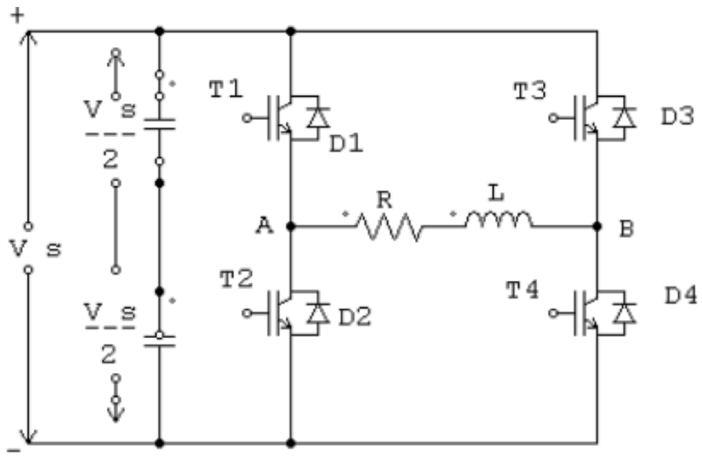
$$V_o = \left[\frac{T_{ON}}{T}\right] V_S$$

Where, V_s **= Converter Input Voltage**

V_o **= Converter Output Voltage**

RESULT: Thus the operations of chopper were studied and waveforms were drawn.

CIRCUIT DIAGRAM:



TABULATION:

Sl.No.	Sine wave Amplitude (V)	Carrier wave Freq (Hz)	Modulation Index	Calculated Value (volt)	Measured Voltage

Sl.No.	Trapezoidal wave Amplitude (V)	Carrier wave Freq (Hz)	Modulation Index	Calculated Value (volt)	Measured Voltage

Sl.No.	Square wave Amplitude (V)	Carrier wave Freq (Hz)	Modulation Index	Calculated Value (volt)	Measured Voltage

Exp. No.: **Date :**

IGBT BASED SINGLE – PHASE PWM INVERTER

AIM: To study the operation of single phase inverter operation by using sine, trapezoidal, square PWM

APPARATUS REQUIRED:

i.	Single IGBT based PWM inverter kit	- 1 No.
ii.	CRO	- 1 No.
iii.	Single phase Load.	- 1 No.

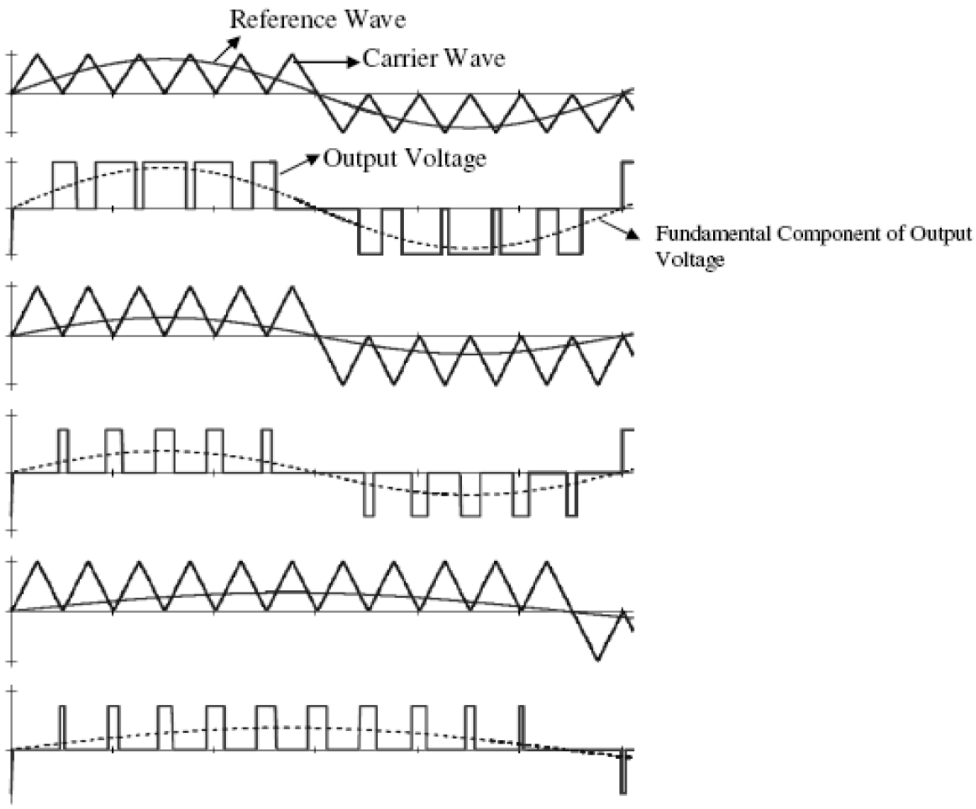
THEORY :

DC to AC converter is known as inverter. The function of an inverter is to change the DC input voltage to a symmetrical output voltage of desired magnitude & frequency. The output voltage could be fixed or variable at a fixed or variable frequency. Varying the input DC voltage and maintaining the gain of the inverter constant can obtain a variable output voltage.

On the other hand if the DC input voltage is fixed and it is not controllable a variable output voltage can be obtained by varying the gain of the inverter, which is normally accomplished by pulse width modulation (PWM) controlled within the inverter. The inverter gain may be defines as the ratio of Ac output voltage to DC input voltage.

It Consists of four S_1, S_2, S_3, S_4 and four inverse diodes D_1, D_2, D_3, D_4 the diodes are essential to conduct the reactive current, and thereby to feed back the stored energy in the inductor to the DC source. These diodes are known as feedback diodes. For many industrial applications the output AC voltage of the inverter must be sinusoidal in shape and the amplitude and frequency must be controllable. This is achieved by PWM of the inverter switches.

Waveforms for single phase inverter



Output Voltage = MI x V_{dc}

$$MI = \text{Modulation Index} = \frac{\text{Sine wave amplitude}}{\text{Carrier wave amplitude}}$$

V_{dc} = Input DC voltage

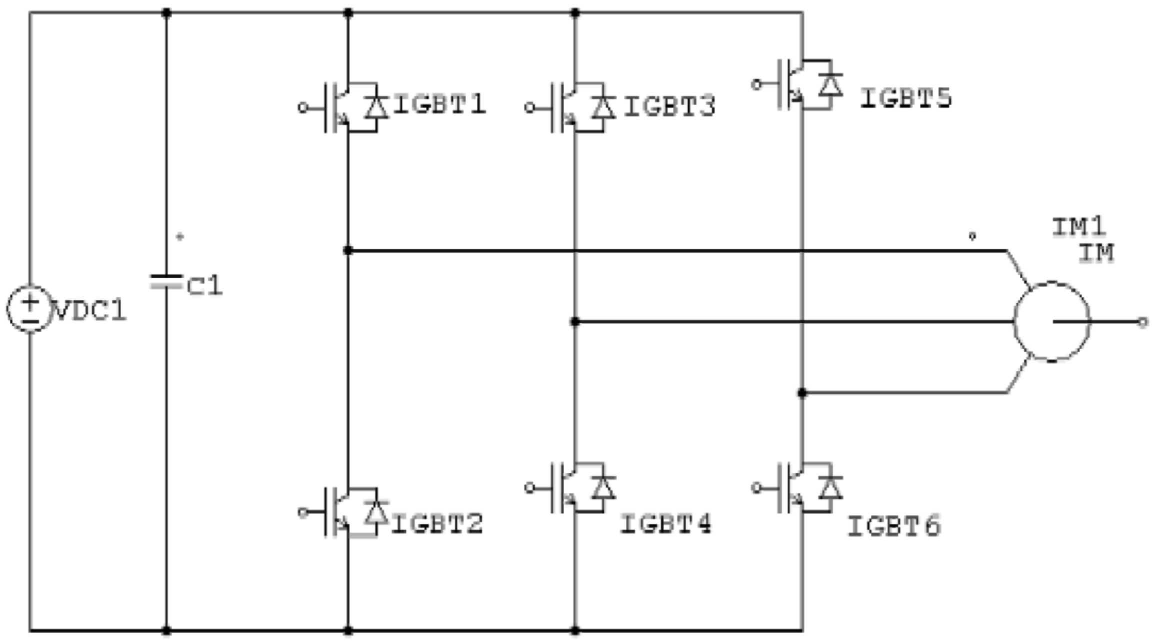
Sl.No.	MI	V_o	Vrms

PROCEDURE:

