SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur–603203.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

1905610 - POWER ELECTRONICS LABORATORY

LAB MANUAL

VI Semester - Electrical and Electronics Engineering

Academic Year 2024-2025 Even Semester

(2019 Regulation)

Prepared by

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General Instructions to students for EEE Lab courses

- Be punctual to the lab class.
- Attend the laboratory classes wearing the prescribed uniform and shoes.
- Avoid wearing any metallic rings, straps or bangles as they are likely to prove dangerous at times.
- Girls should put their plait inside their overcoat
- Boys students should tuck in their uniform to avoid the loose cloth getting into contact with rotating machines.
- Acquire a good knowledge of the surrounding of your worktable. Know where the various live points are situated in your table.
- In case of any unwanted things happening, immediately switch off the mains in the work table.
- This must be done when there is a power break during the experiment being carried out.
- Before entering into the lab class, you must be well prepared for the experiment that you are going to do on that day.
- You must bring the related text book which may deal with the relevant experiment.
- Get the circuit diagram approved.
- Prepare the list of equipment and components required for the experiment and get the indent approved.
- Plan well the disposition of the various equipment on the worktable so that the experiment can be carried out.
- Make connections as per the approved circuit diagram and get the same verified. After getting the approval only supply must be switched on.
- For the purpose of speed measurement in rotating machines, keep the tachometer in the extended shaft.
- Avoid using the brake drum side.
- Get the reading verified. Then inform the technician so that supply to the worktable can be switched off.
- You must get the observation note corrected within two days from the date of completion of experiment.
- Write the answer for all the discussion questions in the observation note. If not, marks for concerned observation will be proportionately reduced.
- Submit the record note book for the experiment completed in the next class.
- If you miss any practical class due to unavoidable reasons, intimate the staff in charge and do the missed experiment in the repetition class.
- Such of those students who fail to put in a minimum of 75% attendance in the laboratory class will run the risk of not being allowed for the University Practical Examination. They will have to repeat the lab course in subsequent semester after paying prescribed fee.
- Use isolated supply for the measuring instruments like CRO in Power Electronics and Drives Laboratory experiments.

1905610- POWER ELECTRONICS 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&3Φsemiconverter, 1Φ&3Φfullconverter, DC-DC converters, AC voltage controllers).

12. Characteristics of GTO.

13. Characteristics of PMBLDC motor.

14. Dynamic Characteristics of SCR and MOSFET

ADDITIONAL EXPERIMENTS

15. Resonant dc to dc converter

16. Speed control of Universal Motor

CYCLE I

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

CYCLE II

8. IGBT based three phase PWM inverter

9. AC Voltage controller

10. Switched mode power converter.

11. Simulation of PE circuits (1Φ&3Φsemiconverter, 1Φ&3Φfullconverter, DC-DC converters, AC voltage controllers).

12. Characteristics of GTO.

13. Characteristics of PMBLDC motor.

14. Dynamic Characteristics of SCR and MOSFET.

ADDITIONAL EXPERIMENTS

15. Resonant dc to dc converter.

16. Speed control of Universal Motor.

S.No	Date	List Of Experiments	Signature
1.			
2.			
3.			
4.			
5.			
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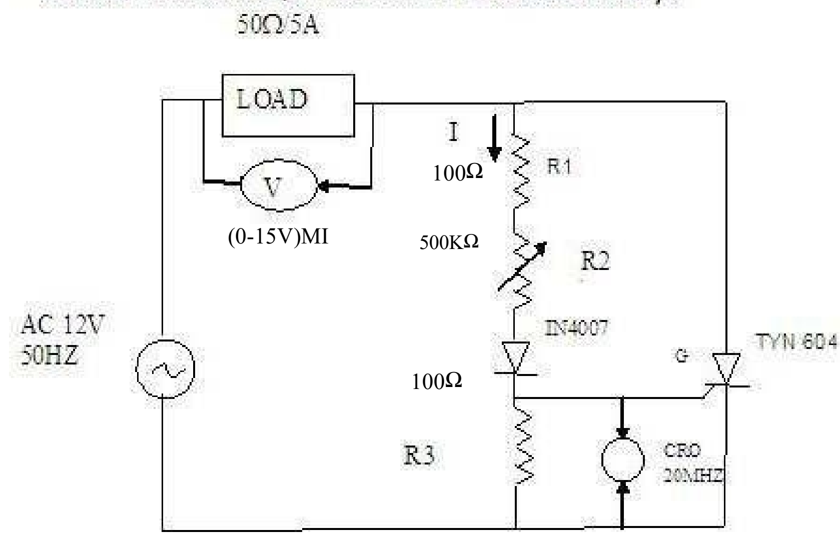
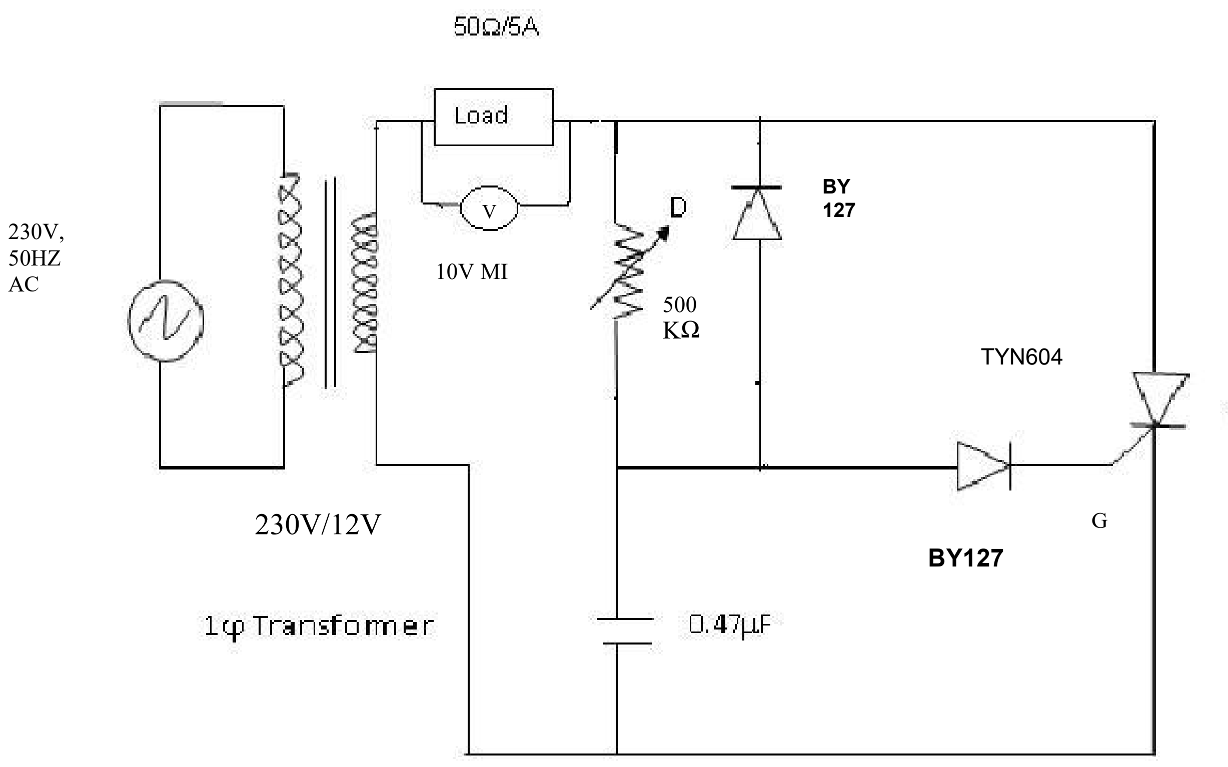
18.			
19.			

CIRCUIT DIAGRAM (RESISTANCE FIRING CIRCUIT) :



CIRCUIT DIAGRAM (RC-TRIGGERING):



Date:

Ex. No.1

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:

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1	CRO	20 MHz		1
2	R.P.S	(0-30)V		1
4	Transformer	230/24V		1
5	Load	100,2A		1
6	Voltmeter	(0-15)V	MI	1

FORMULA:

$$V_{o(avg)} = \frac{V_m}{\pi}(1+\cos\alpha), \quad V_m=\sqrt{2}\, V_{rms;}$$

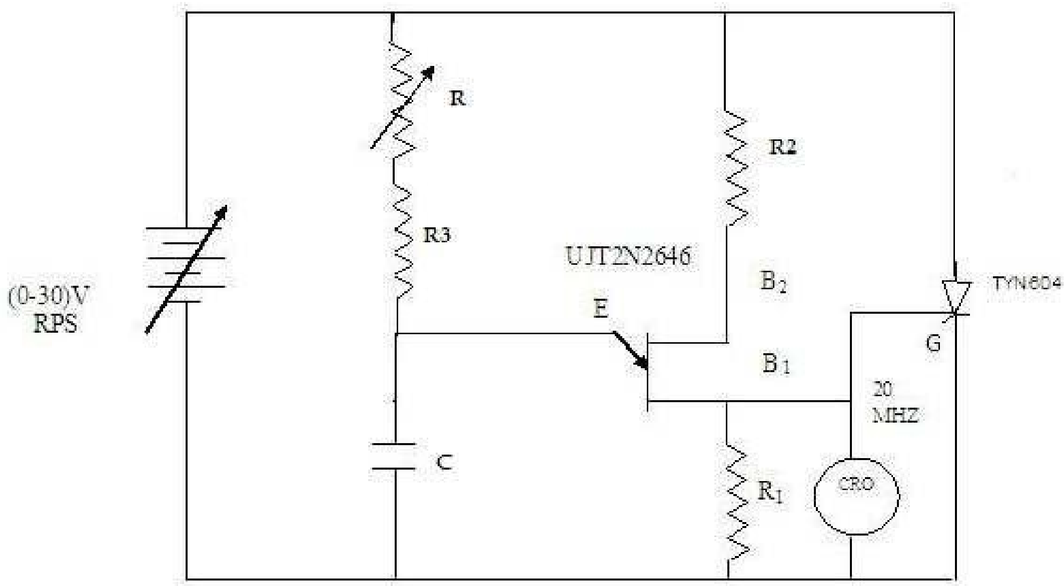
PROCEDURE: (R-TRIGGERING)

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

PROCEDURE: (RC-TRIGGERING)

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

CIRCUIT DIAGRAM (UJT-TRIGGERING):



TABULAR COLUMN (R-TRIGGERING) :

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

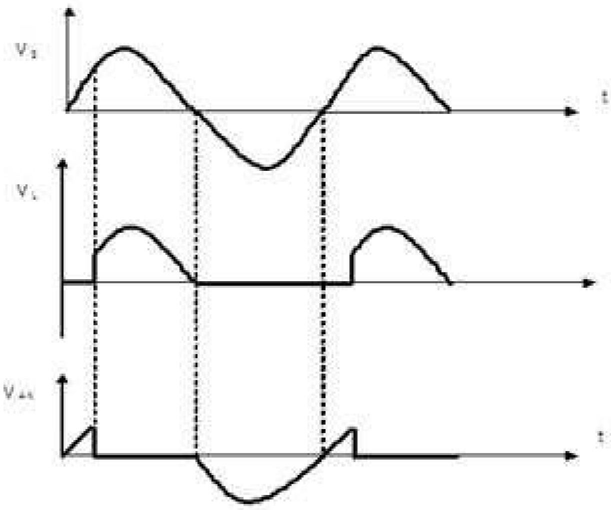
PROCEDURE: (UJT-TRIGGERING)

1. Make the connections as per the circuit diagram.
2. Switch on the power supply and set the biasing voltage to18volts.
3. Note down the waveform of voltages (Vc and Vo) using a CRO.
4. Repeat the procedure for various resistor values of potentiometer.
5. Switch off the power supply and remove the connections.

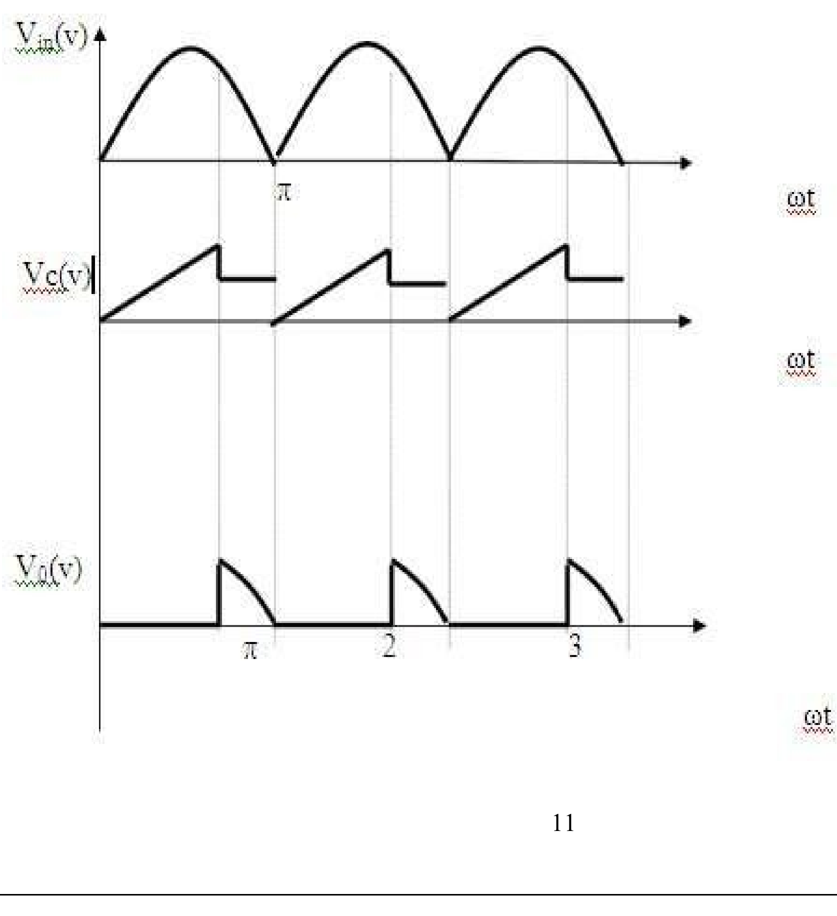
TABULAR COLUMN (RC-TRIGGERING):

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

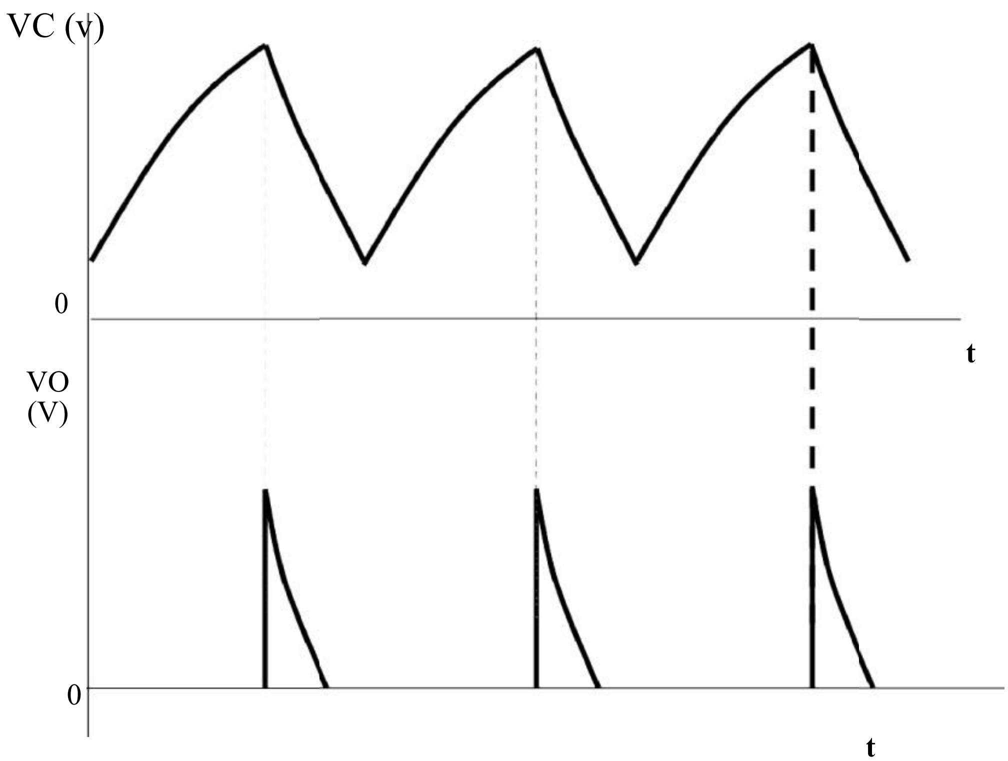
MODEL GRAPH (R-TRIGGERING):



MODEL GRAPH (RC-TRIGGERING):



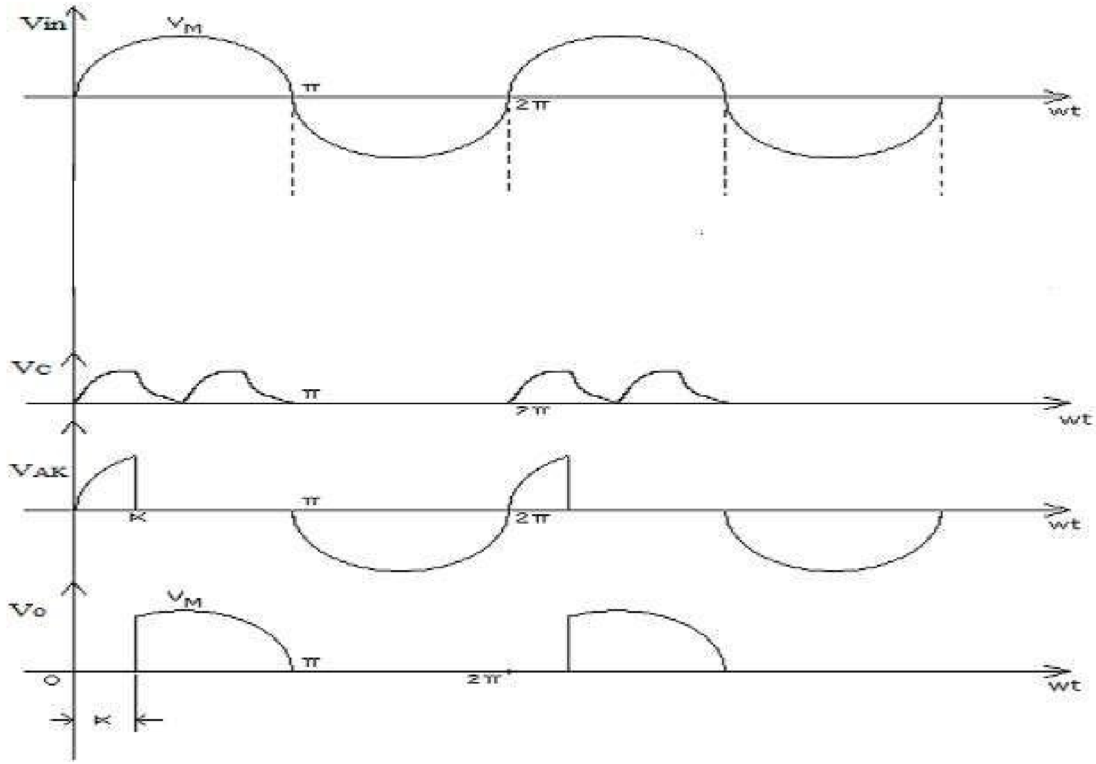
MODEL GRAPH (UJT-TRIGGERING) :



TABULAR COLUMN (UJT TRIGGERING):

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

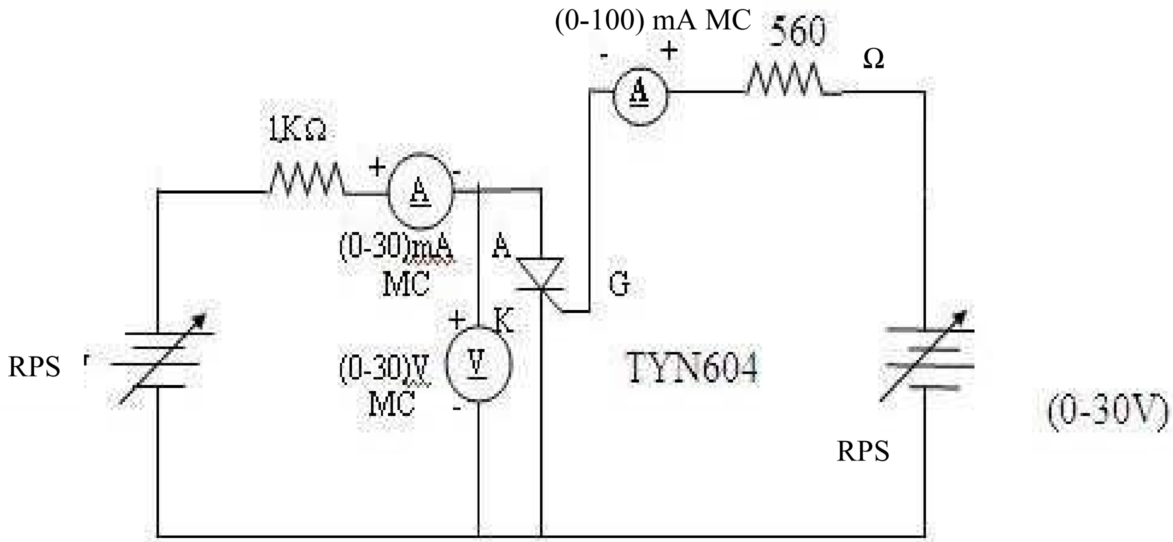
MODEL GRAPH (UJT-TRIGGERING) :



RESULT:

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

CIRCUIT DIAGRAM:



Date:

Ex. No.2

CHARACTERISTICS OF SCR AND TRIAC

Ex. No. 2(a)

CHARACTERISTICS OF SCR

AIM :

To determine the VI characteristics of Silicon Controlled Rectifier.

