EXPERIMENT-1

Study of Characteristics of SCR, MOSFET & IGBT

AIM: To plot the characteristics of SCR, MOSFET & IGBT

APPARATUS: -

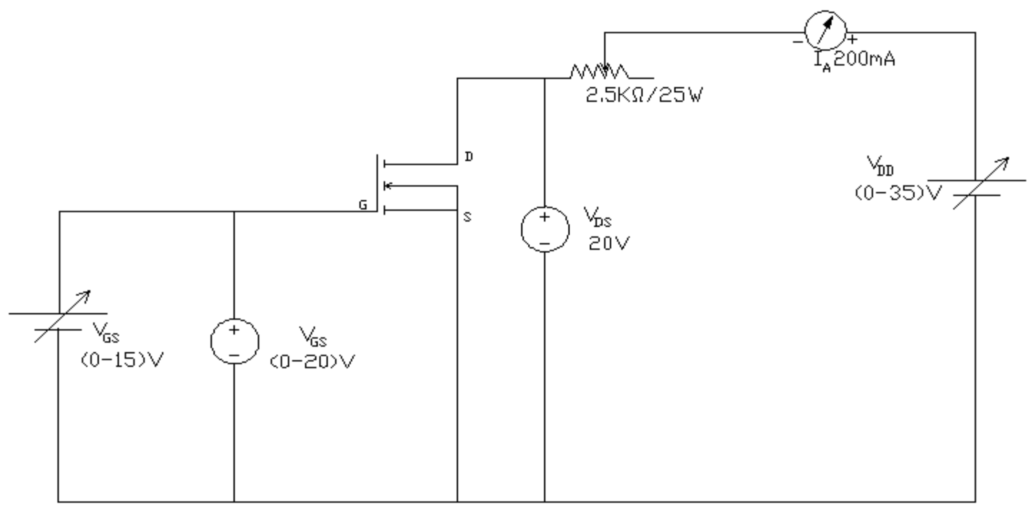
S.no	*Description*	*Quantity*
1	Characteristics Kit	1
2	Ammeter (0-500)mA	2
3	Voltmeter (0-50)V	2
4	RPS (0-30)V,2A	1

PROCEDURE:

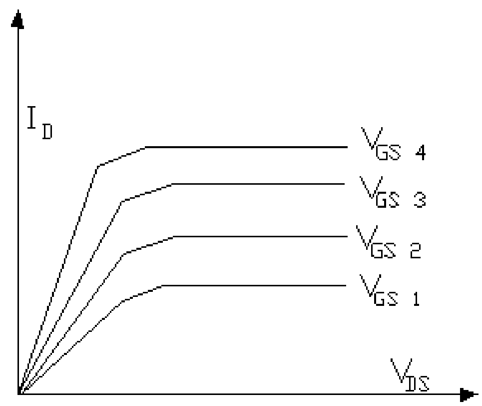
To obtain Characteristics of SCR:

1. The connections are made as per circuit diagram.
2. Switch on the regulated power supply. Apply 10V across anode & cathode of SCR.
3. Gradually increase the gate current till the SCR becomes ON. Note down V_{AK}, I_A.
4. Now increase supply voltage gradually and I_A are noted for three or four readings.
5. Steps 3 to 4 are repeated for another values of V_{AK} say 20V.
6. Tabulate the readings in the table.
7. Plot a graph of V_{AK} versus I_A.
8. To determine Holding current I_H :
   i) Keep proper V_{AK} to trigger SCR by gate current. Trigger SCR by applying gate current .Keep sufficient load current by varying load resistance in fully clock wise direction.

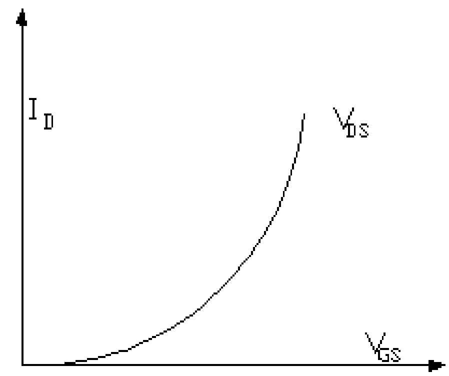
   ii) To open gate circuit, now reduce load current till SCR jump to blocking state.iii) The minimum current for which SCR suspend under ON condition is noted which is Holding current I_H.
9. Latching current is 1.5 to 2 times of holding current value



Circuit Diagram for obtaining the characteristics of MOSFET



Output Characteristics for MOSFET



Transfer Characteristics for MOSFET

<u>To obtain Characteristics of MOSFET :</u>

Output Characteristics:

The connections are made as per circuit diagram

1. Switch on the equipment. 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}.
2. Keep V_{GS} constant, (V_{GS} must be within the range determined by step 2).
3. Vary V_{DS} in steps, note down corresponding I_D.
4. Step 4 is repeated for different values of V_{GS}.
5. Tabulate the readings in the table.
6. Plot a graph of I_D against V_{DS} for different V_{GS}.

Transfer Characteristics:

The connections are made as per circuit diagram

1. Switch on the equipment. Keep V_{DS} say 10V, vary V_{GS} in steps ,note down the corresponding drain current I_D.
2. Tabulate the readings in the table.
3. Plot a graph of I_D against V_{GS}.

<u>To obtain Characteristics of IGBT :</u>

Output Characteristics:

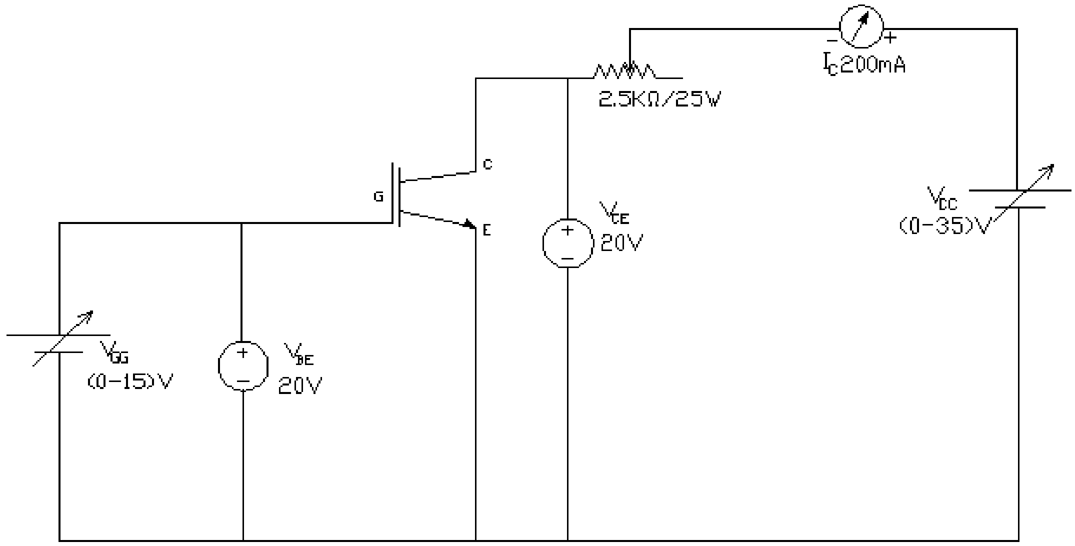
1. Connections are made as per circuit diagram. (Use 20V Voltmeter for V_{GE}, 200V Voltmeter for V_{CE} , 200 ma Ammeter for IC 15V Power supply for base & 35V Power supply for collection circuit).
2. Switch on the equipment. Keep V_{CE} 10V, vary V_{GE} note down the range of V_{GE} for which collector current is varying for constant V_{CE}.
3. Keep V_{GE} constant, (V_{GE} must be within the range determined by step 2).
4. Vary V_{CE} in steps, note down the corresponding I_C.
5. Adjust V_{GE} to constant while doing step 4.
6. Step 4 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}.

Transfer Characteristics:

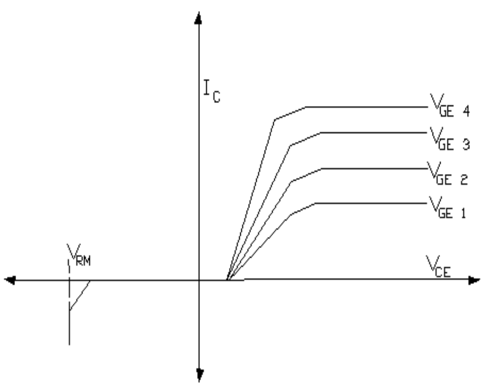
1. Connections are made as per circuit diagram. (Use 20V Voltmeter for V_{GE}, 200V Voltmeter for V_{CE}, 200 ma Ammeter for IC 15V Power supply for base & 35V Power supply for collection circuit).
2. Switch on the equipment. Keep V_{CE} constant, vary V_{GE} in steps , note down corresponding I_C.
3. Adjust V_{CE} to constant while doing step 2.
4. Tabulate the readings in the table.

5. Plot a graph of I_C against V_{GE} for different V_{CE}

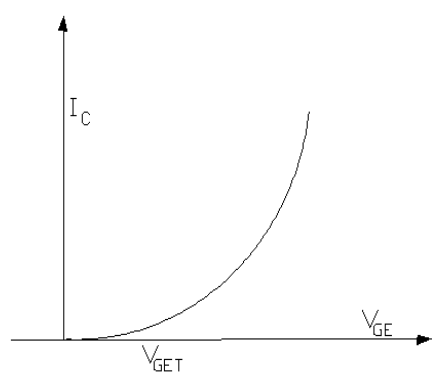
CIRCUIT DIAGRAM FOR IGBT:



Circuit Diagram for obtaining the characteristics of IGBT



Output Characteristics for IGBT



Transfer Characteristics for IGBT

OBSERVATIONS:

Static V-I Characteristics of SCR

V_{G1} =

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

Static V-I Characteristics of SCR

V_{G2} =

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

Output Characteristics of MOSFET

V_{DS} =__________

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

Transfer Characteristics of MOSFET

V_{GS} =

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

Output Characteristics of IGBT

V_{GE} =__________

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

Transfer characteristics of IGBT

V_{GE} =

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

OUTPUT WAVEFORMS

EXPERIMENT 2

SINGLE-PHASE HALF-CONTROLLED CONVERTER

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

Apparatus:

S.no	***Description***	***Quantity***
1	Power Electronics Kit	1
2	CRO	2
3	CRO Probes	2
4	Connecting wires	1

Theory:

A semi converter or half controlled 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 1 shows half controlled rectifier with R load. Figure 2 represents the MATLAB Simulink diagram. 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.

