B. Tech. III Year II Semester

L	T	P	C
0	0	2	1

POWER ELECTRONICS AND SIMULATION LABORATORY

Course Code: A46289

Course Outcomes: Upon the completion of Laboratory course, the student will be able to

CO1. Examine the characteristics of SCR, MOSFET, & IGBT, and analyze triggering circuits.

CO2. Analyze input and output characteristics of AC-DC converters.

CO3. Synthesize characteristics of Cycloconverters.

CO4. Examine characteristics of DC-DC Converters and Inverters.

CO5. Design of converters and inverters using P-Spice software.

List of Experiments

Any ten of the following experiments are required to be conducted.

1. Study of characteristics of SCR, MOSFET &IGBT.
2. Gate Firing Circuits for SCRs (R- Triggering, RC Triggering & UJT Triggering).
3. Single Phase AC voltage Controller with R & RL Loads.
4. Single Phase fully Controlled Bridge Converter with R& RL Loads.
5. DC Jones Chopper with R & RL Loads.
6. Single Phase Parallel Inverter with R& RL Loads.
7. Single Phase Cycloconverter with R& RL Loads.
8. Single Phase Series Inverter with R& RL Loads.
9. Single Phase Half controlled converter with R Load.
10. Simulation of single-phase full converter using RLE loads and single-phase AC voltage controller using RLE loads.
11. Simulation of resonant pulse commutation circuit and Buck Chopper.
12. Simulation of single phase Inverter with PWM control.

Head of the Department
Department of Electrical & Electronics Engg
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HYDERABAD-500 075.

A. Padma

PRINCIPAL
Vidya Jyothi Institute of Technology
Himayatnagar (Vill), C.B. Post.,
Hyderabad-75.

Correlation of COs with Experiments

S.No.	Title of Experiment	COs Mapped
1	Study of characteristics of SCR, MOSFET &IGBT.	**CO1**
2	Gate Firing Circuits for SCRs (R- Triggering, RC Triggering & UJT Triggering).	**CO1**
3	Single Phase AC voltage Controller with R & RL Loads.	**CO2**
4	Single Phase fully Controlled Bridge Converter with R& RL Loads.	**CO2**
5	DC Jones Chopper with R & RL Loads.	**CO4**
6	Single Phase Parallel Inverter with R& RL Loads.	**CO4**
7	Single Phase Cycloconverter with R& RL Loads.	**CO3**
8	Single Phase Series Inverter with R& RL Loads.	**CO4**
9	Single Phase Half controlled converter with R Load.	**CO2**
10	Simulation of single-phase full converter using RLE loads and single-phase AC voltage controller using RLE loads.	**CO2,CO5**
11	Simulation of resonant pulse commutation circuit and Buck Chopper.	**CO4,CO5**
12	Simulation of single phase Inverter with PWM control.	**CO4,CO5**

Programme Outcomes (POs)

Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

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12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes

PSO1: Conceptualize electrical and electronics systems, employ control strategies for power electronics related applications to prioritize societal requirements.

PSO 2: Apply the appropriate techniques and modern engineering hardware and software tools in electrical engineering to engage in multi-disciplinary environments

C328	POWER ELECTRONICS & SIMULATION LAB											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C328.1	3	2	2	2	-	-	-	-	3	-	-	3
C328.2	3	3	3	2	-	-	-	-	3	-	-	3
C328.3	3	3	3	2	-	-	-	-	3	-	-	3
C328.4	3	3	3	2	-	-	-	-	3	-	-	3
C328.5	3	3	3	2	-	-	-	-	3	-	-	3
	3	2.8	2.8	2	-	-	-	-	3	-	-	3

CO – PO Mapping

CO – PSO Mapping

POWER ELECTRONICS AND SIMULATION LAB		
C328	**PSO1**	**PSO2**
C328.1	3	-
C328.2	3	-
C328.3	3	-
C328.4	3	-
C328.5	3	3
	3	**3**

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

Rubrics for Power Electronics and Simulation Laboratory

Rubrics for Hardware based Experiments

Total Marks: 15M

S. No.	Assessment Criteria	Excellent (80 – 100%)	Good (60-80%)	Average (Below 60%)
1	**Theoretical Knowledge to perform the experiment (2M)**	Student replied to all the questions posed by Laboratory teacher	Student replies to a minimum of 50% questions posed by the laboratory teacher	Student could not answer in the first session
2	**Preparation of list of equipment required (2M)**	Correctness in the rating and type of the equipment required	Correctness in the rating and type of equipment required with minor corrections	Student could not prepare the list of equipment required
3	**Making the circuit connections as per the circuit diagram. (3 M)**	Correctness of connections	Correctness of connections with minor corrections.	Unable to connect
4	**Performing the experiment and tabulating the values (3 M)**	Independent performance of the experiment with correct values	Performance of the experiment with teacher assistance	Unable to perform the experiment
5	**Record book (based on calculations, results, graphs) (5 M)**	Practical values matching with theoretical values/ Expected graph obtained.	Minor deviation in the practical values/ expected graph	Deviation of practical values with theoretical values / expected graph.

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

Rubrics for Power Electronics and Simulation Laboratory

Rubrics for Software/Simulation based Experiments

Total Marks: 15 M

S. No	Assessment Criteria	Excellent (80 – 100%)	Good (60-80%)	Average (Below 60%)
1	**Theoretical Knowledge to perform the experiment (2M)**	Student replied to all the questions posed by Laboratory teacher	Student replies to a minimum of 50% questions posed by the laboratory teacher	Student could not answer in the first session
2	**Writing a program / simulation diagram of the experiment (3M)**	Correctness in the rating and type of the equipment required	Correctness in the rating and type of equipment required with minor corrections	Student could not prepare the list of equipment required
3	**Execution of the program / simulation (5 M)**	Executed without errors	Partially Executed	Unable to run the program
4	**Record book (calculations, results, plots) (5 M)**	Simulation output matching with theoretical values/ Expected plot obtained.	Minor deviation in the simulation output/ expected plot	Deviation of simulation output with theoretical values / expected plot.

Department of Electrical and Electronics Engineering

STUDENT PERFORMANCE EVALUATION
TOTAL MARKS (75M)

EXTERNAL EVALUATION (50 Marks)

Circuit Diagram	10M
Procedure write up	10M
Experiment connections & observations	10M
Calculations	10M
Viva Voce	10M

INTERNAL EVALUATION (25 Marks)

Day to day evaluation	10M
Record	5M
Internal Exam	10M

LABORATORY MANUAL
for
Power Electronics and Simulation Lab

III Year B.Tech II Semester

Prepared by
Mr. B. Rajesh and Mrs. P. Vaishnavi Devi,
Assistant Professors,
Department of Electrical and Electronics Engineering

VIDYA JYOTHI INSTITUTE OF TECHNOLOGY
(An Autonomous Institution)
C.B.Post, Aziznagar, Hyderabad

POWER ELECTRONICS AND SIMULATION LAB

INDEX

Vision of the Institution

- To develop into a reputed Institution at National and International level in Engineering, Technology and Management by generation and dissemination of knowledge through intellectual, cultural and ethical efforts with human values.
- To foster Scientific temper in promoting the world class professional and technical expertise.

Mission of the Institution

- To create state-of-the-art infrastructure facilities for optimization of knowledge acquisition.
- To nurture the students holistically and make them competent to excel in the global scenario.
- To promote R&D and consultancy through strong industry-institute interaction to address the societal problems.

Vision of the Department

- To become a reputed department in the impartation of professional and technical expertise in the field of Electrical and Electronics Engineering.

Mission of the Department

- Imparting Quality Technical Education by provision of state-of-the-art learning facilities.
- Preparing the students to think innovatively and find effective solutions to address engineering and societal problems with a multi-disciplinary approach maintaining continuous industry interaction.
- Encouraging team work and preparing the students for lifelong learning with ethical responsibility for a successful professional career.

Programme Educational Outcomes (PEOs)

PEO1: To provide the students with a sound foundation in the mathematics, science and engineering fundamentals necessary to become employable.

PEO2: Graduates should apply their technical knowledge to take up higher responsibilities in industry, academics and create innovative ideas in the field of Electrical and Electronics Engineering.

PEO3: Equip graduates with communication skills, leadership qualities with ethical values, team work with multi-disciplinary approach and zeal to provide solutions for engineering and societal problems.

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C328	PSO1	PSO2
C328.1	3	-
C328.2	3	-
C328.3	3	-
C328.4	3	-
C328.5	3	3
	3	3

1.a) STATIC CHARACTERISTICS OF SCR

CIRCUIT DIAGRAM :

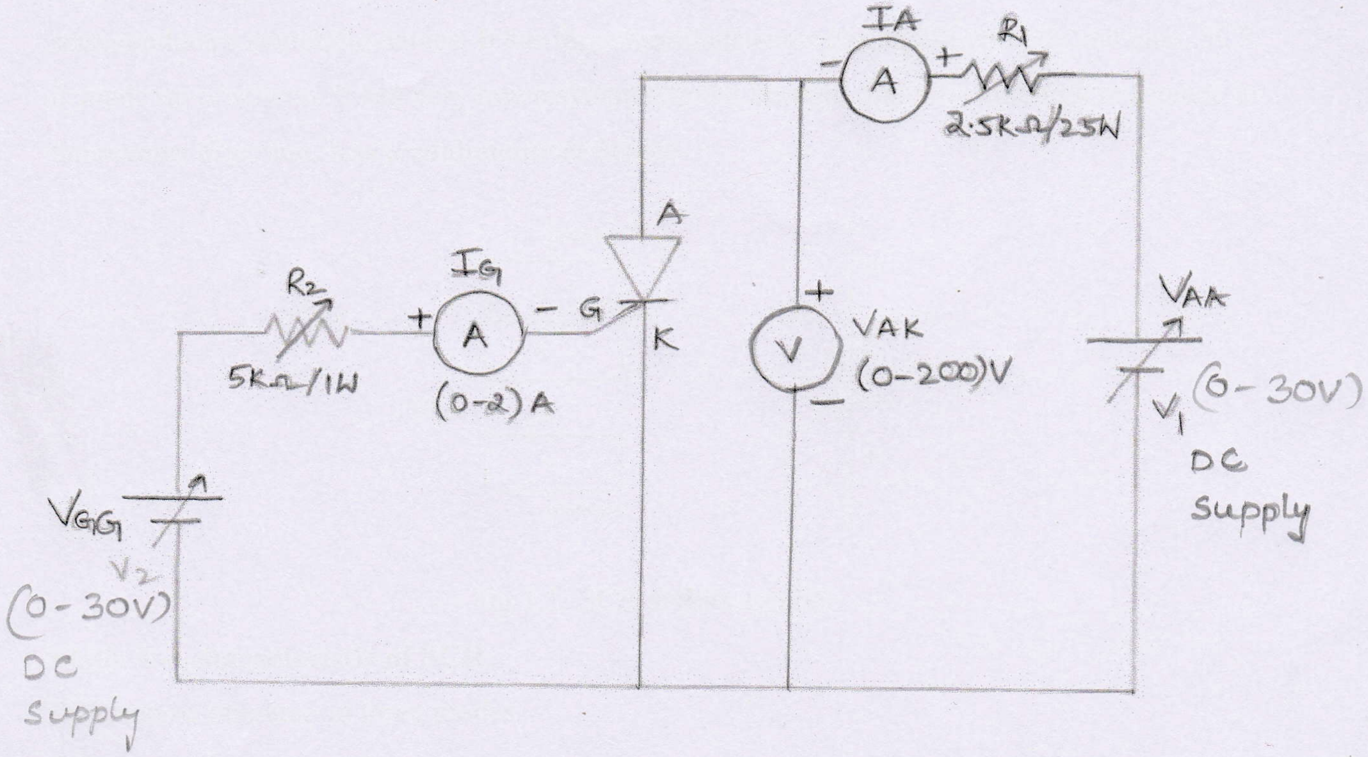

Fig. 1.1

1. a) STUDY OF CHARACTERISTICS OF SCR

AIM: To plot V- I characteristics of SCR and find the latching and holding currents of SCR

THEORY: Silicon Controlled Rectifier (SCR) is a four layered three junction P N P N semiconductor switching device. It has three terminals named as anode, cathode and gate. SCR is made up of silicon. It has very low resistance in the forward direction and high resistance in the reverse direction. It is a unidirectional device.

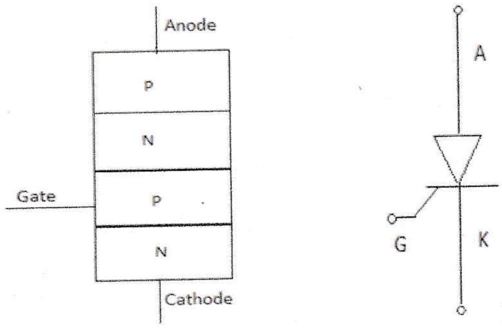

Fig 1.1: SCR and its symbol

Static V-I characteristic of SCR:

SCR can be operated in three modes.

1. Reverse blocking mode
2. Forward blocking mode (Off state)
3. Forward conduction mode (On state)

1. Reverse Blocking Mode:

When the cathode of SCR is made positive with respect to anode, SCR is reverse biased. Junctions J1 and J2 are reverse biased where junction J3 is forward biased. The device behaves as if two diodes are connected in series with reverse voltage applied across them.

A small leakage current of the order of few milli Amperes only flows. As SCR is reverse biased and in blocking mode, it is called as reverse blocking mode of operation. Now if the reverse voltage is increased, at a critical breakdown level called reverse breakdown voltage V_{BR}, an avalanche occurs at J1 and J3 and the reverse current increases rapidly through the SCR. This results in SCR damage as junction temperature may exceed its maximum temperature rise.

2. Forward Blocking Mode:

When anode is positive with respect to cathode, with gate circuit open, SCR is said to be forward biased mode. Then junction J1 and J3 are forward biased and J2 is reverse biased. As

TABULAR COLUMN:

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

I_L = __________(mA) I_H = __________(mA)

MODEL GRAPH :

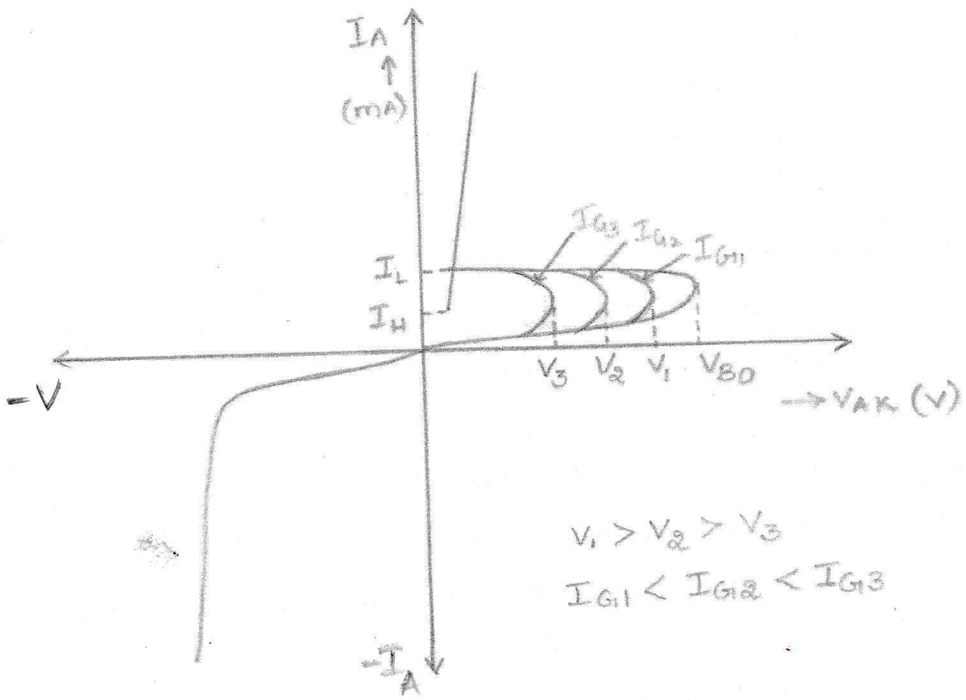

Fig. 1.2

the forward voltage is increased, junction J2 will have an avalanche breakdown at a voltage called forward break over voltage V_{BO}. When forward voltage is less then , SCR offers high impedance. Thus an SCR acts as an open switch in forward blocking mode.

3. Forward Conduction Mode:

In this mode of SCR conducts current from anode to cathode with a very small voltage drop across it. An SCR can be brought from forward blocking mode to forward conducting mode:

1. By exceeding the forward break over voltage.
2. By applying a gate pulse between gate and cathode.

During forward conduction mode of operation, SCR is in on state and behaves like a closed switch. Voltage drop is of the order of 1 to 2mV. This small voltage drop is due to resistance drop across the four layers of the device.

Latching current: The latching current is the minimum value of anode current which must be attained by the SCR to turn ON.

Holding current: It is the minimum value of anode current below which the SCR turns of if it falls, the SCR will turn OFF.

APPARATUS:

1. SCR characteristics study unit.
2. Meters
   a. Voltmeter (0-20) V - 1 No.
   b. Ammeter (0-2) A - 1 No.
   c. Ammeter (0-200) mA - 1 No.
3. Patch cords

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Switch ON the main supply and keep the voltages V1 &V2 at minimum position initially.
3. Vary V_1 and set the voltage V_{AK} to10V.
4. Slowly vary V_2 in steps and note down I_G, I_A and V_{AK} values.
5. Vary V_2 till V_{AK} suddenly drops down. This indicates that the SCR started conduction.
6. Repeat the same procedure for V_{AK} = 15V and 20V.

7. Draw the graph V_{AK} vs I_A for different values of I_G.

Procedure to find Latching current:

1. Apply about 20 V between Anode and Cathode by varying V1.

2. Keep the load potentiometer R1 at minimum position.

3. The device must be in the OFF state with gate open.

4. Gradually increase Gate voltage - V2 till the device turns ON.

5. The minimum anode current at which the SCR turns ON is the latching current.

6. Note down the latching current.

Procedure to find Holding current:

1. Increase the load current from the latching current level by increasing V1.

2. Open the gate switch permanently. The SCR must be fully ON.

3. Now start reducing the load current gradually by adjusting R1. If the SCR does not turns OFF even after the R1 at maximum position, then reduce V1.

4. Observe when the device goes to Blocking mode. The load current through the device at this instant, is the holding current of the device.

5. Note down the holding current.

RESULT: The static characteristics (V I Characteristics) of SCR are studied and latching and holding currents of the SCR are found.

1 b) CHARACTERISTICS OF MOSFET

CIRCUIT DIAGRAM :

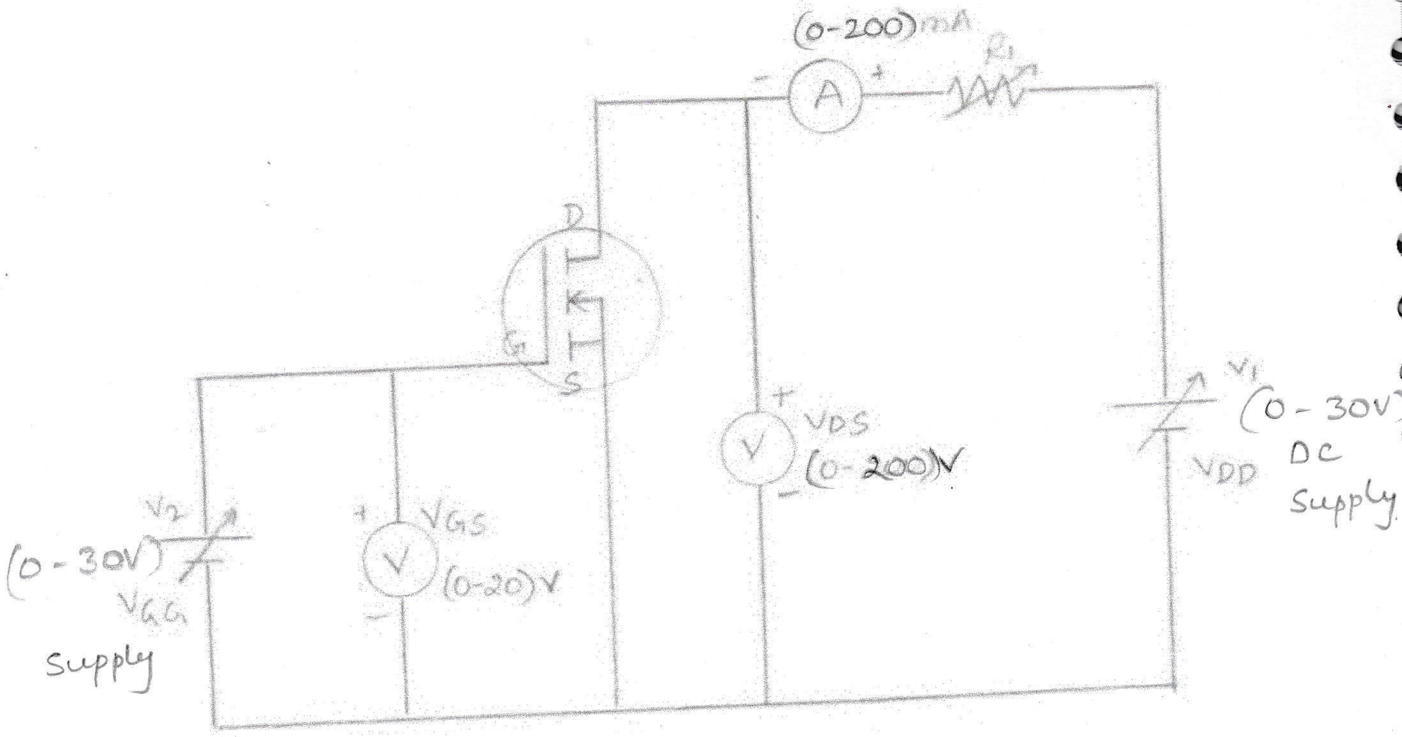

Fig 1.6

TABULAR COLUMN :

Output Characteristics :

S.NO.	V_{GS} = 2V		V_{GS} = 2.7 V		V_{GS} = 2.9 V	
	V_{DS} (V)	I_D (mA)	V_{DS} (V)	I_D (mA)	V_{DS} (V)	I_D (mA)

1. b) STUDY OF CHARACTERISTICS OF MOSFET

AIM: To plot the output and transfer characteristics of MOSFET.

THEORY:

A power MOSFET has three terminals called Drain (D), Source(S) and Gate(G). MOSFET is a voltage controlled device. It's operation depends on the flow of majority carriers only. MOSFET is a unipolar device.

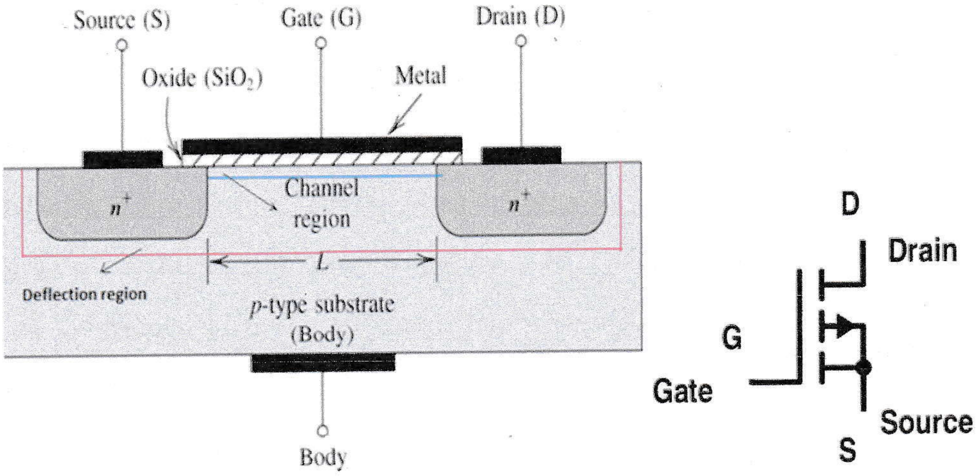

Fig 1.2: MOSFET structure and Symbol

Power MOSFETs are of two types, n-channel enhancement MOSFET and p-channel enhancement MOSFET. Out of these two types, n-channel enhancement MOSFET is commonly used because of higher mobility of electrons.

The IGBT does not conduct when the gate circuit is open. When gate is made positive with respect to source, an electric field is established. Then negative charges are induced in the p-substrate below SiO2 layer. The n-channel current flows from drain to source. If V_{GS} is made more positive, n-channel expands and therefore, more current flows from D to S. The drain current I_D is enhanced by the gradual increase of gate voltage. Hence the name enhancement MOSFET is used.

Output Characteristics: Power MOSFET output characteristics indicate the variation of drain current I_D as a function of drain-source voltage V_{GS}. For low values of V_{DS}, the graph between I_D & V_{DS} is almost linear. This indicates a constant value of on-resistance

$$R_{DS} = V_{DS} / I_D.$$

For given V_{GS}, if V_{DS} is increased, output characteristic is relatively flat indicating that drain current is nearly constant.

Transfer Characteristics :

S.NO.	V_{DS} = 2.5V	
	V_{GS} (V)	I_D (mA)

MODEL GRAPHS :

Output Characteristics:

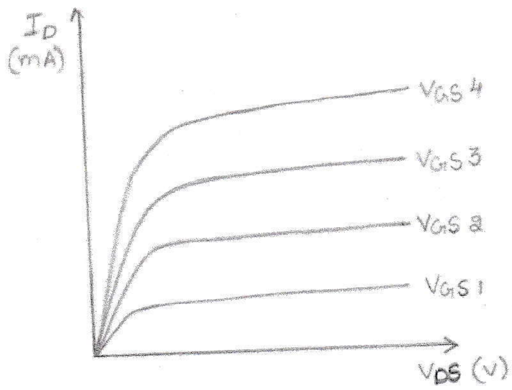

Fig 1.7

Transfer Characteristics:

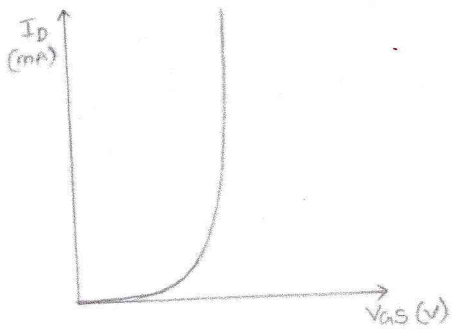

Fig 1.8

Transfer Characteristics: These characteristics show the variation of drain current I_D as a function of gate-source voltage V_{GS}. In the transfer characteristic, the device turns off if VGS is decreased below the threshold voltage V_{GST}.

APPARATUS:

1. MOSFET characteristics study unit.
2. Meters
   a. Voltmeter (0-20) V - 1 No.
   b. Voltmeter (0-200) V - 1 No.
   c. Ammeter (0-200) mA- 1 No.
3. Patch cords.

(a) Drain /Output Characteristics:

1. Make the connections as per the circuit diagram.
2. Vary the supply V2 and adjust $V_{GS} = 2V$.
3. Vary the supply V1 in steps and note down the values of V_{DS} & I_D
4. Repeat the procedure for different values of V_{GS} (at least two different values of V_{GS})
5. Plot the graph of V_{DS} vs I_D for different values of V_{GS}.

(b) Transfer Characteristics:

1. Set V_{DS} to 2.5V by varying V1.
2. Vary V2 in steps, note down V_{GS} and I_D
3. Plot the characteristics V_{GS} vs I_D.

RESULT: The Output and Transfer characteristics of MOSFET are plotted and studied.

1 c) CHARACTERISTICS OF IGBT

CIRCUIT DIAGRAM :

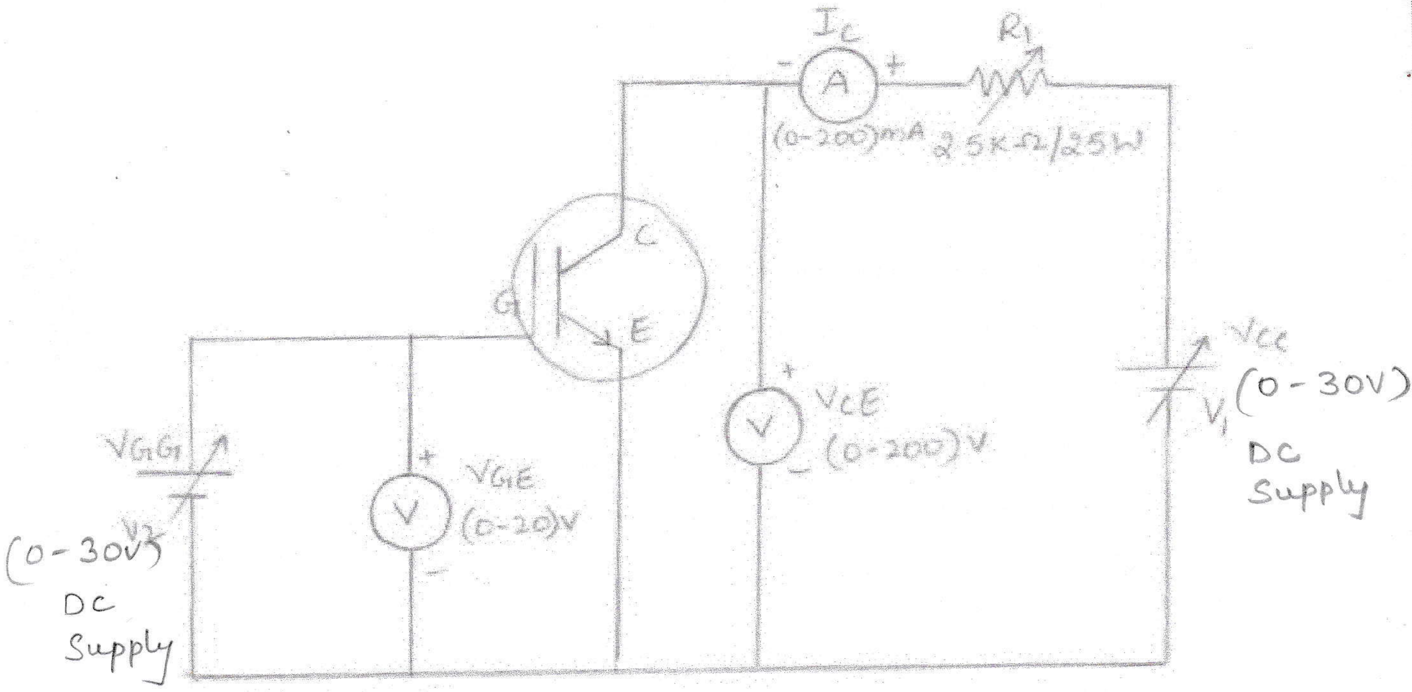

Fig 1.3

TABULAR COLUMN:

Output Characteristics:

S.NO.	V_{GE} = 4V		V_{GE} = 5 V		V_{GE} = 5.2 V	
	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)

1. c) STUDY OF CHARACTERISTICS OF IGBT

AIM: To plot the output and transfer characteristics of IGBT.

THEORY:

An IGBT has three terminals called Collector, Gate and Emitter. When gate is positive with respect to emitter and with gate-emitter voltage more than threshold voltage of IGBT, an n-channel is formed in the p-regions as in a power MOSFET. This n-channel short circuits the n−region with n+ emitter regions. An electron movement in the n-channel, in turn, causes substantial hole injection from pf substrate layer into the epitaxial n− layer. Eventually, a forward current is established. The three layers p+, n− and p constitute a pnp transistor with p+ as, emitter, n− as base and p as collector. Also n−, p and n+ layers constitute npn transistor as shown in below fig 1.3.

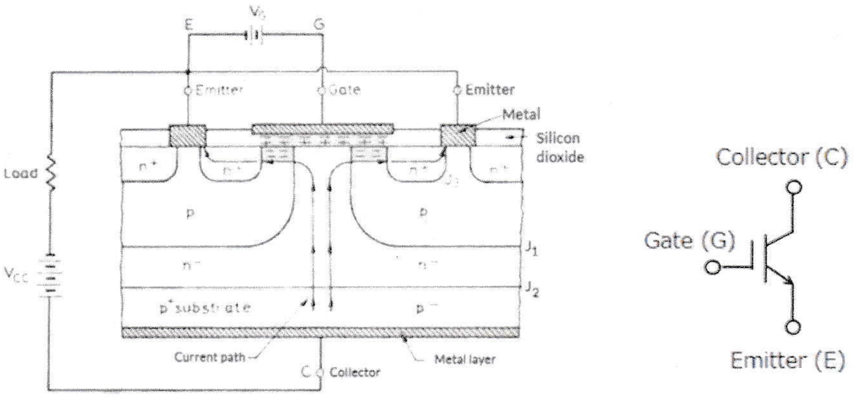

Fig 1.3: IGBT Structure and Symbol

The output characteristics of an IGBT are plot for collector current IC versus collector-emitter voltage VCE for various values of gate-emitter voltages. The output of IGBT is controlled by gate emitter voltage VGE. Hence IGBT is a voltage-controlled device.

The transfer characteristic of an IGBT is a plot of collector current IC versus gate-emitter voltage VGE. This characteristic is identical to that of power MOSFET. When VGE is less than the threshold voltage VGET, IGBT is in off-state. When the device is off, junction J2 blocks forward voltage and in case reverse voltage appears across collector and emitter, junction J1 blocks it.

APPARATUS:

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   a. Voltmeter (0-20)V - 1 No.
   b. Voltmeter (0-200)V - 1 No.
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3. Patch cords.

Transfer Characteristics :

S.NO.	V_{CE} = 5V	
	V_{GE} (V)	I_C (mA)

MODEL GRAPHS :

Output Characteristics :

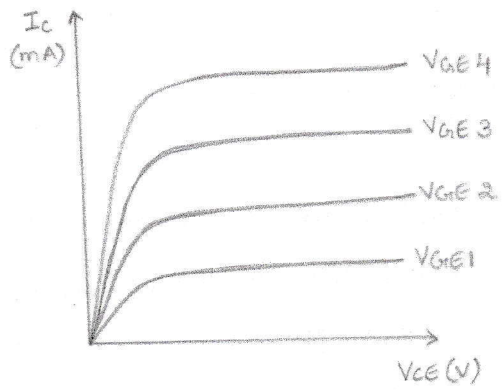


Fig 1.4

Transfer Characteristics:

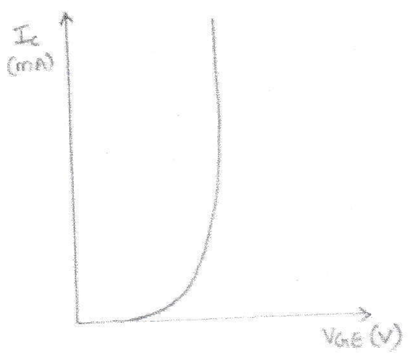


Fig 1.5

PROCEDURE:

(a) Output Characteristics:

1. Make the connections as per the circuit diagram.
2. Vary V2 and set V_{GE} to 4V.
3. Vary V1 in steps and note down V_{CE} and I_C for each step.
4. Plot the graph of I_C vs V_{CE} for different values of VGE.

(b) Transfer Characteristics:

1. Vary V1 and set VCE at 5V.
2. Vary V2 in steps and note down V_{GE} and I_C
3. Plot a graph for V_{GE} vs I_C.

RESULT: The output and transfer characteristics of IGBT are plotted and studied.

GATE FIRING CIRCUITS

CIRCUIT DIAGRAM:

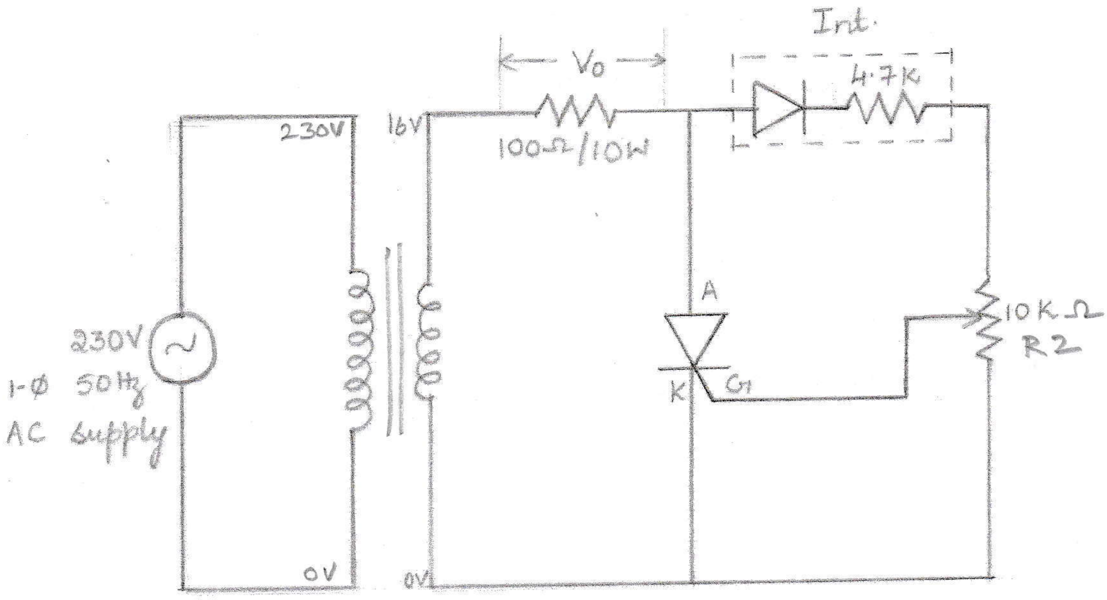


Fig 2.1

TABULAR COLUMN:

S.No.	Firing angle (α)	Load voltage (V)

2. GATE FIRING CIRCUITS OF SCR

1. R TRIGGERING CIRCUIT

AIM: To study the switching control of SCR with R triggering circuit.

THEORY:

The conventional gate triggering circuits used to turn ON an SCR are:

1. Resistance triggering (amplitude control)
2. RC triggering (Phase control)
3. UJT triggering (Phase control)
4. Ramp and pedestal triggering
5. DC triggering.
6. Digital triggering schemes.
7. Microprocessor controlled triggering schemes.
8. Light triggering in LASCR.

Resistance Triggering: This is the simplest method of turning on an SCR in phase control circuit. A resistance of suitable value is connected between anode and gate through a diode. Whenever anode voltage is positive, current flows from gate to cathode circuit through this resistance. Hence SCR turns ON. But the gate current will remain as long as the anode to cathode voltage is positive. But the trigger angle can be controlled only from 0 to π /2 of the applied voltage. V_{GK} can be adjusted with R_2 but its phase positive is same as that of the AC supply voltage. Hence if SCR does not turn on at π /2, it cannot be turned on after π /2 since the magnitude of the voltage will decrease after this instant.

Load voltage $V_{DC} = \frac{Vm(1+Cos\alpha)}{2\pi}$

APPARATUS:

1. SCR Triggering module.
2. C.R.O.
3. Patch cords.
4. Multimeter

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Switch ON the supply.
3. Set the potentiometer to a particular position and observe the waveforms of V_{IN}, V_O,

TABULAR COLUMN :

S.No.	Firing angle (α)	Load voltage (V)

S.No.	Firing angle (α)	Load voltage (V)

V_T, on the C.R.O. and note down the corresponding waveforms.

4. Vary the potentiometer in steps and note down the firing angle and the corresponding load voltage using multimeter.

RESULT: The switching control of SCR with R-triggering is observed and studied.

2 b) RC TRIGGERING

CIRCUIT DIAGRAM:

RC HALF WAVE TRIGGERING

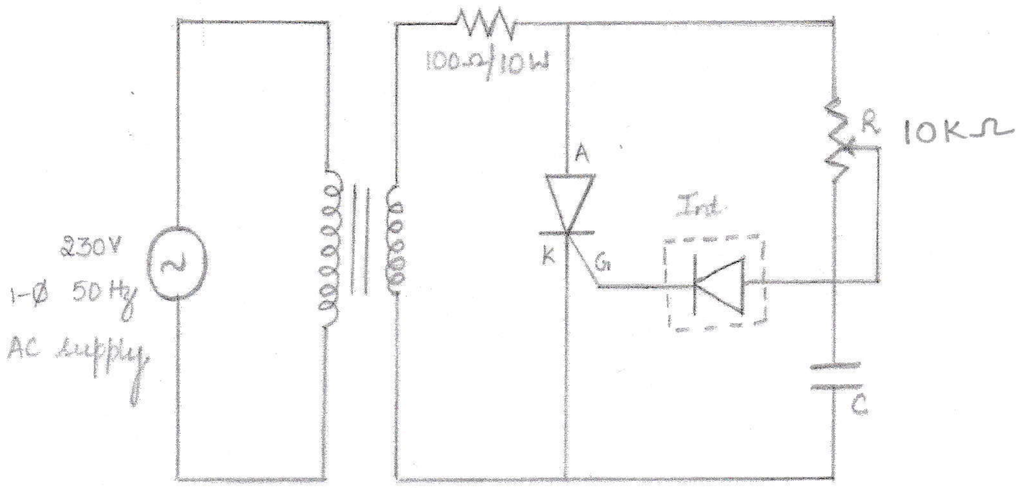


Fig 2.3

RC FULL WAVE TRIGGERING

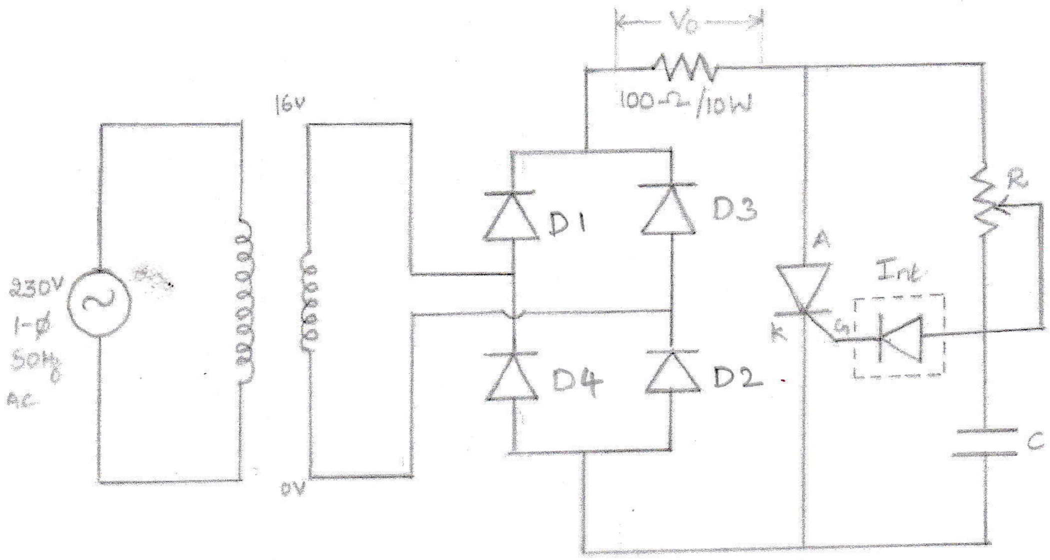


Fig 2.4

2 b) RC TRIGGERING

AIM: To study the phase control of SCR by RC triggering.

THEORY:

In case of resistance triggering, the firing angle of the SCR can be varied from 0 to 90° only. Hence resistance triggering cannot not be employed in practice as the output voltage cannot be varied over a wide range (i.e., 0 to Vm / π in case of half wave and 0 to 2Vm / π in case of full wave).

To overcome the above limitations, Resistance and Capacitance (RC) triggering is employed so as to vary the triggering angle of SCR over the complete range 0 to 180°. RC triggering is very cheap and reliable for low voltage phase controlled circuits.

RC circuit helps to adjust the position of gate to cathode voltage as the voltage across the capacitor lags the current through it by 90°, by varying R, the phase angle w.r.t., applied voltage can be adjusted. Hence the triggering angle α can be varied over a wide range from 0 to 180°. By varying R, we can vary the triggering angle α. The load voltage can be obtained from $V_{DC} = \frac{Vm(1+Cos\alpha)}{2\pi}$

APPARATUS:

1. SCR Triggering module.
2. C.R.O.
3. Patch cords.
4. Multimeter.

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Switch ON the module.
2. Set the potentiometer to a particular position and observe the waveforms of V_{IN}, V_O, V_T, V_C on the C.R.O. and note down the corresponding waveforms.
3. Vary the potentiometer in steps and note down the corresponding load voltage using multimeter.

RESULT: The Phase control of SCR with RC triggering is studied.

2.c) UJT TRIGGERING CIRCUIT.

