MALLA REDDY ENGINEERING COLLEGE
(Autonomous)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

LAB MANUAL
FOR
POWER ELECTRONICS LAB

COURSE : B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)

CLASS : III YEAR EEE/ I SEM

SUBJECT CODE : 80217

SUBJECT : Power Electronics Lab

POWER ELECTRONICS LAB

1. Study of Characteristics of SCR, MOSFET & IGBT.
2. Gate firing circuits for SCR.
3. Single Phase AC Voltage Controller with R and RL Loads.
4. Single Phase fully controlled bridge converter with R and RL loads.
5. Forced Commutation circuits (Class A, Class B, Class C, Class D & Class E).
6. DC Jones chopper with R and RL Loads.
7. Single Phase Parallel, inverter with R and RL loads.
8. Single Phase Cycloconverter with R and RL loads.
9. Single Phase Half controlled converter with R load.
10. Three Phase half controlled bridge converter with R-load.
11. Single Phase dual converter with RL loads.
12. PSPICE simulation of single-phase full converter using RLE loads and single-phase AC voltage controller using RLE loads and also of resonant pulse commutation circuit and Buck chopper.

EXPERIMENT NO 1

STUDY OF CHARACTERISTICS OF SCR, MOSFET AND IGBT

AIM: To study various characteristics of SCR, MOSFET and IGBT.

APPARATUS:

S.No	Apparatus	Type	Range	Quantity
01.	Voltmeter	MI	200V, 20V	02
02.	Ammeter	MI	2A, 20 mA	02

THEORY:

Silicon Controlled Rectifier: Silicon Controlled Rectifier is a four-layer three junction p-n-p-n switching device. It has three terminals, Anode, cathode and gate. In normal operation of thyristor anode held with high positive potential with respect to cathode and gate has a small positive with respect to cathode.

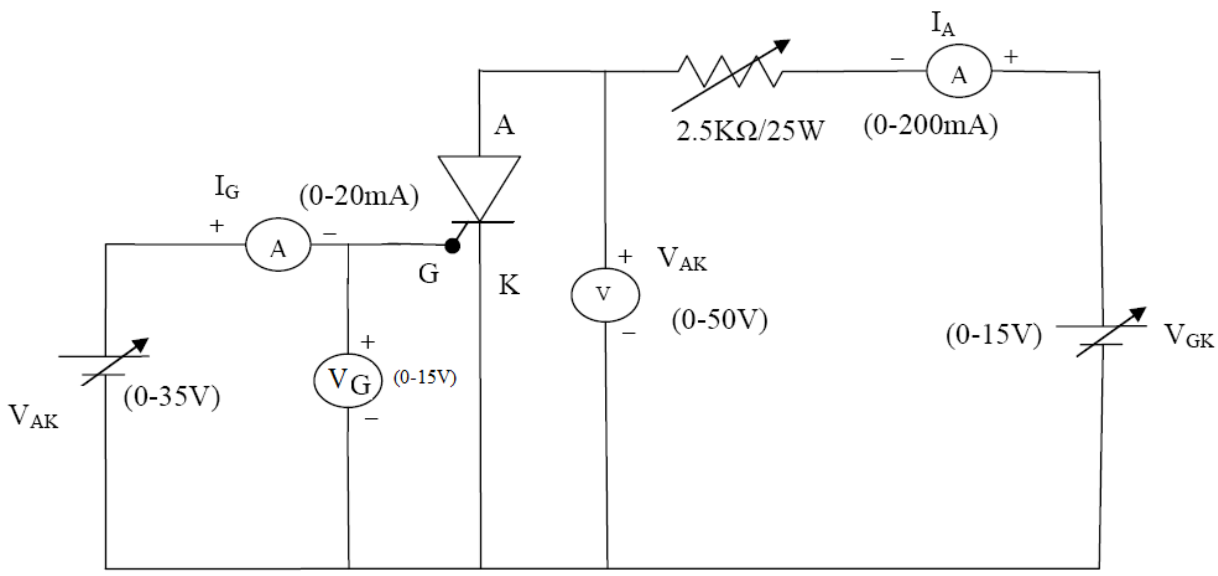
When Anode is made positive with respect to cathode and switch is open in the gate circuit ,then p-n junction j1 and j3 are forward biased ,where as j2 becomes wider and j1 thinner at j1 and j3. There is no base current in transistor t2 and hence that of t1.under such conditions the SCR is in a state of blocking forward direction. If now gate is made positive w.r.t. cathode or switch is closed, a small gate current will flow through junction j2 as a result anode starts flows if anode current is greater than latching current of SCR.SCR is forward conduction state or simply SCR is closed state.

MOSFET: A Power MOSFET has three terminal called drain, source and gate. MOSFET is avoltage controlled device. As its operation depends upon the flow of majority carriers only. MOSFET is unipolar device. The control signal or gate current less than a BJT. This is because of fact that gate circuit impedance in MOSFET is very high of the order of 10^9 ohm. This larger
impedance permits the MOSFET gate be driven directly from microelectronic circuits. Power MOSFET‟s are now finding increasing applications in low-power high frequency converters.

IGBT: IGBT is a new development in the area of Power MOSFET Technology. This devicecombines into it‟s the advantages of both MOSFET and BJT. So an IGBT has high input impedance like a MOSFET and low-on-state power loss in a BJT.IGBT is also known as metal oxide insulated gate transistor (MOSIGT). Conductively –modulated field effect transistor (COMFET) or gain modulated FET (GEMFET). It was initially called insulated gate Transistor (IGT).

CIRCUIT DIAGRAM:

SCR CHARACTERISTICS:



PROCEDURE:

SCR CHARACTERISTICS:

A) Forward V-I Characteristics:

1. The connections are made as shown in the circuit diagram.
2. Switch on the power supply .Apply constant V_{AK} voltage say 10V varying V_{AA}
3. Gradually increase the gate current till the SCR becomes on i.e. V_{AK} and I_A
4. Now V_{AK} is increased gradually and I_A noted for two to three readings,
5. Steps 3 to 4 are repeated for another values of V_{AK} say 30V.
6. Tabulate the readings in the tabule.
7. Plot a graph of V_{AK} versus I_A for different(two) values of I_G

B) Reverse V-I Characteristics :

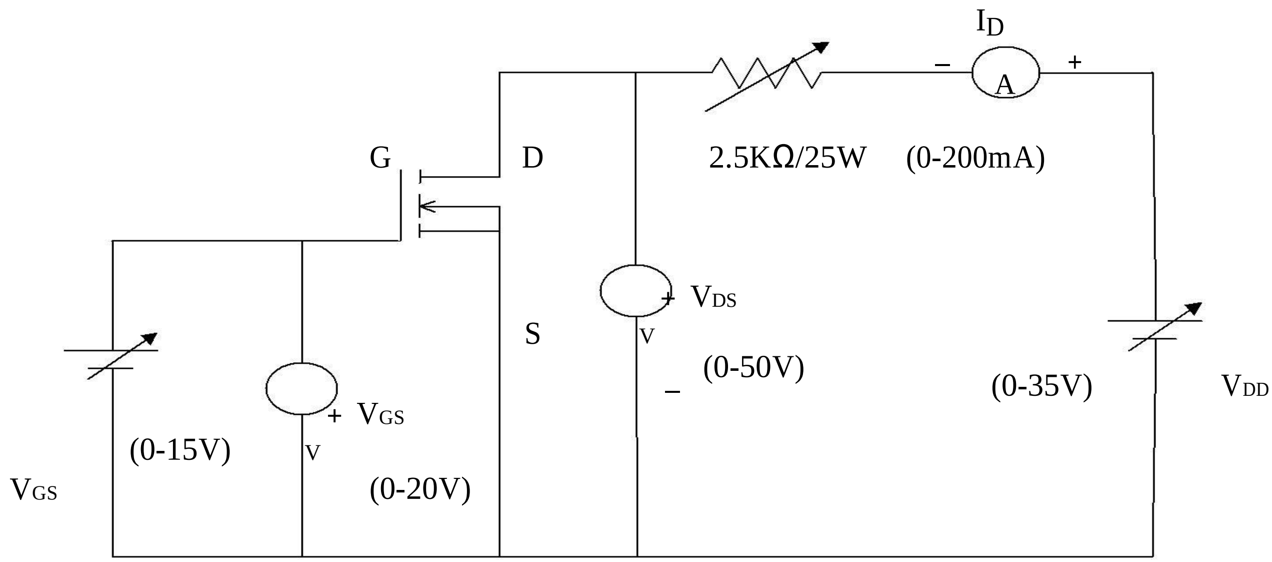
1. Now reverse the polarities of the anode voltage source.
2. Open the switch in the gate circuit.
3. Note down the readings of anode voltage and current by increasing the value of voltage source in the anode circuit.

C) Gate Characteristics:

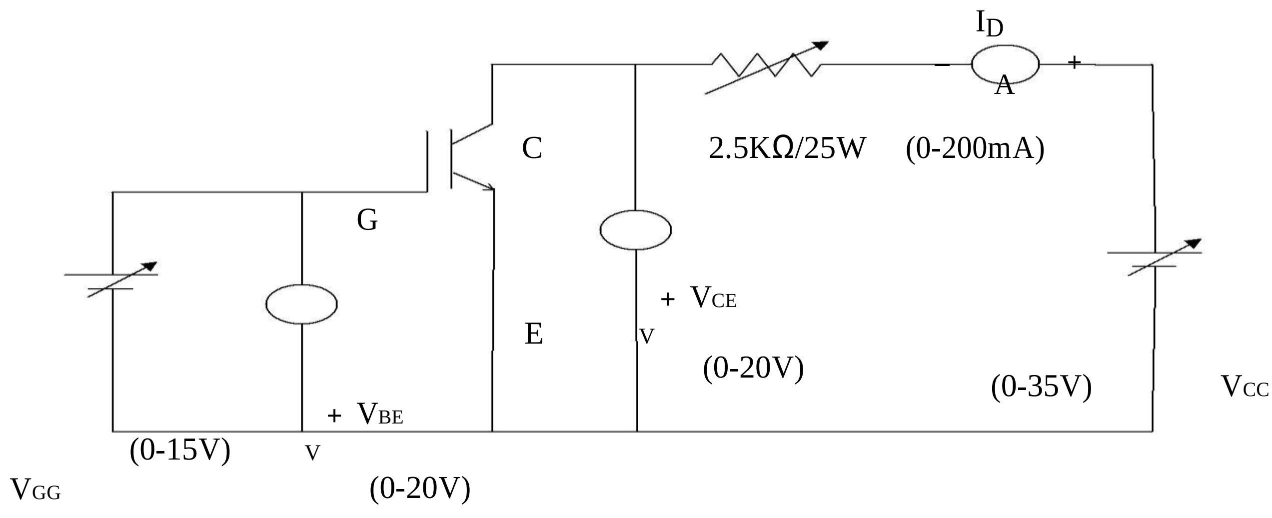
1. Now open the switch in the anode circuit.
2. Set the gate circuit voltage source and anode circuit voltage source as per the given value.

3. Note down the readings of gate voltage and gate current by reducing the value of gate side rheostat

MOSFETCHARACTERISTICS:



IGBT CHARACTERISTICS:



MOSFET CHARACTERISTICS:

A) OUTPUT CHARACTERISTICS:

1. The connections are made as shown in the circuit diagram.
2. Switch on the Supply. Keep V_{DS} say 10V vary V_{GS} note down the range of V_{GS} for which drain current is varying for constant V_{GS}
3. Keep V_{GS} constant (V_{GS} must be within the range determined by step2)
4. Vary V_{DS} in steps ,note down corresponding I_D
5. Step4 is repeated for different V_{GS}
6. Tabulate the readings in the table.
7. Plot a graph of I_D against V_{DS} for different V_{GS}

B) TRANSFER CHARACTERISTICS:

1. The connections are made as shown in the circuit diagram.
2. Switch on the regulated power supplies. Keep V_{DS} constant say 10V. Vary V_{GS} in steps, note down the corresponding I_D
3. Tabulate the readings in the table.
4. Plot a graph of I_D against V_{GS}

IGBT CHARACTERISTICS:

A) OUTPUT CHARACTERISTICS:

1. Connections are made as shown in the circuit diagram
2. Switch on power supply. Keep V_{GE} say 5v, vary V_{GE} note down the range of V_{GE} for which collector current is varying for constant V_{GE}.
3. Keep V_{GE} constant (V_{GE} must be within the range)
4. Vary V_{CE} in steps ,note down corresponding I_C
5. Adjust V_{GE} to constant while doing step4.
6. Step4 is repeated for different V_{GE}.
7. Tabulate the readings in the table.
8. Plot a graph of I_C against V_{CE} for different V_{GE}

B) TRANSFER CHARACTERISTICS:

1. Connections are made as shown in the circuit diagram
2. Switch on the power supply. Keep V_{CE} constant. Vary V_{GE} in steps .note down corresponding I_C
3. Adjust V_{CE} to constant while doing step2.
4. Tabulate the readings in the table.
5. Plot a graph of I_C against V_{GE} for the constant V_{CE}.

TABULAR COLUMN:

SCR CHARACTERISTICS:

A) FORWARD V-I CHARACTERISTICS

S.NO.	I_{G1}= mA		I_{G2}= mA	
	V_{AK}= V	I_A= mA	V_{AK}=V	I_A= mA

B) REVERSE V-I CHARACTERISTICS

S .NO.	V_{AK}= V	I_A= mA

C) GATE CHARACTERISTICS:

S.No.	V_G	I_G

MOSFET CHARACTERISTICS:

A) OUTPUT CHARACTERISTICS

S.NO.	V_{GS1}= V		V_{GS2}= V	
	V_{DS}= V	I_D=mA	V_{DS}= V	I_D=mA

B) TRANSFER CHARACTERISTICS

S.NO.	V_{DS1}= V	
	V_{GS}= V	I_D = mA

IGBT CHARACTERISTICS:

A) OUTPUT CHARACTERISTICS

S.NO.	V_{GE1}= V		V_{GE2}= V	
	V_{BE}= V	I_C= mA	V_{BE}= V	I_C= mA

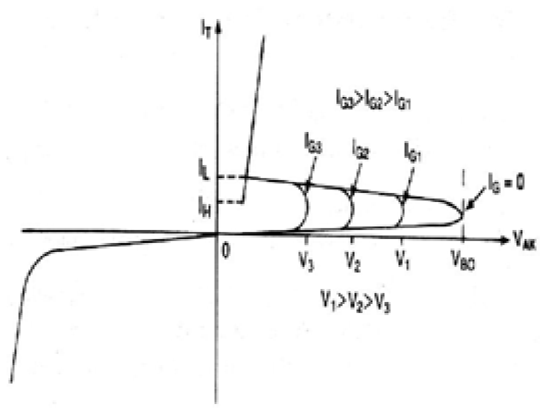
B) TRANSFER CHARACTERISTICS

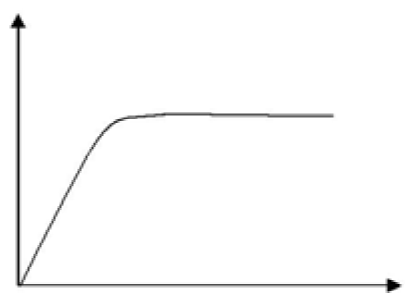
S.NO.	V_{CE}= V	
	V_{GE}=V	I_C = mA

MODEL GRAPHS:

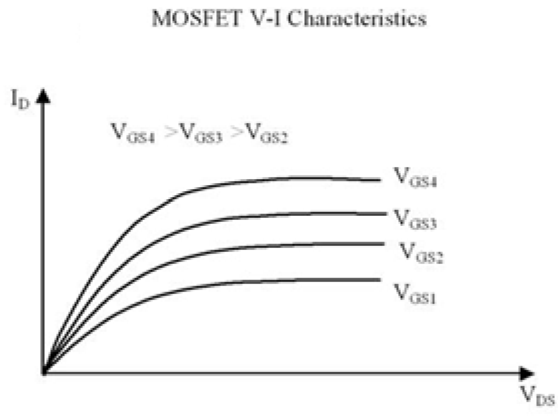
SCR CHARACTERISTICS:

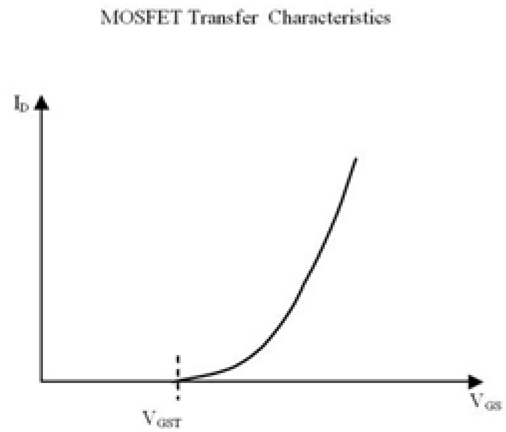
Forward And Reverse Characteristics:Gate characteristics:



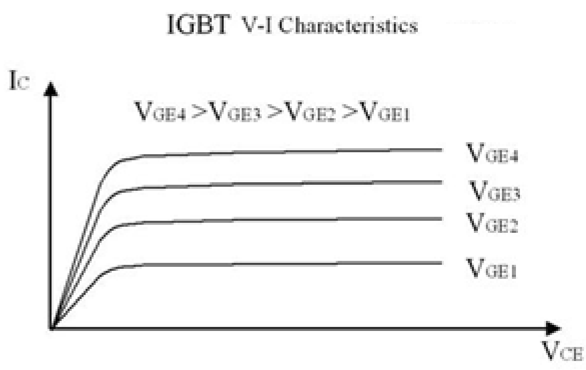


MOSFET CHARACTERISTICS





IGBT CHARACTERISTICS:



RESULT:Output and Transfer Characteristics of SCR, MOSFET and IGBT are studied.

In SCR characteristics anode current increaseswhen values of I_{G1}= mA

In MOSFET transfer characteristics observe the values of V_{DS1}=10v&V_{DS2}=20v.

In MOSFET Drain characteristics observe the values of V_{GS1}=3.5v& V_{GS2}=3.8v.

EXPERIMENT NO 2

GATE FIRING CIRCUITS OF SCR

AIM: To observe the output waveforms of resistance, Resistance- Capacitance and UJT gate firing Circuits of SCR.

APPARATUS:

Sl.No	Apparatus	Type	Range	Quantity
01.	AC Supply source		20V/1A	02
02.	DC Supply source		10V	01
03.	Control Potentiometer		5KΩ	01
04.	Capacitor		6.467µF	01
05.	Load resistor			

THEORY:

R-firing Circuit: Instead of using a gate pulse to triggering the SCR during the +ve half cycle of the voltage source Vs. Thyristor T is in FB but it does not conduct because of insufficient gate current hence load voltage $V_L$is zero.

As voltage Vs increases SCR & diode both are in FB & gate current Ig flows in the circuit when Ig is minimum. The thyristor turned-ON& load voltage follows source voltage and voltage drop across thyristor is equal to on state drop. During the –ve half cycle of Vs SCR is reverse biased the load current is below the holding current and hence SCR is turned OFF V_L is zero and $V_T$follows Vs.As sown in fig the firing angle and the output voltage can be controlled by varying the variable resistance Rv. If Rv is large, then current „I" is small and hence firing angle α increases.