APPARATUS REQUIRED:

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1	SCR	TYN 604		1
2	Regulated Power Supply	(0-30) V		1
3	Voltmeter	(0-30) V	MC	1
4	Ammeter	(0-30)mA	MC	1
5	Ammeter	(0-100)µA	MC	1
6	Resistor	1 kΩ,560Ω		1
8	Connecting wires			Few

PROCEDURE:

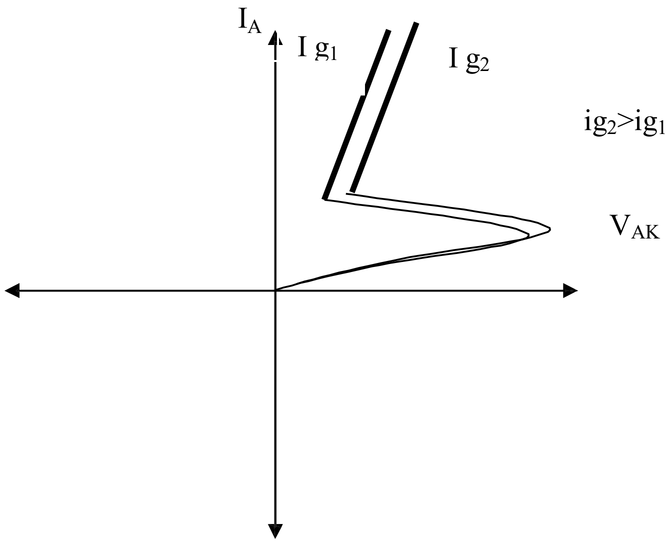
1. **To determine the Characteristics of SCR**

1) Make the connections as per the circuit diagram.
2) Switch on the supply
3) Set the gate current at a fixed value by varying RPS on the gate-cathode side.
4) Increase the voltage applied to anode-cathode side from zero until breakdown occurs.
5) Note down the breakdown voltage.
6) Draw the graph between anode to cathode voltage (v_{ak}) and anode current(i_a)

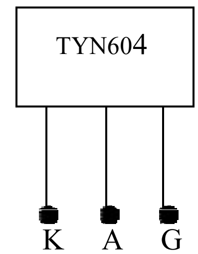
TABULAR COLUMN:SCR

Status	V_{AK} (V)	I_A (mA)	I_G(mA)

MODELGRAPH:



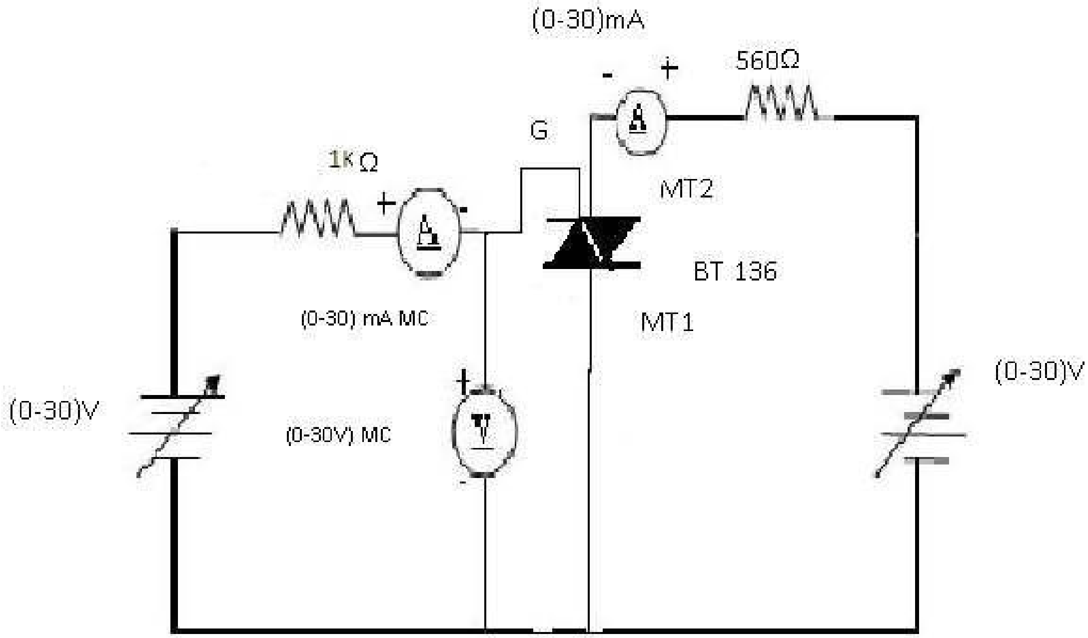
Pin configuration



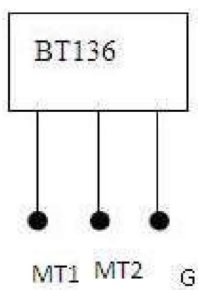
RESULT:

Thus the Characteristics of SCR and the Output waveforms were obtained.

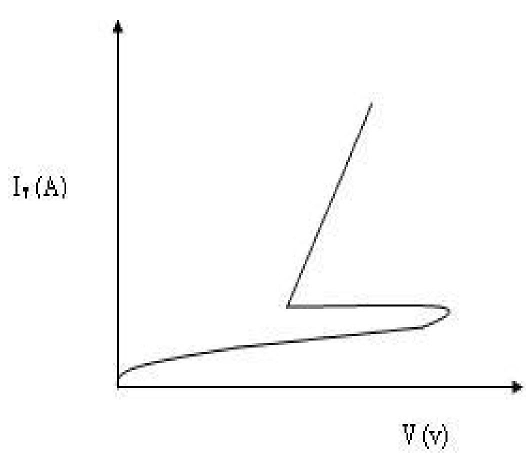
CIRCUIT DIAGRAM:



Pin configuration



MODEL GRAPH:



Date:

Ex. No. 2(b)

CHARACTERISTICS OF TRIAC

AIM:

To determine the V-I characteristics of TRIAC.

APPARATUS REQUIRED:

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1	Triac	BT136		1
2	Regulated Power Supply	(0-30) V		1
3	Voltmeter	(0-30) V	MC	1
4	Ammeter	(0-30) mA	MC	1
5	Ammeter	(0-100) μA	MC	1
6	Resistor	1KΩ,560Ω		1
7	Connecting wires			Few

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Switch on the supply.
3. Set the gate current at a fixed value by varying RPS on the
4. gate- cathode side.
5. Increase the voltage applied across anode and corresponding current is noted.
6. The above steps are repeated for different values of I_G.
7. Draw the graph between anode to cathode voltage (V_{AK}) and anode
8. current (I_A)

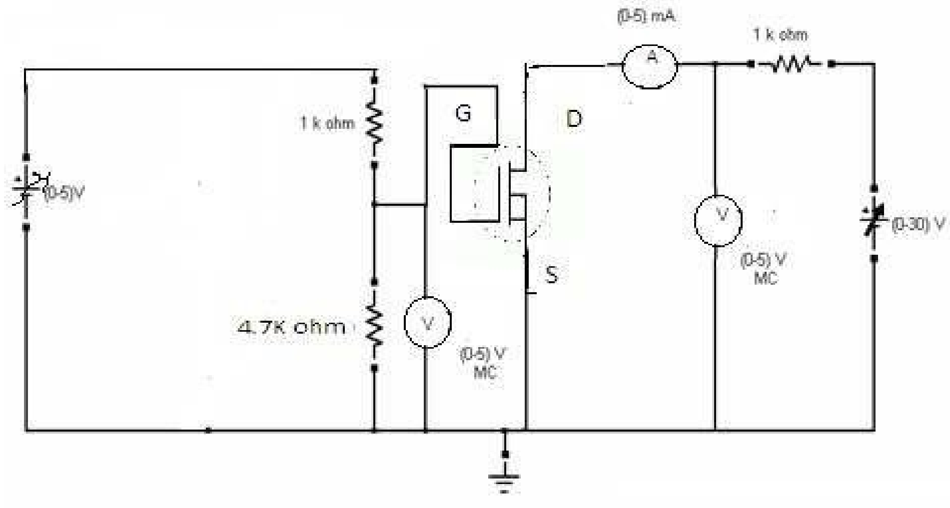
TABULAR COLUMN: TRIAC

Status	V_{AK} (V)	I_A (mA)	I_G(mA)
Before Triggering			
At Triggering			
After Triggering			

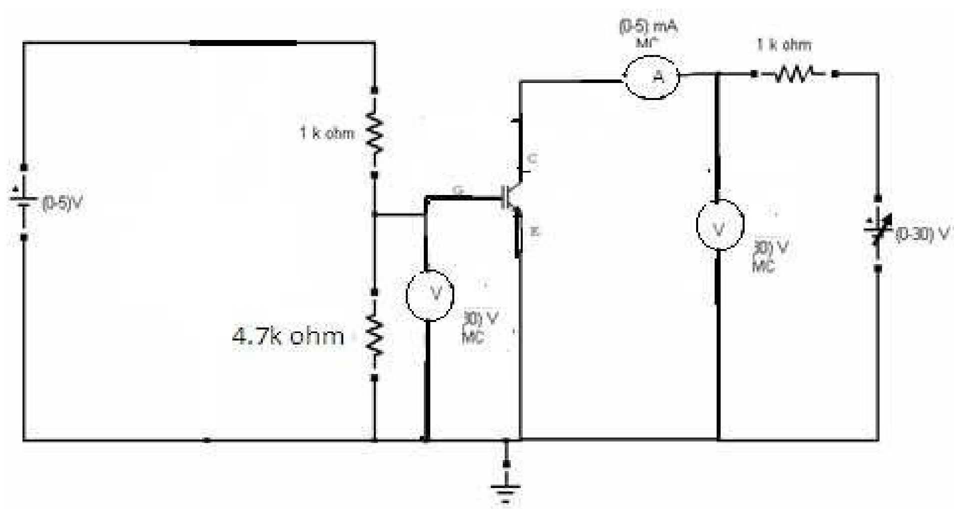
RESULT:

Thus the Characteristics of TRIAC was obtained.

CIRCUIT DIAGRAM (MOSFET):



CIRCUIT DIAGRAM (IGBT) :



Date:

Ex. No.3

CHARACTERISTICS OF MOSFET & IGBT

AIM:

To determine the characteristics of MOSFET & IGBT.

APPARATUS REQUIRED:

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1	MOSFET & IGBT Module kit	220 V / 5 A		1
2	Regulated Power Supply	(0-15) V		1
3	Regulated Power Supply	(0-30) V		1
4	Voltmeter	(0-5) V	MC	1
5	Voltmeter	(0-30) V	MC	1
6	Ammeter	(0-5) mA	MC	1
7	Resistor	4.7 KΩ, 1 kΩ		1
8	Patch Chords			10

PROCEDURE:

1) Make the connections as per the circuit diagram.
2) Switch on the supply.
3) Set the gate current at a fixed value by varying RPS on the gate-cathode side.
4) Vary the voltage applied across Gate and corresponding V_{DS} (V_{CE}) and I_D(I_C) is noted.
5) The above steps are repeated for different values of I_G.
6) Vary the voltage across Collector and Emitter and noted down V_{GE} and I_C.
7) Draw the graph between V_{GS}(V_{CE})and I_D(I_C) and V_{GS}(V_{GE})and I_D(I_C).

TABULAR COLUMN (MOSFET):

DRAIN CHARACTERISTICS:

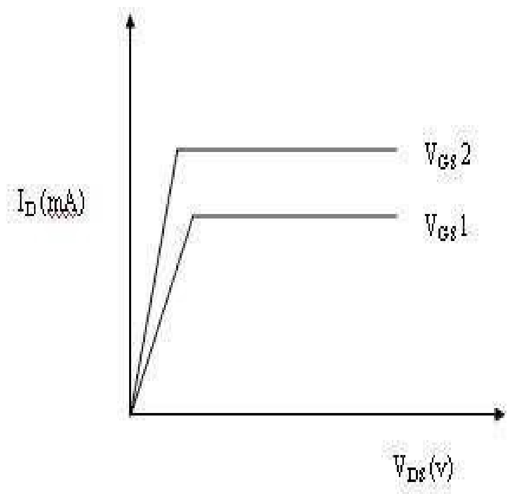
S.No	V_{GS} =….(V)		V_{GS} =….(V)	
	V_{DS} (mV)	I_D (mA)	V_{DS} (mV)	I_D (mA)

TRANSFER CHARACTERISTICS:

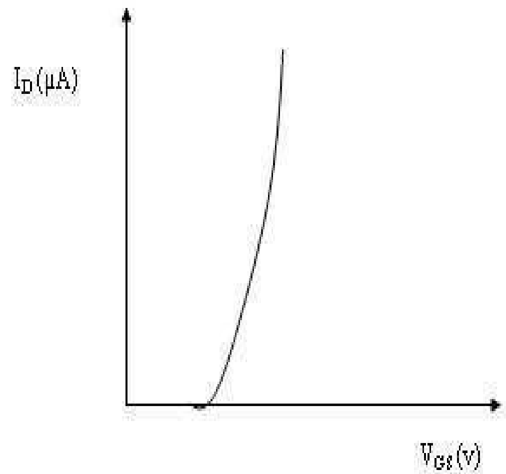
S.No	V_{DS} =….(V)	
	V_{GS} (mV)	I_D (mA)

MODEL GRAPH (MOSFET):

DRAIN CHARACTERISTICS



TRANSFER CHARACTERISTICS



TABULAR COLUMN (IGBT):

DRAIN CHARACTERISTICS:

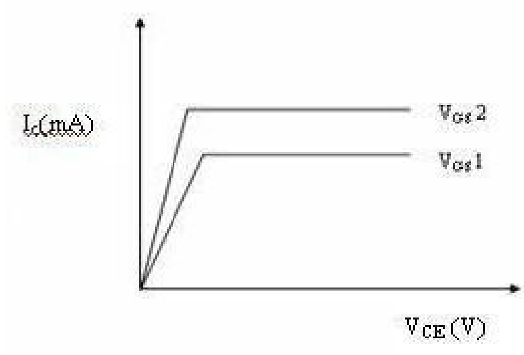
S.No	V_{GE} =….(V)		V_{GE} =….(V)	
	V_{CE} (mV)	I_C (mA)	V_{CE} (mV)	I_C (mA)

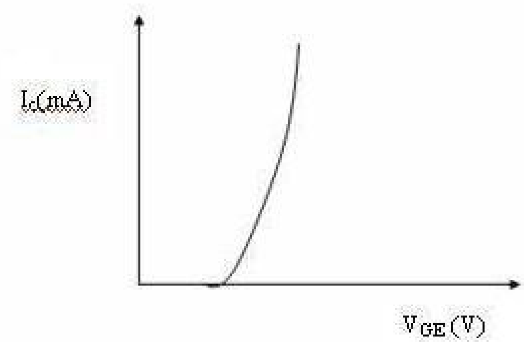
TRANSFER CHARACTERISTICS:

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

MODEL GRAPH (IGBT):

DRAIN CHARACTERISTICS **TRANSFER CHARACTERISTICS**

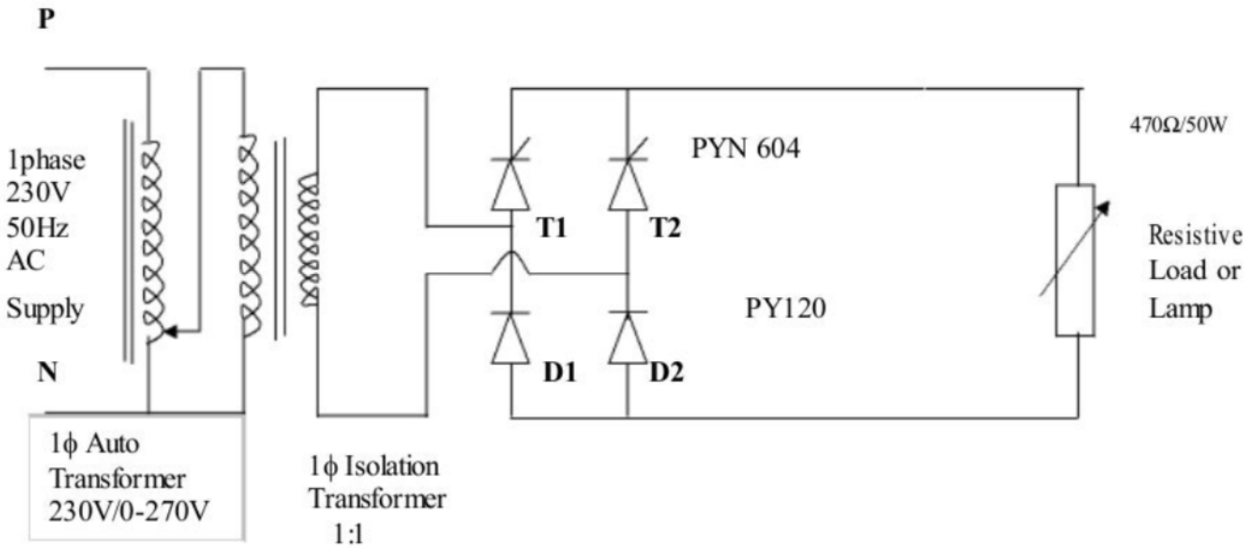




RESULT:

Thus the Characteristics of MOSFET & IGBT were obtained.