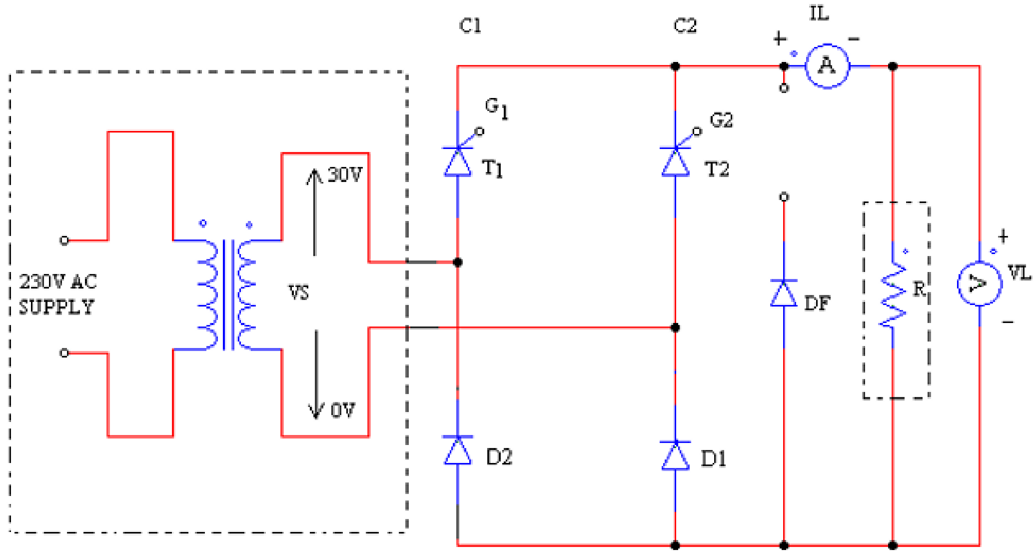


Fig 1: Single Phase Half controlled Converter

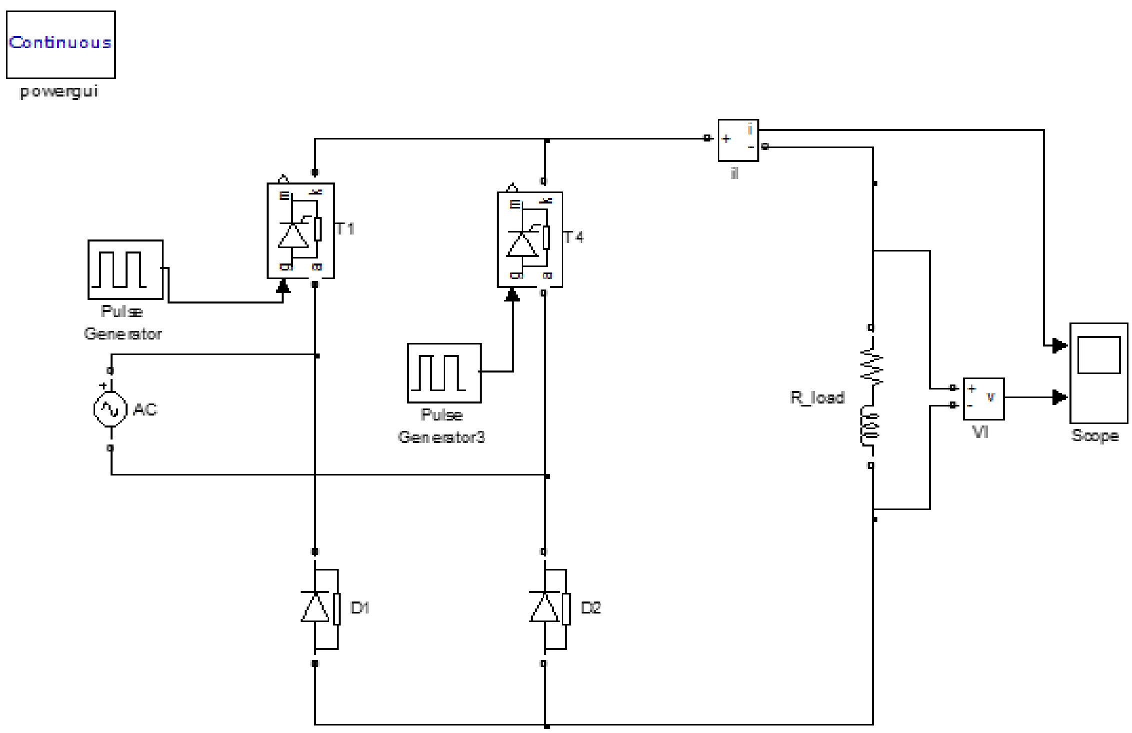


Fig 2: MATLAB Simulink Diagram

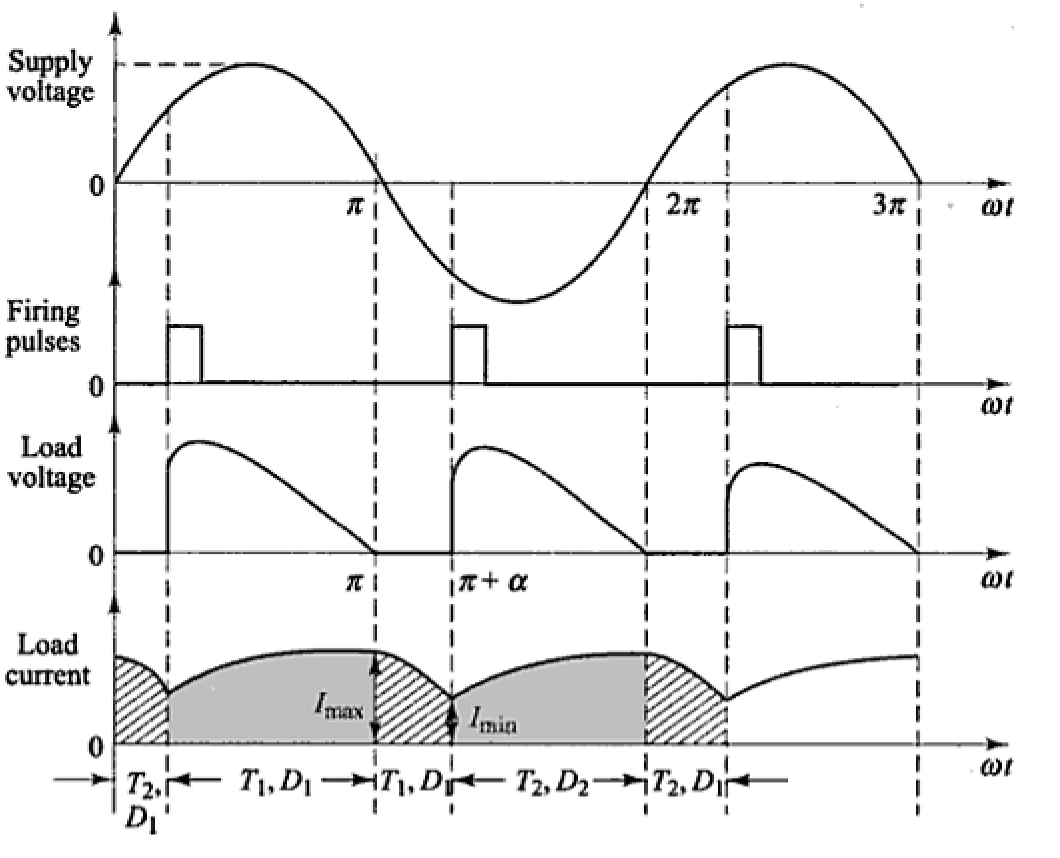


Fig 3: Output voltage and current waveforms of single- phase half controlled converter for RL-Load

For R load the average out voltage can be found from

$$V_0=1/\pi\int_{\alpha}^{\pi}V_m \sin\theta \, d\theta= V_m/\pi \, (1+\cos\alpha)$$

$$V_{rms}=V_m\sqrt{\left(\frac{\pi-\alpha+\frac{\sin 2\alpha}{2}}{\pi}\right)}$$

Where V_0 - average output voltage

V_m - peak voltage

α-firing angle

V_{rms}-Output RMS voltage

Procedure:

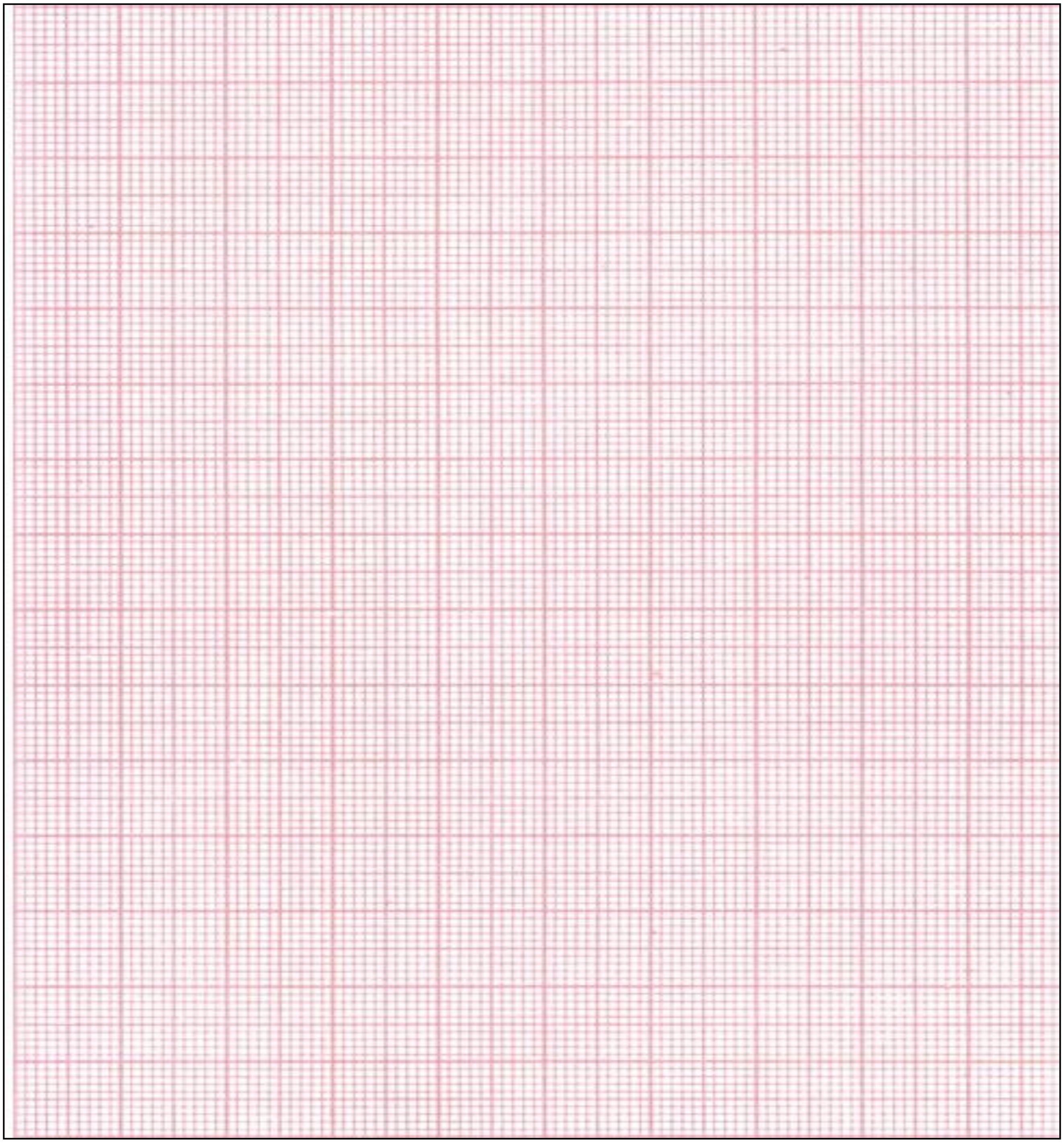
1. Make the connections as per the circuit diagram.
2. Connect CRO across the load.
3. Keep the potentiometer at the minimum position i.e. at the maximum firing angle position(180^0)
4. Check the gate pulses at G1-K1 & G2-K2, respectively.
5. Switch on the AC Supply
6. Observe the wave form on CRO and note the triggering angle ‘α’ and note the corresponding reading of the voltmeter and Ammeter. Also note the value of Maximum amplitude Vm from the waveform.
8. Set the potentiometer at different triggering angle positions and follow the step given in (6) for every position.
9. Tabulate the readings in the observation column.

Observation Table:

S.No	Firing angle	Output voltageV_0 (V)	Output Current I_0 (mA)

OUTPUT WAVEFORMS

OUTPUT WAVEFORMS



Result:

EXPERIMENT 3

SINGLE PHASE FULLY CONTROLLED BRIDGE CONVERTER

AIM: To construct a single phase fully controlled full wave bridge rectifier and to observe the output wave forms with R-Load

1. R load
2. R-L load with freewheeling diode
3. R-L load without freewheeling diode

APPARATUS:

S.no	***Description***	***Quantity***
1	Power Electronics Kit	1
2	CRO	2
3	CRO Probes	2
4	Connecting wires	1

THEORY:

In the bridge rectifier the entire four rectifier is the capability of wide voltage variation between $+V_{dc\,(av)}$ to $-V_{dc\,(av)}$, maximum i.e. 2Vm/ π volts. Such rectifiers find application in DC motor loads for both motoring and electrical braking of the motor.

FULL CONTROLLED BRIDGE CONVERTER WITH R LOAD:

During positive half cycle, SCR T1 and SCR $T1^1$ are triggered simultaneously through independent isolated gate pulses. The pair of SCR's conducts up to π. SCR T2 and SCR $T2^1$ are to be triggered in the next half cycle with another pair of isolated gate pulses. The triggering angle of the pairs of SCR's can be varied by varying the control voltages.

For R load, the average output voltage can be found from

$V_{dc\,(av)} = (1/\pi)\alpha f^{\pi} V_m \sin\Theta d\theta$

$= (Vm/\pi)\ [-\cos\Theta]_{\alpha}^{\pi}$

$V_{dc\ (av)} = (Vm/\pi)\ [1+\cos\alpha]$

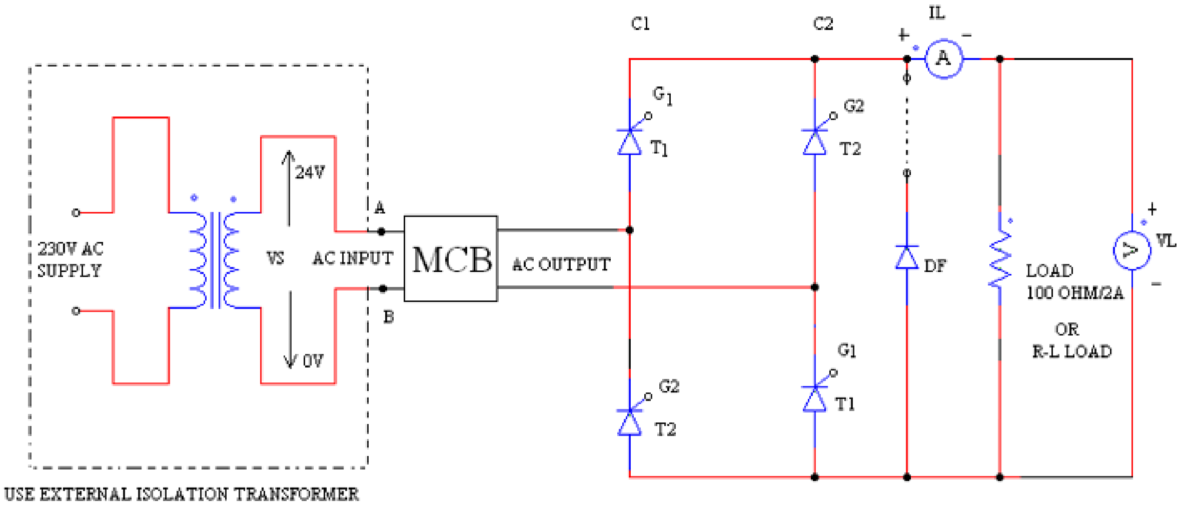


Fig :Single phase fully controlled bridge converter with R-Load

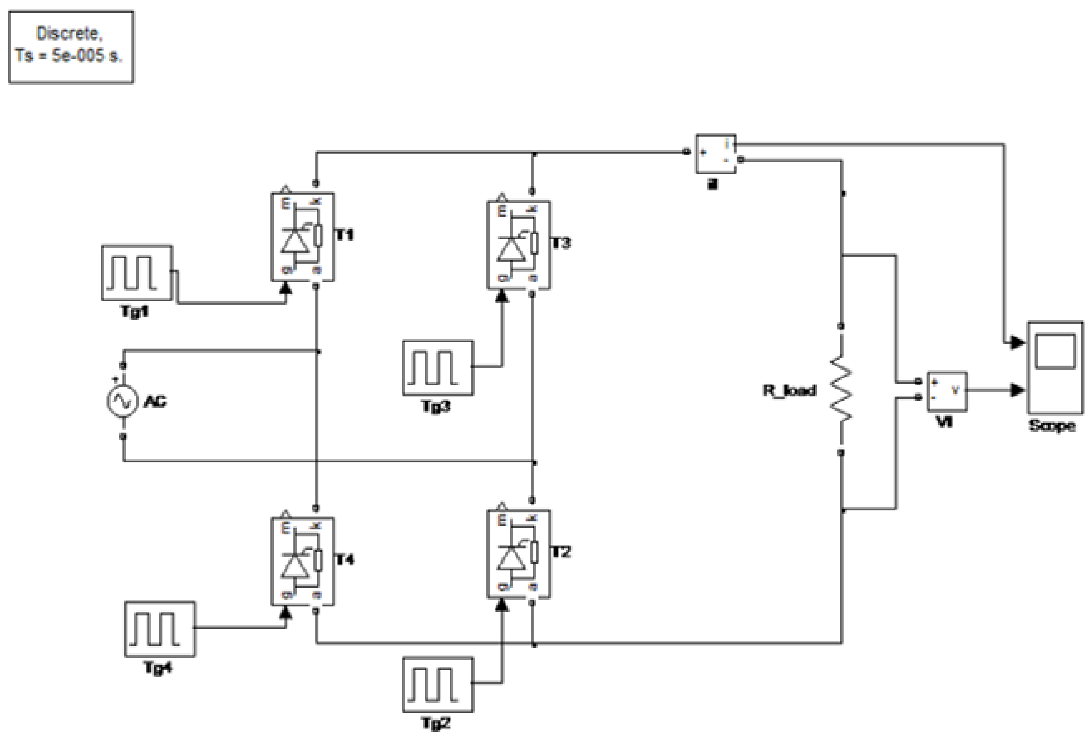


Fig: MATLAB Simulink diagram of Single phase fully controlled bridge converter with R-Load