Uni-Junction Transistor firing Circuit: UJT exhibits negative resistance characteristics; it can be used as relaxation oscillator. The external characteristics R_{B1} and R_{B2} are resistances which are small in comparison with internal resistances R_1 and R_2 of the UJT base. The emitter potential V is Varied depending on the charging rate of capacitance C. The charging resistance R_c should be such that the load line intersects the device only in the negative resistance region. η is called as the intrinsic standoff ratio. It is defined as

$$\eta = R_{B1} / (R_{B1} + R_{B2})$$

UJT is a highly efficient switch .It"s switching time is in a range of nano seconds. Since UJT exhibits negative resistance characteristics it can be used as a relaxation oscillator. The rise time output pulse will depend on the switching speed of the UJT and duration will be proportional to the time constant $R_{B1}C$ of the discharge circuit.

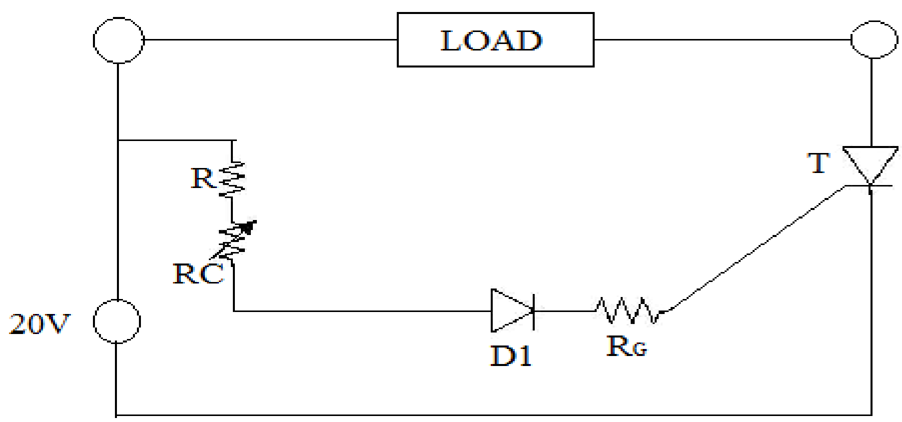
The output pulses of UJT are identical in magnitude and time period

$$T=RC(\ln(1/(1-\eta)))$$

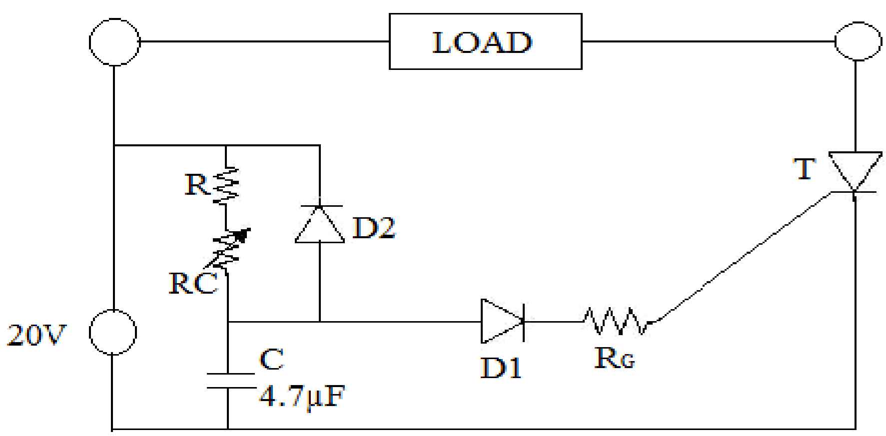
The value of η is specified for each device .For UJT η=0.63.

CIRCUIT DIAGRAM:

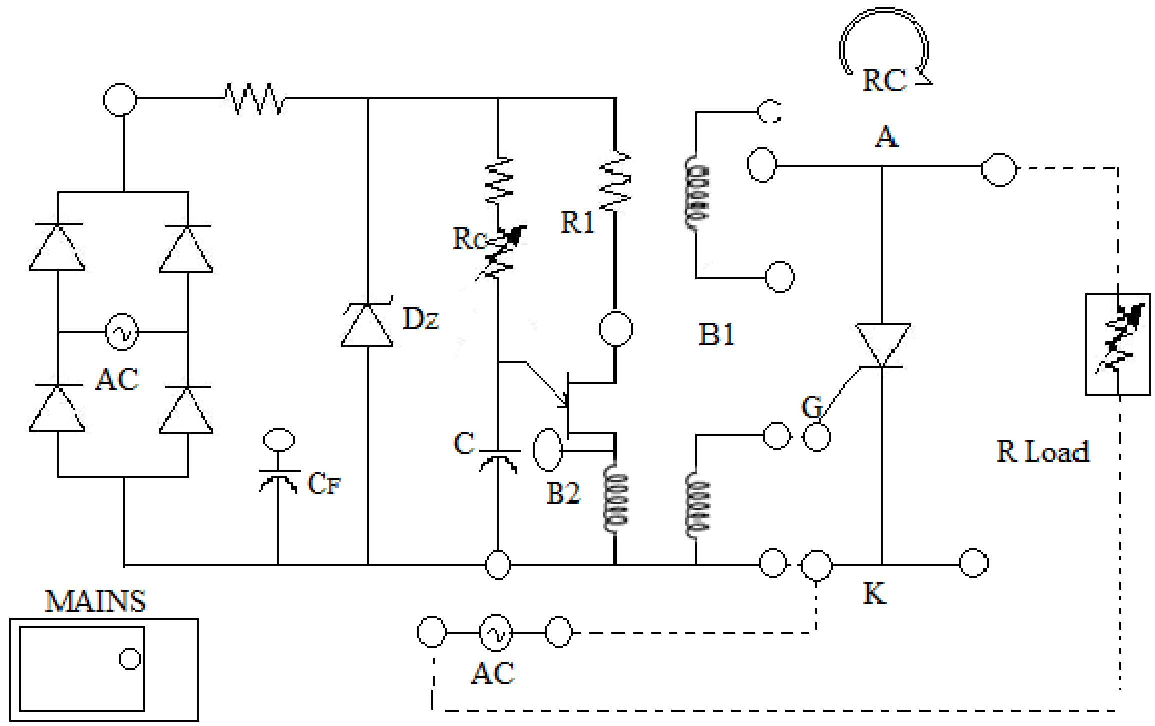
A) R firing circuit:



B) RC-firing circuit:



C)UJT firing circuit:



PROCEDURE:

A) R firing circuit:

1. Turn the potentiometer fully anti clockwise, connect load as shown by jumpers,

2. Connect SCR in the ckt by using shorting links as shown by the dashed lines.

3. Connect the Oscilloscope across the load.

4. Vary the firing angle and observe the waveforms on the CRO

5. Draw the corresponding waveforms.

B) RC-firing circuit:

1. Connect the load and SCR in the CKT by jumpers as shown in the ckt diagram.
2. Tune the potentiometer fully anticlockwise.
3. Connect oscilloscope in the load divider and switch on the power supply.
4. Vary the firing angle and draw the corresponding waveforms.

C) UJT firing circuit:

1. Connect the circuit as shown in figure.

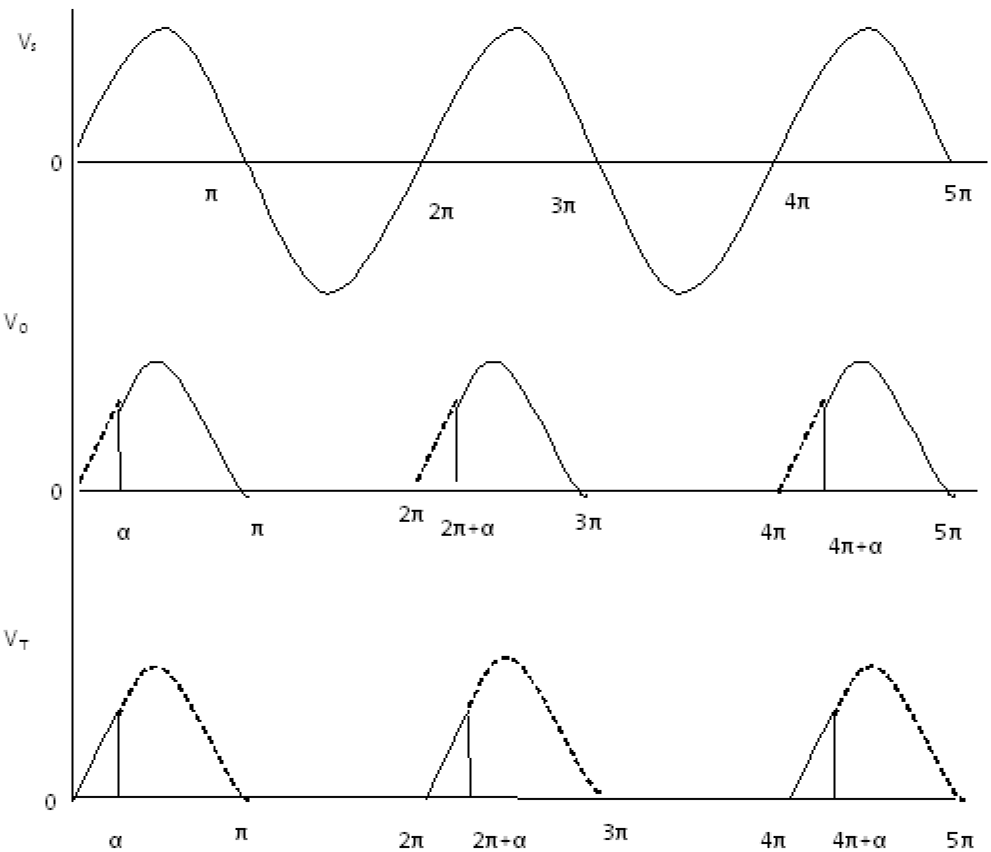
2. Connect a capacitor C_1 in series with variable resistance.

3. Place the knob of variable resistance at either of the extreme positions and place one capacitor in series and take the reading of firing angle at that time period. i.e. total time is equal to the sum of turn off and turn on times.

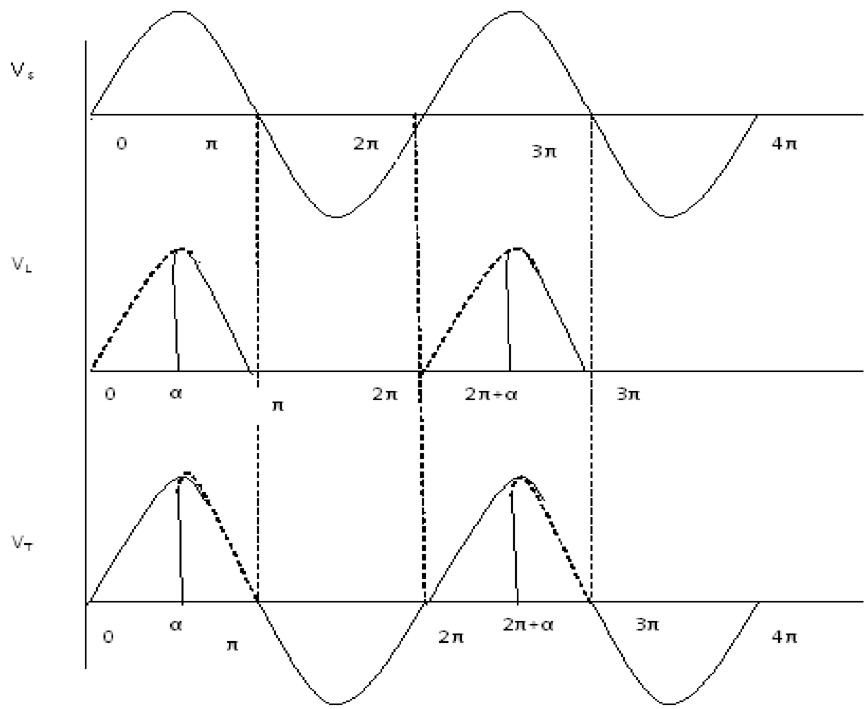
4. Vary the resistance to the other extreme position and note down the readings.

5. Replace the capacitor with another one and calculate the RC from noted reading.

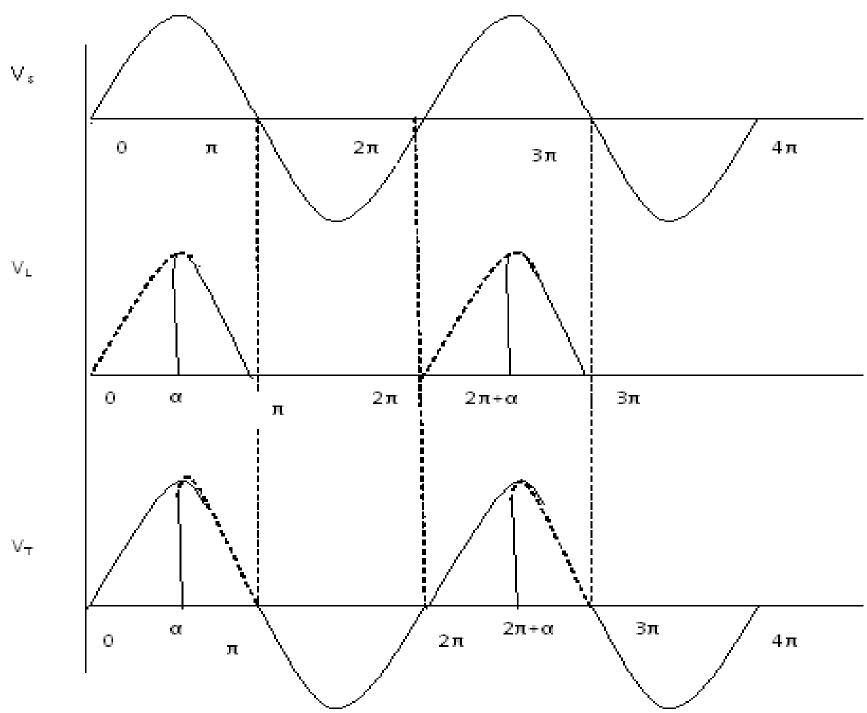
Model Graphs of R firing circuit:



Model Graphs of RC firing circuit:



Model Graphs of UJT firing circuit:



RESULT: The waveforms across the load and device for different values of firing angles arestudied.In UJT firing is varied 15^0 to 180^0.Not possible to vary 0^0 to 180^0 . In R-C firing at 90^0 to 180^0 .

EXPERIMENT NO 3

SINGLE PHASE AC VOLTAGE CONTROLLER WITH R & RL LOADS

AIM: To Verify the operation of single phase AC Voltage controller with R and RL Loads andto observe the output and input waveforms

APPARATUS:

Sl.No	Apparatus	Type	Range	Quantity
01.	Rheostat	Wire wound	50Ω/2A	01
02.	Loading inductor		0-15 mH/2A	01
03.	CRO			01

THEORY:

AC voltage controller"s are thyristor based devices ,which converts the fixed Acvoltage into variable AC voltage with same frequency .The circuit diagram of Single phase AC voltage controller is shown in figure .It consists of two SCR"s connected in anti parallel. The input and output voltage waveforms are also shown. The SCR"s are gate controlled and gate pulses are obtained from firing unit.

A) For R-Load: For the first half cycle of input voltage waveform SCR T1 conducts and givescontrolled output to load. During the other half cycle of input voltage waveform SCR T2 conducts .During the Positive half cycle T1 is triggered at a firing angle of wt= α .T1 starts

conducting and source voltage is applied to the load from α to π. At wt= π both V_o and I_o falls to zero. Just after wt= π, T1 is reverse biased and therefore it is turned off by self commutation. During the negative half cycle of T2 is triggered at wt= π+α, then T2 conducts from wt = π+α

$$V_{o\,rms}=V_{ph}[(\Pi-\alpha)+(1/2)\sin 2\alpha]/\Pi^{1/2}$$

Where V_{orms} is the theoretical RMS value of the output voltage,

V_{ph} is the phase voltage of the input voltage and α is the firing angle.

B) For RL –Load: During the first half cycle wt = 0 to π SCR T1 is forward biased and is triggered at wt=α and output current starts building up through load .At wt=π, load and source voltage are zero. But the output current is not zero because of inductive load. At wt= (β>π), the load current reduces to zero, angle β is called extinction angle. After wt = π, SCR T1 is reverse biased, but does not turn off because the output current is not zero.

At wt=β, only when output current is zero T1 turns off.During the negative half cycle SCR T2 is forward biased and is triggered at wt = π+α. The output current flows through the load in reverse direction. The operation of SCR T2 is similar as that of SCR T1 during the period wt = π+α to wt = (2β-α) but in the negative direction. At wt= (2β-α) the SCR t2 is commutated and the next positive half cycle will be regulated by SCR T1. In this way the AC Voltage controller will be useful for regulating the AC voltage.

$V_{orms}=V_{ph}\,[(\beta-\alpha)+(1/2)(\sin 2\alpha-(1/2)\sin 2\beta)]\,/\,2\pi^{1/2}$

Theoretically the value of Extinction angle calculated by $\beta=(\pi+\varphi)$; Where $\varphi=\tan^{-1}(wL/R)$

CIRCUIT DIAGRAM:

AC VOLTAGE CONTROLLER:

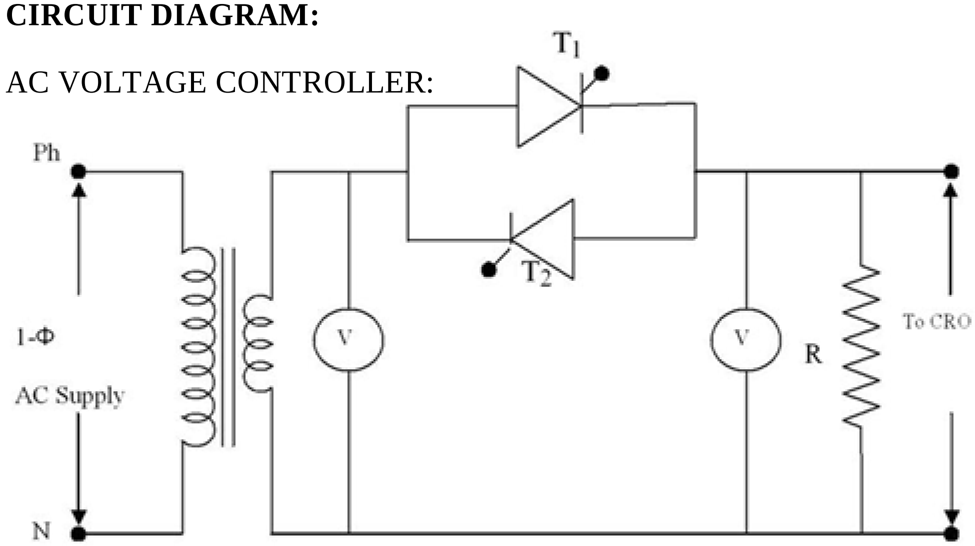


Fig-1 Single Phase AC Voltage controller with R-load

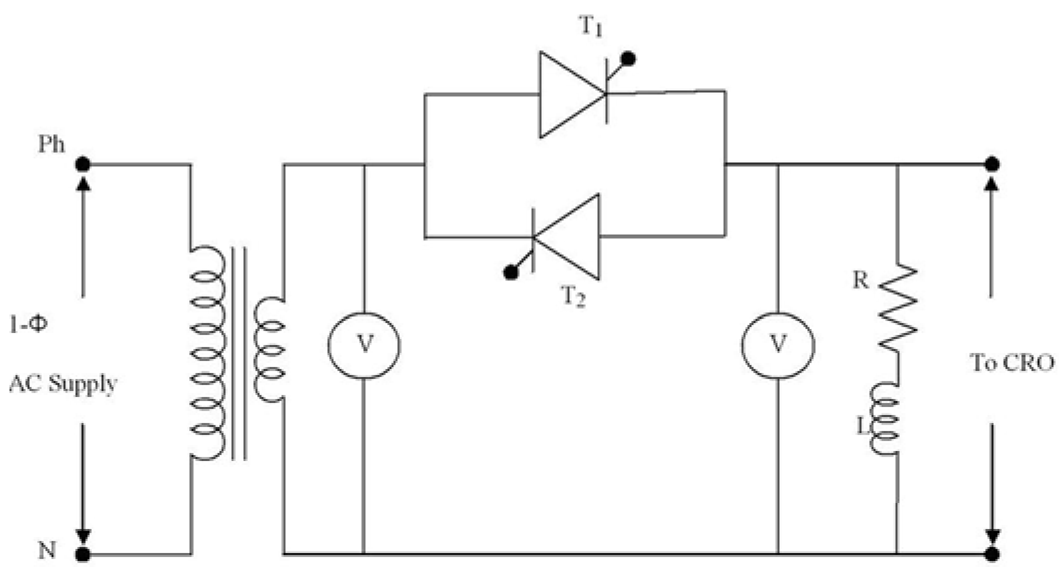


Fig-2 Single Phase AC Voltage controller with RL-load

PROCEDURE:

A) For R-Load:

1. Connect the circuit as shown in figure
2. Verify the connections from the lab instructor before switch on the supply.
3. Keep the rheostat position in safe value of current.
4. Switch ON the CRO and calibrate it with the input voltage.
5. Switch on the power circuit and firing circuit.
6. Observe the output voltage waveform in the CRO.
7. Note down the reading of α from the CRO and V_o from the voltmeter
8. Also calculate the theoretical value of output voltage from the formula and compare it with the practical value of the output voltage, which is observed from the voltmeter.
9. Repeat the above process from step 6 to 8 for various firing angles.