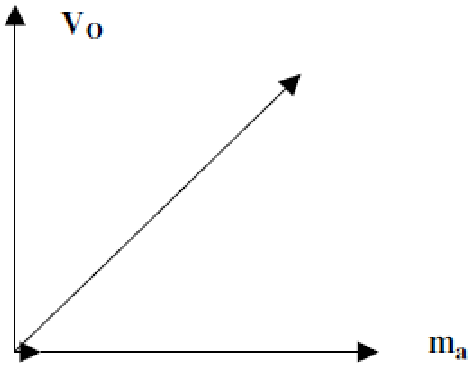
- Ensure that the circuit breaker and pulse release ON / OFF toggle switch are in OFF position
- Connect the R-L load across the output terminals Lo and No provided in the front panel. Include an ammeter to measure the current and a voltmeter to measure the voltage.
- Connect the ac input at the input terminals L and N provided in the front panel. With the pulse release ON / OFF switch and circuit breaker in OFF condition give the power to the inverter module. This will ensure the control power supply to all control circuitry.
- Set the amplitude of the reference sine wave to minimum value.
- Keeping the pulse release ON / OFF switch in OFF position, switch ON the power supply to the bridge rectifier.
- Release the gating signals to the inverter switches by turning ON the pulse release ON I OFF switch.
- Observe the triangular carrier and the reference sine waveforms on the CRO.
- Measure the amplitude and frequency of the triangular carrier through CRO and note it down. Adjust the sine wave frequency to about 50 Hz.
- Connect the CRO probes to observe the load voltage and current waveforms.
- Observe the load voltage and load current waveforms. Sketch the waveforms on a graph sheet to scale for one cycle period of the inverter output frequency. Measure the amplitude of the voltage pulses.
- Measure the output voltage either by using an analog meter or a digital multimeter
- Calculate the modulation index ma and the rms output voltage
- Increase the amplitude of the reference sine wave and note down its value.
- Repeat steps 8 to 13 for various amplitude of reference sine wave and tabulate the readings. Plot the characteristics of modulation index versus output voltage.

RESULT: The operation of the single-phase bridge inverter using IGBT, with sinusoidal pulse width modulation has been studied.

CIRCUIT DIAGRAM:



MODEL GRAPH:



Exp. No.: **Date :**

IGBT BASED THREE – PHASE PWM INVERTER

AIM: To control the speed of a 3-phase induction motor using three phase voltage source PWM invert er by (a) varying the stator voltage at a constant frequency and (b)keeping the Volts/Hz ratio constant

APPARATUS REQUIRED:

i. Power circuit module
ii. Firing circuit module
iii. CRO
iv. 1 H.P. – 3- Phase induction motor
v. Tachometer

THEORY:

Inverters produce a sinusoidal ac output whose magnitude and frequency can be controlled. The dc voltage is obtained by rectifying and filtering the line voltage most often by the diode rectifier circuits. In an ac motor load, the voltage at its terminals is desired to be sinusoidal and adjustable in its magnitude and frequency. This is accomplished by means of the inverters, which accepts a dc voltage as the input and produces the desired ac voltage input.

In PWM inverters, the input dc voltage is essentially constant in magnitude. DC voltage is obtained by a diode rectifier, which is used to rectify the line voltage. The inverter must control the magnitude and the frequency of the ac output voltages. This is achieved by PWM of the inverter switches and hence such inverters are called PWM inverters.

PROCEDURE:

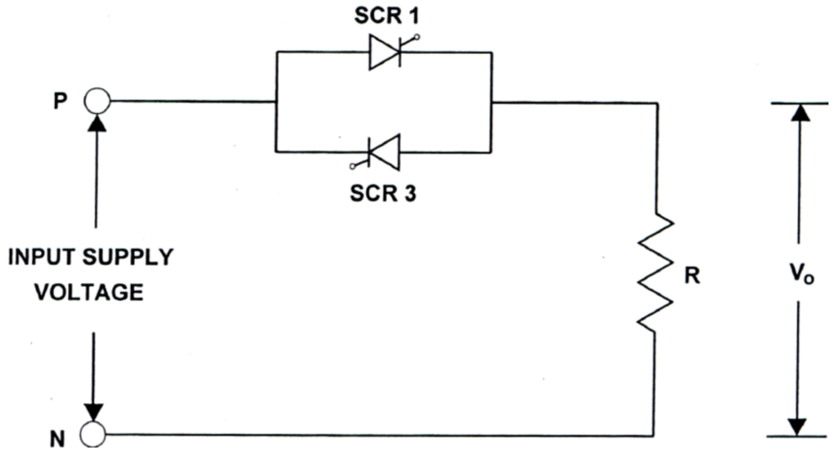
- Keep the main switch in off position initially.
- Keep the MCB in off position. Check whether the kit is disconnected from the supply or not.
- phase of motor –V B
- phase of motor –W
- Switch on the main supply.
- Switch on the pulse release switch.
- Keep the frequency pot of the control voltage is in constant position.
- Amplitude pot of the control voltage is the variable one.
- Switch on the MCB. Now, voltmeter shows the output voltage of the bridge rectifier.

- For particular amplitude of control voltage with fixed frequency, the motor picks up speed and it runs.
- Measure the speed of the motor using Tachometer.
- For various position of amplitude pot of reference sine wave, measure the speed.
- Find out the output voltages across u-v, v-w and w-u with the help of multimeter.
- Calculate the modulation index and the output voltage. The modulation index is given by ma = Amplitude of sine wave / Amplitude of triangular wave.
- Increase the amplitude of the reference wave and calculate the modulation index. Then plot the characteristics of modulation index versus output voltage.
- Follow the same procedure keeping voltage as fixed and varying the frequency. Also, the speed of the motor is controlled by varying both the voltage and frequency.
- Also, draw the graph between speed and voltage for voltage control and speed versus V/f for V/f control

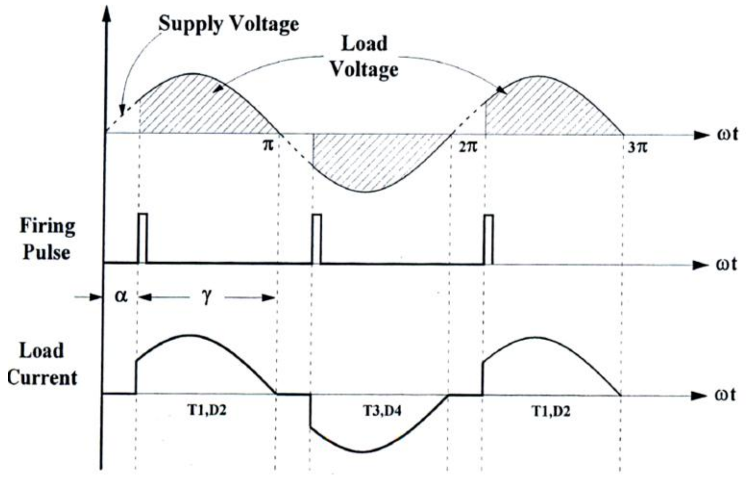
RESULT: Thus the speed of the induction motor is controlled using three phase voltage source PWM inverter.

Single Phase AC Voltage Controller

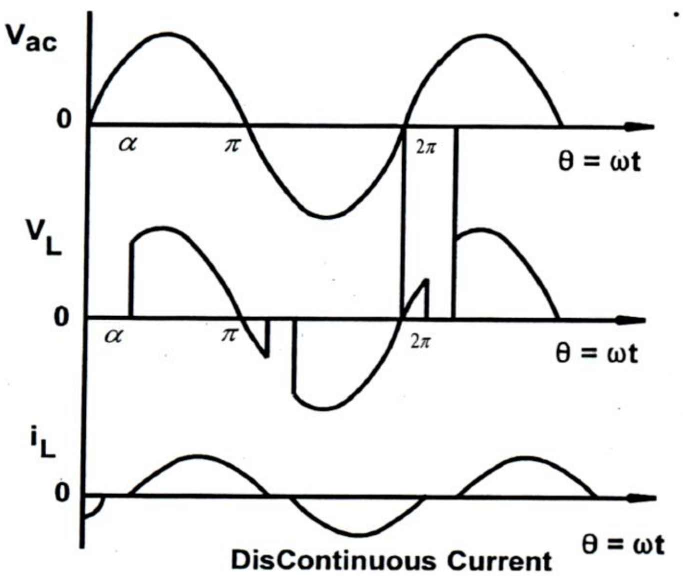
Circuit Diagram



For R load



For RL load



Exp. No.: **Date :**

SINGLE PHASE AC VOLTAGE CONTROLLER

AIM: To Study the operation of single phase voltage controller and to obtain the output waveform and output voltage for various firing angle using R-L load