CIRCUIT DIAGRAM:



TABULAR COLUMN:

V_{in}=____________V

S.No.	Firing Angle (Degree)	Time Period		Output Voltage Vo(Volts)	
		T_{on}	T_{off}	Practical	Theoretical

Date:

AC TO DC HALF CONTROLLED CONVERTER

Ex. No.4

AIM:

To construct a single phase half controlled Converter and plot its output response.

APPARATUS REQUIRED:

S.NO.	APPARATUS	RANGE	TYPE	QUANTITY
1	Half controlled Converter Power circuit kit	1, 230V,10A	-	1
3	SCR firing circuit kit	1 ,230V,5A	-	1
4	Isolation Transformer	230V/115-55-0-55-115	-	1
5	Auto-transformer	230V/0-270V, 4A	-	1
6	Loading Rheostat	100 / 2A	-	1
7	CRO	20MHz	-	1
8	Patch chords			Few

FORMULA:

$$V_{o\,(avg)} = \frac{V_m}{\pi}(1+\cos\alpha),\quad V_m=\sqrt{2}\,V_{rms;}$$

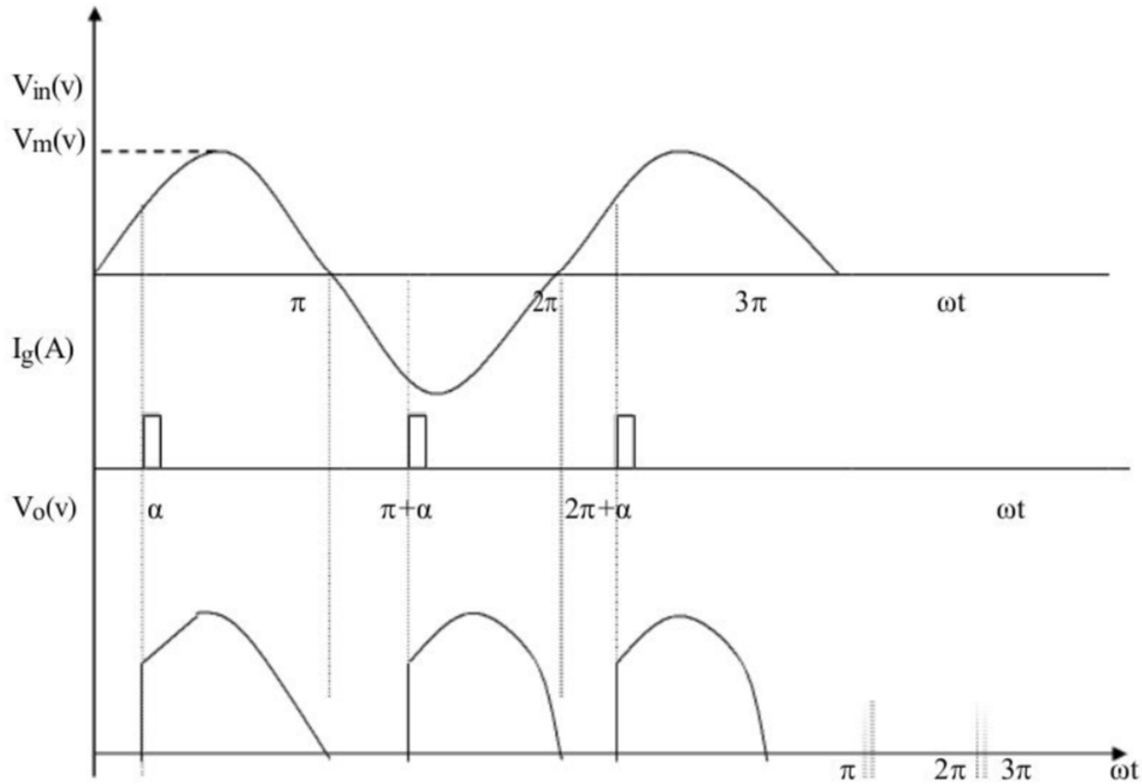
Where, V_s - Rms voltage (V), $V_{o(avg)}$ - Average output voltage (V),

V_m- Maximum peak voltage (V), α- Firing angle (degree).

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Keep the multiplication factor of the CRO’s probe at the maximum position.
3. Switch on the thyristor kit and firing circuit kit.
4. Keep the firing circuit knob at the 180position.
5. Vary the firing angle insteps.
6. Note down the voltmeter reading and waveform from the CRO.
7. Switch off the power supply and disconnect.

MODEL GRAPH:

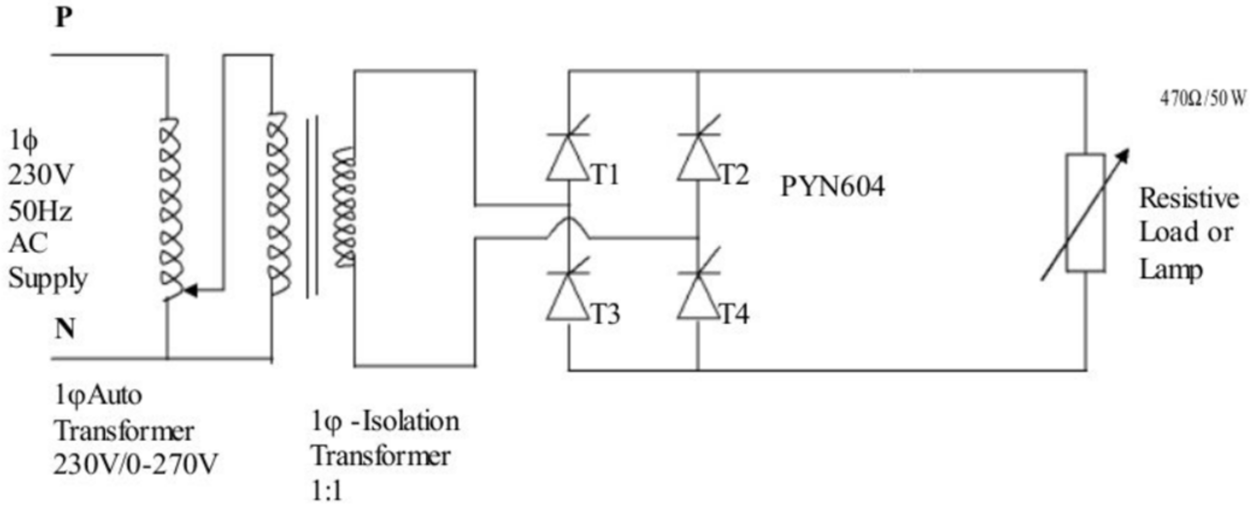


Model Calculation:

RESULT:

Thus a single-phase half controlled converter was constructed and their Output waveforms were plotted.

CIRCUIT DIAGRAM:



TABULAR COLUMN:

V_{in}=_____________V

S.No.	Firing Angle (Degree)	Time Period		Output Voltage Vo(Volts)	
		T_{on}	T_{off}	Practical	Theoretical

Date:

Ex. No.5

AC TO DC FULLY CONTROLLED CONVERTER

AIM:

To construct a single phase fully controlled Converter and plot its response.

APPARATUS REQUIRED:

S.NO	ITEM	RANGE	TYPE	QUANTITY
1	Fully controlled Converter Power circuit kit	1, 230V,10A	-	1
3	SCR firing circuit kit	1 ,230V,5A	-	1
4	Isolation Transformer	230V/115-55-0-55-115	-	1
5	Auto-transformer	230V/0-270V, 4A	-	1
6	Loading Rheostat	100 / 2A	-	1
7	CRO	20MHz	-	1
8	Patch chords	-	-	Few

FORMULA:

$$V_{o\,(avg)} = \frac{2V_m}{\Pi} \cos\alpha, \quad V_m = \sqrt{2}\, V_{rms}$$

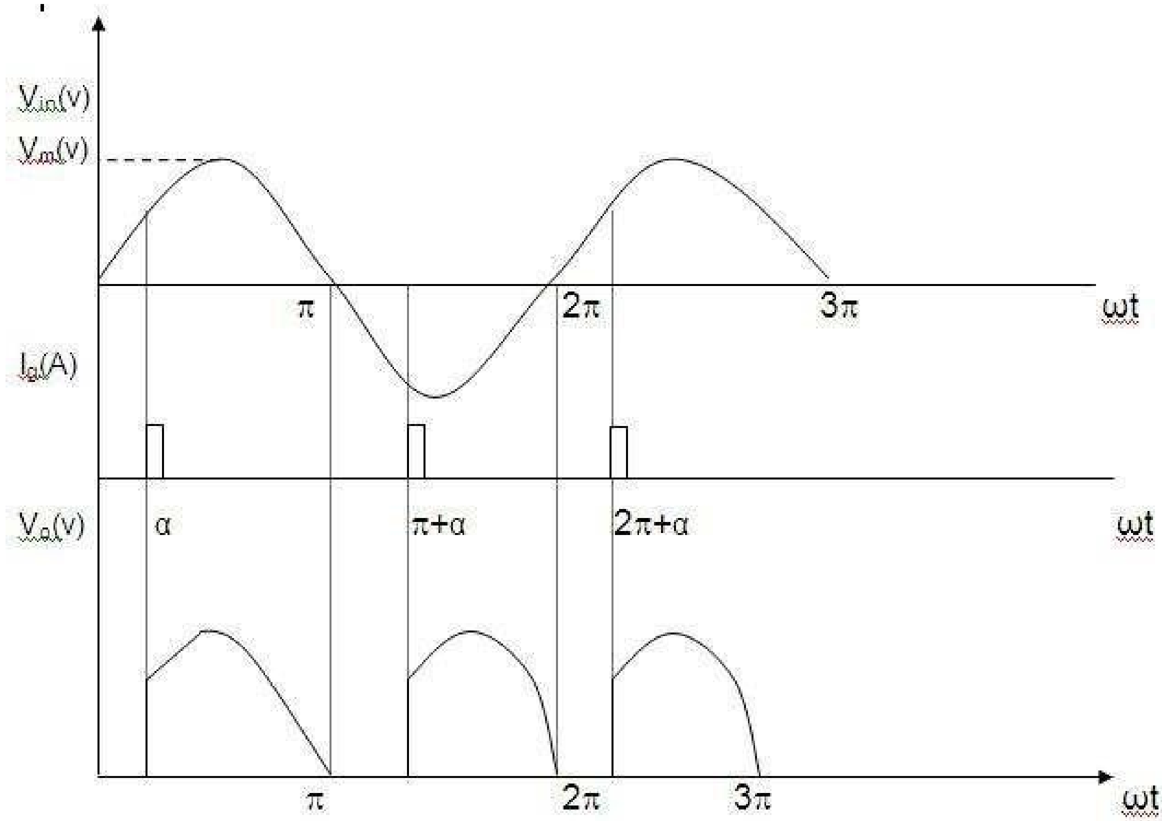
Where, V_s - Rms voltage (V), $V_{o(avg)}$ - Average output voltage (V),

V_m- Maximum peak voltage (V), α- Firing angle (degree).

PROCEDURE:

1. Make the connections as per the circuit diagram..
2. Keep the multiplication factor of the CRO's probe at the maximum position.
3. Switch on the thyristor kit and firing circuit kit.
4. Keep the firing circuit knob at the 180 position.
5. Vary the firing angle insteps.
6. Note down the voltmeter reading and waveform from the CRO.
7. Switch off the power supply and disconnect.

MODEL GRAPH :



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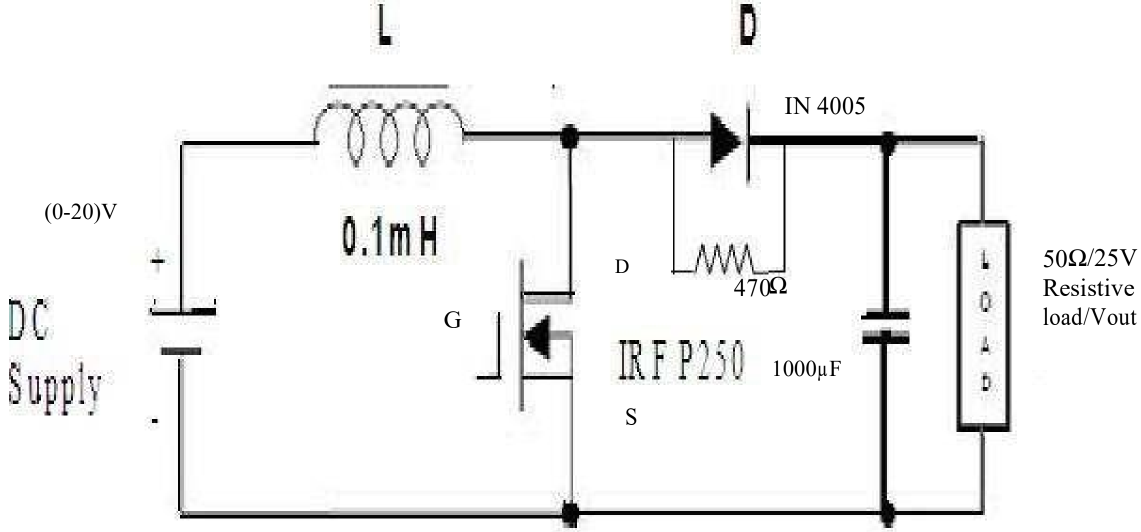
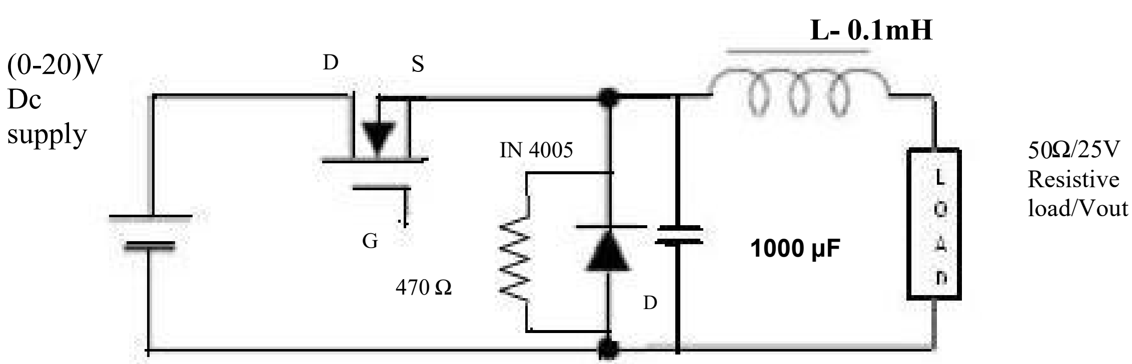
RESULT:

Thus a single-phase fully controlled converter was constructed and their responses were plotted.

CIRCUIT DIAGRAM (STEP UP CHOPPER):



CIRCUIT DIAGRAM (STEP DOWN CHOPPER):



Date:

Ex. No.6

STEP UP AND STEP DOWN MOSFET BASED CHOPPERS

AIM:

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

APPARATUS REQUIRED:

S.NO	ITEM	RANGE	QUANTITY
1	Step up & Step down MOSFET based chopper kit		1
2	CRO	20 MHZ	1
3	Patch chords		15

PROCEDURE (STEP UP CHOPPER & STEP DOWN CHOPPER) :

1. Initially keep all the switches in the OFF position
2. Initially keep duty cycle POT in minimum position
3. Connect banana connector 24V DC source to 24V DC input.
4. Connect the driver pulse [output to MOSFET input
5. Switch on the main supply
6. Check the test point waveforms with respect to ground.
7. Vary the duty cycle POT and tabulate the Ton, T off & output voltage
8. Trace the waveforms of Vo Vs &Io
9. Draw the graph for Vo Vs Duty cycle, K

   Formula used:

   1. Duty Ratio, k=TON / T; Vo=Vs/(1-K)(STEP UPCHOPPER)
   2. Duty Ratio, k=TON / T; Vo=k Vs(STEP DOWNCHOPPER)

TABULAR COLUMN (STEP UP CHOPPER):

Vs=______________V

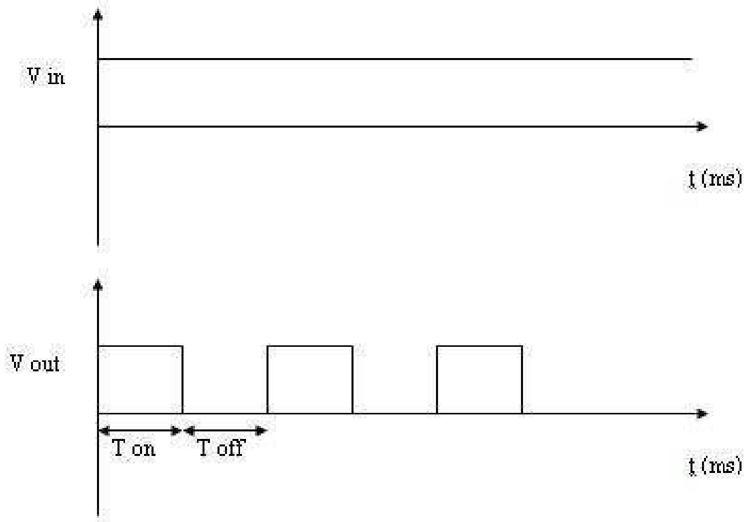
S.NO	T ON (sec)	TOFF (sec)	T (sec)	Duty Ratio, k=TON / T	Vo=Vs/(1-K) Theoretical	Vo Practical

TABULAR COLUMN (STEP DOWN CHOPPER):

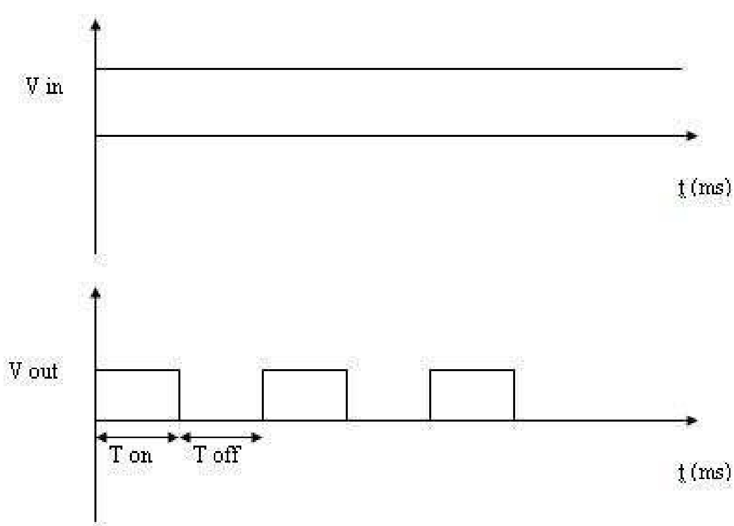
Vs=______________V

S.NO	T ON (sec)	TOFF (sec)	T (sec)	Duty Ratio, k=TON / T	Vo=kVs Theoretical	Vo Practical

MODEL GRAPH (STEP UP CHOPPER):



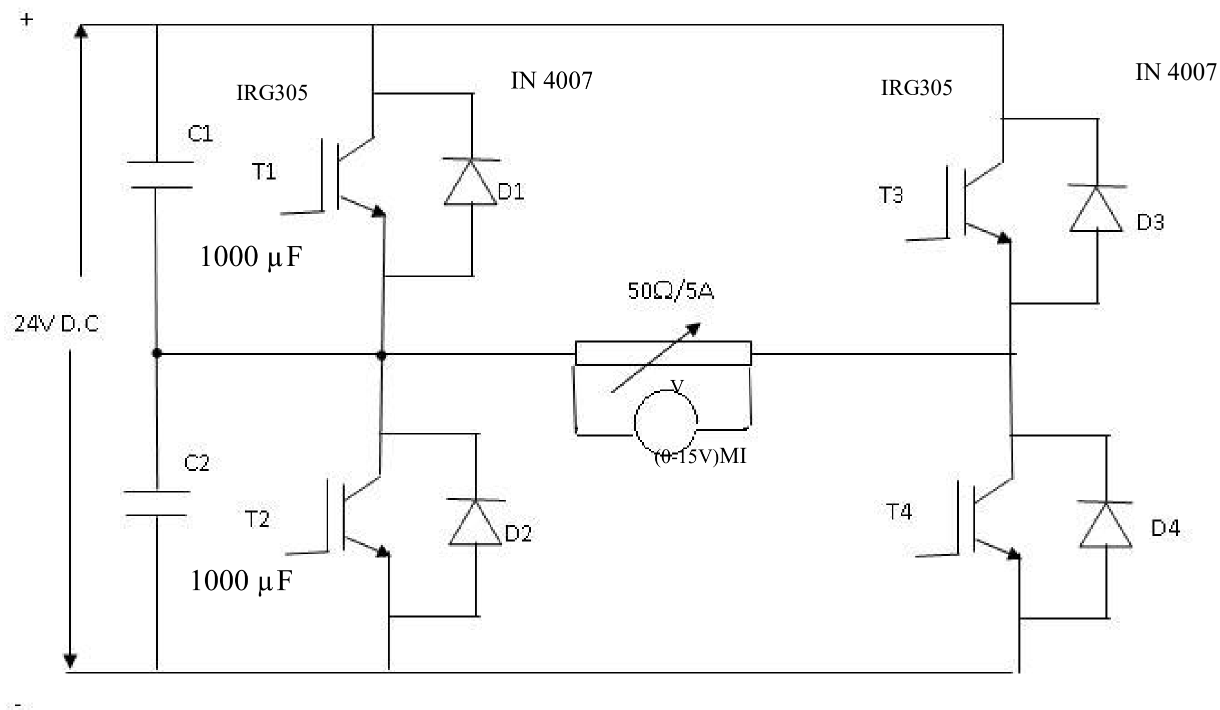
MODEL GRAPH (STEP DOWN CHOPPER):



RESULT:

Thus the output responses of Step down & Step up MOSFET based choppers were drawn.