CIRCUIT DIAGRAM :

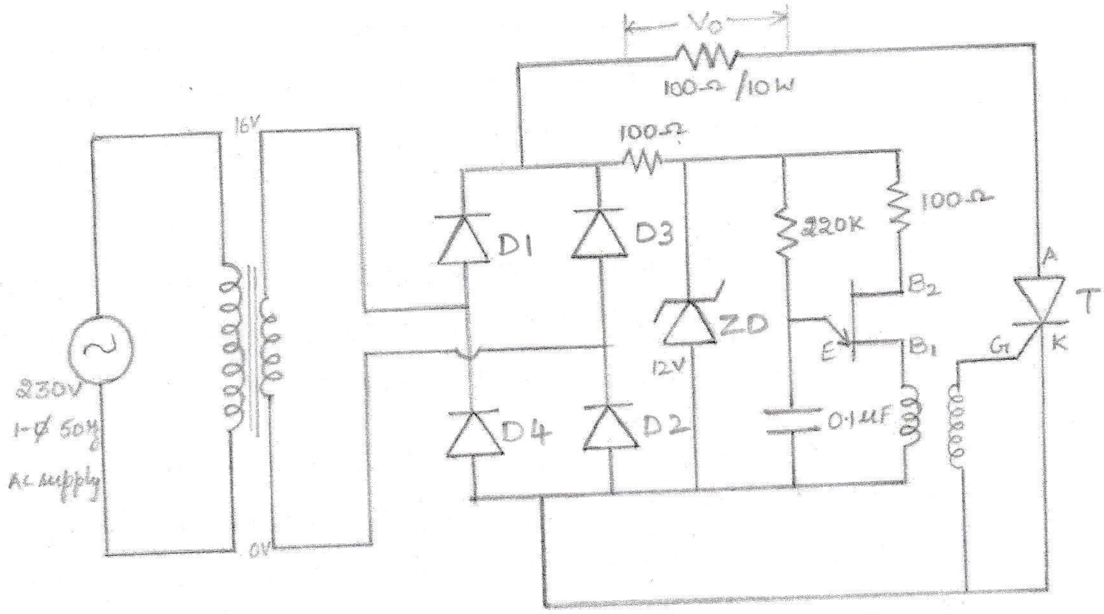


Fig 2.2

TABULAR COLUMN:

S.No.	Firing angle (α)	Load voltage (V)

2. c) UJT TRIGGERING CIRCUIT

AIM: To study triggering control of SCR using UJT triggering circuit.

THEORY:

Uni Junction Transistor (UJT) is a three terminal device with two bases (B1 and B2) and an Emitter (E) as shown in fig 2.1. Output pulses of variable time period are possible by suitably increasing the emitter to base voltage from valley voltage level to peak level either by employing a constant current source or by charging a capacitor by a resistor. The RC network can be easily employed to obtain output pulses, since the time period is fixed by RC circuit through the capacitor voltage V_C. The output pulses derived from the capacitor can be observed in fig 2.2.

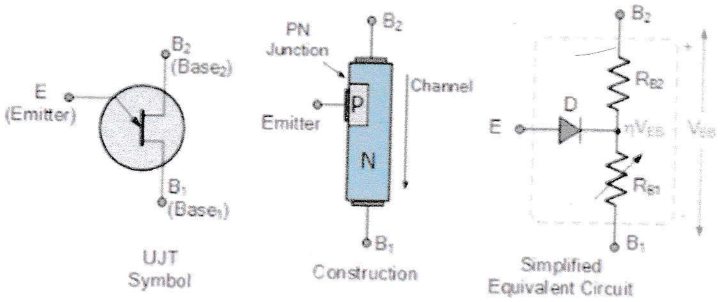


Fig 2.1: UJT Symbol, Structure and simplified equivalent circuit

In phase controlled rectifier circuit, trigger pulses to SCR must be synchronized or phase locked with the AC supply frequency. This helps constant DC output voltage across the load for a specified triggering angle. On the other hand, if synchronization or phase locking is not achieved, then even for a minute variation in AC supply frequency, triggering angle of SCR varies from instant to instant, resulting in variation in DC output voltage across the load. To overcome this problem, the supply voltage to UJT circuit is derived from the AC mains using step down transformer, rectifier and Zener diode.

EXPECTED WAVEFORMS:

R – Triggering

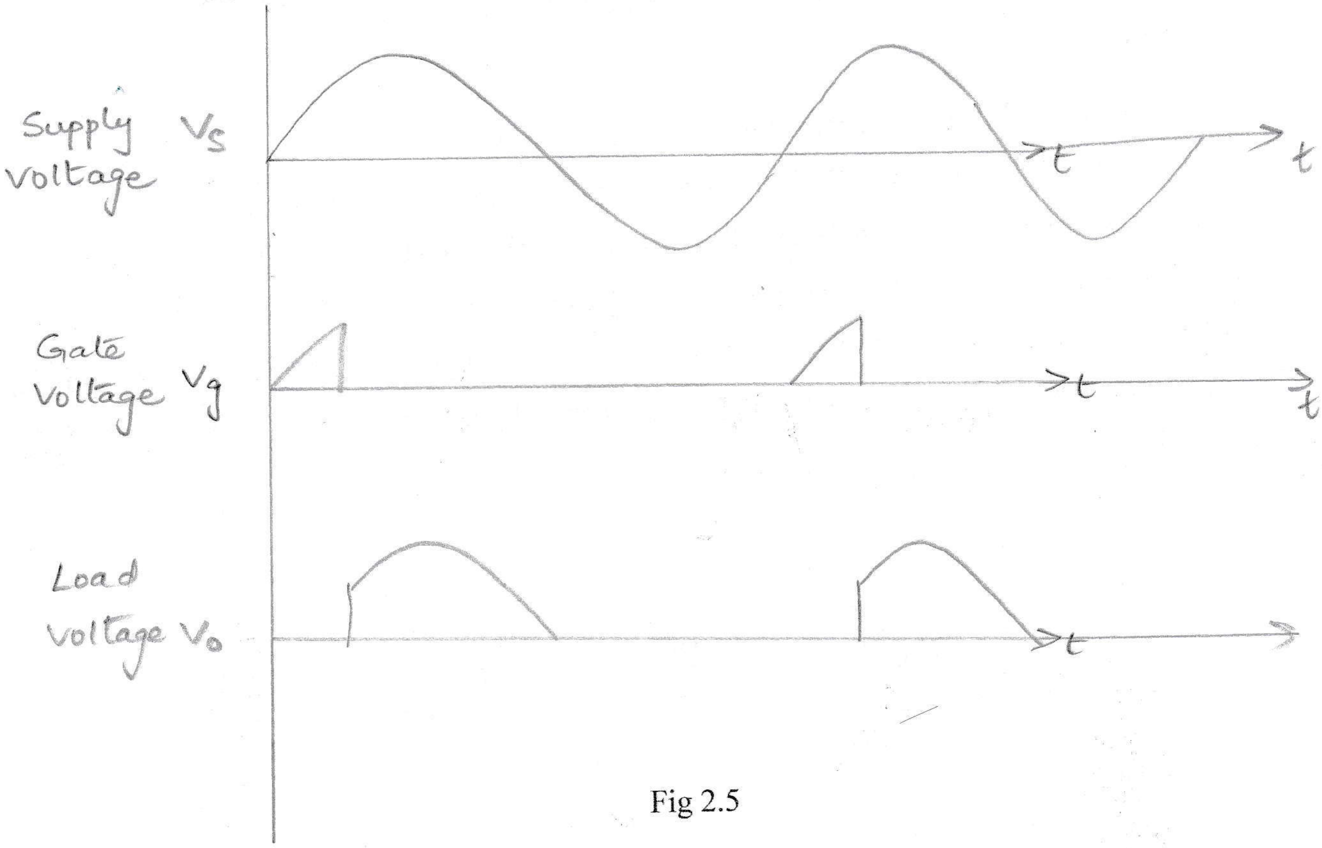


Fig 2.5

RC Half-Wave Triggering

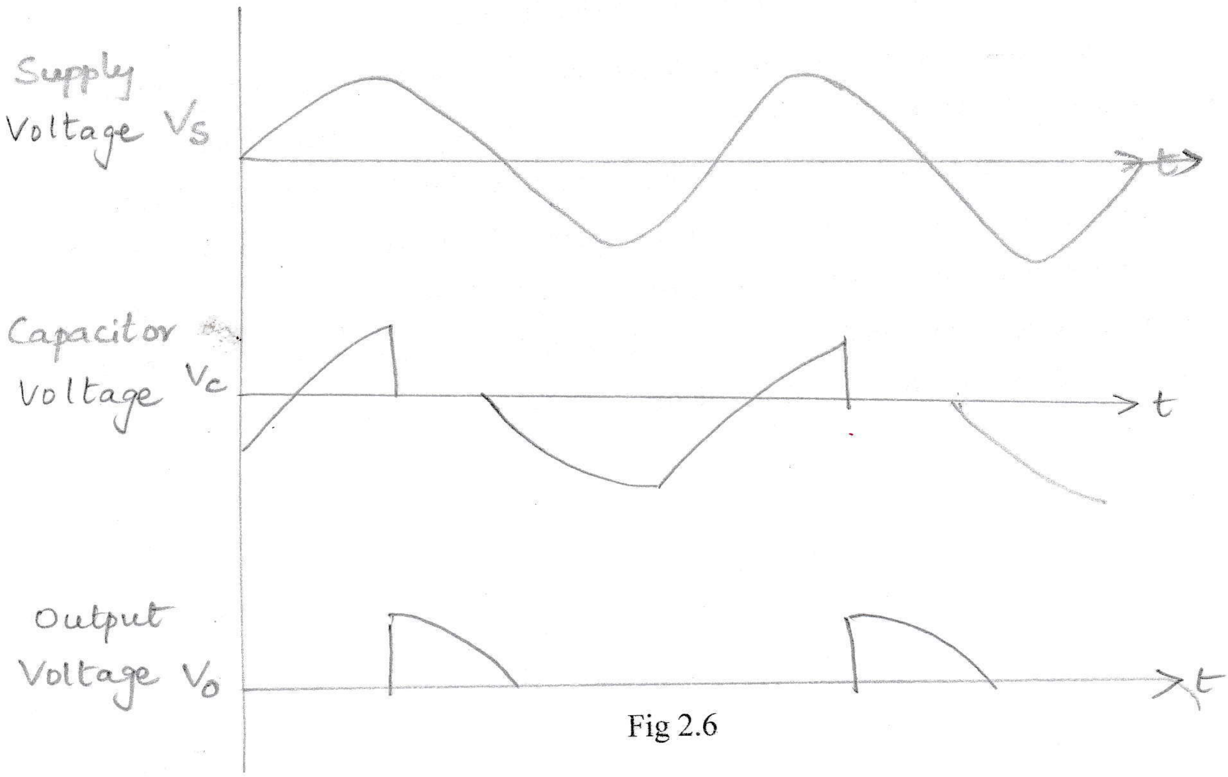


Fig 2.6

RC Full-Wave Triggering

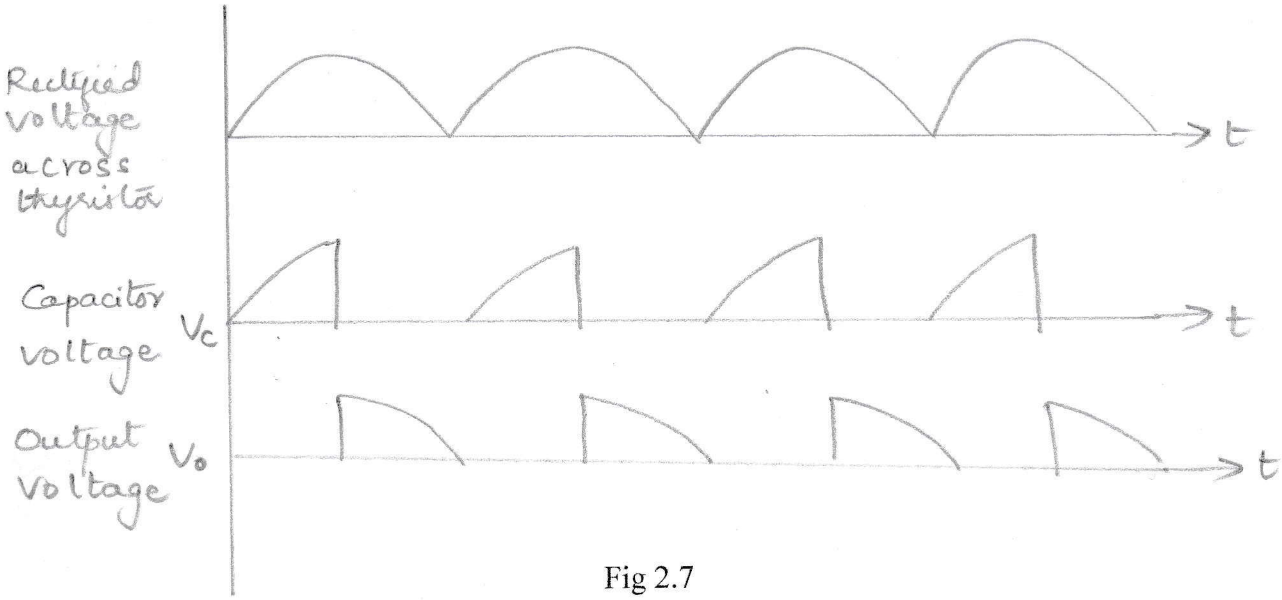


Fig 2.7

UJT Triggering

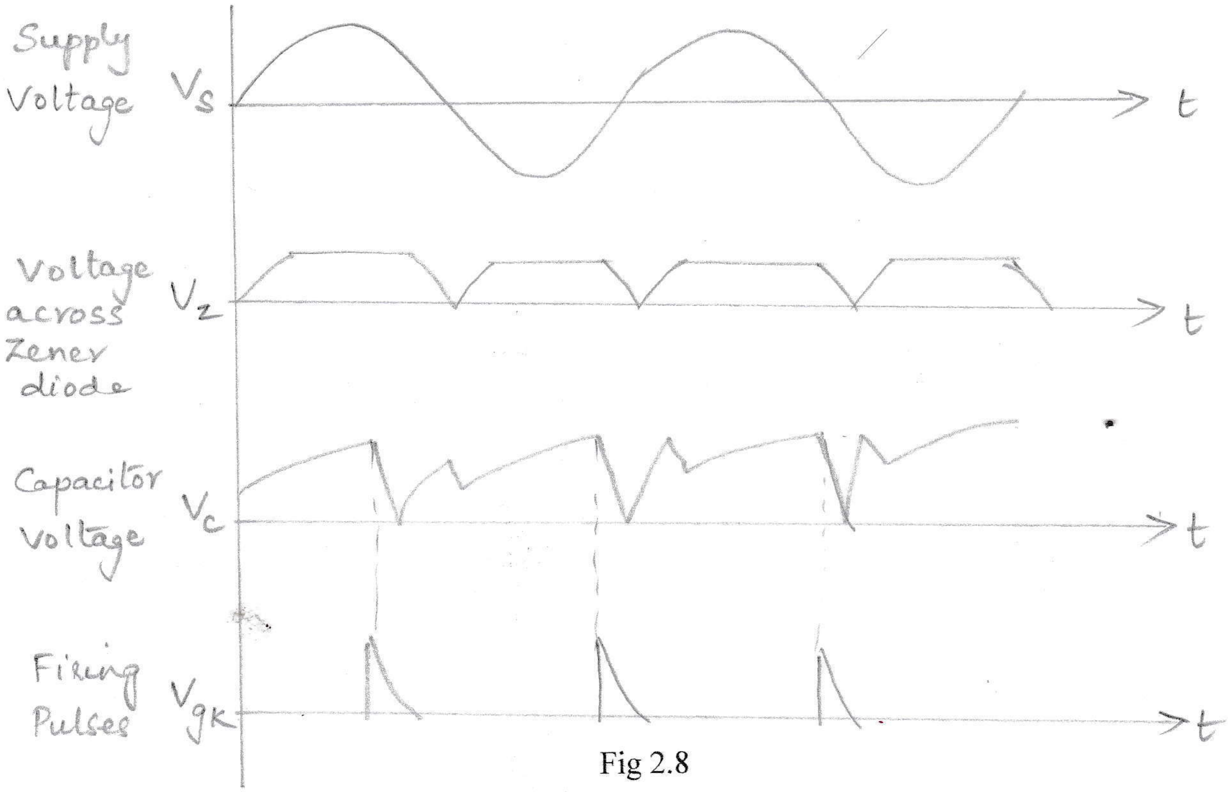


Fig 2.8

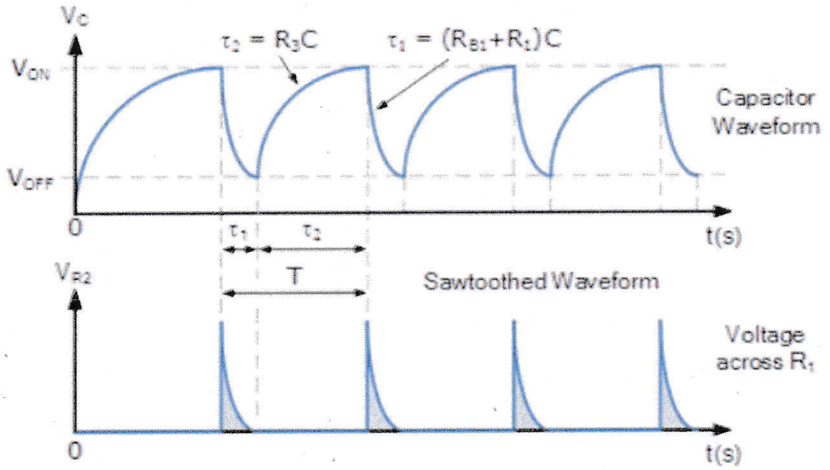


Fig 2.2: UJT Oscillator Waveforms

The rectifier circuit converts AC supply available at transformer secondary into full wave DC voltage. The DC voltage is clipped to the required DC voltage using a zener diode. The series resistance R_S limits the current through the zener diode. The clipped voltage V_Z is applied to the RC charging network and also to the UJT circuit. Depending on the resistance R and capacitance of C, trigger pulses can be obtained across isolation pulse transformer connected to base1. These pulses can be used to trigger SCRs. For SCRs of higher rating, this small pulse is amplified using a pulse amplifier and then by connecting across gate and cathode of the SCR.

APPARATUS:

1. SCR Triggering module.
2. C.R.O.
3. Patch cords.
4. Multimeter.

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Switch ON the module.
3. Set the potentiometer to a particular position and observe the waveforms of V_{IN}, V_O, V_T, V_C on the C.R.O. and note down the corresponding waveforms.
4. Vary the potentiometer in steps and note down the corresponding load voltage using multimeter.

RESULT: The UJT triggering circuit to trigger an SCR is connected and the phase control of SCR using UJT is studied.

SINGLE PHASE AC VOLTAGE CONTROLLER.

CIRCUIT DIAGRAM :

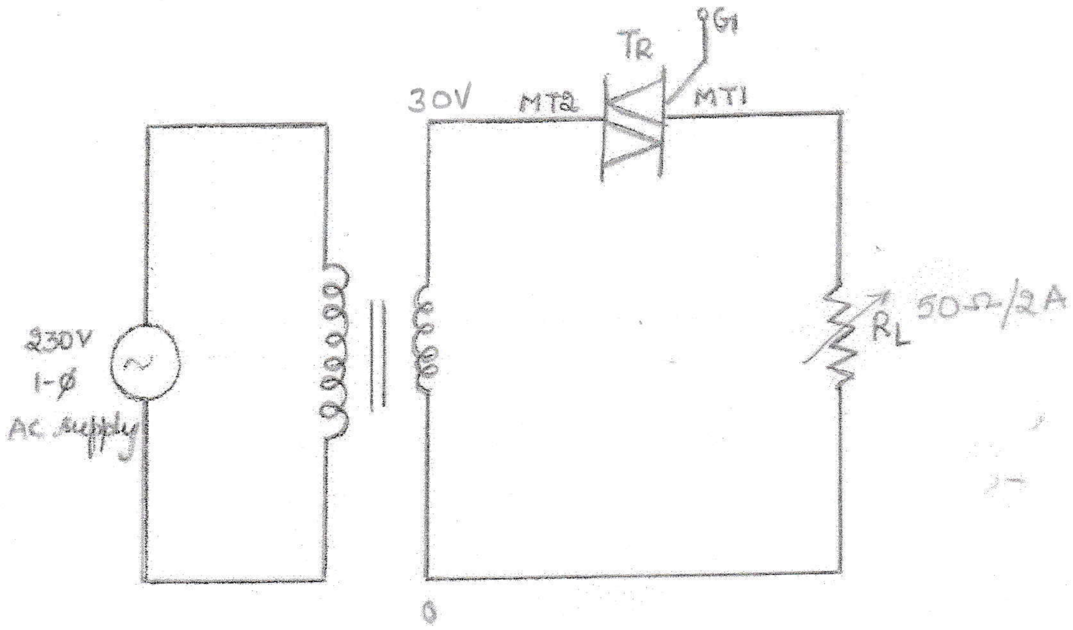


Fig 3.1

3. SINGLE PHASE AC VOLTAGE CONTROLLER WITH R AND RL LOADS

AIM: To obtain the output of Single phase AC Voltage Controller with R & RL load by implementing phase control technique.

THEORY:

AC Voltage Controller converts fixed alternating voltage to variable alternating voltage without change in frequency. The output of AC Voltage controller is controlled by Phase control technique. AC Voltage controller can be constructed using two antiparallel connected SCRs or a TRIAC. The arrangement of SCRs and TRAIC for the respective circuits can be understood from the following circuits.

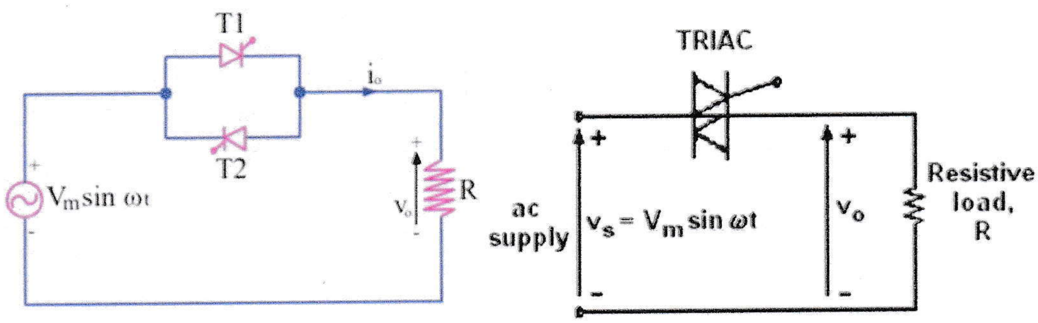


Fig 3: Single Phase AC Voltage Controllers with anti parallel SCRs and TRIAC

In the first circuit with two antiparallel SCRs, T1 conducts for the positive half cycle and T2 conducts for negative half cycle.

In the second circuit, TRIAC conducts for both the half cycles of AC supply. Therefore, for the firing angle α symmetrical AC voltage is available across the load. The load voltage is given by

$$V_O = \frac{Vm}{\sqrt{2}}\left[\frac{1}{\pi}\{(\pi-\alpha)+\frac{Sin2\alpha}{2}\}\right]^{\frac{1}{2}}$$

The voltage control of AC Voltage controller can be done by simply adjusting the firing angle of the SCRs or TRIAC by using phase control. The output can be controlled from 0 to maximum value for both the half cycles.

APPARATUS:

1. Single Phase AC Voltage Controller Unit.
2. Loading Rheostat (50Ω/2A)
3. Loading Inductor (0-150 mH / 2A)
4. Digital Multimeter.
5. C.R.O.
6. Patch cords.

TABULAR COLUMN:

For R Load:

Vm = _______ Volts

S.No.	Firing Angle α (deg)	V_L(V)
1	180	
2	150	
3	120	
4	90	
5	60	
6	30	
7	0	

For RL Load :

Vm = _______ Volts.

S.No.	Firing Angle α (deg)	V_L(V)
1	180	
2	150	
3	120	
4	90	
5	60	
6	30	
7	0	

EXPECTED WAVE FORMS :

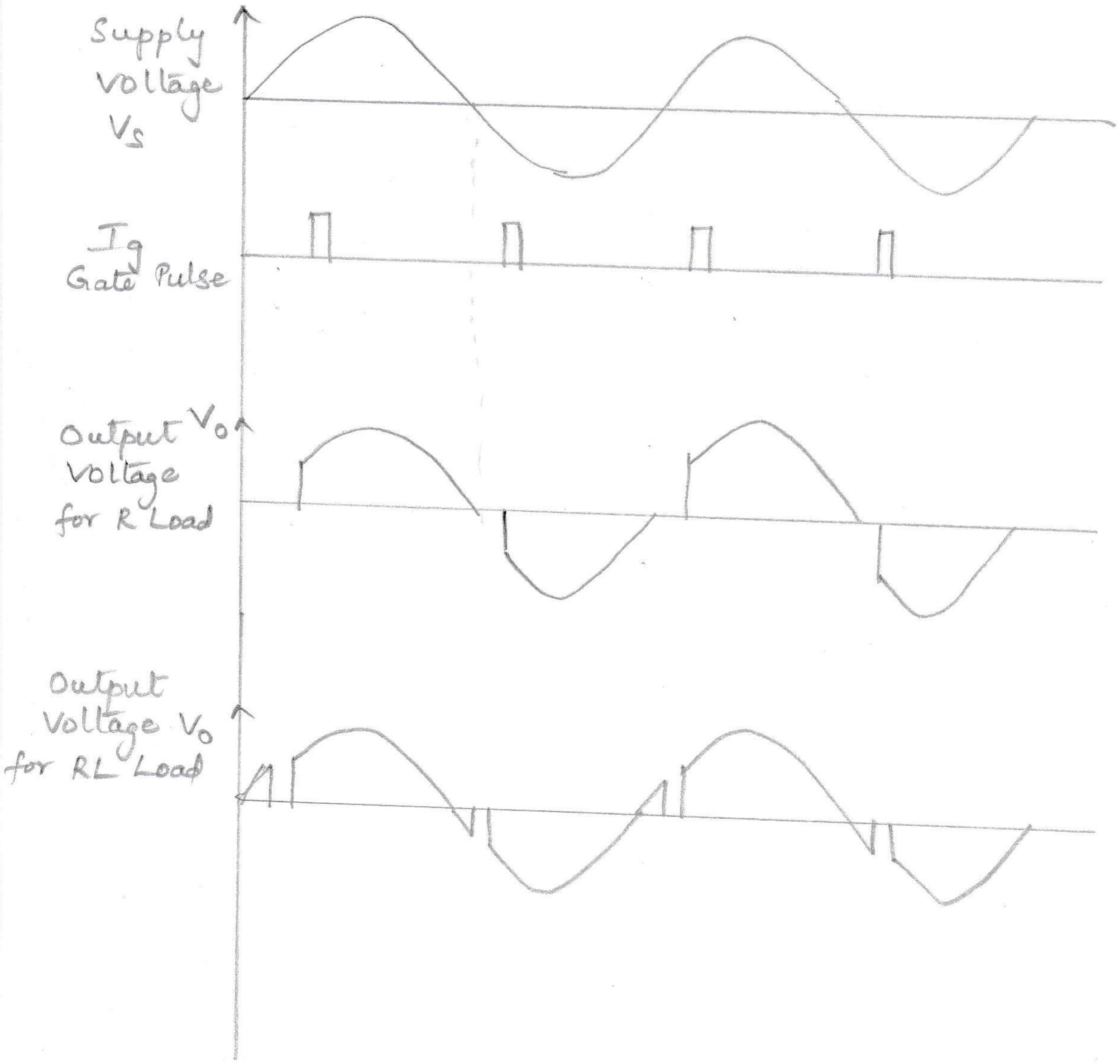


Fig 3.2

PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Switch ON the mains supply to the unit.
3. The firing angle of the switching circuit can be varied in steps and the corresponding firing angle, Input voltage, Output voltage, SCR/TRIAC Voltage waveforms can be recorded from the C.R.O.
4. The load voltage is measured using a multimeter.
5. Then connect an Inductive load in series to the resistive load.
6. Repeat the above steps for AC Voltage controller with RL Load.

RESULT: The operation of a Single Phase AC Voltage Controller is observed and its control is output waveforms are obtained for R & R L Loads.

SINGLE PHASE FULLY CONTROLLED BRIDGE CONVERTER.

CIRCUIT DIAGRAM:

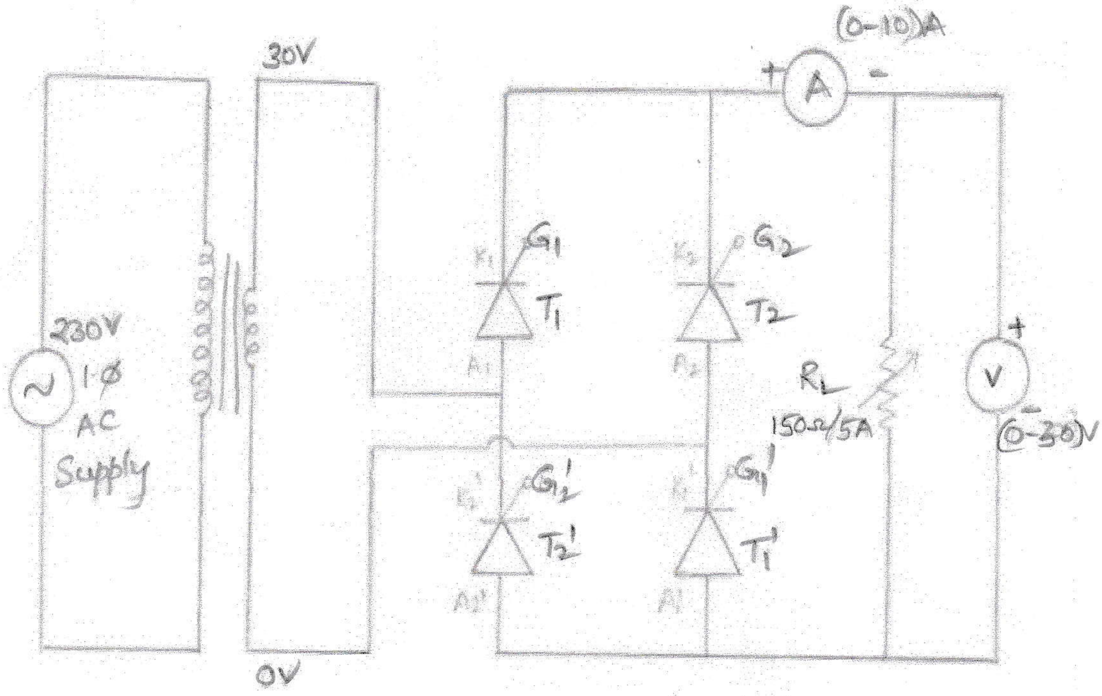


Fig 4.1

4. SINGLE PHASE FULLY CONTROLLED BRIDGE CONVERTER WITH R& RL LOADS

AIM: To obtain the output of Single phase Single Phase fully controlled converter with R & RL loads.

THEORY:

A Single Phase fully controlled converter converts Single phase AC supply to DC Supply. The circuit of the converter is as shown in the circuit diagram.

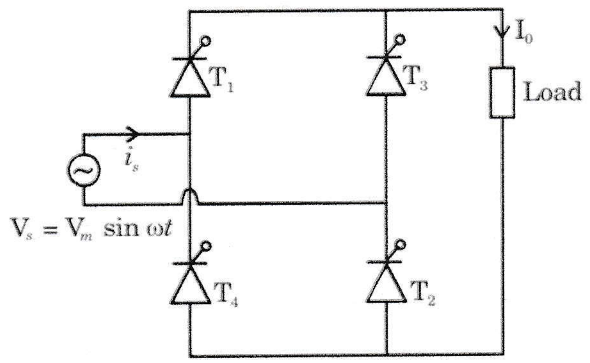


Fig 4.1: Single Phase Fully Controlled Converter

Full Controlled Bridge Converter with R Load:

During positive half cycle, thyristors T_1 and T_2 are triggered simultaneously through independent isolated pulse transformers. The pair of SCR's conduct up to π. SCR T_3 & SCR T_4 are triggered in the next half cycle with another pair of isolated pulse transformers.

Full Controlled Bridge Converter with RL load :

During positive half cycle, thyristors T_1 & T_2 are forward biased and when these 2 thyristors are fired simultaneously, at $\omega t = \alpha$. the load is connected to the input supply through T_3 & T_4. Due to inductive load, T_1 & T_2 will continue to conduct beyond $\omega t = \pi$, even though the input voltage is already negative. During negative half-cycle of the input voltage, thyristor T_3 & T_4 are forward biased, and firing of thyristors T_3 & T_4 will apply the supply voltage across the load. Due to inductive load, T3 & T4 will continue to conduct beyond $\omega t = 2\pi$, even though the input voltage is already positive.

During the period from α to π, the input voltage V_S and input current are positive and the current flows from the supply to the load. The converter is said to be operated in rectification mode. During the period from π to π +α, the input voltage V_S is negative and the

TABULAR COLUMN:

For R Load:

Vm = _______ Volts.

S.No.	Firing Angle α (deg)	V_L (V)	I_L (A)	$V_L = \frac{V_m(1+\cos\alpha)}{\pi}$
1	180			
2	150			
3	120			
4	90			
5	60			
6	30			
7	0			

For R_L Load:

Vm = _______ Volts.

S.No.	Firing Angle α (deg)	V_L(V)	I_L(A)	$V_L=V_m(1+\cos\alpha)/\pi$
1	180			
2	150			
3	120			
4	90			
5	60			
6	30			
7	0			

EXPECTED WAVEFORMS:

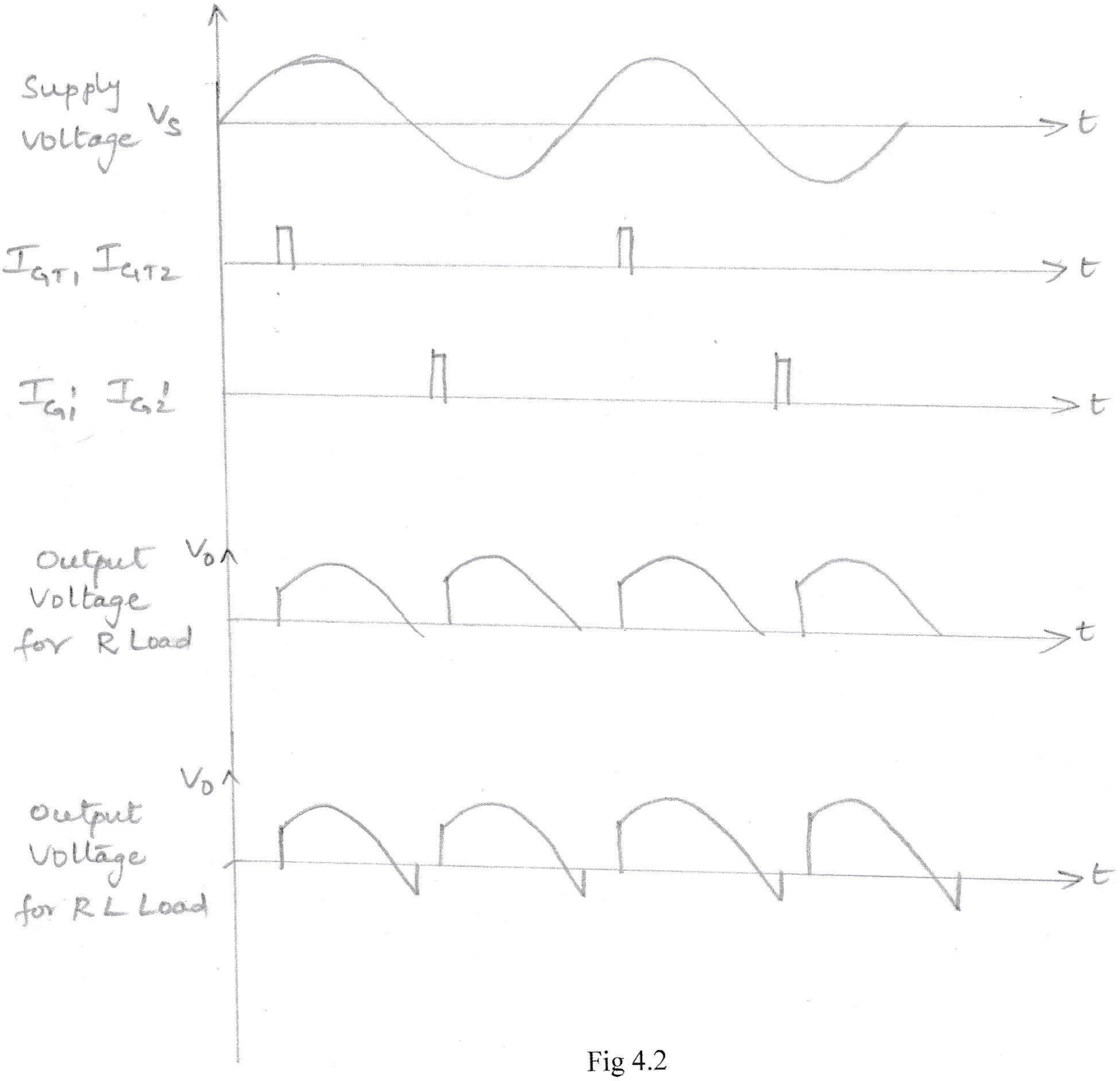


Fig 4.2

input current I_S is positive and there will be reverse power flow from the load to the supply. The converter is said to be operated in inversion mode.

APPARATUS:

1. Single phase fully controlled bridge converter power unit
2. Single phase fully controlled bridge converter firing unit
3. Single phase Isolation transformer (0-230)V/5A with tappings.
4. Loading Rheostat - 150Ω/5A.
5. Inductor – 150 mH / 5A
6. C.R.O.
7. Patch cords.

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Switch on the Power Supplies of the main circuit and switching circuit.
3. Vary the firing angle in steps and record output voltage, thyristor voltage waveforms.
4. Note down the output voltage & output current from the voltmeter and ammeter.
5. Repeat the same procedure after connecting L load in series with the R load.

RESULT: The output of Single phase Single Phase fully controlled converter with R & RL loads is obtained and studied.

D. C. JONES CHOPPER

CIRCUIT DIAGRAM :

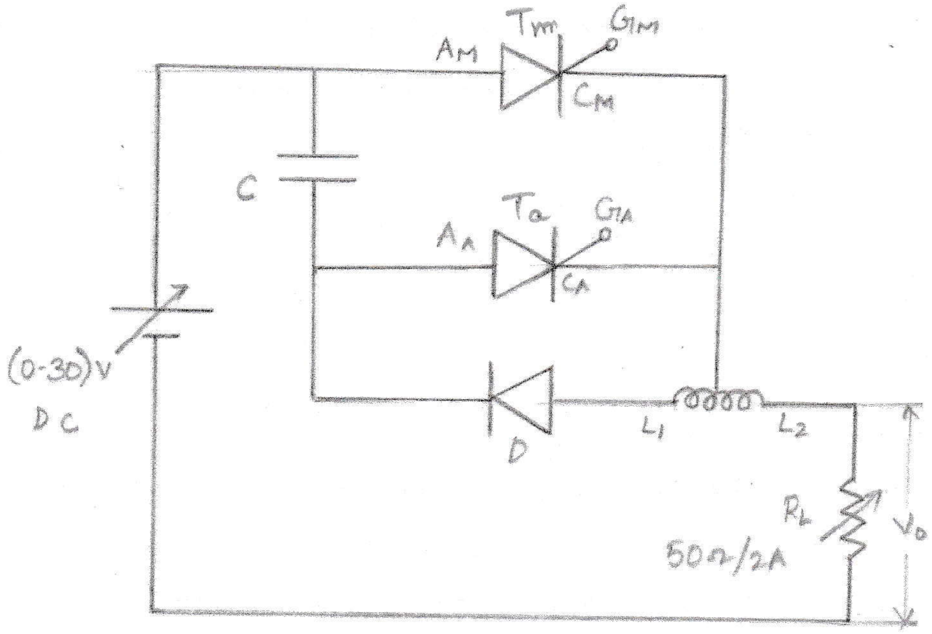


Fig 5.1

5. DC JONES CHOPPER WITH R & RL LOADS

AIM: To obtain the output of DC Jones Chopper with R and RL Load.

THEORY:

Chopper converts fixed DC Voltage to variable DC voltage. The control strategies used for control of DC DC choppers are Time Ratio Control and Current Limit Control.

Chopper circuit consists of a thyristor switch connected between the source and the load. The switch is closed & opened periodically such that the load is connected and disconnected from the supply alternatively. Thus the average voltage impressed on the load is controlled by controlling the ratio of ON state interval to one cycle duration.

The average output voltage of the chopper is given by

$$V_{avg} = \left(\frac{T_{ON}}{T}\right) V$$

Where V is input voltage, TON is ON time duration of the chopper. The ratio T_{ON} / T is called the duty ratio of the chopper. The duty ratio can be controlled in many ways such as by changing the ON period duty ratio by keeping frequency constant or by changing frequency and keeping ON period constant. Fixed frequency choppers with a variable ON period technique are generally used because of less harmonic contents.

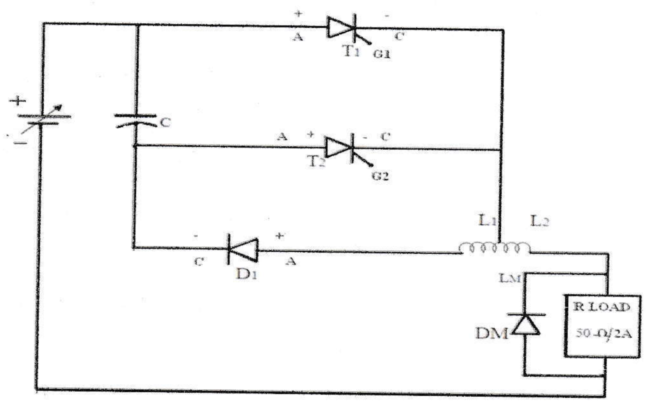


Fig 5.1: DC Jones Chopper

The Jones chopper circuit uses a Class-D commutation circuit. Here, an auxillary thyristor is used to turn OFF the main SCR TM. It is assumed that the capacitor C is initially charged to voltage with the polarity shown. When T_M is turned ON, the capacitor is discharged through it and through the inductor L. At the end of discharge cycle, the capacitor voltage will reverse and will be held by diode D to stay with this polarity when T_A is fired, the capacitor will discharge through TM and will turn it OFF. Since a reverse voltage is applied across the

TABULAR COLUMN :

Frequency : ________

S.No.	Duty Ratio	T_{ON}	T_{OFF}	Load Voltage (V)

Duty Ratio : ________

S.No.	Frequency (Hz)	T_{ON} (ms)	T_{OFF} (ms)	Load Voltage (V)

TM immediately after turning ON the SCR, this phenomenon is known as Voltage Commutation.

APPARATUS:

1. Chopper power module
2. Chopper firing unit
3. Regulated Power supply (0-30)V
4. Loading Rheostat (50Ω/2A)
5. Inductor – 50 mH /2A
6. Multimeter.
7. CRO
8. Patch cords

PROCEDURE:

1. Make the connections as per the circuit diagram with R Load.
2. Keep the frequency knob and duty ratio knob at some intermediate position.
3. Set the DC power supply to 30V & switch ON the DC power supply to the chopper and the firing circuit.
4. Observe VO, VT1, VT2, VP1, VP2, VC waveforms on the CRO and note down the corresponding waveforms.
5. Keeping the frequency constant, vary the duty cycle in steps & note down T_{ON}, T_{OFF} and load voltage for each step.
6. Repeat the above step by varying frequency and keeping duty ratio constant.
7. Connect RL load and note down the output voltage VO & repeat the above procedure.

NOTE:

1. At lower frequencies, SCR may not turn ON due to insufficient voltage across the capacitor.
2. If the duty cycle is increased to large value, SCR may not turn OFF due to insufficient voltage across the capacitor to commutate the SCR. In such cases, switch OFF the kits and after some time switch ON and continue the procedure.

RESULT: The output of Single Phase Jones Chopper circuit and its operation is studied.