B) For RL-Load:

1.Switch off the power supply and connect an inductance of given value in series with the load resistance.
2. Repeat steps 2 to 9 in this case and also note down the reading of β.

TABULAR COLUMN:

A) For R-Load:

The input voltage V_{ph} = V
Value of load resistance R_L = Ω
CRO calibration: 180^0 = millisec = π radians

S.NO.	Firing angle(α) in ms	Firing angle(α) in degrees	Firing angle(α) in radians	Vo (Practical)	Vo(Theoretical)

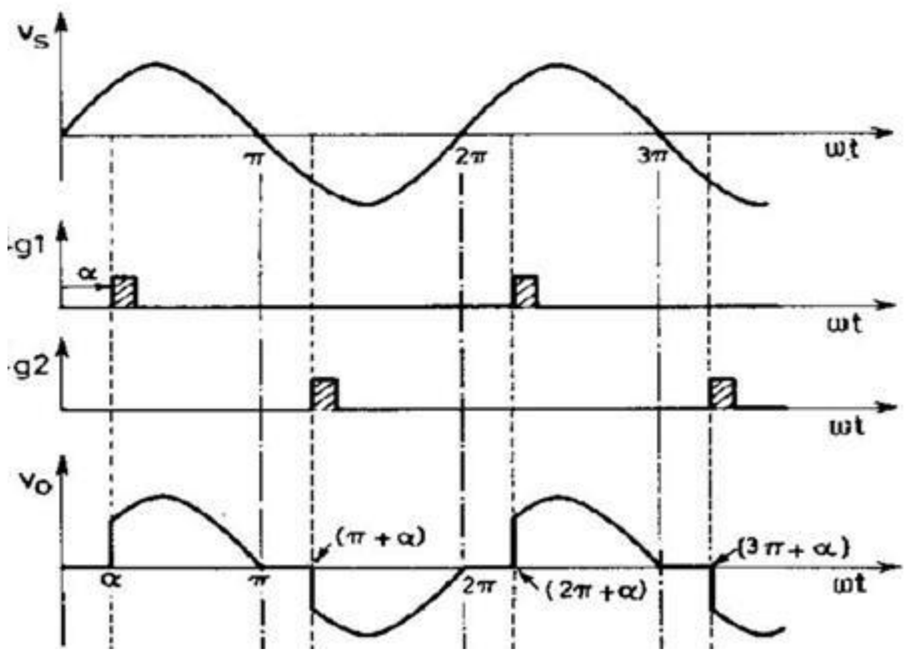
B) For RL-Load:

The input voltage V_{ph} = V
Value of load resistance R_L = Ω
Value of Load inductance L =mH
CRO calibration: 180^0 = millisec = π radians
Theoretical Extinction angle β = (in msec) = (radians) = (degrees)
Practical Extinction angle β = (in msec) = (radians) = (degrees)

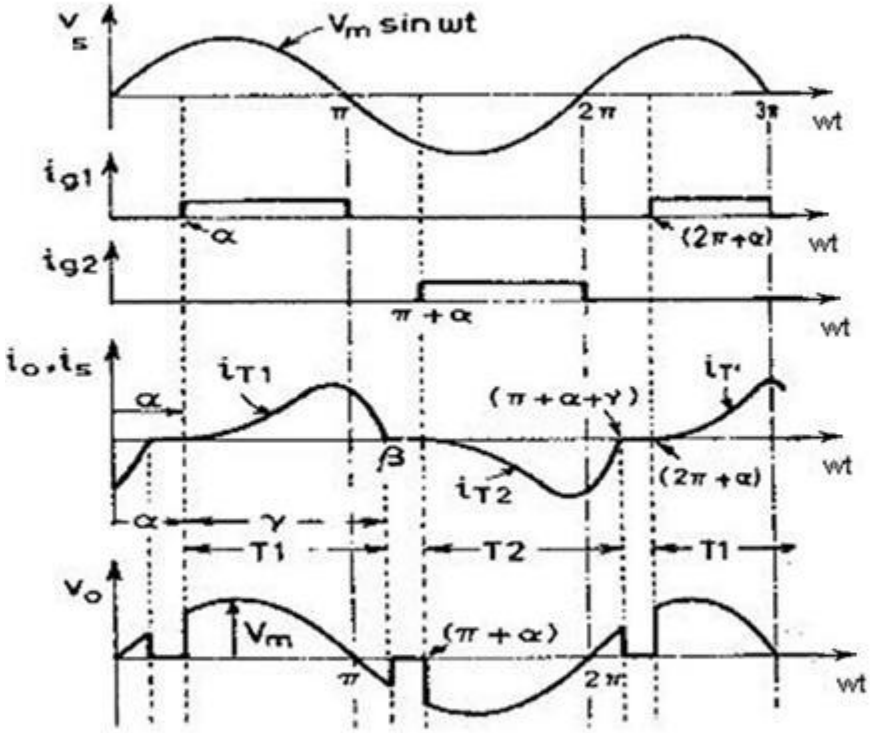
S.NO.	Firing angle(α) in milli seconds	Firing angle(α) in degrees	Firing angle(α) in radians	V_o (Practical)	V_o(Theoritical)

MODEL GRAPHS:

A) R-Load:



B) RL-LOAD



RESULT: The operation of I-φac voltage controller with R&RL loads is verified andthe theoretical and practical values of output voltages with R and RL loads are found.

EXPERIMENT NO 4

SINGLE PHASE FULL CONTROLLED BRIDGE CONVERTER WITH R & RL LOAD

AIM: To obtain controlled output waveforms of a single phase fully controlled bridge converter with R and RL Loads.

APPARATUS:

Sl.No	Apparatus	Type	Range	Quantity
1.	I-φ Transformer		230/24-0-24	1
2.	I-φ fully controlled power circuit with firing unit			1
3.	Voltmeter	MI		1
4.	Voltmeter	MC		1
5.	Rheostat		50Ω/2A	1
6.	Inductive load			1
7.	CRO with (1:10) Probe			1

THEORY:

A) For R-Load:A fully controlled bridge converter using four SCR"s is shown in the circuitdiagram. In the bridge circuit diagonally opposite pair of SCR"s are made to conduct and are commutated simultaneously. During the first positive half cycle SCR"s T1 and T2 are forward biased and they are triggered simultaneously at wt =α then the current flowing through the path A-T1-R-T2-B. During the negative half cycle of the input SCR"s T3 and T4 are forward biased and they are triggered at wt= (π+α) simultaneously then the current flows through B-T3-R-T4-A. Thyristors T1,T2 and T3,T4 are triggered at same firing angle α in each positive and negative half cycle of the input voltage respectively.

When the output voltage falls to zero, the output current also falls to zero because of resistive load .Hence SCR"s T1, T2 in positive half cycle and T3,T4 in negative half cycle turn off by natural commutation.

The related voltage and current wave forms are shown in the diagram.

The theoretical value of the average DC output voltage can be calculated by

$V_{oth}= (V_m/\pi)(1+\cos\alpha)$.

Where V_{oth} is the theoretical value of the output voltage

V_m is the maximum value of the AC input voltage and

α is the firing angle.

B) For RL-Load:

A fully controlled bridge converter using four SCR‟s is shown in the circuit diagram. To conduct the SCR‟s simultaneously firing of SCR‟s T1,T2 in the first half cycle and T3,T4 in the next half cycle is necessary. To ensure this both T1,T2 are fired from the same firing angle.

As shown in the diagram when wt=α, SCR‟s T1, T2 are triggered simultaneously. The current flow through A-T1-R-L-T2-B.Supply voltage from this instant appears across output terminals and forces the current through load. At wt=π,the output voltage tends to reverse its direction where as the output current tries to flows on the same direction because of inductive load. The output current becomes zero at a angle of wt=β.

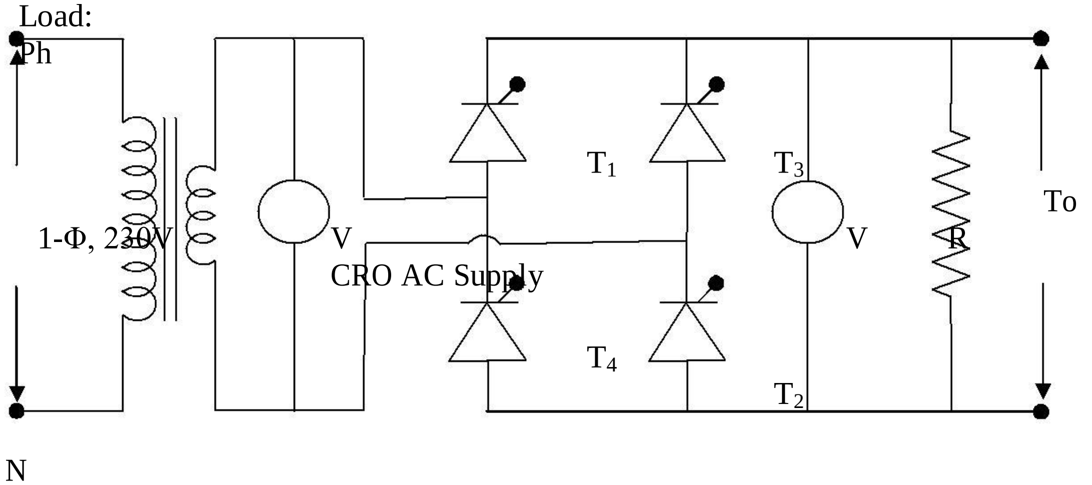
At an angle wt=(π+α) SCR‟s T_3 ,T_4 are triggered, with this negative line voltage reverse biases SCR‟s T1 and T2 hence the SCR‟s T1 and T2 are commutated.Now the current flows through the path B-T3-R-L-T4-A.This continue in every half cycle and we get output voltage as shown in waveforms.

The theoretical value of the average DC output voltage can be calculated by

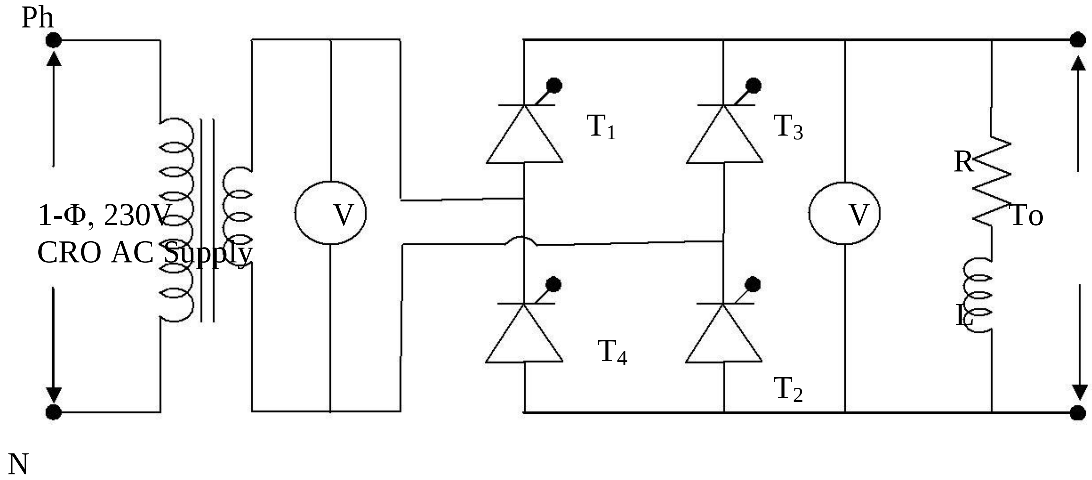
$V_{OTH}=(2V_m/\prod)(\cos\alpha - \cos\beta)$

CIRCUIT DIAGRAM:

With R-Load:



With RL-Load:



PROCEDURE:

A) For R-Load:

1. Connect the circuit as shown in figure.
2. Verify the connections from the lab instructor before switch on the supply.
3. Keep the rheostat position value given by the lab instructor
4. Switch ON the CRO and calibrate it with the input voltage.
5. Switch on the power circuit and firing circuit.
6. Observe the output voltage waveform in the CRO.
7. Note down the reading of α from the CRO and V_o from the voltmeter
8. Also calculate the theoretical value of output voltage from the formula and compare it with the practical value of the output voltage, which is observed from the voltmeter.
9. Repeat the above process from step 6 to 8 for various firing angles.

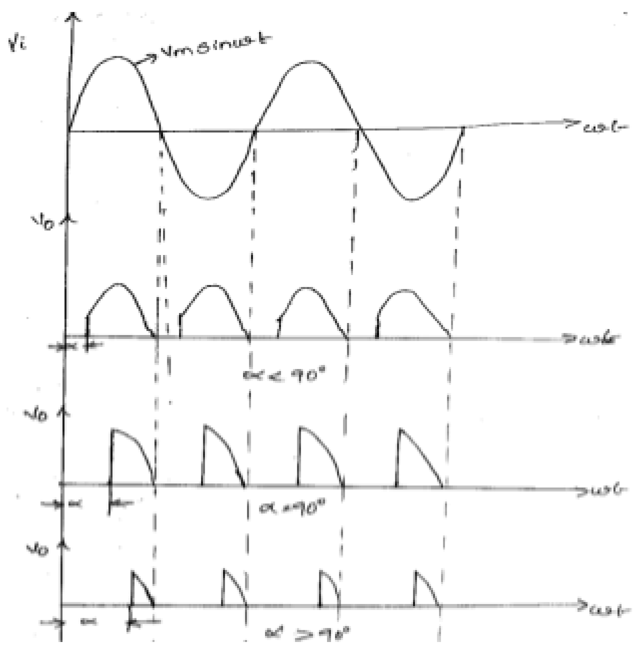
B). For RL-Load:

1. Switch off the power supply and connect an inductance of given value in series with the load resistance.

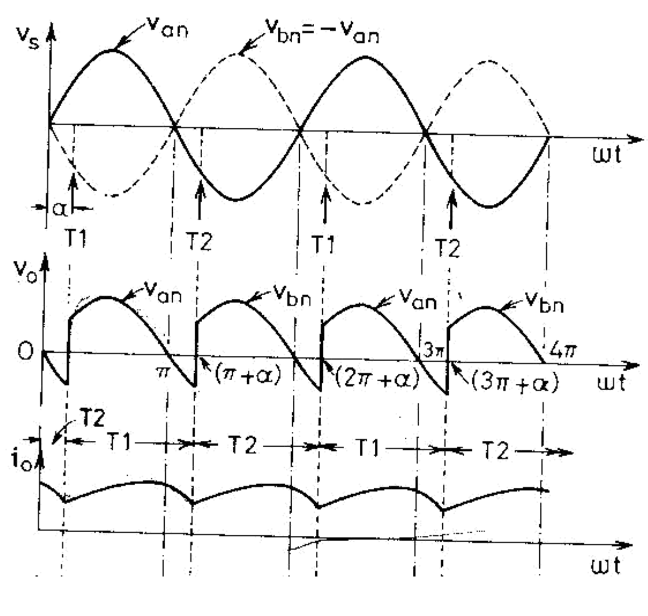
2. Repeat steps 2 to 9 in this case and also note down the reading of β.

MODEL GRAPHS:

With R-Load:



With RL-Load:



TABULAR COLUMN:

A) For R-Load:

The input voltage V_{ph} = V (As given by the instructor)

Value of load resistance R_L= Ω(As given by the instructor)

CRO calibration: 180 degrees = msec = π radians

S.NO.	Firing angle(α) in milli seconds	Firing angle(α) in degrees	Firing angle(α) in radians	V_o (Practical)	V_o (Theoritical)

B)For RL Load:

The input voltage V_{ph} = V (As given by the instructor)

Value of load resistance R_L= Ω (As given by the instructor)

S.NO.	Firing angle(α) in milli seconds	Firing angle(α) in degrees	Firing angle(α) in radians	V_o (Practical)	V_o (Theoritical)

RESULT: The operation of I-φfully controller converter is verified and the theoretica land practical values of output voltages are found, both for R and RL loads at different firing angles.

EXPERIMENT NO 5
Forced Commutation circuits
(Class A, Class B, Class C, Class D & Class E)

AIM:
To study the module and waveforms of forced commutation circuits

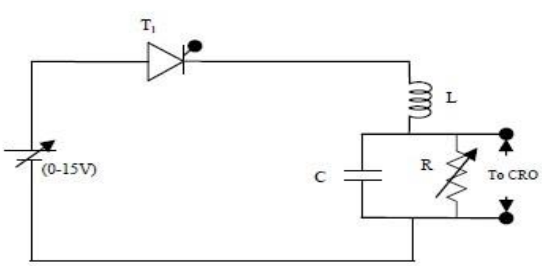
1. Class A commutation – Self commutation by resonating load
2. Class B commutation – self commutation by LC circuit
3. Class C commutation – Complementary SCR commutation.
4. Class D commutation – Auxiliary commutation.
5. Class E commutation – External source of pulse commutation.

APPARATUS REQUIRED:

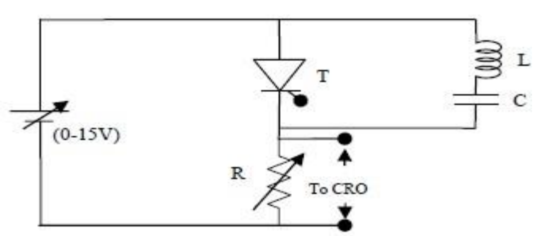
1. Forced commutation unit.
2. Loading Rheostat : 100 Ohms, 2A.
3. Regulated power supply : 0-30VDC, 2A.
4. 20 MHz dual trace oscilloscope with 1:1 probes.