CIRCUIT DIAGRAM:



TABULAR COLUMN:

S.no	Vin (Volts)	Amplitude (Volts)	Time Period(ms)		Time (ms)	Output voltage (v)
			T_{on}	T_{off}		

Date:

Ex. No.7

IGBT BASED SINGLE PHASE PWM INVERTER

AIM :

To obtain Single phase output wave forms for IGBT based PWM inverter

APPARATUS REQUIRED:

S.No.	ITEM	RANGE	TYPE	QUANTITY
1	IGBT Based PWM inverter Kit	220/10A		1
2	CRO	20MHZ		1
3	Patch Chord	-	-	Few
4	Load rheostat	50/5A		1

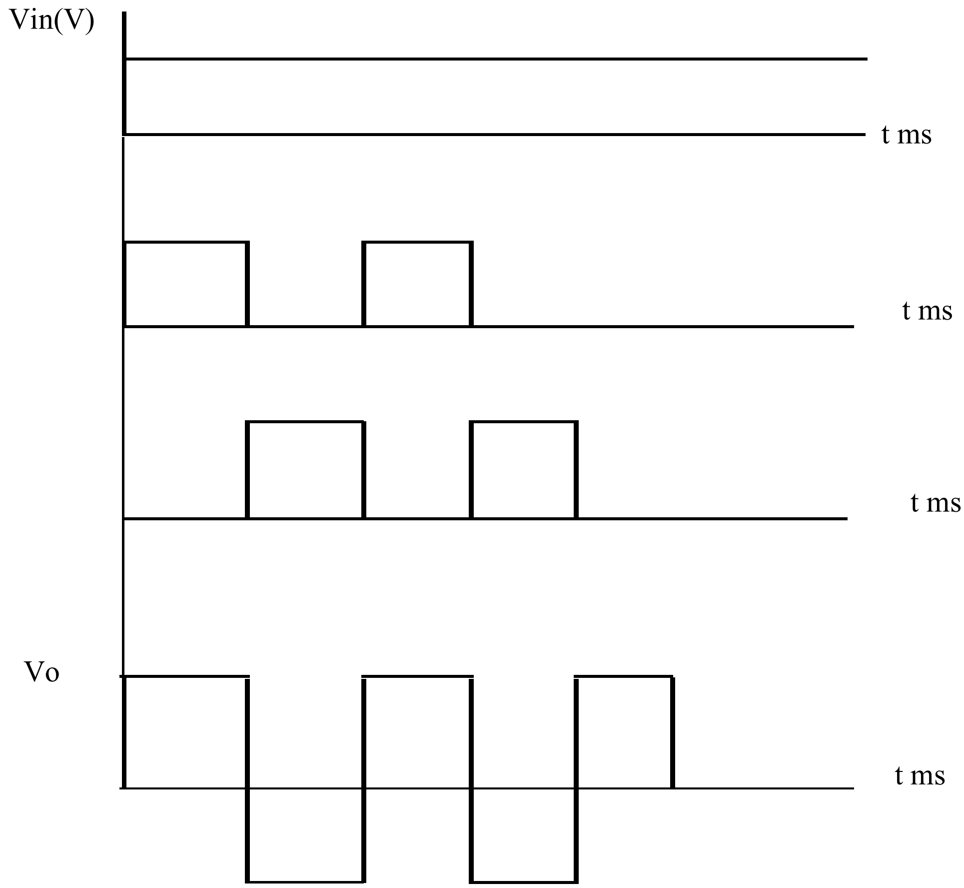
PROCEDURE :

1. Make the connection as per the circuit diagram.
2. Connect the gating signal from the inverter module.
3. Switch ON D.C 24V.
4. Keep the frequency knob to particulars frequency.
5. Observe the rectangular and triangular carrier waveforms on the CRO.
6. Obtain the output waveform across the load Rheostat.

Formula used:

$T=T_{on} + T_{off}$

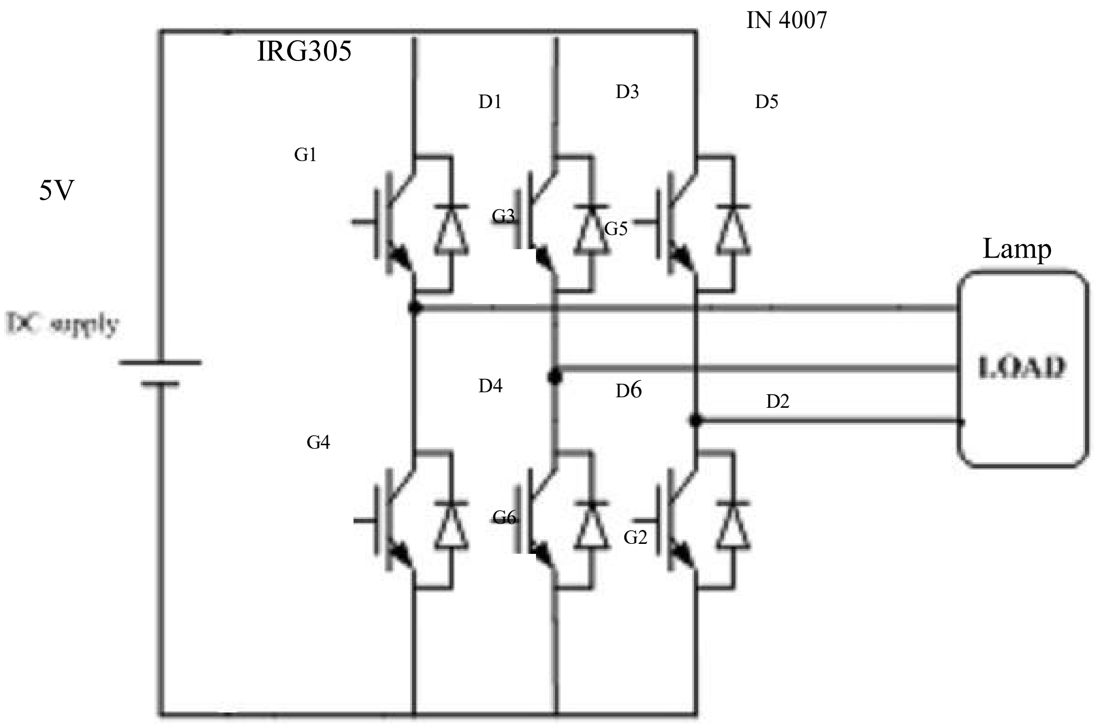
MODEL GRAPH:



RESULT:

Thus the output waveform for IGBT inverter (PWM) was obtained.

CIRCUIT DIAGRAM:



Date:

Ex. No.8

IGBT BASED THREE PHASE PWM INVERTER

AIM:

To obtain three phase output wave forms for IGBT based PWM inverter

APPARATUS REQUIRED:

S.No.	ITEM	RANGE	TYPE	QUANTITY
1	IGBT Based PWM inverter Kit	220/10A		1
2	CRO	20MHZ		1
3	Patch Chord	-		Few
4	Load rheostat	50/5A		1

PROCEDURE:

1. Make the connection as per the circuit diagram.
2. Connect the gating signal from the inverter module.
3. Switch ON D.C 24V.
4. Keep the frequency knob to particulars frequency.
5. Observe the input and output waveforms for 180° conduction mode and 120°conduction mode in the CRO.
6. Obtain the output waveform across the load Rheostat.

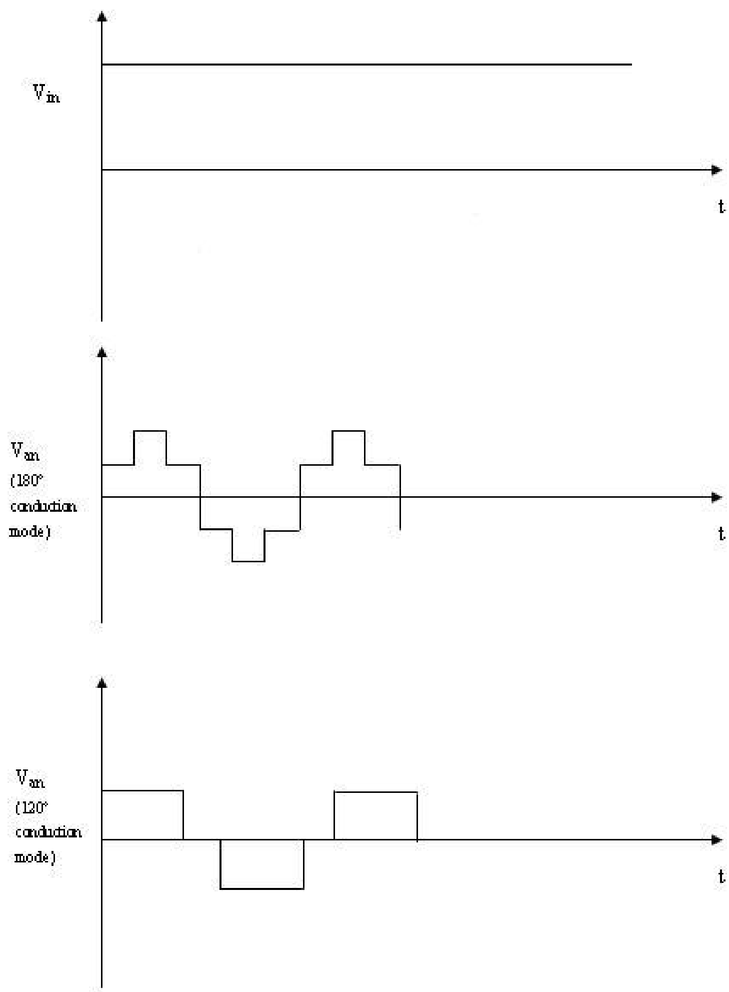
Formula used:

$T = T_{on} + T_{off}$

TABULAR COLUMN:

S.No.	Conduction Mode	V_{out} (Volts)	Time Period(ms)		Time (ms)
			T_{on}	T_{off}	

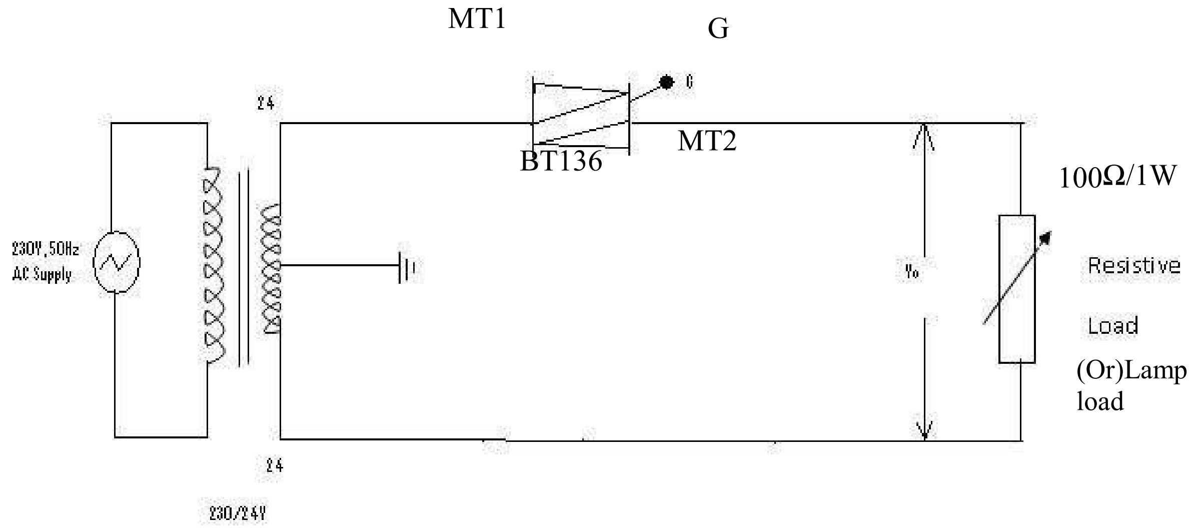
MODEL GRAPH:



RESULT:

Thus the output waveform for IGBT inverter (PWM) was obtained.

CIRCUIT DIAGRAM



Date:

Ex. No.9

AC VOLTAGE CONTROLLER

AIM:

To study the Single-phase AC voltage control using TRIAC with DIAC or UJT Firing Circuit.

APPARATUS REQUIRED:

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1	AC voltage control trainer kit			
2	Lamp	60w		1
3	Resistor	100 ohm/1W 1Kohm		1
4	DIAC	DB3		1
5	TRIAC	BT 136		1
6	CRO			1
7	Patch Chords			15

CIRCUIT OPERATION:

1. When potentiometer is in minimum position drop across potentiometer is zero and hence maximum voltage is available across capacitor. This Vc shorts the diac (Vc > Vbo) and triggers the triac turning triac to ON – state there lamp glows with maximum intensity.

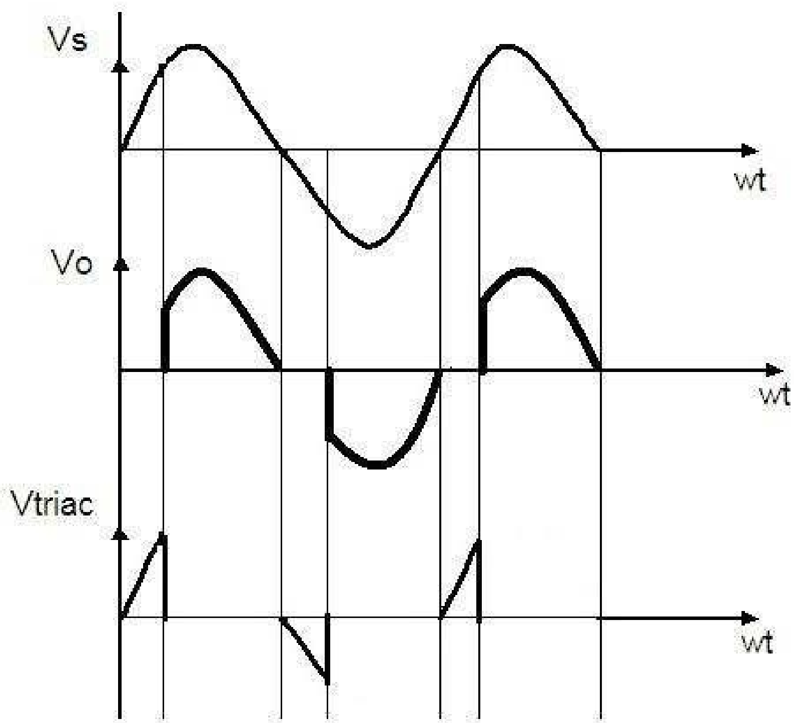
2. When the potentiometer is in maximum position voltage drop across potentiometer is maximum. Hence minimum voltage is available across capacitor (Vc M Vbo) hence triac to is not triggered hence lamp does not glow.

3. When potentiometer is in medium position a small voltage is available across capacitor hence lamp glows with minimum intensity.