SINGLE PHASE PARALLEL INVERTER

CIRCUIT DIAGRAM :

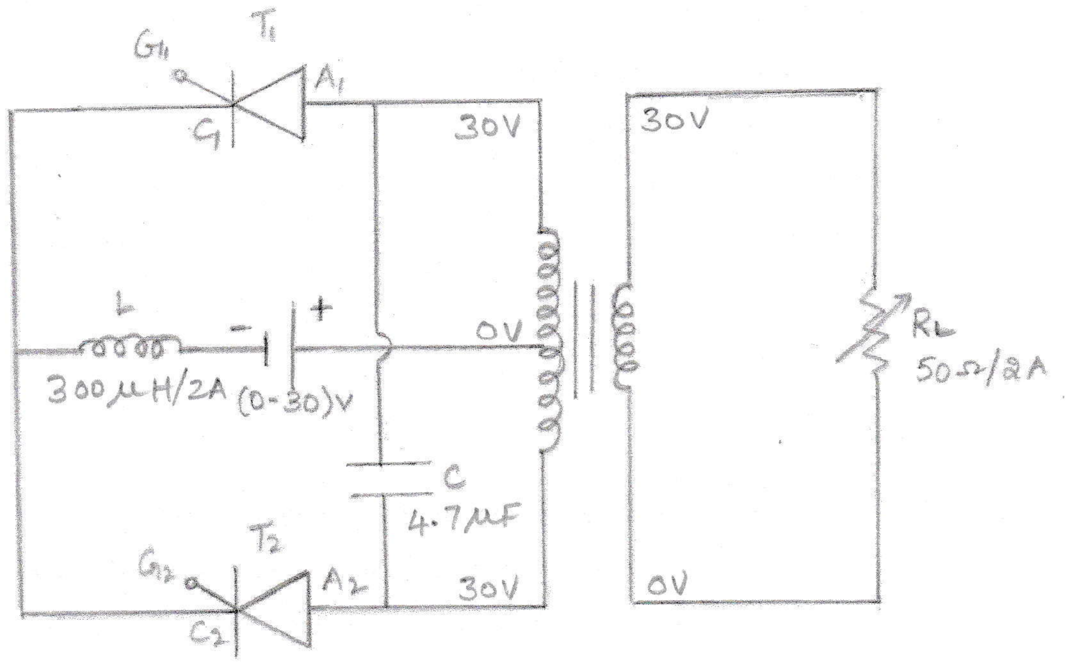


Fig 6.1

6. SINGLE PHASE PARALLEL INVERTER

AIM: To obtain the output of Single phase Parallel Inverter and study its operation with R & RL load.

THEORY:

An Inverter converts DC power into AC power at desired output voltage and frequency.

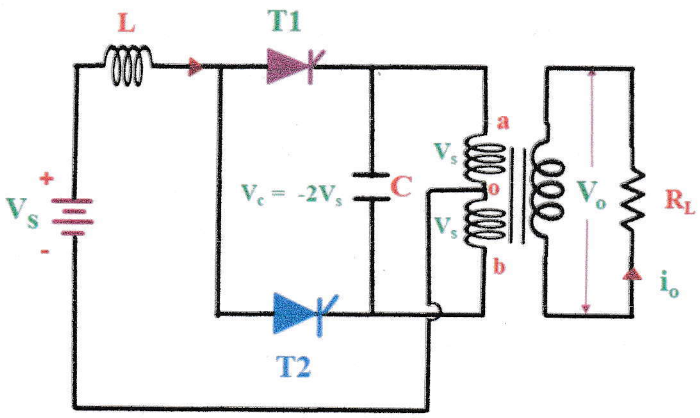


Fig 6.1 Parallel Inverter

In Single Phase Parallel Inverter, the capacitor is used for commutation of two thyristors T_1 & T_2. An inductor is connected in series with the supply voltage because the source current becomes constant. During the operation of this inverter circuit, commutating capacitor C comes in parallel due to this, it is called Parallel Inverter.

In mode 1 operation, when SCR $T_1$is fired, the current flows in the upper half of the primary winding. Here, SCR T_2 is OFF. This current produces magnetic flux which links with both the halves of the primary winding. Due to this, the capacitor charges to the voltage V_{DC} with upper plate positive w.r.t. lower plate.

In mode 2 operation, when SCR T_2 is triggered, the capacitor starts discharging with upper plate negative. Then T_1 gets into OFF state. Based on capacitor charging and discharging, the SCRs gets into OFF and ON states with positive and negative output voltages. When the capacitor current decays to zero, the capacitor voltage becomes $+2V_{DC}$.The same process is repeated for next cycle.

APPARATUS:

1. Parallel Inverter Module.
2. Regulated Power supply(0-30)V

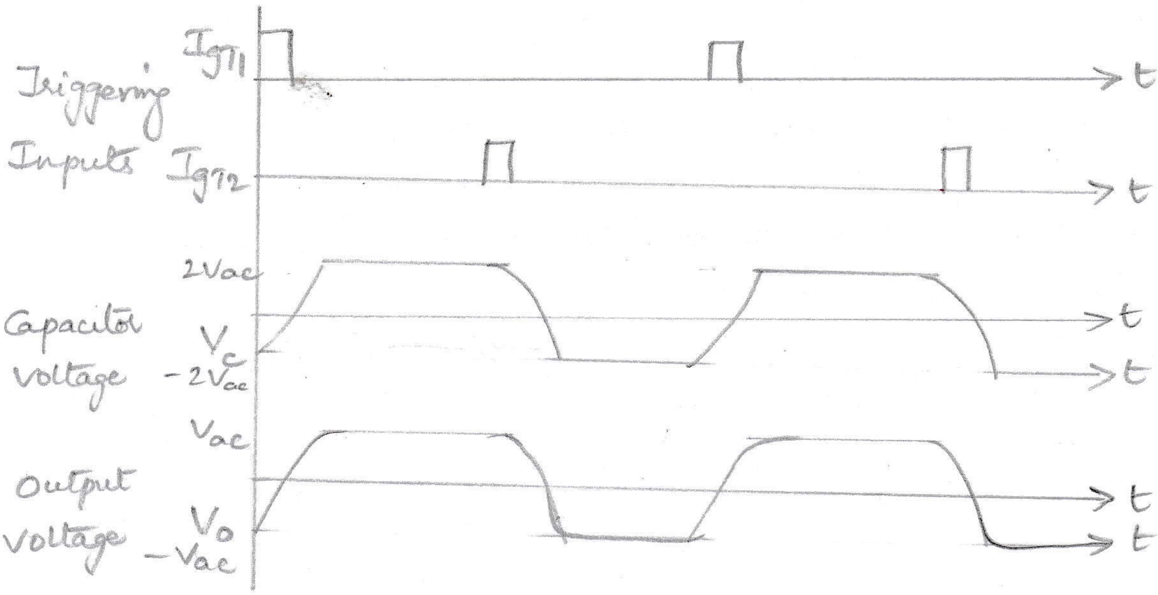
TABULAR COLUMN :

R Load

S.No.	Frequency (Hz)	Output Voltage (V)

RL Load

S.No.	Frequency (Hz)	Output Voltage (V)



3. Loading Rheostat (50Ω/2A)
4. Inductor – 50 mH /2A
5. Digital Multimeter.
6. Patch cords.
7. CRO.

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Adjust the DC supply to 15V and Switch ON the Main unit and the firing unit.
3. Set the frequency at a particular value and observe the load voltage waveform V_O, V_{T1}, V_{T2}, V_{P1}, V_{P2}, V_C on CRO and note down the corresponding waveforms.
4. By changing the frequency, note down the output AC voltage using a multimeter.
5. Connect the RL load and repeat the same procedure

NOTE:

1. At lower frequencies SCR may not turn ON due to insufficient voltage across the capacitor. Hence adjust the frequency to a higher value (approximately above 100 Hz).
2. For commutation failure switch OFF the firing circuit as well as power circuit and switch it ON again.

RESULT: The output of Single Phase Parallel Inverter is observed and studied.

SINGLE PHASE CYCLO CONVERTER.

CIRCUIT DIAGRAM:

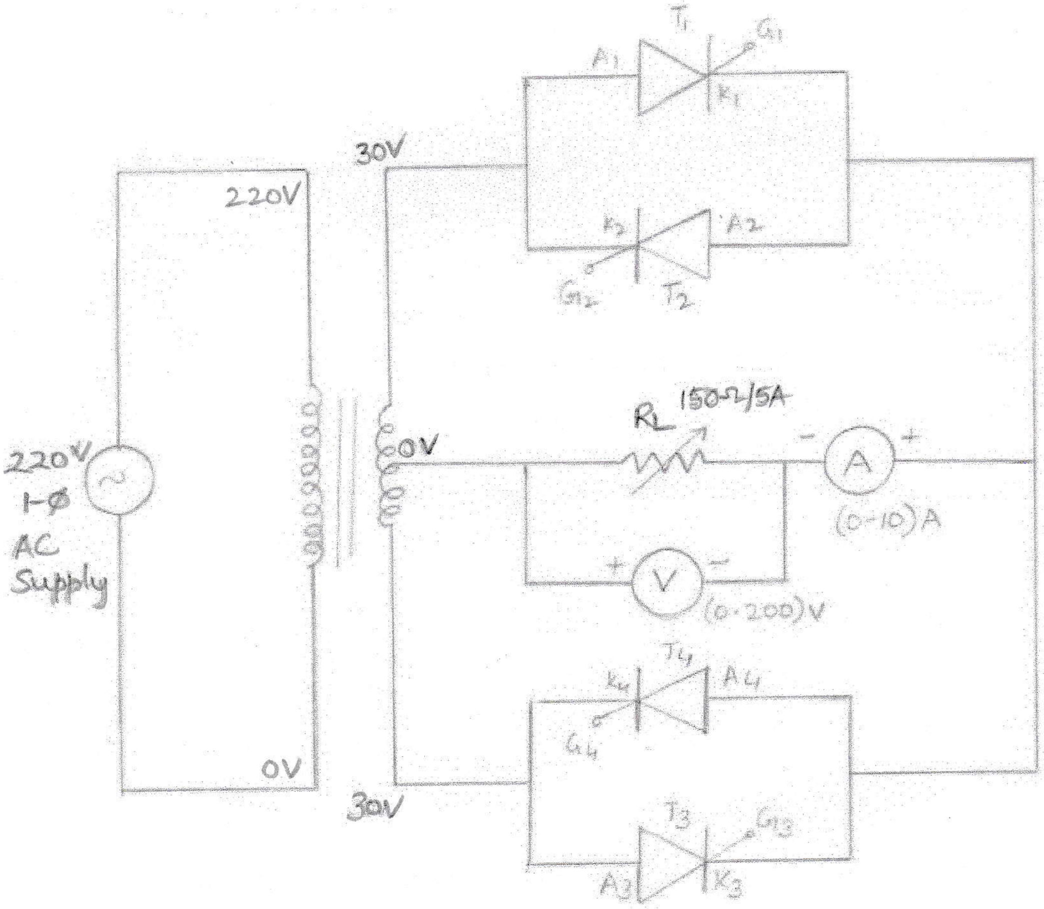


Fig 7.1

7.SINGLE PHASE CYCLO CONVERTER

AIM: To obtain the output of Single Phase Cyclo Converter circuit and to study its operation with R and RL loads.

THEORY:

Cyclo converter converts input power at one frequency to output power at a different frequency. Cyclo Converters are used in speed control of high power AC drives, induction heating etc.

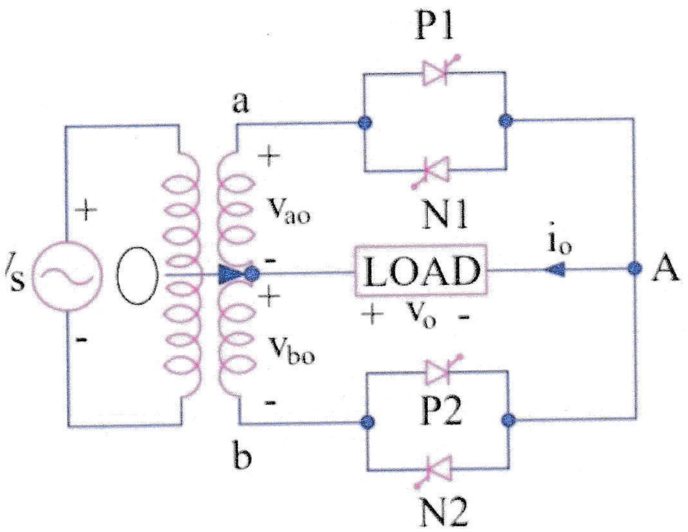


Fig 7.1: Single Phase Cyclo converter

The Single Phase Cycloconverter circuit is as shown above. The following sequence of operation can be followed One group of SCR's produces positive polarity load voltage and other group produces negative half cycle of the output. SCR's P_1 & N_2 of the positive group are gated together depending on the polarity of the input. Only one of them is allowed conduct when a is positive with respect to O. SCR's N_1 & P_2 of the negative group are gated together depending on the polarity of the input. Only one of them is allowed conduct when b is positive with respect to O. By triggering the respective SCR during negative or positive half cycles, any of the half cycle can be achieved at the load side. The order of switching sequence decides the frequency of Cyclo converter.

APPARATUS:

1. Cycloconverter Power unit.
2. Cycloconverter firing unit.

TABULAR COLUMN:

For R Load:

Vm = _______ Volts.

S.No.	Frequency	V_L (V)
1		
2		
3		
4		
5		
6		
7		

For RL Load :

Vm = _______ Volts.

S.No.	Frequency	V_L (V)
1		
2		
3		
4		
5		
6		
7		

EXPECTED WAVEFORMS :

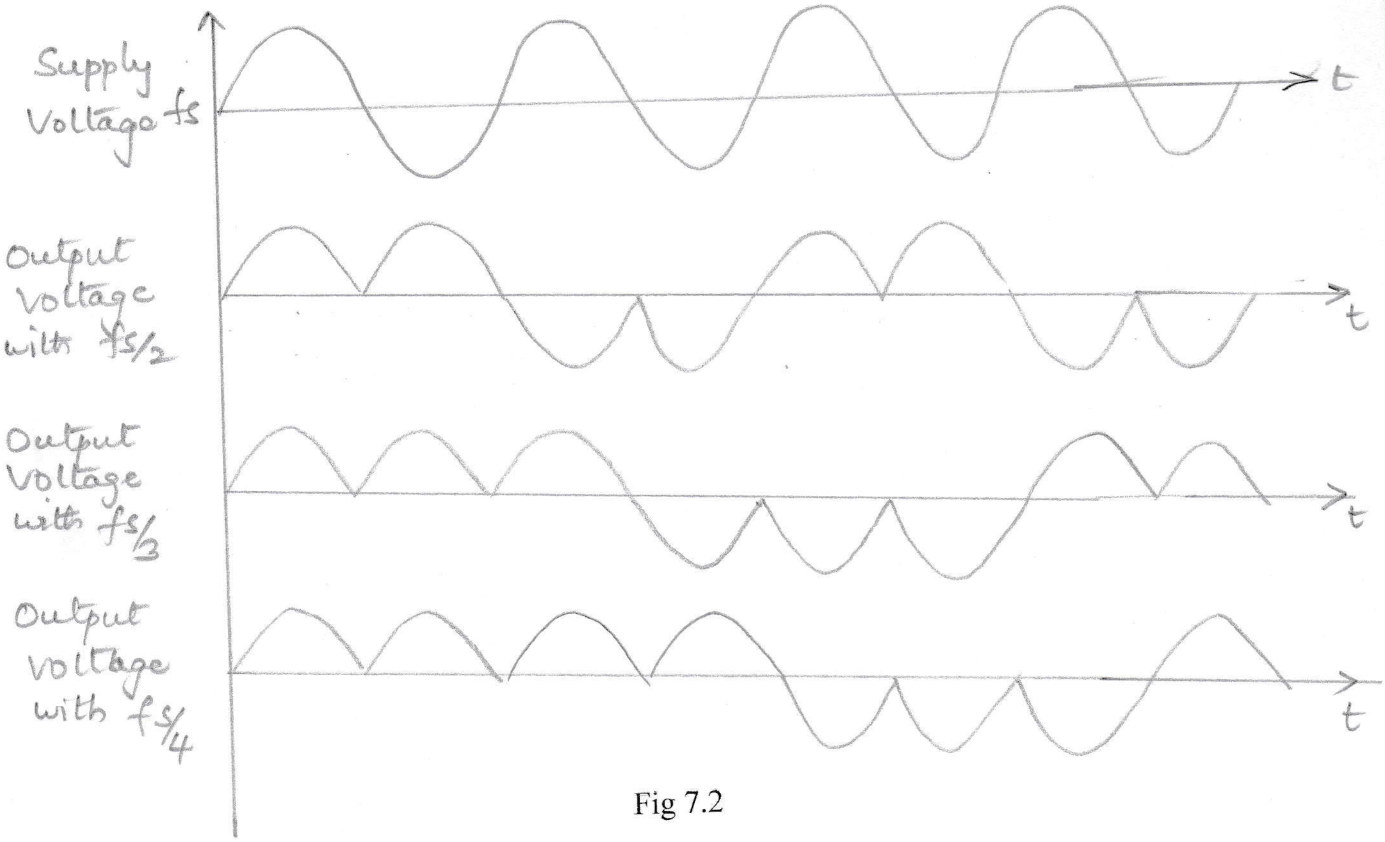


Fig 7.2

3. Single Phase Isolation transformer (center tapped)
4. Loading Rheostat - 150Ω/2A
5. Inductor – (0-150 mH / 5A
6. Digital Multimeter.
7. C.R.O.
8. Patch cards.

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Switch ON the power unit and the firing unit .
3. Set the frequency division to 2., note down the waveform across the load Vo and note down the output voltage and current readings from the voltmeter and the ammeter.
4. Note down the output voltage waveform for different frequency divisions and note down the output voltages and currents.
5. Now connect RL load.
6. Repeat the above steps for Cyclo Converter with RL load.

RESULT: The output and operation of Single Phase Cycloconverter with R & RL load is observed.

SINGLE PHASE SERIES INVERTER

CIRCUIT DIAGRAM :

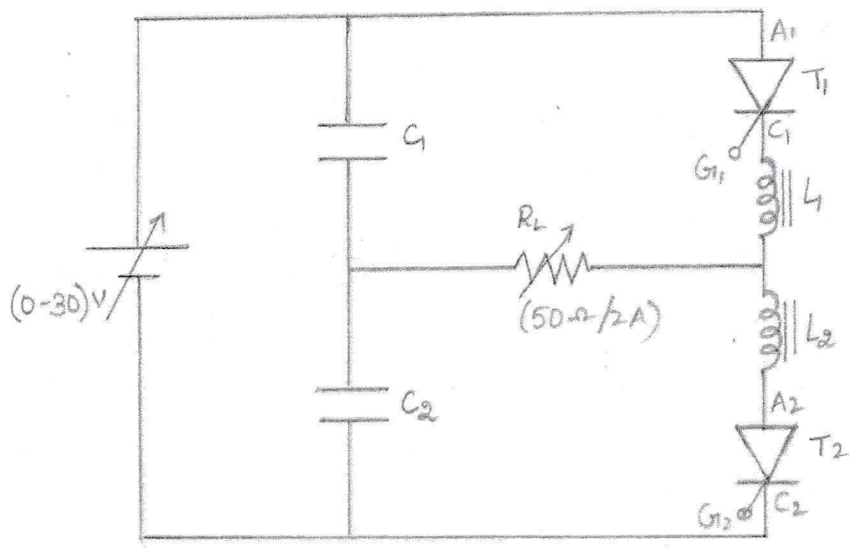


Fig 8.1

8. SINGLE PHASE SERIES INVERTER

AIM: To obtain the output of Single phase Series Inverter circuit with R and RL Load and study its operation.

THEORY:

In Series Inverter, commutating components are permanently connected in series with the load. Series Inverters are also classified as self-commutated inverters & Load commutated Inverters.

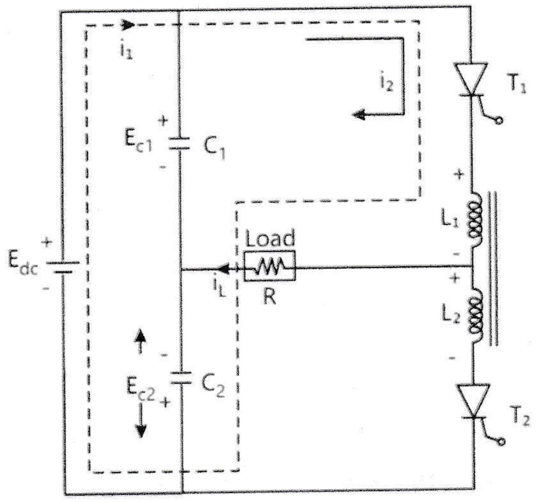


Fig 8.1: Series Inverter

This circuit consists of load resistance R in series with commutating components L & C. The values of L & C are so chosen that the series RLC circuit forms an under damped circuit. Two thyristors T1 and T2 are turned on appropriately so that output voltage of desired frequency can be obtained.

When thyristor T1 is turned ON with T2 OFF, current starts building up in the RLC circuit. As the circuit is under damped, the load current after reaching peak value, decays to zero. After thyristor T1 has commuted, upper plate of capacitor attains positive polarity. Now, when T2 is turned ON, capacitor discharges and load current flows in reverse direction up to some peak negative value and then decays to zero. The capacitor sores charge during one half cycle and releases the same amount of charge during next half cycle.

APPARATUS:

1. Series Inverter unit
2. Loading Rheostat - 50Ω/2A
3. Regulated Power supply (0-30)V

TABULAR COLUMN:

R Load

S.NO.	Time Period (ms)	Frequency (Hz)	Output voltage (V)

RL Load

S.NO.	Time Period (ms)	Frequency (Hz)	Output voltage (V)

EXPECTED WAVEFORMS :

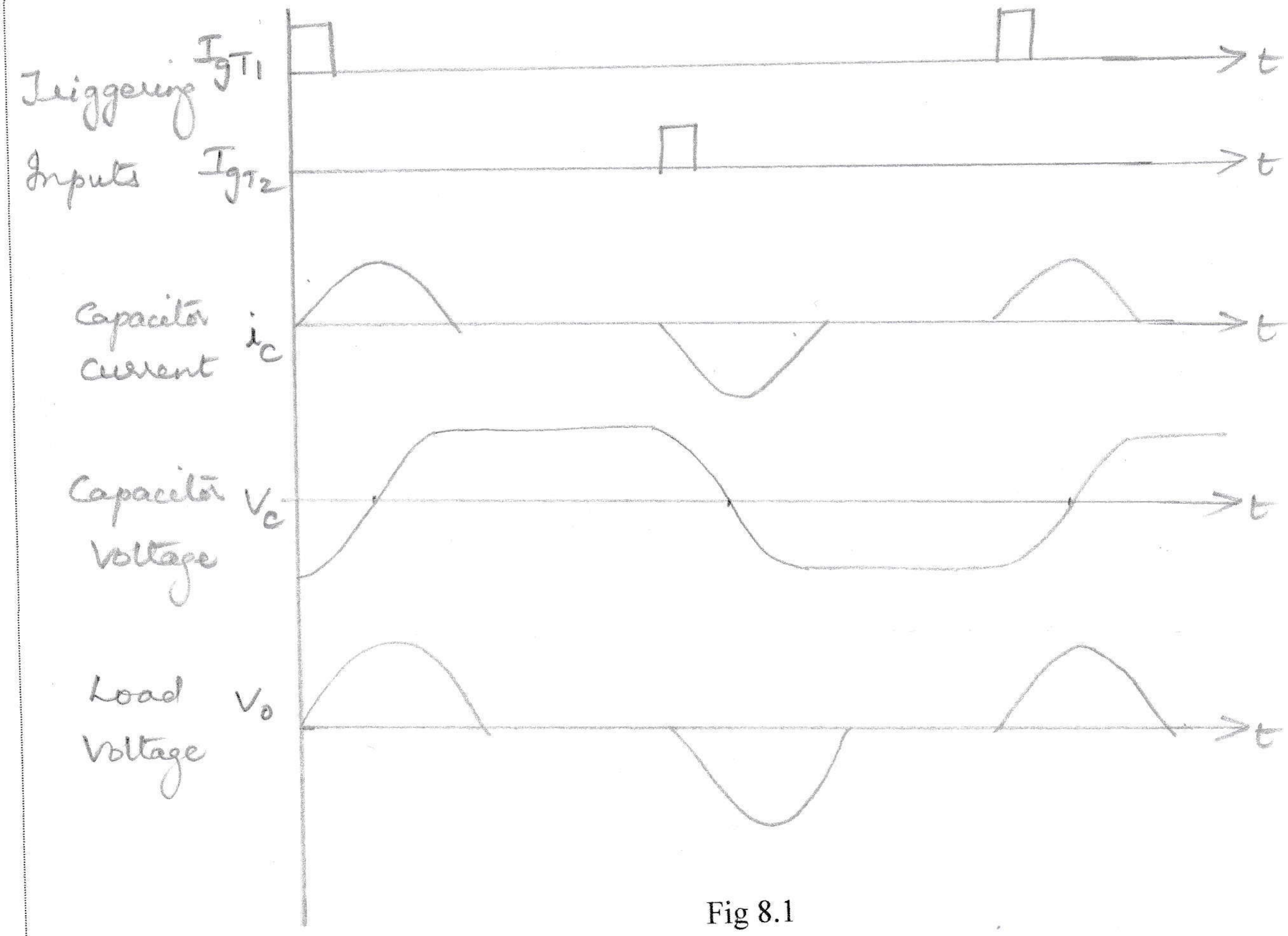


Fig 8.1

4. Inductor – 50 mH / 2A
5. Multimeter.
6. Patch cords
7. CRO

PROCEDURE:

1. Make the connections as per the circuit diagram with R Load.
2. Adjust the DC supply voltage to 30 V and Switch ON the DC power supply and the firing unit.
3. Set the frequency at a particular position and observe the output waveform V_O,V_{T1}, V_{T2},V_{P1},V_{P2},V_{C1},V_{C2} on the CRO and note down the corresponding waveforms.
4. By varying the frequency in steps, note down the AC output voltage using multimeter.
5. Connect RL load and note down the output voltage V_O and repeat the same procedure.

NOTE: In case of Commutation failure, switch OFF the power module and the firing unit and again switch it ON.

RESULT: The output of Single Phase Series Inverter and its operation with R& RL load is observed and studied.

SINGLE PHASE HALF CONTROLLED CONVERTER

CIRCUIT DIAGRAM:

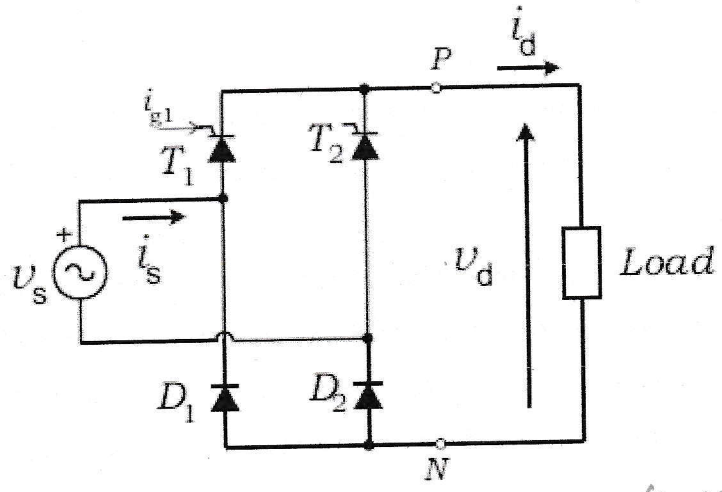
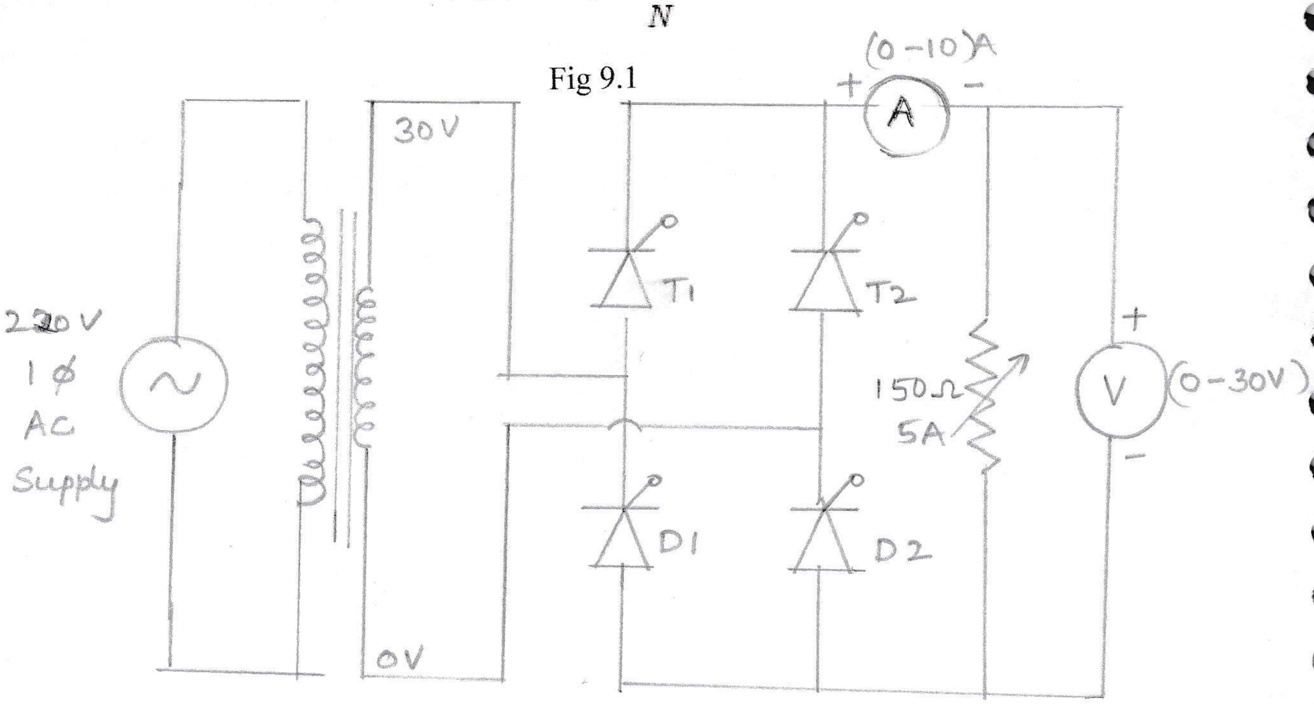


Fig 9.1



9. SINGLE PHASE HALF CONTROLLED CONVERTER

AIM: To obtain the output of Single phase Half Controlled Bridge Converter and study the operation.

THEORY:

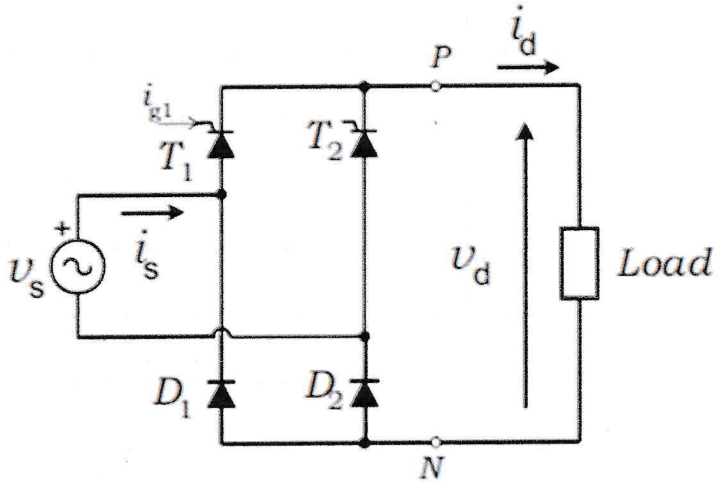


Fig 9.1: Single Phase Half controlled Converter

The Single Phase Half controlled Converter circuit consists of two SCR's and two diodes. During the positive half cycle, the SCR T_1 and diode D_2 conduct when triggered at firing angle α. T_1 and D_2 conducts from α to π. For negative Half cycle, the SCR T_2 and diode D_1 conducts from $\pi + \alpha$ to 2π.

This converter will not allow negative voltage across the load as it turns off soon after the diode gets reverse biased. It has better power factor due to this reason and is commonly used in application up to 15KWatts and it has lot of advantages compare to fully controlled converter like low cost, good power factor and low load current ripple. Some of the disadvantages are higher harmonic content in the source current and since the output voltage cannot be made negative, inverter operation is not possible.

APPARATUS:

1. Single phase Half controlled Bridge Converter power circuit.
2. Single phase Converter firing circuit.
3. Single phase Isolation transformer 230V/2A
4. R Load – 50 ohms / 2Amps.

TABULAR COLUMN:

S.No	Input Voltage (V_{in})	Firing angle(α)	Output voltage(V)	Output Current

5. L Load
6. CRO

PROCEDURE:

1. Switch ON the Mains Supply to the Firing circuit. Observe all the test points by varying the firing angle and trigger outputs ON/OFF switch.
2. Switch ON the main circuit supply and firing circuit and note down the voltage wave forms across load and devices for firing angle zero.
3. Note down the wave forms across load and devices for different firing angles.
4. Repeat the same procedure for different firing angles.
5. Repeat the same for R-L load with and without freewheeling diode and note down the wave forms.

RESULT : The operation of single phase Half controlled converter and wave forms for different firing angles are observed.

SINGLE PHASE FULL CONVERTER USING RL and E LOAD

CIRCUIT DIAGRAM:

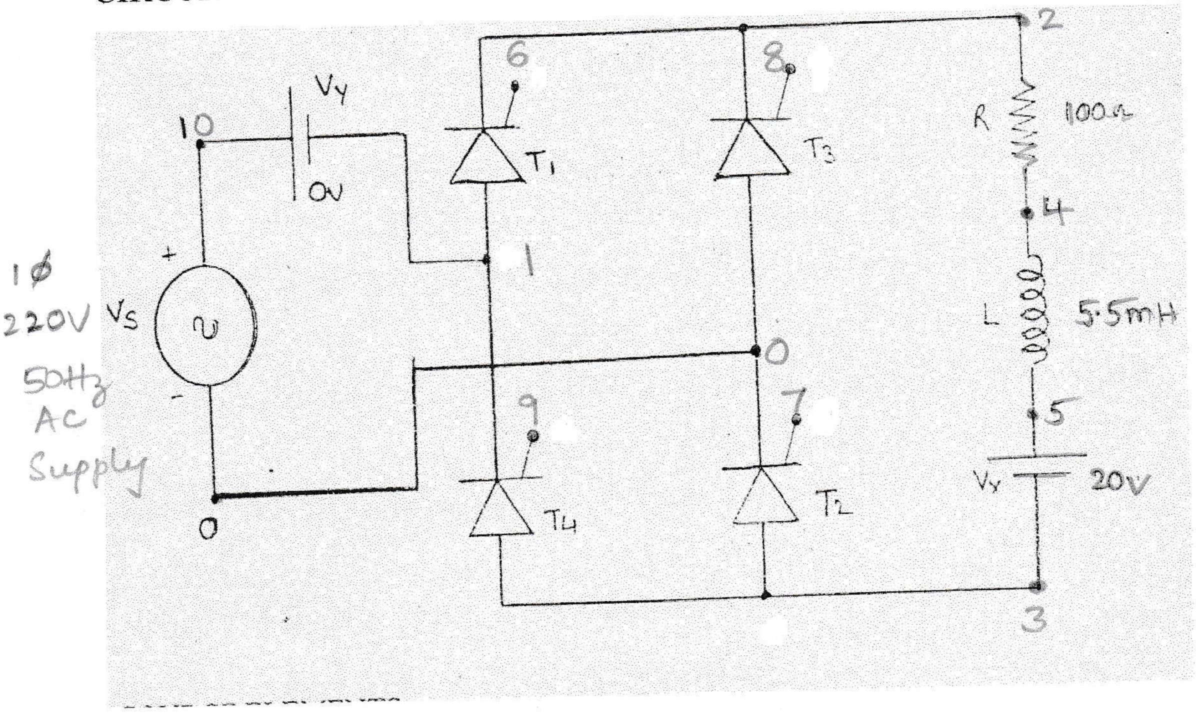


Fig 10.1

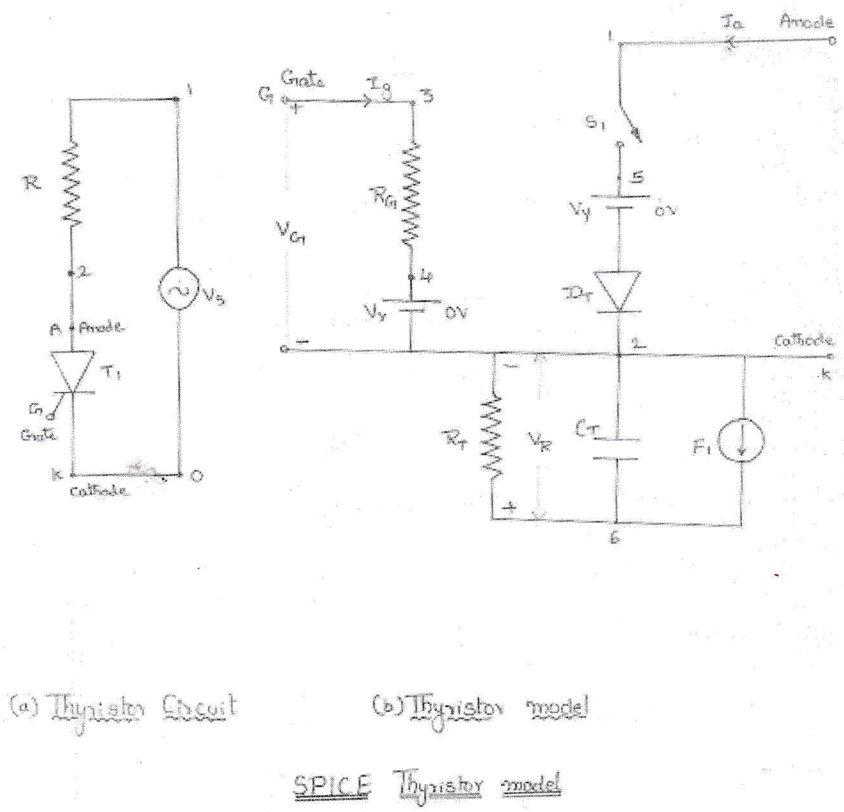


Fig 10.2

10. SIMULATION OF SINGLE-PHASE FULL CONVERTER USING RLE LOADS AND SINGLE-PHASE AC VOLTAGE CONTROLLER USING RLE LOADS.

a) SINGLE PHASE FULL CONVERTER USING RL AND E LOAD

AIM: To simulate single phase full converter using PSPICE and obtain its output.

APPARATUS: Computer and PSPICE Software

THEORY:

PSpice A/D is a simulation program that models the behaviour of a circuit containing any mix of analog and digital devices. Because the analog and digital simulation algorithms are built into the same program, PSpice A/D simulates mixed-signal circuits with no performance degradation because of tightly coupled feedback loops between the analog and digital sections.

PSpice A/D can perform DC, AC, and transient analyses, so the response of a circuit to different inputs can be tested. The range of models built into PSpice A/D include resistors, inductors, capacitors, and bipolar transistors, diodes and different types of sources.

.TRAN (transient analysis)

Purpose: The .TRAN command causes a transient analysis to be performed on the circuit and specifies the time period for the analysis.

General form .TRAN[/OP] +[no-print value [step ceiling value]][SKIPBP]

Examples .TRAN 1ns 100ns

.TRAN/OP 1ns 100ns 20ns SKIPBP

.TRAN 1ns 100ns 0ns .1ns

.TRAN 1ns 100ns 0ns {SCHEDULE(0,1ns,25ns,.1ns)}

.PROBE (Probe)

Purpose: The .PROBE command writes the results from DC, AC, and transient analyses to a data file used by Probe.

General form .PROBE[/CSDF][output variable]

Examples .PROBE .PROBE V(3) V(2,3) V(R1) I(VIN) I(R2) IB(Q13) VBE(Q13)

OPTIONS (analysis options)

Purpose: The .OPTIONS command is used to set all the options, limits, and control parameters for the simulator.

General form .OPTIONS [option name]* [<option name>= <value>]*

OUTPUT WAVE FORMS: -

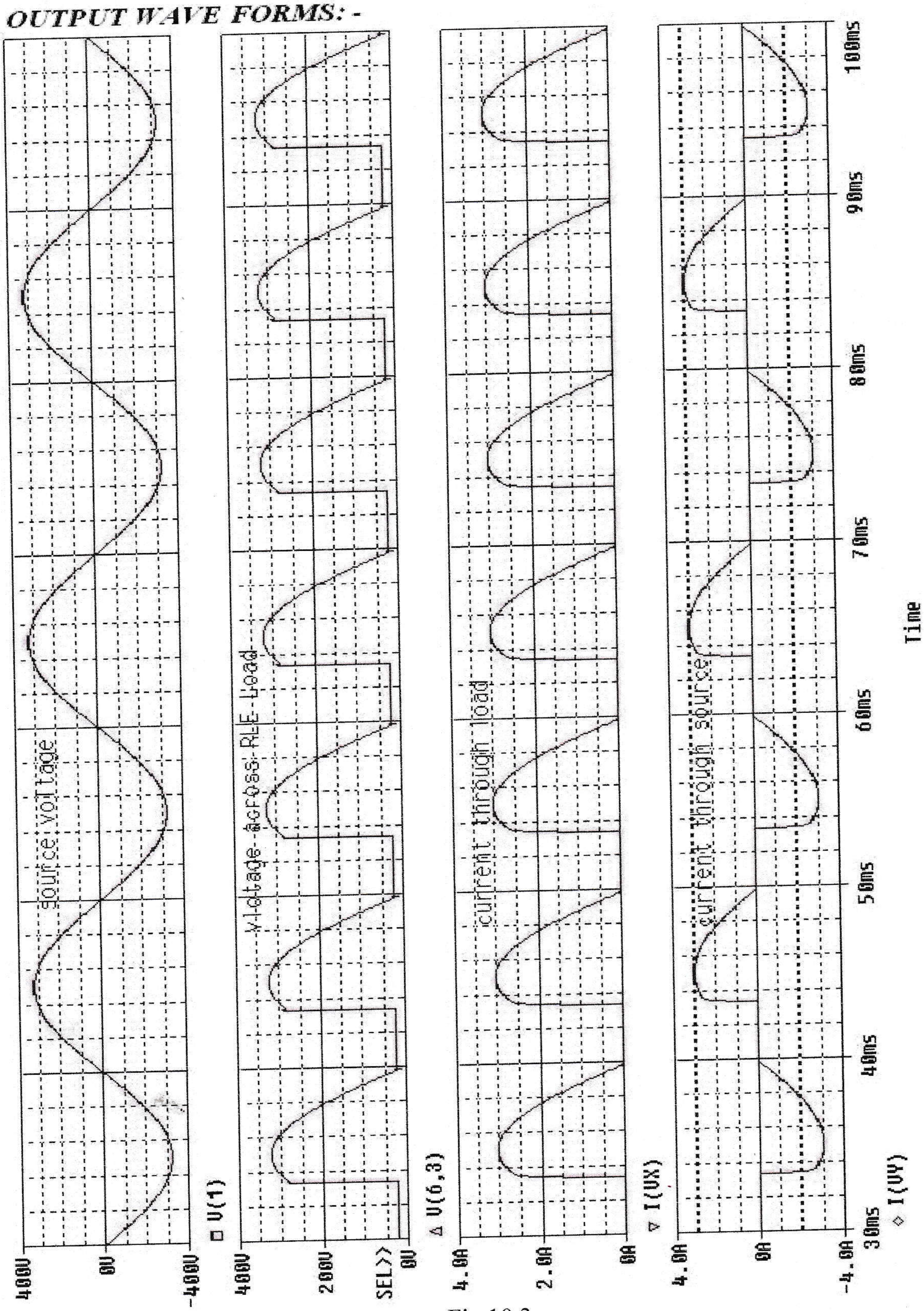


Fig 10.3

Supply Voltage

Load voltage

Load Current

Source Current

FOURIER COMPONENTS OF TRANSIENT RESPONSE I(VY)

DC COMPONENT = -2.420296E-07

HARMONIC NO	FREQUENCY (HZ)	FOURIER COMPONENT	NORMALIZED COMPONENT	PHASE (DEG)	NORMALIZED PHASE (DEG)
1	5.000E+01	2.495E+00	1.000E+00	-1.632E+01	0.000E+00
2	1.000E+02	5.052E-07	2.025E-07	1.474E+02	1.801E+02
3	1.500E+02	7.715E-01	3.092E-01	1.474E+02	1.963E+02
4	2.000E+02	4.720E-07	1.892E-07	3.130E+01	9.656E+01
5	2.500E+02	4.018E-01	1.610E-01	5.824E+01	1.398E+02
6	3.000E+02	5.385E-07	2.158E-07	-9.582E+01	2.072E+00
7	3.500E+02	1.976E-01	7.917E-02	-7.201E+01	4.220E+01
8	4.000E+02	4.328E-07	1.735E-07	1.469E+02	2.774E+02
9	4.500E+02	2.010E-01	8.054E-02	1.616E+02	3.085E+02

TOTAL HARMONIC DISTORTION = 3.664522E+01 PERCENT

JOB CONCLUDED

TOTAL JOB TIME .27 Sec

OUTPUT:

```
*********Diode                                                    MODEL
PARAMETERS**********************************************
**********************************************************************
***
          XT1.DMOD       XT2.DMOD       XT3.DMOD       XT4.DMOD
   IS     2.200000E-15   2.200000E-15   2.200000E-15   2.200000E-15
   BV     1.200000E+03   1.200000E+03   1.200000E+03   1.200000E+03

*********Voltage         Controlled          Switch               MODEL
PARAMETERS******************************
**********************************************************************
***
          XT1.SMOD       XT2.SMOD       XT3.SMOD       XT4.SMOD
   RON    .0105          .0105          .0105          .0105
   ROFF   1.000000E+06   1.000000E+06   1.000000E+06   1.000000E+06
   VON    .5             .5             .5             .5
   VOFF   0              0              0              0
**********INITIAL TRANSIENT SOLUTION     TEMPERATURE =   27.000 DEG C
**********************************************************************
***
 NODE   VOLTAGE    NODE   VOLTAGE    NODE   VOLTAGE    NODE   VOLTAGE
(   1)   0.0000 (   2)  10.0000 (   3)  -9.9998 (   4)  10.0000
(   5)  10.0000 (   6)  10.0000 (   7)   0.0000 (   8)  10.0000
(   9)   0.0000 (  10)   0.0000 (XT1.4)  10.0000 (XT1.5) 10.00E-06
(XT1.6)  10.0000 (XT1.7) 10.00E-06 (XT2.4)   0.0000 (XT2.5)  -9.9998
(XT2.6)-110.0E-12 (XT2.7)  -9.9998 (XT3.4)  10.0000 (XT3.5) 10.00E-06
(XT3.6)  10.0000 (XT3.7) 10.00E-06 (XT4.4)   0.0000 (XT4.5)  -9.9998
(XT4.6)-110.0E-12 (XT4.7)  -9.9998
   VOLTAGE SOURCE CURRENTS
   NAME        CURRENT
   VS         4.163E-16
   VG1        0.000E+00
   VG2        0.000E+00
   VG3        0.000E+00
   VG4        0.000E+00
   VX        -2.000E-11
   VY        -4.163E-16
   XT1.VX     0.000E+00
   XT1.VY    -1.000E-11
   XT2.VX     0.000E+00
   XT2.VY    -1.000E-11
   XT3.VX     0.000E+00
   XT3.VY    -1.000E-11
   XT4.VX     0.000E+00
   XT4.VY    -1.000E-11
   TOTAL POWER DISSIPATION   4.00E-10  WATTS
***********FOURIER ANALYSIS          TEMPERATURE =   27.000 DEG C
**********************************************************************
***
```

PROCEDURE:

1. Write the Program in PSPICE .cir file or in .txt file, by identifying nodes in the circuit.
2. Save the program and run it in PSPICE A/D.
3. Observe the Output file for outputs like nodal voltages, source currents and power dissipated.
4. Open probe and enter the waveforms to be plotted and get the plots.
5. Note down the plots in graph sheets and verify it with theoretical values.