APPARATUS REQUIRED:

i.	Single phase voltage controller kit	-	1No
ii.	MultiMeter	-	1No
iii.	CRO	-	1No
iv.	Patch Cards	-	Required numbers

FORMULA USED:

$$V_{rms} = V_s \left[\frac{1}{\pi} (\pi\text{-}\alpha + \sin \frac{2\alpha}{2}) \right]^{1/2}$$

PROCEDURE:

- Give the circuit connections as per the circuit diagram.
- Connect the Gate, cathode for each thyristors
- By adjusting the firing angle , the output voltage is noted from CRO
- The firing angle is varied from 0-180 for each angle ,output voltage is noted
- Plot the characteristic curve for each variation of output

CONNECTION PROCEDURE:

- Connect anode (A 1) of SCR 1 to cathode K3 of SCR3.
- Connect 24V AC P terminal to Al of SCR1.
- Connect R - Load 1 terminal to KI of SCR 1.
- Connect L - Load terminal '2' to N terminal of24V AC.
- Connect CRO probe across load terminals 1 and 2.
- Connect Voltmeter or digital multimeter across the load terminals.

TABULATION:

Sl.No.	Firing angle (α)	Measured output Voltage (volt)	Calculated Value (volt)

PULSE PATCHING:

- Connect G1K1 of Firing Circuit to G1K1 of SCR switch.
- Connect G2K2 of Firing Circuit to G2K2 of SCR switch.

EXPERIMENT PROCEDURE:

- Switch ON the trainer Power ON/OFF switch
- Place the switch S2 in SCR mode (Upward).
- Switch ON the 24V AC ON/OFF switch.
- Switch ON the Debounce Logic switch.
- Note down the peak value of AC input voltage Vm, triggering angle, and conduction angle.
- Adjust the firing Angle gradually and note down the output voltage. Calculate the output voltage by using the above given formula.
- Plot the graph Vm Vs Angle (Triggering Angle, Conduction Angle).

RESULT: Thus the operation of single phase Ac voltage controller was studied and their output waveforms were drawn.

Exp. No.: **Date :**

SIMULATION OF POWER ELECTRONICS CIRCUITS

AIM: To simulate the Power Electronics Circuits – Single phase and Three phase Converters , Single phase and Three phase semi converter and Ac Voltage Regulator using MATLAB Software.

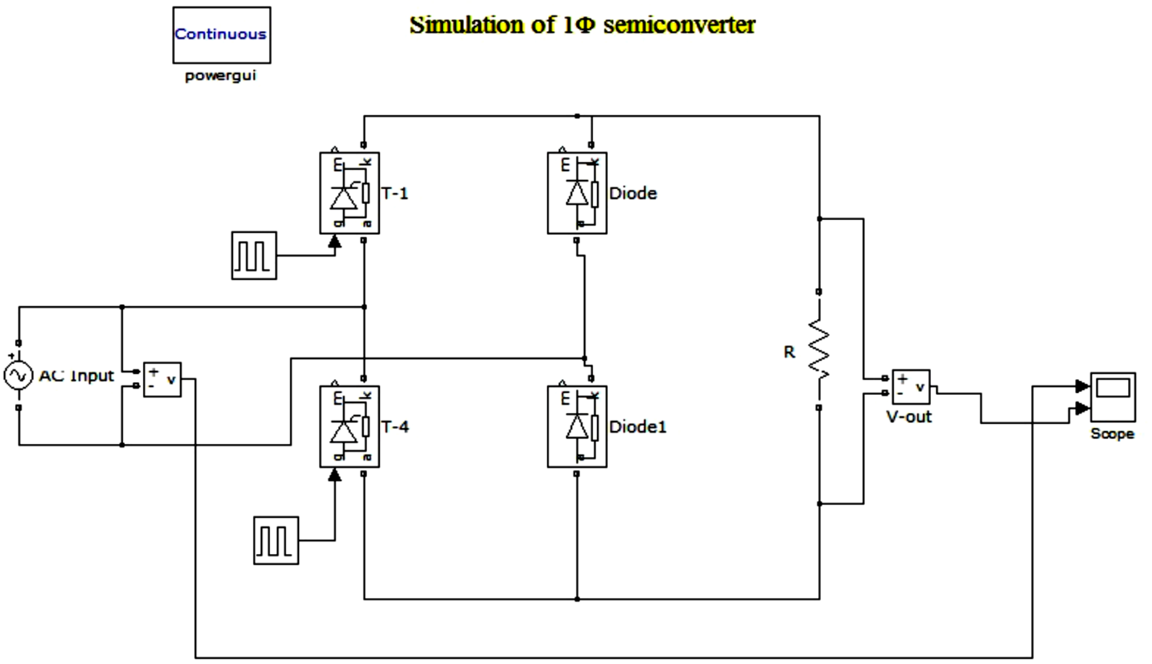
BASIC MATLAB

The name **MATLAB** stands for **MATRIX LABORATORY**. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB engines incorporate the LAPACK and BLAS libraries, embedding the state of the art in software for matrix computation. It has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses **in MATHEMATICS, ENGINEERING AND SCIENCE**. In industry, MATLAB is the tool of choice for high productivity research, development, and analysis. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include,

- Math and computation Algorithm development
- Data acquisition Modeling, simulation and prototyping
- Data analysis, exploration, and visualization,
- Scientific and engineering graphics
- Application development, including graphical user interface building

It is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non-interactive language such as C or FORTRAN. It also features a family of add-on application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include **SIGNAL PROCESSING, CONTROL SYSTEMS, NEURAL NETWORKS, FUZZY LOGIC, WAVELETS, SIMULATION, AND MANY OTHERS**.

MATLAB MODEL:



OUTPUT WAVEFORMS:

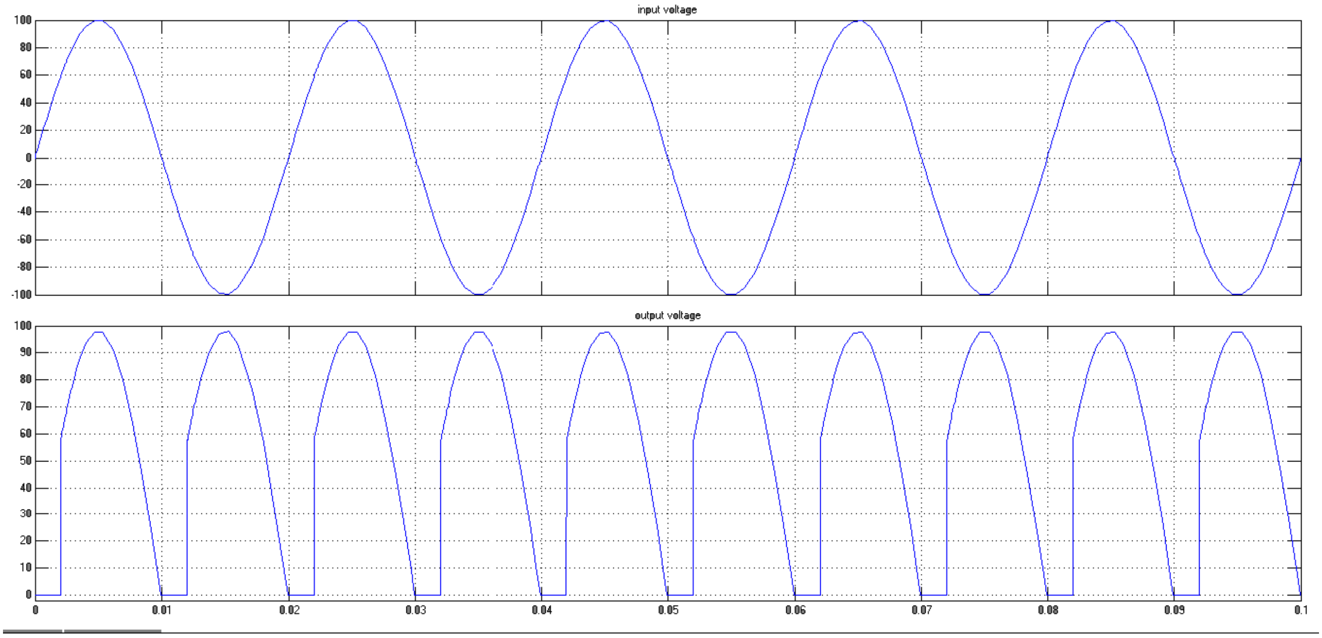
Set AC Input Parameter

(Peak amplitude =100 V, Phase=0 deg and Frequency=50 Hz)

Set Pulse generator Parameter

(First pulse generator period=0.02 sec, Pulse width=50% and Phase delay=0.002 sec)

(Second pulse generator period=0.02 sec, Pulse width=50% and Phase delay=0.012 sec)



Ex.No: **Date:**

SIMULATION OF SINGLE PHASE SEMI CONVERTER

AIM:

To simulate single Phase Semi Converter circuit with R load in MATLAB - SimuLink.