CIRCUIT DIAGRAM:

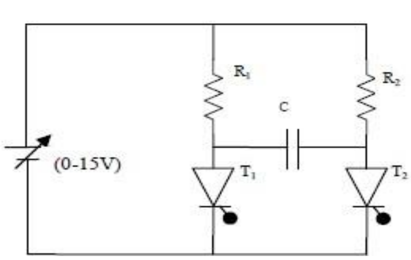
CLASS-A COMMUTATION:



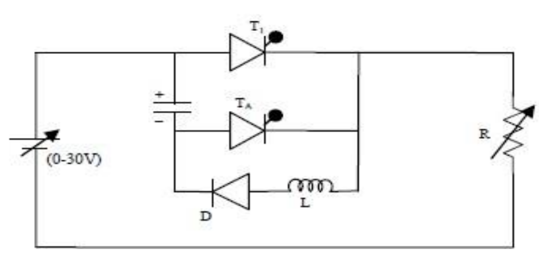
CLASS-B COMMUTATION:



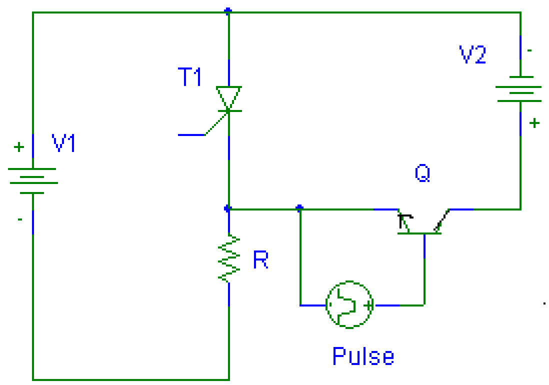
CLASS-C COMMUTATION:



CLASS-D COMMUTATION:



Class E Commutation Circuit



PROCEDURE:

1. Switch ON the mains supply to the firing circuit. Observe the trigger outputs in the firing circuit by varying frequency potentiometer and duty cycle potentiometer. Make sure the firing pulses are proper before connecting to the power circuit.
2. Check the DC power supply between the DC input points.
3. Check the resistance between anode and cathode of all SCRs.
4. Check the resistance between the Gate and cathode of SCRs.
5. Check the diode and Transistor and their polarities.
6. Check the fuse in series with the DC input.
7. Make sure that all the components are good and firing pulses are correct before starting the experiment.

For class A&B:

1. Make the connections as per the circuit diagram.
2. Connect the trigger output T1 from the firing circuit to the Gate and cathode of SCR T1.
3. Switch ON the DC supply to the power circuit.
4. Observe the voltage waveform across load using oscilloscope by varying the frequency potentiometer.
5. Duty cycle potentiometer is of no use in this experiment.
6. Repeat the same for different values of R, L and C.
7. Draw the waveforms in the Graph for different R, L and C.

For class C:

1. Make the connections as per the circuit diagram.
2. Connect the trigger output T1 &T2 from the firing circuit to the Gate and cathode of SCR T1 &T2.
3. Switch ON the DC supply and switch ON the trigger pulses by operating ON/OFF switch in the firing circuit.
4. Observe the voltage waveform across R1, R2 and C using oscilloscope by varying the frequency and duty cycle potentiometers.
5. Repeat the same for different values of R & C.

6. L is of no use in this circuit.
7. Draw the waveforms in the graph for different R & C.

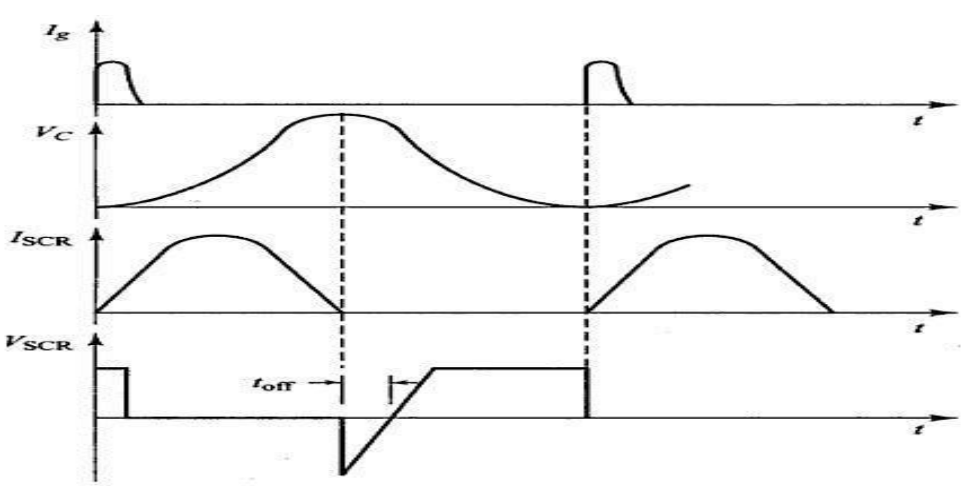
For Class D:

1. Make the connections as per the circuit diagram.
2. Connect the trigger outputs T1 and T2 from the firing circuit to gate and cathode of SCRs T1 & T2.
3. Initially keep the trigger ON/OFF switch at OFF position to charge the capacitor. This can be observed by connecting CRO across the capacitor.
4. Switch ON the DC supply and switch ON the trigger pulses by operating ON/OFF switch in the firing circuit.
5. Observe and note down the voltage waveform across the load. T1, T2 and C using oscilloscope by varying the frequency and duty cycle potentiometers.
6. Repeat the same for different values of load. L & C.

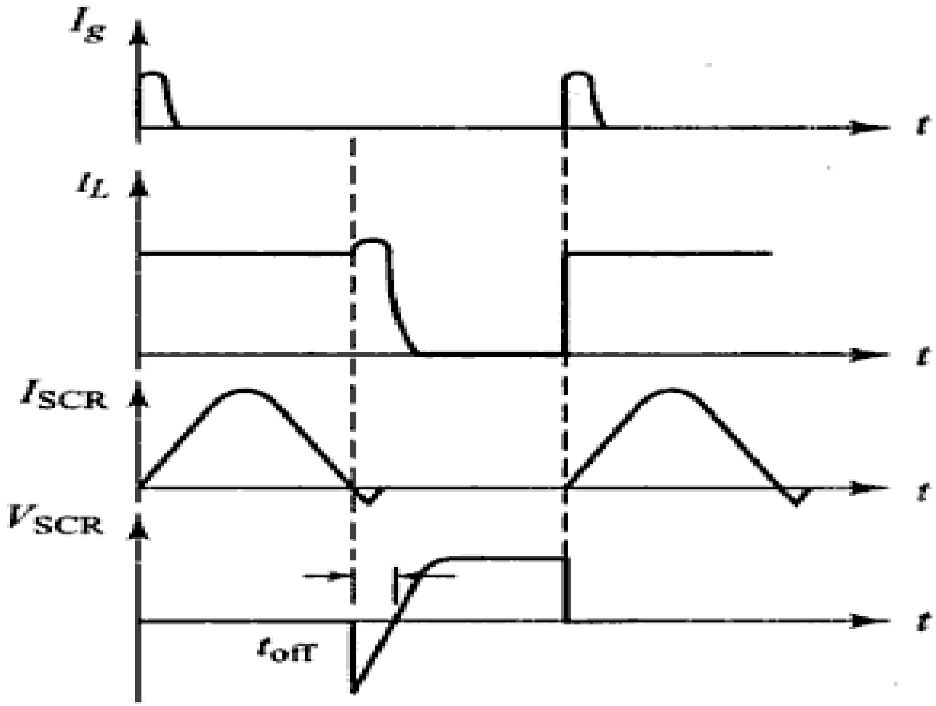
For Class E:

1. Make the connections as per the circuit diagram.
2. Connect V2 supply from an external DC power supply unit.
3. Connect the trigger output T1 from the firing circuit to gate and cathode of SCR T1.
4. Connect T2 to the transistor base and emitter points.
5. Switch ON the DC supply, external DC supply and the trigger pulses by operating ON/OFF switch in the firing circuit.
6. Observe and note down the voltage waveform across the load.
7. Repeat the same by varying the frequency and duty cycle potentiometers.
8. Draw the waveforms in the graph for different frequency and duty cycle.

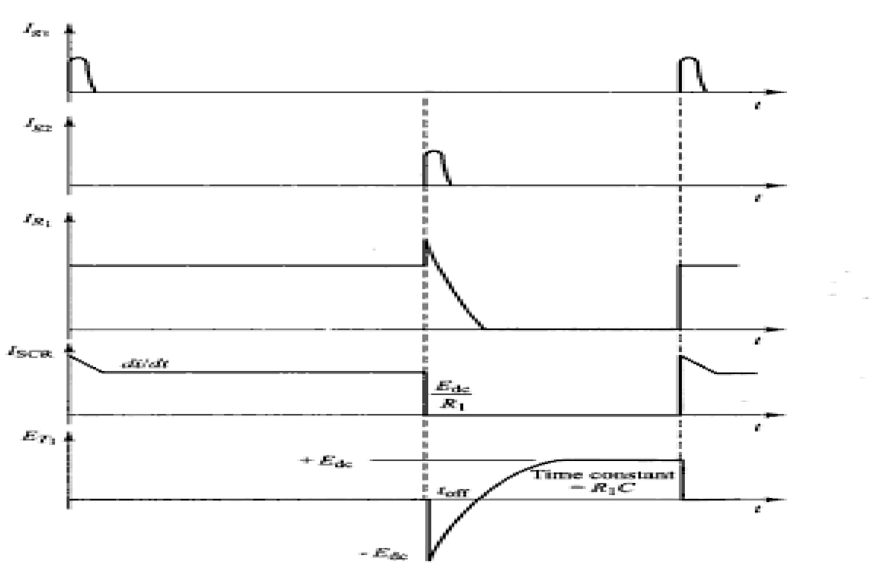
CLASS A COMMUTATION:



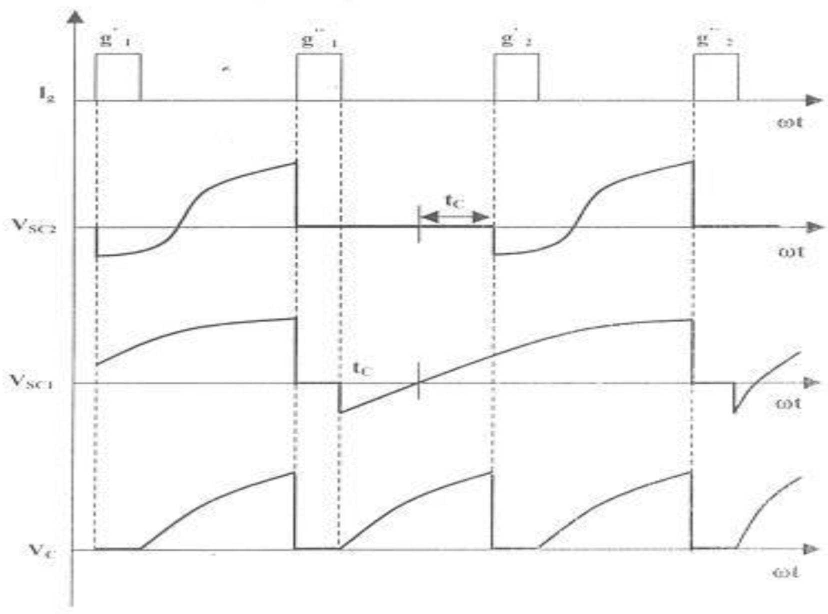
CLASS-B COMMUTATION:



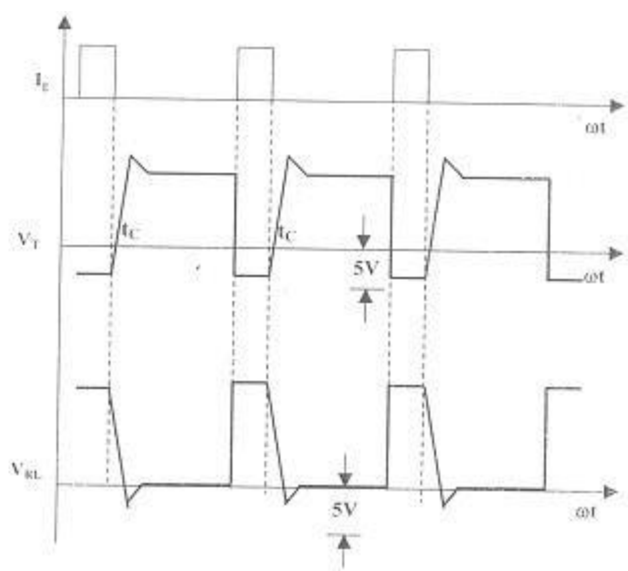
CLASS-C COMMUTATION:



CLASS D COMMUTATION WAVEFORMS:



CLASS-E COMMUTATION:



RESULT: The different types of commutation circuits have been studied.

EXPERIMENT NO 6
DC JONES CHOPPER WITH R& RL LOADS

AIM: To obtain the output waveform of single phase fully controlled bridge converter With R and RL Loads.

APPARATUS:

Sl.No	Apparatus	Type	Range	Quantity
01.	DC Chopper firing circuit			
02.	DC Chopper power circuit		30V/2A	01
03.	Rheostat	Wire wound	50Ω/2A	01
04.	Loading Inductor		0.150mH/2A	01
05.	CRO			01

THEORY:

The Jones Chopper circuit is another example of class D commutation. In this circuit SCR TM is the main thyristor, where as SCR TA, capacitor C, diode D1 and auto transformer forms the commutating circuit for the main thyristor TM. Therefore the special feature of this circuit is the tapped auto T/F through a portion of which the load current flows L1 and L2 are closely coupled so that the capacitor always gets sufficient energy to turn off the main SCR TM.

Let us assume that initially capacitor C is charged to a voltage Edc with the polarity shown SCR TM is triggered current flows through the path CA-TM-L1-D1-CB and capacitor C charges to opposite polarity i.e., plate B positive and plate A negative, however diode D1 prevents further oscillation of the resonating L2C circuit. Hence capacitor C retains its charge until SCR TA is triggered. Now, SCR TA is triggered current flows through the path CB-TA-TM-CA. Therefore, discharge of capacitor C reverse biases SCR TM and turns it off. The capacitor again charges up with plate a positive and SCR TA turns off because the current through it falls below the holding current value when capacitor C is recharged.

The cycle repeats when SCR TM is again triggered. The use of autotransformer involves that whenever current is delivered from dc source to the load, a voltage is induced in L1 in the correct polarity for changing the commutating capacitor to a voltage higher than Edc. Thus the autotransformer measurably enhances the reliability of the circuit.

The theoretical average value of the Dc output voltage can be found from

$$V_{ODC} = \delta \, (V_{1DC})$$

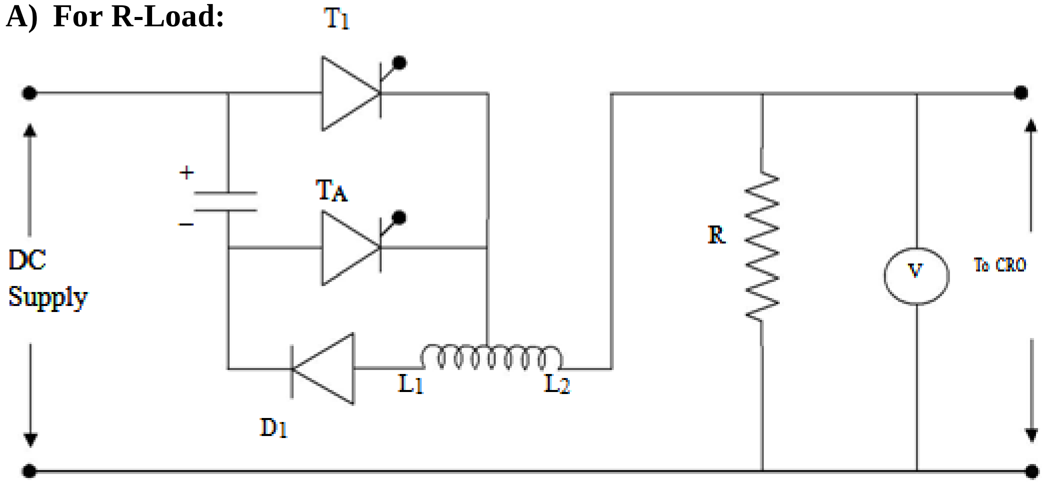
Where V_{ODC} is the average value of the DC output voltage

δ is the duty cycle and

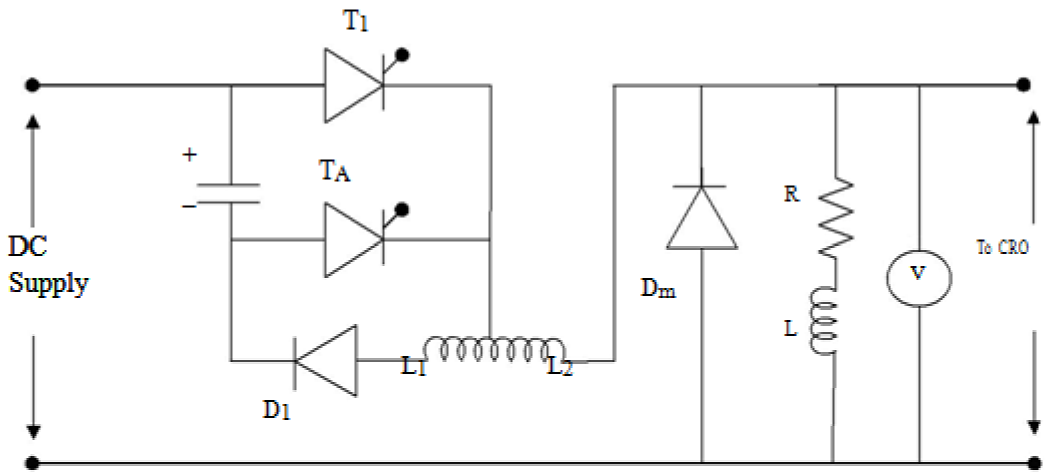
V_{1DC} is the average value of the DC input voltage

CIRCUIT DIAGRAMS:

A) For R-Load:



B) For RL-Load:



PROCEDURE:

A) R LOAD:

1. Set the rheostat for given value, before connecting in the circuit.
2. Make the connections as per the circuit diagram.
3. Switch on the supply and set the input voltage to the given value.
4. For a particular firing angle note down the readings of ON time (Ton), OFF time (Toff), Total time (T) from the CRO and the practical value of the output voltage from the voltmeter.
5. Calculate the theoretical value of the output voltage from the data Ton, T and input voltage.
6. Repeat the step 4 and 5 for a set of different duty cycle.

B) RL-LOAD:

1. Now connect an inductance of given value and repeat the steps 3 to 6.

2. Repeat the step 4 and 5 for a set of different duty cycle.

OBSERVATIONS:

A) R LOAD:

Value of input voltage V = V
Value of load resistance R_L = Ω

S.No:	Ton(ms)	Toff(ms)	Total Time(ms)	Duty cycle	Vo(practical)	Vo(Theoretical)

B) RL-LOAD:

Value of input voltage V = V
Value of load resistance R_L = Ω
Value of load inductance =mH

S.No:	Ton(ms)	Toff(ms)	Total Time(ms)	Duty cycle	Vo(practical)	Vo(Theoretical)

RESULT: The operation of DC Jones"s Chopper is verified and the theoretical and practical values of output voltage are found, both for R and RL loads.

EXPERIMENT NO 7

SINGLE PHASE PARALLEL INVERTER WITH R AND RL LOAD

AIM: To study the characteristics of single phase parallel inverter.