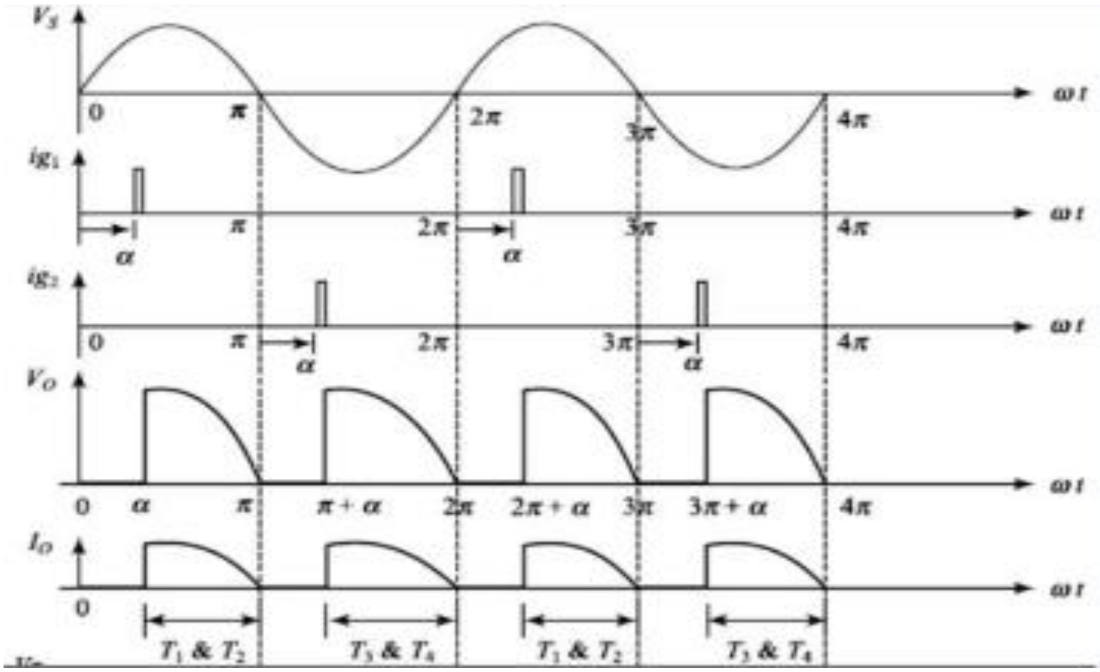


Fig: Output current and voltage waveforms of single phase full bridge rectifier for R-load

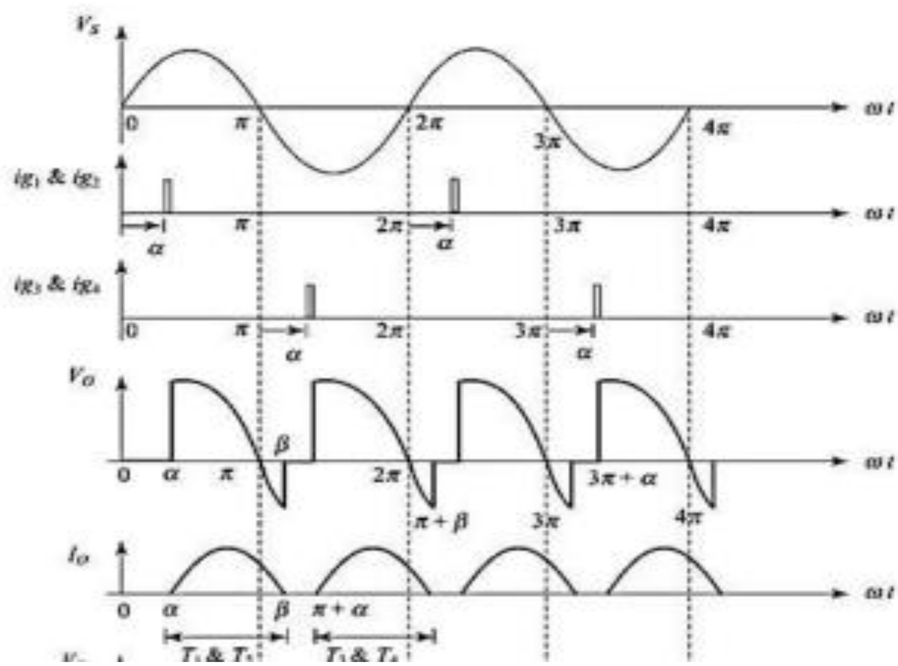


Fig: Output current and voltage waveforms of single-phase full bridge rectifier for RL-Load(discontinuous current)

FULLY CONTROLLED BRIDGE CONVERTER FOR R-L LOAD WITH FREE WHEELING DIODE:

When the single phase fully controlled bridge converter is connected with RL load with freewheeling diode during positive half cycle T_1 and T_1^1 are forward biased. When T_1 and T_1^1 fired at wt=α, the load is connected to the input supply through T_1 and T_1^1 during period $\alpha \le wt \le \pi$. During the period from $\pi \le wt \le (\pi+\alpha)$, the input voltage is negative and freewheeling diode D_F is forward biased, DF conducts to provide the continuity of current in the inductive load. The load current is transferred from T_1 and T_1^1 to $D_F$andthyristor are turned off at wt=π. During negative half cycle of input voltage, thyristor T_2 and T_2^1 are forward biased, and the firing of T2and T_2^1 at wt=π+α will reverse bias D_F. The diode is turned off and the load connected to the supply through T_2 and T_2^1.

This conversion has better power factor due to the freewheeling diode.

The average output voltage can be found from

$$V_{dc\ (av)} = (1/\pi) \int_{\alpha}^{\pi} V_m \sin\Theta \, d\Theta$$

$$= (V_m/\pi) [-\cos\Theta]_{\alpha}^{\pi}$$

$$V_{dc\ (av)} = (Vm/\pi) [1+\cos\alpha]$$

FULLY CONTROLLED BRIDGE CONVERTER FOR R-L LOAD WITH OUT FREEWHEELING DIODE:

When the single phase fully controlled bridge converter is connected with R-L load, during the positive half cycle thyristor T_1 and T_1^1 are forward biased and these two thyristors are fired simultaneously at wt=α, the load is connected to the input supply through T_1 and T_1^1. Due to inductive load T_1 and T_1^1 will continue to conduct till wt=π+α, even though the input voltage is already negative. During negative half cycle of the input voltage, thyristor are forward biased, and firing of thyristors T_2 and T_2^1 at wt= π+α will apply the supply voltage across thyristors T_1 and T_1^1 as reverse blocking voltage. T_1 and T_1^1 will be turned off due to line or natural commutation and load current will be transferred from T_1 and T_1^1 to T_2 and T_2^1.

During the period from α to π, the input voltage Vs and input current is positive, and the power flows from the supply to the load. The converter is said to be operated in rectification mode. During period from π to π+α, the input voltage Vs is negative and the input current is positive, and there will be reverse from the load to the supply. The converter is said to be operated in inversion mode.

The average output voltage can be found from

$$V_{0\ (av)} = (1/\pi) \int_{\alpha}^{\pi+\alpha} V_m \sin\Theta \, d\Theta$$

$$= (V_m/\pi)\ [-\cos\Theta]_{\alpha}^{\pi+\alpha}$$

$$V_{0\ (av)} = (2Vm/\pi)\ [1+\cos\alpha]$$

NOTE:

In case of fully controlled bridge the triggering angle should not increase beyond α_{max} (approx. 150^0) to allow conducting SCR sufficient time to turn off. The maximum value of firing angle is obtained from the relation.

$$E= V_m \sin(\pi+\alpha)$$

$$\text{Therefore } \alpha=\pi-\sin^{-1}(E/V_m)$$

Where E is the counter e.m.f. generated in the inductor.

Procedure:

1. Make the connections as per the circuit diagram.
2. Connect CRO across the load.
3. Keep the potentiometer at the minimum position i.e. at the maximum firing angle position(180^0)
4. Check the gate pulses at G1-K1 & G2-K2, respectively.
5. Switch on the AC Supply
6. Observe the wave form on CRO and note the triggering angle 'α' and note the corresponding reading of the voltmeter and Ammeter. Also note the value of Maximum amplitude Vm from the waveform.
8. Set the potentiometer at different triggering angle positions and follow the step given in (6) for every position.
9. Tabulate the readings in the observation column.

Observation Table:

S.No	Firing angle	Output voltageV_0 (measured)	Output voltage V_0 (theoritical)

CALCULATIONS:

OUTPUT WAVEFORMS

OUTPUT WAVEFORMS

OUTPUT WAVEFORMS

Result:

EXPERIMENT 4

DC-DC BOOST CONVERTER

AIM: To study the open loop analysis of of DC-DC Boost Converter and observe the output waveforms

APPARATUS:

S.no	***Description***	***Quantity***
1	DC-DC Converter Kit	1
2	CRO	1
3	CRO Probes	2
4	Connecting wires	8

THEORY:

A boost converter is also known as a step-up converter. It is a type of DC-DC converter that increases the input voltage to a higher output voltage. Generally, It is used to including power supplies, battery chargers, and renewable energy systems. The boost converter consists of several key components like, an inductor, a diode, a capacitor, and a switch (usually a transistor). These components work together to regulate the voltage and provide a stable output.

The working principles of a boost converter involve the efficient transformation of input voltage to a higher output voltage. It operates through the interaction of key components such as an input voltage source, an inductor, a switch (often a transistor), a diode, and an output capacitor. Understanding its operation typically involves two primary modes: Mode I and Mode II:

Mode I:

During this mode, the switch is on and allows current to flow from the input source to the inductor. The inductor stores energy in the form of a magnetic field. As the current increases, the energy stored in the inductor also increases. The diode remains reverse-biased and in the OFF state, preventing any current flow through it and acting as an open circuit. Mode I primarily focuses on storing energy in the inductor.

Circuit Diagram

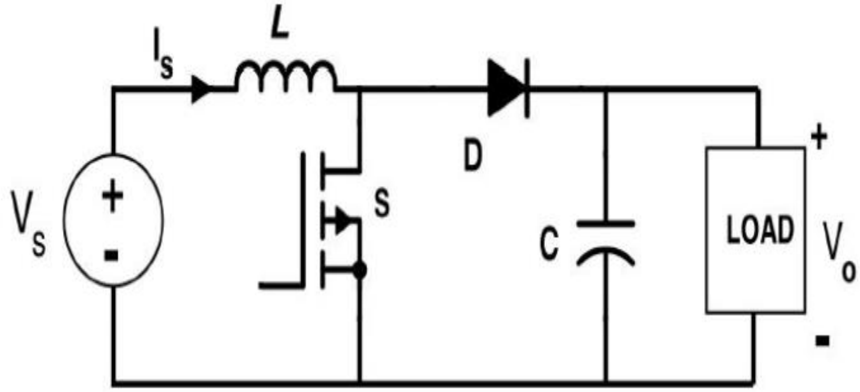


Fig: DC-DC Boost Converter

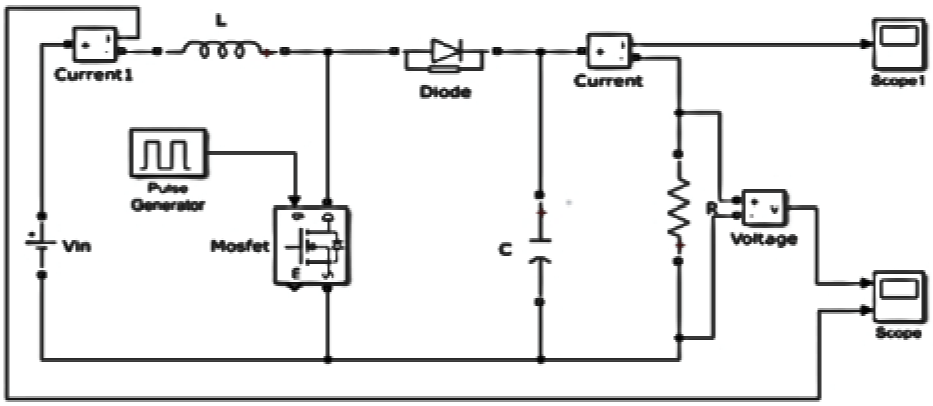


Fig: Matlab Simulink diagram of DC-DC Boost Converter

Mode II:

When the switch is turned off, Mode II begins. In this mode, the diode connected across the inductor becomes forward biased. This allows the inductor to discharge its stored energy into the load. The diode acts as a closed switch, enabling the current to flow in a loop through the inductor, diode, and load. Mode II is important for maintaining a continuous flow of current and energy transfer in the circuit, which ensures that the output voltage remains higher than the input voltage. Boost converters rely on Mode II to step up the input voltage to a higher level by allowing the inductor to discharge its stored energy into the load.