APPARATUS REQUIRED:

A PC with MATLAB package.

THEORY:

SINGLE PHASE SEMI CONVERTER

A semi converter uses two diodes and two thyristors and there is a limited control over the level of dc output voltage. A semi converter is one quadrant converter. A one quadrant converter has same polarity of dc output voltage and current at its output terminals and it is always positive. It is also known as two- pulse converter. Figure shows half controlled rectifier with R load. This circuit consists of two SCRs T1 and T2, two diodes D1 and D2.

During the positive half cycle of the ac supply, SCR T1 and diode D2 are forward biased when the SCR T1 is triggered at a firing angle $\omega t = \alpha$, the SCR T1 and diode D2 comes to the on state. Now the load current flows through the path L - T1- R load –D2 - N. During this period, we output voltage and current are positive. At $\omega t = \pi$, the load voltage and load current reaches to zero, then SCR T1 and diode D2 comes to off state since supply voltage has been reversed. During the negative half cycle of the ac supply, SCR T2 and diode D1 are forward biased.

When SCR T2 is triggered at a firing angle $\omega t = \pi + \alpha$, the SCR T2 and diode D1 comes to on state. Now the load current flows through the path N - T2- R load – D1 -L. During this period, output voltage and output current will be positive. At $\omega t = 2\pi$, the load voltage and load current reaches to zero then SCR T2 and diode D1 comes to off state since the voltage has been reversed. During the period ($\pi + \alpha$ to 2π) SCR T2 and diode D1 are conducting.

$$V_{out} = (\sqrt{2}V_s)(1+\cos\alpha)/\pi$$

PROCEDURE:

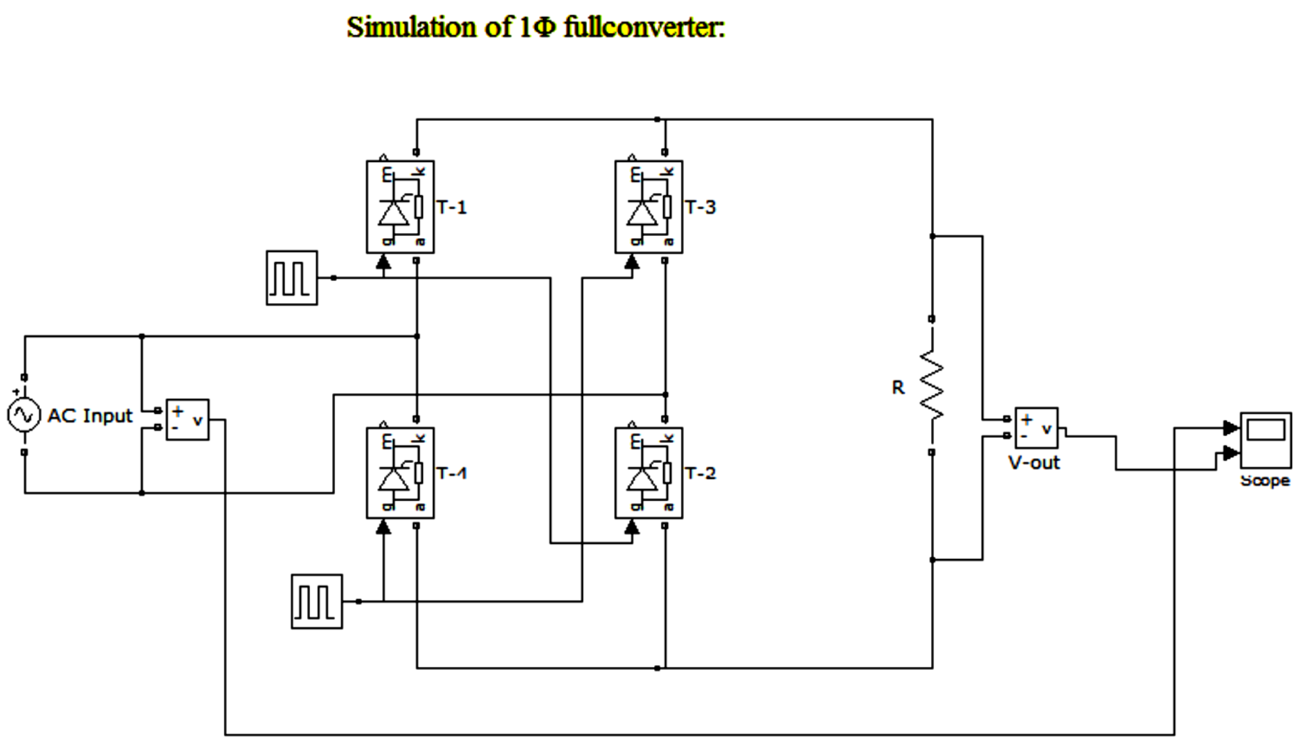
- In MATLAB software open a new model in **File->New->model.**
- Start SIMULINK library browser by clicking the symbol in toolbar
- And Open the libraries that contain the blocks you will need. These usually will include the sources, sinks, math and continuous function block and possibly other.

- Drag the needed blocks from the library folders to that new untitled Simulink window. You must give it a name using the **Save As** menu command under the **File menu** heading. The assigned filename is automatically appended with an **.mdl** extension.
- Arrange these blocks in orderly way corresponding by **Matlab Model** Shown Below.
- Interconnect the blocks by dragging the cursor from the output of one block to the input of another block.
- Double click on any block having parameters that must be established and set these parameters.
- It is necessary to specify a stop time for the simulation; this is done by clicking on the simulation parameters entry on the simulation-> parameters entry on the simulation toolbar.
- Now we are ready to simulate our block diagram. Press start icon to start the simulation. After simulation is done, double click the scope block to display the output. Click the auto scale icon in the display window to scale the axis as per variable range.
- Finally Save the Output.

RESULT:

Thus the simulation of single phase semi converter model is done and the output is verified using MATLAB Simulink.

MATLAB MODEL:



OUTPUT WAVEFORMS:

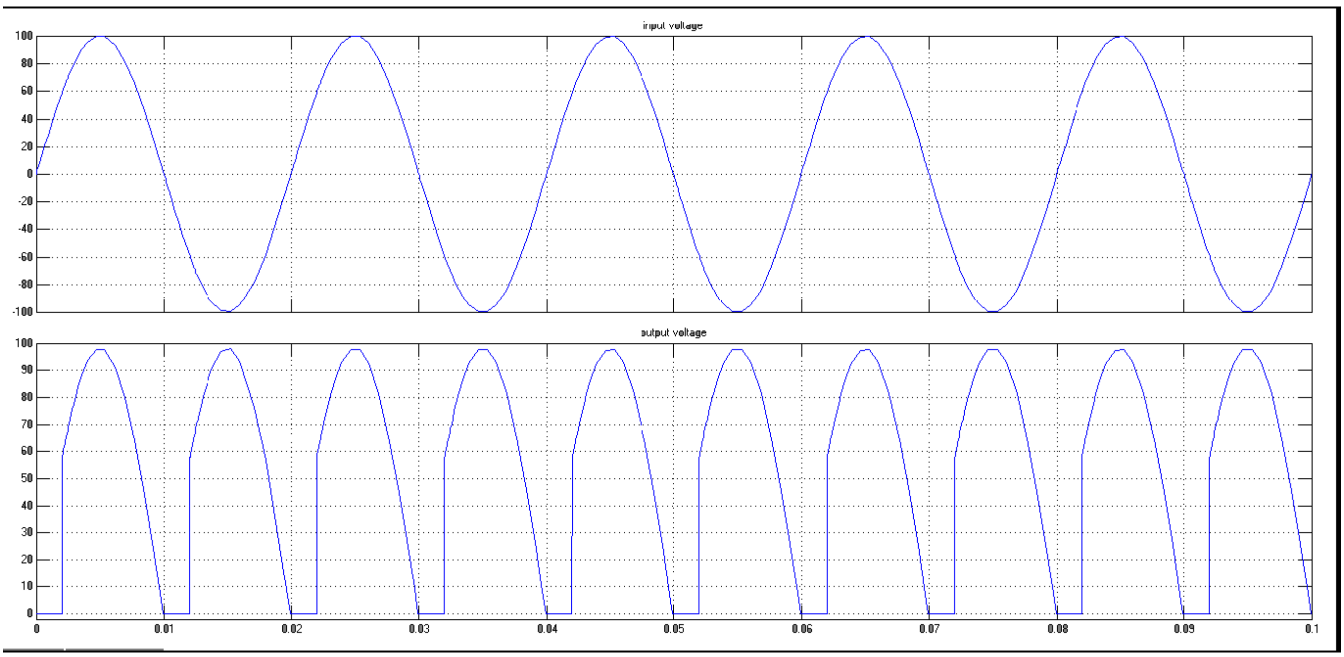
Set AC Input Parameter

(Peak amplitude =100 V, Phase=0 deg and Frequency=50 Hz)