APPARATUS:

Sl.No	Apparatus	Type	Range	Quantity
01	Rheostat	Wire wound	50Ω/2A	01
02	D.C Regulated power supply		30V/2A	01
03	C.R.O		20MHz	01

THEORY:

The circuit is a typical class C Parallel inverter.

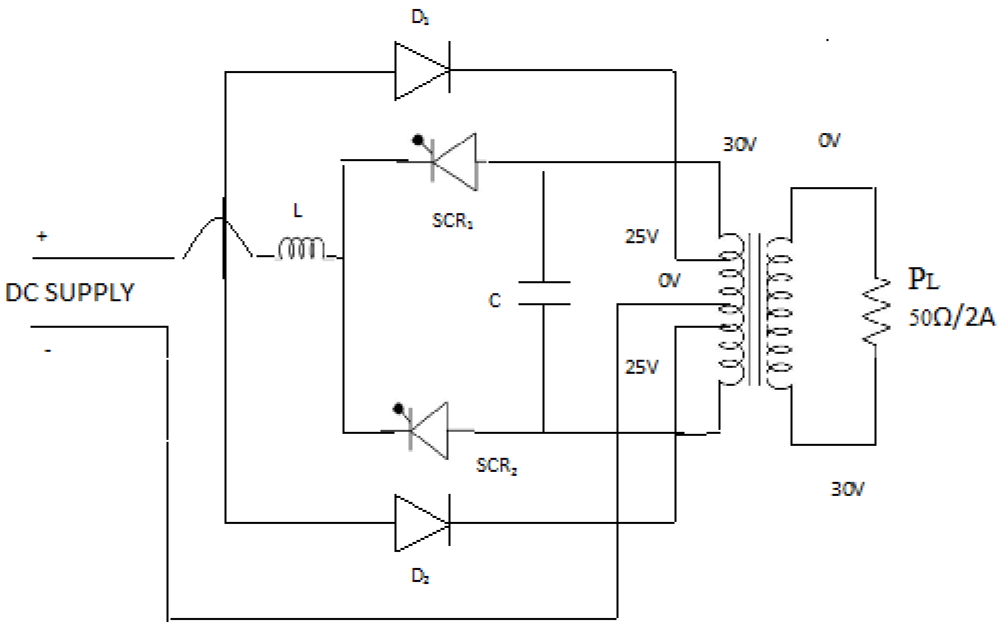
Assume T_N to be ON and T_p to be OFF. The bottom of the commutation capacitor is charged to twice the supply voltage and remains at this value until T_p is turned ON.When$T_{p,}$ is turned ON, the current flows through lower half of the primary, $T_p$and commutating inductance L.

Since voltage across C cannot change instantaneously, the common SCR cathode point rises approximately to $2V_{dc}$ and reverse biased T_N .Thus T_N turns OFF and C discharges through L, the supply circuit and then recharges in the reverse direction. The autotransformer action makes C to charge making now its upper point to reach $+2V_{dc}$ Volts ready to commutate T_p when T_N is again turned ON and the cycle repeats.

The major purpose of commutating inductor –L is to limit commutating capacitor charging current during switching.

Freewheeling diodes D_p and D_N assist the inverter in handling a wide range of loads and the value of C may be reduced since the capacitor now does not have to carry the reactive current. To dampen the feedback diode currents within the half period, feedback diodes are connected to tapping"s of the transformer at 25V tapping.

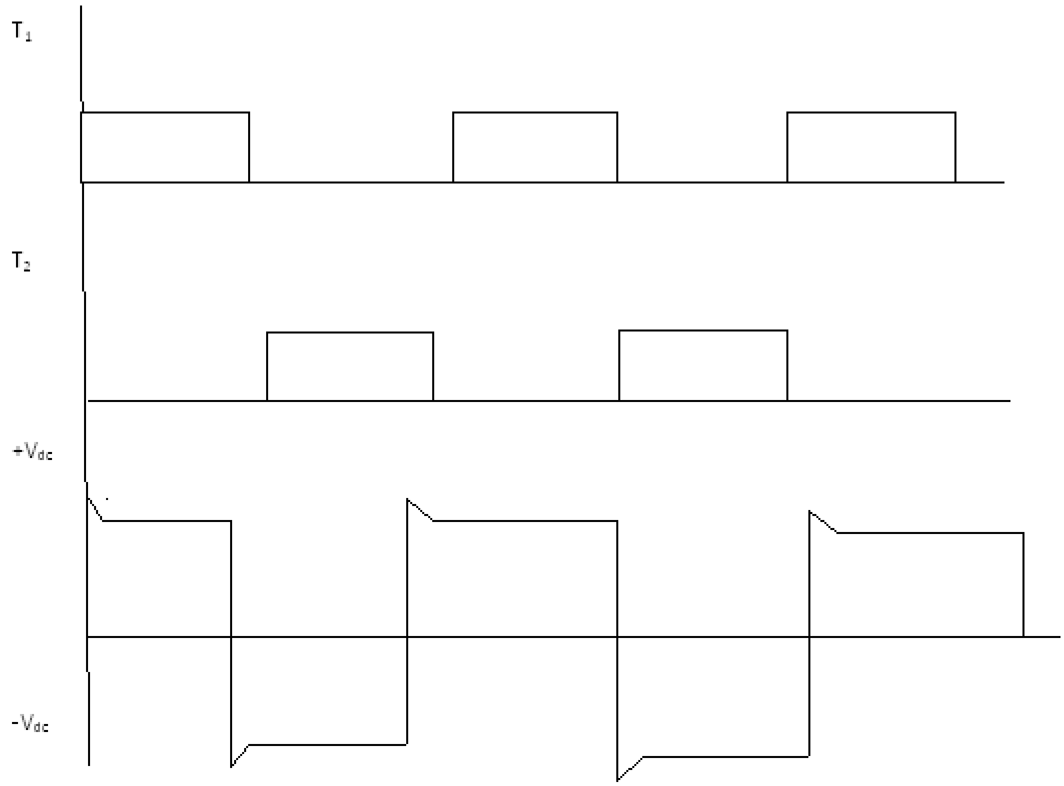
CIRCUIT DIAGRAM:



PROCEDURE:

1. Switch ON the firing circuit. Observe the trigger output T_P and T_N by varying frequency potentiometer and by operating ON/OFF switch.
2. Then connect input DC supply to the power circuit from DC Regulated power supply (30V/2A)
3. Connect trigger outputs to Gate and Cathode of SCR T_P and T_N.
4. Make the interconnections as shown in circuit diagram.
5. Connect load between load terminals (50ohms/2A)
6. Connect freewheeling diodes in the circuit.
7. To begin with set input voltage to 15V.Apply trigger pulses to SCR and observe voltage waveforms across load.
8. Output voltage is square wave only. Then remove freewheeling diode connections and observe the waveforms.
9. Then vary the load, vary the frequency and observe waveforms. To switch OFF the inverter switch OFF DC supply only. Switch OFF the trigger pulses will lead to short circuit.
10. Since the parallel inverter works on forced commutation. There is a chance of commutation failure.
11. If the commutation fails, there is a dead short circuit in the input DC supply, which will leads to the blown off the input fuse. Please check the fuse if the commutation fails .Preferably connect the input DC supply from the 30V/2A regulated DC power supply unit which has over current tripping facility thereby protect the DC supply unit.
12. If the commutation fails, switch off the DC supply first and then trigger Outputs. Check the connections again.

MODEL GRAPHS:



RESULT: Hence we obtained the characteristics of single phase parallel inverter. In R-Load the approximate voltage at 4to 4.5v.The R-L load approximate voltage is1.4 to 1.8v.

EXPERIMENT N0 8
SINGLE PHASE CYCLO CONVERTER WITH R & RL LOADS

AIM: To verify the operation of single phase Cycloconverter with R and RL Loads and to observe the output and input waveforms.

APPARATUS:

S.No	Apparatus	Type	Range	Quantity
1.	I-φ Center tapped Transformer		230V/(24-0-24)	1
2.	I-φCycloconverter power circuit with firing unit			1
3.	Rheostat			1
4.	Inductive load			1
5.	Voltmeter	MI		1
7.	CRO with (1:10) Probe			1
8.	Patch cards			1 set

THEORY:

The circuit diagram of 1-φ cyclo converter with R and RL load are shown in fig

Constructional there are four SCR"s T_1, T_2, T_3&T_4.Out of them T_1, T_2 are responsible for generating positive halves forming the positive group. The other two T_3, T_4 are responsible for negative haves forming negative group. This configuration and waveforms are shown for ½ and 1/3 of the supply frequency. Natural commutation process is used to turn off the SCR"s.

A)For R-Load: During the half cycle when point A is positive with respect to O, SCR T_1isin conducting mode and is triggered at wt =α then current flows through positive point A-T_1-load-negative O. In the negative half cycle when B point is positive with respect to the point O,SCR T_1 is automatically turned off due to natural commutation and SCR T_2 is triggered at wt = π+α. In this condition the current flows through B-T_2-load-O. The flow ofthe current direction is same as in the first case. After two positive half cycles of load voltage and load current SCR T_4 is gated at wt=2π+α when O is positive with respect to B. In this condition the load current flows through O-load-T_4-B. Thus the direction of load current is reversed. In the next half cycle when O is positive with respect to A when wt=3π, T_4 turnoff due to natural commutation and at wt=3π+α T_3 is triggered.

In this condition the load current flows through O-load-T_3-A. The direction of load current is same as previous case. In this manner two negative half cycles of load voltage and load current, equal to

the number of two positive half cycles are generated. Now T_1 is again triggered to fabricate further two positive half cycles of load voltage and so on. Like this the input frequency 50Hz is reduced to ½ at the output across the load. The input and output waveforms are shown in figure.

The frequency of the output voltage can be calculated by:

$$\text{Frequency } (f_o) = (\text{Time period})^{-1}$$

B) For RL-Load:

When A is positive with respect to O forward biased SCR T_1 is triggered at wt=α and the current start to flow through A-T_1-R-L-O. Load voltage becomes zero at wt=π but load current will not become zero at this angle due to inductance. It becomes zero at wt =β which is called extinction angle. So it is naturally commutated at wt=β.

After half cycle point B positive with respect to point O. Now at angle wt=π+α. T_2 is triggered and the load current takes path from B-T_2-R-L_o and its direction is positive as in the previous case. The load current decays zero at wt =π+β and SCR T_2 is naturally commutated.

In the half cycle when O is positive with respect to B point, T_4 is triggered instead of T_1 at an angle of wt= (2π+α). Now the load current flows through O-L-R-T_4-B but the direction of load current reversed. When the load current becomes zero at an angle wt= (2π+α) , T_4 naturally commutated because the voltage is already reversed at wt = 3π.When wt = (3π+α) and point O, is positive with respect to point A,T_3 is triggered then the current flows through O-L-R-T_3-A , and the direction of load current is same in previous case. In the next half cycle again T_1 will triggered like this we get one cycle of output frequency for two cycles of input frequency, when the frequency division switch is at 2. The waveforms of load voltage and load current are shown in fig.

The frequency of load voltage can be calculated by $f_o = (\text{Time period})^{-1}$

CIRCUIT DIAGRAMS:

A) For R-Load:

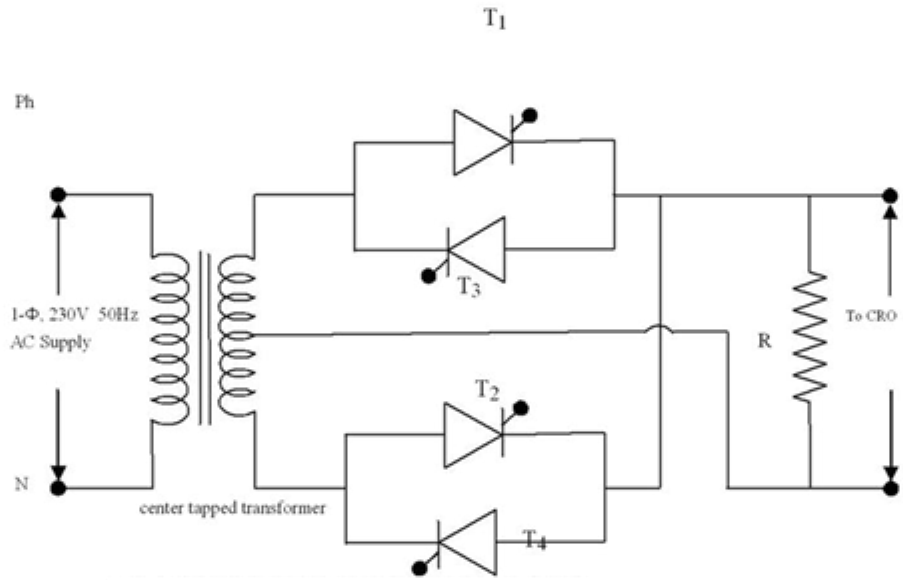


Fig1-Single phase cyclo converter with R-load

B) For RL-Load:

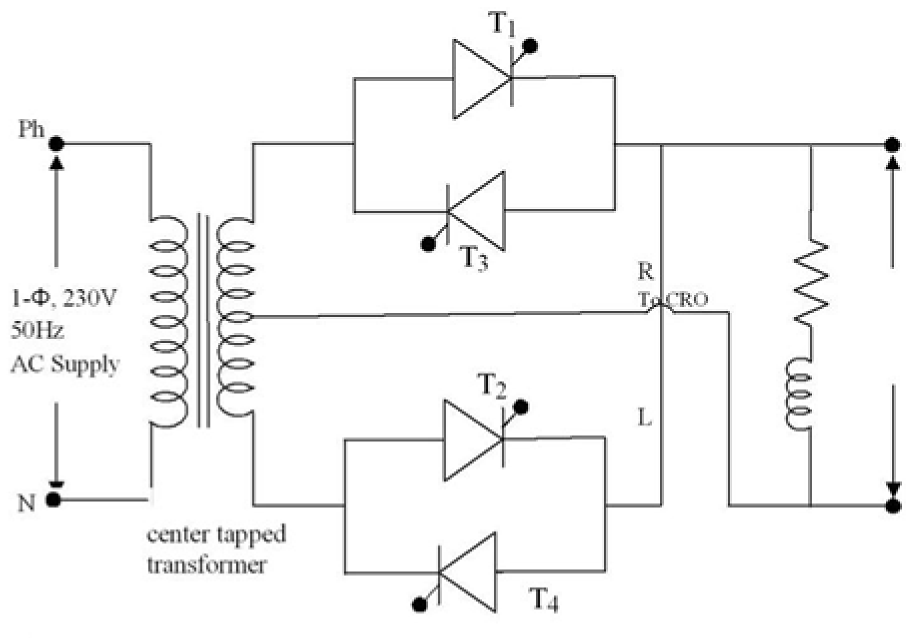


Fig2-Single phase cyclo converter with RL-load

PROCEDURE:

A)For R-Load:

1. Connect the circuit as shown in figure.1
2. Verify the connections from the lab instructor before switch on the supply.
3. Keep the rheostat position value given by the lab instructor
4. Switch ON the supply and note down the frequency of input voltage from the CRO.
5. Set the frequency division switch at 2 and note the readings of time period of output voltage waveform for different set of firing angles
6. Calculate the practical value of output frequency by reciprocating the value of time period and theoretical value of frequency will be found from frequency division setting
7. Repeat the above process from step 5 to 6 for frequency division of 3 and 4.

B)For RL-Load:

1. Connect the circuit as shown in figure.
2. Connect an inductance of given value in series with the load resistance.
3. Verify the connections from the lab instructor before switch on the supply.
4. Keep the rheostat position value given by the lab instructor
5. Switch ON the supply and note down the frequency of input voltage from the CRO.
6. Set the frequency division switch at 2 and note the readings of time period of output voltage waveform for different set of firing angles
7. Calculate the practical value of output frequency by reciprocating the value of time period and theoretical value of frequency will be found from frequency division setting
8. Repeat the above process from step 5 to 6 for frequency division of 3 and 4.

ABULAR COLUMN:

A) R LOAD:

The input voltage V_{ph} = V
Value of load resistance R_L = Ω
Input frequency = Hz

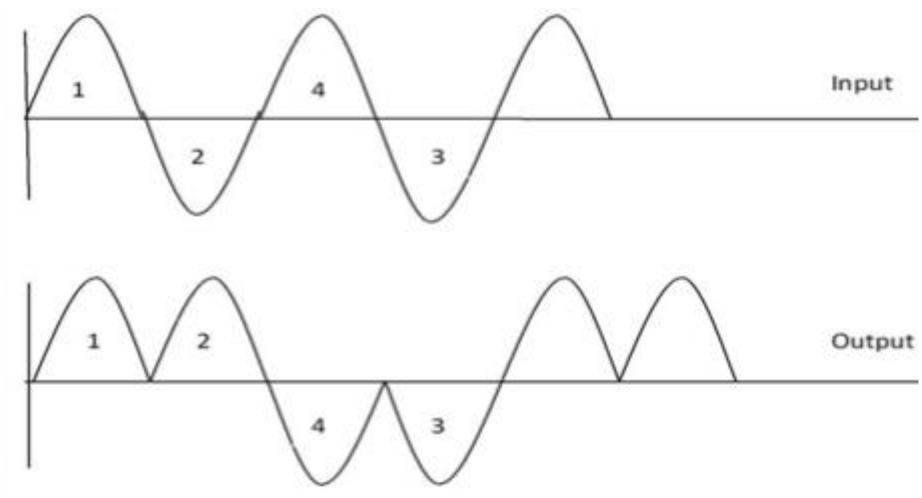
S.No.	Frequency division	Firing angle(α) in degrees	Time period inmillisec	Frequency(practical)	Frequency(t heoretical)

A) RL-LOAD:

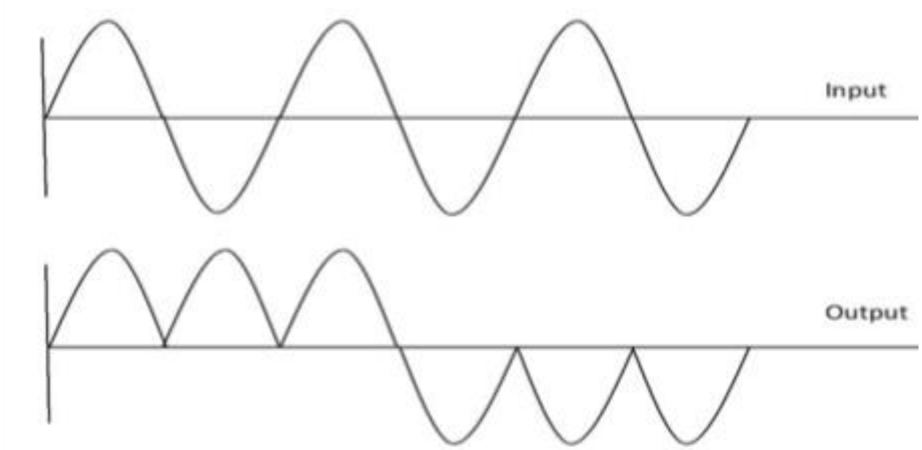
The input voltage V_{ph} = V
Value of load resistance R_L = Ω
Value of load inductance =mH
Input frequency = Hz

S.No.	Frequency division	Firing angle(α) in degrees	Time period inmillisec	Frequency(practical)	Frequency(t heoretical)

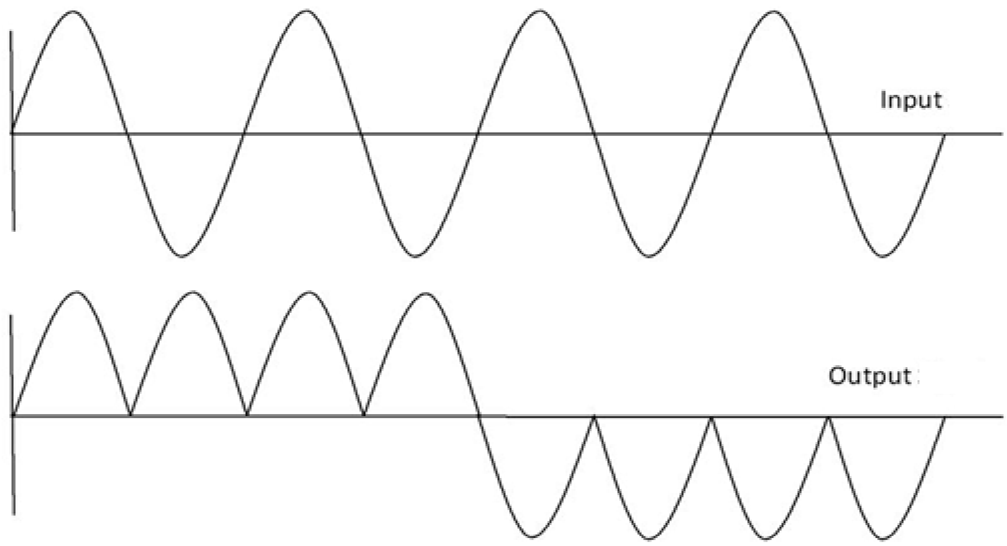
MODEL GRAPHS:



Gate signals for 2/1 Frequency Reduction



Gate Signal for 3/1 Frequency Reduction



Gate Signal for 4/ 1 Frequency Reduction

RESULT: The operation of I-φcyclo converter is verified and the theoretical andpractical values of output frequencies at different frequency divisions are found both for R & RL loads .The frequencies are varied at 50HZ,25HZ,16.33HZ.