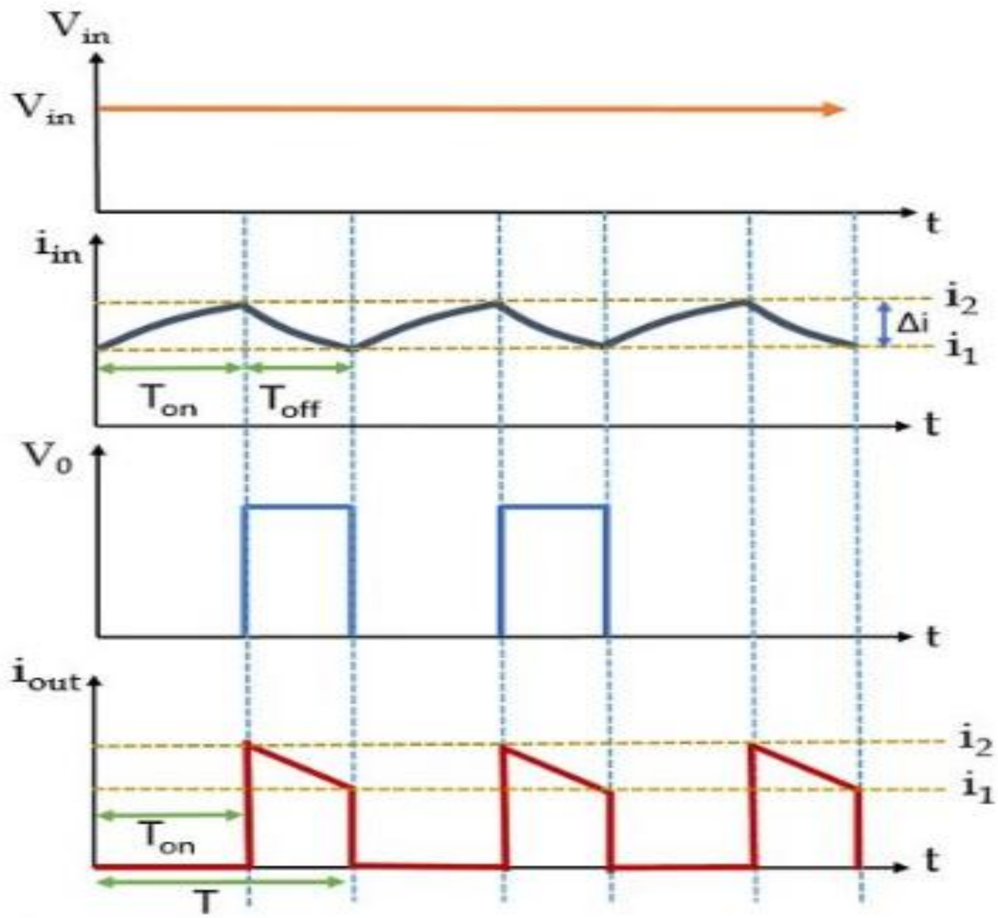
Model Calculation:

T = TON +TOFF = 22 s +33 s = 55 s

D = TON / T = 22/55 =0.4

Vo (calculated) = [D/(1-D)]*Vs = 0.4/(1-0.4)]*3 Vo =1.98V

Calculations:



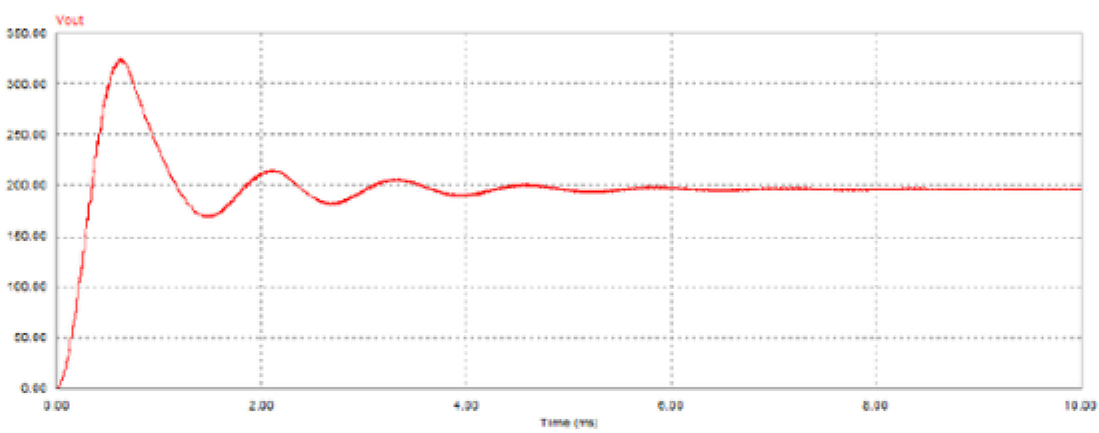


Fig: Output Voltage and Current waveforms of DC-DC Boost converter

Procedure:

1. Make the connections as per the circuit diagram.

2. Switch on the Supply and turn on the RPS and set the required input voltage

3 Turn on the DC-DC Boost converter kit and press the reset button.

3. Select the open loop or closed loop option

4. In open loop select the duty ratio , after selecting the duty ratio, note down the corresponding output voltage and output current values from the voltmeter and ammeter respectively

5. Connect the CRO and observe the wave form on CRO.

OBSERVATIONS:

Boost Converter:

S.No	Vin	Ton	Toff	D=Ton/T	Vo	Output calculated Vo=D*Vs

OUTPUT WAVEFORMS

Result:

EXPERIMENT 5

DC-DC BUCK CONVERTER

AIM: To study the open loop analysis of of DC-DC Buck Converter and observe the output waveforms

APPARATUS:

S.no	***Description***	***Quantity***
1	DC-DC Converter Kit	1
2	CRO	1
3	CRO Probes	2
4	Connecting wires	8

THEORY:

The buck converter is a form of DC to DC converter that can take an input directly from a DC source, such as a battery. The input could also be DC derived from the AC mains (line) as shown in Fig. 3.1.1 via a rectifier/reservoir capacitor circuit. The AC input to the rectifier circuit could be AC at high voltage directly from the AC mains supply, or alternatively at a lower voltage via a step-down transformer. However the DC applied to the Buck Converter is obtained, it is then converted to a high frequency AC, using a switching or 'chopper' transistor, driven by a (usually pulse width modulated) square wave. It operates in two modes

Mode I:

when the switch is on, it is supplying the load with current. Initially current flow to the load is restricted as energy is also being stored in L1, therefore the current in the load and the charge on C1 builds up gradually during the 'on' period. Notice that throughout the on period, there will be a large positive voltage on D1 cathode and so the diode will be reverse biased and therefore play no part in the action.

Mode II:

When the transistor switches off , the energy stored in the magnetic field around L1 is released back into the circuit. The voltage across the inductor (the back e.m.f.) is now in reverse polarity to

CIRCUIT DIAGRAM

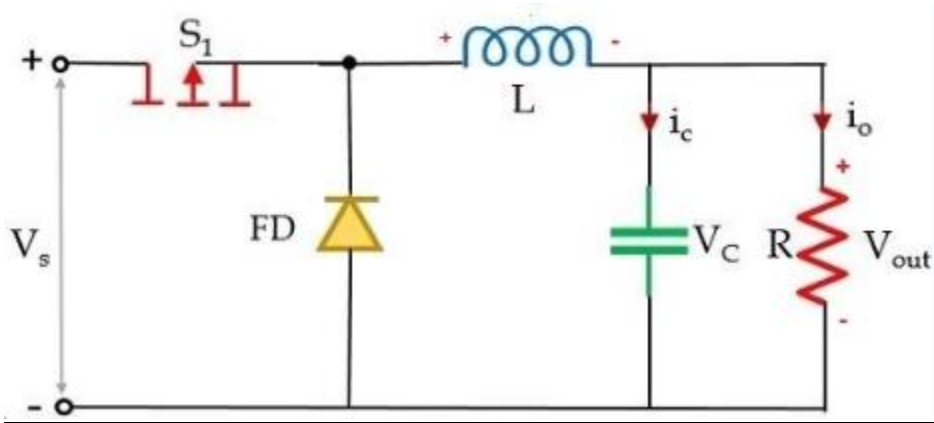


Fig: DC-DC Buck Converter

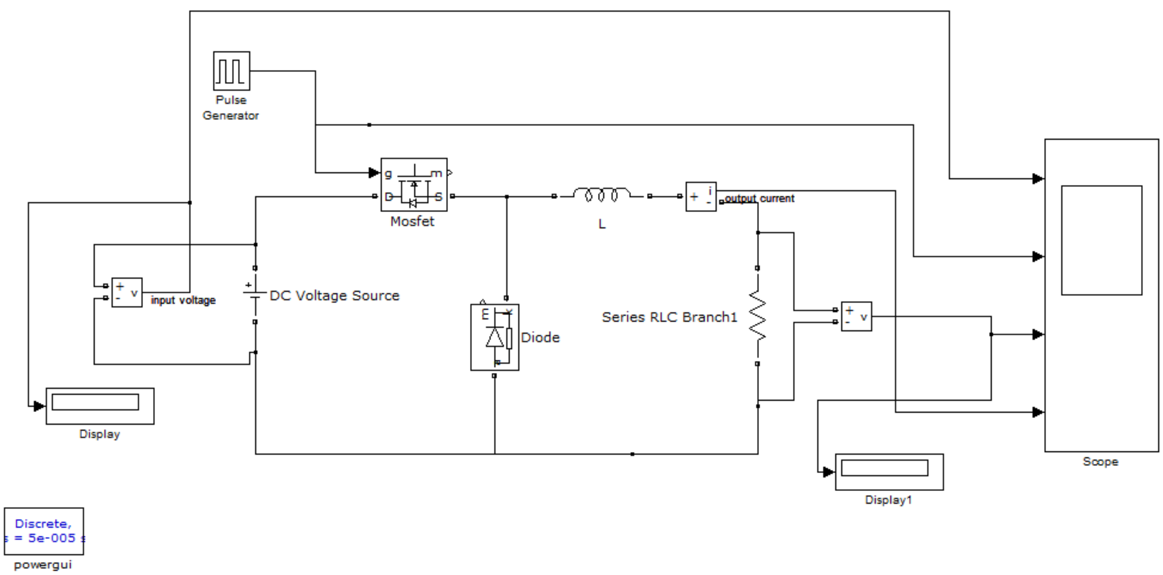
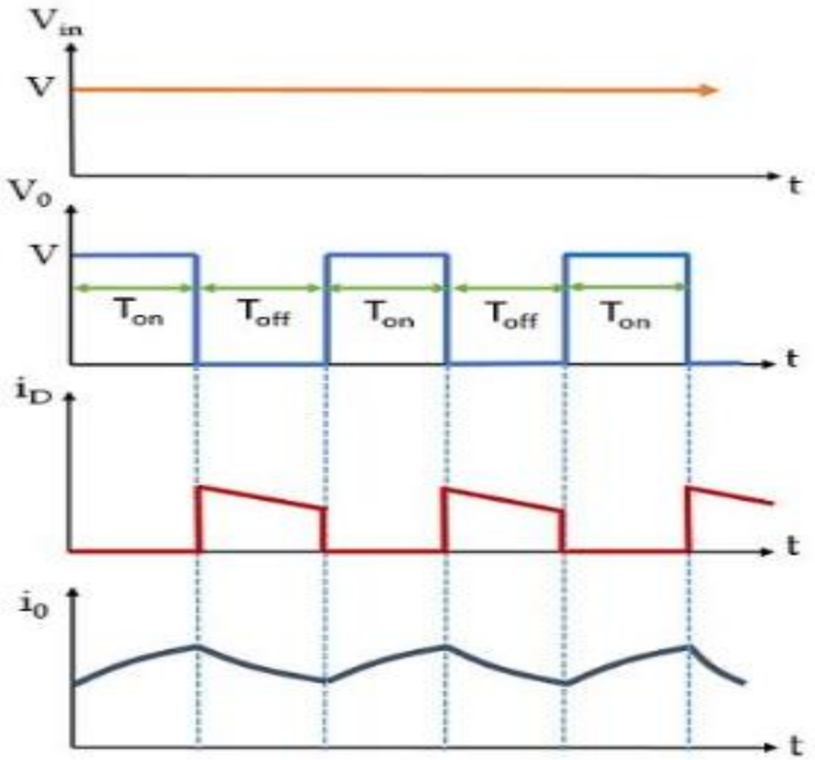


Fig: Matlab Simulink diagram of DC-DC Buck converter the voltage across L1 during the 'on' period, and sufficient stored energy is available in the collapsing magnetic field to keep current flowing for at least part of the time the transistor switch is open.

Once the inductor has returned a large part of its stored energy to the circuit and the load voltage begins to fall, the charge stored in C1 becomes the main source of current, keeping current flowing through the load until the next 'on' period begins.



Procedure:

1. Make the connections as per the circuit diagram.

2. Switch on the Supply and turn on the RPS and set the required input voltage

3 Turn on the DC-DC Buck converter kit and press the reset button.

3. Select the open loop or closed loop option

4. In open loop select the duty ratio, after selecting the duty ratio, note down the corresponding output voltage and output current values from the voltmeter and ammeter respectively

5. Connect the CRO and observe the wave form on CRO.

OBSERVATIONS:

Boost Converter:

S.No	Vin	Ton	Toff	D=Ton/T	Vo	Output calculated Vo=D*Vs

Calculations:

OUTPUT WAVEFORMS

Result:

EXPERIMENT 6

SINGLE PHASE FULL BRIDGE INVERTER

AIM: To study the performance of a single-phase full bridge inverter with R & RL -load.

APPARATUS:

S.no	Description	Quantity
1	Power Electronics Trainer Kit	1
2	CRO	1
3	CRO Probes	2
4	Connecting wires	8

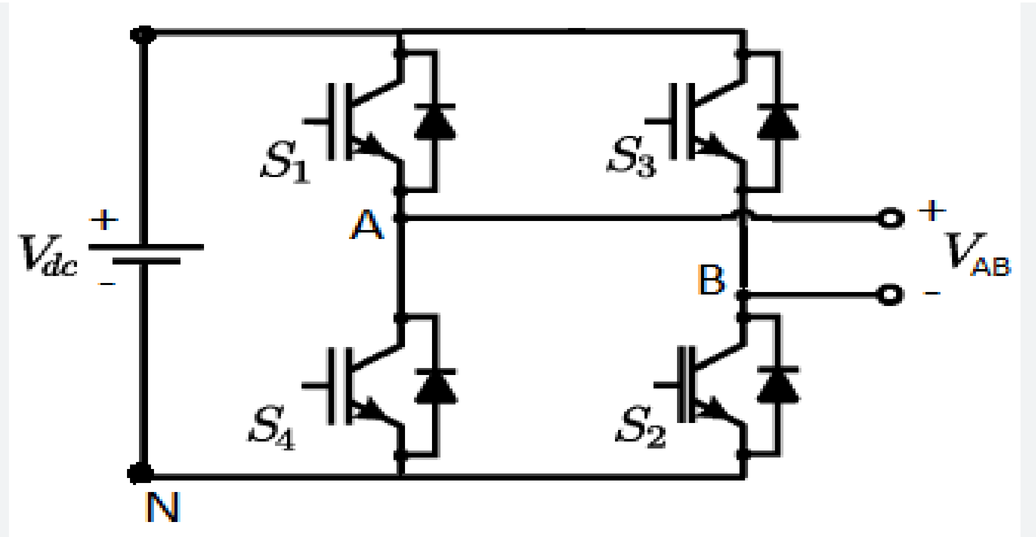


Fig: Single phase full bridge inverter

THEORY:

In the full bridge inverter thyristors SCR1, SCR2, SCR3 & SCR4 are connected in series with the source. During inverter operation it should be ensured that two SCRs in the same branch such as SCR1 & SCR2 do not conduct simultaneously as this would lead to a direct short circuit of the source.

For a full bridge inverter thyristors SCR1 and SCR2 conduct for positive half cycle and SCR3 & SCR4 for conduct for negative half cycle.