Set Pulse generator Parameter

(First pulse generator period=0.02 sec, Pulse width=50% and Phase delay=0.002 sec)

(Second pulse generator period=0.02 sec, Pulse width=50% and Phase delay=0.012 sec)



Ex.No: **Date:**

SIMULATION OF SINGLE PHASE FULL CONVERTER

AIM:

To simulate single Phase Full Converter circuit with R load in MATLAB - SimuLink.

APPARATUS REQUIRED:

A PC with MATLAB package.

THEORY:

SINGLE PHASE FULL CONVERTER

A fully controlled converter or full converter uses thyristors only and there is a wider control over the level of dc output voltage. With pure resistive load, it is single quadrant converter. Here, both the output voltage and output current are positive. With RL- load it becomes a two-quadrant converter. Here, output voltage is either positive or negative but output current is always positive. Figure shows the quadrant operation of fully controlled bridge rectifier with R-load. Fig shows single phase fully controlled rectifier with resistive load. This type of full wave rectifier circuit consists of four SCRs. During the positive half cycle, SCRs T1 and T2 are forward biased. At $\omega t = \alpha$, SCRs T1 and T3 are triggered, and then the current flows through the L – T1- R load – T3 – N. At $\omega t = \pi$, supply voltage falls to zero and the current also goes to zero. Hence SCRs T1 and T3 turned off. During negative half cycle (π to 2π).SCRs T3 and T4 forward biased. At $\omega t = \pi + \alpha$, SCRs T2 and T4 are triggered, then current flows through the path N – T2 – R load- T4 – L. At $\omega t = 2\pi$, supply voltage and current goes to zero, SCRs T2 and T4 are turned off.

The Fig-3, shows the current and voltage waveforms for this circuit. For large power dc loads, 3-phase ac to dc converters are commonly used. The various types of three-phase phase-controlled converters are 3 phase half-wave converter, 3-phase semi converter, 3-hase full controlled and 3-phase dual converter. Three-phase half wave converter is rarely used in industry because it introduces dc component in the supply current. Semi converters and full converters are quite common in industrial applications. A dual is used only when reversible dc drives with power ratings of several MW are required. The advantages of three phase converters over single phase converters are as under: In 3-phase converters, the ripple frequency of the converter output voltage is higher than in single-phase converter. Consequently, the filtering requirements for smoothing out the load current are less. The load current is mostly continuous in 3-phase converters. The load performance, when 3- phase converters are used, is therefore superior as compared to when single-phase converters are used.

$$V_{out} = (2V_s)(\cos\alpha)/\pi$$

$$I_{avg} = V_{avg}/R$$

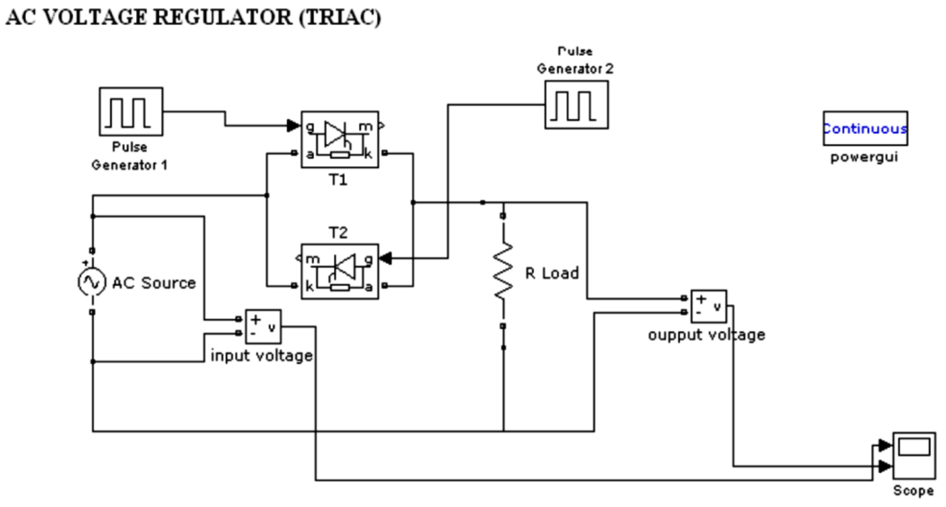
PROCEDURE:

- In MATLAB software open a new model in **File->New->model.**
- Start SIMULINK library browser by clicking the symbol in toolbar
- And Open the libraries that contain the blocks you will need. These usually will include the sources, sinks, math and continuous function block and possibly other.
- Drag the needed blocks from the library folders to that new untitled simulink window. You must give it a name using the **Save As** menu command under the **File menu** heading. The assigned filename is automatically appended with an **.mdl** extension.
- Arrange these blocks in orderly way corresponding by **Matlab Model** Shown Below.
- Interconnect the blocks by dragging the cursor from the output of one block to the input of another block.
- Double click on any block having parameters that must be established and set these parameters.
- It is necessary to specify a stop time for the simulation; this is done by clicking on the simulation parameters entry on the simulation-> parameters entry on the simulation toolbar.
- Now we are ready to simulate our block diagram. Press start icon to start the simulation. After simulation is done, double click the scope block to display the output. Click the auto scale icon in the display window to scale the axis as per variable range.
- Finally Save the Output.

RESULT:

Thus the simulation of single phase Full converter model is done and the output is verified using MATLAB Simulink.

MATLAB MODEL:



OUTPUT WAVEFORMS:

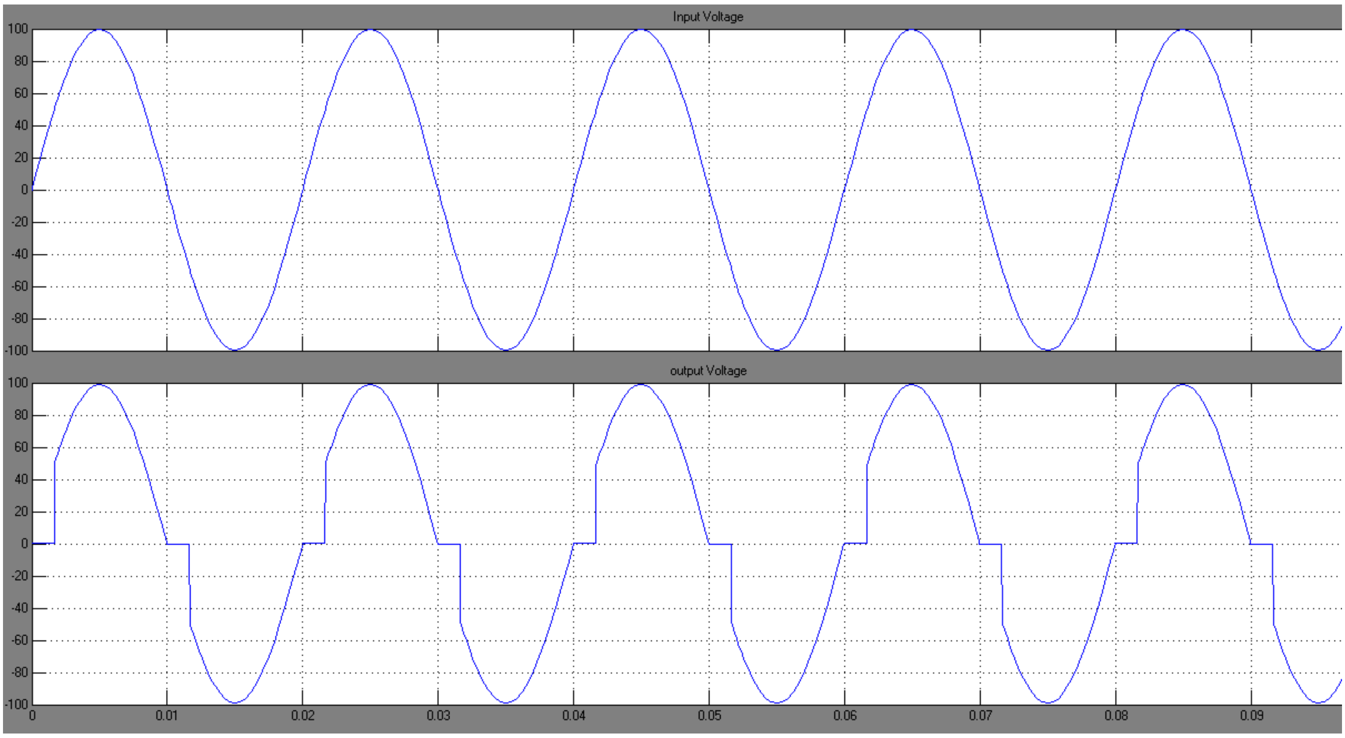
Set AC Input Parameter

(Peak amplitude =100 V, Phase=0 deg and Frequency=50 Hz)

Set Pulse generator Parameter

(First pulse generator period=0.02 sec, Pulse width=50% and Phase delay=0.003 sec)

(Second pulse generator period=0.02 sec, Pulse width=50% and Phase delay=0.013 sec)



Ex.No: **Date:**

SIMULATION OF SINGLE PHASE AC VOLTAGE CONTROL USING TRIAC

AIM:

To simulate single Phase AC Voltage Control Using TRIAC circuit with R load inMATLAB – SimuLink.

APPARATUS REQUIRED:

A PC with MATLAB package.

THEORY:

SINGLE PHASE AC VOLTAGE CONTROL USING TRIAC

Triac is a bidirectional thyristor with three terminals. Triac is the word derived by combining the capital letters from the words TRIode and AC. In operation triac is equivalent to two SCRs connected in anti- parallel. It is used extensively for the control of power in ac circuit as it can conduct in both the direction. Its three terminals are MT1 (main terminal 1), MT2 (main terminal 2) and G (gate).

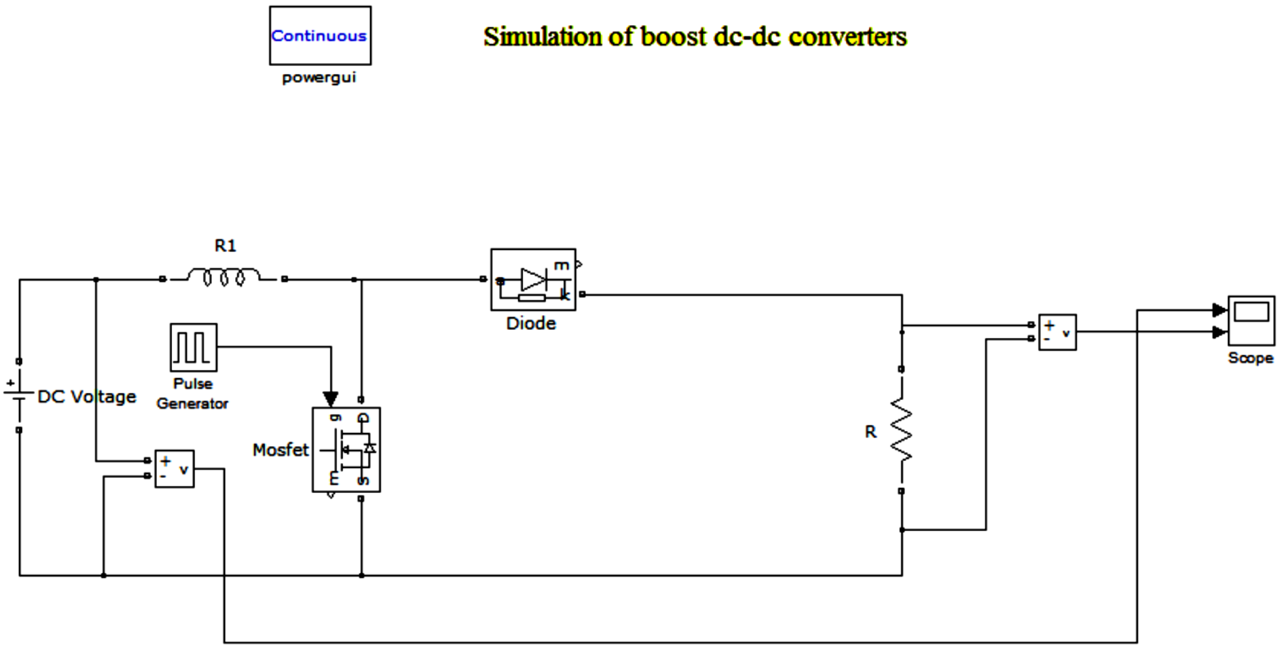
PROCEDURE:

- In MATLAB software open a new model in **File->New->model.**
- Start SIMULINK library browser by clicking the symbol in toolbar
- And Open the libraries that contain the blocks you will need. These usually will include the sources, sinks, math and continuous function block and possibly other.
- Drag the needed blocks from the library folders to that new untitled simulink window. You must give it a name using the **Save As** menu command under the **File menu** heading. The assigned filename is automatically appended with an **.mdl** extension.
- Arrange these blocks in orderly way corresponding by **Matlab Model** Shown Below.
- Interconnect the blocks by dragging the cursor from the output of one block to the input of an-other block.
- Double click on any block having parameters that must be established and set these parameters.
- It is necessary to specify a stop time for the simulation; this is done by clicking on the simulation parameters entry on the simulation-> parameters entry on the simulation toolbar.
- Now we are ready to simulate our block diagram. Press start icon to start the simulation. After simulation is done, double click the scope block to display the output. Click the auto scale icon in the display window to scale the axis as per variable range.
- Finally Save the Output.

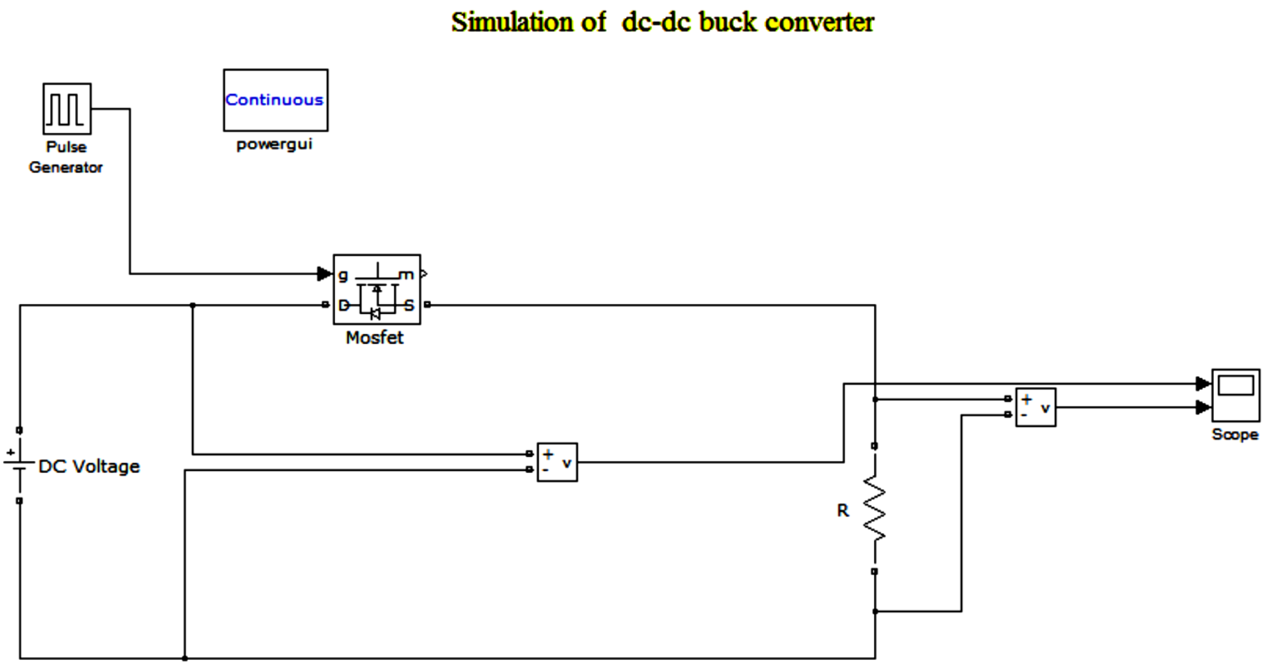
RESULT: Thus the simulation of single Phase AC Voltage Control Using TRIAC model is done and the output is verified using MATLAB Simulink.