TABULAR COLUMN: (DIAC or UJT Firing Circuit)

S.No	Vo (Volts)	Vin (Volts)	Ton (ms)	Toff (ms)	Firing Angle (Degree)

MODAL GRAPH:



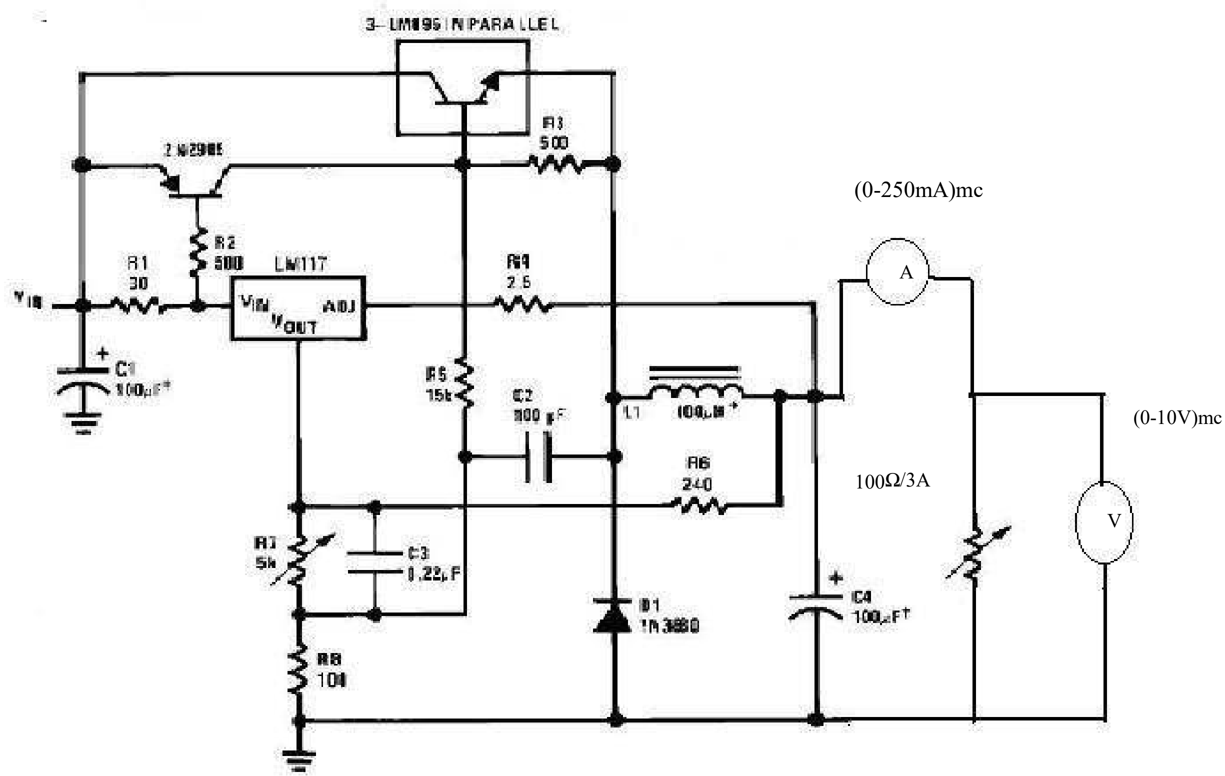
PROCEDURE:

1. Connections are given as per the circuit diagram
2. Initially potentiometer kept at minimum position so lap does not glow at this instant.
3. Note the voltage across the diac and triac.
4. Capacitor and potentiometer using multimeter and CRO.
5. Potentiometer is now placed at medium and then to minimum position and their voltages were noted.

RESULT:

Thus the operation and performance of the single phase AC voltage control using TRIAC is done and output Verified.

CIRCUIT DIAGRAM :



TABULAR COLUMN:

To find Line Regulation:

S.No.	V_{in}(Volts)	V_{out}(Volts)	I_t (Amps)	Regulation (%)

Date:

Ex. No. 10

SWITCHED MODE POWER CONVERTER

AIM:

To construct a switched mode power Converter and find its efficiency.

APPARATUS REQUIRED:

S.NO.	APPARATUS	RANGE	TYPE	QUANTITY
1	Switched mode power converter kit	(0-30V),AC input	-	1
3	Ammeter	(0-1A)	MC	2
4	Voltmeter	(0-30V)	-	2
5	Loading Rheostat	100 / 2A	-	1
6	Connecting wires	-	-	Required

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Connect the mains card to the 220V AC and note the regulated DC output as 10V in the voltmeter.
3. Connect a Rheostat of 100 / 2A across output voltmeter and measure the load current in the Ammeter.
4. Increase the load from the rheostat and note that there is no decrease from the output voltage 10VDC.
5. Note down the voltmeter reading.
6. Switch off the power supply and disconnect.

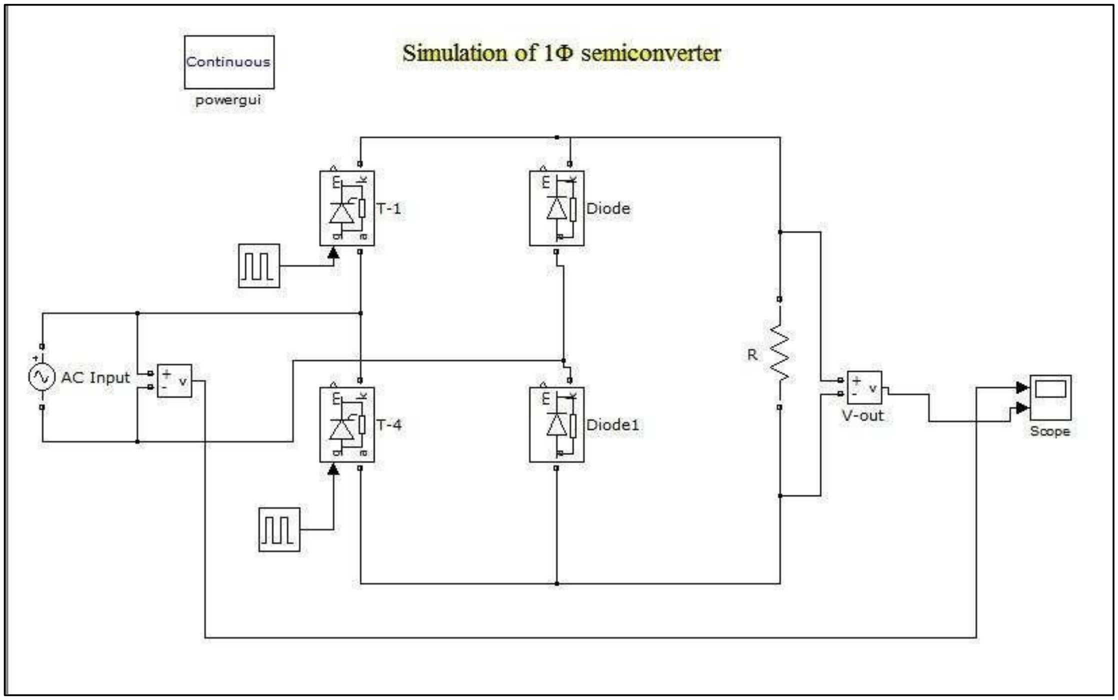
To find Load Regulation:

S.No.	V_{in}(Volts)	V_{out}(Volts)	I_t (Amps)	Regulation (%)

RESULT:

Thus a Switched mode power converter was constructed and found out the efficiency.

MATLAB MODEL:



OUTPUT WAVEFORMS:

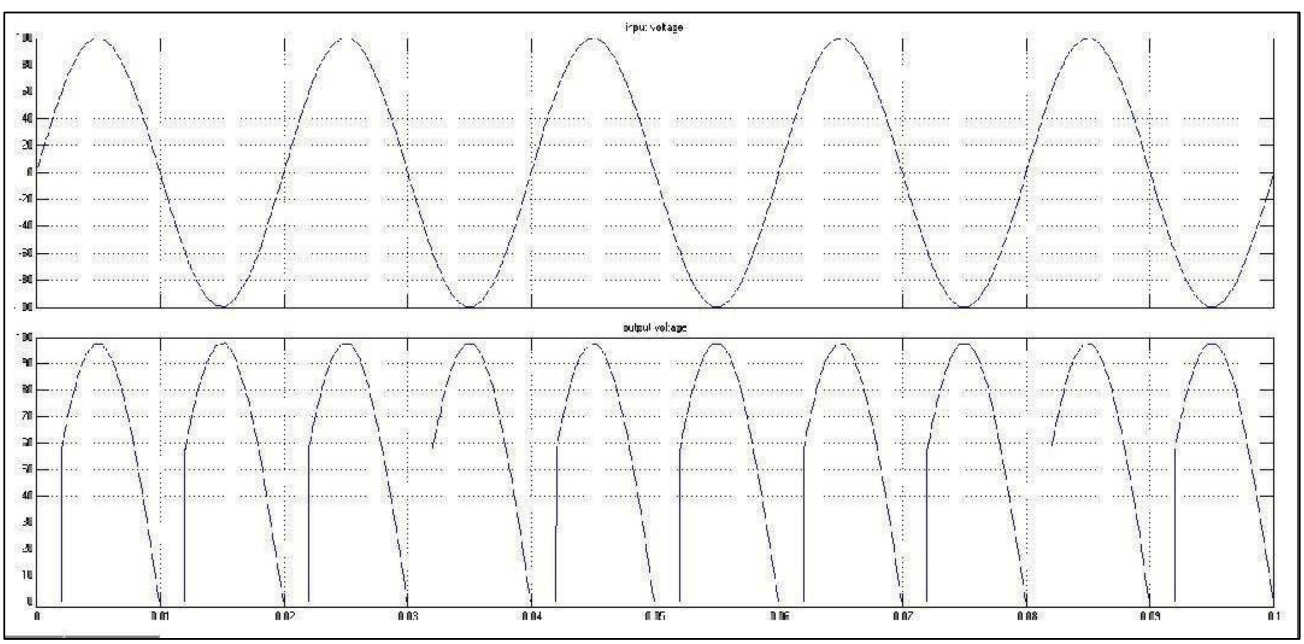
Set AC Input Parameter

(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)



DATE:

Ex. No. 11

SIMULATION OF POWER ELECTRONICS CIRCUITS

STUDY OF BASIC MATLAB COMMANDS:

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**.

Date:

Ex. No. 11(A)

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 SEMICONVERTER

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:

1. In MATLAB software open a new model in**File->New->model.**
2. Start SIMULINK library browser by clicking the symbol  in tool bar
3. 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.

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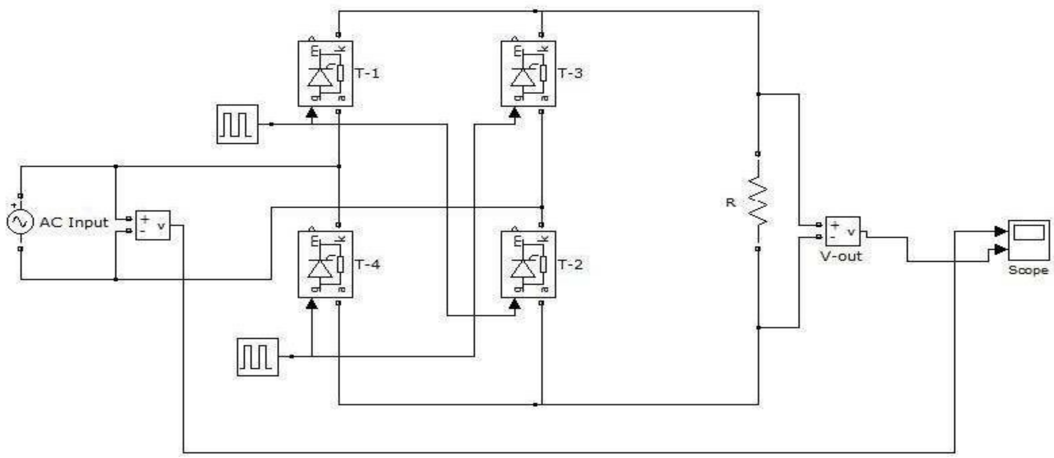
4. Drag the needed blocks from the library folders to that new untitled simulink window. You must give it a name using the **Save As** menu command under the **File menu** heading. The assigned filename is automatically appended with an **.mdl** extension.
5. Arrange these blocks in orderly way corresponding by **Mat lab Model** Shown Below.
6. Interconnect the blocks by dragging the cursor from the output of one block to the input of another block.
7. Double click on any block having parameters that must be established and set these parameters.
8. 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 tool bar.
9. 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.
10. Finally Save the Output.

RESULT:

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

Simulation of 1Φ fullconverter:



<u>OUTPUT WAVEFORMS:</u>

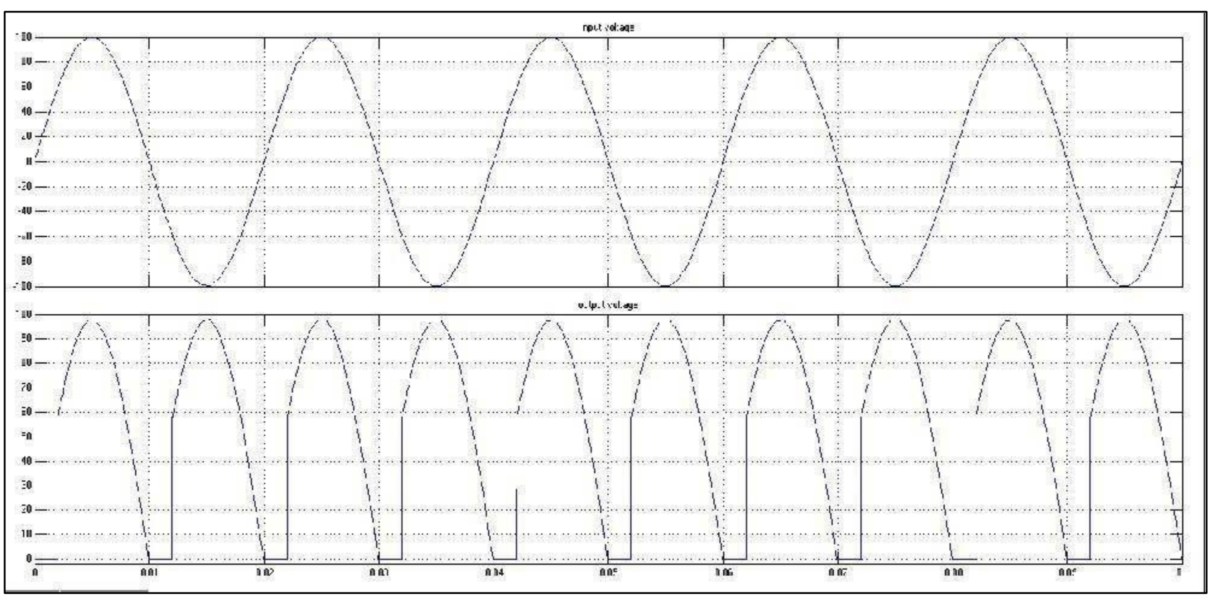
Set AC Input Parameter

(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)



Date:

Ex. No. 11(B)

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 FULLCONVERTER

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-phase 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.

Vout=(2Vs)(Cosα)/π

Iavg=Vavg/R

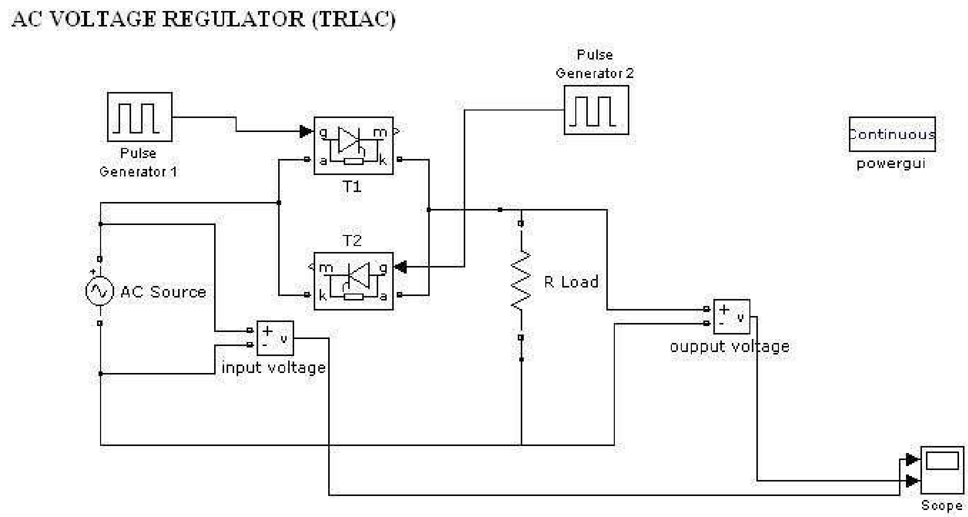
PROCEDURE:

1. In MATLAB software open a new model in **File->New->model.**
2. Start SIMULINK library browser by clicking the symbol  in tool bar
3. 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.
4. 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.
5. Arrange these blocks in orderly way corresponding by **Matlab Model** Shown Below.
6. Interconnect the blocks by dragging the cursor from the output of one block to the input of another block.
7. Double click on any block having parameters that must be established and set these parameters.
8. 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.
9. 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.
10. 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:

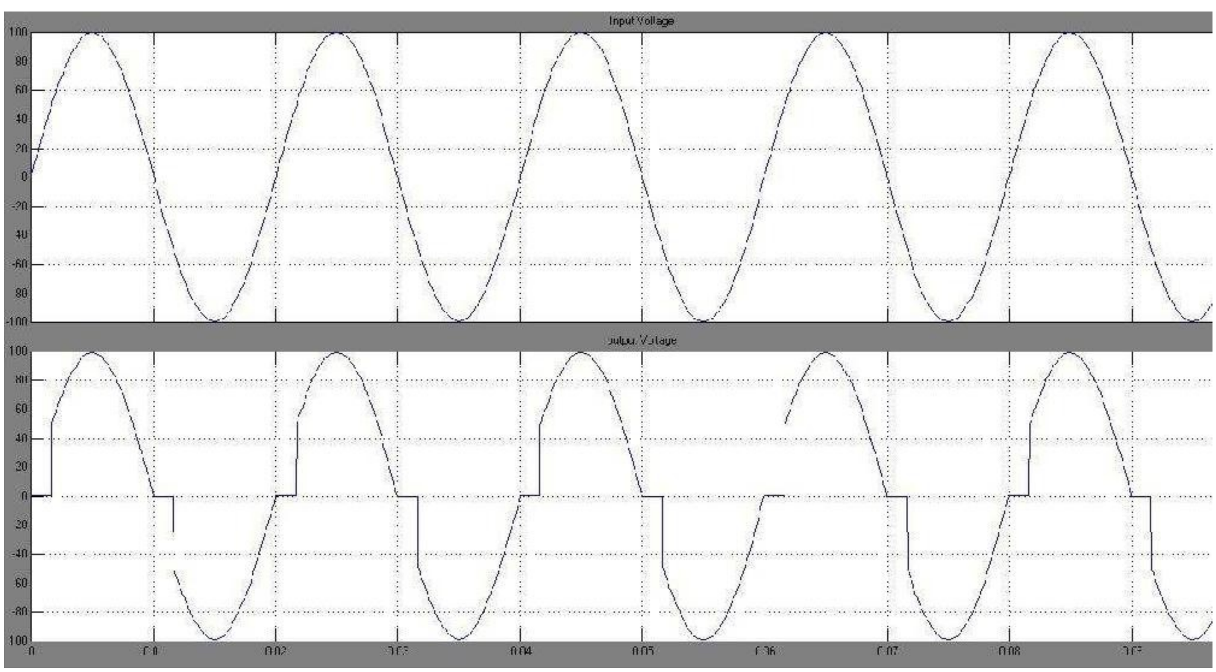
Set AC Input Parameter

(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)



Date:

Ex. No. 11(C)

SIMULATION OF SINGLE-PHASE AC VOLTAGE CONTROL USING TRIAC

AIM:

To simulate single Phase AC Voltage Control Using TRIAC circuit with R load in MATLAB - 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:

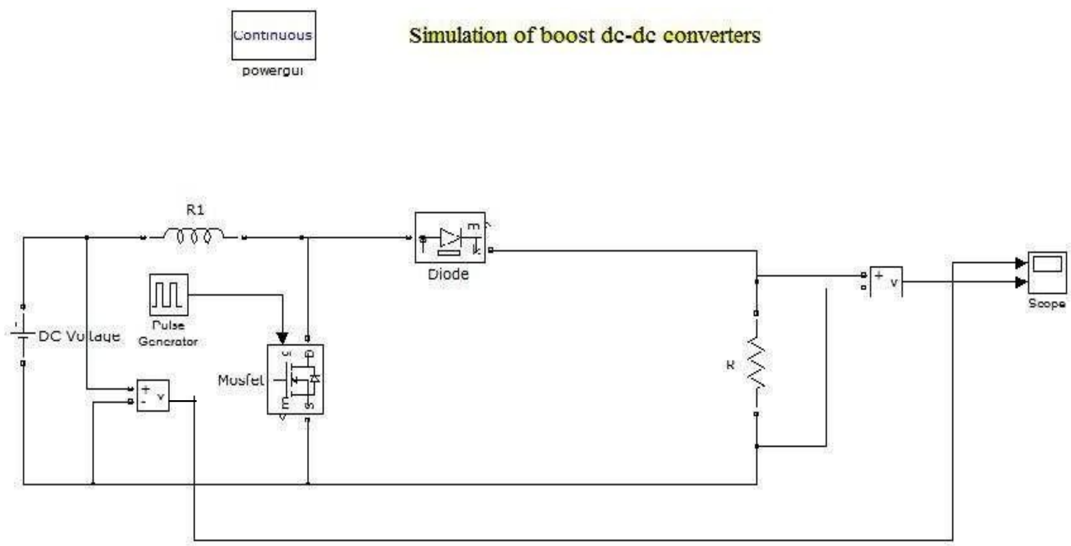
1. In MATLAB software open a new model in **File->New->model.**
2. Start SIMULINK library browser by clicking the symbol  in toolbar
3. And Open the libraries that contain the blocks you will need. These usually will include the sources, sinks, math and continuous function block and possibly other.
4. 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.
5. Arrange these blocks in orderly way corresponding by **Matlab Model** Shown Below.
6. Interconnect the blocks by dragging the cursor from the output of one block to the input of another block.
7. Double click on any block having parameters that must be established and set these parameters.
8. 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.
9. 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.
10. Finally Save the Output.