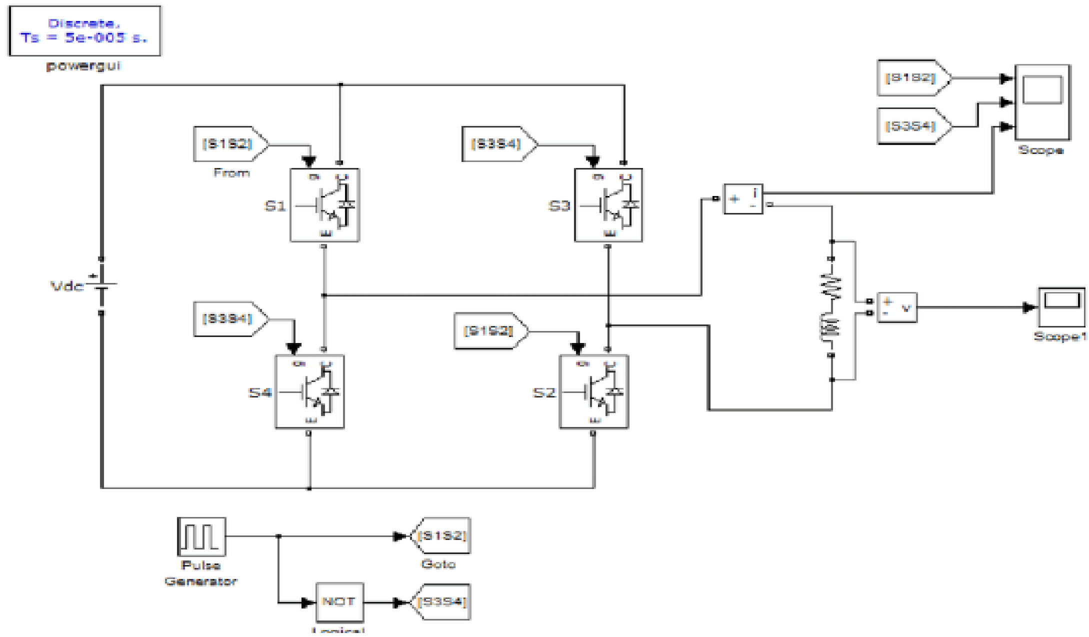


Fig: Matlab Simulink diagram of Single phase full bridge inverter

MODEL WAVEFORMS:

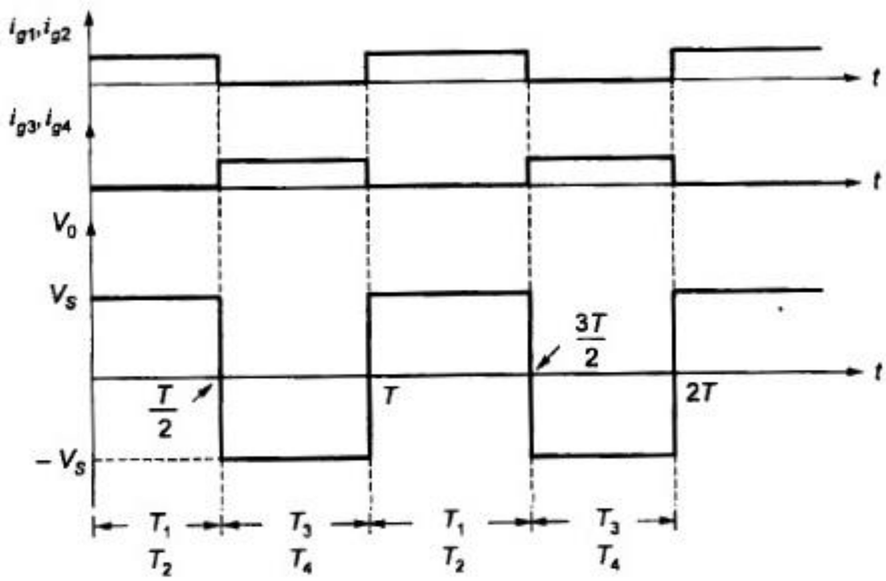


Fig Output voltage waveform of single phase full bridge inverter with R-Load

Procedure:

1. Make the connections as per the circuit diagram.
2. Switch on the Supply and turn on the RPS and set the required input voltage

3 Turn on the inverter converter kit and press the reset button.

3. Select the open loop or closed loop option
4. In open loop select the duty ratio , after selecting the duty ratio, note down the corresponding output voltage and output current values from the voltmeter and ammeter respectively
5. Connect the CRO and observe the wave form on CRO.

Model calculations:

- The fundamental RMS output voltage obtained from

$$V_{01(rms)} = \frac{4V_S}{\pi\sqrt{2}} = 0.90V_S$$

- RMS output voltage is $V_{0(rms)} = \sqrt{\frac{2}{\pi}\int_0^{\pi} V^2 s\, d\theta} = V_S$
- Fourier series of output voltage $V_0 = \left(\sum_{n=1,3,5,..}^{\infty} \frac{4V_S}{n\pi}\sin(n\omega t)\right)$

= 0 for n=2,4....

- For an RL load instantaneous load current i_0 is

$$i_0 = \sum_{n=1,3,5....}^{\infty} \frac{4V_S}{n\pi\sqrt{(R)^2 + (n\omega L)^2}} \sin(n\omega t - \theta_n)$$

OUTPUT WAVEFORMS

EXPERIMENT 7

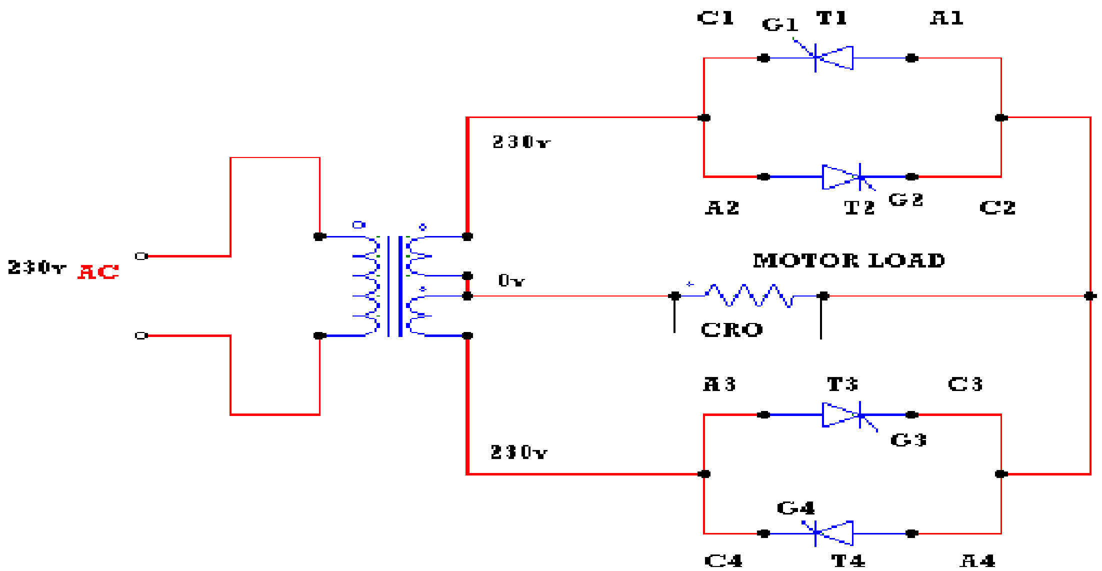
SINGLE PHASE CYCLO CONVERTER

AIM: To construct a single phase cycloconverter circuit and study its performance.

APPARATUS:

230V input 150V-0-15V output AC step down transformer (provided within the unit), cycloconverter power circuit with firing circuit, loading rheostat 100 ohms/2A. Digital multimeter, CRO, Path cards etc.

CIRCUIT DIAGRAM:



THEORY:

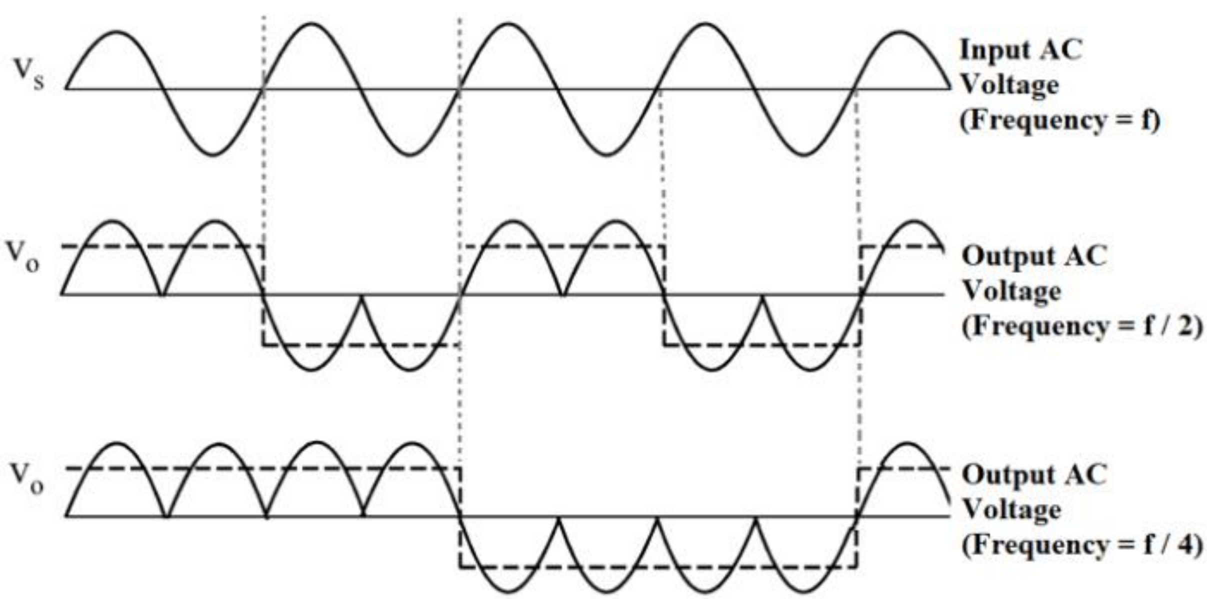
A cycloconverter converts input power at one frequency to output power at a different frequency with one stage conversion. cycloconverter is used in speed control of high power AC drives , induction heating etc.

The circuit shown is for obtaining single phase frequency divided output from a single phase AC input. One group of SCR's produces positive polarity load voltage and other group produces negative half cycle of the output. SCR's T_1 and T_3 of the positive group are gated together depending on the polarity of the input, only one of them will conduct, when upper AC terminal is positive with respect to O, SCR T_1will conduct and when upper AC terminal is negative, SCR T_3will conduct thus in both half cycles of input, the load voltage polarity will be positive by changing firing angle, the duration of conducting of each SCR (and there by the magnitude of the output voltage) can be varied. For the sake of simplicity it is assumed that the load is positive. Then each SCR will have a conduction angle of (π –α) and turn off by natural commutation at the end of every half cycle of the input. At the end of each half period of the output, the firing pulses to the SCR's of the positive group will be stopped and SCR's T2 and T_4 of the negative group will be fired.

PROCEDURE:

1. The connections are made as shown in the circuit of single phase cycloconverter with Motor Load with divided by 2 frequency.
2. The gate cathode terminals of the thyristors are connected to the respective points on the firing module.
3. Check all the connections and confirm connections made are correct before switching on the equipments.
4. Switch ON unit.
5. The output wave forms are seen on a CRO.
6. The firing angle is varied and AC output voltage across the load is noted.
7. A graph of V_{ac}verses load voltage is plotted.
8. Repeat the above procedure for divided by four frequency.

Model Waveforms:



OBSERVATIONS:

Frequency divided by 2

Sl.No	Firing angle α(in degrees)	Load voltage in volts using AC voltmeter in volts	RPM
1.	180^o		
2.	150^o		
3.	120^o		
4.	90^o		
5	60^o		
6	30^o		
7	0^o		

OUTPUT WAVEFORMS

RESULT:

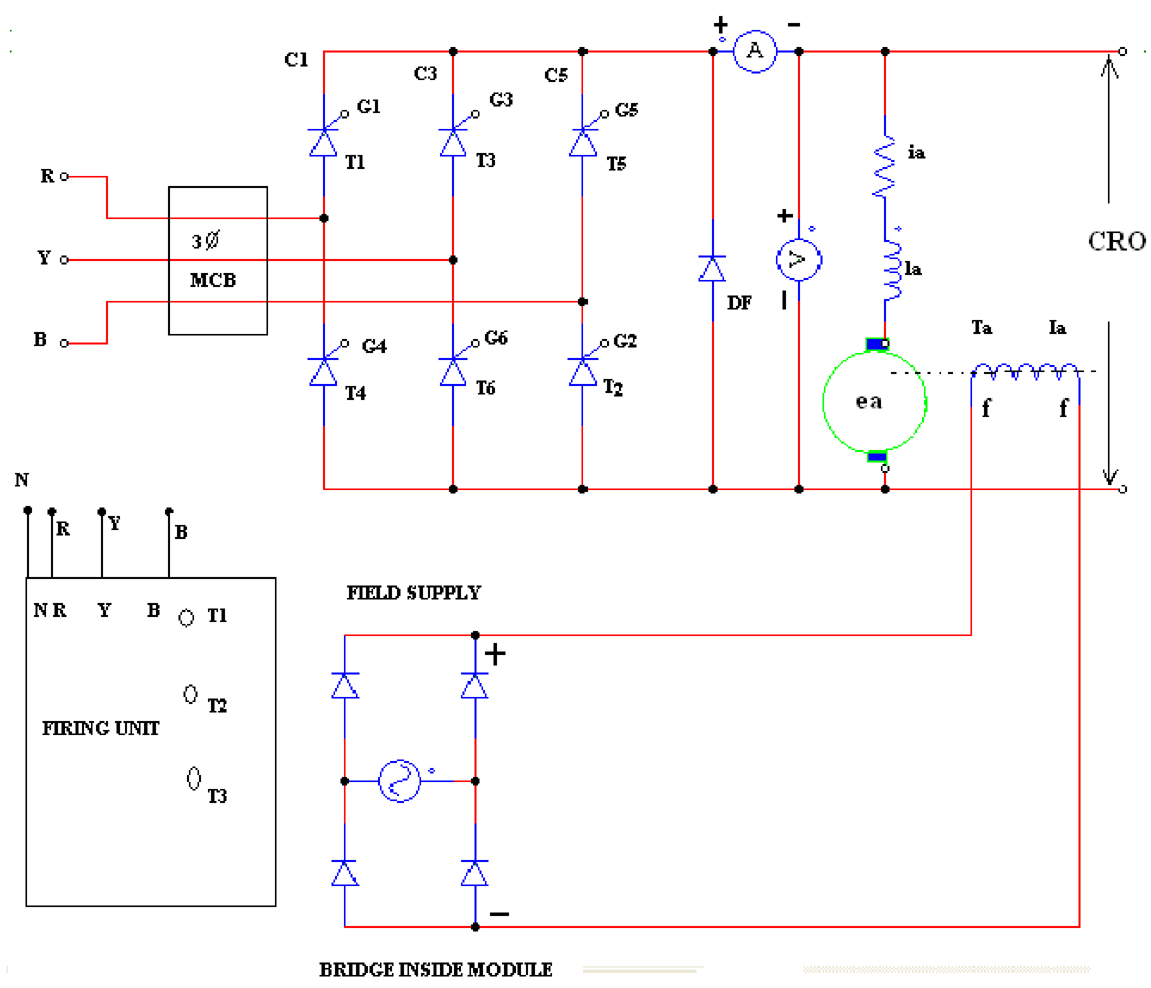
EXPERIMENT 8

THREE PHASE INPUT THYRISTORISED DRIVE FOR DC MOTOR WITH CLOSED LOOP CONTROL

AIM: To construct a three phase fully controlled full wave bridge rectifier and to control speed of the DC motor.