MATLAB MODEL:

DC-DC BOOST CONVERTER



DC-DC BUCK CONVERTER



Ex.No: **Date:**

SIMULATION OF DC-DC CONVERTERS

AIM:

To simulate DC-DC Converter circuit with R load in MATLAB - SimuLink.

APPARATUS REQUIRED:

A PC with MATLAB package.

THEORY:

DC-DC BOOST CONVERTER

In this circuit, the transistor is either fully on or fully off; that is, driven between the extremes of saturation or cutoff. By avoiding the transistor's active" mode (where it would drop substantial voltage while conducting current), very low transistor power dissipations can be achieved. With little power wasted in the form of heat, Switching" power conversion circuits are typically very efficient. Trace all current directions during both states of the transistor. Also, mark the inductor's voltage polarity during both states of the transistor.

PROCEDURE:

- In MATLAB software open a new model in **File->New->model.**
- Start SIMULINK library browser by clicking the symbol in toolbar
- And Open the libraries that contain the blocks you will need. These usually will include the sources, sinks, math and continuous function block and possibly other.
- Drag the needed blocks from the library folders to that new untitled simulink window. You must give it a name using the **Save As** menu command under the **File menu** heading. The assigned filename is automatically appended with an **.mdl** extension.
- Arrange these blocks in orderly way corresponding by **Matlab Model** Shown Below.
- Interconnect the blocks by dragging the cursor from the output of one block to the input of an-other block.
- Double click on any block having parameters that must be established and set these parameters.
- It is necessary to specify a stop time for the simulation; this is done by clicking on the simulation parameters entry on the simulation-> parameters entry on the simulation toolbar.
- Now we are ready to simulate our block diagram. Press start icon to start the simulation. After simulation is done, double click the scope block to display the output. Click the auto scale icon in the display window to scale the axis as per variable range.
- Finally Save the Output.

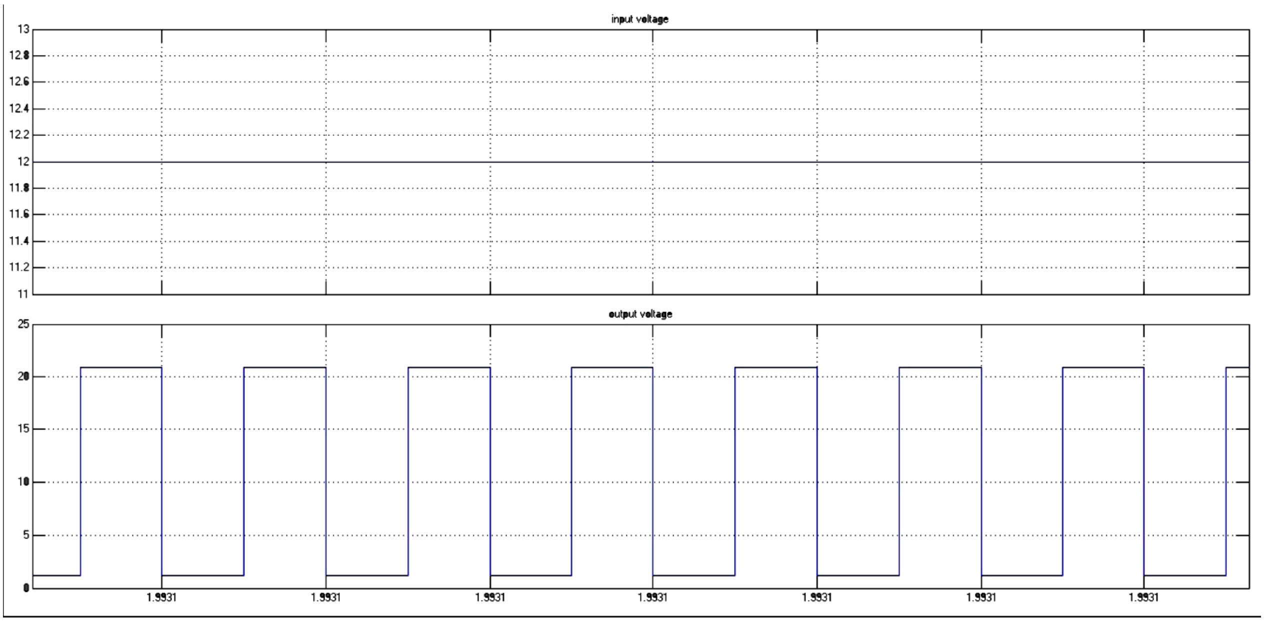
OUTPUT WAVEFORMS:

DC-DC BOOST CONVERTER

Set DC Input Parameter (Amplitude =12 V)

Set Inductor Parameter (Inductance=0.1 H)

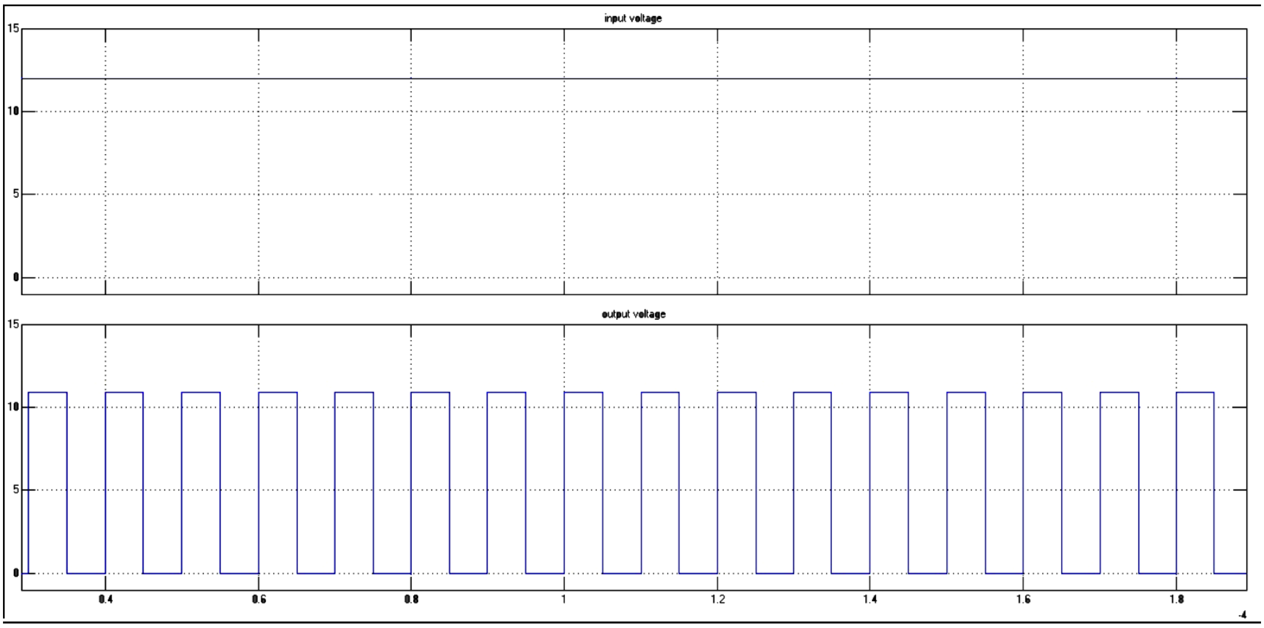
Set Pulse generator Parameter (Period=10e-6 sec, Pulse width=50% and Phase delay=0 sec)



DC-DC BUCK CONVERTER

Set DC Input Parameter (Amplitude =12 V)

Set Pulse generator Parameter (Period=10e-6 sec, Pulse width=50% and Phase delay=0 sec)



RESULT:

Thus the simulation of dc-dc converters (Buck and Boost Converter) model is done and the output is verified using MATLAB Simulink.

Ex.No: **Date:**

SIMULATION OF THREE PHASE CONVERTER

AIM:

To simulate three phase Converter circuit with RL load in MATLAB - SimuLink.

APPARATUS REQUIRED: A PC with MATLAB package.