RESULT:

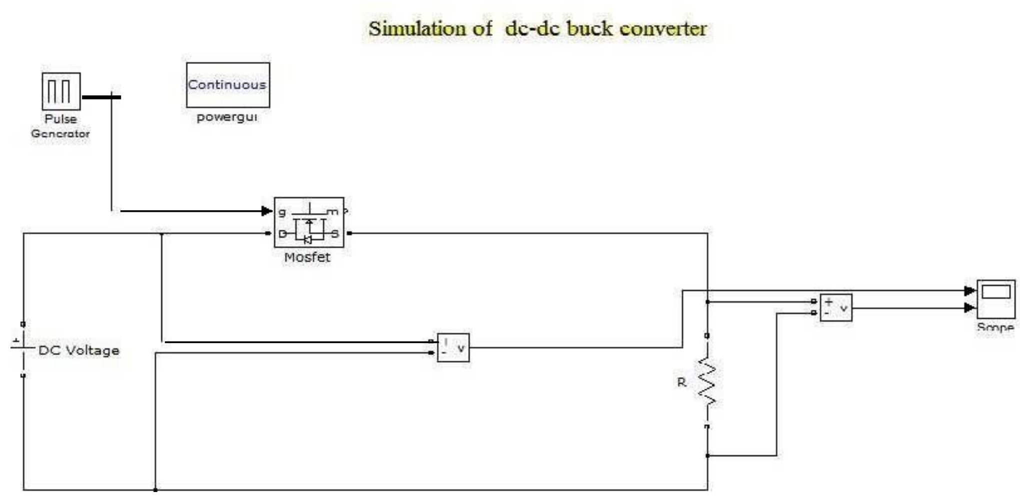
Thus the simulation of single Phase AC Voltage Control Using TRIAC model is done and the output is verified using MATLAB Simulink.

MATLAB MODEL:

DC-DC BOOST CONVERTER



DC-DC BUCK CONVERTER



Date:

Ex. No. 11(D)

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:

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:

1. In MATLAB software open a new model in **File->New->model.**
2. Start SIMULINK library browser by clicking the symbol  in tool bar
3. 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.
4. 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.
5. Arrange these blocks in orderly way corresponding by **Matlab Model** Shown below.
6. Interconnect the blocks by dragging the cursor from the output of one block to the input of another block.
7. Double click on any block having parameters that must be established and set these parameters.
8. 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.
9. 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.
10. Finally Save the Output.

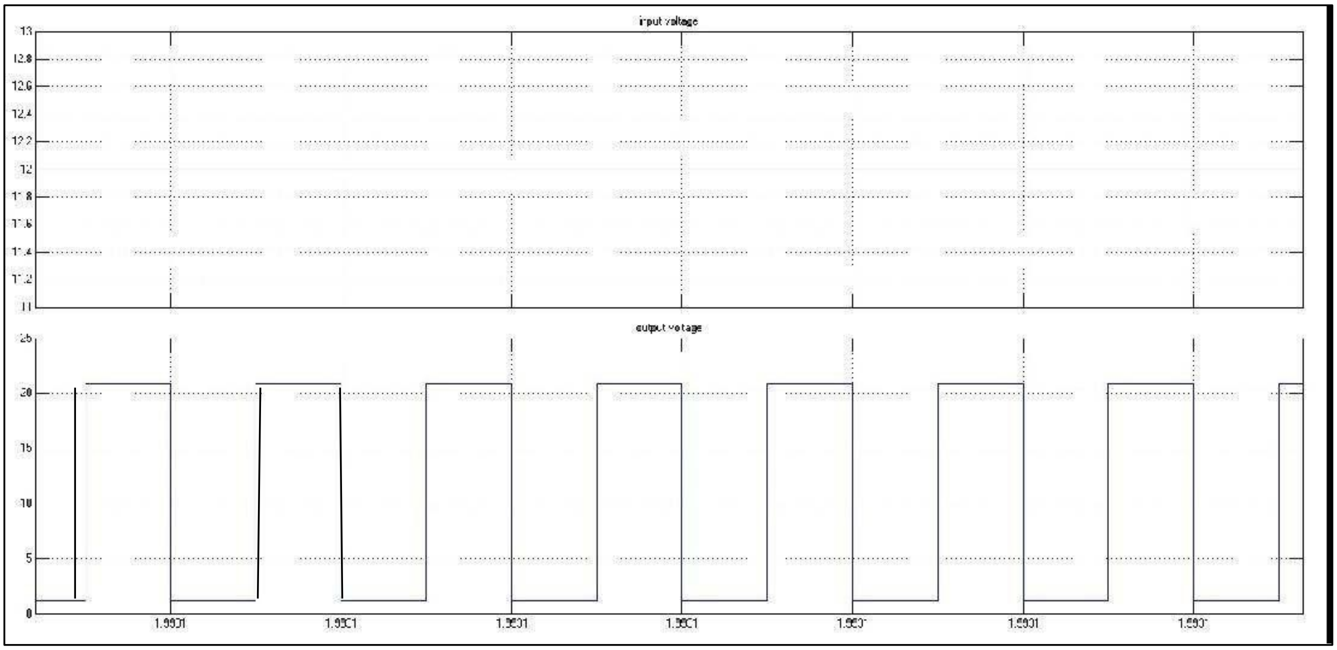
<u>OUTPUT WAVEFORMS:</u>

DC-DC BOOST CONVERTER

Set DC Input Parameter (Amplitude =12 V)

Set Inductor Parameter (Inductance=0.1 H)

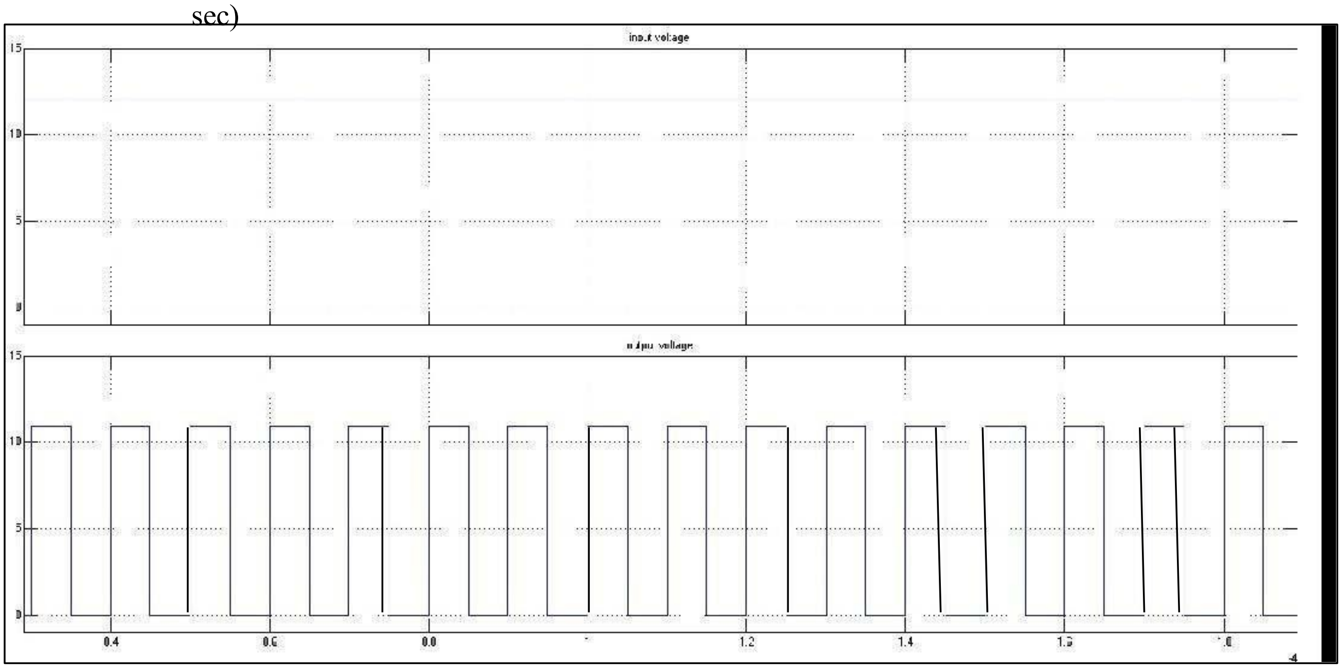
Set Pulse generator Parameter (Period=10e-6 sec, Pulse width=50% and Phase delay=0 sec)



DC-DC BUCK CONVERTER

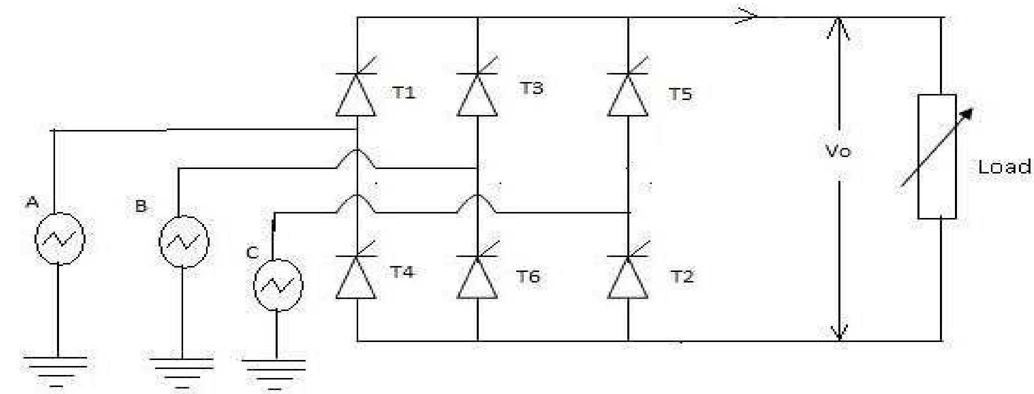
Set DC Input Parameter (Amplitude =12 V)

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

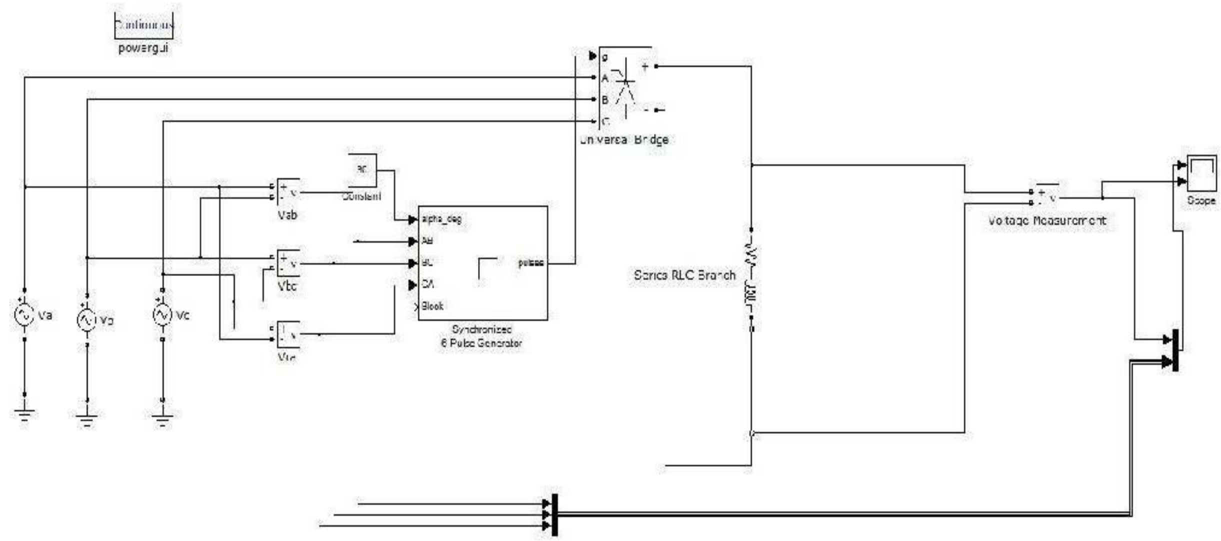


RESULT:

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



MATLAB MODEL:



Date:

Ex. No. 11(E)

SIMULATION OF THREE PHASE FULL CONVERTER

AIM:

To simulate three phase Full 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=30^0. Hence T1 can be triggered only at wt=30^0.If firing angle is α, then T1 starts conduction at wt=30 + α and conducts for 120^0 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 instant(degree)**	**Triggering instant(degree)**	**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

$Vavg = \frac{3\sqrt{3}}{} Vmcos\ \alpha$ where Vm is the maximum value of phase to neutral voltage

Average Value of output current is given by

$Iavg = \frac{3\sqrt{3}}{\Gamma R} Vmcos\ \alpha$ where R is the load resistance

OUTPUT WAVEFORMS:

DC-DC BOOST CONVERTER

Set AC Input Parameter

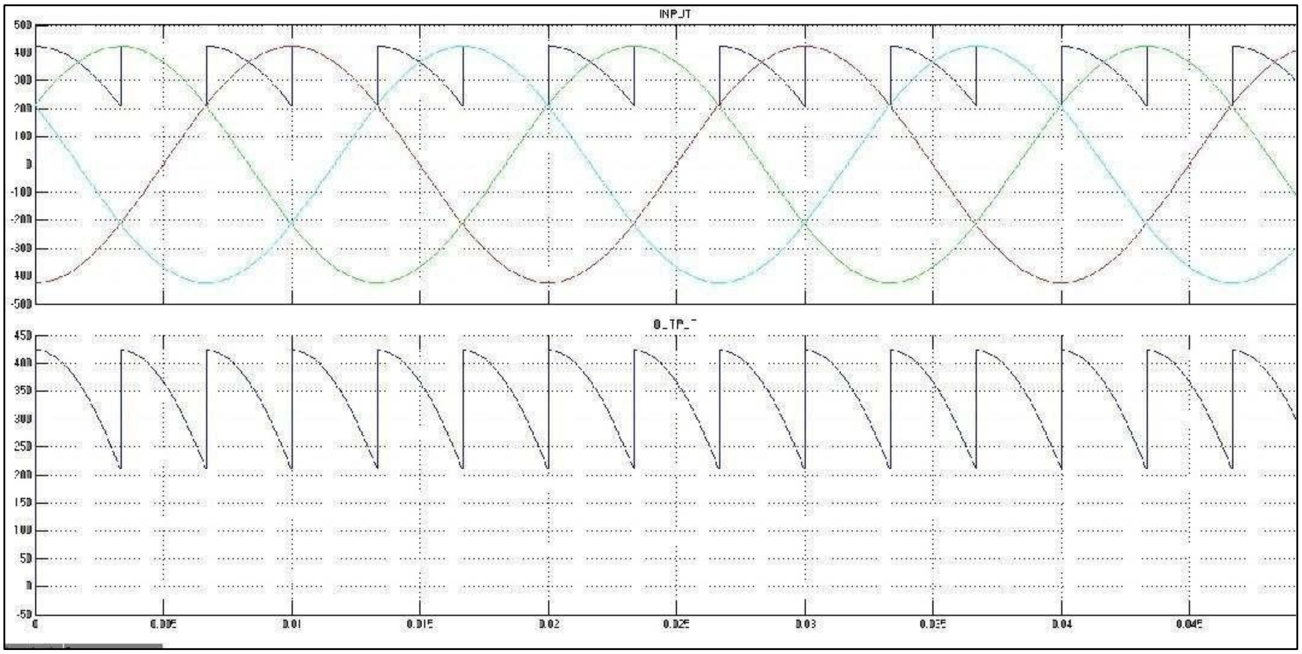
(For Va : Peak amplitude =245 V, Phase=0 deg and Frequency=50 Hz)

(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)



PROCEDURE:

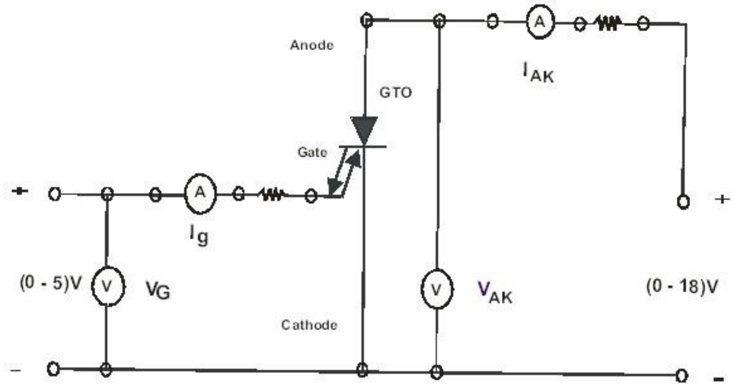
1. In MATLAB software open a new model in **File->New->model.**
2. Start SIMULINK library browser by clicking the symbol  in tool bar
3. And Open the libraries that contain the blocks you will need. These usually will include the sources, sinks, math and continuous function block and possibly other.
4. 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.
5. Arrange these blocks in orderly way corresponding by **Matlab Model** Shown Below.
6. Interconnect the blocks by dragging the cursor from the output of one block to the input of another block.
7. Double click on any block having parameters that must be established and set these parameters.
8. 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.
9. 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.
10. Finally Save the Output.