APPARATUS: 415 V input, 185V output or any suitable isolation transformer, controlled rectifier module, firing unit, DC shunt motor, patch cards etc.,

CIRCUIT DIAGRAM:



THEORY:

A three phase full wave controlled rectifier consists of three single phase full wave controlled rectifiers connected in such a way that all the three phase voltages are used for DC power production. Each singlephase full wave controlled rectifier contains two thyristors or transistors which act as electrically controlled switches. When gate pulses are applied to thyristors, it starts conducting immediately and allows current to flow in one direction only.

The thyristors are numbered in the circuit diagram corresponding to the order in which they are triggered. The trigger sequence (firing sequence) of the thyristors is 12, 23, 34, 45, 56, 61, 12, 23, and so on.

$$V_{O(dc)} = V_{dc} = \frac{6}{2\pi} \int_{\frac{\pi}{6}+\alpha}^{\frac{\pi}{2}+\alpha} v_O . d\omega t \qquad ;$$

$$v_O = v_{ab} = \sqrt{3} V_m \sin\left(\omega t + \frac{\pi}{6}\right)$$

$$V_{dc} = \frac{3}{\pi} \int_{\frac{\pi}{6}+\alpha}^{\frac{\pi}{2}+\alpha} \sqrt{3} V_m \sin\left(\omega t + \frac{\pi}{6}\right) . d\omega t$$

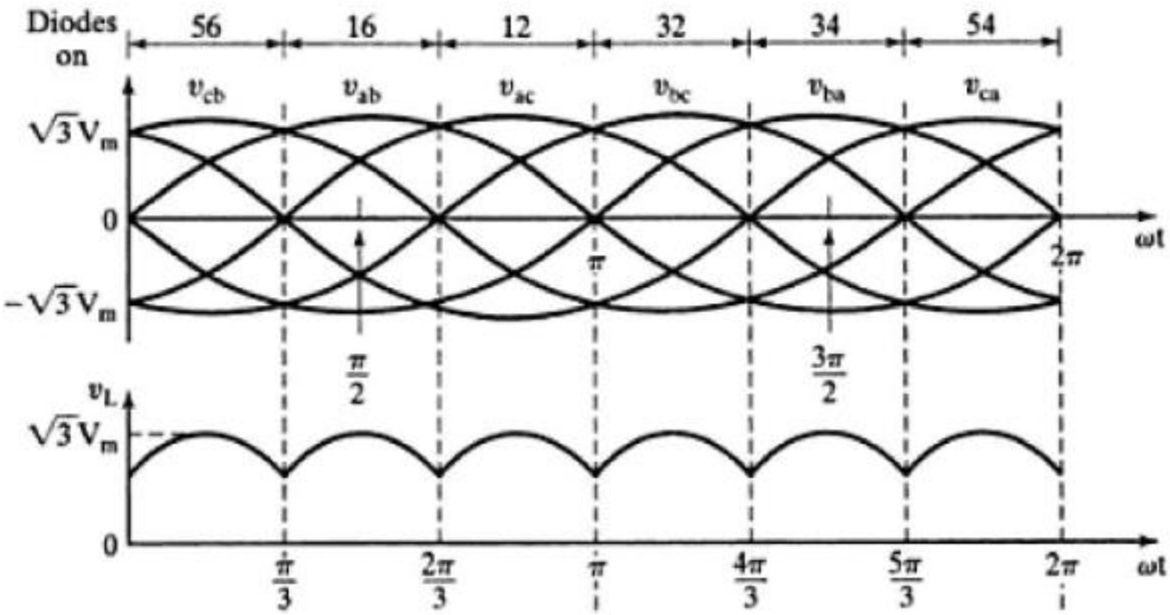
$$V_{dc} = \frac{3\sqrt{3} V_m}{\pi} \cos\alpha = \frac{3 V_{mL}}{\pi} \cos\alpha$$

PROCEDURE:

1. Connect motor terminals (field & armature) to respective points in the power circuit & speed sensor to feedback socket.
2. Circuit connections are made as shown in the circuit diagram.
3. Connect 3 pin power cards from power unit (rectifier) to the mains supply.
4. Switch on the field supply of the motor.
5. Switch on the three phase power input.
6. Switch on the power circuit through MCB.
7. Keeping PID OFF now switch on the firing unit.
8. Set the rpm through the knob.
9. Switch on P, I, D switches, adjust the gains.
10. Load the motor up to 3 to 4A load. Note down the speed for different loads.

11. Switch off power circuit by MCB, switch off firing circuit, switch off field supply & remove the connections.

MODEL WAVEFORMS:



TABULAR COLUMN:

Set RPM =

SL. NO.	Load Current	Load Voltage	Running rpm
1.			
2.			
3.			
4.			

Note: Field supply must be switched on before applying voltage to armature.

RESULT:

EXPERIMENT 9

R, RC & UJT firing circuits.

AIM: To trigger an SCR by using R, RC & UJT triggering circuits and observe the output waveforms for different firing angles.

APPARATUS: -

S.no	Description	Quantity
1	Triggering circuit Kit	1
2	Unearthed C.R.O	1
3	Connecting probes	1

PROCEDURE:

Resistance firing circuit:

(1) Apply 12V of AC input to the anode and cathode of SCR terminals from a step-down transformer.

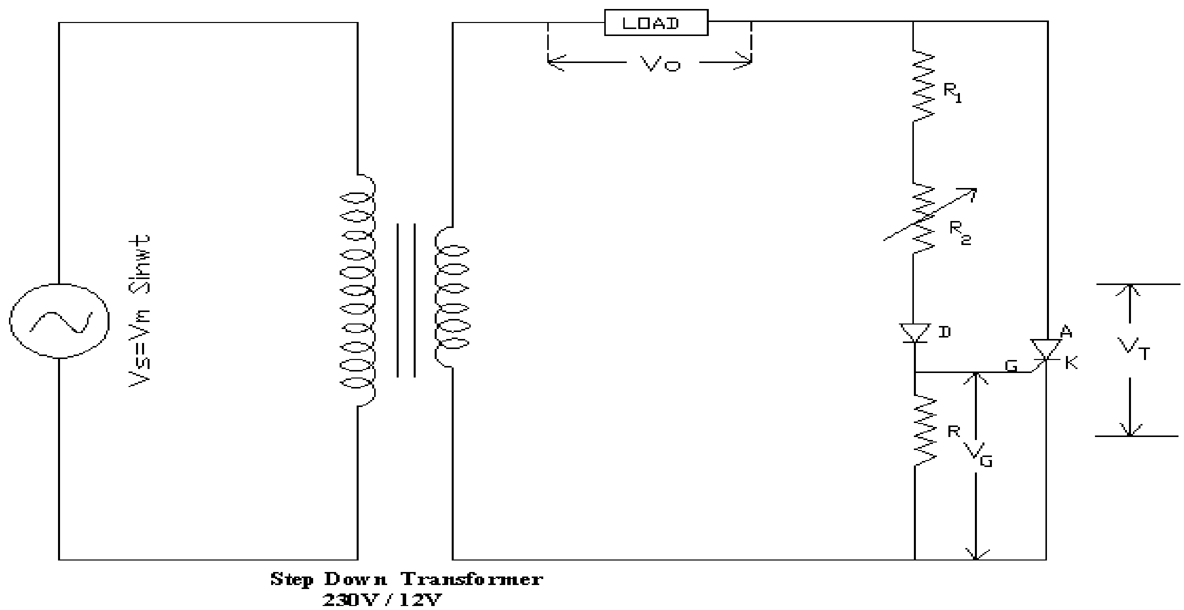
(2) Connect the anode, cathode & gate terminals of SCR to the corresponding A, K, G terminals in the R – Triggering circuit.

(3) Connect the load of 50Ω/2A between the load terminals.

(4) Observe the variations in the voltage across the load for different firing angles (by varying potentiometer) with the help of CRO, plot waveforms of firing signals & output voltage for firing angle 45^0, 90^0.

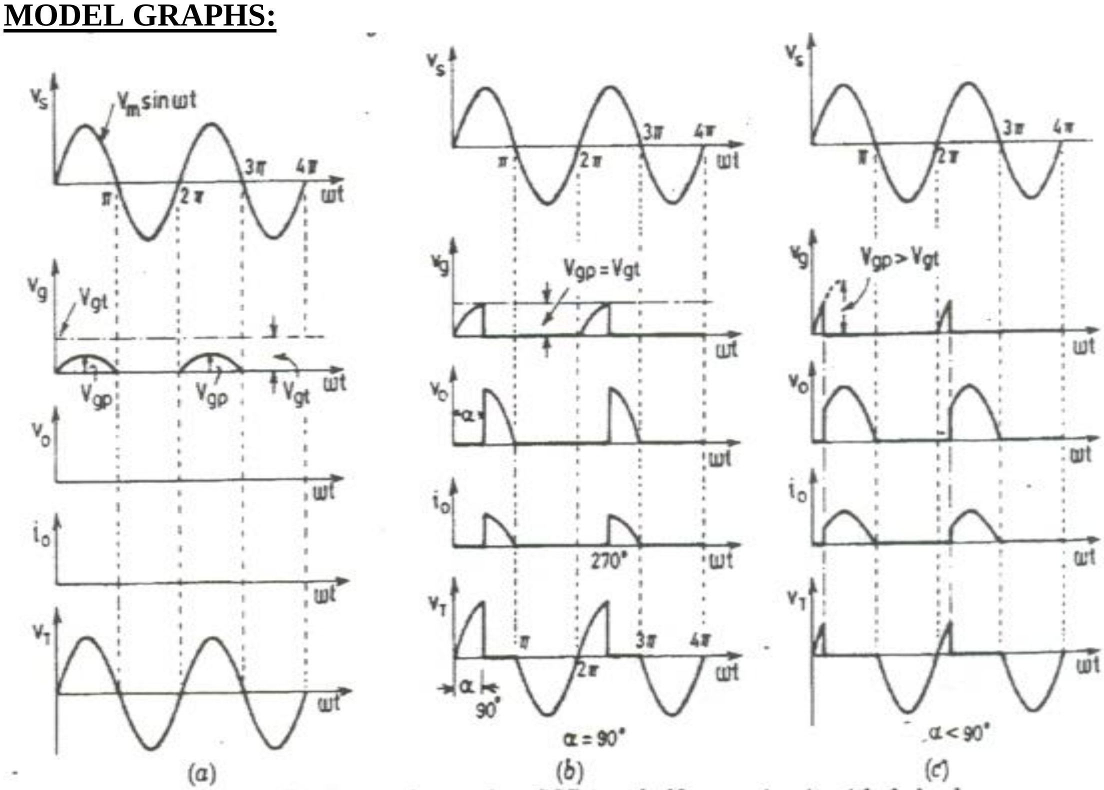
CIRCUIT DIAGRAM:

R- Triggering:



Circuit Diagram to obtain Resistance Triggering

MODEL GRAPHS:



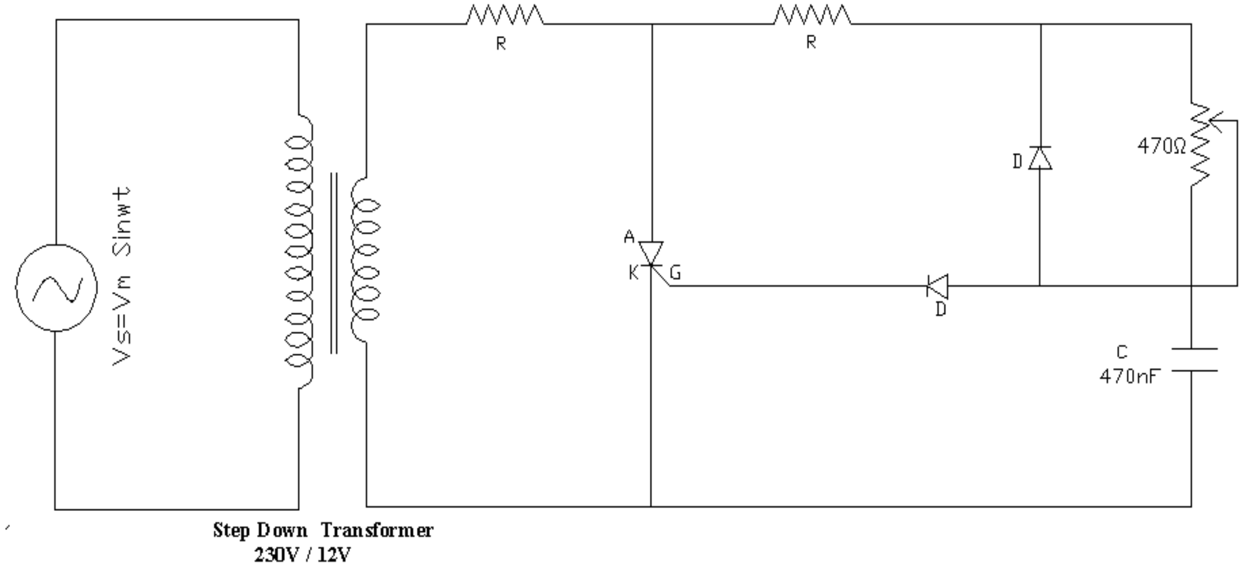
RC firing circuits:

1. Apply 12V of AC input to the anode and cathode of SCR terminals from a step down transformer.

2. Connect the anode, cathode & gate terminals of SCR to the corresponding A, K, G terminals in the R – Triggering circuit.