THEORY:

Figure shows the circuit diagram of three phase bridge controlled rectifier. It consist of upper group (T1,T3,T5) and lower group (T2,T4,T5) of thyristors.Thyristor T1 is forward biased ad can be triggered for conduction only when Va is greater than both Vb and Vc. From figure this condition occurs at wt=300. Hence T1 can be triggered only at wt=300.If firing angle is α, then T1 starts conduction at wt=30 + α and conducts for 1200 where it get commutated by turning on of next thyristor ie,T3.Similarly triggering instant for T3 and T5 are determined when considering Vb and Vc respectively. For lower group T4,T6 and T2, negative voltages,ie,-Va,-Vb and -Vc respectively are considered. Thus the forward bias instant and triggering instants are obtained as:

Thyristor	Forward Bias	Triggering instant (deg)	Conduction period
T1	30	30+α	30+α to 150+α
T2	90	90+α	90+α to 210+α
T3	150	150+α	150+α to 270+α
T4	210	210+α	210+α to 330+α
T5	270	270+α	270+α to 390+α
T6	330	330+α	330+α to 450 +α

Average Value of output voltage is given by $$Vavg = \frac{3\sqrt{3}}{\Pi} Vmcos\ \alpha$$

where Vm is the maximum value of phase to neutral voltage

Average Value of output current is given by $$Iavg= \frac{3\sqrt{3}}{\Pi R} Vmcos\ \alpha$$

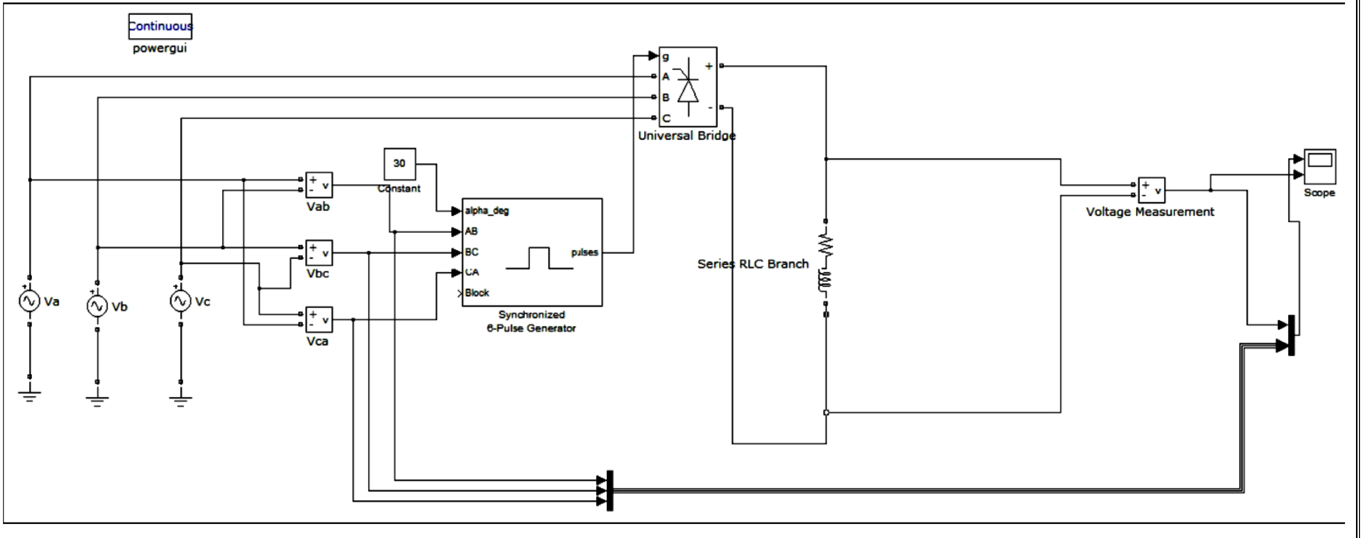
where R is the load resistance

PROCEDURE:

- In MATLAB software open a new model in **File->New->model.**
- Start SIMULINK library browser by clicking the symbol in toolbar
- And Open the libraries that contain the blocks you will need. These usually will include the sources, sinks, math and continuous function block and possibly other.

- Drag the needed blocks from the library folders to that new untitled simulink window. You must give it a name using the **Save As** menu command under the **File menu** heading. The assigned filename is automatically appended with an **.mdl** extension.
- Arrange these blocks in orderly way corresponding by **Matlab Model** Shown Below.

MATLAB MODEL:



OUTPUT WAVEFORMS:

Set AC Input Parameter

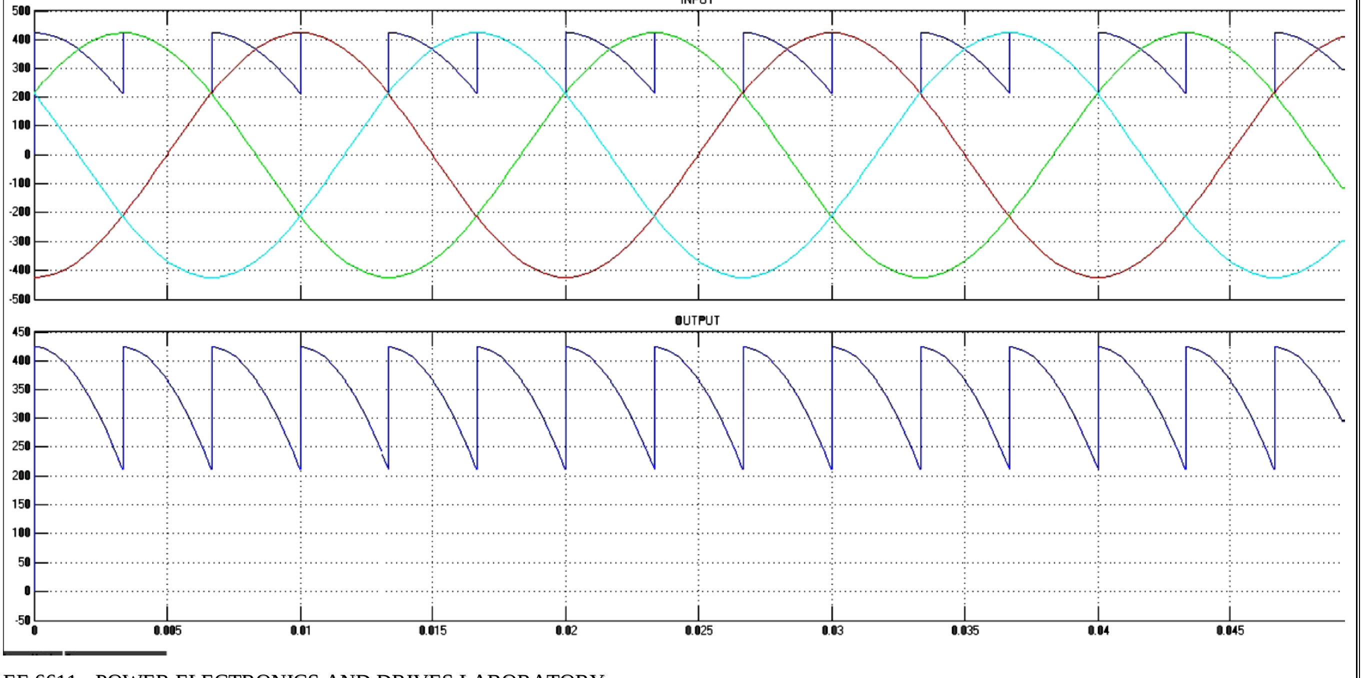
(For Va : Peak amplitude =245 V, Phase=0 deg and Frequency=50 Hz)

(For Vb : Peak amplitude =245 V, Phase= -120 deg and Frequency=50 Hz)

(For Vc : Peak amplitude =245 V, Phase=120 deg and Frequency=50 Hz)

Set Synchronized 6-Pulse Generator Parameter(Frequency=50 Hz, Pulse width=10 deg)

Set RL Branch Parameter (Resistance =1000 Ohms, Inductance =350e-3 H)



- Interconnect the blocks by dragging the cursor from the output of one block to the input of another block.
- Double click on any block having parameters that must be established and set these parameters.
- It is necessary to specify a stop time for the simulation; this is done by clicking on the simulation parameters entry on the simulation-> parameters entry on the simulation toolbar.
- Now we are ready to simulate our block diagram. Press start icon to start the simulation. After simulation is done, double click the scope block to display the output. Click the auto scale icon in the display window to scale the axis as per variable range.
- Finally Save the Output.

RESULT:

Thus the simulation of three phase converter model is done and the output is verified using MATLAB Simulink.