EXPERIMENT NO 9

SINGLE PHASE HALF CONTROLLED BRIDGE RECTIFIER

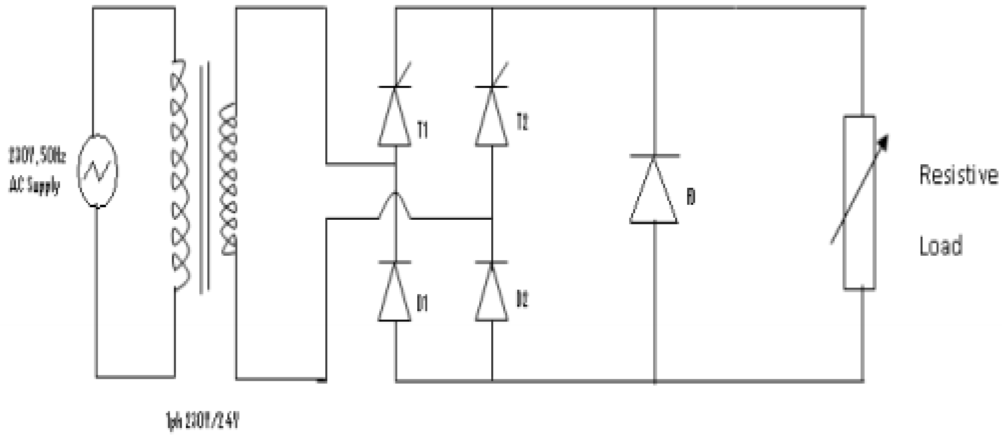
Aim:

To study the operation of single phase half controlled converter using R and RL load and to observe the output waveforms.

Apparatus required:

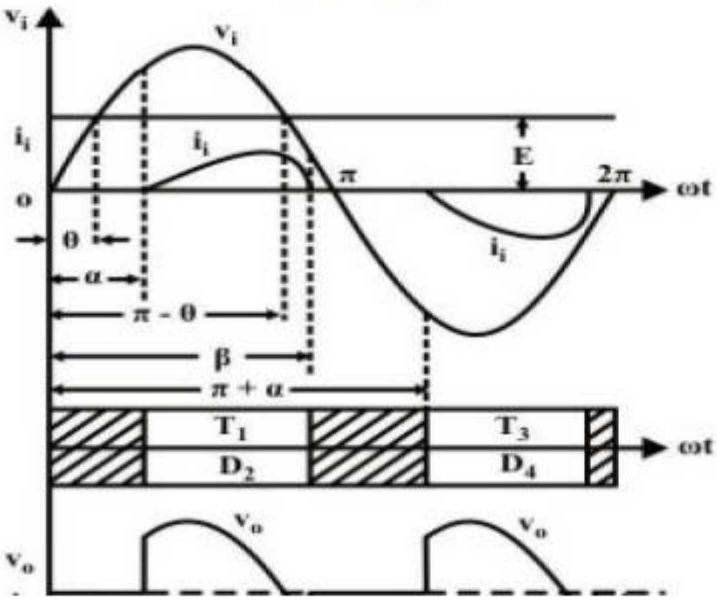
1. Power thyristors
2. Rheostat
3. CRO
4. Transformer (1-phase) 230V/24V
5. Connection wires

Single Phase Half Controlled Bridge Rectifier:



Circuit Diagram

Model Graph:



Observation Table:

Serial No.	Triggering angle 'α' degree	Output voltage Vo (volt) (measured)	Time period(ms)
1			
2			
3			

Procedure:

1. Make the connections as per the circuit diagram.
2. Connect CRO and voltmeter across the load.
3. Keep the potentiometer at the minimum position.
4. Switch on the step down ac source.
5. Check the gate pulses at G1-K1 & G2-K2, respectively.
6. Observe the wave form on CRO and note the triggering angle 'α' and
7. Note the corresponding reading of the voltmeter. Also note the value of Maximum amplitude Vm from the waveform.

8. Set the potentiometer at different positions and follow the step given in (6) for every position.
9. Tabulate the readings in the observation column.

Theory:

A semi converter uses two diodes and two thyristors and there is a limited control over the level of dc output voltage. A semi converter is one quadrant converter. A one-quadrant converter has same polarity of dc output voltage and current at its output terminals and it is always positive. It is also known as two-pulse converter. Figure shows half controlled rectifier with R load. This circuit consists of two SCRs T1 and T2, two diodes D1 and D2. During the positive half cycle of the ac supply, SCR T1 and diode D2 are forward biased when the SCR T1 is triggered at a firing angle $\omega t = \alpha$, the SCR T1 and diode D2 comes to the on state. Now the load current flows through the path L - T1- R load –D2 - N. During this period, we output voltage and current are positive. At $\omega t = \pi$, the load voltage and load current reaches to zero, then SCR T1 and diode D2 comes to off state since supply voltage has been reversed. During the negative half cycle of the ac supply, SCR T2 and diode D1 are forward biased. When SCR T2 is triggered at a firing angle $\omega t = \pi + \alpha$, the SCR T2 and diode D1 comes to on state. Now the load current flows through the path N - T2- R load – D1 -L. During this period, output voltage and output current will be positive. At $\omega t = 2\pi$, the load voltage and load current reaches to zero then SCR T2 and diode D1 comes to off state since the voltage has been reversed. During the period ($\pi + \alpha$ to 2π) SCR T2 and diode D1 are conducting.

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

Result:

Thus the operation of single phase half controlled converter using R and RL load has studied and the output waveforms has been observed.

1. What is conduction angle?
2. What are the effects of adding freewheeling diode in this circuit?
3. What are the effects of removing the freewheeling diode in single phase semi converter?
4. Why is the power factor of semi converters better than that of full converters?
5. What is the inversion mode of converters?

EXPERIMENT NO 10

THREE PHASE HALF CONTROLLED BRIDGE CONVERTER WITH R-LOAD

Aim: To verify and measure output voltage of half control of a three phase bridge rectifiers

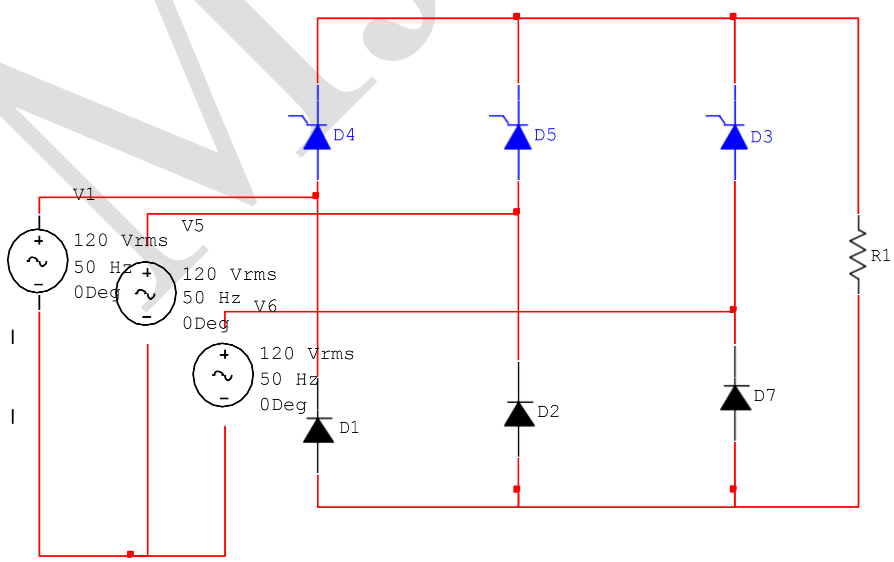
Apparatus: Three Phase bridge rectifier trainer Kit
CRO, DC Voltmeter
Patch chords

Theory: Phase control thyristors can control the output voltage of a rectifier, by varying the firing angle or delay angle α of the thyristor. In phase control thyristor commutation or turning OFF takes place by line or natural commutation. It has applications in industrial variable speed drives from very low to very high power levels as high as few Mega watts.

Circuit Diagram:

Half controlled Rectifier

3Ph Star AC supply, 50 Hz



Procedure:

Full wave Half controlled rectifier

1. Connect RL1 from load panel across load
2. Connect R-R1 , Y-Y1 & B-B1 and also R-R3 , Y-Y3 & B-B3
3. Connect load between Positive terminal of DC supply and negative terminal of DC supply
4. Connect the oscilloscope through attenuator across the load and switch on the power.
5. Observe the Load voltage and Phase diode voltage waveforms
6. Turn the phase control clockwise ie. Firing angle"α"and calculate load voltage V_L
7. Repeat for various loads and observe the change in the waveforms

Observation Table:

Vrms (line)	Vm (line)	T(msec)	t (msec)	α (degrees)	Vo(measured)	Vo(calculated)

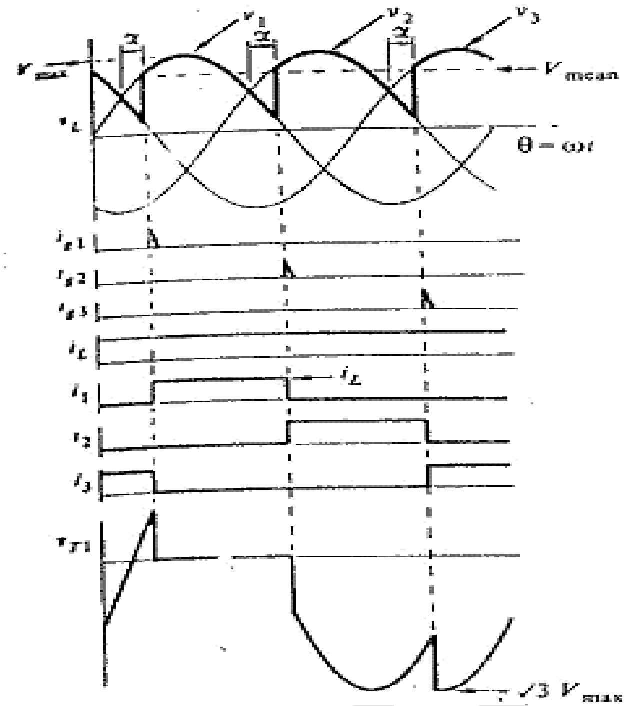
Model Calculation:

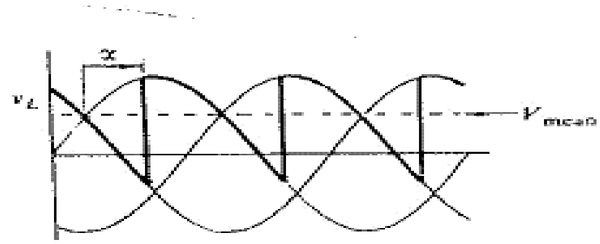
$$V_m = V_{rms} * \sqrt{2}$$

$$\alpha = (t/T)*120$$

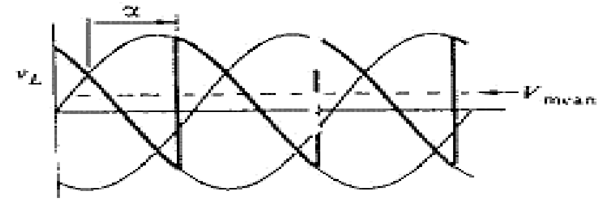
$$\text{Vo (calculated)} = \frac{3\text{Vm (line)}}{2\pi}(1+\cos\alpha)\ \text{V}$$

Expected graphs:



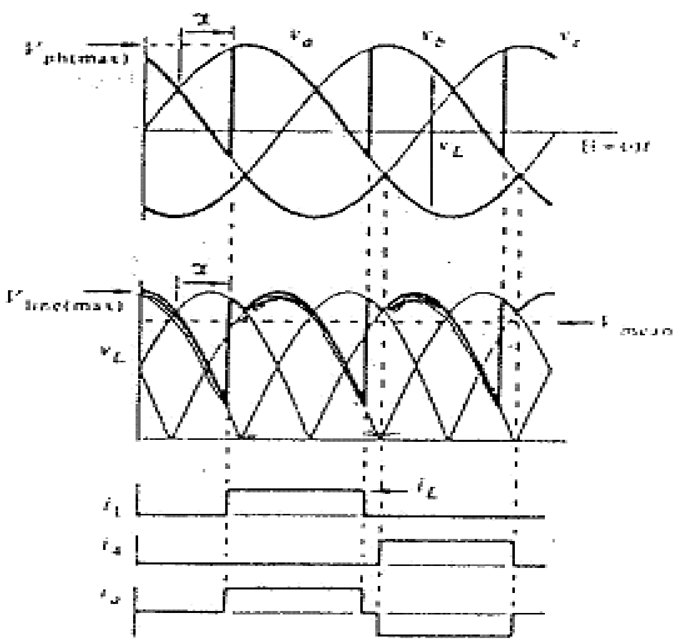


(c)

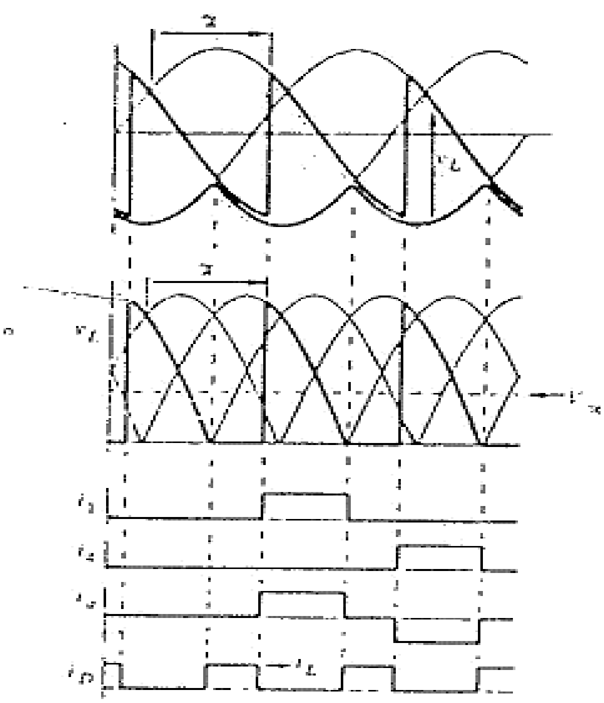


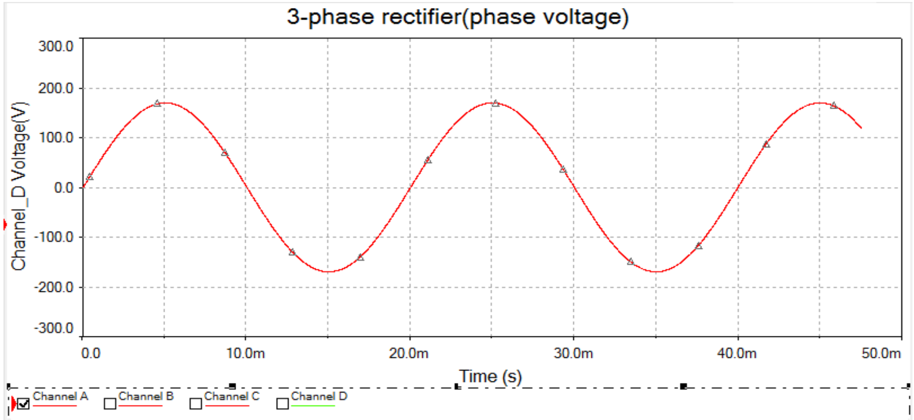
(d)

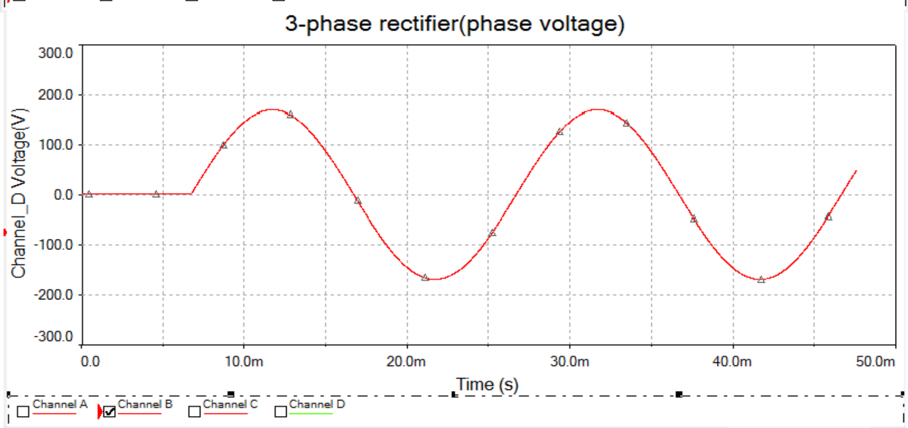
Half controlled

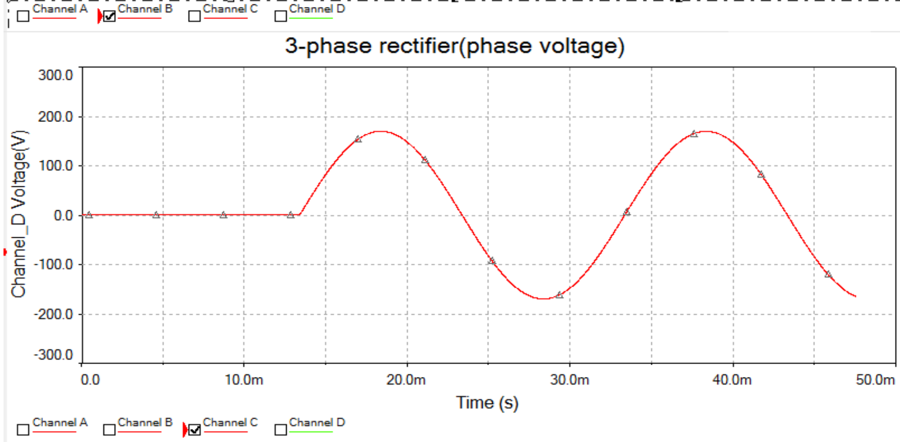


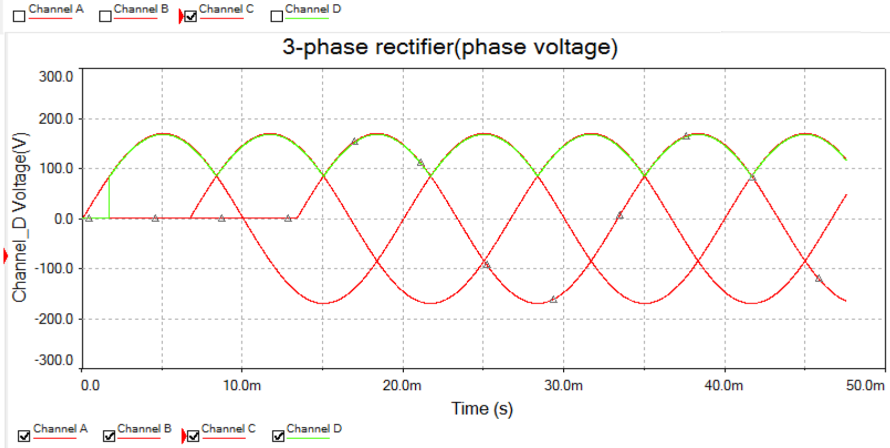
(b)