PROGRAM:

```
*********SINGLE PHASE AC SUPPLY****************************
VS  10 0 SIN(0 325V 50HZ)
***************MAIN CIRCUIT*****************************
VG1 6  2 PULSE(0V 10V 3333.33US  1NS 1NS 100US 20000US)
VG2 7  0 PULSE(0V 10V 3333.33US  1NS 1NS 100US 20000US)
VG3 8  2 PULSE(0 10V  13333.33US 1NS 1NS 100US 20000US)
VG4 9  1 PULSE(0 10V  13333.33US 1NS 1NS 100US 20000US)
*************************LOAD********************************
R 2 4 100OHM
L 4 5 5.5MH
VX 5 3 DC  20V
VY 10 1 DC 0V
**********************SWITCHES*******************************
XT1 1 2 6 2 SCR

XT2 3 0 7 0 SCR
XT3 0 2 8 2 SCR
XT4 3 1 9 1 SCR
***********************Begin of Sub circuit for SCR*****************
.SUBCKT SCR 1 2 3 2
S1 1 5 6 2 SMOD
RG 3 4 50
VX 4 2 DC 0V
VY 5 7 DC 0V
DT 7 2 DMOD
RT 6 2 1
CT 6 2 10UF
F1 2 6 POLY(2) VX VY 0 50 11
.MODEL SMOD VSWITCH (RON=0.0105 ROFF=10E+5 VON=0.5V VOFF=0V)
.MODEL DMOD D(IS=2.2E-15 BV=1200V TT=0 CJO=0)
.ENDS SCR
***********************End of Sub circuit for SCR******************
.TRAN 50US 100MS 30MS 50US
.OPTIONS ABSTOL=1.00N RELTOL=1.0M VNTOL=0.01 ITL5=20000
.FOUR 50HZ I(VY)
.PROBE
.END
```

RESULT: The response of single phase full wave bridge converter is verified using SPICE software.

10.b) SINGLE PHASE AC VOLTAGE CONTROLLER USING RL LOAD

CIRCUIT DIAGRAM:

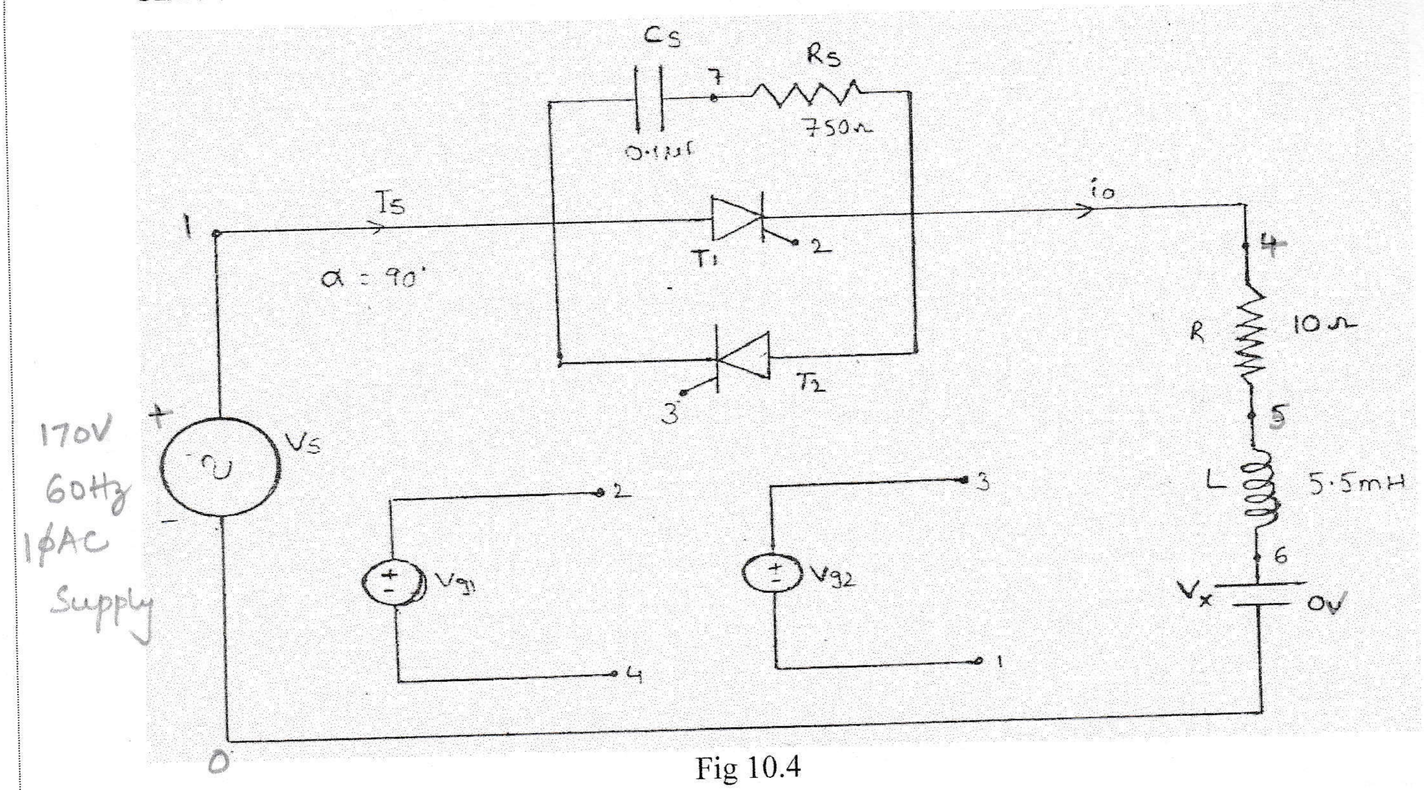


Fig 10.4

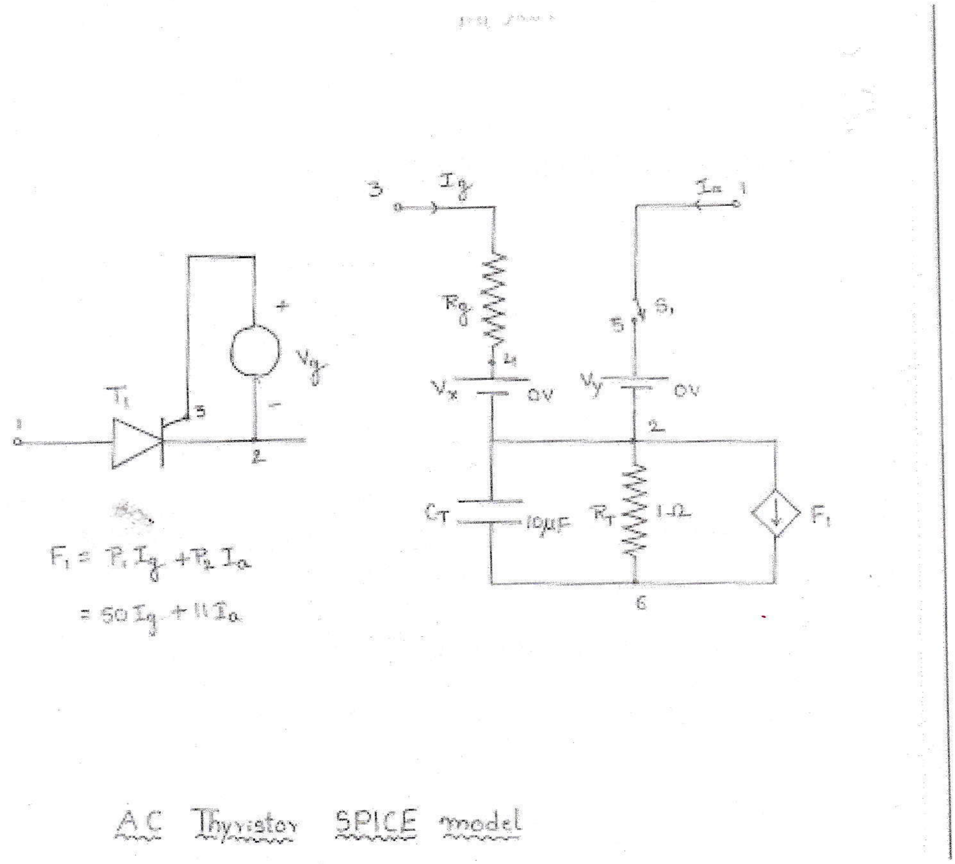


Fig 10.5

OUTPUT WAVE FORMS: -

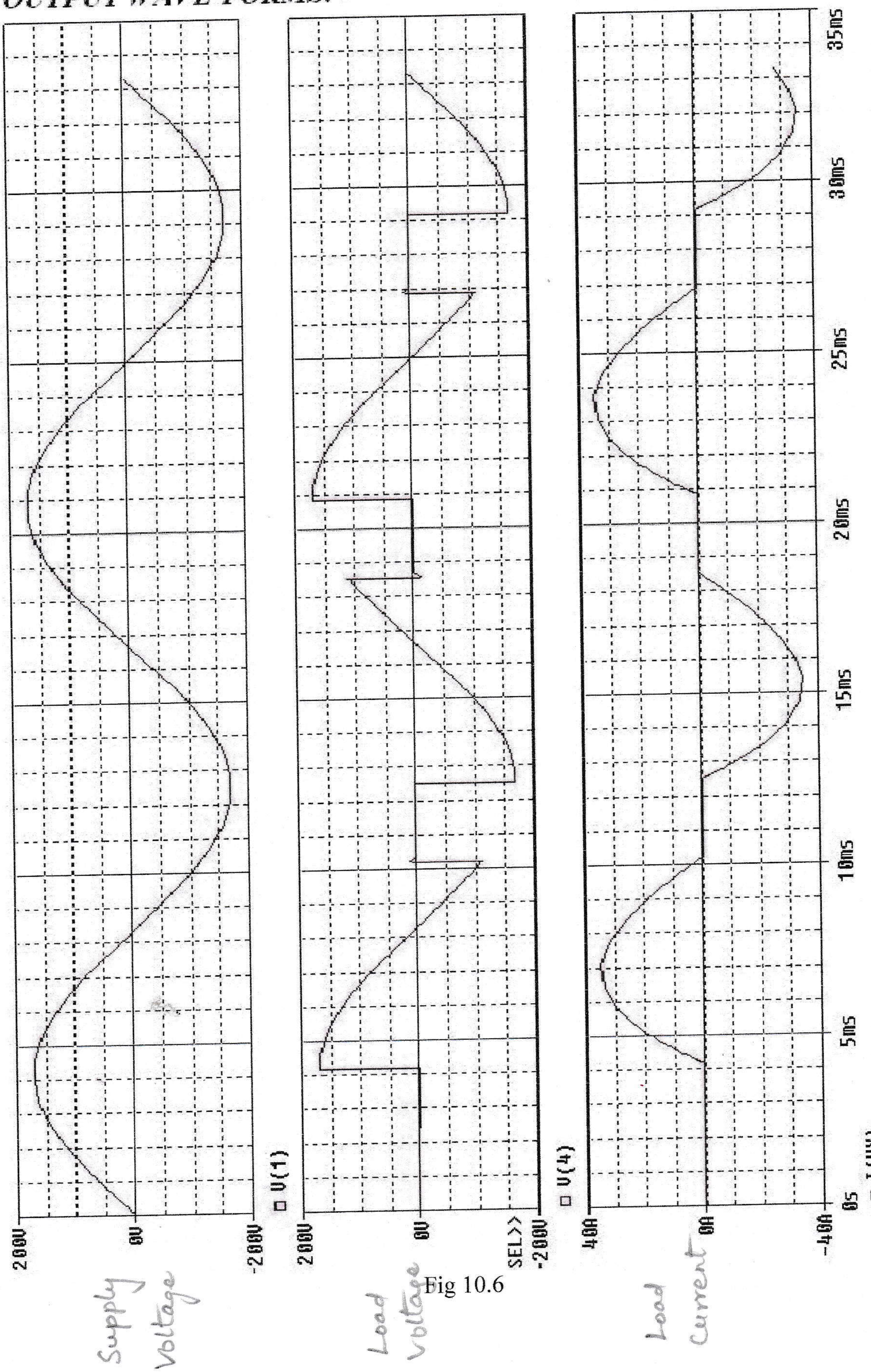


Fig 10.6

OUTPUT:

```
*********VOLTAGE CONTROLLED SWITCH MODEL
PARAMETERS****************
*************************************************************************
***
          XT1.SMOD       XT2.SMOD
   RON    .01            .01
   ROFF   1.000000E+06   1.000000E+06
   VON    .1             .1
   VOFF   0              0
*******INITIAL TRANSIENT SOLUTION     TEMPERATURE =   27.000 DEG C
*************************************************************************
***
 NODE  VOLTAGE   NODE  VOLTAGE   NODE  VOLTAGE   NODE  VOLTAGE
(   1)  0.0000  (   2)  0.0000  (   3)  0.0000  (   4)  0.0000
(   5)  0.0000  (   6)  0.0000  (   7)  0.0000  (XT1.4)  0.0000
   VOLTAGE SOURCE CURRENTS
   NAME       CURRENT
   VS         0.000E+00
   VG1        0.000E+00
   VG2        0.000E+00
   VX         0.000E+00
   XT1.VX     0.000E+00
   XT1.VY     0.000E+00
     TOTAL POWER DISSIPATION   0.00E+00  WATTS
*********FOURIER ANALYSIS           TEMPERATURE =   27.000 DEG C
*************************************************************************
***
FOURIER COMPONENTS OF TRANSIENT RESPONSE V(4)
DC COMPONENT =  -5.019307E-04
HARMONIC  FREQUENCY  FOURIER    NORMALIZED  PHASE      NORMALIZED
  NO        (HZ)     COMPONENT  COMPONENT   (DEG)      PHASE (DEG)P
  1     6.000E+01   1.011E+02   1.000E+00  -1.788E+01   0.000E+00
  2     1.200E+02   9.565E-04   9.459E-06  -8.191E+01  -4.614E+01
  3     1.800E+02   6.167E+01   6.098E-01   6.883E+01   1.225E+02
  4     2.400E+02   9.083E-04   8.982E-06  -6.561E+01   5.928E+00
  5     3.000E+02   3.372E+01   3.335E-01  -6.876E+01   2.067E+01
  6     3.600E+02   9.699E-04   9.591E-06  -5.180E+01   5.551E+01
  7     4.200E+02   7.505E+00   7.421E-02   1.232E+02   2.484E+02
  8     4.800E+02   1.003E-03   9.921E-06  -4.581E+01   9.727E+01
  9     5.400E+02   1.308E+01   1.293E-01  -1.270E+02   3.397E+01
  TOTAL HARMONIC DISTORTION =   7.108297E+01 PERCENT
     JOB CONCLUDED
     TOTAL JOB TIME           .05 sec
```

```
.OPTIONS ABSTOL=1.00n RELTOL=1.0m VNTOL=1.0m ITL5=10000
.FOUR 60HZ V(4)
.END
```

RESULT: The response of single phase AC voltage controller is verified using SPICE software.

SIMULATION OF RESONANT PULSE COMMUTATION CIRCUIT

CIRCUIT DIAGRAM:

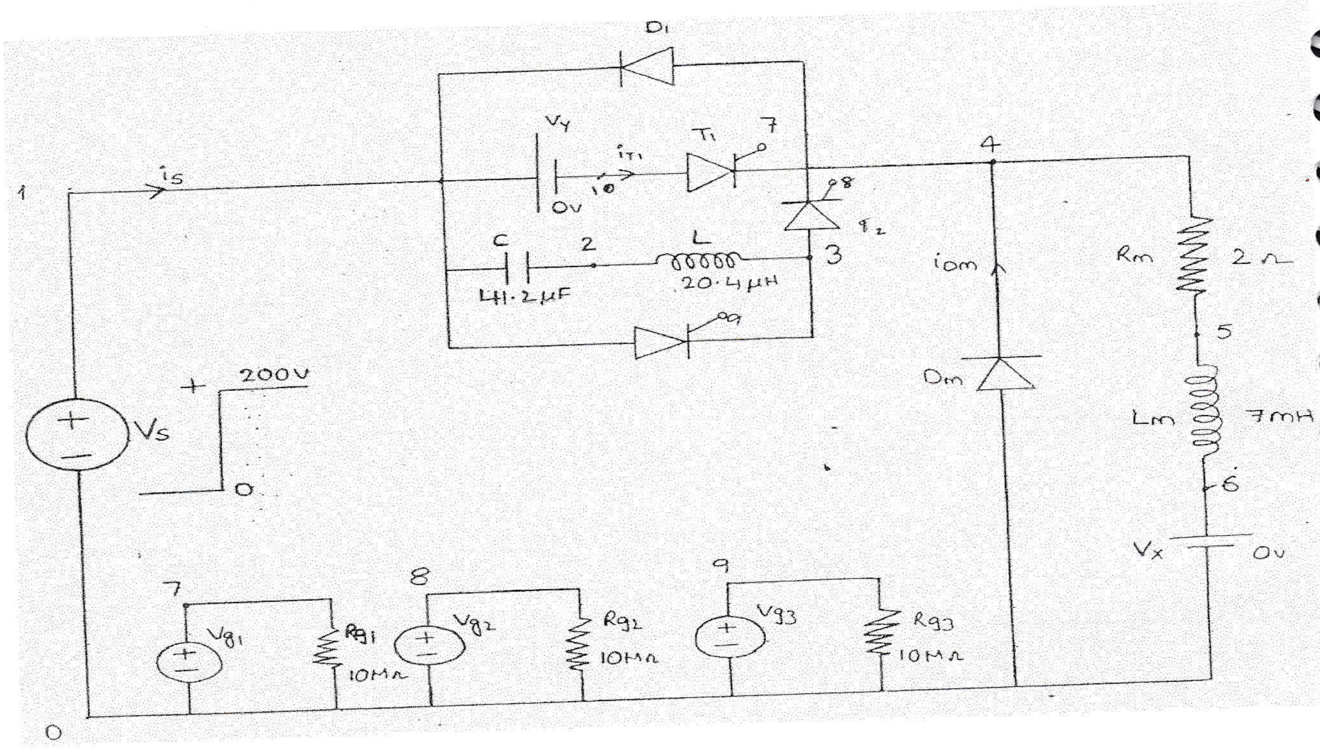


Fig 11.1

11. SIMULATION OF RESONANT PULSE COMMUTATION CIRCUIT

AIM: To simulate Resonant commutation using PSPICE and obtain its output.

APPARATUS: Computer and PSPICE software

PROCEDURE:

1. Write the Program in PSPICE .cir file or in .txt file, by identifying nodes in the circuit.
2. Save the program and run it in PSPICE A/D.
3. Observe the Output file for outputs like nodal voltages, source currents and power dissipated.
4. Open probe and enter the waveforms to be plotted and get the plots.
5. Note down the plots in graph sheets and verify it with theoretical values.

PROGRAM:

```
************SINGLE PHASE AC SUPPLY****************************
VS  1 0 DC 200V
****************MAIN CIRCUIT****************************
VG1 7  0 PULSE(0V 100V 0      1US  1US 0.4MS 1MS)
VG2 8  0 PULSE(0V 100V 0.4MS  1US  1US 0.6MS 1MS)
VG3 9  0 PULSE(0V 100V 0      1US  1US 0.2MS 1MS)
************************LOAD**********************************
RG1 7 0 10MEG
RG2 8 0 10MEG
RG3 9 0 10MEG
L 2 3 20.4UH
C 1 2 41.2UF IC=200V
D1 4 1 DMOD
DM 0 4 DMOD
.MODEL DMOD D(IS=1E-25 BV=1000V)
RM 4 5 2
LM 5 6 7MH
VX 6 0 DC 0V
VY 1 10 DC 0V
***********************SWITCHES*******************************
XT1 10 4 7 0 TMOD
XT2 3  4 8 0 TMOD
XT3 1  3 9 0 TMOD
***********************Begin of Sub circuit for SCR*****************
.SUBCKT TMOD 1 2 3 4
DT 5 2 DMOD
ST 1 5 3 4 SMOD
.MODEL DMOD D(IS=2.22E-15 BV=1200V CJO=0 TT=0)
.MODEL SMOD VSWITCH (RON=0.01 ROFF=10E+6 VON=10V VOFF=5V)
.ENDS TMOD
***********************End of Sub circuit for SCR******************
.PROBE
.TRAN 1US 6MS 4MS
```

OUTPUT WAVE FORMS: -

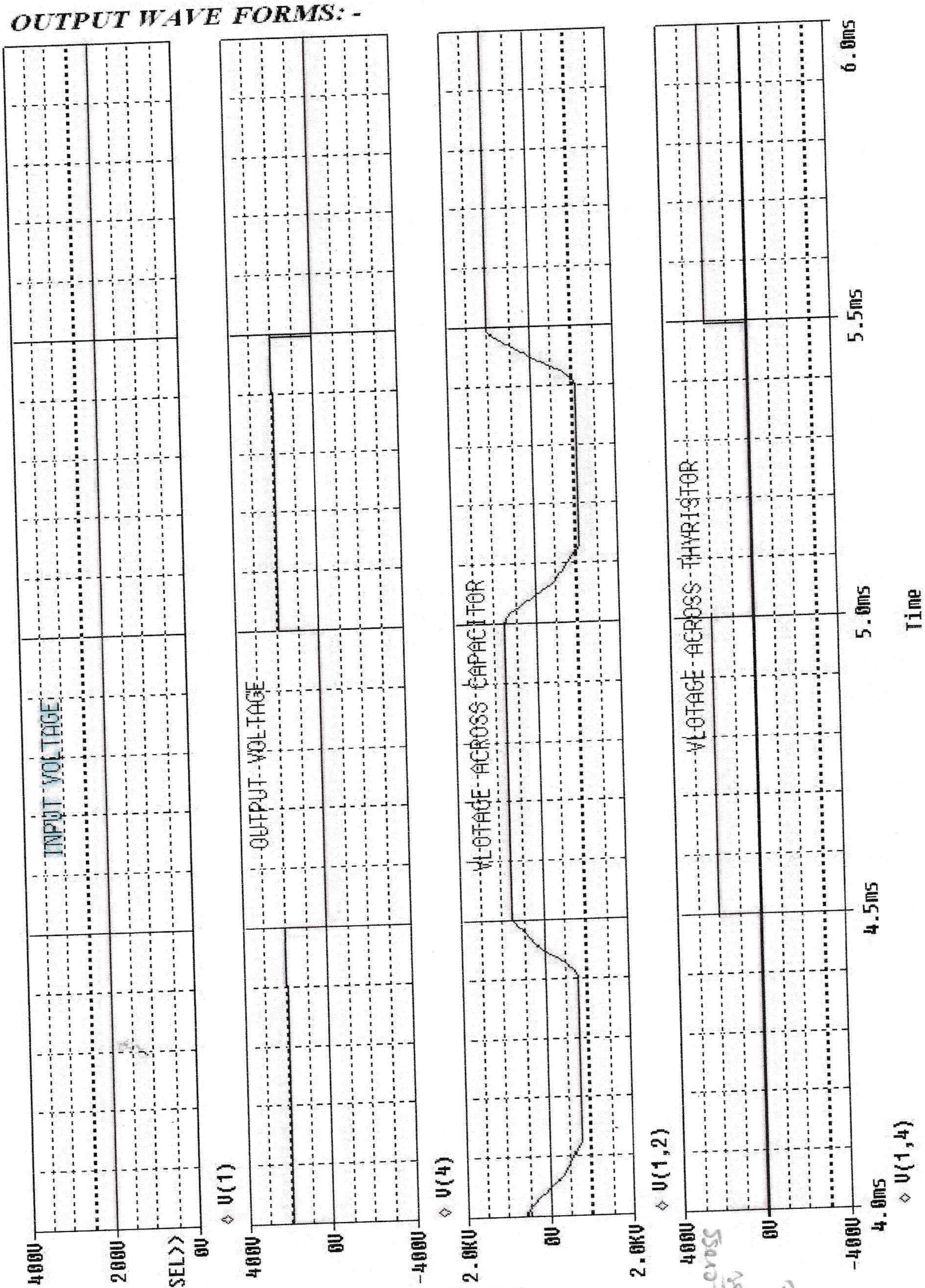


Fig 11.2

Supply voltage

Output voltage

Voltage across Capacitor voltage

Voltage across Thyristor voltage

OUTPUT:

******DIODE MODEL PARAMETERS**

	DMOD	XT1.DMOD	XT2.DMOD	XT3.DMOD
IS	100.000000E-27	2.220000E-15	2.220000E-15	2.220000E-15
BV	1.000000E+03	1.200000E+03	1.200000E+03	1.200000E+03

************Voltage Controlled Switch MODEL PARAMETERS************************

	XT1.SMOD	XT2.SMOD	XT3.SMOD
RON	.01	.01	.01
ROFF	10.000000E+06	10.000000E+06	10.000000E+06
VON	10	10	10
VOFF	5	5	5

*********INITIAL TRANSIENT SOLUTION TEMPERATURE = 27.000 DEG C
****

NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE
(1)	200.0000	(2)	39.88E-09	(3)	39.88E-09	(4)	39.88E-06
(5)	0.0000	(6)	0.0000	(7)	0.0000	(8)	0.0000
(9)	0.0000	(10)	200.0000	(XT1.5)	.5928	(XT2.5)	40.31E-09
(XT3.5)	.5928						

VOLTAGE SOURCE CURRENTS

NAME	CURRENT
VS	-1.994E-05
VG1	0.000E+00
VG2	0.000E+00
VG3	0.000E+00
VX	1.994E-05
VY	1.994E-05

TOTAL POWER DISSIPATION 3.99E-03 WATTS

JOB CONCLUDED

TOTAL JOB TIME .08 Sec

```
.OPTIONS ABSTOL=1.000U RELTOL=0.01 VNTOL=0.1 ITL5=20000
.END
```

RESULT: The response of Resonant commutation circuit is verified using SPICE software.

SIMULATION OF SINGLE PHASE INVERTER WITH PWM CONTROL.

CIRCUIT DIAGRAM:

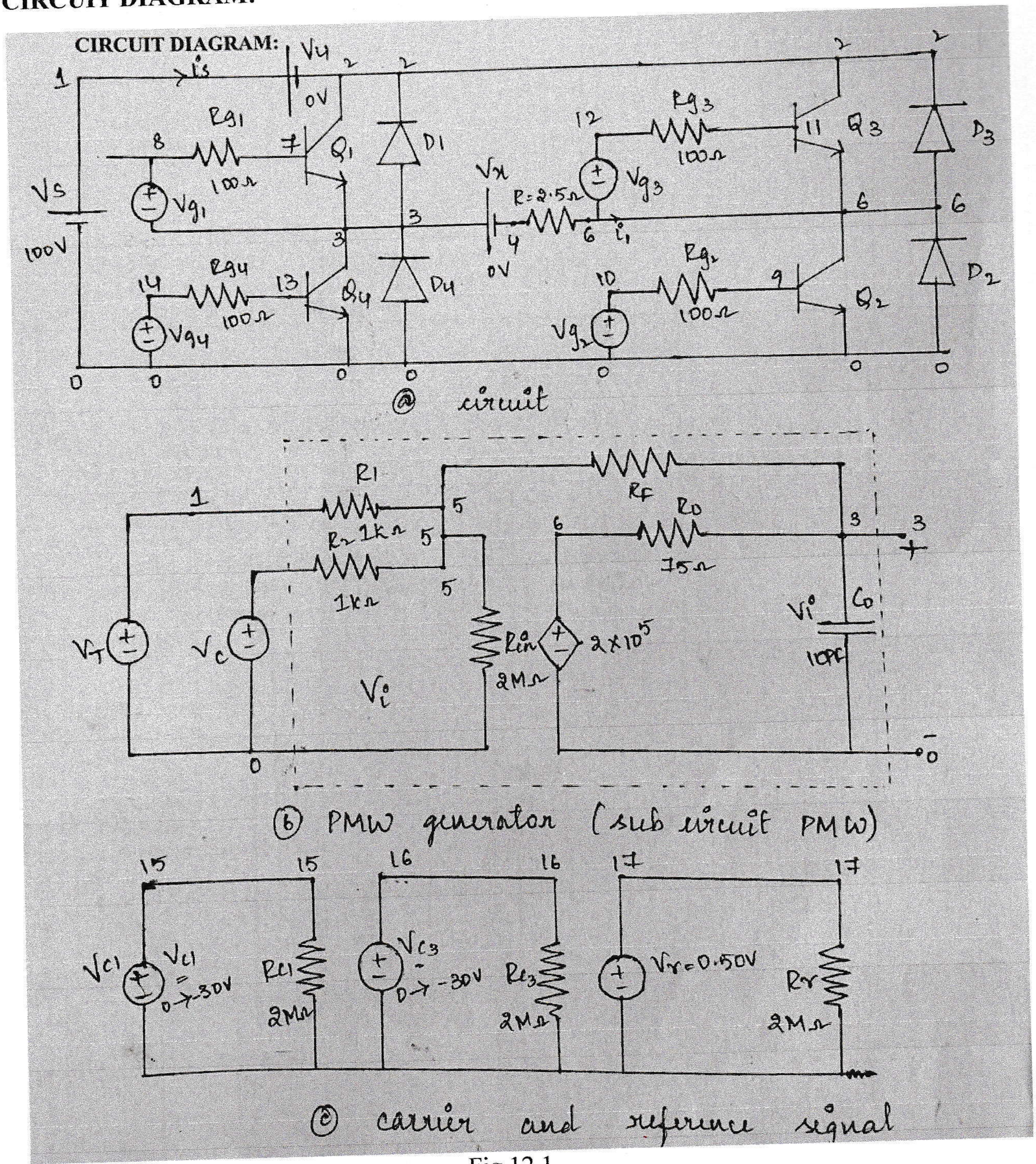


Fig 12.1

12. SIMULATION OF SINGLE PHASE INVERTER WITH PWM CONTROL.

AIM: To simulate single phase inverter with PWM controller using PSPICE and obtain its output.

APPARATUS: Computer and PSPICE software

PROCEDURE:

1. Write the Program in PSPICE .cir file or in .txt file, by identifying nodes in the circuit.
2. Save the program and run it in PSPICE A/D.
3. Observe the Output file for outputs like nodal voltages, source currents and power dissipated.
4. Open probe and enter the waveforms to be plotted and get the plots.
5. Note down the plots in graph sheets and verify it with theoretical values.

PROGRAM:

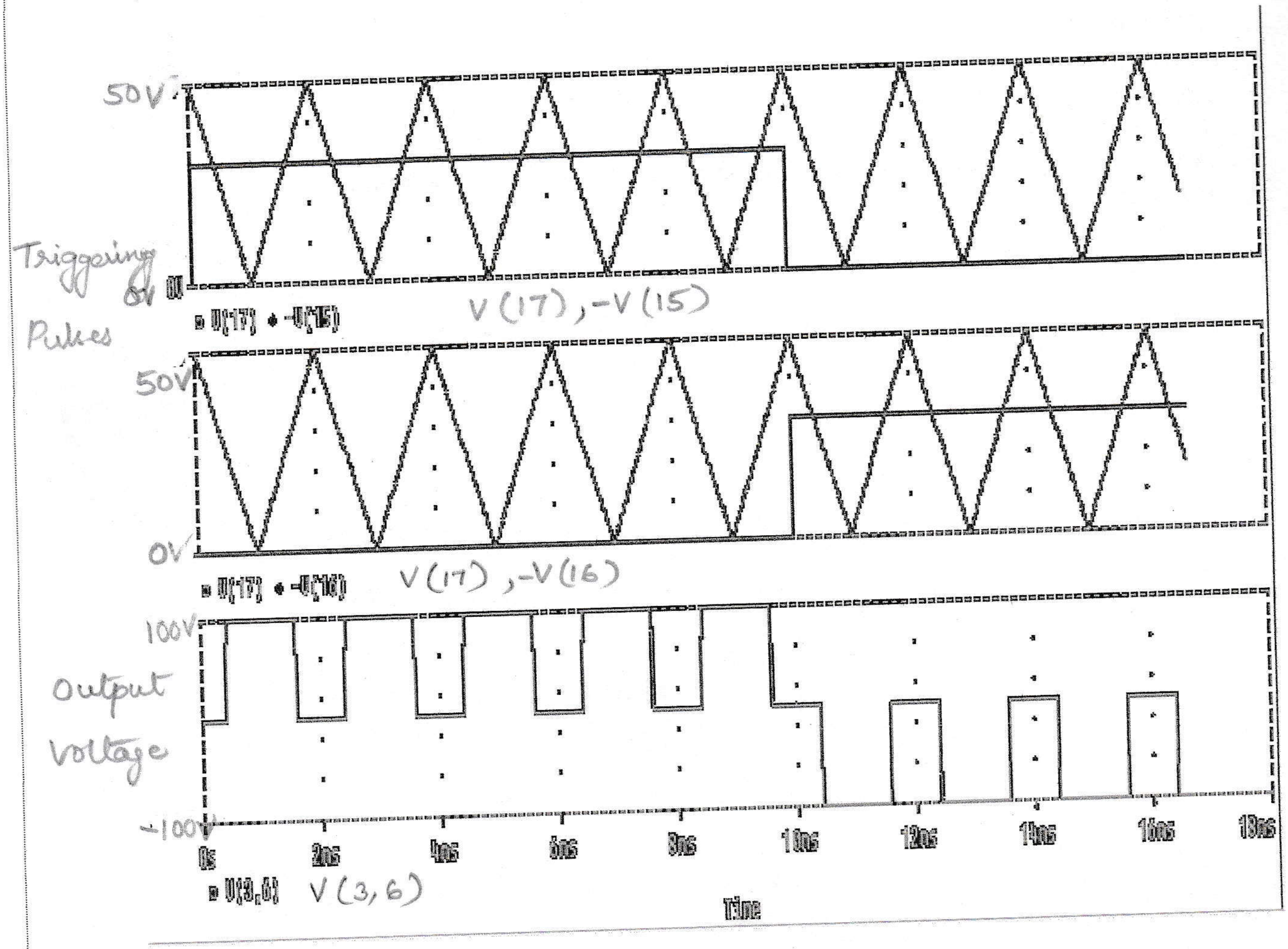
```
****    CIRCUIT DESCRIPTION : 1-PH PWM INVERTER

VS 1 0 DC 100V
VR 17 0 PULSE(50V 0V 0 1MS 1MS 1NS 2MS)
RR 17 0 2MEG
VC1 15 0 PULSE(0 -30V 0 1NS 1NS 10MS 20MS)
RC1 15 0 2MEG
VC3 16 0 PULSE(0 -30V 10MS 1NS 1NS 10MS 20MS)
RC3 16 0 2MEG
R 4 6 2.5OHM
VX 3 4 DC 0V
VY 1 2 DC 0V
D1 3 2 DMOD
D2 0 6 DMOD
D3 6 2 DMOD
D4 0 3 DMOD
.MODEL DMOD D(IS=2.2E-15 BV=1890V)
Q1 2 7 3 QMOD
Q2 6 9 0 QMOD
Q3 2 11 6 QMOD
Q4 3 13 0 QMOD
.MODEL QMOD NPN(IS=6.73F BF=416.4 CJC=3.638P CJE=4.493P)
RG1 8 7 100OHM
RG2 10 9 100OHM
RG3 12 11 100OHM
RG4 14 13 100OHM

XPW1 17 15 8 3 PWM
XPW2 17 15 10 0 PWM
XPW3 17 16 12 6 PWM
XPW4 17 16 14 0 PWM

.SUBCKT PWM 1 2 3 4
R1 1 5 1K
R2 2 5 1K
```

OUTPUT WAVEFORMS



```
RIN 2 0 2MEG
R0 6 3 75OHM
C0 3 4 10PF
RF 5 3 100K
E1 6 4 0 5 2E+5
.ENDS PWM
.TRAN 10US 16.67MS 0 10US
.OPTIONS ABSTOL=1.00N RELTOL=0.01 VNTOL=0.1 ITL5=20000
.PROBE
.END
```

RESULT: The output voltage and currents of PWM Inverter are observed by simulating the circuit in PSPICE.

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(Accredited by NAAC, Approved by AICTE New Delhi & Permanently Affiliated to JNTUH)
Aziznagar Gate, C.B. Post, Hyderabad-500 075

Department of Electrical and Electronics Engineering (Accredited by NBA)

LAB ASSESSMENT

2020-21

Name of the Laboratory: Power Electronics & Simulation **Branch/Section:** A **Year/Sem:** III-II **Page:**

S.Nos.	Roll Number	Day to Day Assessment Week																Day To Day	Record (5)	Internal	Total Mark
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16				
1	18911A0201	9	9	9	9	9	10	10	10	10	10							10	5	8	23
2	18911A0202	9	9	9	10	10	10	10	10	10	10							10	5	8	23
3	18911A0203	8	8	8	8	9	9	9	9	9	9							9	5	7	21
4	18911A0204	7	7	7	8	8	8	8	8	8	8							8	5	AB	13
5	18911A0205	7	7	8	8	8	8	8	8	8	8							8	5	7	20
6	18911A0206	8	8	8	9	9	9	9	9	9	9							9	5	7	21
7	18911A0208	9	9	9	10	10	10	10	10	9	10							10	5	8	23
8	18911A0209	8	8	8	9	9	9	9	9	9	9							9	5	8	22
9	18911A0210	8	8	9	9	9	9	9	9	9	9							9	5	7	21
10	18911A0211	9	9	9	10	10	10	10	10	10	10							10	5	8	23
11	18911A0212	8	8	9	9	9	9	9	9	9	9							9	5	9	23
12	18911A0213	8	8	8	9	9	9	9	9	9	9							9	5	7	21
13	18911A0214	8	8	9	9	9	9	9	9	9	9							9	5	8	22
14	18911A0215	7	7	8	8	8	8	8	8	8	8							8	5	10	23
15	18911A0216	8	8	9	9	9	9	9	9	9	9							9	5	7	21
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17	18911A0219	8	8	9	9	9	9	9	9	9	9							9	5	7	21
18	18911A0220	8	8	9	9	9	9	9	9	9	9							9	5	8	22
19	18911A0221	7	7	8	8	8	8	8	8	8	8							8	5	~~8~~ 9	22
20	18911A0223	8	8	8	9	9	9	9	9	9	9							9	5	7	21
21	18911A0224	6	6	7	7	7	7	7	7	7	7							7 ~~10~~	5	8	20
22	18911A0225	8	8	8	9	9	9	9	9	9	9							9	5	7	21
23	18911A0226	7	7	8	8	8	8	8	8	8	8							8	5	6	19
24	18911A0227	9	9	10	10	10	10	10	10	10	10							10	5	8	23
25	18911A0228	7	7	8	8	7	7	8	8	8	8							8	5	9	22

		1	2	3	4	5	6	7	8	9	10	DAY	REC	EXAM	TOTAL
26	18911A0230	8	8	8	8	9	9	9	9	9	9	9	5	7	21
27	18911A0231	9	9	9	9	10	10	10	10	10	10	10	5	8	23
28	18911A0232	8	8	9	9	9	9	9	9	9	9	9	5	8	22
29	18911A0234	8	8	9	9	9	9	9	9	9	9	9	5	10	24
30	18911A0237	8	9	9	9	9	9	9	9	9	9	9	5	7	21
31	18911A0238	8	8	9	9	9	9	9	9	9	9	9	5	7	21
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37	18911A0246	9	9	10	10	10	10	10	10	10	10	10	5	8	23
38	18911A0247	9	9	9	10	10	10	10	10	10	10	10	5	8	23
39	18911A0248	8	8	8	9	9	9	9	9	9	9	9	5	7	21
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44	19915A0201	9	9	10	10	10	10	10	10	10	10	10	5	9	24
45	19915A0202	9	9	10	10	10	10	10	10	10	10	10	5	8	23
46	19915A0203	8	8	9	9	9	9	9	9	9	9	9	5	10	24
47	19915A0204	9	9	10	10	10	10	10	10	10	10	10	5	8	23
48	19915A0205	7	7	8	8	8	8	8	8	8	8	8	5	8	21
49	19915A0206	7	7	8	7	8	8	8	8	8	8	8	5	8	21
50	19915A0207	9	9	10	10	10	10	10	10	10	10	10	5	8	23
51	19915A0208	10	9	10	10	10	10	10	10	10	10	10	5	8	23
52	19915A0209	7	7	8	8	8	8	8	8	8	8	8	5	7	20
53	19915A0210	9	9	10	10	10	10	10	10	10	10	10	5	8	23
54	19915A0211	9	9	10	9	10	10	10	10	10	10	10	5	8	23
55	19915A0212	10	10	10	10	9	10	10	10	10	10	10	5	9	24
56	19915A0213	7	7	8	8	8	8	8	8	8	8	8	5	9	23
57	19915A0214	9	8	9	9	9	9	9	9	9	9	9	5	7	21
58	19915A0215	7	7	8	8	8	8	8	8	8	8	8	5	9	22
59	19915A0216	10	9	10	10	10	10	10	10	10	10	10	5	8	23

B. Rajesh (B. RAJESH)
Name & Signature of the Faculty

HOD/EEE

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Name of the College: Vidya Jyothi Institute of technology

Certificate

This is to certify that the bonafide record of the practical work carried out by

Mr/Miss B. Aditya *Roll No.* 18911A0202

of Class EEE-A *in the* PES Lab (Power Electronics & Simulation)

laboratory during the academic year 2021-22

B Rajesh 2/8/21

Faculty In-charge *Head of the Dept.* *External Examiner*

INDEX

S. No.	Date	Name of the Experiment	Page No.	Remarks
1.	26/7/21	study of characteristics of SCR, MOSFET & IGBT.	1-7	BRajil 28/7/21 (A)
2.	26/7/21	Gate firing circuits for SCR's [R- Triggering, RC -Triggering & UJT Triggering]	8-13	BRajil 28/7/21 (A)
3.	26/7/21	single phase AC voltage controller with R & RL loads	14-16	BRajil 28/7/21 (A)
4.	28/7/21	single phase fully controlled bridge converter with R & RL loads	17-19	BRajil 30/7/21 (A+)
5.	28/7/21	DC Jones chopper with R & RL loads	20-22	BRajil 30/7/21 (A+)
6.	28/7/21	single phase parallel inverter with R & RL loads	23-24	BRajil 30/7/21 (A+)

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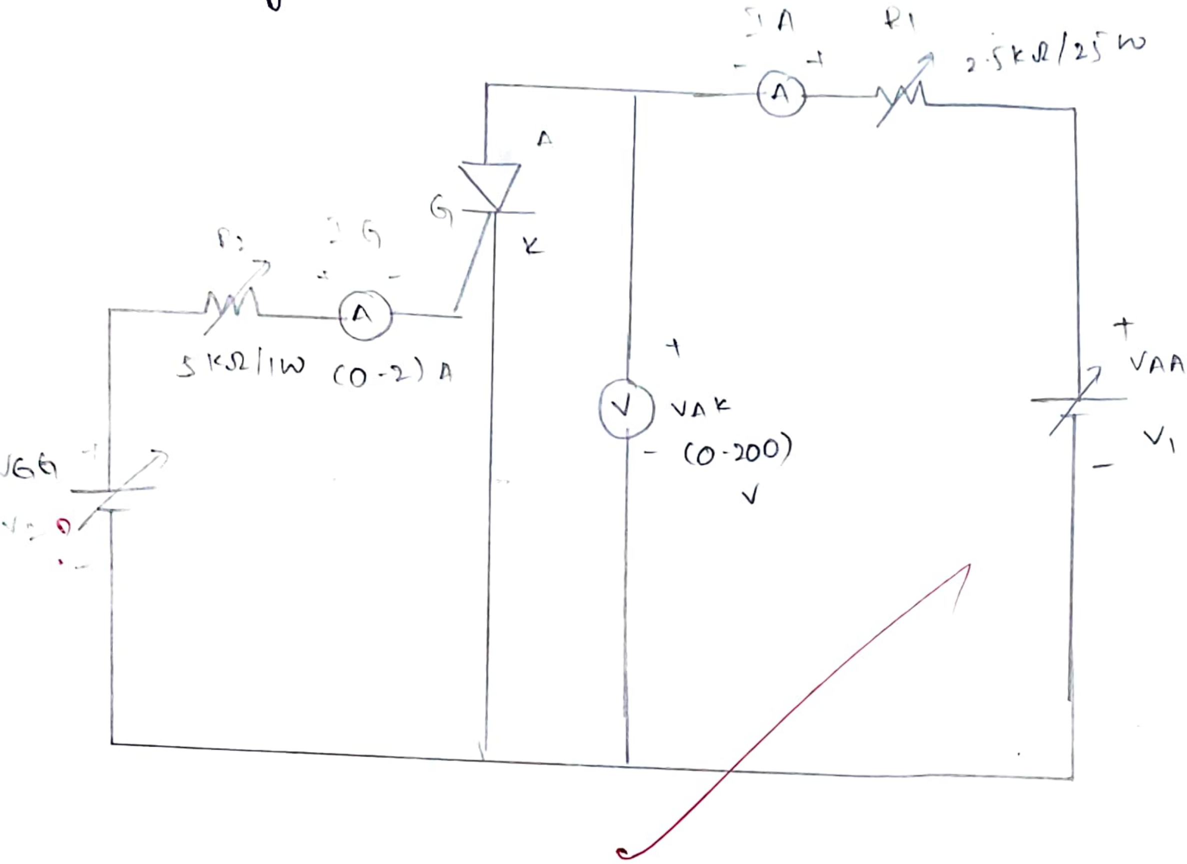
Circuit diagram.