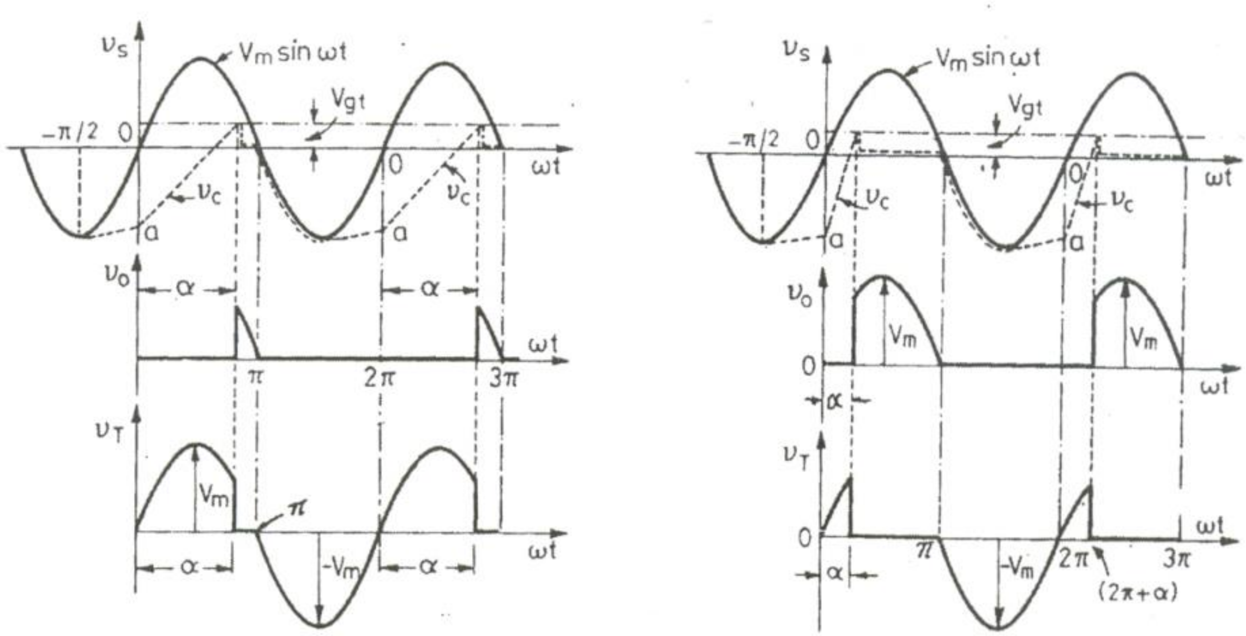
3. Connect the load of 50Ω/2A between the load terminals.

4. Observe the variations in the voltage across the load for different firing angles (by varying potentiometer) with the help of CRO, plot waveforms of firing signals & output voltage for firing angle 45^0, 180^0.



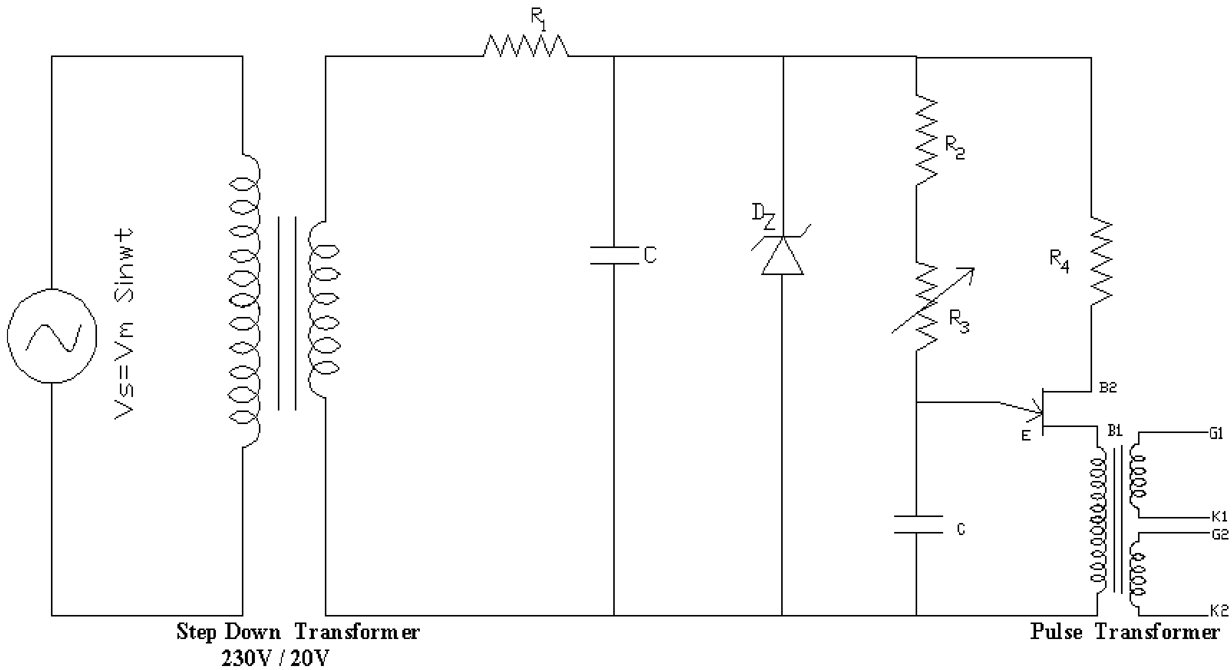
Circuit Diagram to obtain RC Triggering

<u>MODEL GRAPHS:</u>



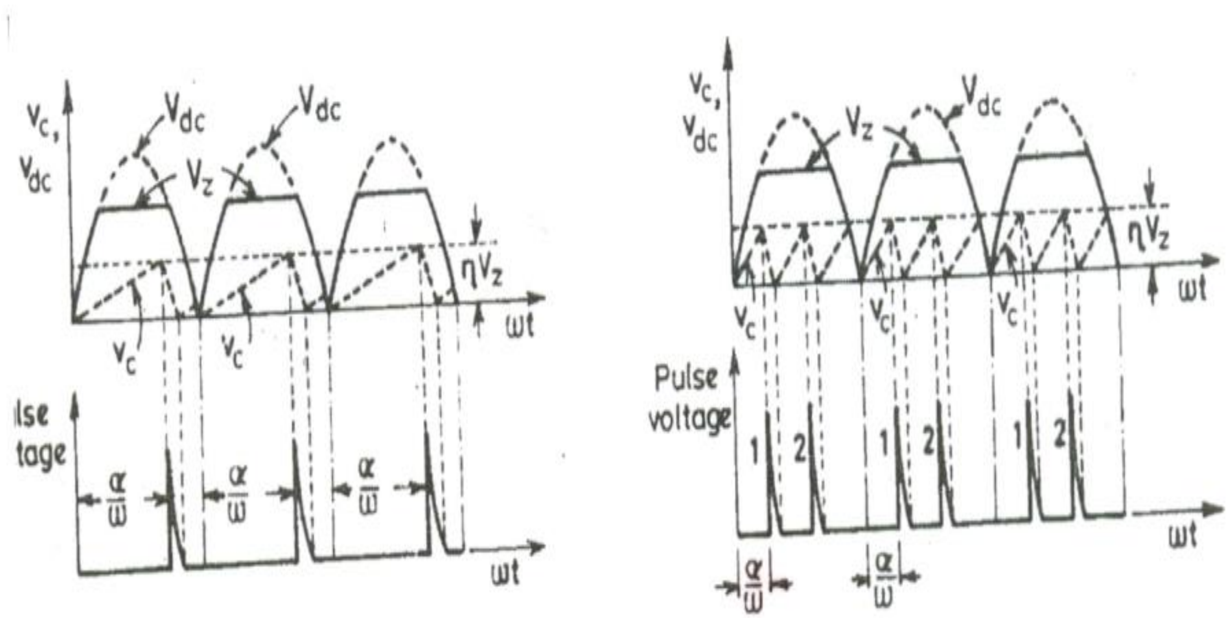
(a) (b)

UJT Firing Circuits



Circuit Diagram to obtain UJT Triggering

Model Graphs:



UJT firing circuit:

1. Apply 12V of AC input to the anode and cathode of SCR terminals from a step down transformer.
2. The rectified output is applied to the UJT terminals through the résistance as shown in the circuit diagram.
3. Connect the cathode & gate terminals of SCR to the corresponding K, G terminals in the UJT – Triggering circuit.
4. Connect the load of 50Ω/2A between the load terminals.
5. Switch ON the supply for UJT Triggering circuit.
6. Observe the variations in the voltage across the load for different firing angles (by varying potentiometer) with the help of CRO, plot waveforms of firing signals & output voltage for firing angle 45^0, 180^0.

<u>PRECAUTIONS:</u>

(1) Initially the potentiometer should be in minimum resistance position.
(2) Vary the Potentiometer gradually.
(3) Observe the output waveforms carefully on the CRO

OUTPUT WAVEFORMS

Output Waveforms:

Result:

EXPERIMENT 10

SINGLE PHASE AC VOLTAGE CONTROLLER WITH R&RL LOAD

AIM: To study the performance of a single phase AC Voltage controller with RL-load.

APPARATUS: MATLAB -SIMULINK

CIRCUIT DIAGRAM:

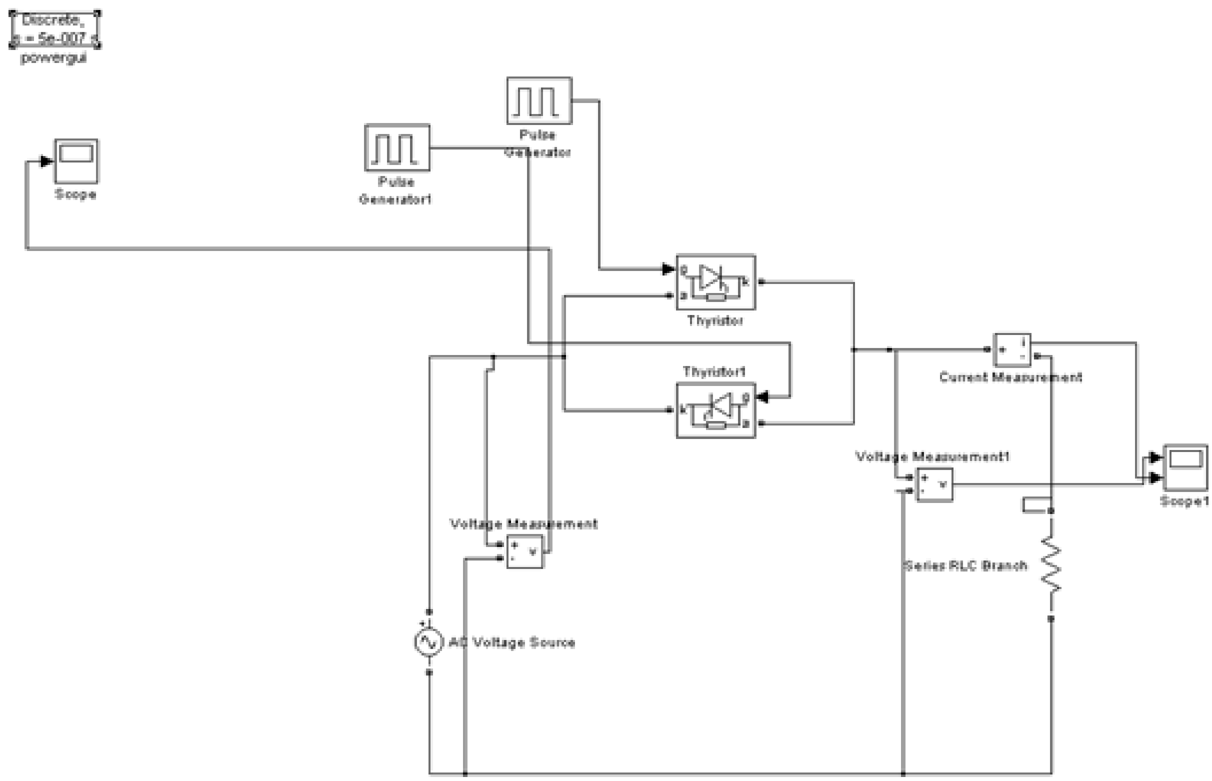
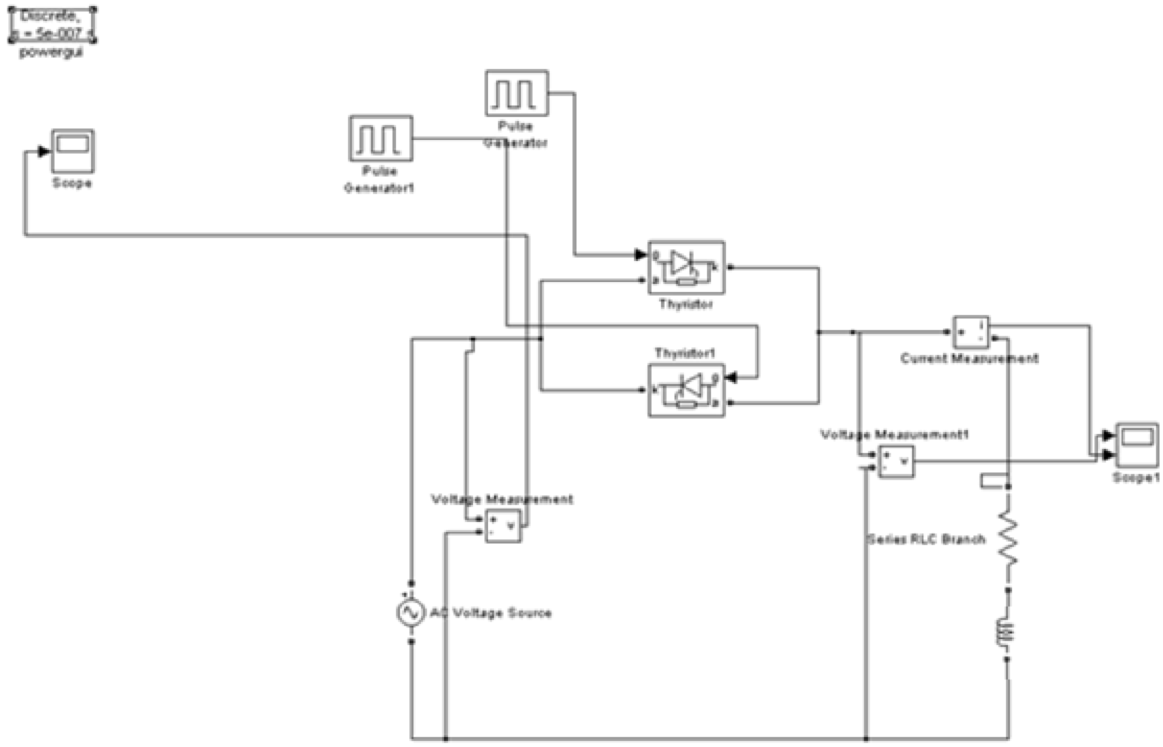


Fig: Single Phase AC Voltage Controller Using R Load



Single Phase AC Voltage Controller Using RL Load

THEORY:

The AC regulators are used to obtain a variable AC output voltage from a fixed AC source. A single phase AC regulator is shown in the figure. It consists of two SCRs connected in anti-parallel. Instead of two SCRs connected in antiparallel, a TRIAC may also be used. The operation of the circuit is explained with reference to RL load. During positive half-cycle SCR-1 is triggered into conduction at a firing angle. The current raises slowly due to the load inductance. The current continues to flow even after the supply voltage reverses polarity because of the stored energy in the inductor. As long as SCR-1conducts, conduction drop across it will reverse bias SCR-2.Hence SCR-2 will not turn on even if gating signal is applied. SCR-2 can be triggered into conduction during negative half cycle after SCR-1 turns off.