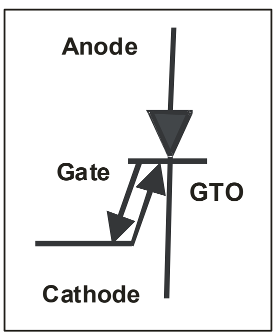
RESULT:

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

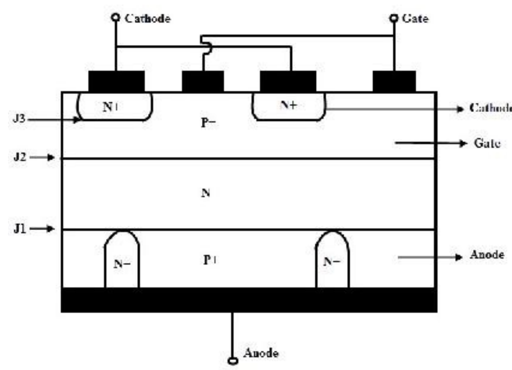
Circuit Diagram:



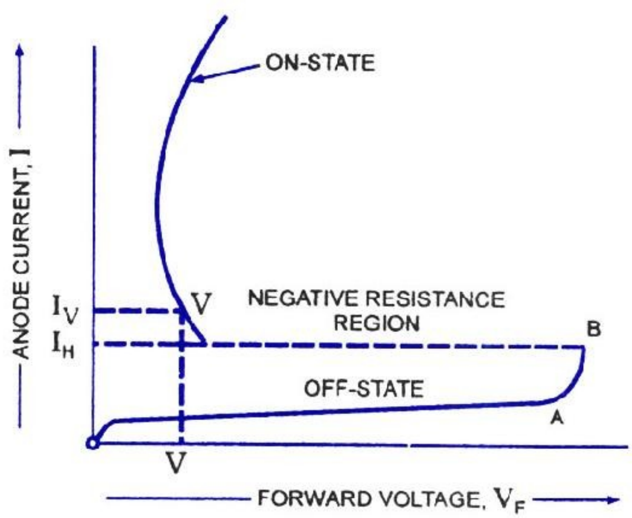
GTO SYMBOL:



GTO Construction:



MODELGRAPH:



Date:
Ex. No. 12

CHARACTERISTICS OF GTO (Gate Turn off Thyristor)

AIM :

To determine the static characteristics of Gate Turn off Thyristor.

APPARATUS REQUIRED:

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1	GTO unit	BTV 68 750 R		1
2	Regulated Power Supply	(0-30) V		2
3	Voltmeter	(0-30) V	MC	1
4	Ammeter	(0-30)mA	MC	1
5	Ammeter	(0-15)mA	MC	1
6	Connecting wires			Few

THEORY:

GTO: A gate turn-off thyristor (GTO) is a special type of thyristor, a high-power semiconductor device. GTOs, as opposed to normal thyristors, are fully controllable switches which can be turned on and off by their GATE lead. Turn on is accomplished by a "positive current" pulse between the gate and cathode terminals. As the gate-cathode behaves like PN junction, there will be some relatively small voltage between the terminals. The turn on phenomenon in GTO is however, not as reliable as an SCR (thyristor) and small positive gate current must be maintained even after turn on to improve reliability. Turn off is accomplished by a "negative voltage" pulse between the gate and cathode terminals. Some of the forward current is used to induce a cathode-gate voltage which in turn induces the forward current to fall and the GTO will switch off (transitioning to the 'blocking' state).GTO thyristors suffer from long switch off times, whereby after the forward current falls, there is a long tail time where residual current continues to flow until all remaining charge from the device is taken away.

OBSERVATION TABLE:

S.NO	For Turn on GTO		For Turn off GTO	
	Positive gate Ig =		Negative gate -Ig =	
	Vg =	Ig =	-Vg =	-Ig =
1				
2				
3				
4				
5				

PROCEDURE:

1. Connections are made as shown in the diagram.
2. Set the voltage between anode and cathode as anode is made positive with respect to cathode (18V).
3. Set the voltage between gate and cathode as gate is made positive with respect to cathode for turn on the GTO (3.3V).
4. Vary the gate current by varying the potentiometer.
5. Note the different values for Vak , Ig & Iak and make gate current constant (at threshold).
6. Draw the graph between Vak and Ig.
7. Make the gate voltage zero and gate current pot to minimum. Still the device will be in on state.
8. Set the voltage between gate and cathode (-3.3V) as gate is made negative with respect to cathode for turn off the GTO.
9. Vary the gate current (negative). Now the device will come to the off state.
10. Note the different values for Vak and Ig and make negative gate current constant (at threshold).
11. Draw the graph between Vak and Ig.

RESULT:

Thus the Static Characteristics of GTO was obtained.

Date:

Ex. No. 13

CHARACTERISTICS OF PMBLDC MOTOR

AIM:

To study the open and closed loop Characteristics of PMBLDC motor.

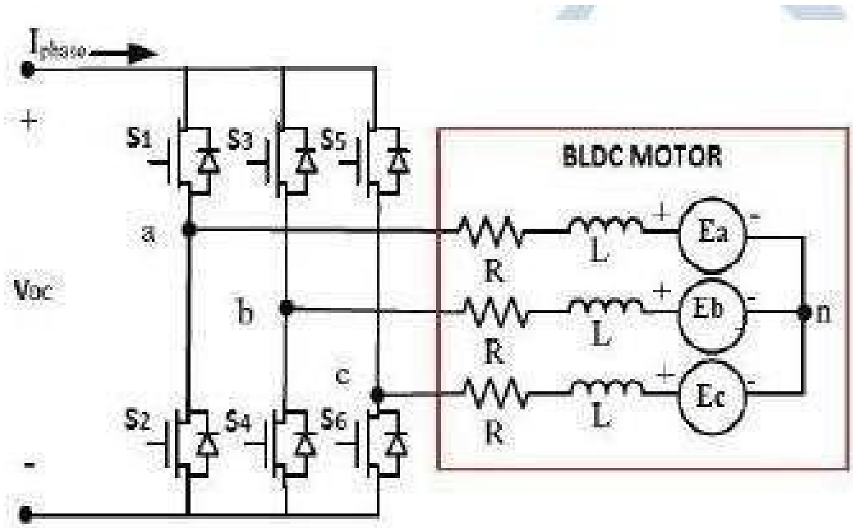
APPARATUS REQUIRED:

1. PEC16DSMOITrainer
2. Micro-2812Trainer
3. BLDC Motor
4. RPS(0-30V)
5. Hall sensor signal conditioner
6. Cables

CONNECTION PROCEDURE:

1. Connect the 3phase AC supply to R, Y and B terminals of PEC16DSMOI power Module.
2. Connect the U, V Wire terminals (through switching output connector) in the PEC16DSMOI power Module to the 7 pin supply connector to the motor.
3. Connect the 17 pin feedback Connection from the motor in to hall sensor signal conditioner (through 9 pin D connector).
4. Connect the 34 PIN FRC cable one ends to the 34 pin FRC Header in Micro-2812 Trainer one end of Hall sensor signal conditioner and the other end to IGBT-PWM INPUTS in the PEC16DSMOI power module.
5. Connect the serial port of PC to the serial port connection in the Micro-2812Trainer
6. Connect the one end of 26 pin FRC cable to 26 pin connector placed in Micro-2812 trainer and the other end to feedback inputs in PEC16DSMOI power Module
7. Connect (0-30V) DC supply to the Eddy current coil terminals
8. Switch of the power supply and disconnect the connection

PMBLDC MOTOR Characteristics:



EXPERIMENT PROCEDURE:

1. Verify the connections as per the connection procedure connection diagram.
2. Switch on the Micro-2812Trainer
3. Switch on the MCB and the power ON/OFF switch in the Intelligent power Module

   (PEC16DSMOI)
4. Check weather shutdown LED “SD” glows or not. If “SD” LED glows press the reset switch,

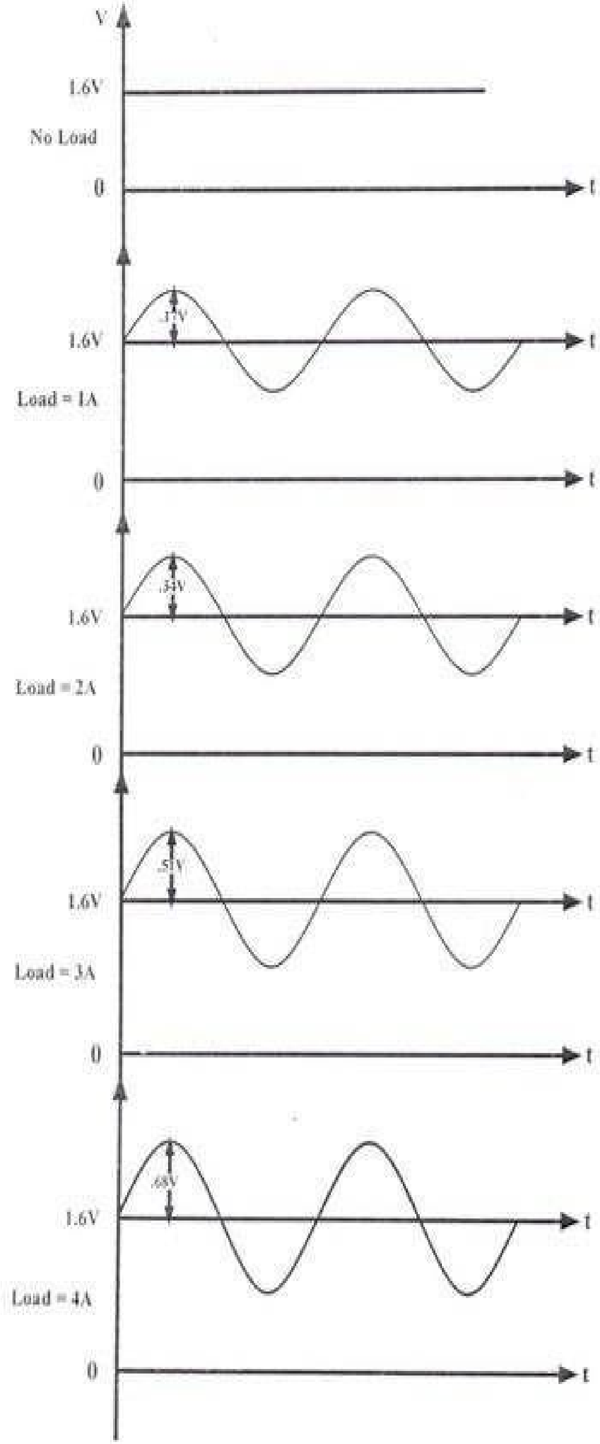
   the LED gets OFF.
5. Apply the input voltage slowly to 450V(DC rail Voltage, which is

   shown in the power modules voltmeter)
6. Switch ON the PC and then press reset Switch of the Micro-2812Trainer
7. Download and execute the program by following the program download

   procedure given below.
8. Clicks open the Vi BLDC-2812 from the desktop (or) from the target directory. The window

   displays as shown below.

Wave Form:

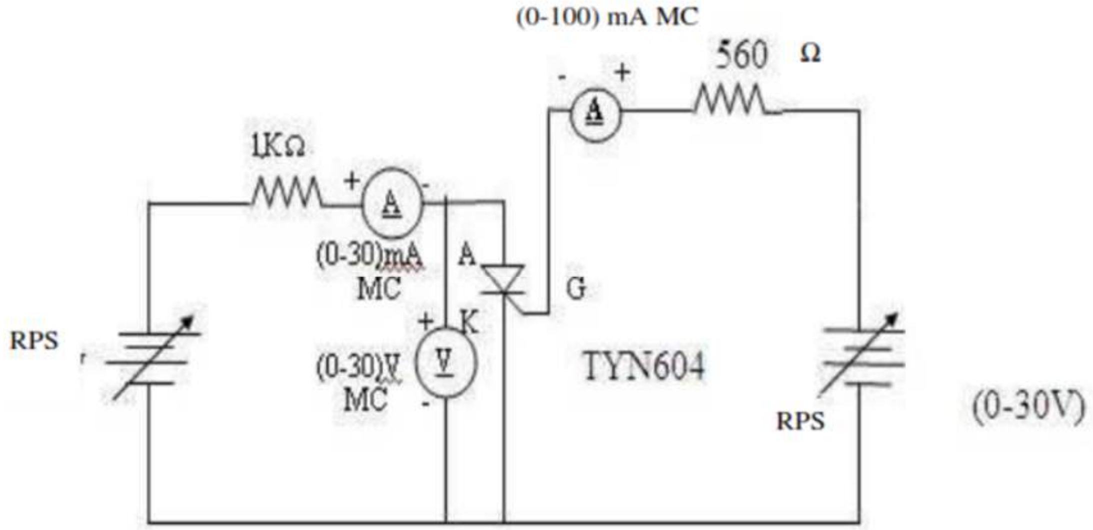


V
1.6V
No Load
0
t
.17V
1.6V
Load = 1A
0
t
.34V
1.6V
Load = 2A
0
t
.51V
1.6V
Load = 3A
0
t
.68V
1.6V
Load = 4A
0
t

RESULT:

Thus the open and closed loop Characteristics of PMBLDC motor operation were studied and its output waveform were plotted.

CIRCUIT DIAGRAM:



Date:

Ex. No.14

DYNAMIC CHARACTERISTICS OF SCR AND MOSFET

Ex. No. 14(a)

DYNAMIC CHARACTERISTICS OF SCR

AIM :

To determine the Dynamic characteristics of Silicon Controlled Rectifier.

APPARATUS REQUIRED:

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1	SCR	TYN 604		1
2	Regulated Power Supply	(0-30) V		1
3	Voltmeter	(0-30) V	MC	1
4	Ammeter	(0-30)mA	MC	1
5	Ammeter	(0-100)µA	MC	1
6	Resistor	1 kΩ,560Ω		1
8	Connecting wires			Few

PROCEDURE:

1. To determine the Characteristics of SCR

1) Make the connections as per the circuit diagram.
2) Switch on the supply
3) Set the gate current at a fixed value by varying RPS on the gate-cathode side.
4) Increase the voltage applied to anode-cathode side from zero until breakdown occurs.
5) Note down the breakdown voltage.
6) Draw the graph between anode to cathode voltage (v_{ak}) and anode current(i_a)

Dynamic characteristic:

- The switching action does not take place instantaneously but it will take some finite time.
- We will discuss turn on and turn off switching characteristic of the SCR in this section.

Turn on time (ton)

- The turn on time of the SCR is defined as the time during which the SCR changes from forward blocking state to forward conducting state.
- The total turn on time of the SCR is divided in to two intervals : Delay time and Rise time

  ton = td + tr

Delay time (td)

- It is time duration from the instant at which the gate current reaches 90% of its final value to the instant at which anode current reaches 10% of its final value.
- OR
- It is defined as time during which anode voltage falls from VA to 90% of VA.
- OR
- It is defined as time during which anode current rises up to 10% of final value from forward leakage current.
- The delay time can be decreased by applying high gate current and more forward anode to cathode voltage.
- Rise time (tr)
- It is defined as time during which anode current rises from 10% to 90% of final value.
- OR
- It is defined as the time required for the forward off state voltage reduces form 90% to 10% of initial value.
- The rise time is reduced by applying high and steep gate pulses.
- However the rise time depends upon the nature of the anode current i.e. The rise time is less for RC circuit and more for RL circuit.
- The total turn on time is given in the range of micro second.
- The actual turn on time of the SCR is much higher than the turn on time given in the manufacturer’s data sheet.

Dynamic characteristic of SCR:

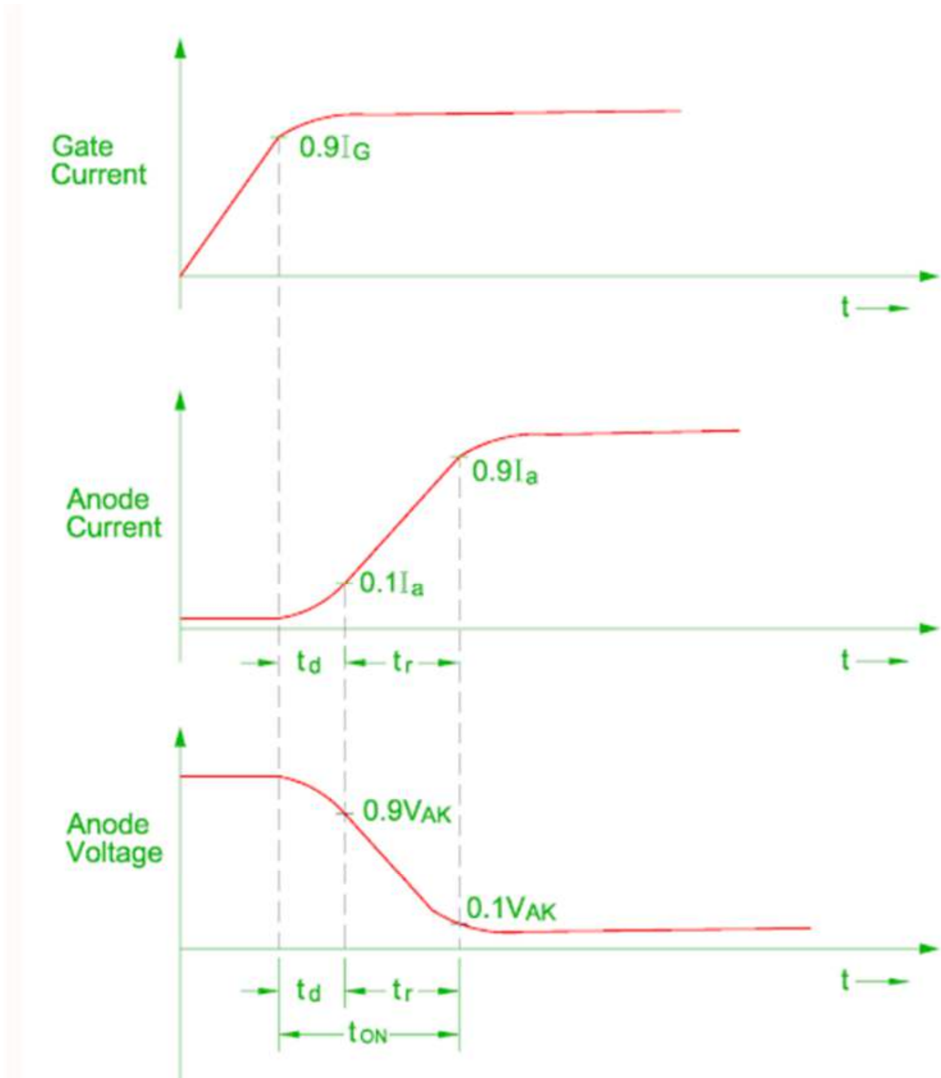


FIG C : SCR - turn on Waveforms

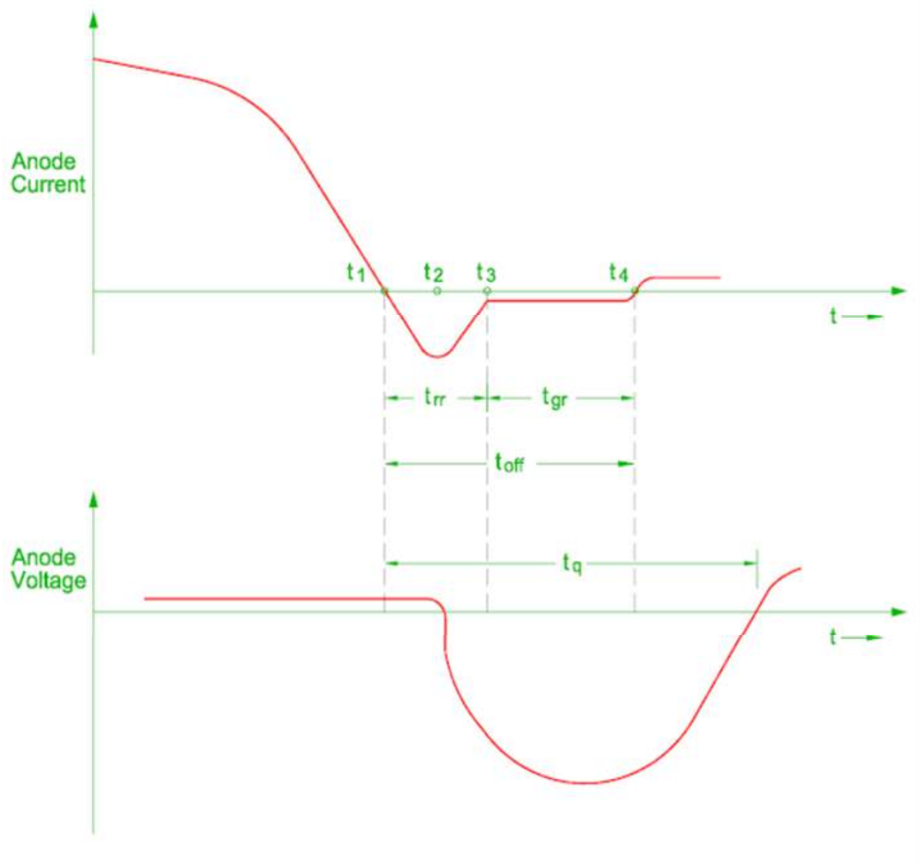
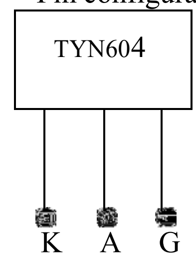