Title : 1. static characteristics of SCR.   Date : 28/7/21
Page No. : 1

Aim: To plot the characteristics of SCR and to find the latching & holding currents.

Apparatus:

1. SCR characteristics study unit.
2. Meter unit - voltmeter (0-20)V - 1NO
   Ammeter (0-2)A - 1NO
   Ammeter (0-200) mA - 1NO

Theory: SCR is a semi conductor device which acts as an electronic switch. It controls the amount of power fed to load. SCR is most popular member of thyristor family. It is a four layer three junction PNPN device having three terminals & used as a switch. SCR has two states i.e it does not conduct & conducts heavily.

Observations.

V_{AK} (V)	I_G (mA)	I_A (mA)	V_{AK} (V)	I_G (mA)	I_A (mA)	V_{AK} (V)	I_G (mA)	I_A (mA)
10	0.002	0	15	0.002	0	20	0.002	0
10	0.004	0	15	0.003	0	20	0.003	0
10	0.005	0	14.9	0.004	0	20	0.004	0
10	0.006	0	14.9	0.005	0	20	0.005	0
9.3	0.007	0.1	14.9	0.006	0	20	0.006	0
0.7	0.008	3.9	0.7	0.007	6.3	19.9	0.007	0
0.7	0.009	3.8	0.7	0.008	6.4	0.7	0.008	8.6
0.7	0.01	3.9	0.7	0.009	6.4	0.7	0.009	8.6

Procedure :-

1) Make the connections as shown in fig. including meters

2) Switch ON the main supply to the unit & keep the voltages V_1 & V_2 at min position.

3) Set V_{AK} = 10V by varying V_1

4) Slowly vary V_2 in steps & note I_G, I_A & V_{AK} values

5) Vary V_2 till SCR conduct which can be noticed by sudden drop of V_{AK} & rise of I_A.

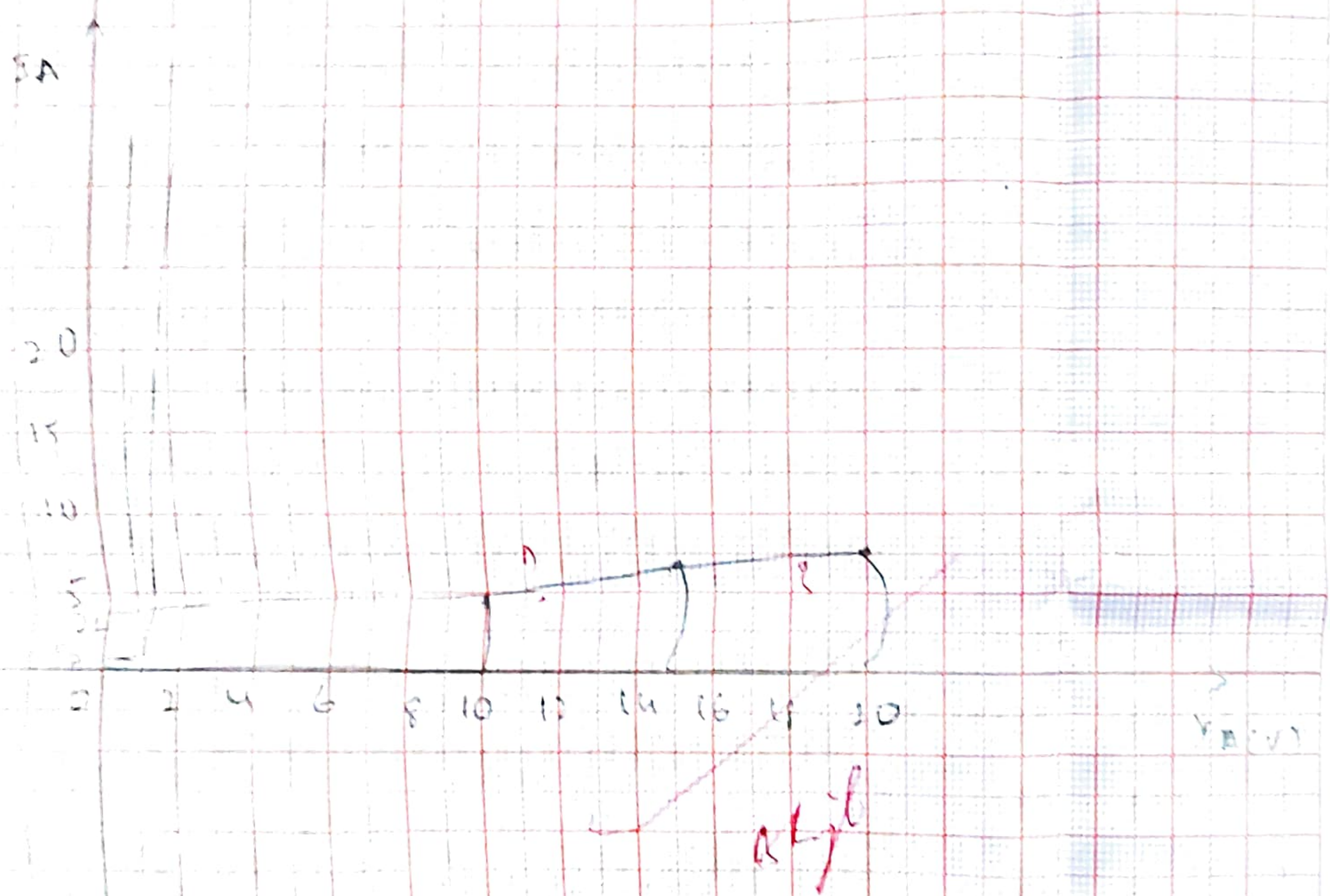
6) Repeat same procedure for V_{AK} = 15 V & 20 V

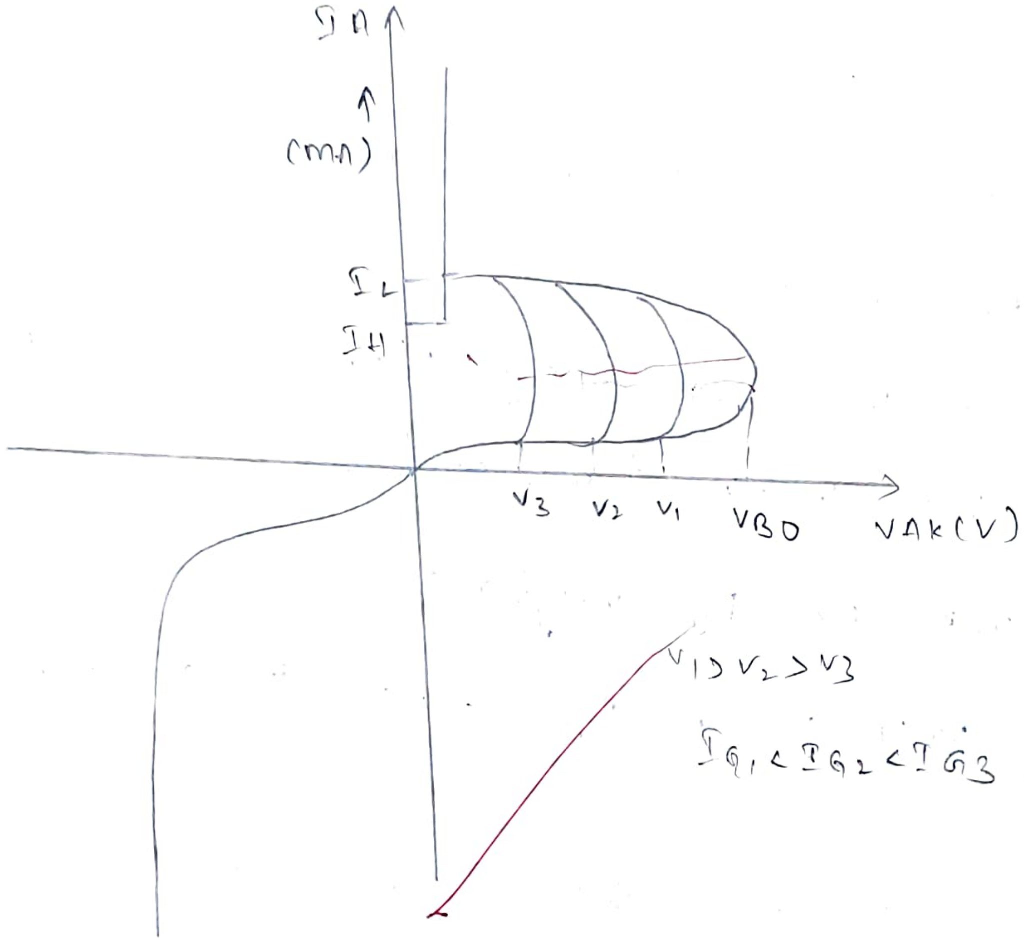
7) Draw V_{AK} vs I_A graph for different values of I_G.

Scale

x-axis unit = 2V

y-axis unit = 5mA





$V_1 > V_2 > V_3$

$I_{G1} < I_{G2} < I_{G3}$

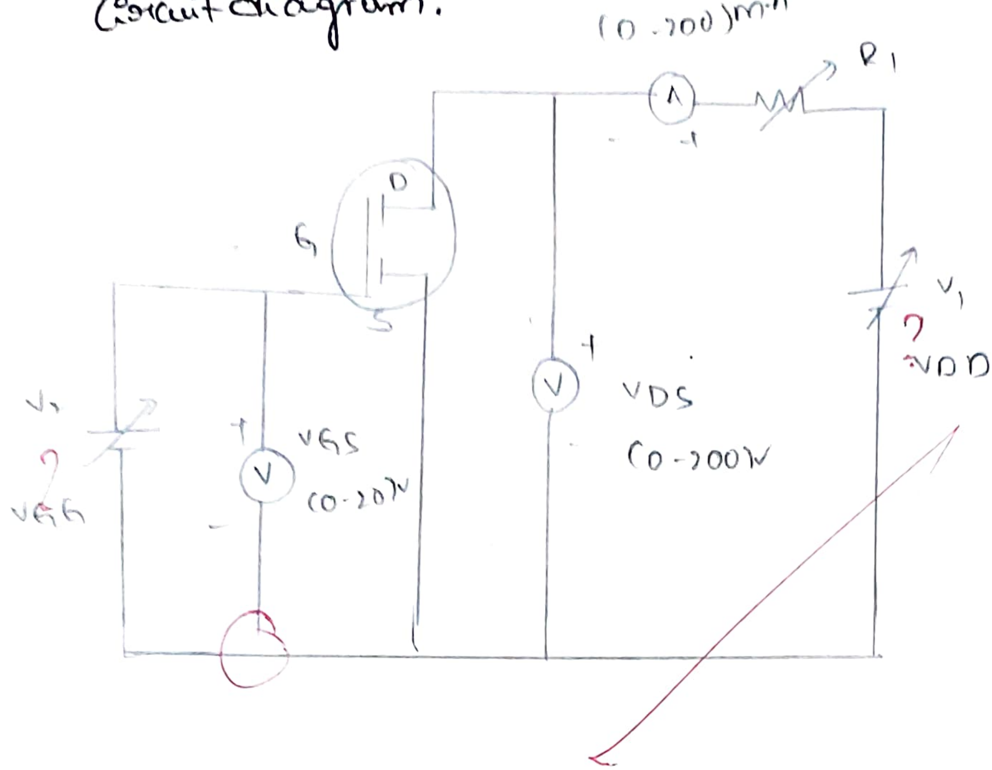
Title :

Result :- we have done the characteristics of SCR and determined the latching & holding current.

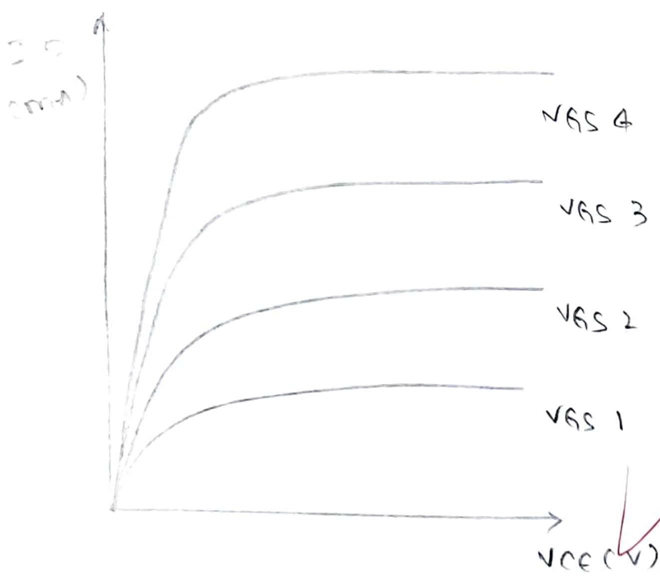
BKJL 28/7/21

(A)

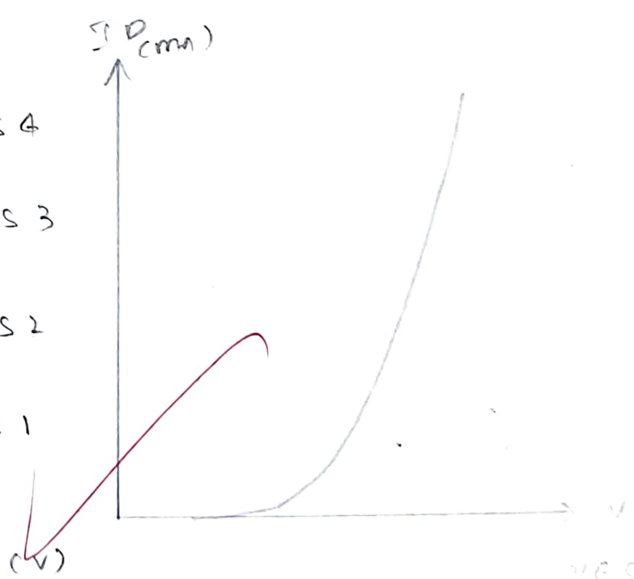
Circuit diagram.



o/p characteristics :



Transfer characteristics



Title : characteristics of MOSFET

Date : 26-7-21

Page No. : 4

Aim :- To plot the drain and transconductance characteristics of MOSFET.

Apparatus :-

1. MOSFET characteristics study unit.
2. Meter unit - Voltmeter (0-20)V - 1 NO
   Voltmeter (0-200)V - 1 NO
   Ammeter (0-200)mA - 1 NO
3. patch cards.

Theory :-

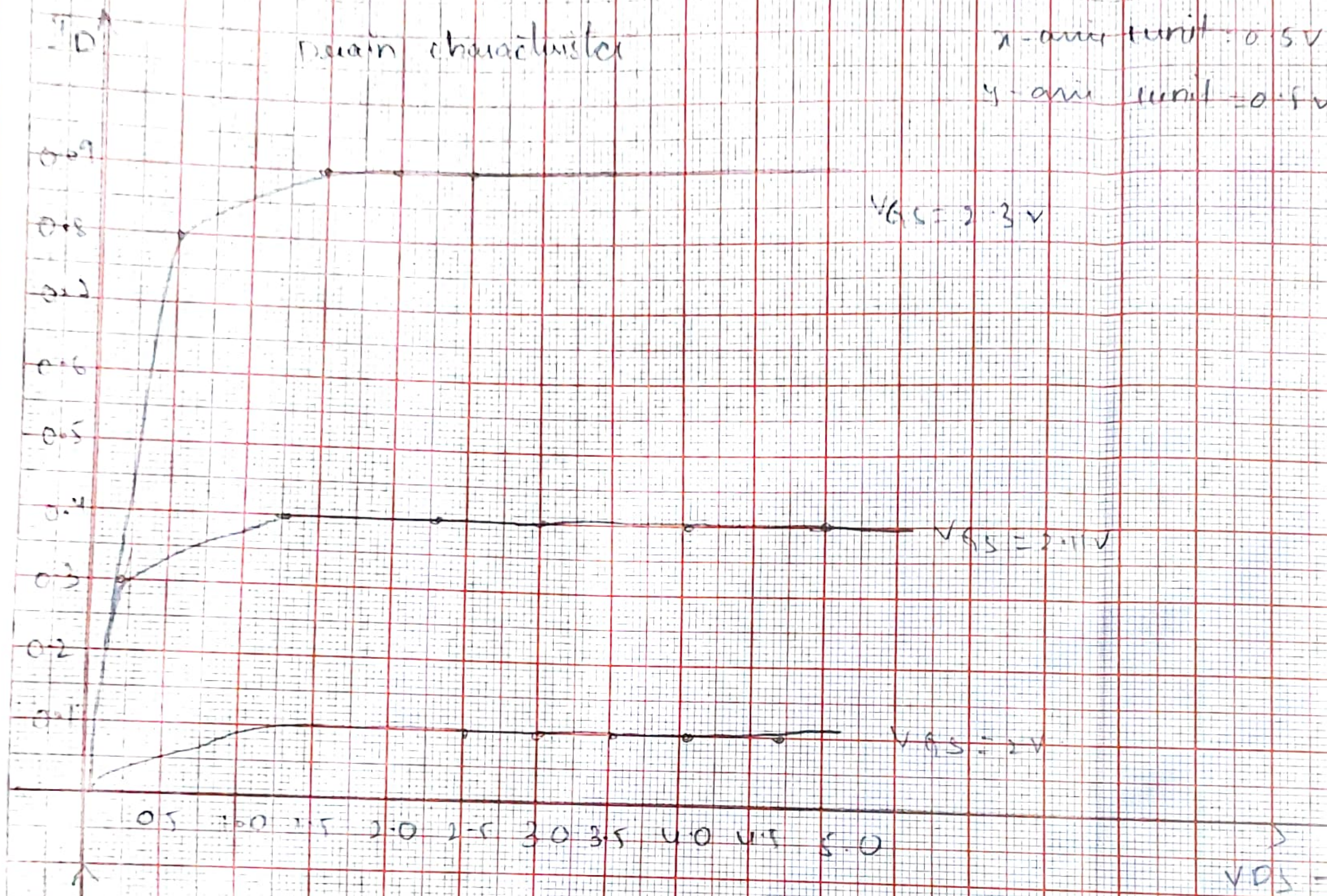
A power MOSFET has three terminals called drain, source and Gate. MOSFET is a voltage controlled device & its operation depends on flow of majority carriers only. MOSFET is unipolar device. The control signal & base current required in MOSFET is less. This is because the gate circuit impedance in MOSFET extremely high.

o/p characteristics

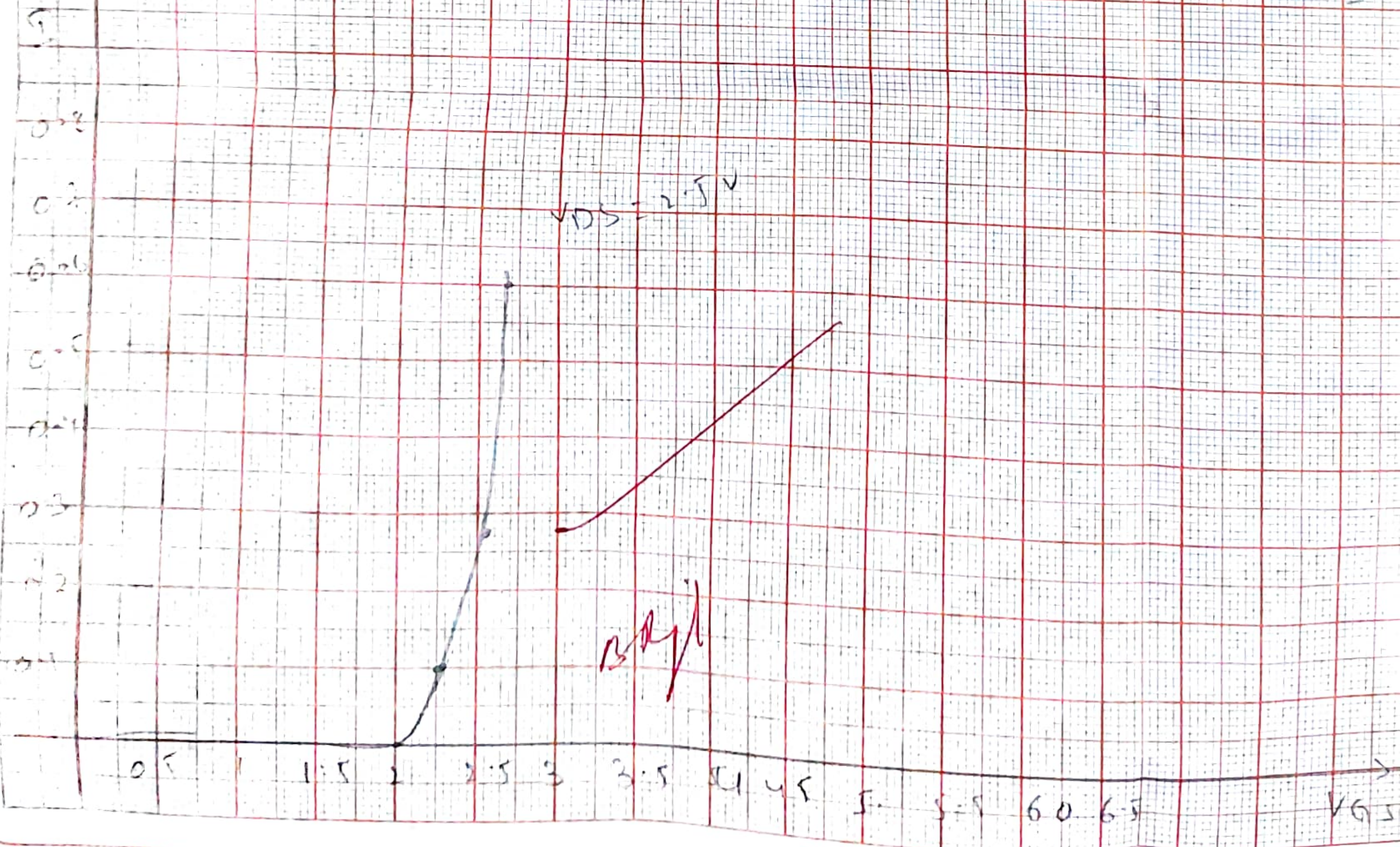
V_{GS} = 2 V		V_{GS} = 2.3 V		V_{GS} = 3.1 V	
V_{DS} (V)	I_D (mA)	V_{DS} (V)	I_D (mA)	V_{DS} (V)	I_D (mA)
0.02	0.0	2.1	0	2.75	0.1
2.7	0.1	2.8	0.1	2.79	0.1
2.85	0.2	2.9	0.3	2.83	0.2
3.08	0.5	3.0	0.6	2.94	0.5
3.2	0.6	3.2	0.7	3.0	0.8
4.0	0.6	3.4	0.7	3.1	0.9
5.0	0.6	5	0.7	4	0.9

Transfer characteristics

V_{DS} = 2.5 V	
V_{GS} (V)	I_D (mA)
1.23	0
2.7	0.1
2.9	0.4
3.0	0.7
3.1	0.1
3.2	0.9



ID
Drain characteristic
x - axis unit : 0.5 V
y - axis unit = 0.1
VGS = 2.3 V
VGS = 2.1 V
VGS = 2 V
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
VDS



VDS = 2.5 V
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6.0 6.5
VGS

Procedure :-

a) Drain / output characteristics :-

1. Give the connections as shown in circuit diag. with meters.
2. slowly vary V_2 & adjust $V_{GS} = 2V$.
3. vary V_1 in steps & note V_{DS} & I_D.
4. Repeat procedure $V_{GS} = 2.7V$ & 2.9V.
5. plot V_{DS} vs I_D for different V_{GS} values.

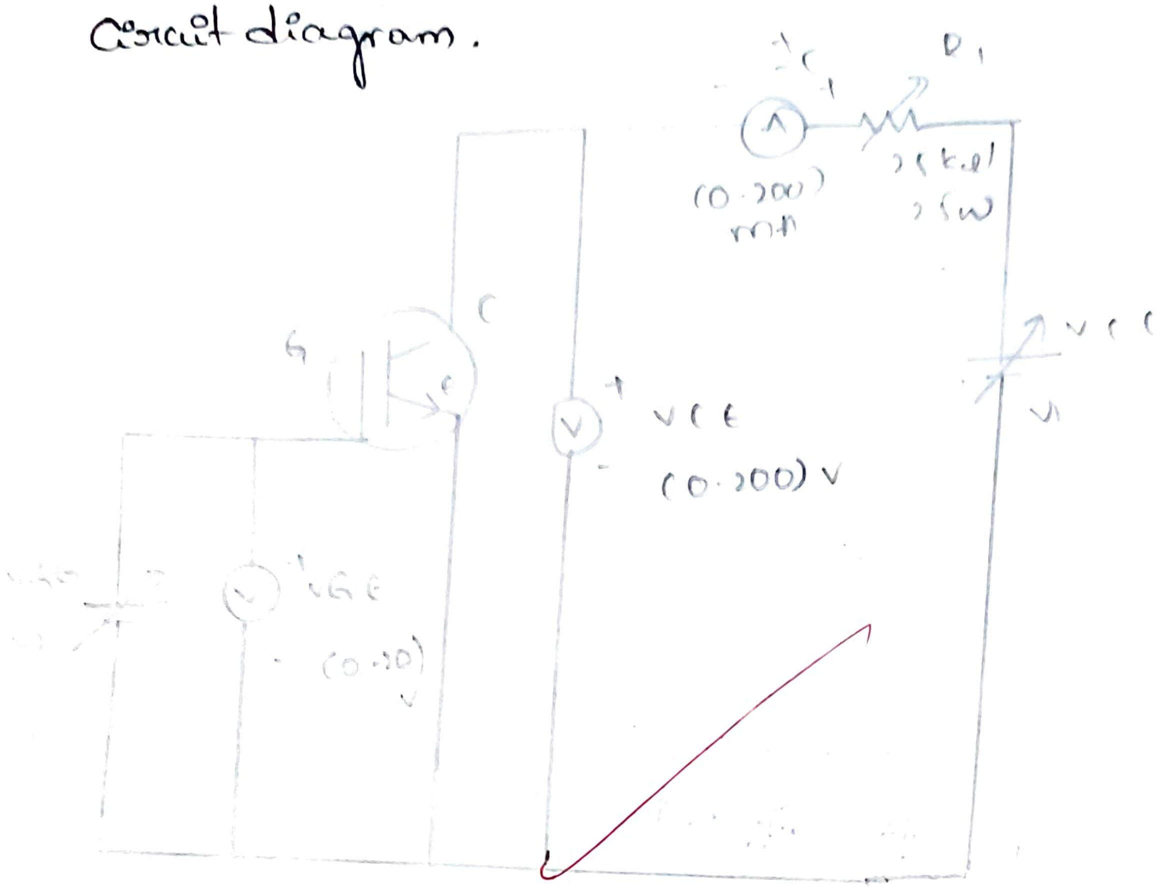
b) Transfer characteristics :-

1). set $V_{DS} = 2.5V$ by varying V_1
2) By varying V_2 in steps, note V_{GS} & I_D for each step, adjust $V_{DS} = 2.5V$ & note V_{GS} vs I_D values.
3) plot V_{GS} vs I_D for V_{DS}.

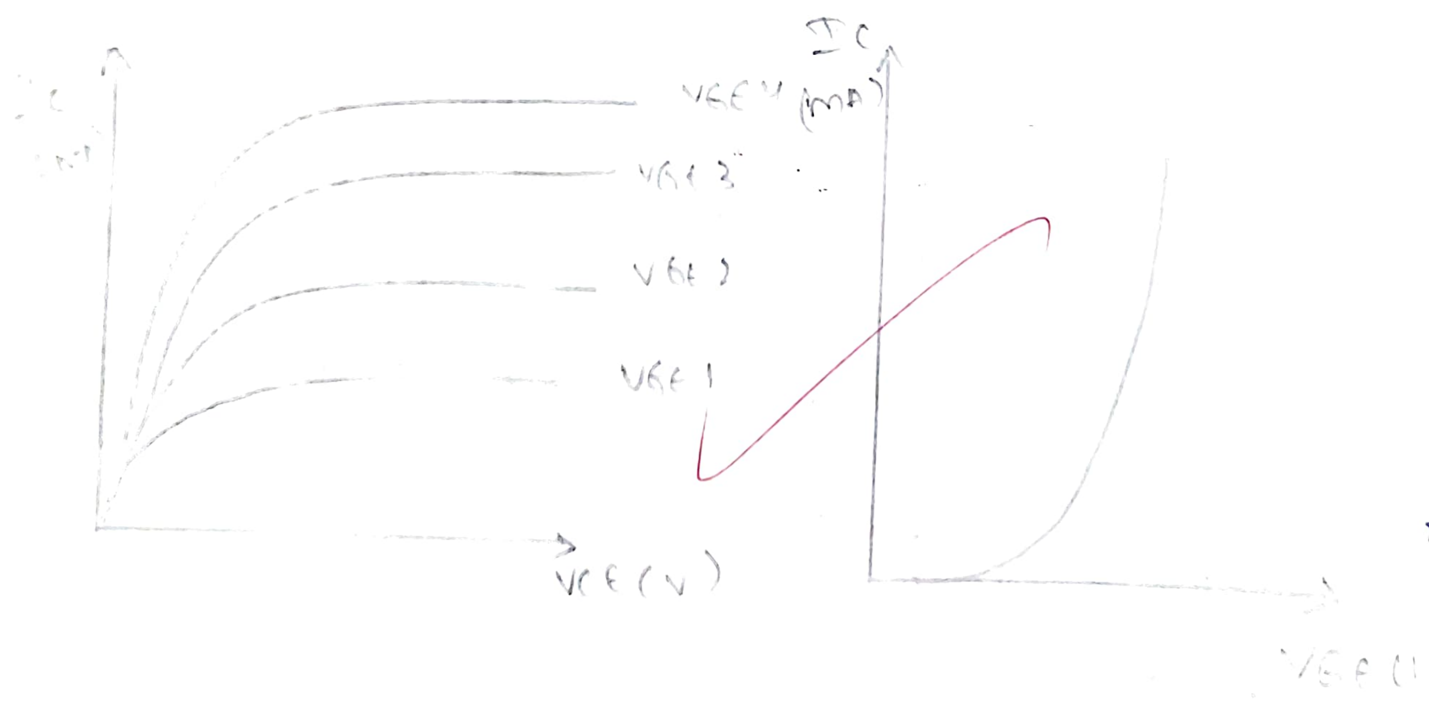
Result :- we have studied drain & transconductance characteristics of MOSFET.

Bhagil
28/7/21
A

Circuit diagram.



Model graph



Title : Characteristics of IGBT.
Date : 26-7-21
Page No. : 6

Aim:- To plot the collector & transfer characteristics of IGBT.

Apparatus:-

1. IGBT characteristics study unit.
2. Meter unit - voltmeter (0-20)V - 1 No
   voltmeter (0-200)V - 1 No
   Ammeter (0-200)mA - 1 No.
3. patch cords.

procedure:-

a) collector characteristics:-

1) Give connections as shown in circuit diagram.
2) slowly vary V_2 & adjust $V_{GE} = 4V$.
3) Now vary V_1 in steps & note down V_{CE} & I_C for each step.
4) Plot V_{CE} & I_C for different values of V_{GE}.

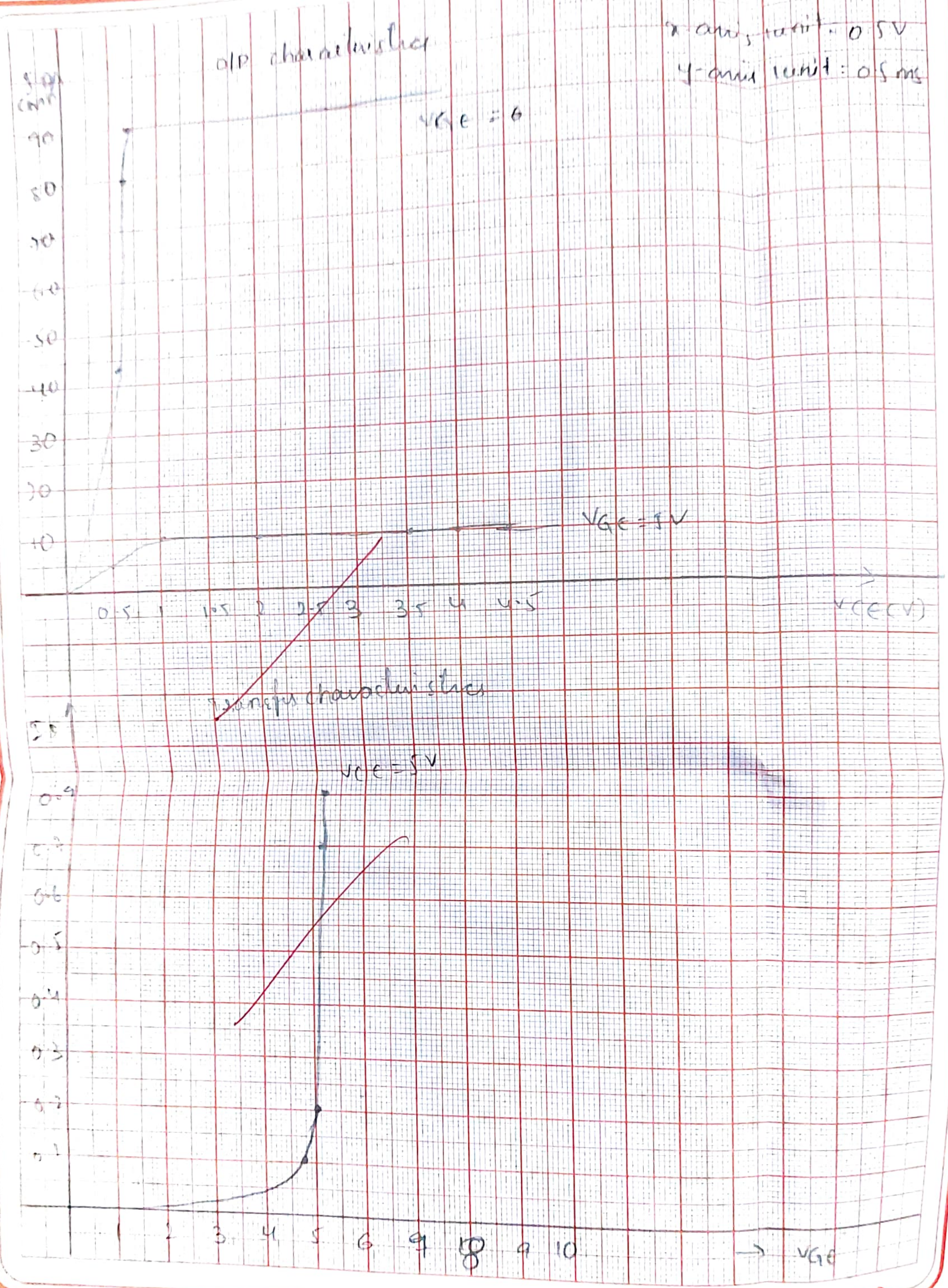
O/P characteristics

VGE = 2V		VGE = 3V		VGE = 4V	
VCE (V)	Ic (mA)	VCE (V)	Ic (mA)	VCE (V)	Ic (mA)
1.2	0	0.5	0.3	0.4	0.3
2.1	0	1.0	0.5	0.5	0.5
3.9	0	2.0	0.5	0.6	4.3
4.0	0	1.5	0.5	0.7	8.7
5.0	0	4	0.5	0.8	9.7
7	0	4.5	0.5		

Transfer characteristics

VCE = 5V	
VGE	Ic (mA)
1.21	0
2.03	0
3	0
4	0
4.7	0.1
4.91	0.3
5.1	0.9
6.02	0.9
7	0.9

IGBT


o/p characteristics
x axis, unit : 0.5V
y-axis unit : 0.5 mA
VGE = 6
90
80
70
60
50
40
30
20
10
VGE = 5V
0.5
1
1.5
2
2.5
3
3.5
4
4.5
VCE(V)
Transfer characteristics
VCE = 5V
0.9
0.8
0.6
0.5
0.4
0.3
0.2
0.1
1
2
3
4
5
6
7
8
9
10
VGE

b) Transfer characteristics :-

1) Set $V_{CE} = 5V$ by varying V_1.

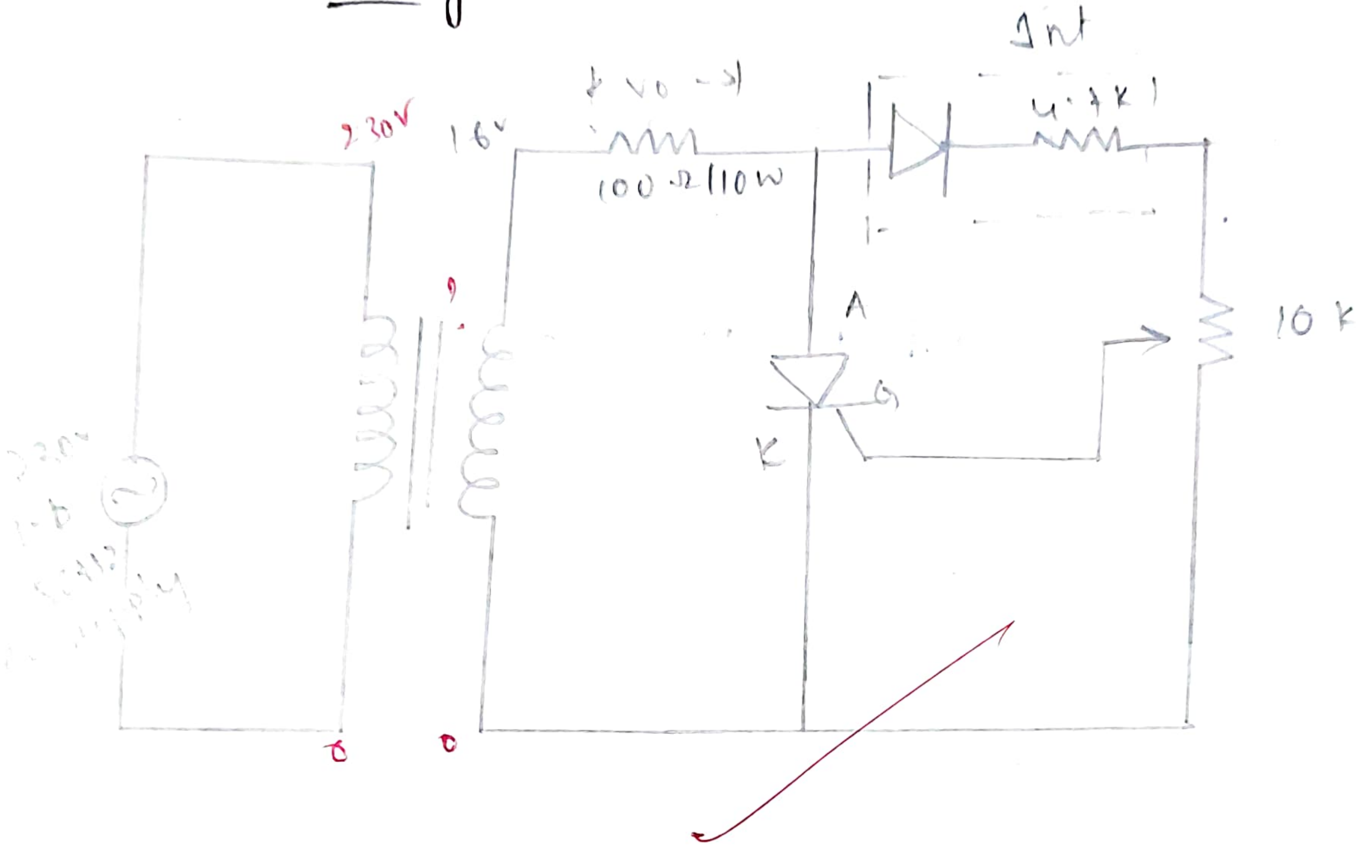
2) By varying V_2 in steps, note V_{GE} & I_C for each step, adjust $V_{CC} = 5V$ & note V_{GE} & I_D.

3) plot V_{GE} vs I_C for different values of V_{CE}.

Result: we have studied the characteristics of collector & transfer of IGBT.

BR 28/7/21
(A)

Circuit diagram.



Date : 26-7-21
Page No. : 8

Title : 2. Gate firing circuits for SCRs

[R- Triggering, RC triggering & UJT triggering]

Aim :- To study the amplitude control of SCR with R triggering.