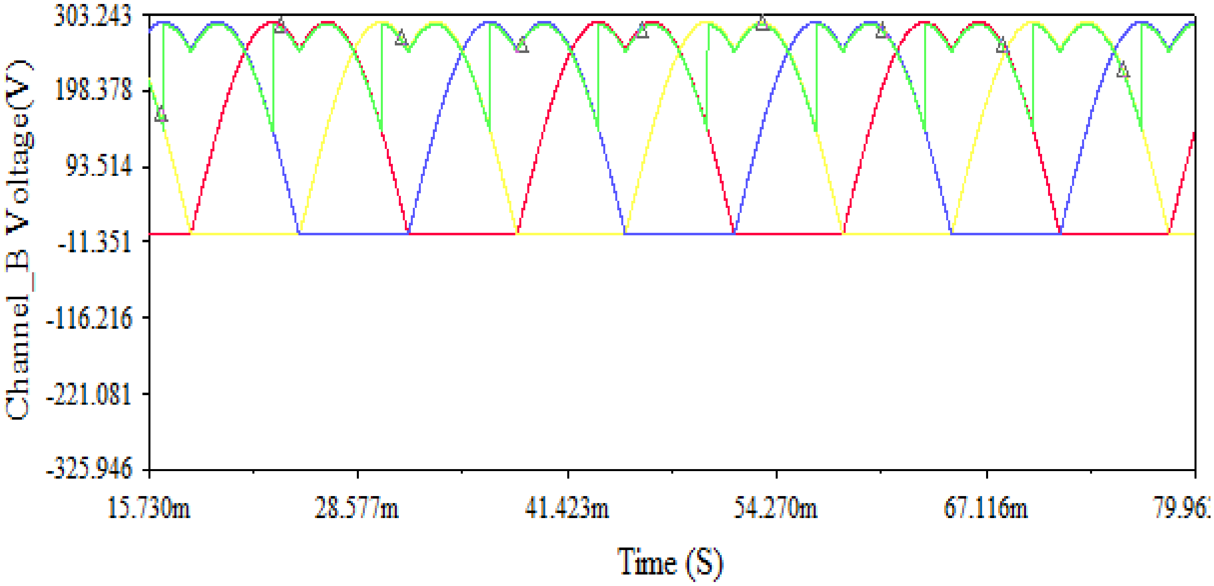



3-phase rectifier(phase voltage)
Channel_D Voltage(V)
300.0
200.0
100.0
0.0
-100.0
-200.0
-300.0
0.0
10.0m
20.0m
30.0m
40.0m
50.0m
Time (s)
Channel A
Channel B
Channel C
Channel D


3-phase rectifier(phase voltage)
Channel_D Voltage(V)
300.0
200.0
100.0
0.0
-100.0
-200.0
-300.0
0.0
10.0m
20.0m
30.0m
40.0m
50.0m
Time (s)
Channel A
Channel B
Channel C
Channel D


3-phase rectifier(phase voltage)
Channel_D Voltage(V)
300.0
200.0
100.0
0.0
-100.0
-200.0
-300.0
0.0
10.0m
20.0m
30.0m
40.0m
50.0m
Time (s)
Channel A
Channel B
Channel C
Channel D


3-phase rectifier(phase voltage)
Channel_D Voltage(V)
300.0
200.0
100.0
0.0
-100.0
-200.0
-300.0
0.0
10.0m
20.0m
30.0m
40.0m
50.0m
Time (s)
Channel A
Channel B
Channel C
Channel D



Results: The output waveforms across the load have been observed for half controlled 3 phase rectifier

EXPERIMENT NO 11
SINGLE PHASE DUAL CONVERTER WITH RL LOADS

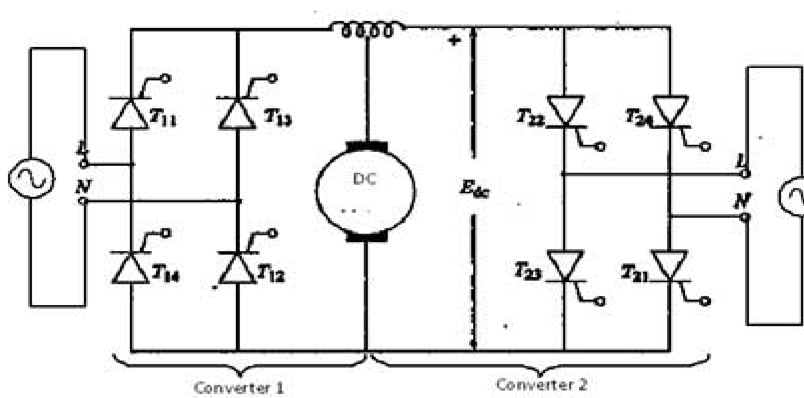
Aim:

To construct a **single** phase **dual converter** in with and without circulating current mode Operation.

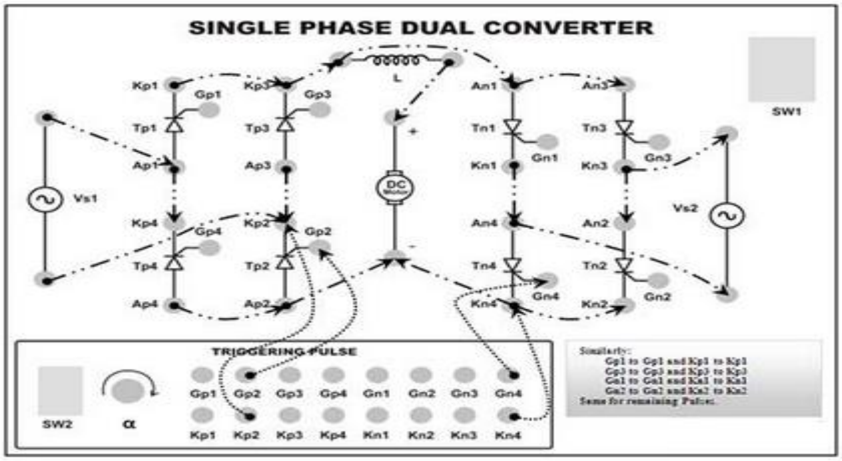
Apparatus required:

- **Single Phase Dual Converter kit**
- Patch chords
- Power chord
- DC motor or Resistive Load
- CRO

Circuit Diagram



Mimic Diagram



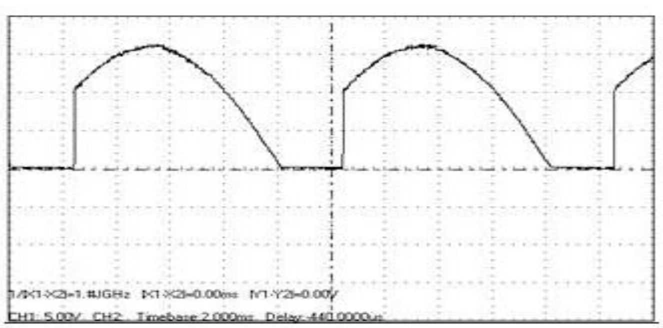
Procedure:

- Connections are made as shown in circuit diagram.
- First turn on SW2 (triggering pulse supply).
- Select the position either in With or Without Circulation mode. **Note:** If it is With Circulation Mode then Inductor must be connected.
- Verify pulse across test points.
- Turn on SW1 (input power supply).
- By varying α ,Observe corresponding Output voltage at load terminal
- To verify the motor speed and direction.

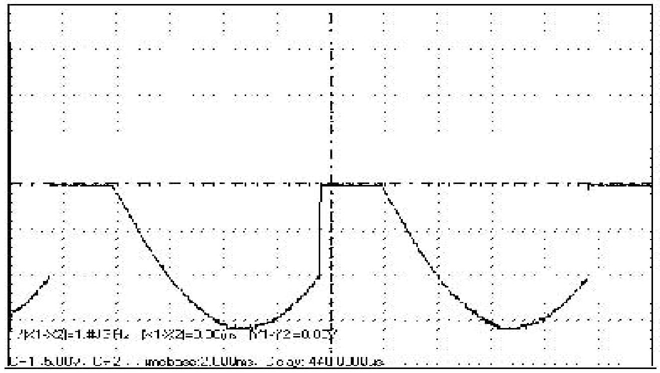
Output Waveform

Without Circulating Current Mode

Positive Converter



Negative Converter



Tabulation

Without Circulating Mode:

S.No	P-Converter			N-Converter		
	Firing Angle (Deg)	Measured (V)	Calculated (V)	Firing Angle (Deg)	Measured (V)	Calculated (V)

With Circulating Mode:

S.No	P-Converter (deg)	N-Converter (deg)	Total (deg)	Measured Voltage (Volts)

1. Total Time Period

T = 2 x (on time + off time)
if F = 50Hz
T = 20ms

360degree=20ms
1ms=**360/20**
=**18 deg**ree
0.1ms =**1.8deg**ree
when off time is **4**ms
alpha α = **(4/0.1)*1.8**= **72deg**ree

2. The Average Output Voltage

The dc output voltage V_{dc} can be varied from a maximum value of **2**V_m/π**for** $\alpha=0°$ to a minimum value of **-2**V_m/π **for α = π radians = 180°**

$$V_o = \left(\sqrt{2}V/\pi\right)*(1+\cos\alpha)$$

Where,

V= input ac voltage in volt.
α = firing angle in degree

if, $V_m=\sqrt{2}*24V$,

$$if, \; Vm = \sqrt{2} * 24V,$$

$$Vo = (\frac{24 * \sqrt{2}}{\pi})(1 + \cos(72))$$

$$= \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Volts.$$

Result:

Above experiment for **Single Phase Dual Converter** was done and the result was verified.

EXPERIMENT N0 12
PSPICE SIMULATION OF SINGLE PHASE FULL CONVERTER USING RLE LOAD

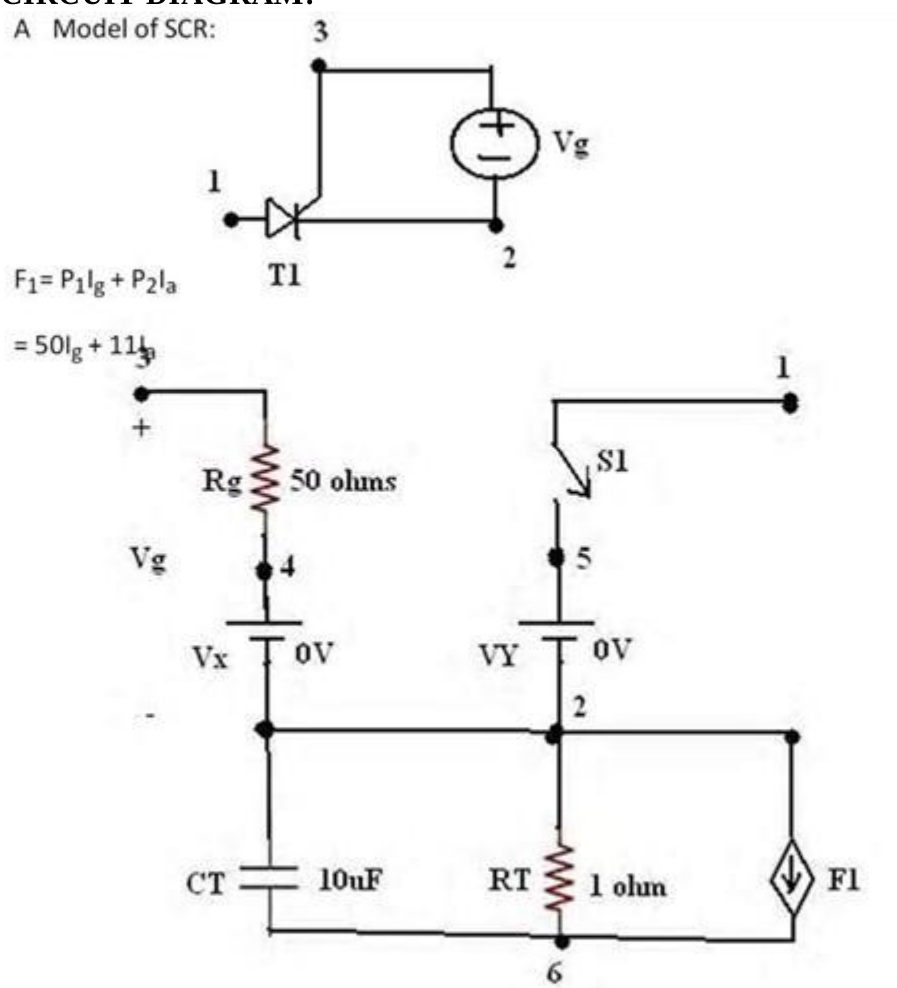
AIM: The objective is to study the output waveforms of single phase full converter using thyristors at various load condition.

APPARATUS: PSPICE Software.

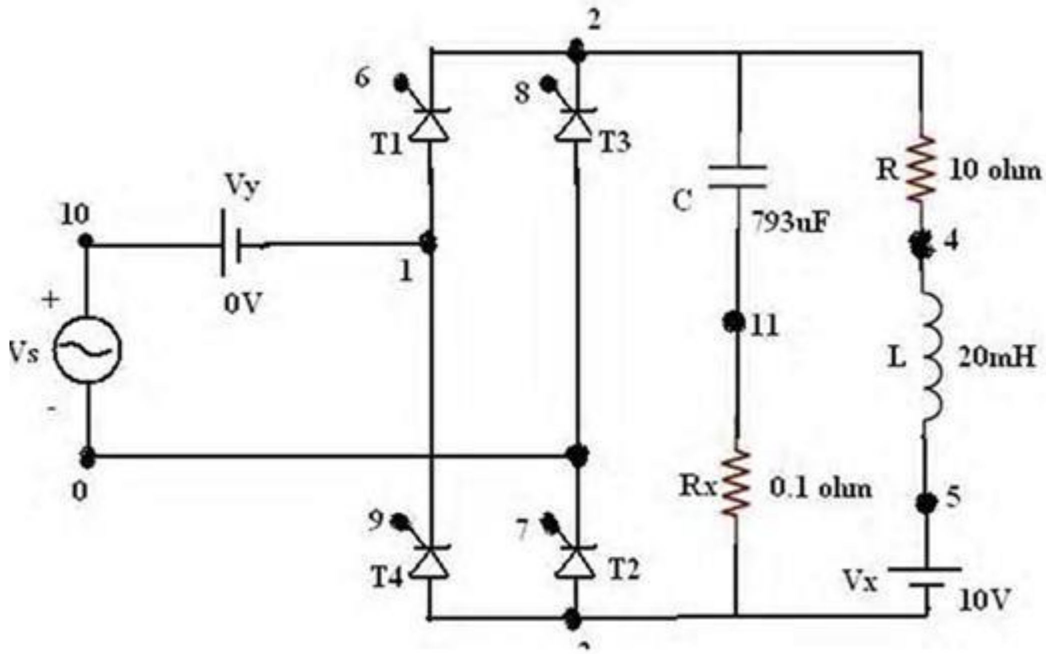
Problem**:**A single phase full converter is connected to a RLE load. With R=100 ohms, L=5.5mH and voltage 20v. it is supplied with a voltage of 325.27V, 50hz supply simulate the converter by using PSPICE for delay angle 60 degrees & plot.

1. Output voltage across load
2. Input current
3. Load current

CIRCUIT DIAGRAM:



Circuit Diagram of Single Phase Full Converter:



THEORY: A single phase full converter bridge using four scrs as shown in fig. the load is assumed to be of RLE type where E is the load circuit e.m.f. voltage E may be due to a battery in the load circuit. Or may be generated e.m.f of a dc motor. Thyristor pair T1 & T2 is simultaneously triggered and Π radians later, pair T3 & T4 is gated to trigger. When “a” is positive with respect to “b” supply voltage waveform is shown dotted as Vba. Obviously treated as positive . Load current or output current I0 is assumed to be continuous. Over the working range.

PROCEDURE:

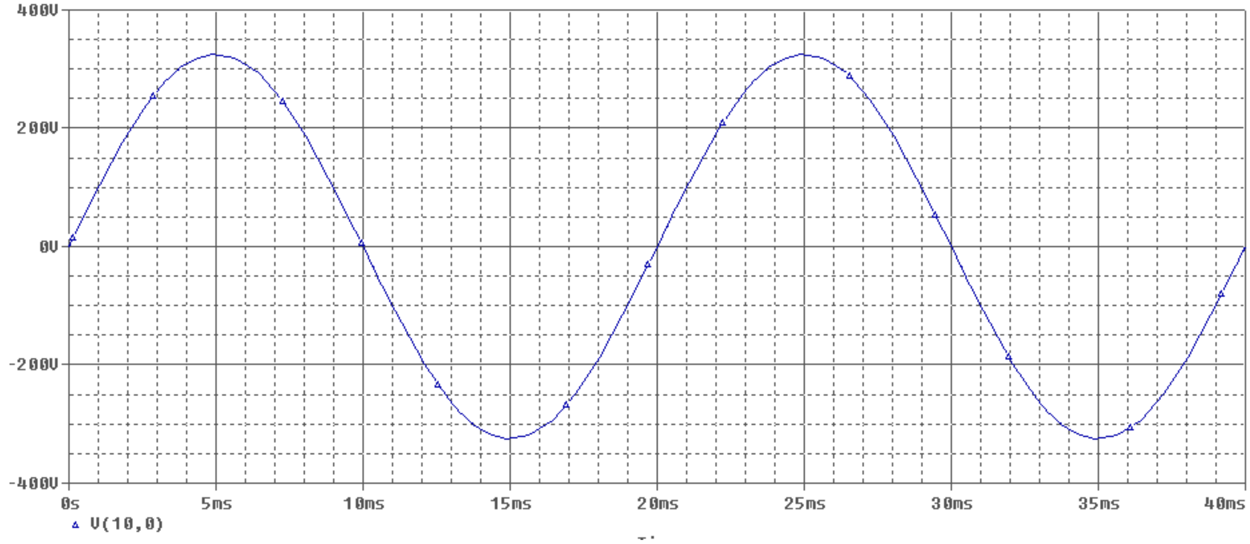
1. Represent the nodes for a given circuit.
2. Write spice program by initializing all the circuit parameter as per given flow chart.
3. From desktop of your computer click on “START” menu followed by “programs” and then clicking appropriate program group as “DESIGN LAB EVAL8 followed by “DESIGN MANAGER.”
4. Open the run text editor from microsim window & start writing pspice program.
5. Save the program with .cir extension.
6. Open the run spice A/D window from microsim window.
7. Open file menu from run spice A/D window then open saved circuit file.
8. If there are any errors, simulates will be displayed with statement as “simulation error occurred”.
9. To see the errors click on o/p file icon and open examine o/p.
10. To make changes in the program open the circuit file, modify, save & Run the program.
11. If there are no errors, simulation will be completed & it will be displayed with a statement as “simulation completed”.
12. To see the o/p click on o/p file icon & open examine o/p then note down the values.
13. If .probe command is used in the program, click on o/p file icon &open run probe. Select variables to plot on graphical window and observe the o/p plots then take print outs of that.