FIG D : SCR turn off Waveforms

Pin configuration



Turn off time (toff)

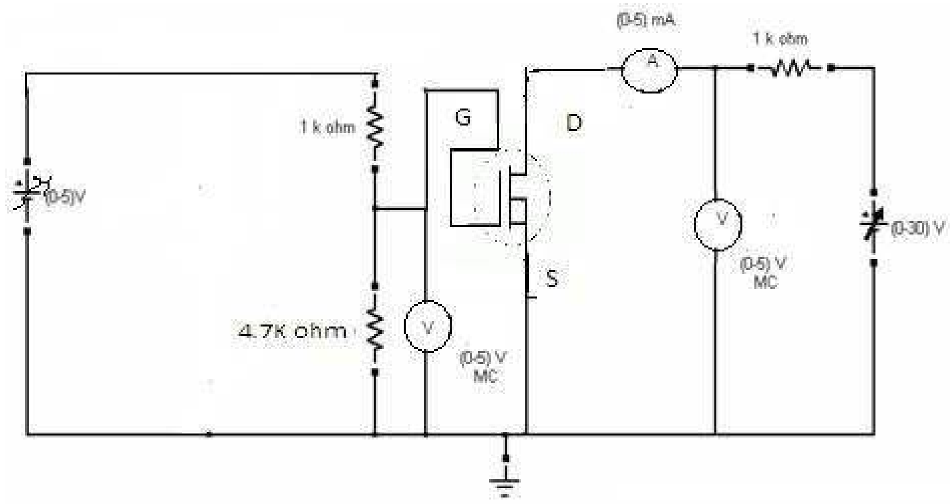
- Once the SCR start to conduct, gate loses control.
- The SCR can be turned off by reducing the anode current below holding current for sufficient time.
- This can be achieved by natural commutation or forced commutation.
- The turn off time of the SCR is defined as the time interval between the instant at which the anode current becomes zero and the instant at which SCR regain forward blocking voltage.
- The total turn off time can be divided in to two intervals : reverse recovery time (trr) and gate recovery time (tgr)

- The anode current becomes zero at instant t1.
- The anode current flows in the opposite direction during reverse recovery time (t3 – t1).
- The reverse anode voltage developed across the SCR at the instant t2 and reverse current continue to decrease.
- Therefore the reverse recovery time is defined as the time between the current reversal and the instant at reverse current has decayed to 10% of negative peak value.
- The reverse recovery time increases as the forward current increases.
- When the reverse recovery current stops, high transient voltage appears across the SCR which may damage it.
- The middle junction J2 contains charges which must decay only by recombination at the end of reverse recovery time.
- This recombination is possible if a reverse voltage is maintained across the SCR therefore the time for recombination of charges (t3 – t4) is called as gate recovery time tgr.
- The recombination is stopped at time t4 and forward voltage can be reapplied at time instant.
- The turn off time of the SCR is given is in the range of 3 to 100 micro second.
- The circuit turn off time must be greater than the SCR turn off time in actual practice.
- Therefore the circuit turned off time tc is defined as the time between the instant anode current becomes zero and at the instant reverse voltage becomes practically zero.
- The circuit turned off time tc must be greater than the SCR turn off time otherwise the SCR may turn on at undesired instant and it is known as commutation failure.
- The turn off time increases with increase in the magnitude of anode current and junction temperature.
- It also depends upon type of commutation circuit i.e. natural commutation or forced commutation

RESULT:

Thus the Dynamic Characteristics of SCR were obtained.

CIRCUIT DIAGRAM (MOSFET):



Date:

Ex. No.14(b)

DYNAMIC CHARACTERISTICS OF MOSFET

AIM:

To determine the Dynamic characteristics of MOSFET.

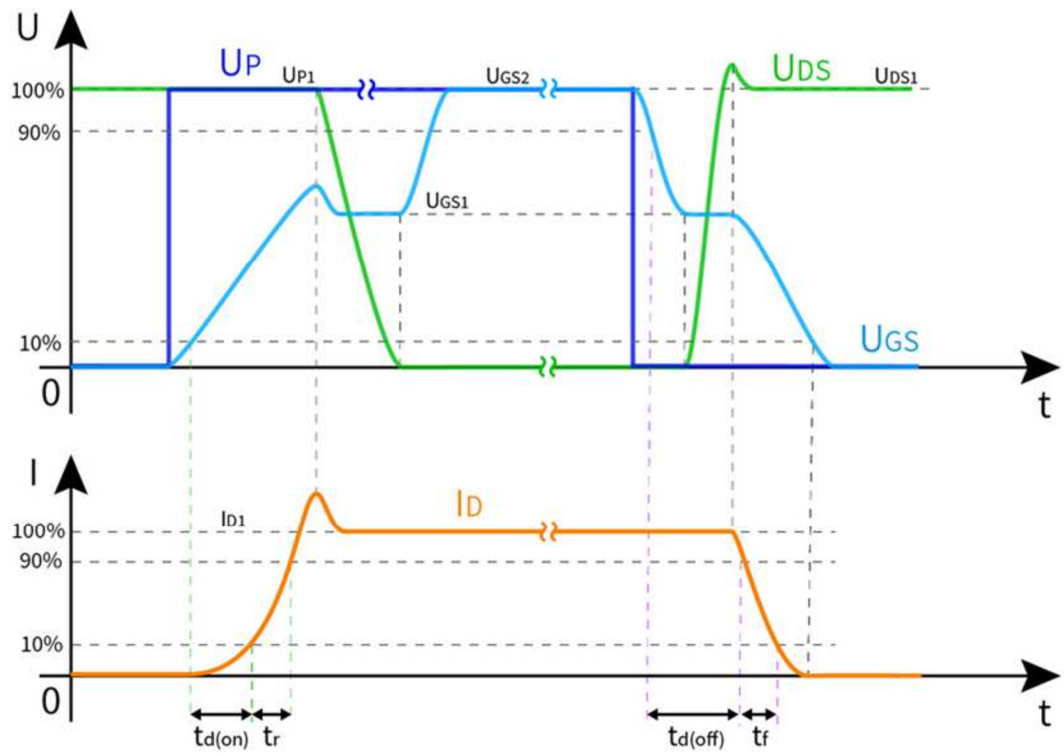
APPARATUS REQUIRED:

S.No.	APPARATUS	RANGE	TYPE	QUANTITY
1	MOSFET Module kit	220 V / 5 A		1
2	Regulated Power Supply	(0-15) V		1
3	Regulated Power Supply	(0-30) V		1
4	Voltmeter	(0-5) V	MC	1
5	Voltmeter	(0-30) V	MC	1
6	Ammeter	(0-5) mA	MC	1
7	Resistor	4.7 KΩ, 1 kΩ		1
8	Patch Chords			10

PROCEDURE:

1) Make the connections as per the circuit diagram.
2) Switch on the supply.
3) Set the gate current at a fixed value by varying RPS on the gate-cathode side.
4) Vary the voltage applied across Gate and corresponding V_{DS} (V_{CE}) and I_D(I_C) is noted.
5) The above steps are repeated for different values of I_G.
6) Vary the voltage across Collector and Emitter and noted down V_{GE} and I_C.
7) Draw the graph between V_{GS}(V_{CE})and I_D(I_C) and V_{GS}(V_{GE})and I_D(I_C).

Dynamic characteristic of MOSFET:



Turn-on Process

In order to switch the MOSFET to the on-state, a steep input power source U_{P1} must be applied to its gate. Due to the existence of the internal resistance R_S of the driving circuit and the gate-source parasitic capacitance C_{GS}, the gate voltage U_{GS} of the MOSFET cannot form a pulse waveform as steep as U_{P1}, but rises with a certain slope. When the driving current starts to charge C_{GS} so that U_{GS} reaches U_T, the MOSFET enters the on state, and the drain current I_D starts to rise. When C_{GS} is fully charged, U_{GS} is maintained at U_{GS1}, and I_D is maintained at I_{D1}. At this time, the drain-source parasitic capacitance C_{DS} starts to discharge, and U_{DS} starts decrease. When U_{DS} reaches the minimum value, the driving current starts to charge the gate-drain parasitic capacitance C_{GD}, and U_{GS} rises again until it remains at U_{GS2}. Generally, the time from U_{GS} rising to 10% U_{GS2} to I_D rising to 10% I_{D1} is called the turn-on delay time $t_{d(on)}$. The time taken for I_D to rise from 10% I_{D1} to 90% I_{D1} is called the rise time t_r. The turn-on time t_{on} of the MOSFET is the sum of the turn-on delay time $t_{d(on)}$ and the rise time t_r.

The calculation formula of the turn-on time: $t_{on} = t_{d(on)} + t_r$

Turn-off Process

When the driving pulse signal U_{P1} is removed, because of R_S and C_{GD}, U_{GS} decreases with a certain slope. When C_{GD} is discharged, U_{GS} remains at U_{GS1}, at this time, C_{DS} starts to charge, and U_{DS} starts to rise. When C_{DS} is fully charged, U_{DS} remains at 100% U_{DS1}, at this time, C_{GS} starts to discharge, and U_{GS} drops again. When U_{GS} drops below U_T, the

MOSFET enters the off state, and I_D drops to 0. Since the MOSFET does not have a minority carrier storage effect, its turn-off process is very fast (about tens of nanoseconds). Generally, the time from 90% U_{GS2} to 90% I_{D1} is called the turn-off delay time $t_{d(off)}$. The time it takes for I_D to fall from 90% I_{D1} to 10% I_{D1} is called the fall time t_f. The turn-off time t_{on} of the MOSFET is the sum of the turn-off delay time $t_{d(off)}$ and the fall time t_f.

The calculation formula of the turn-off time: $t_{off} = t_{d(off)} + t_f$

How to speed up the Switch Process of MOSFET

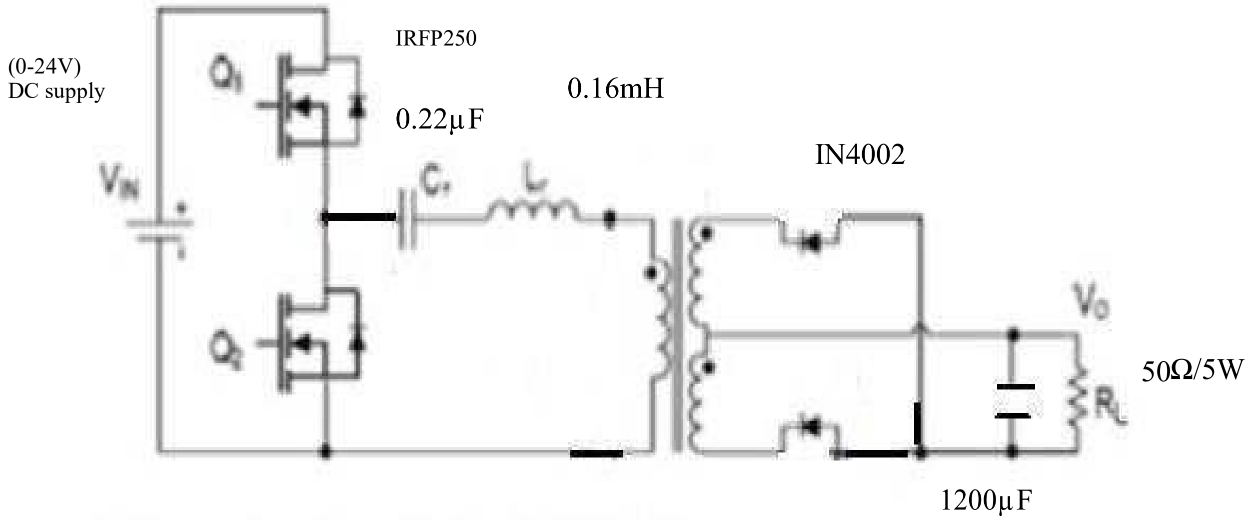
● Using a drive circuit with low internal resistance and inductance can speed up the turn-on process of the MOSFET.

● Improve the MOSFET's ability to charge and discharge the parasitic capacitance during the turn-on and turn-off process, which can effectively reduce the delay time, so that no transient error occurs.

RESULT:

Thus the Dynamic Characteristics of MOSFET were obtained.

CIRCUIT DIAGRAM



TABULAR COLUMN

S.No.	voltage (v_i) V	Ton	Toff	Frequency KHz

Date:

Ex. No. 15

RESONANT DC TO DC CONVERTER

AIM:

To study Zero Voltage Switching Resonant converter and Zero Current Switching Resonant Converter and plot its output waveforms.

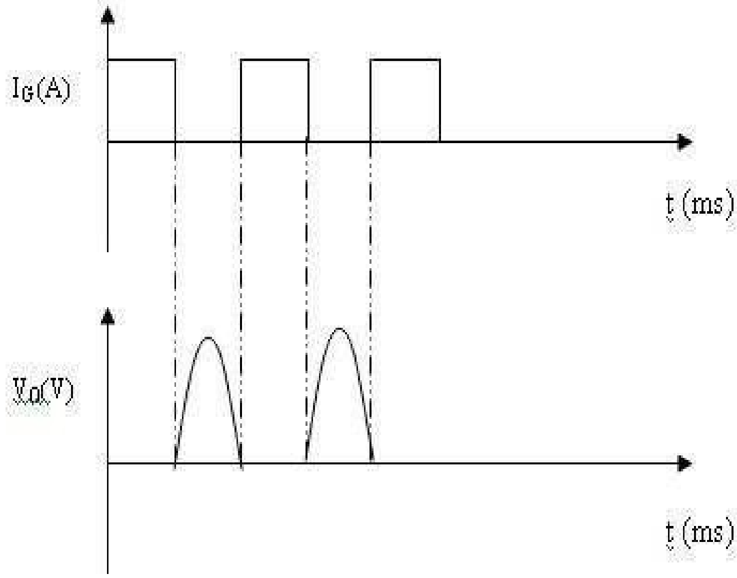
APPARATUS REQUIRED:

S.No.	ITEM	RANGE	TYPE	QUANTITY
1	Resonant Converter Module			1
2	Loading rheostat	100 / 2A		1
3	CRO	20 MHZ		1
4	Patch chords			15

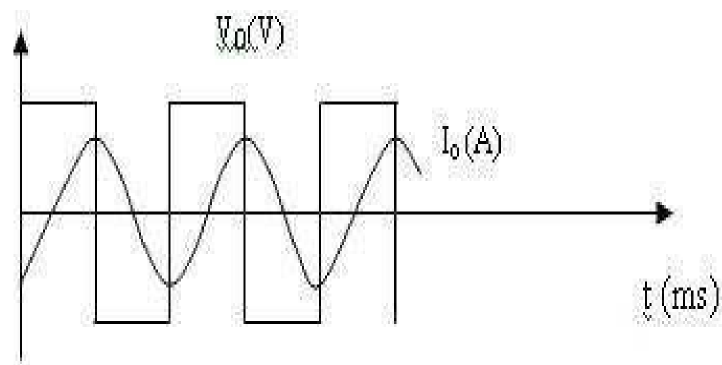
PROCEDURE

1. Make the connections as per the circuit diagram.
2. Switch on the resonant converter module.
3. Keep the frequency knob of the firing circuit kit below the resonance Frequency of power circuit kit
4. Switch on the DC power supply connected to the power circuit kit and Switch on the firing circuit kit
5. Vary the frequency knob of the firing circuit kit
6. Observe the waveform from the CRO.
7. Repeat the same procedure for different values of switching frequency.
8. Switch of the power supply and disconnect the connection

MODEL GRAPH (ZVS RESONANT CONVERTER) :



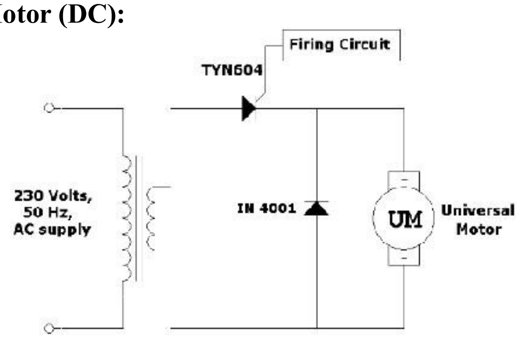
MODEL GRAPH (ZCS RESONANT CONVERTER) :



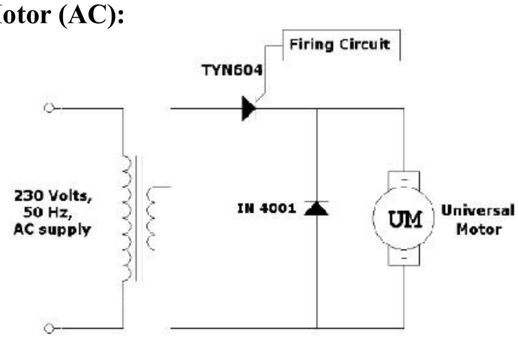
RESULT :

Thus ZVS and ZCS Resonant Converter operation were studied and their output waveforms were plotted.

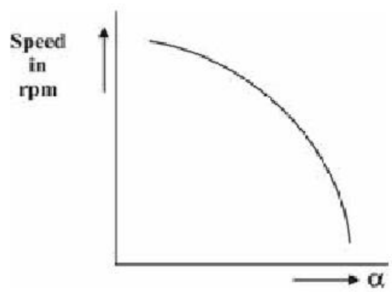
Universal Motor (DC):



Universal Motor (AC):



Graph:



Tabulation:-

DC Motor:

S.No	Firng Angle(α)	Speed in RPM

A C Motor:

S.No	Firng Angle(α)	Speed in RPM

Date:

Ex. No. 16

SPEED CONTROL OF UNIVERSAL MOTOR

AIM:

To study speed control of universal motor and plot speed v/s α

Apparatus required:

Module, TRIAC-BT 136, universal motor, diode-IN4001 etc.

Procedure:

Dc Motor:

1. Connections are made as per the circuit Diagram.
2. Firing angle is varied in steps gradually, note down corresponding speed of the induction motor using tachometer and tabulate.
3. A graph of α v/s speed is plotted.

Ac motor:

1. Above procedure is repeated for AC motor.

Result:

Speed control of universal motor is studied and a graph of α v/s speed is plotted.