Apparatus :-

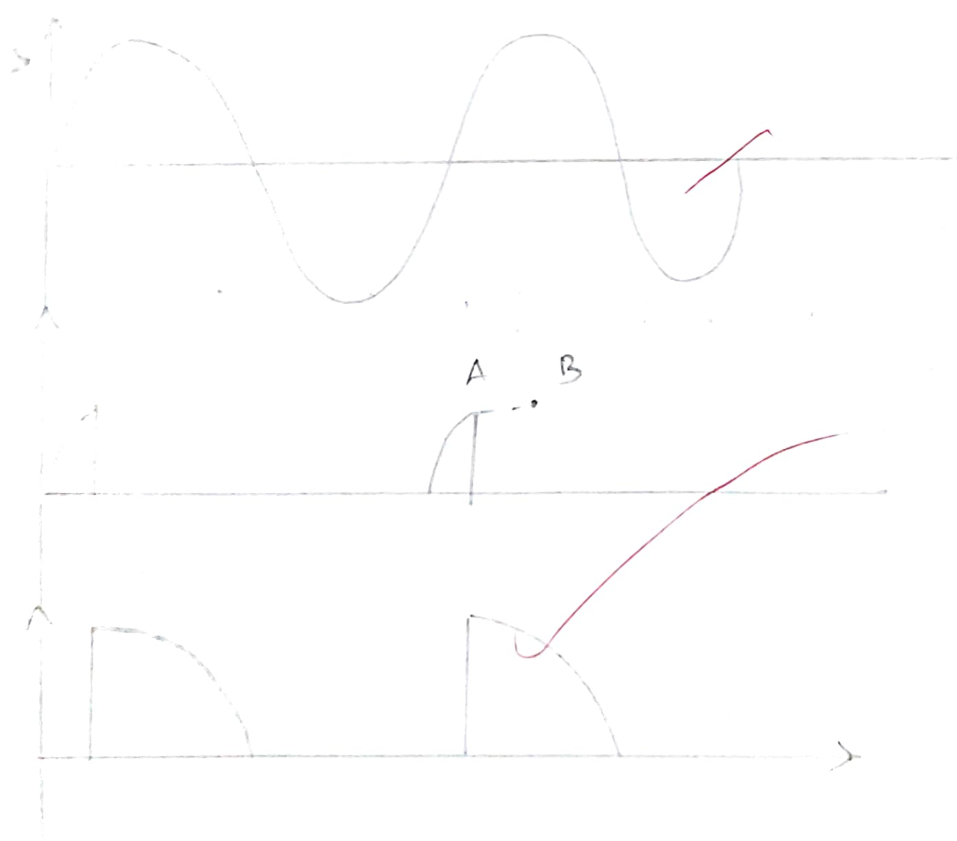
1. SCR triggering module.
2. CRO
3. patch cards
4. Multimeter.

Theory :- SCRs are widely used as controlled rectifiers to obtain variable DC voltage from fixed AC source. SCR conducts like a diode only when the anode is positive w.r.to cathode and on application of sufficient gate current at specified gate to cathode voltage.

Observations.

Firing angle	load voltage
min	9·7
36°	9·65
56°	9·22
max	7·2

Model graphs



Date :

Title :

Page No. : 9

Procedure :-

1) Give the connections as per the circuit diagram.

2) switch ON module.

3) set the potentiometer to any particular position & observe the waveforms of VIN, VO, VT, VP on CRO & note waveforms.

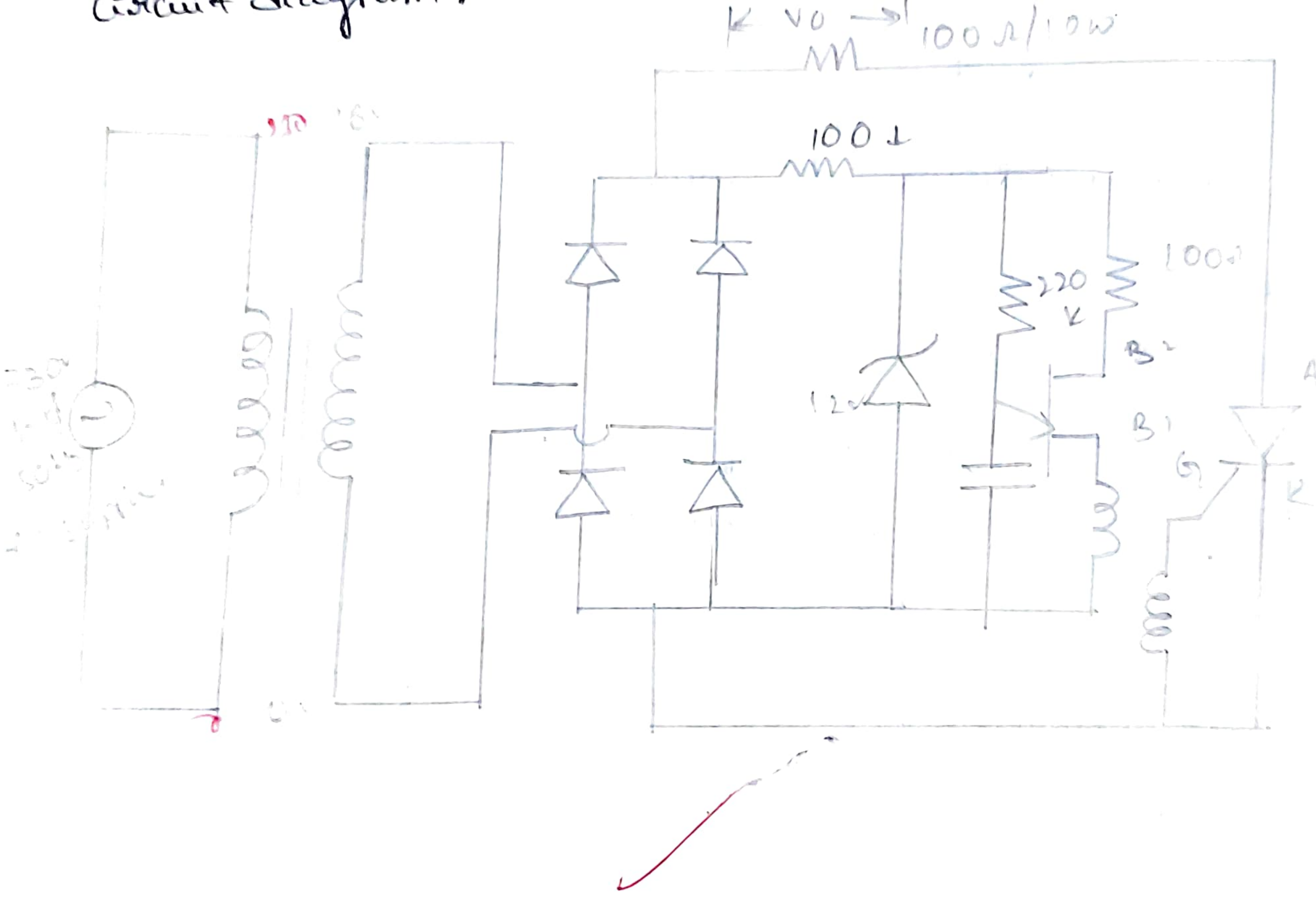
4) vary potentiometer & note firing angle & corresponding load voltage using multimeter.

Results :- Amplitude control of SCR with R-triggering was studied.

BRJ 28/7/21

(A)

Circuit diagram.



Title : UJT triggering circuit

Date : 26-7-21
Page No. : 10

Aim :- To construct & study UJT triggering circuit to trigger an SCR.

Apparatus :-

1. SCR Triggering module.
2. CRO
3. patch cords
4. multimeter.

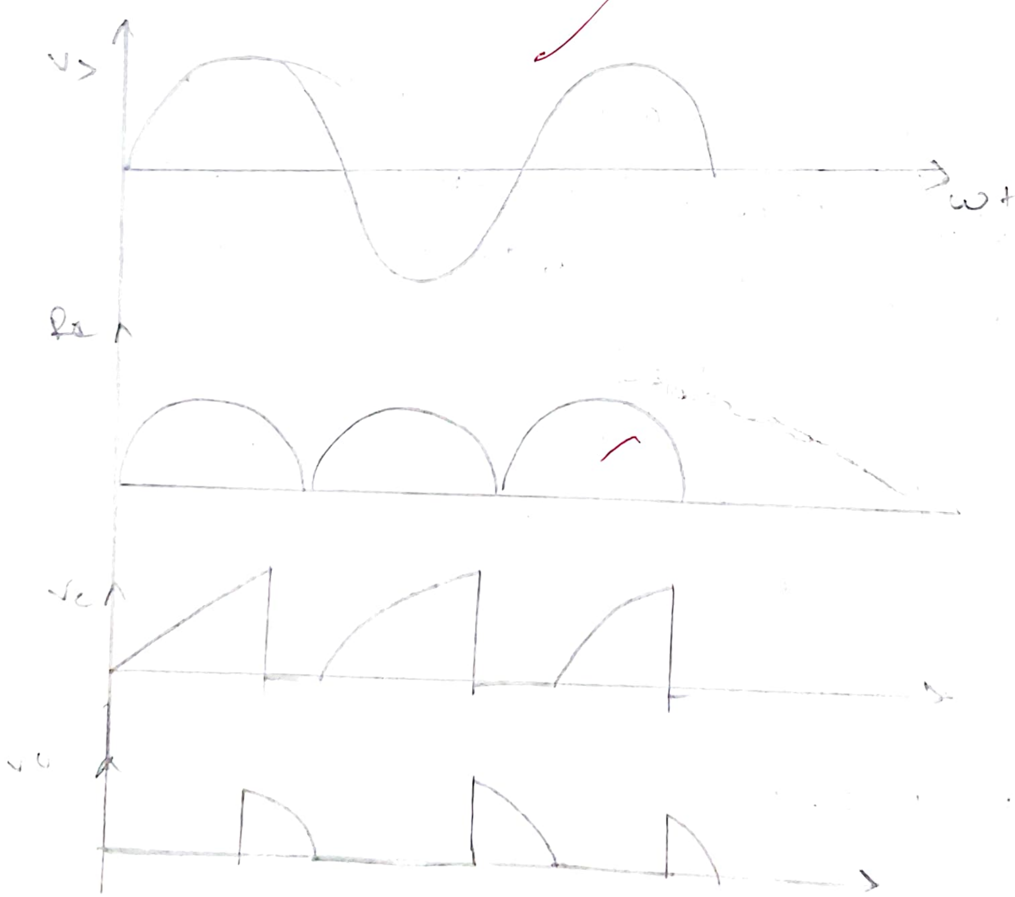
Theory :-

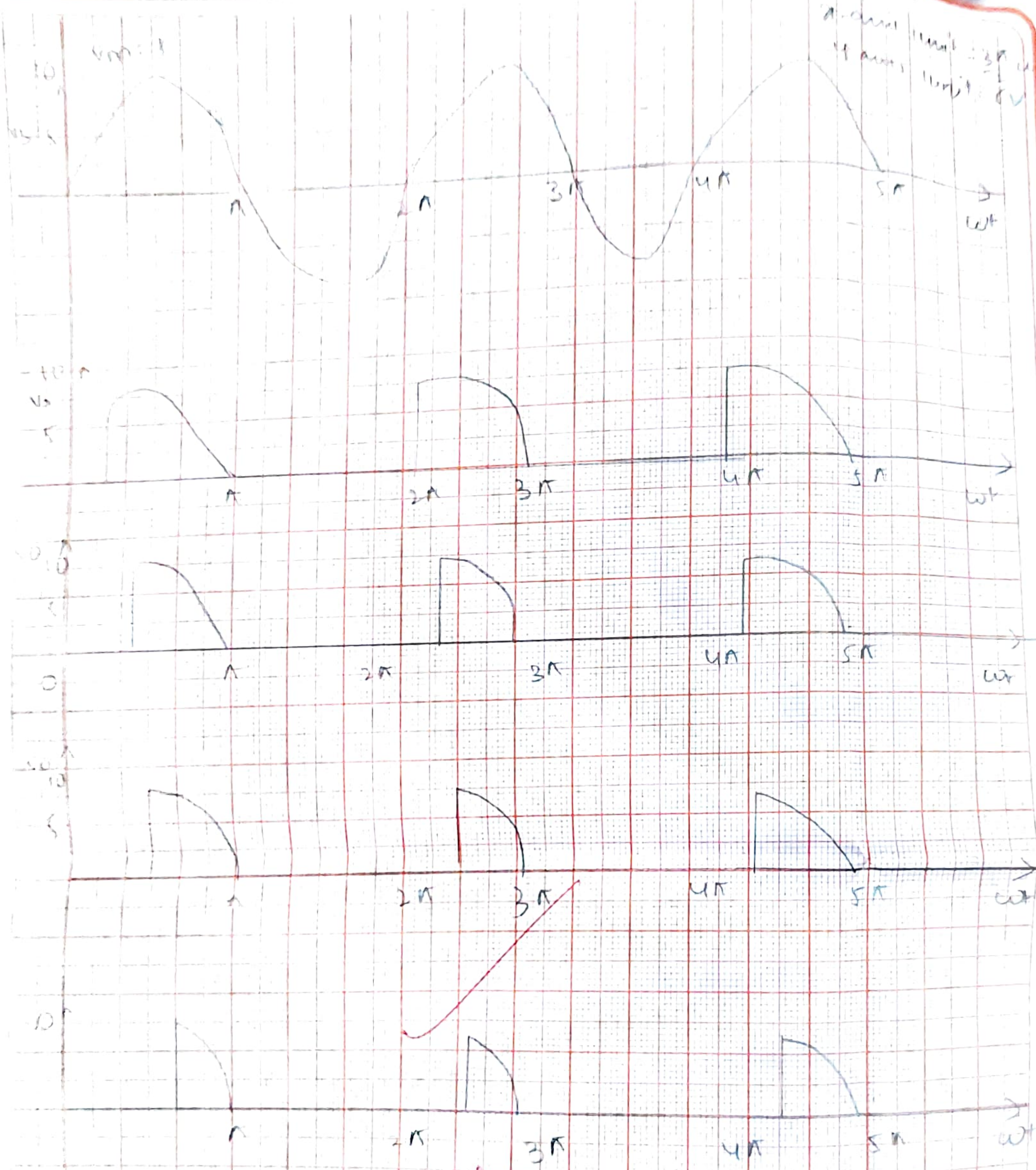
UJT works as Relaxation oscillator. output pulses of variable time period are possible by suitably increasing the emitter to base 1 voltage from valley voltage level to peak level either by employing a constant source or by charging a capacitor by a resistor. The RC network can be easily employed to obtain o/p pulses.

Observations

Firing angle (α)	Load voltage (V)
15	7.4
36	7
90	4.1
162	0.1

Model graph.





π
2π
3π
4π
5π
ωt

Procedure :-

1) Give the connections as per circuit diagram.

2) switch ON the module.

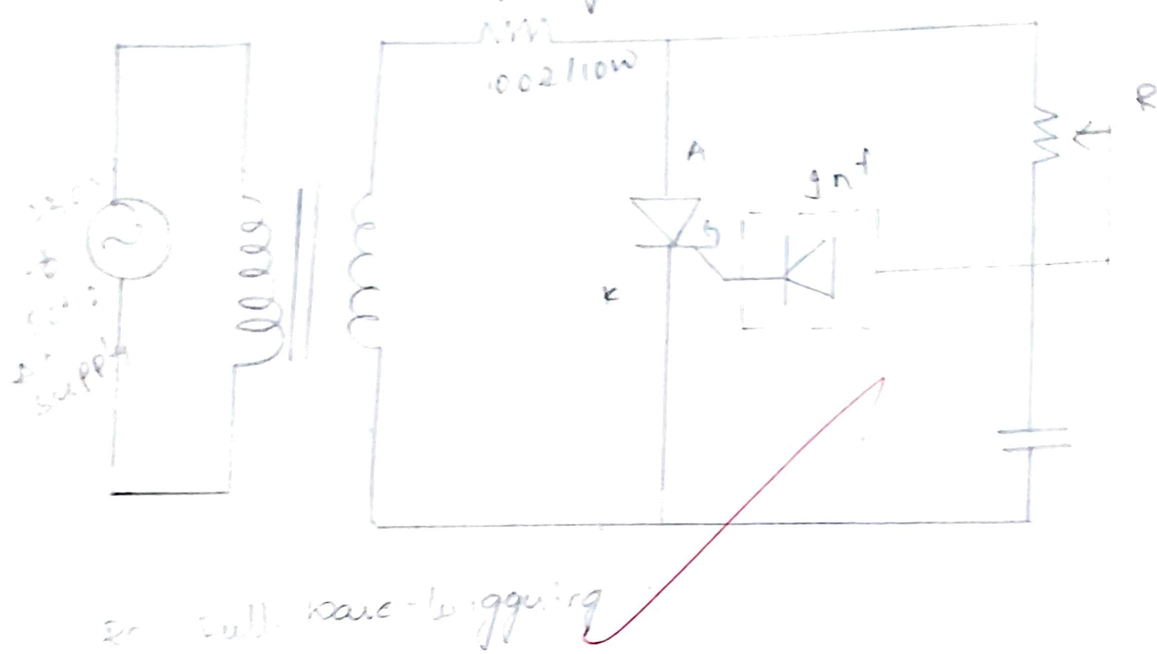
3) set potentiometer & observe the waveforms V_{IN}, V_O, V_T, V_P, V_D, V_Z, V_C on CRO & note waveforms.

4) By varying R, note down the firing angle & load voltage.

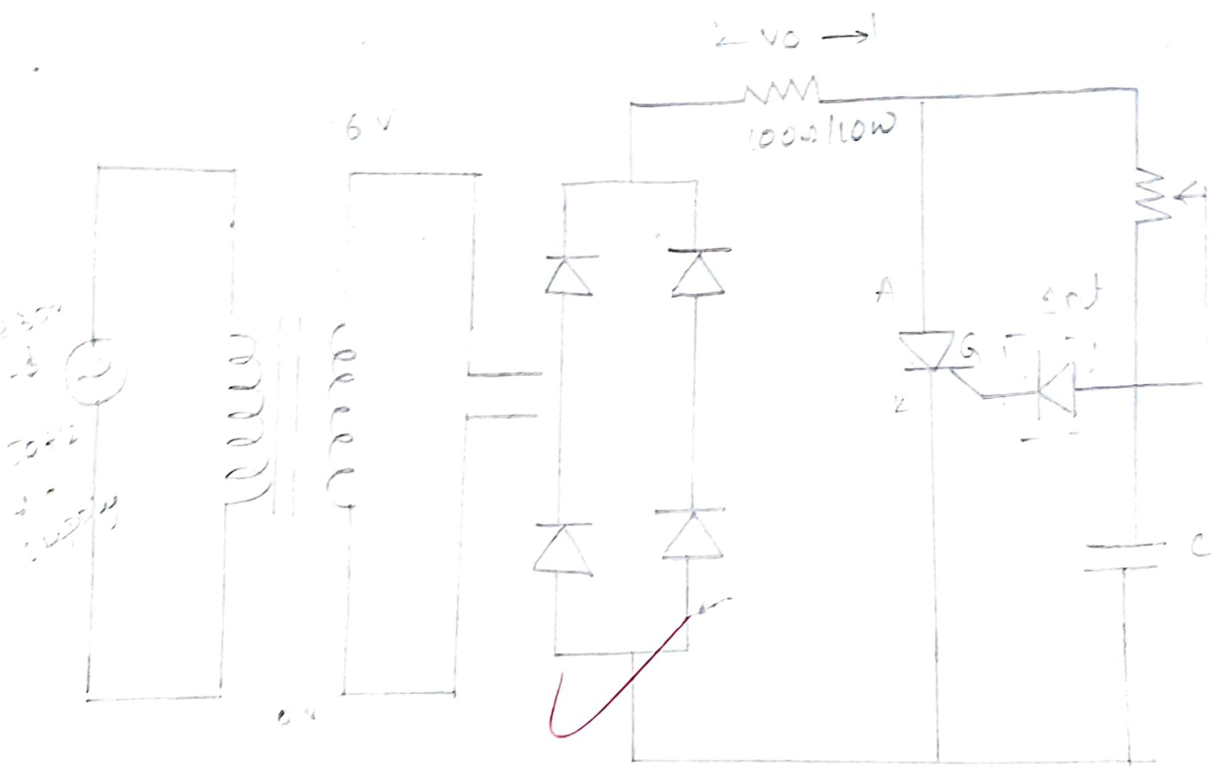
Result : The UJT triggering circuit to trigger an SCR was studied.

BR 28/7/21
(A)

RC half wave triggering



RC full wave triggering



Title : RC Triggering

Date : 26/7/21

Page No. : 12

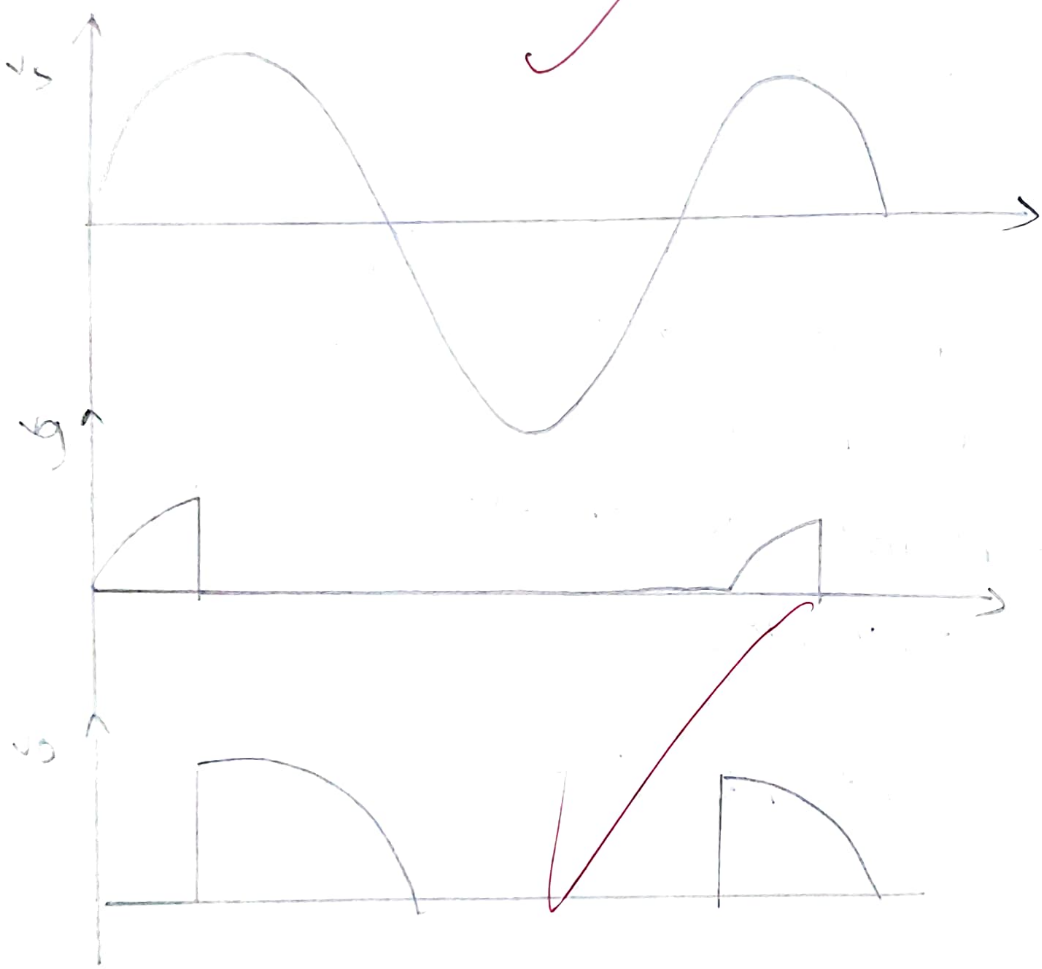
Aim :: To study the phase control of SCR by RC triggering.

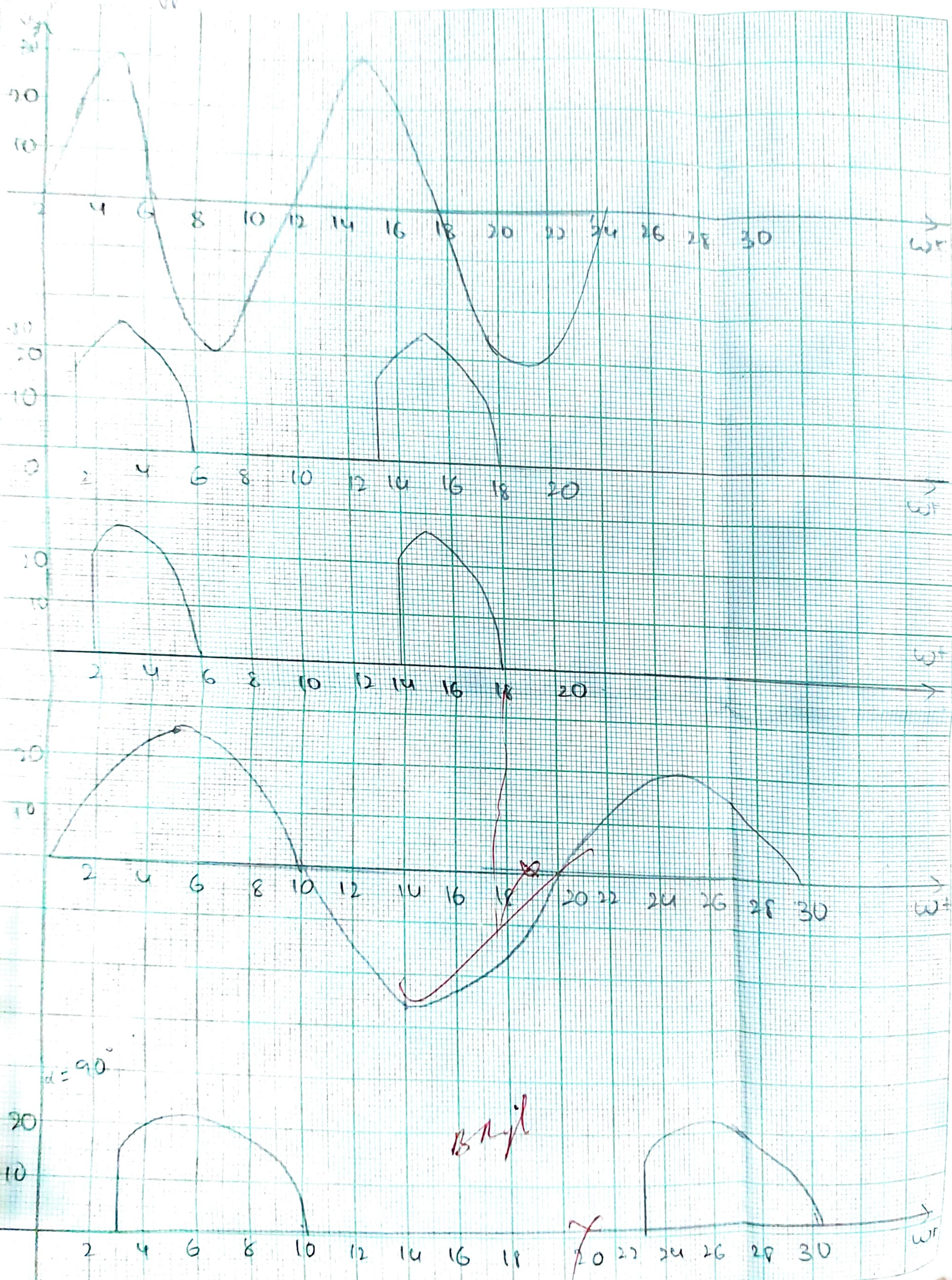
Apparatus ::
1. SCR triggering module.
2. CRO
3. patch cords
4. Multimeter.

Procedure ::

1) Give the connections as per circuit diagram.
2) switch ON the module.
3) Set potentiometer & observe waveform of V_{IN}, V_O, V_T, V_P, V_C on CRO & note waveforms.
4) Vary the potentiometer & note down the corresponding load voltage using multimeter.

Firing angle	load voltage (V)
0°	9.2
36°	9.2
90°	7.46




α = 90°
ωt

Date :

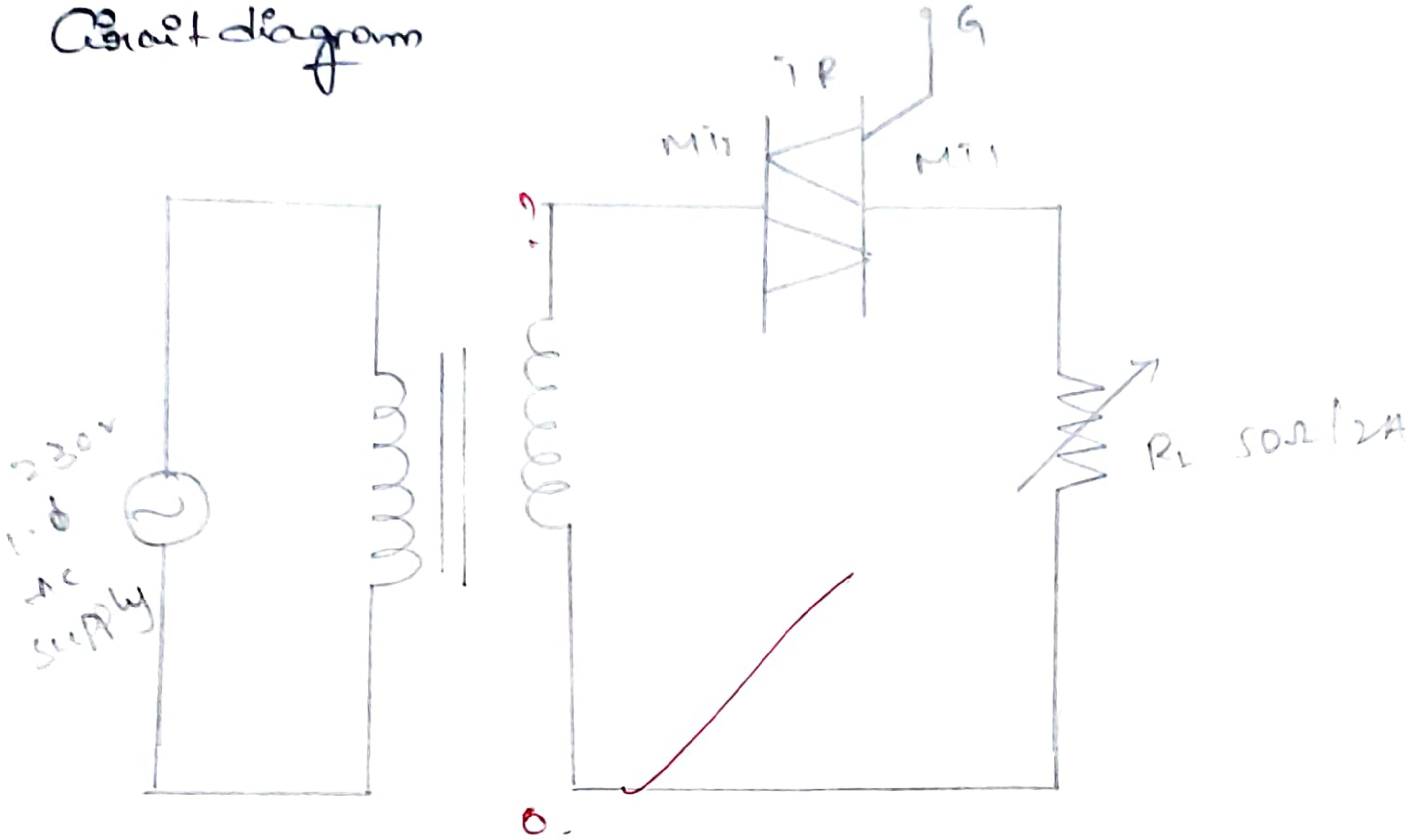
Title :

Page No. : 13

Result: phase control of SCR with RC triggering was studied.

(A) B.Rajil 28/7/21

Circuit diagram



Date : 26-7-21

Title : 3. single phase AC voltage controller Page No. : 14

Aim:- To construct single phase AC voltage controller circuit & to study its operation with R & RL loads.

Apparatus:-

1. single phase AC voltage controller unit.
2. Loading Rheostat (50 Ω | 2A)
3. Loading Inductor (0-150mH | 2A)
4. Digital multimeter
5. CRO
6. patch cords.

Theory:- AC voltage controller convert fixed alternating voltage directly to variable alternating voltage without change in frequency. some of main application of AC voltage controller are domestic and industrial heating.

Observations

R

Vin = 22.3 V

Firing angle α	V_L
180	0
110	0 1
120	6.4
90	9.9
60	14.9
30	19.6
0	22.3

R-L

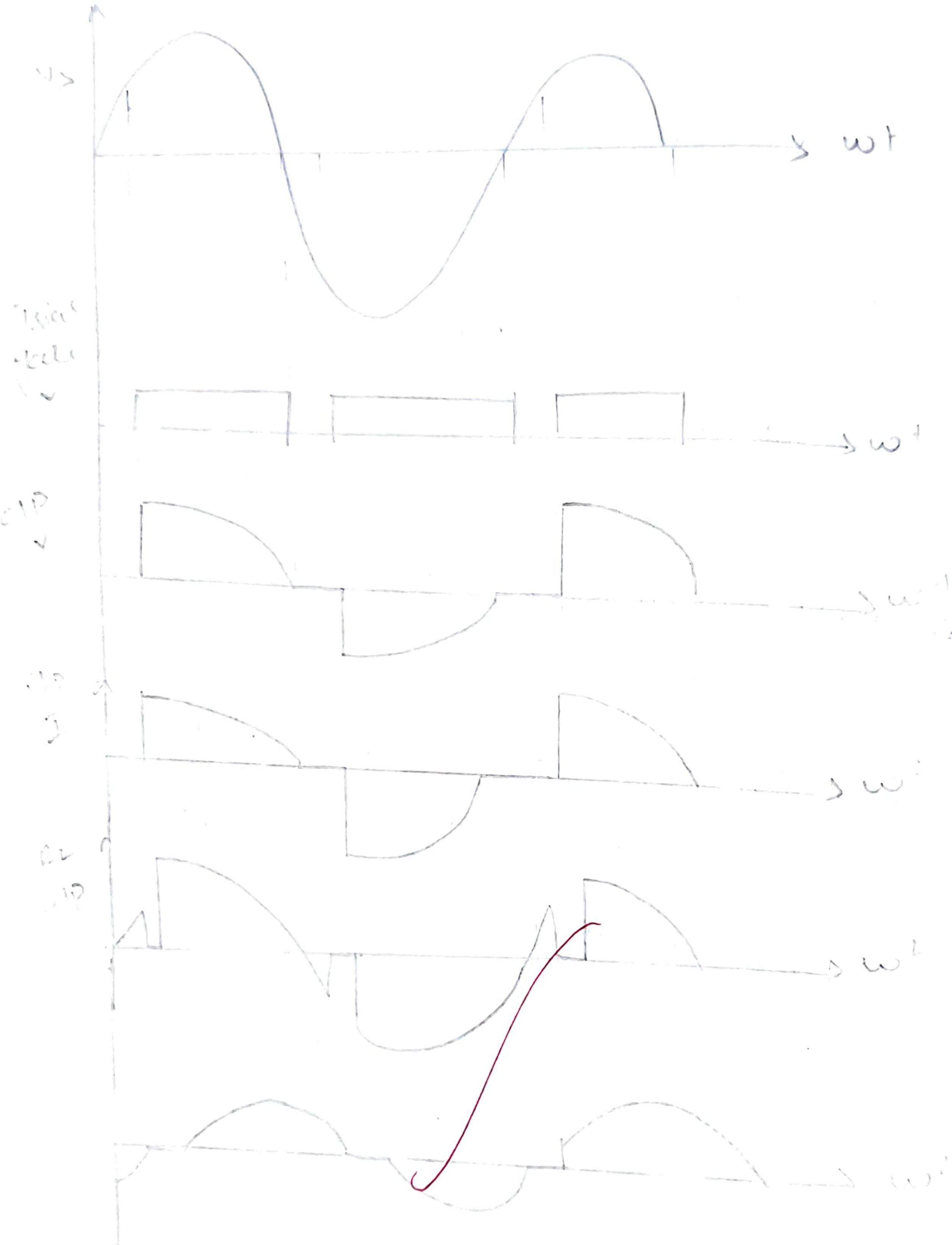
Vin = 22.1 V

Firing angle α	VL
1[illegible]	0
[illegible]	[illegible].4
[illegible]	[illegible]
[illegible]	10.[illegible]
[illegible]	[illegible]6
[illegible]	[illegible]
0	22.1

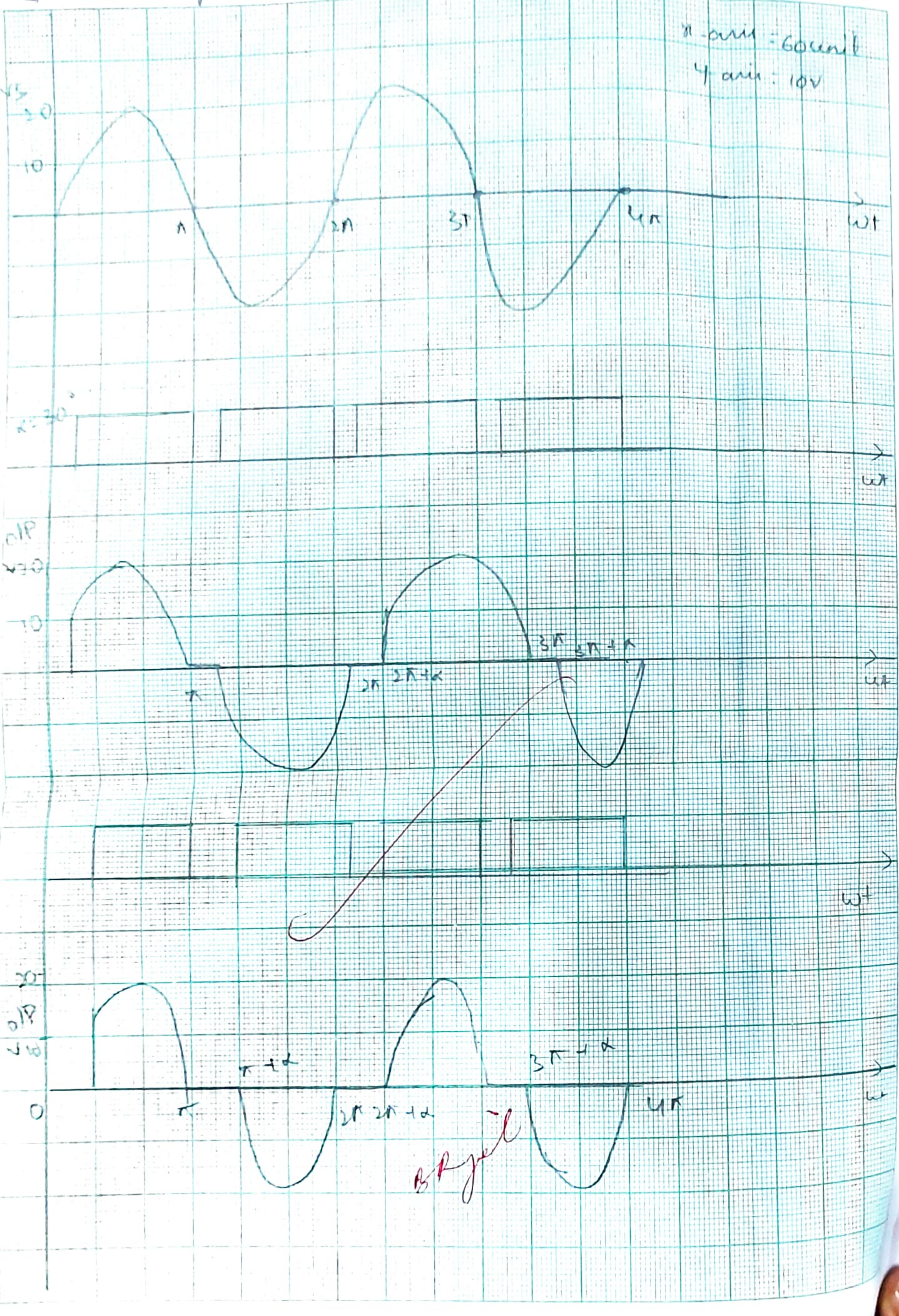
Procedure :-

1) switch ON the main supply to unit.
2) Give the connections as shown in circuit diagram for single phase AC voltage controller using SCR / TRIAC connect the AC supply to circuit through step down T/F.
3) connect the trigger o/p's T_1 & T_2 from firing circuit to SCR / TRIAC. select SCR / TRIAC switch to SCR for AC voltage.
4) Keeping firing angle knob at some intermediate position, switch ON the step down T/F supply & trigger o/p's & observe the o/p voltage waveform.
5) vary the firing angle & measure the load voltage using multimeter.
6) For the single phase AC voltage controller.

Model graph :



AC voltage R-load.



Title :

Date :

for RL load, connect the inductor in series with load R.

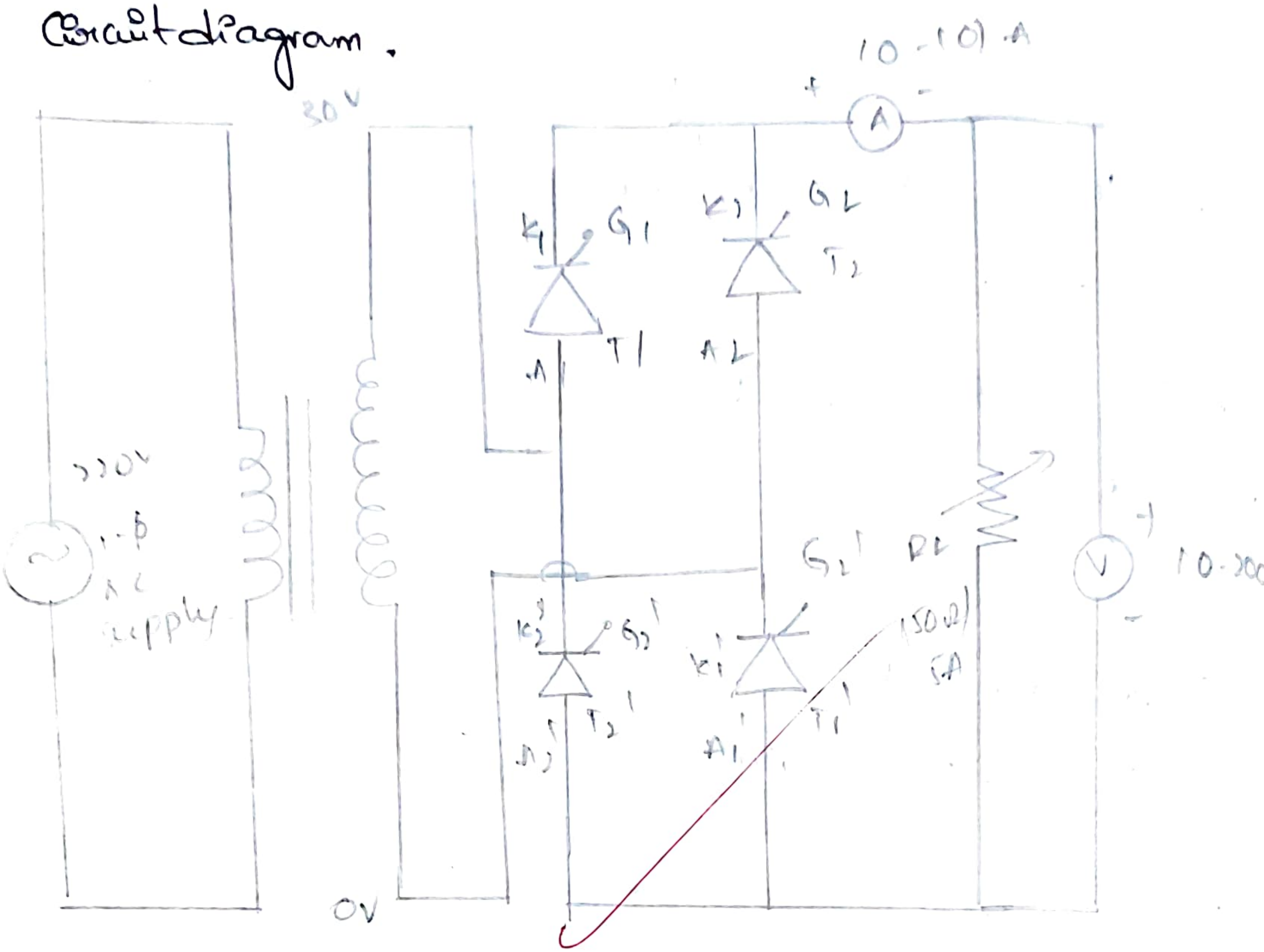
7) Repeat above steps for AC voltage controller with RL load.