PROGRAM CODE:

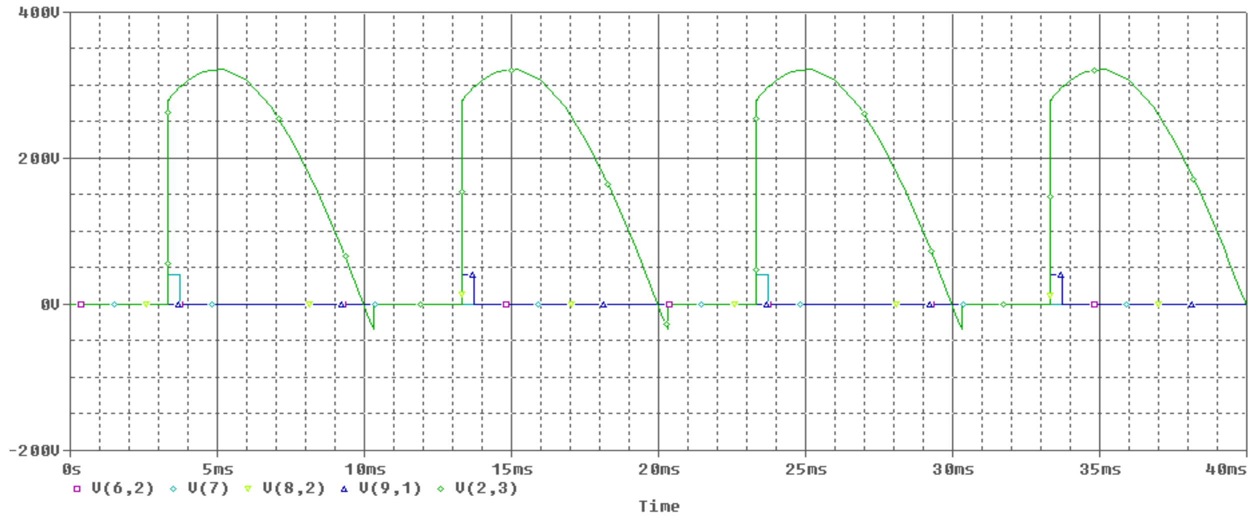
```
VS 1 0 SIN(0 220V 50HZ);
Vg1 7 3 PULSE(0 10V 1666.6US 1NS 1NS 100US 20000US);
Vg2 8 0 PULSE(0 10V 1666.6US 1NS 1NS 100US 20000US);
Vg3 9 3 PULSE(0 10V 11666.6US 1NS 1NS 100US 20000US);
Vg4 10 2 PULSE(0 10V 11666.6US 1NS 1NS 100US 20000US);

*CIRCUIT ELEMENTS

R 3 4 0.6OHM;
L 4 5 5.5MH;
VX 5 6 DC 0V;
VY 1 2 DC 0V;
VE 6 11 DC 20V;

*SCR IN THE CIRCUIT

XT1 2 3 7 3 SCR;          Thyristor T1
XT2 6 0 8 0 SCR;          Thyristor T2
XT3 0 3 9 3 SCR;           Thyristor T3
XT4 6 2 10 2 SCR;          Thyristor T4

*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=0.0125 ROFF=10E+5 VON=0.5 VOFF=0);

.MODEL DMOD D(IS=2.2E-15 BV=1800 TT=0 CJO=0);

.ENDS SCR

*ANALYSIS
.TRAN 50US 100MS 30MS 50US;
.OPTIONS ITL5=0 ABSTOL=1N RELTOL=1M VNTOL=1M
.FOUR 50HZ V(6,5)
.PROBE
.END
```

WAVEFORMS:

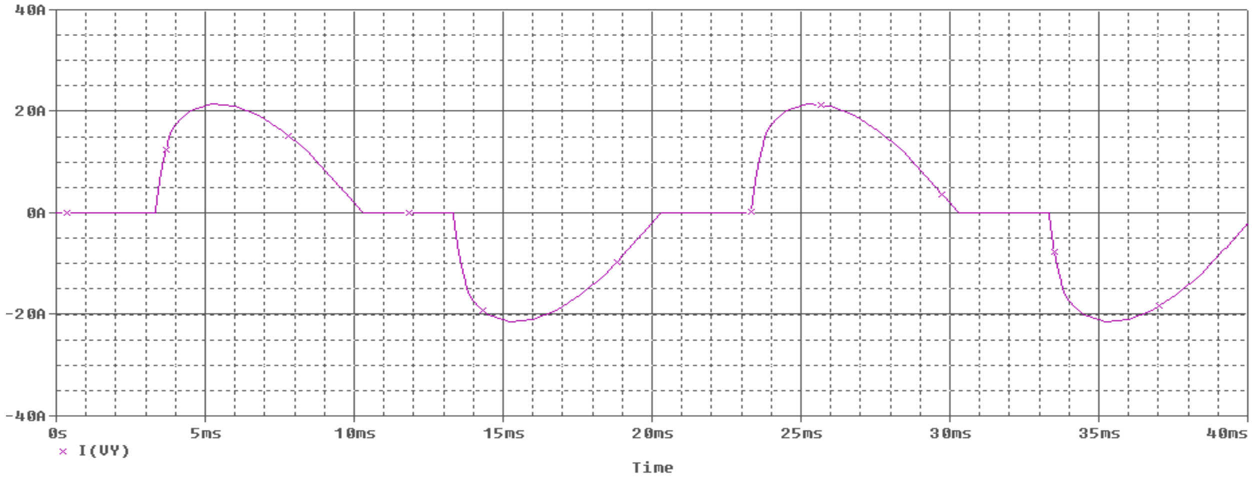
INPUT VOLTAGE:



OUTPUT VOLTAGE:



INPUT CURRENT:

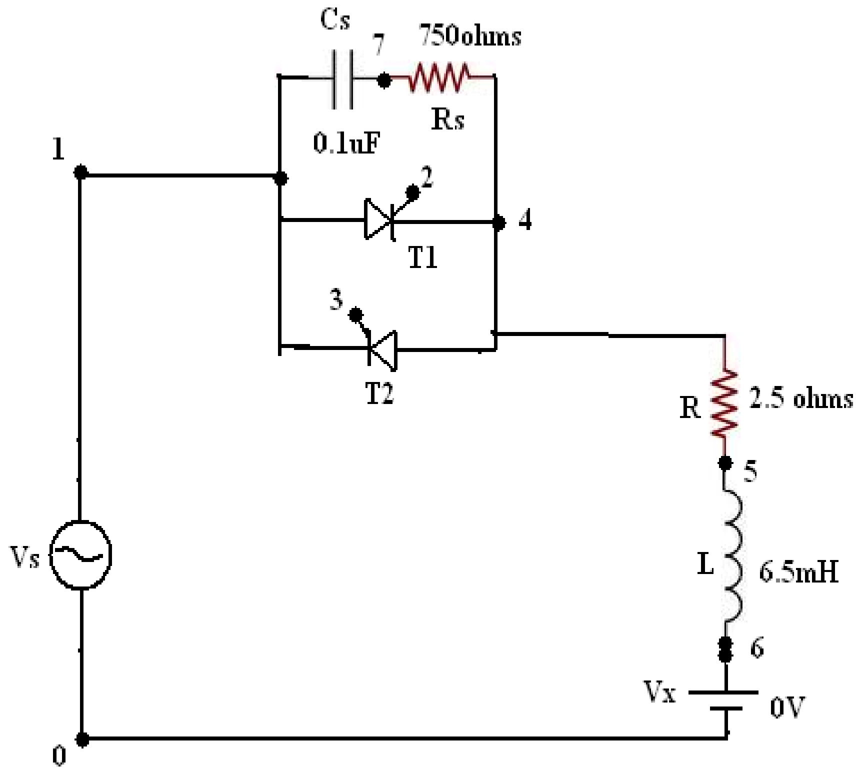


RESULT: PSPICE simulation of Single Phase Full Converter Using RLE Load is studied and output waveforms are observed

PSPICE SIMULATION OF SINGLE-PHASE AC VOLTAGE CONTROLLER USING RLE LOADS

AIM: To study the output waveforms of single-phase full converter using RLE Loads using PSPICE simulation.

AC VOLTAGE CONTROLLER

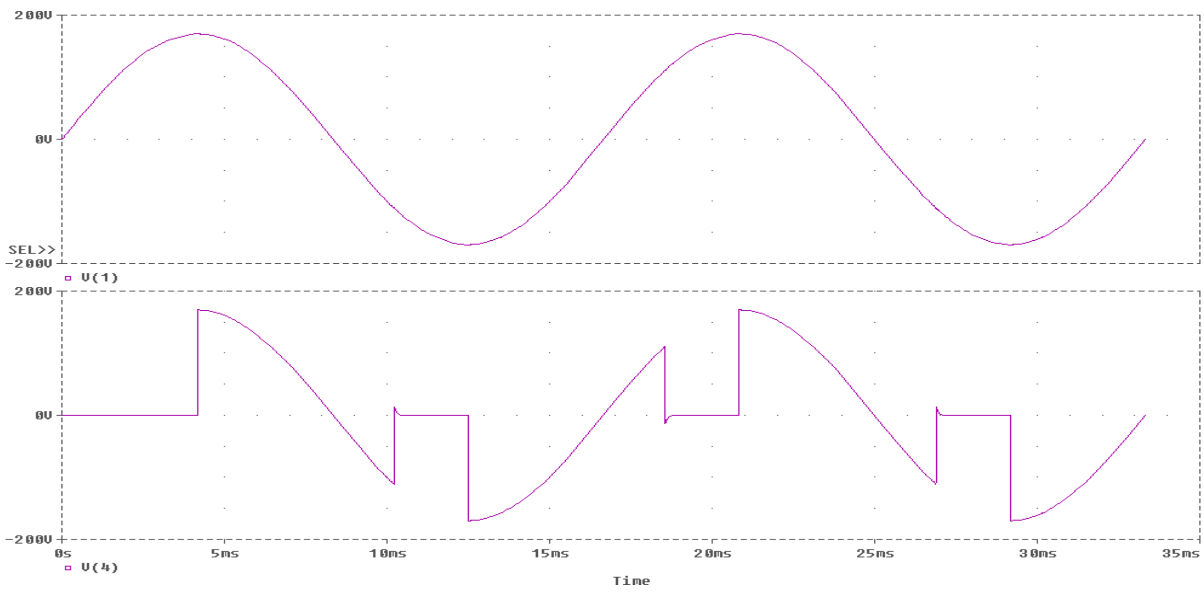


PROGRAM: *ac voltage controller

VS 1 0 SIN (0 169.7V 60HZ)
Vg1 2 4 PULSE (0V 10V 4166.7US 1NS 1NS 100US 16666.7US)
Vg2 3 1 PULSE (0V 10V 12500.0US 1NS 1NS 100US 16666.7US)
R 4 5 2.5
L 5 6 6.5MH
VX 6 0 DC 0V;VOLTAGE SOURCE TO MEASURE THE LOAD CURRENT
*C 4 0 1245.94UF; OUTPUT FILTER CAPACITANCE
CS 1 7 0.1UF
RS 7 4 750
* SUBCIRCUIT CALL FOR THYRISTOR MODEL
Xt1 1 2 4 SCR; THYRISTOR T1
Xt2 4 3 1 SCR; THYRISTOR T2

```
*subcircuit for ac thyristor model
.SUBCKT SCR 1 3 2
* model anode +control cathode
* name voltage
S1 1 5 6 2 SMOD ;switch
RG 3 4 50
VX 4 2 DC 0V
VY 5 2 DC 0V
DT 7 2 DMOD; Switch diode
RT 2 6 1
CT 6 2 10UF
F1 2 6 POLY(2) VX VY 0 50 11
.MODEL SMOD SW RON=0.01 ROFF=10E+5 VT=1 VH=0.2
.MODEL DMOD D(IS=2.2E-15 BV=1200V TT=0) ; Diode model parameters
.ENDS SCR ; Ends subcircuit definition
.TRAN 10US 33.3MS
.PROBE
.OPTIONS ABSTOL=1.00n RELTOL=1.0m VNTOL=1.0m
.FOUR 60HZ I(VX)
.END
```

OUTPUT WAVE FORMS:



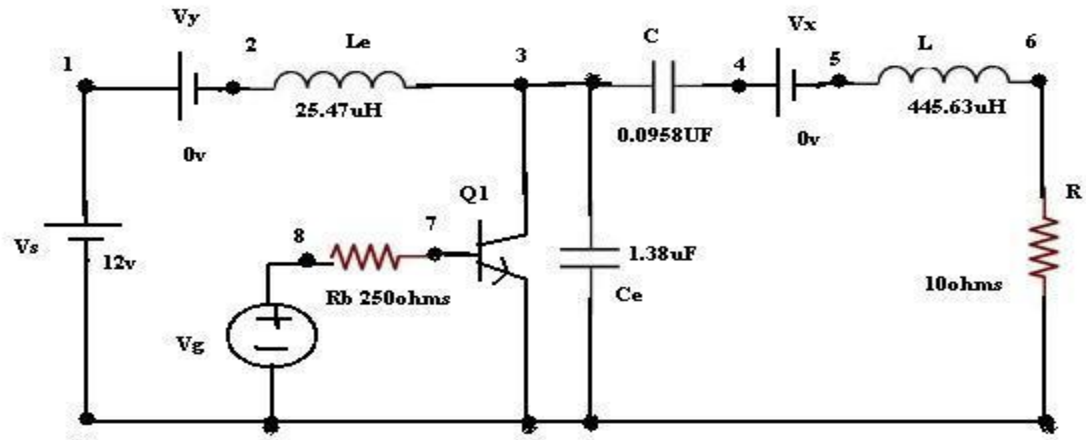
RESULT: PSPICE simulation of Single-Phase Ac Voltage Controller Using Rle Loads is studied and output waveforms are observed

PSPICE SIMULATION OF BUCK CHOPPER AND RESONANT PULSE COMMUTATION

AIM: Study of resonant pulse commutation circuit and Buck chopper with PSPICE simulation

APPARATUS: PSPICE Software

Circuit diagram of buck chopper



CIRCUIT FILE FOR RESONANT PULSE COMMUTATION

*SINGLE PHASE AC VOLTAGE CONTROLLER

V 1 0 SIN(0V 311.1V 50HZ);
Vg1 3 5 PULSE(0V 10V 1677US 1NS 1NS 100US 20000US);
Vg2 4 2 PULSE(0V 10V 11677US 1NS 1NS 100US 20000US);

R 5 6 0.6OHM;
L 6 7 5.5MH;
VX 7 8 DC 0V;
VY 2 1 DC 0V;
VE 8 0 DC 20V;

*SUBCIRCUIT CALL FOR THYRISTOR MODEL

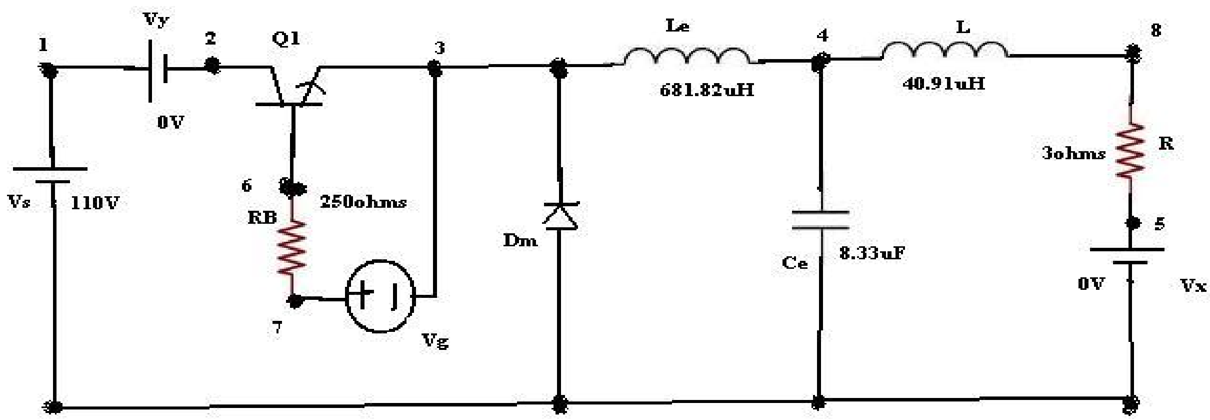
XT1 2 5 3 5 SCR; Thyristor T1
XT2 5 2 4 2 SCR; Thyristor T2
.SUBCKT SCR 1 2 3 2
S1 1 5 6 2 SMOD; SCR MODEL
RG 3 4 50
VX 4 2 DC 0V
VY 5 7 DC 0V
DT 7 2 DMOD
RT 6 2 1
CT 6 2 10UF
F1 2 6 POLY (2) VX VY 0 50 11

.MODEL SMOD VSWITCH(RON=0.0125 ROFF=10E+5 VON=0.5 VOFF=0);

.MODEL DMOD D(IS=2.2E-15 BV=1800 TT=0 CJO=0);
.ENDS SCR

*ANALYSIS
.TRAN 10US 33.33MS;
.OPTIONS ITL5=10000 ABSTOL=1N RELTOL=1M VNTOL=1M
.FOUR 50HZ V(5,0); Fourier Analysis Of Output Voltage
.PROBE
.END

Circuit diagram of buck converter



CIRCUIT MODEL FOR BUCK CHOPPER

VS 1 0 DC 110V

VY 1 2 DC 0V

VG 7 3 PULSE (0V 20V 0 0.1NS 0.1NS 27.28US 50US

RB 7 6 250

LE 3 4 681.82UHCE 4 0 8.33UF IC=60V

L 4 8 40.91UH

R 8 5 3

VX 5 0 DC 0V

DM 0 3 DMOD

```
.MODEL DMOD D (IS=2.2E-15 BV=1800V TT=0)

Q1 2 6 3 QMOD

.MODEL QMOD NPN (IS=6.734F BF=416.4 BR=.7371

CJC=3.638P + CJE=4.493P TR=239.5N TF=301.2P)

.TRAN 1US 1.6MS 1US UIC

.PROBE

.OPTIONS ABSTOL=1.00N RELTOL=0.01 VNTOL=0.1 ITL5=50000

.FOUR 20KHZ I(VY)

.END
```

RESULT: PSPICE simulation of resonant pulse commutation circuit and Buck chopper is studied and output waveforms are observed.