Result: A single phase AC voltage controller was constructed & its operation with R & RL load is observed.

BRgil 28/7/21

(A)

Circuit diagram.



Title: 4. single phase fully controlled Bridge converter

Date: 28-7-21
Page No.: 17

Aim: To construct single phase fully controlled bridge converter circuit & to study its operation with R & RL load.

Apparatus:-

1) single phase fully controlled bridge converter power unit.
2) single phase fully controlled bridge converter firing unit
3) 1-ϕ isolation transformer (0-230)V / 5A with tappings.
4) Loading Rheostat - 150 Ω / 5A.
5) Inductor - 150 mH / 5A.
6) CRO
7) patch cards

Theory: In bridge converter, all the four arms of SCR's are connected as control switches. This is called Fully controlled bridge as all the SCR's are connected in bridge form.

Observation.

R. load

Firing angle α	V_L	I_L	$V_L = \frac{V_m(1+\cos\alpha)}{\pi}$
180	0	0	0
150	2	0.05	1.2
120	10	0.22	6.4
90	17	0.35	12.8
60	22	0.50	19.3
30	24	0.56	24.05
0	25	0.56	25.7

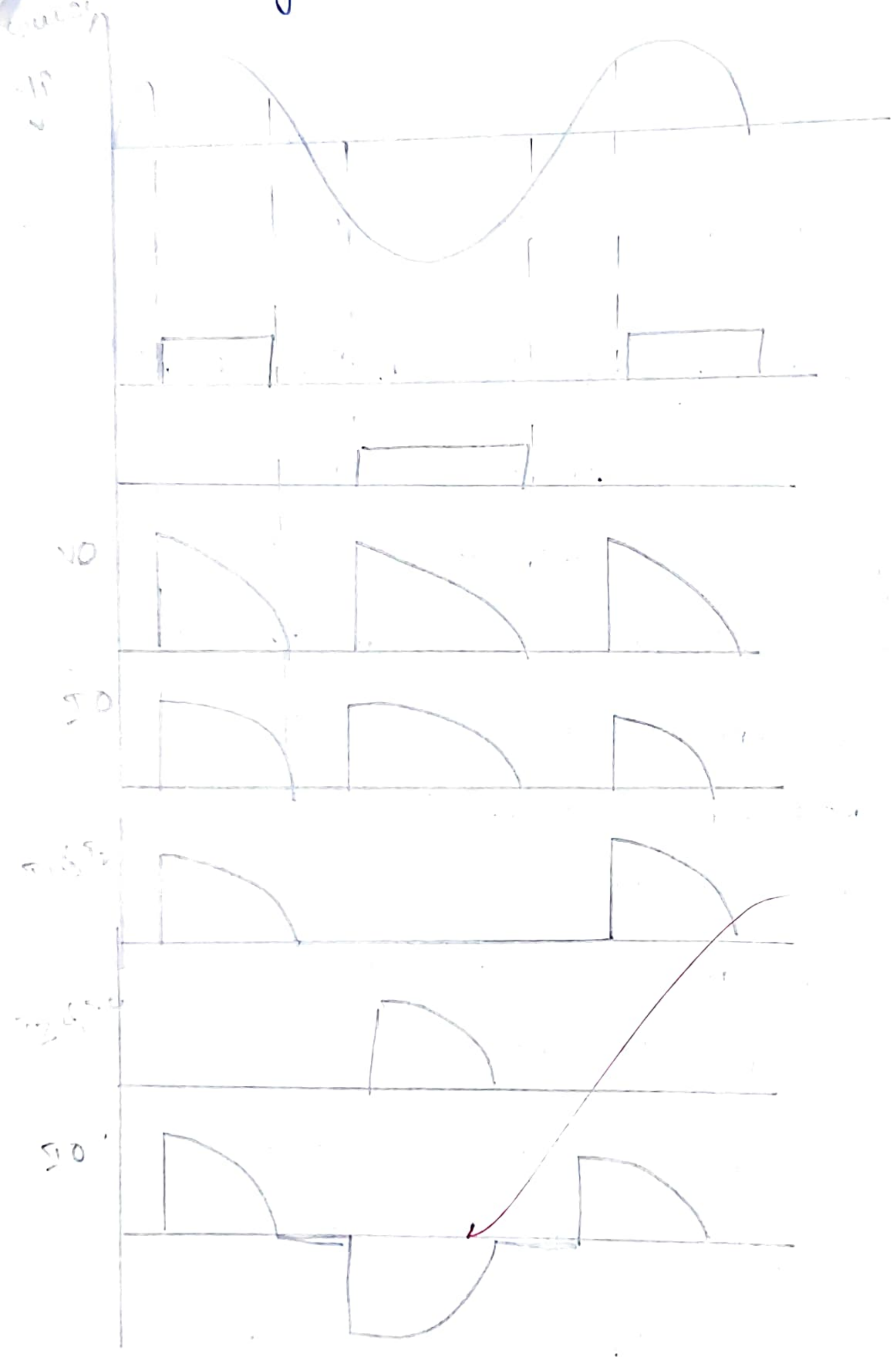
RL

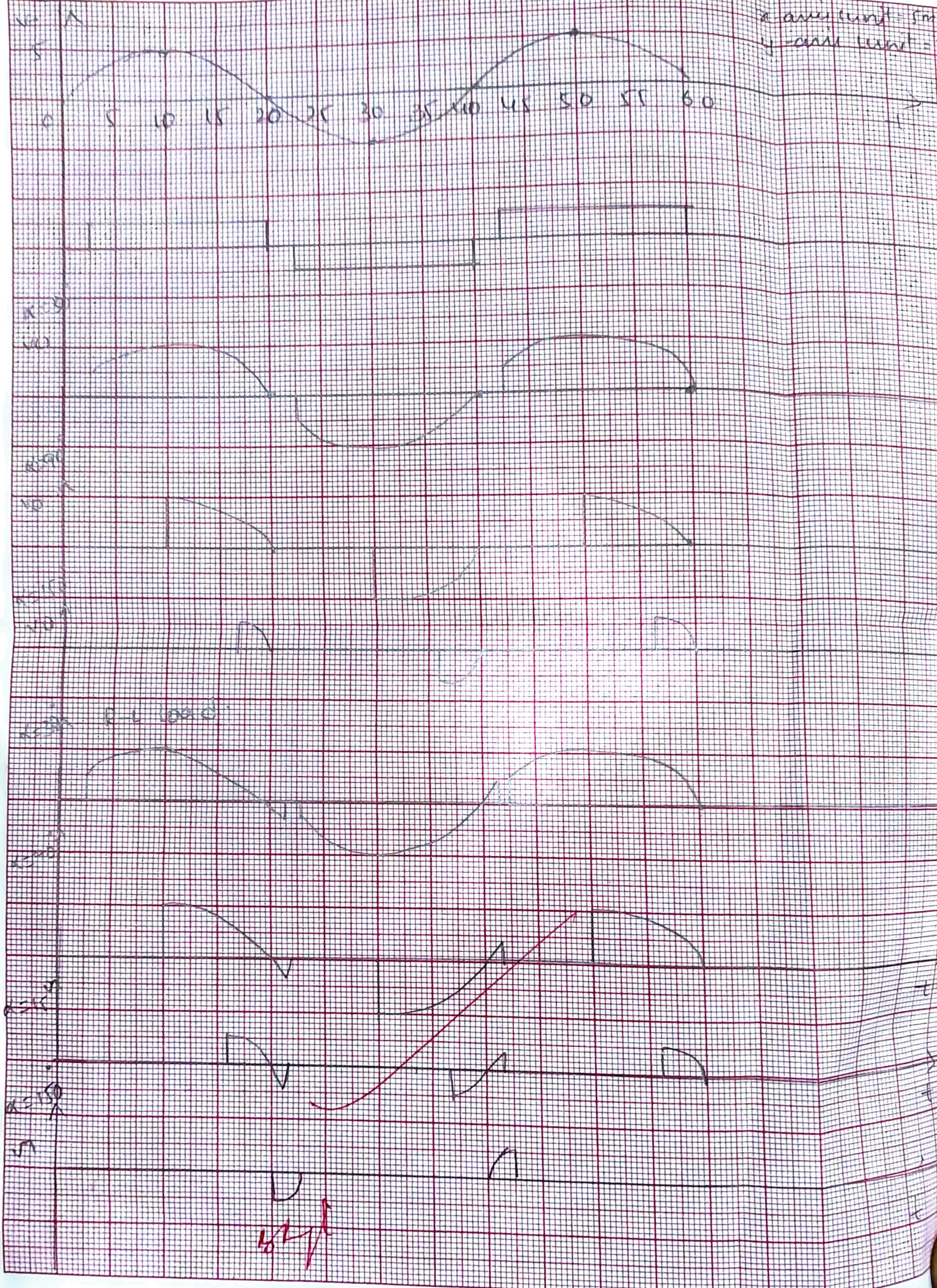
Firing angle (α)	V_L	I_L	$V_L = \frac{V_m(1+\cos\alpha)}{\pi}$
180	0	0	0
150	1	0.01	1.05
120	6	0.12	6.8
90	11	0.24	11.6
60	21	0.43	17.5
30	24	0.5	21.7
0	25	0.52	23.3

procedure :

1) Give the connections as shown in circuit diagram.
2) connect 30V tapping of isolation T/F secondary to power circuit.
3) connect R-L load (150 Ω / 5A) between the o/p points.
4) connect the trigger pulses from converter using firing circuit T_1, T_1' & T_2 T_2' to corresponding SCR's (T_1, T_1' & T_2 T_2') in power circuit.
5) switch ON main supply to firing circuit.
6) switch ON MCB in power circuit & switch on trigger o/p's in firing unit.
7) keep the firing angle at some position & draw waveforms in Vin & vo.
8) draw the waveforms across the load for different firing angles & note o/p voltage & o/p current from voltmeter & ammeter.

Model graph.





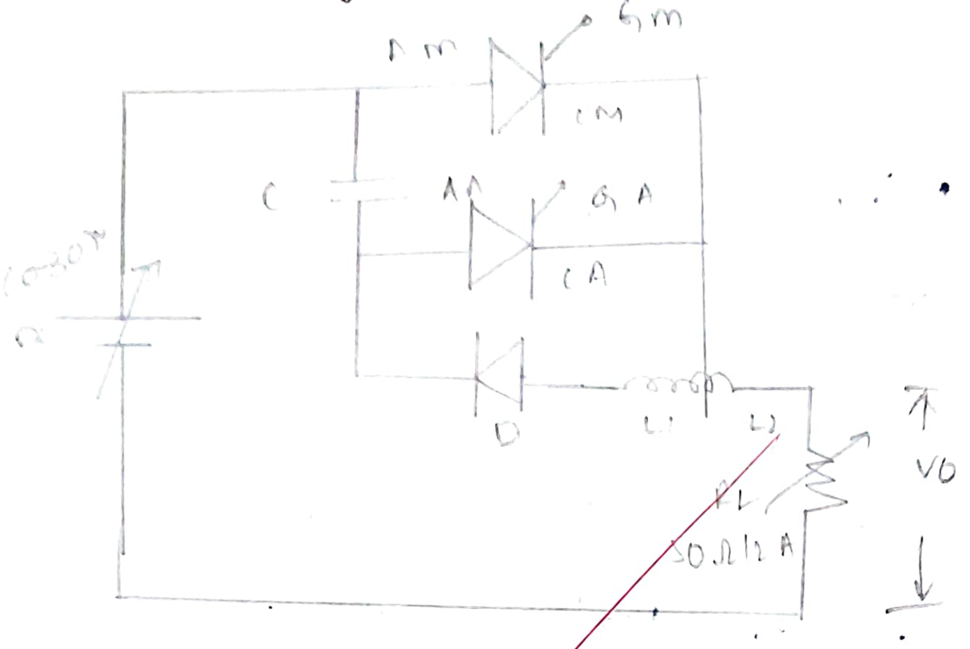
x-axis unit: 5m
y-axis unit =
0
5
10
15
20
25
30
35
40
45
50
55
60

7) At any firing angle, note the o/p waveform vo & for different firing angle note o/p voltage & o/p current from voltmeter & ammeter.

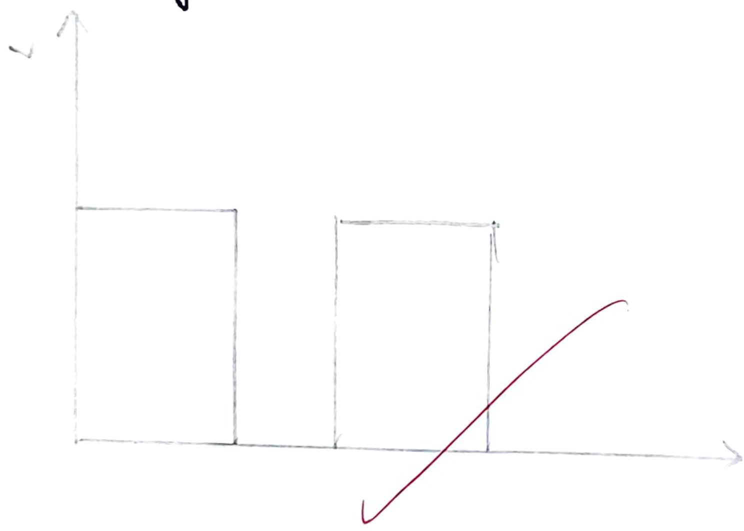
Result: A 1-ϕ fully controlled bridge constructed & its operation with R & RL load observed.

B.Rajesh 30/7/24
At

Circuit diagram.



Model graph.



Title : 5. DC Jones chopper with R and RL loads

Aim :- To construct Jones chopper circuit & to study its operation with R & RL load.

Apparatus :-

1. chopper power module.
2. chopper firing unit.
3. Regulated power supply (0-30)v
4. loading rheostat (50 Ω / 2A)
5. Inductor - 50 mH / 2A
6. Digital multimeter
7. CRO
8. patch cords.

Theory :- chopper converts fixed DC voltage to variable DC voltage. The DC to DC converters have gained popularity in modern industry. Some practical applications of DC to DC converters include armature voltage control of DC motors converting one DC voltage level to another level.

Observations.

Duty ratio	TON	TOFF	(V)
57.1	8	6	9
50	7	7	9
42	6	8	9
35.7	5	9	9
28	4	10	9

Observations.

Frequency	TON	TOFF	V
66	6	9	9
83.6	5	7	9
111.1	4	5	9
125	3	5	9

Procedure :-

1) Give connections as per circuit diagram with R load.

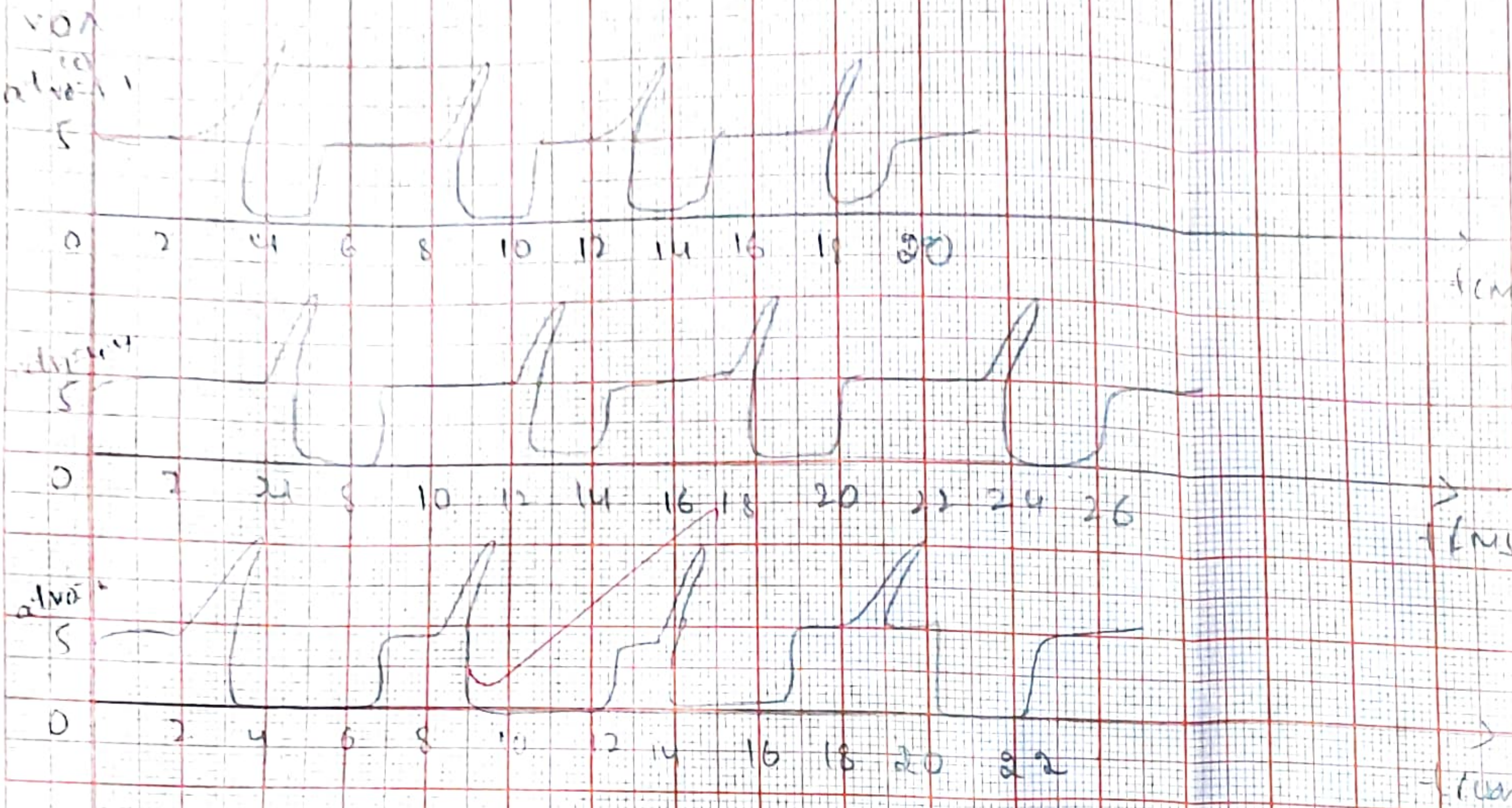
2) connect Gate cathode terminals of SCR's to respective points on firing unit.

3) keep the frequency knob & duty ratio knob at some intermediate position.

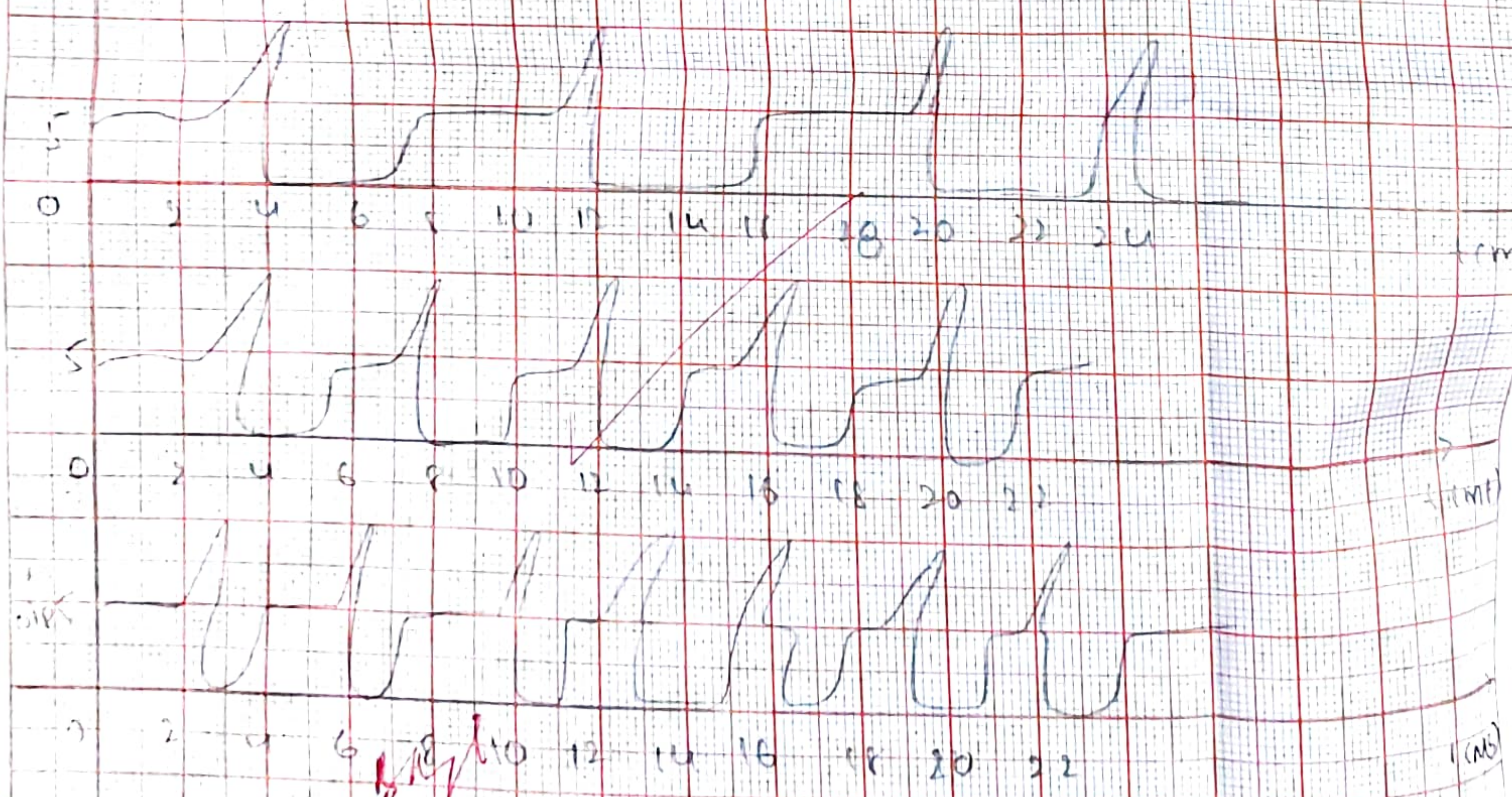
4) set DC power supply to 30V & switch ON the DC power supply to chopper.

5) observe V_O, V_{T1}, V_{T2}, V_{P1}, V_{P2}, V_C waveforms on CRO & note down the corresponding waveforms.

6) keeping the frequency const. vary duty cycle in steps & note T_{ON}, T_{OFF} & load voltage for each step.



constant duty cycle Ton -



7. Repeat step 6 by varying frequency & keeping duty ratio constant.

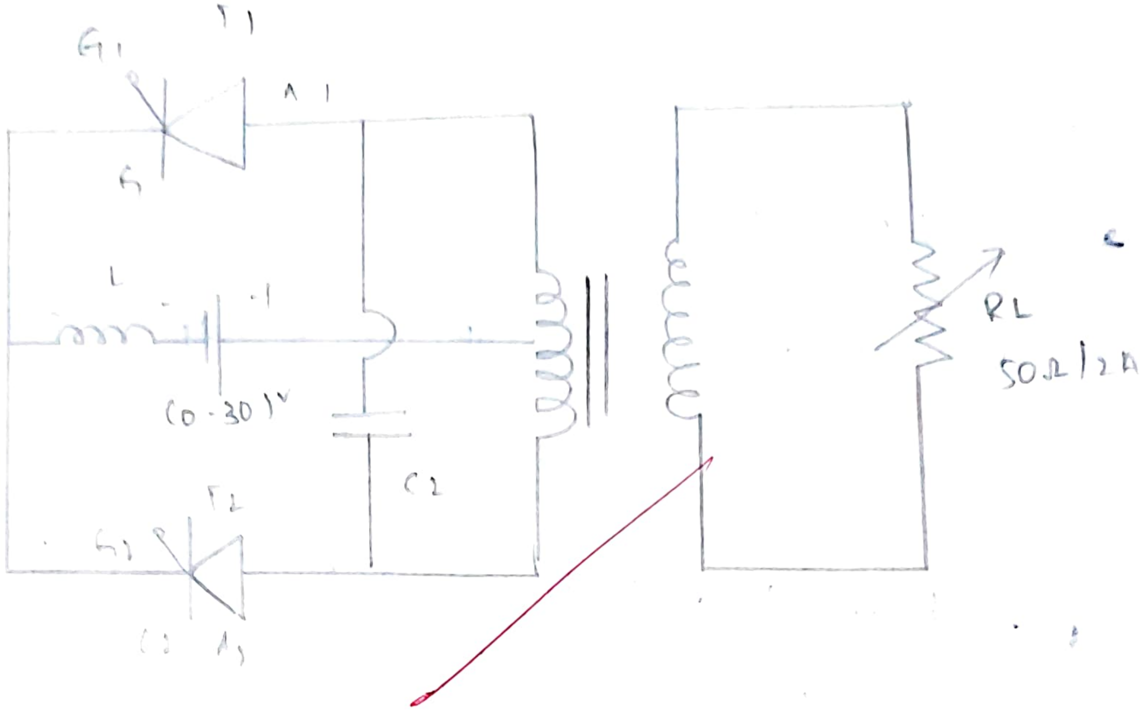
8. connect RL load & note O/P Vo & repeat step 6.

Result : we have studied the characteristics of D.C Jones chopper.

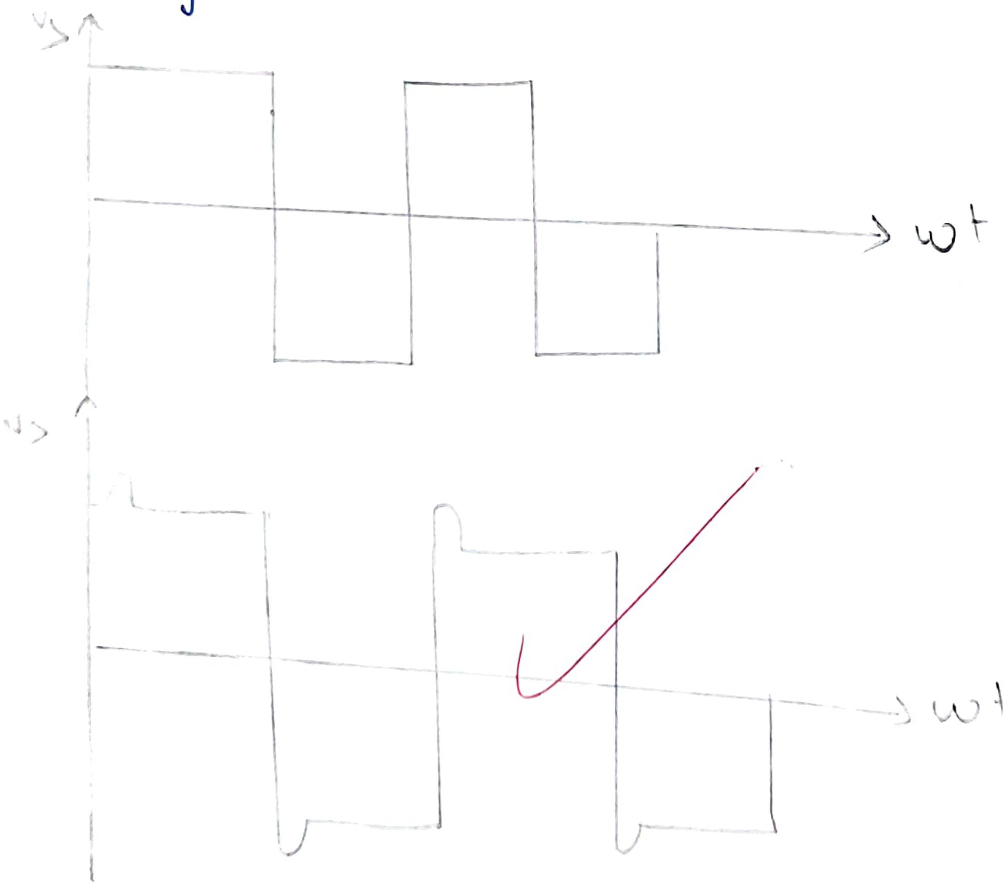
A. Rajee 30/7/21

A+

circuit diagram



Model graph.



Title : 6. single phase parallel inverter with R and RL loads

Date : 28/6/21
Page No. : 23

Aim : To construct single phase parallel inverter circuit & to study its operation with R & RL load.

Apparatus:

1. parallel inverter module.
2. Regulated power supply (0-30) V
3. Loading Rheostat (50 Ω / 2A)
4. Inductor - 50mH / 2A.
5. Digital multimeter.
6. patch cords
7. CRO.

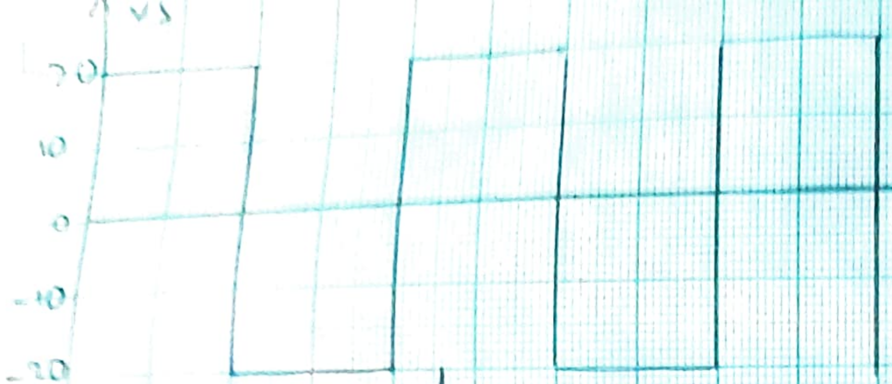
Theory: A device that converts DC power into AC power at desired output voltage and frequency is called as inverter. Some industrial applications of inverters are for adjustable speed AC drives, induction heating stand by aircraft power supplies, UPS.

R load Observations

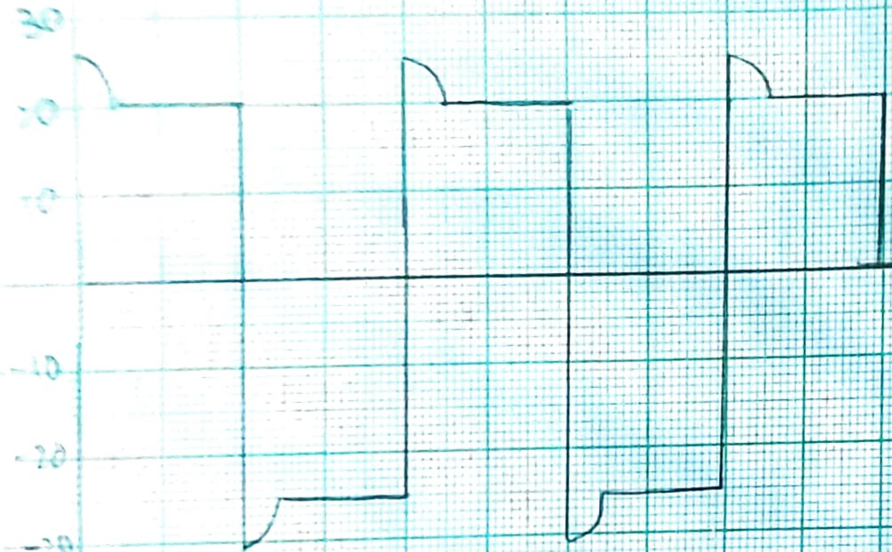
Frequency	O/P (V)
89.21	63.212
92.49	62.812
109.16	64.812

RL load

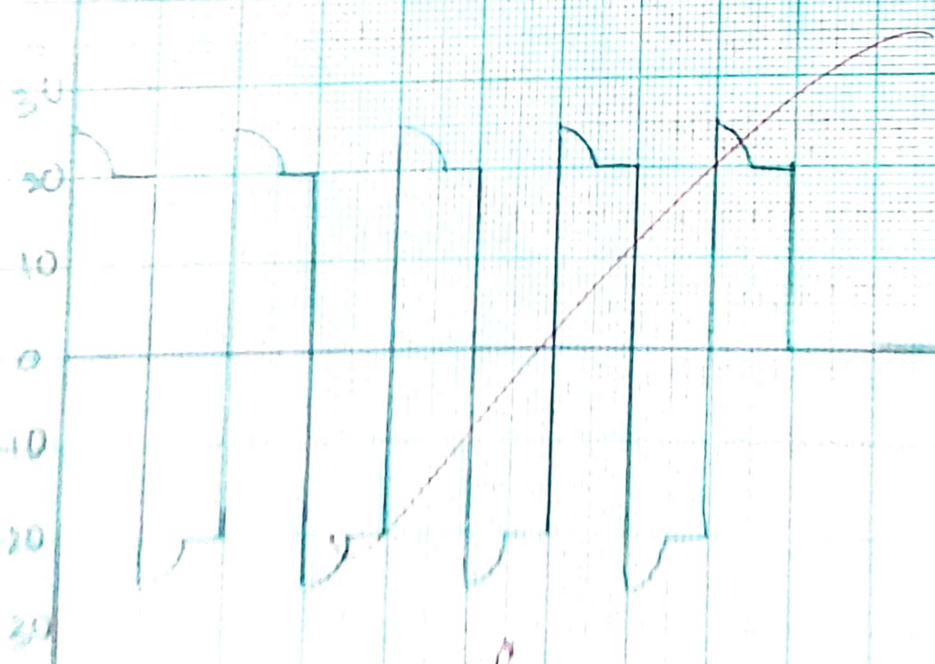
Frequency	O/P voltage	VT	VC
109.24	38.12	53.612	36.6
82.4	32.81	22.1	36.6



R - load



R-L load



Procedure:

1) Give the connections as shown in circuit diagram.
2) connect the firing unit to main unit.
3) Adjust the DC supply to 13V & switch on the main unit & firing unit.

4) set the frequency at a particular value & observe the load voltage waveforms V_O, V_T, V_{T2}, V_{P1}, V_{P2}, V_C on CRO. & note waveforms.

5) By varying the frequency, note O/P AC voltage using multimeter.

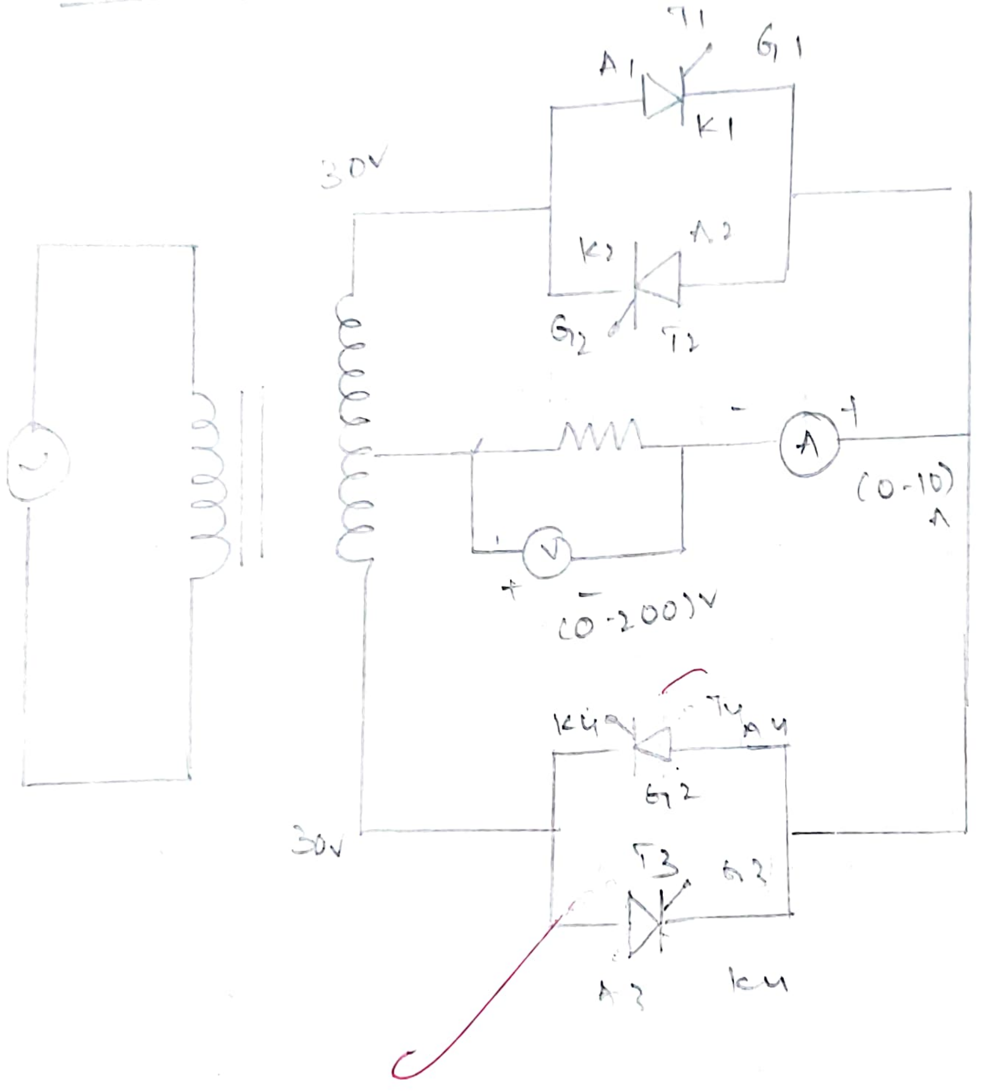
6) connect RL load & note O/P V_O.

7) Repeat step 5 for RL load.

Result: Hence studied the 1-ϕ parallel inverter with R & RL load.

A+ 30/7/21

circuit diagram



Title : 7. Single phase cyclo-converter with R and RL loads

Date : 30-7-21
Page No. : 25

Aim : To construct a single phase cyclo converter circuit & to study its operation with R & RL loads.

Apparatus :

1) cycloconverter power unit.
2) cyclo converter firing unit.
3) single phase isolation transformer.
4) Loading rheostat - 50Ω / 2A.
5) Inductor (0 - 150 mH / 5A)
6) Digital multimeter
7) CRO
8) patch cords

Theory :- A circuit which converts input power at one frequency to output power at different frequency with one stage conversion is called a cyclo converter. cyclo converter are used in speed control of high power AC drives, induction heating etc.

Observations

R

f_s	voltage	current
f_s	27	0.22
$f_s/2$	27	0.22
$f_s/3$	27	0.22
$f_s/4$	27	0.22

RL

frequency	V	I
f_s	27.2	0.22
$f_s/2$	27.2	0.22
$f_s/3$	27.2	0.22
$f_s/4$	27.2	0.22

Procedure :-

1) Give the connections as per circuit diag with R load with ammeter & voltmeter.

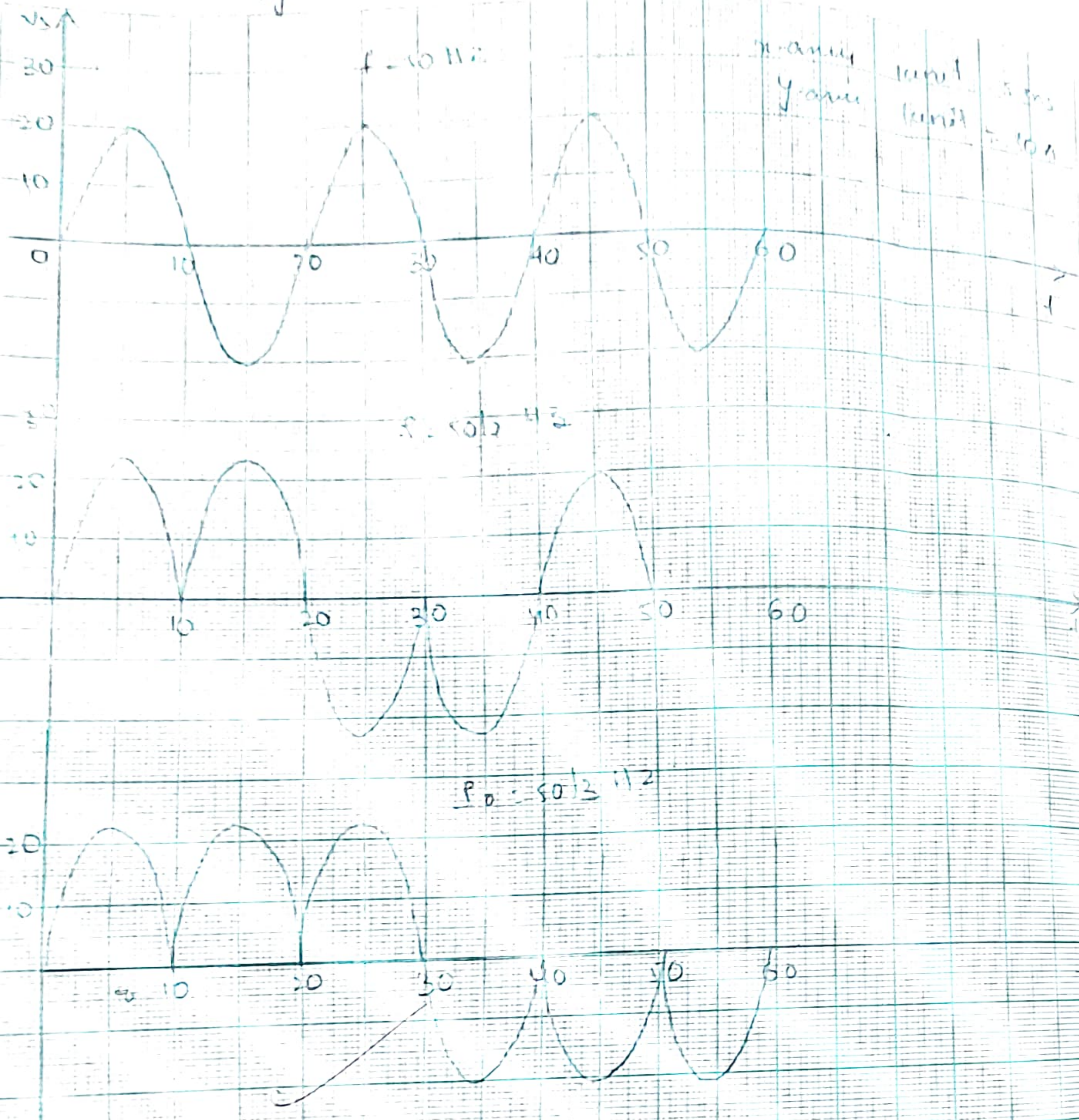
2) connect the firing pulses from the firing unit to respective SCR's in power unit.

3) connect the i/p supply of 30-30V from the centre tapped.., T/F & loading rheostat at o/p terminals.

4) switch ON power unit & the firing unit switch ON the MCB in power unit & switch ON triggering pulses in firing unit.

5) set frequency division to 2. At any firing angle, note waveform across load vo & note o/p voltage & current readings from voltmeter & ammeter.

cyclo converter



7) note o/p voltage waveform for different frequency division

8) note o/p voltage & current.

9) connect to RL & repeat the above steps.

Result: Hence we studied the 1-ϕ cyclo converter with R & RL load is verified.

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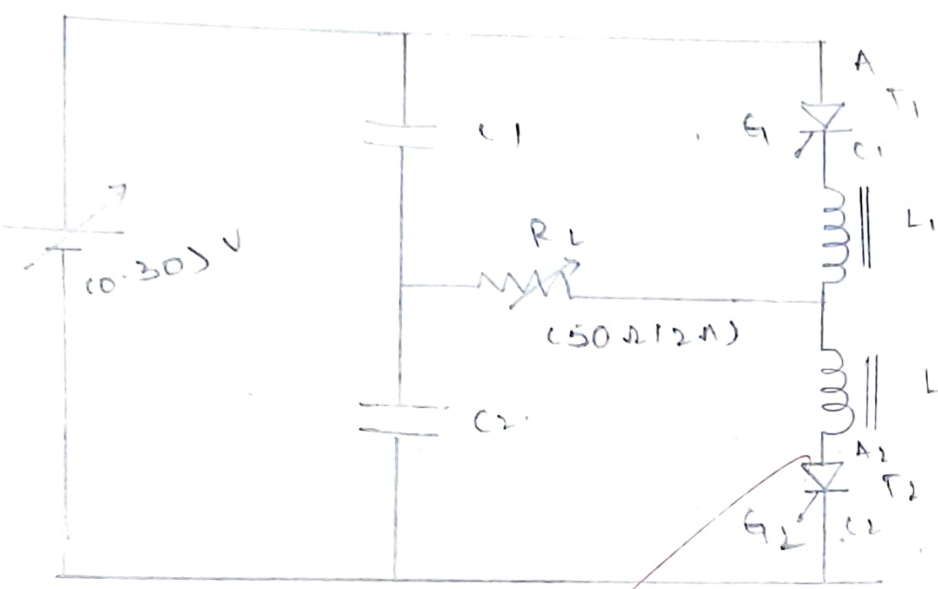
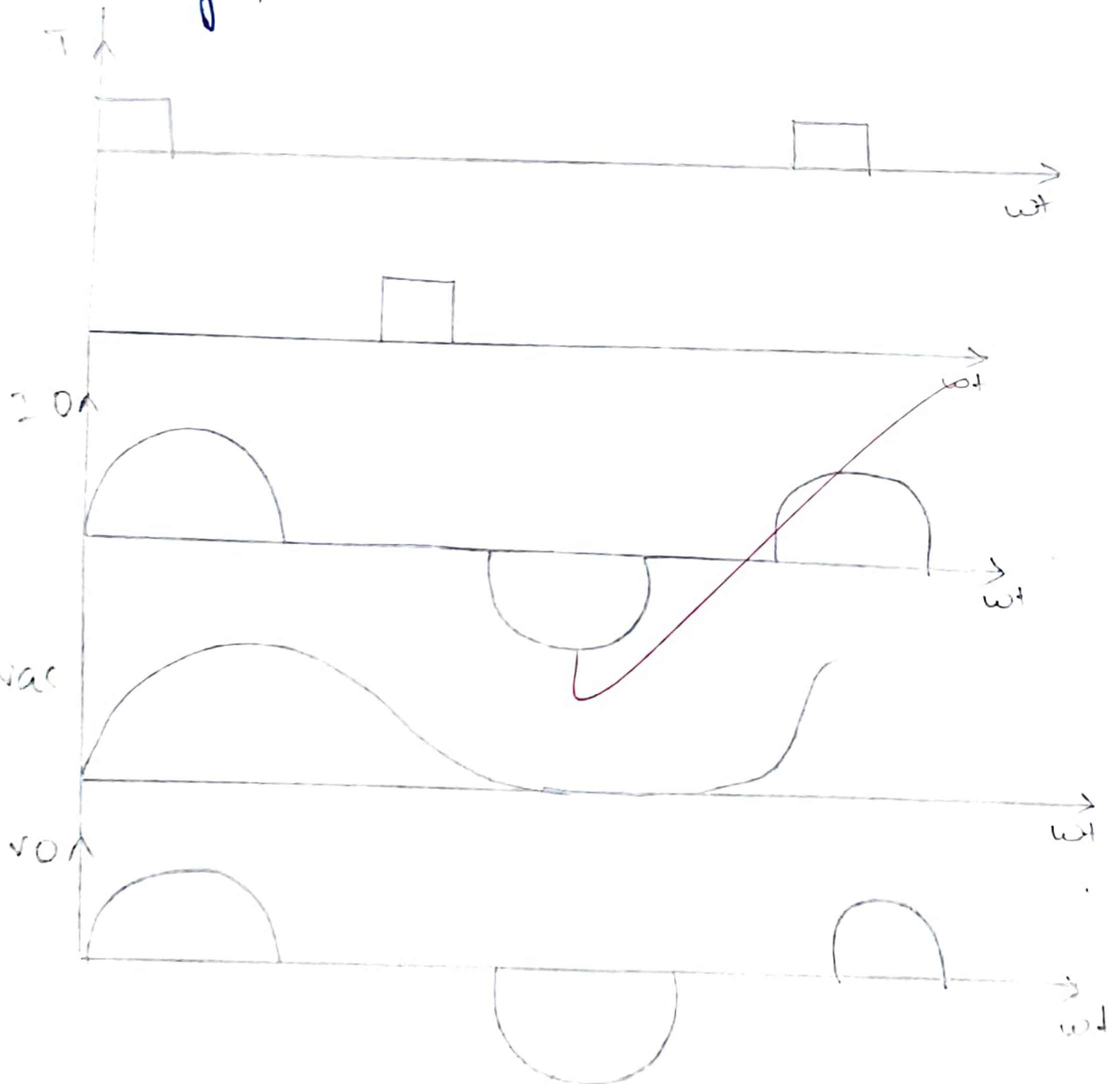
circuit diagram.



Model graph



Title : 8. single phase series inverter with R and RL loads

Aim: To construct single phase series inverter circuit & to study its operation with R & RL load.

Apparatus:-

1) series inverter unit.
2) Loading Rheostat - 50Ω / 2A.
3) Regulated power supply - (0-30)V
4) Inductor - 50mH / 2A.
5) Digital multimeter.
6) patch cords.
7) CRO.

Theory:- The inverter in which commutating components are permanently connect in series with load called series inverter. Series inverter can also classified as self commutated inverters & load commutated inverters

$$F = \frac{1}{2(T_{ON} + T_{OFF})} Hz.$$

Observations

R V = 6.18

Time Period	Frequency (Hz)	O/P voltage (V)
5ms	83.7	64.1 mV
5ms	86.6	83.2 mV
5ms	91.3	85.1 mV
5ms	94.9	63.1 mV
5ms	108.2	-24.8 mV
5ms	128	20.9
5ms	158	-5.25
5ms	120	44.4

R 1

Time period	Frequency	O/P V
5ms	81.4	26 mV
5ms	83.4	44.9 mV
5ms	93.6	58.1 mV
5ms	96.6	34.9 mV
5ms	98.9	-53.7 mV
5ms	76	-31.1
5ms	80	37.2

Procedure :

1) Give the connections per circuit diagram with R- load.

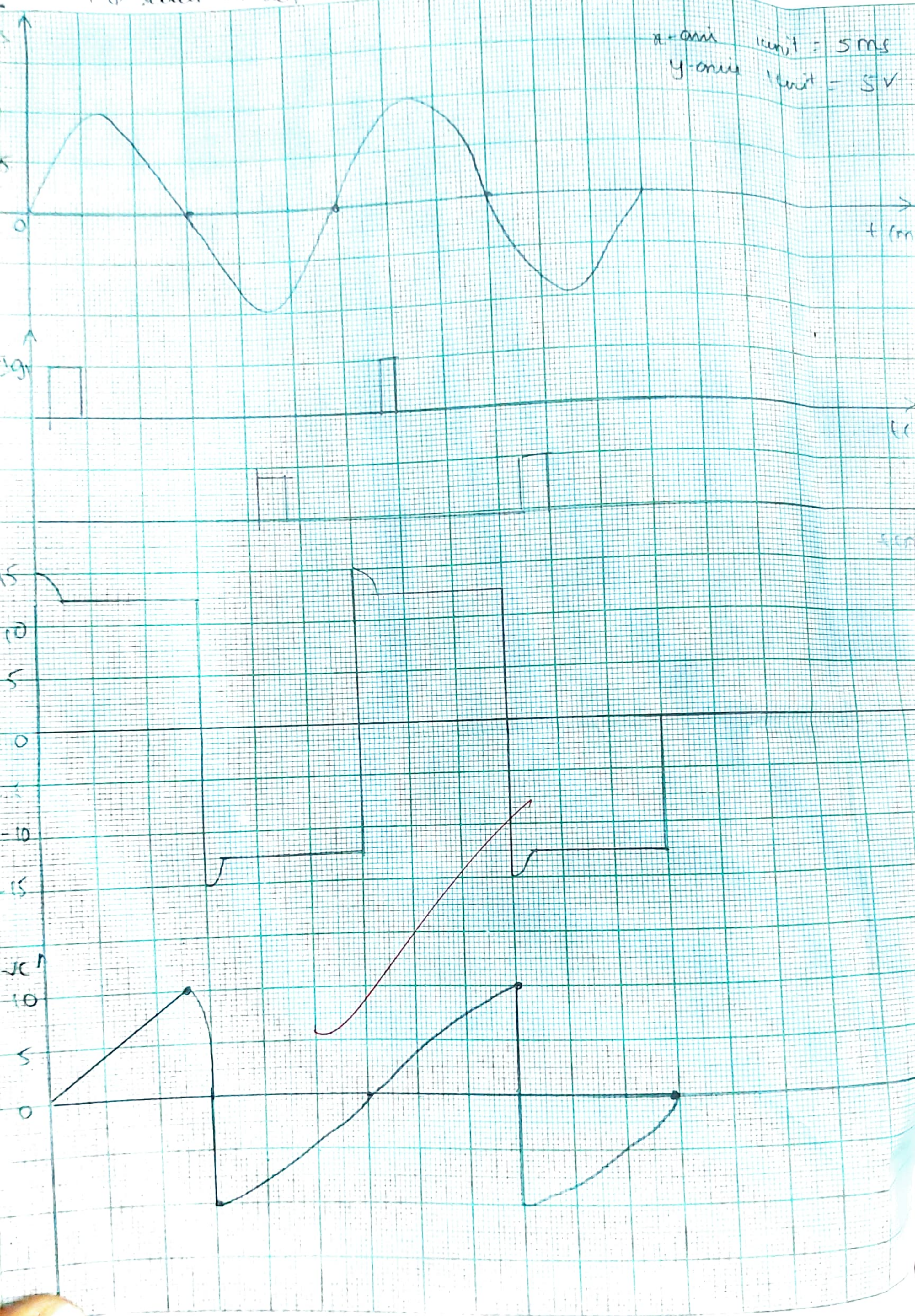
2) connect the gate cathode terminals of SCR's to respective points on firing unit.

3) Adjust the DC supply voltage to 30v & switch on DC supply & firing unit.

4) set frequency at particular position & observe o/p waveform V_{o}, V_{T1}, V_{T2}, V_{T1}, V_{T2}, V_{C1} on CRO & note waveform.

5) vary frequency in steps and note corresponding waveforms.

6) connect RL load & note o/p voltage & repeat above steps.


x-axis 1 unit = 5 ms
y-axis 1 unit = 5 V
0
t (m
15
10
5
0
-10
-15
vc
10
5
0

Result : Hence observed the single phase series inverter with R & RL load.

B.R.y.l, 1.8.21

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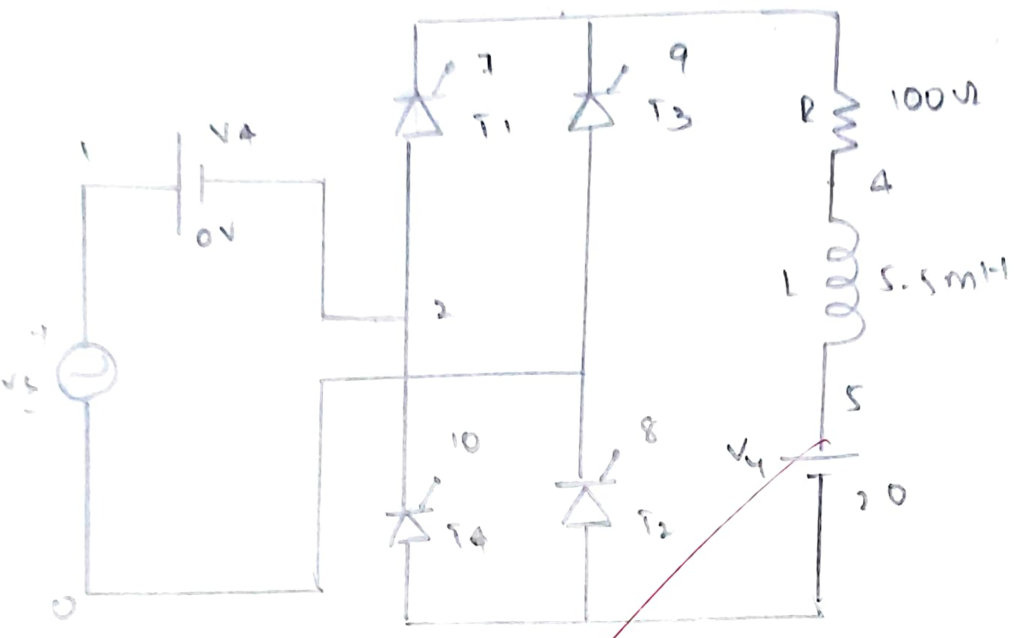
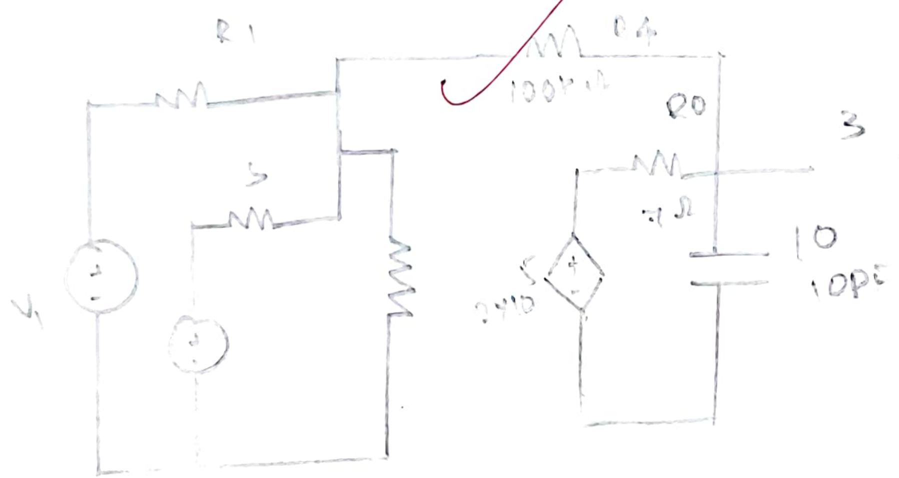
Circuit diagram





Title: 9. single phase full converter using RL and E load.

Date: 28-7-21
Page No.: 31

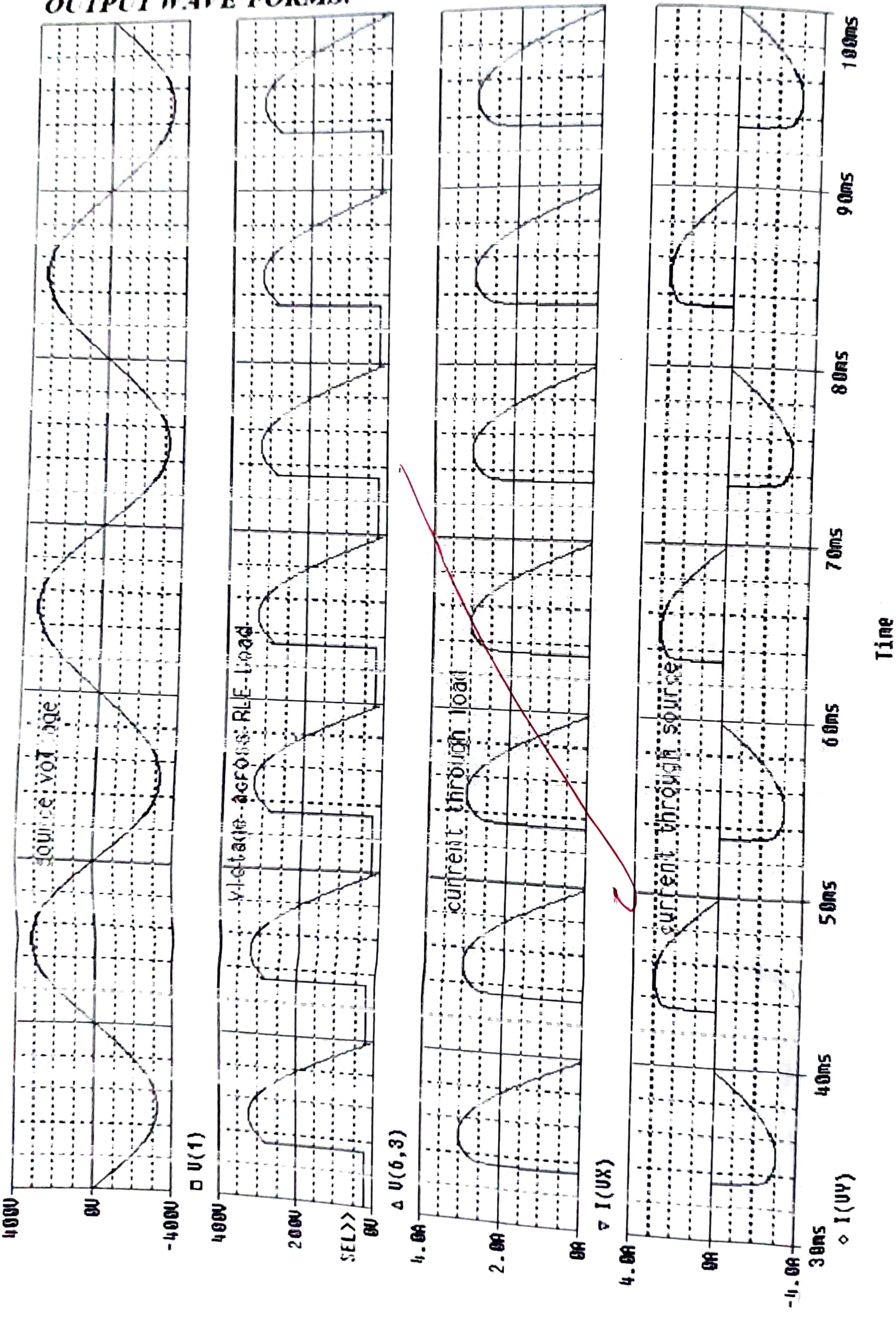
Aim: To simulate single phase full converter using PSPICE.

Apparatus: computer
PSPICE software.

code:

```
VG1 6 2 PULSE (0V 10V 3333.33US 1NS 1NS
        100US 20000US)

VG2 7 0 PULSE (0V 10V 3333.33US 1NS 1NS 100US
        20000US)

VG3 8 2 PULSE (0 10V 13333.33US 1NS 1NS 100US
        20000US)

VG4 9 1 PULSE (0 10V 13333.33US 1NS 1NS 100US
        20000US)

R 2 4 100 OHM
L 4 5 5.5 MH
VX 5 3 DC 20V
VY 1 0 1DC 10V
```

OUTPUT WAVE FORMS: -



XT1 1 2 6 7 SCR

XT2 3 0 10 SCR

XT3 0 2 8 2 SCR

XT4 3 1 9 1 SCR

- SUBCKT

SCR 1 2 3 2

S1 1 5 6 2 SMOD

RG 3 4 50

VX 4 2 DC 0V

VY 5 7 DC 0V

DT 7 2 DMOD

RT 6 2 1

CT 6 2 10 UF

F1 2 6 POW(L) VX VY 0 50 11.

- MODEL SMOD VSWITCH (RON=0.0105 ROFF=10E+5 VON=0.5V VOFF=00)

- MODEL DMOD D (IS=2.2E-15 BV=1200V TT=0 C30=0)

- ENDS SCR

Title :

Date :
Page No. : 33

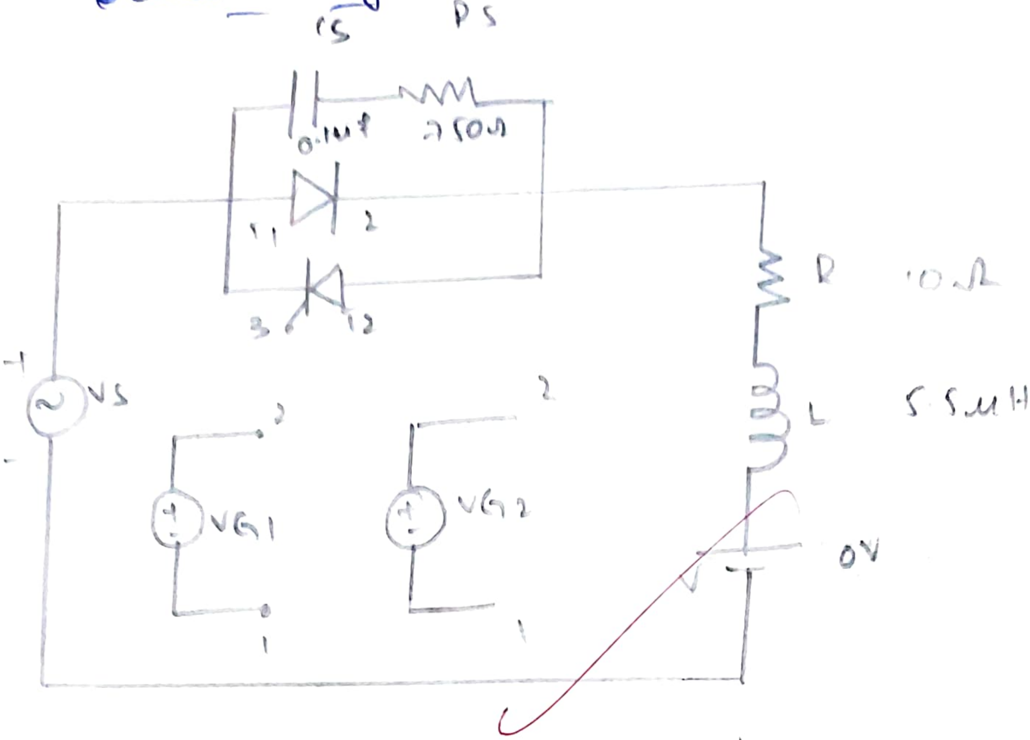
- .TRAN 50 US 100 ms 30 ms 50 US
- .OPTIONS ABSTOL = 1.00 N RETOL = 10 N UNTOL = 0.01
  ITLS = 20000
- .FOUR 50HZ I(uy)
- .PROBE
- .END.

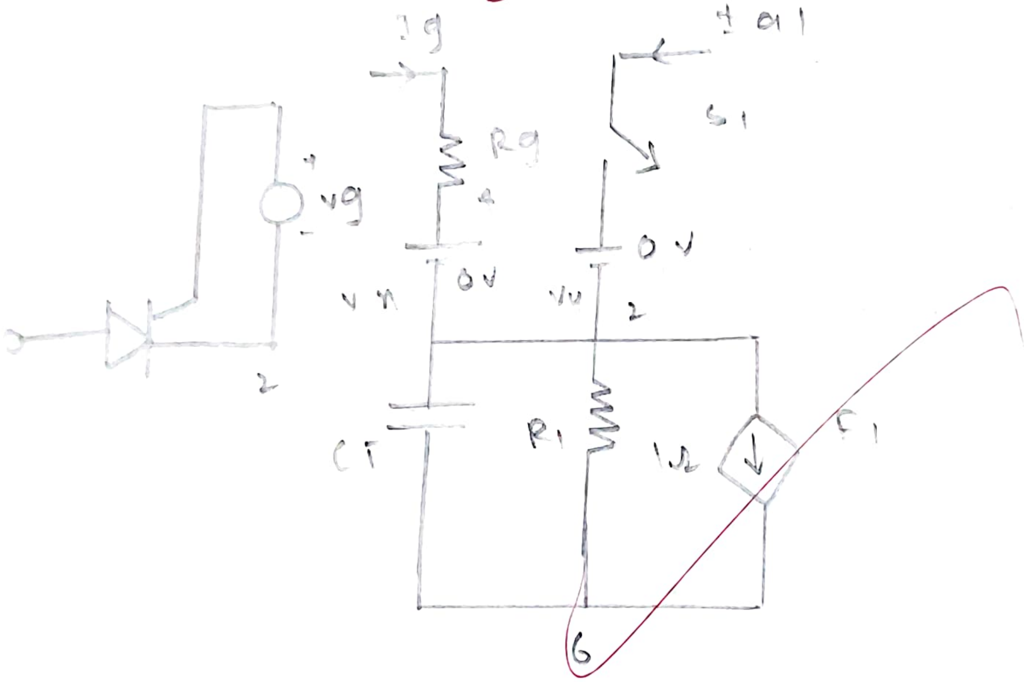
Result :- verified single phase fully converter using RL & E loads

BRajil 2/8/21

A+

● Circuit diagram





Title : 10. Single phase AC voltage controller using RL load

Date : 30-7-21
Page No. : 34

Aim :- To stimulate single phase AC voltage controller using PSPICE.

Apparatus :-

computer
PSPICE software.

Program :-

VS 1 0 SIN (0 170V 60HZ)

VG1 2 4 PULSE (0V 10V 4166.70S 1NS 1NS 100US 16666.70S)

VG2 3 1 PULSE (0V 10V 12500US 1NS 1NS 100US 16666.70S)

R 4 5 2.5

L 5 6 6.5 mH

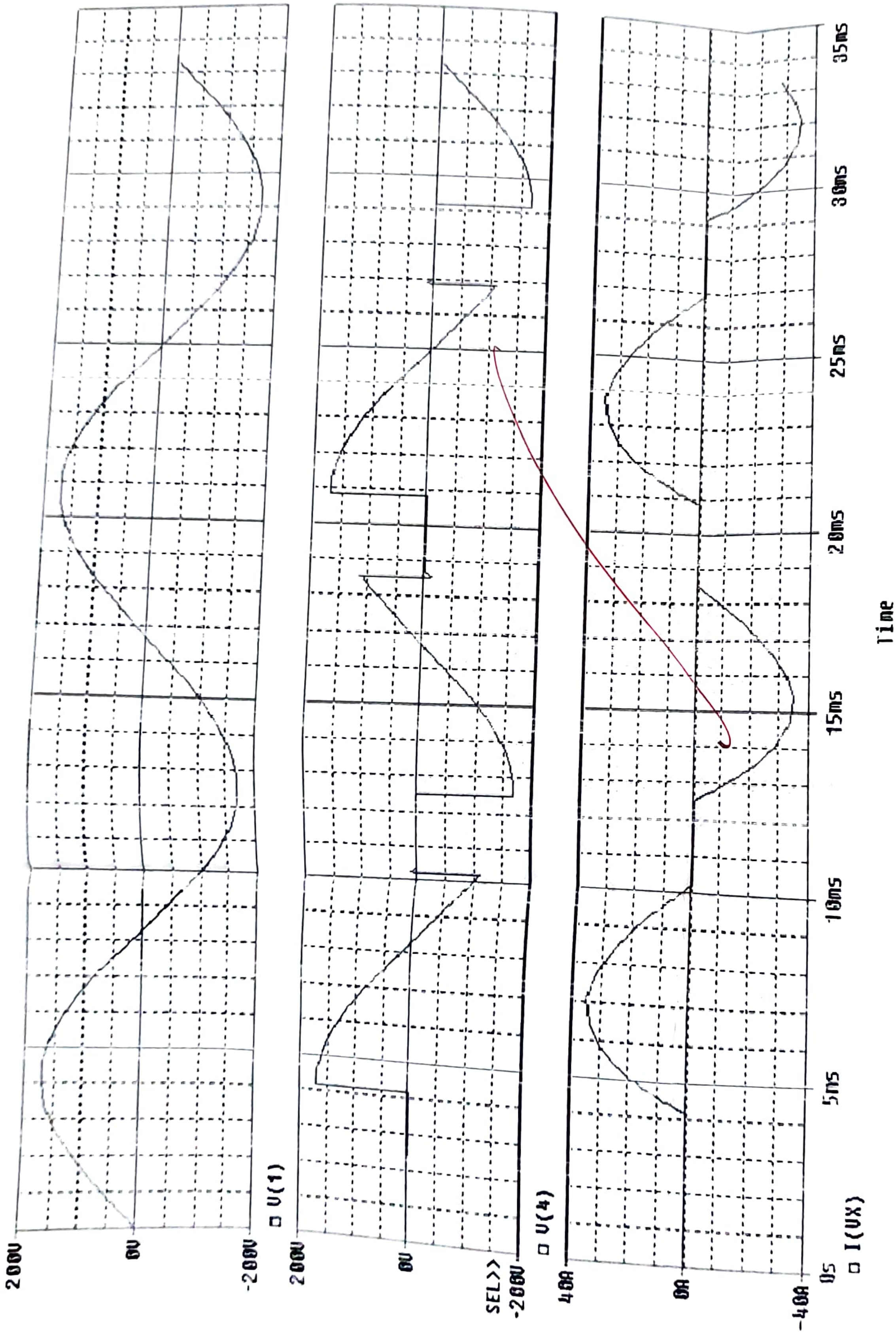
VX 6 0 DC 0V

CS 1 7 0.1UF

RS 7 4 750

XT1 1 4 2 4 SCR

OUTPUT WAVE FORMS: -



XT2 4 1 3 1 SCR .

. SUBCKT SCR 1 2 3 2

S1 1 5 6 2 SMOD

RG 3 4 50

VX 4 2 DC 10V

VY 5 2 DC 0V

RT 2 6 1

CT 6 2 10UF

F1 2 6 POLY(2) VX VY 0 50 11

. MODEL SMOD USWITCH (RON=0.01 ROFF=10E+5 VON=0.1 VOFF=0V)

. ENDS SCR

. TRAN 10US 33.33ms

. PROBE

. OPTIONS ABSTOL = 1.00n RELTOL = 1.0m VNTOL = 10m ITLS = 1000

. FOUR 60HZ 4Y

. END .

Title :

Date :

Result : Hence verified 1ϕ voltage controlled using RL load.

BKy 2/8/21

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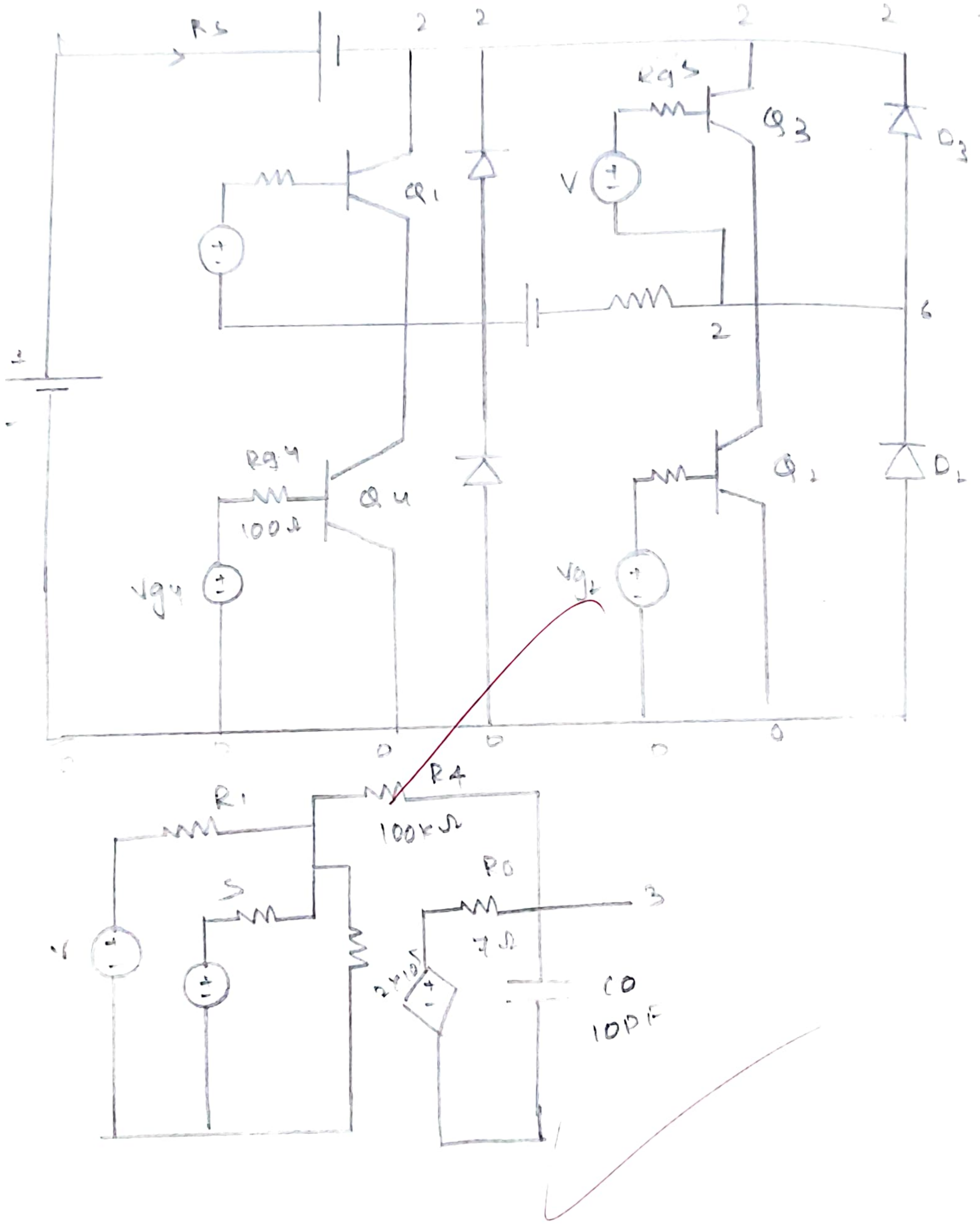
Circuit Diagram.



Title : Single phase PWM inverter

Date : 30-7-21

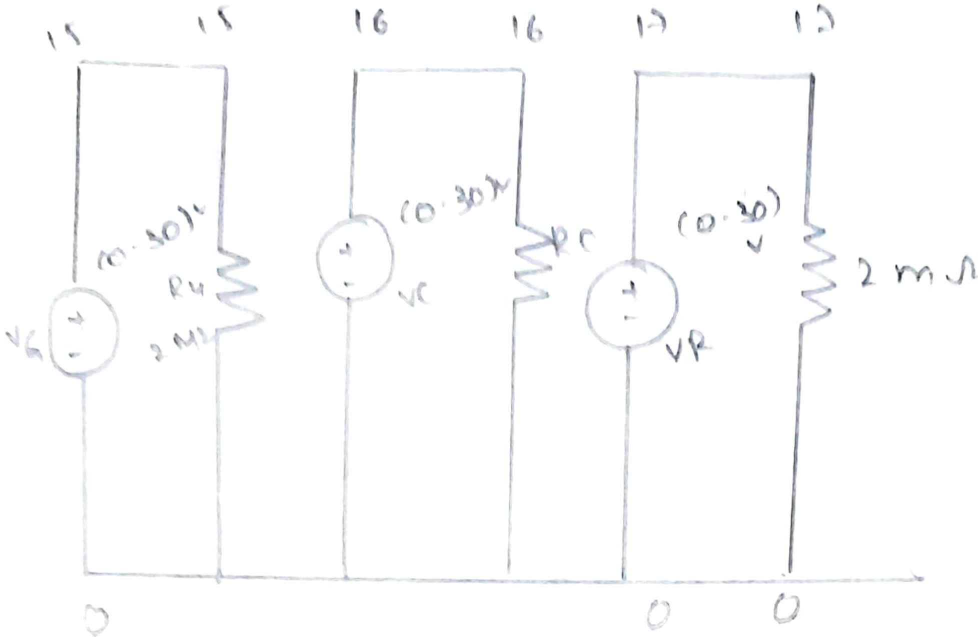
Aim : To stimulate single phase PWM inverter using PSPICE.

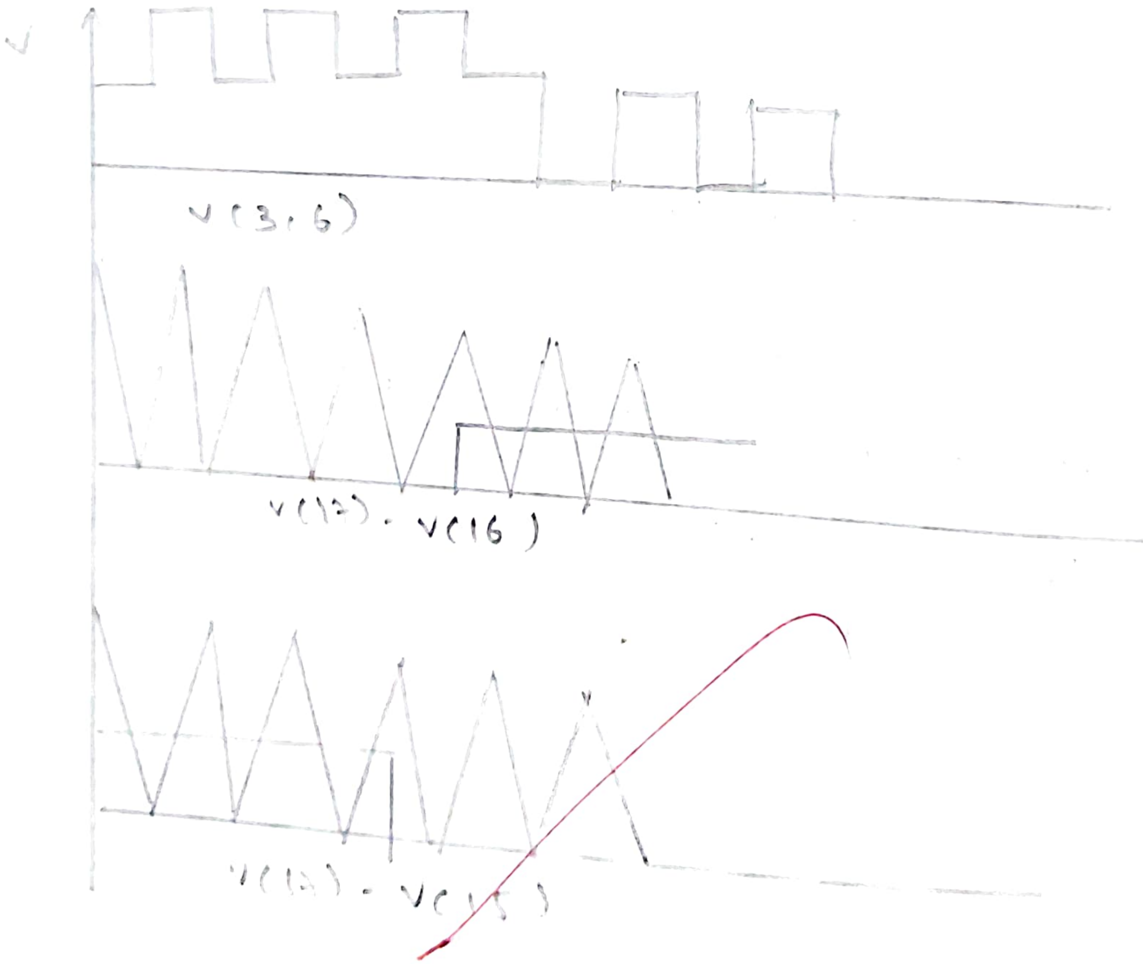
Apparatus :-

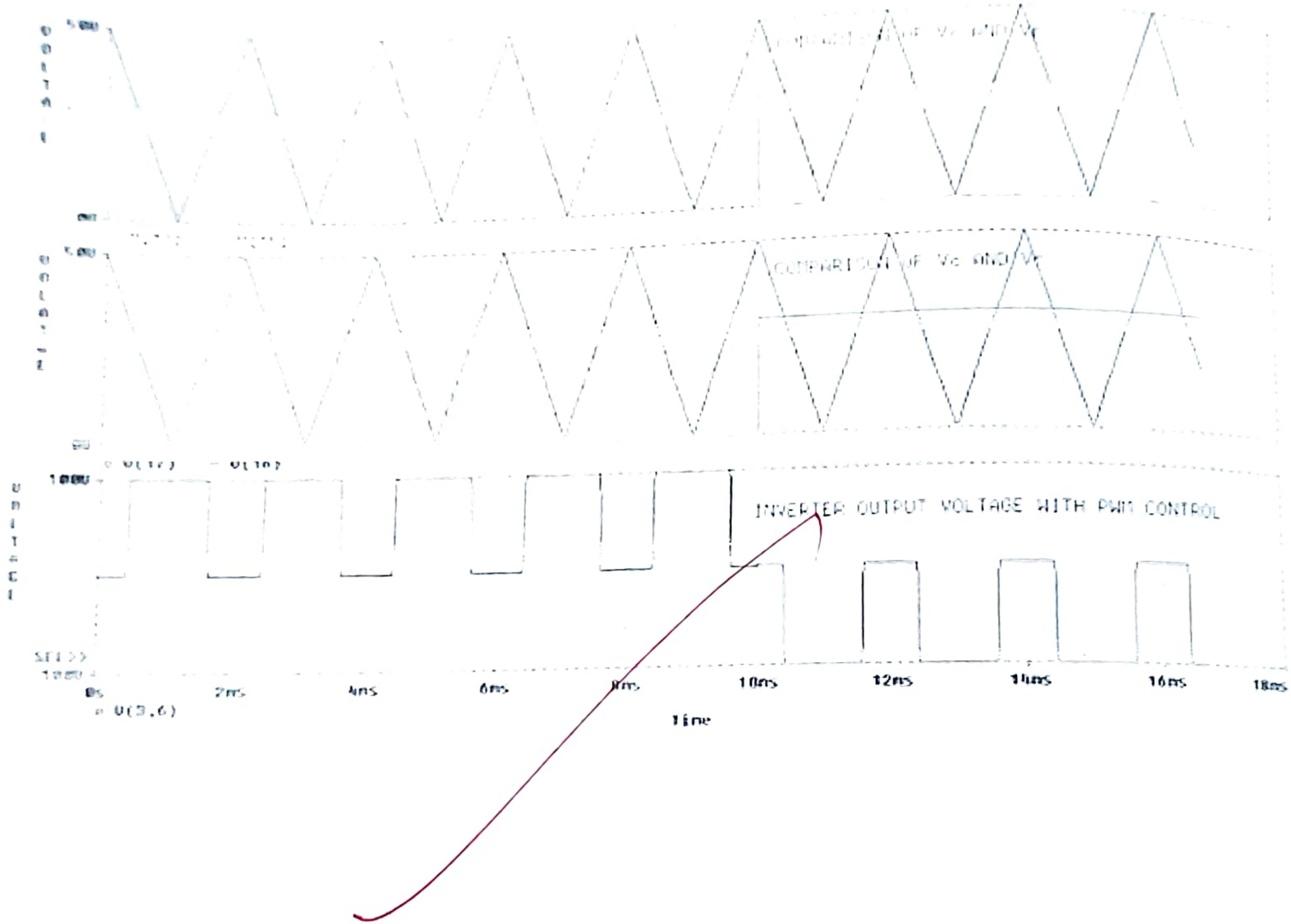
1. computer and PSPICE software.

Program :-

VS	1	0	DC	100 V
VR	17	0	PULSE	(50V 0V 0 1MS 1MS 1NS 2MS)
RR	17	0	2MEG	
VC1	15	0	PULSE	(0-30V 0 1MS 1NS 10MS 20MS)
RC1	15	0	2 MEG.	
VC3	16	0	PULSE	(0-30V 10MS 1NS 1NS 10MS 20MS)
RC3	16	0	2MEG	
R	4	6	2.5 OHM	
V_x	3	4	DC	0V
V_y	1	2	DC	0V
D_1	3	2	DMOD	
D_2	0	6	DMOD	
D_3	6	2	DMOD	
D_4	0	3	DMOD.	


15
15
16
16
17
17
(0-30)v
(0-30)v
(0-30)
v
VC
VR
2 mΩ
0
0
0


V
V(3,6)
V(17)-V(16)



VOLTAGE
5.0V
0V
COMPARISON OF Vc AND Vr
V(17)
V(18)
100V
INVERTER OUTPUT VOLTAGE WITH PWM CONTROL
SEL>>
-100V
0s
2ms
4ms
6ms
8ms
10ms
12ms
14ms
16ms
18ms
V(3,6)
Time

Title :

- MODEL DMOD D (IS = 2.2E - 15 BV = 1890 V)

Q1 2 7 3 QMOD

Q2 6 9 0 QMOD

Q3 2 11 6 QMOD

Q4 3 13 0 QMOD

- MODEL QMOD NPN (IS = 6.73 F BF = 416.4 CJC = 3.638P
CJE = 4.493 P)

RG1 8 7 100 OHM

RG2 10 9 100 OHM

RG3 12 11 100 OHM

RG4 14 13 100 OHM

XPW1 17 15 8 3 PWM

XPW2 17 15 10 0 PWM

XPW3 17 16 12 6 PWM

XPW4 17 16 14 0 PWM .

- SUBCKT PWM 1 2 3 4

R1 1 5 1K

R2 2 5 1K

RIN 5 0 2MEG

RO 6 3 75 OHM

CO 3 4 10 PF

RF 5 3 100K

E1 6 4 0 5 2E+5

Title :

Date :

Page No. : 39

.ENDS PWM

.TRAN 100 S 16.67 NS 0 10US

.PROBE

.OPTIONS ABSTOL = 1.00N RELTOL=0.01 VNTOL=0.1

ITLS = 20000

.END

Result: Verified the working & operation of 1-ϕ PWM inverter using PSPICE.

BKjil 2/8/21

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