PROCEDURE:

1. Connect the circuit as shown in the circuit diagram.

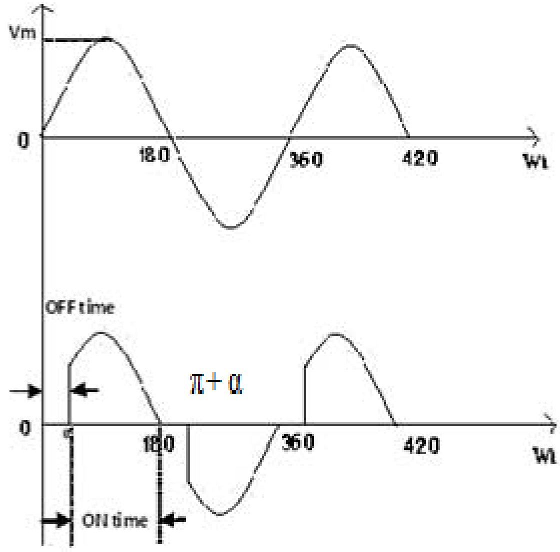
2. Give the firing pulses accordingly at a suitable firing angle from the firing circuit.

3. Draw the waveforms and calculate the RMS value of output voltage.

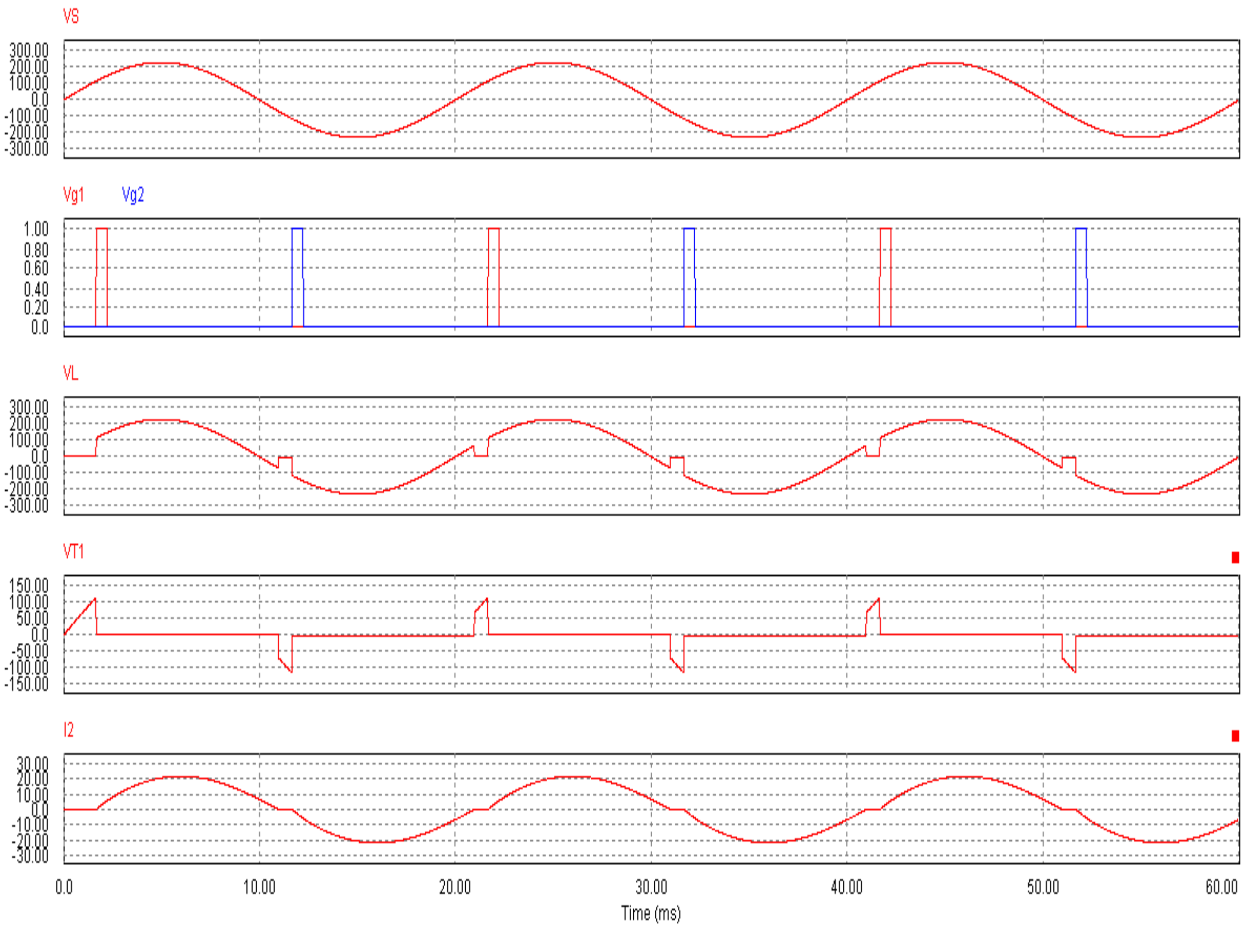
CALCULATIONS:

MODEL WAVEFORMS:

R-LOAD



RL- LOAD



GRAPH SHEET:

GRAPH SHEET:

RESULT:

Experiment 11

THREE PHASE HALF CONTROLLED BRIDGE CONVERTER

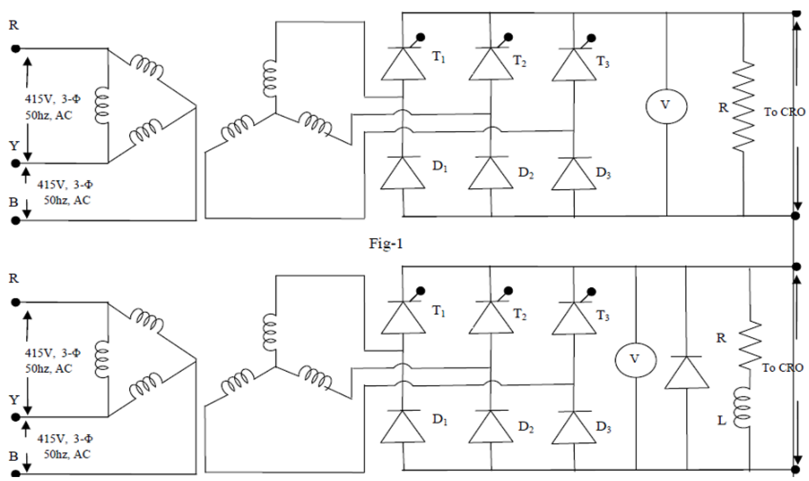
AIM: To obtain the output waveforms of three-phase full wave half-controlled bridge rectifier with R and RL load and with or without commutating or freewheeling Diode.

APPARATUS: MATLAB Simulink

THOERY:

The three phase half controlled converter has several other advantages over a three phase fully controlled converter. For the same firing angle it has lower input side displacement factor compared to a fully controlled converter. It also extends the range of continuous conduction of the converter. It has one serious disadvantage however. The output voltage is periodic over one third of the input cycle rather than one sixth as is the case with fully controlled converters. This implies both input and output harmonics are of lower frequency and require heavier filtering. For this reason half controlled three phase converters are not as popular as their fully controlled counterpart.

CIRCUIT DIAGRAM:

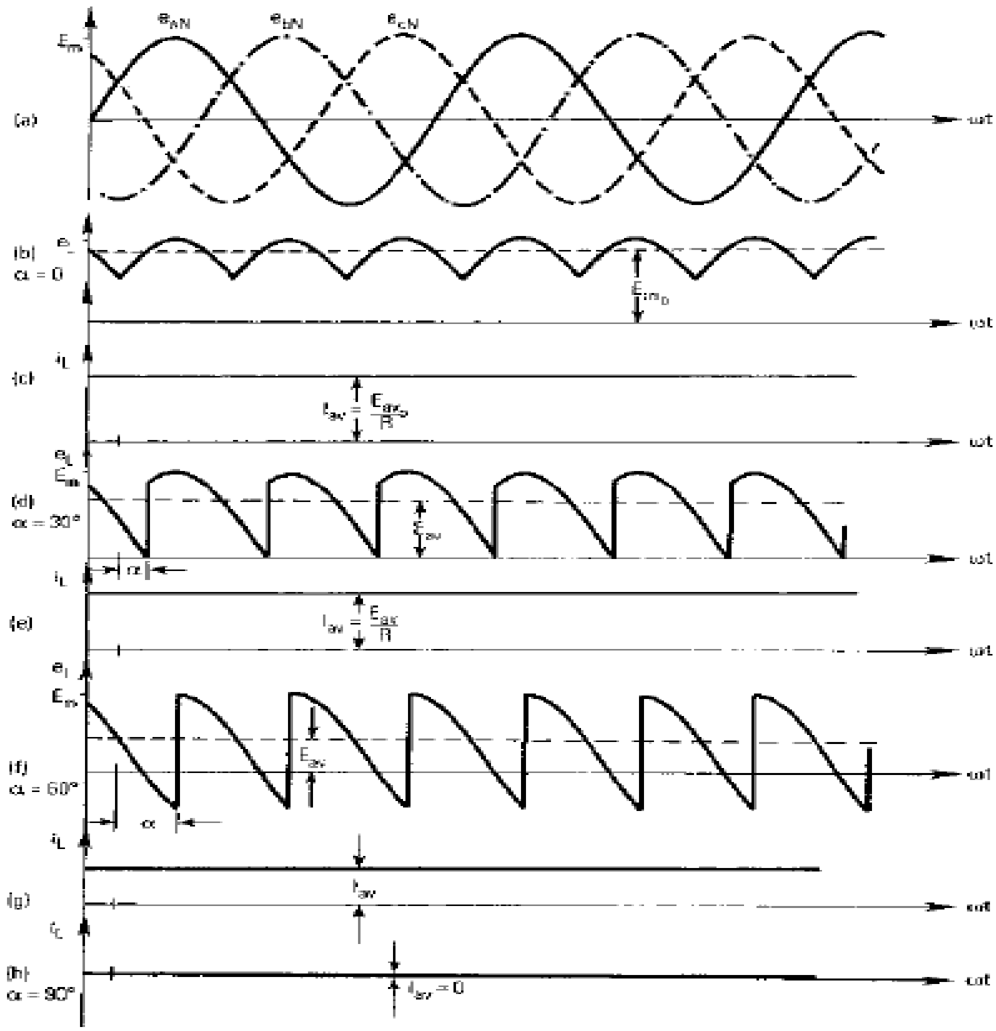


Procedure:

1. Make the connections as per the circuit diagram.

2. Observe the waveforms and draw the waveforms

Model Graphs:



Output waveforms:

Result:

EXPERIMENT 12

DC-DC BUCK BOOST CONVERTER

AIM: To study the open loop analysis of of DC-DC Buck Boost Converter and observe the output waveforms

APPARATUS: MATLAB Simulink

THEORY:

This converter is an inverting DC-DC converter i.e. polarity of the output voltage is reversed compared to the input supply. Thus, it is a negative-output buck-boost converter. Let the capacitor be totally charged up before switching on the switch S. When the switch S is closed as shown in Fig. 13,

$-V_S + V_L = 0$

$\Rightarrow VS=VL=Ldidt$

Also,

$-V_C + V_O = 0$

$\Rightarrow VO=VC$

Now, when the switch S is opened as given in Fig. 14,

$+V_L + V_C = 0$

$L\ di/dt+ VC=0$

$di/dt=-VCL$

Circuit Diagram

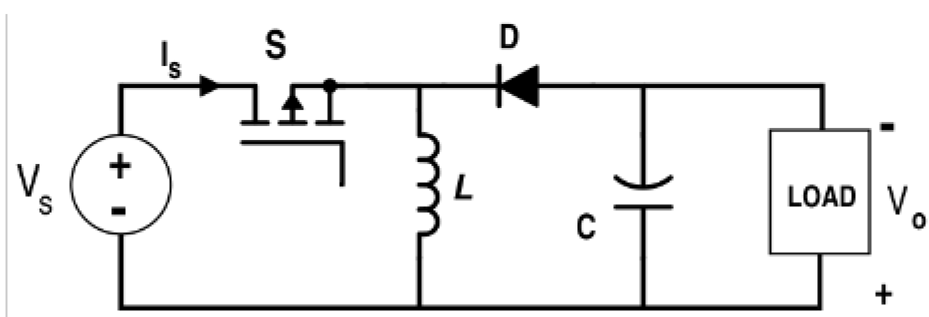


Fig: DC-DC Buck Boost Converter

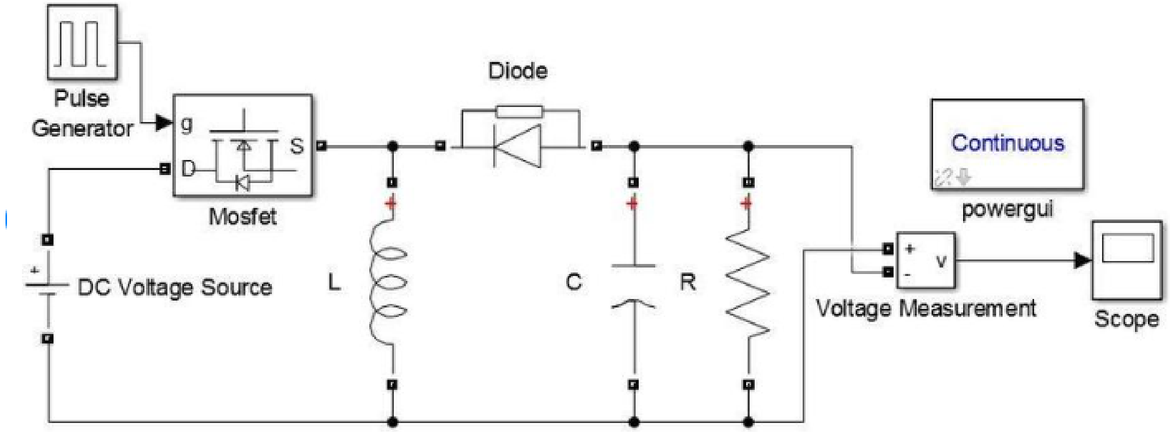


Fig: Matlab Simulink diagram of DC-DC Buck Boost Converter

MODEL WAVEFORMS:

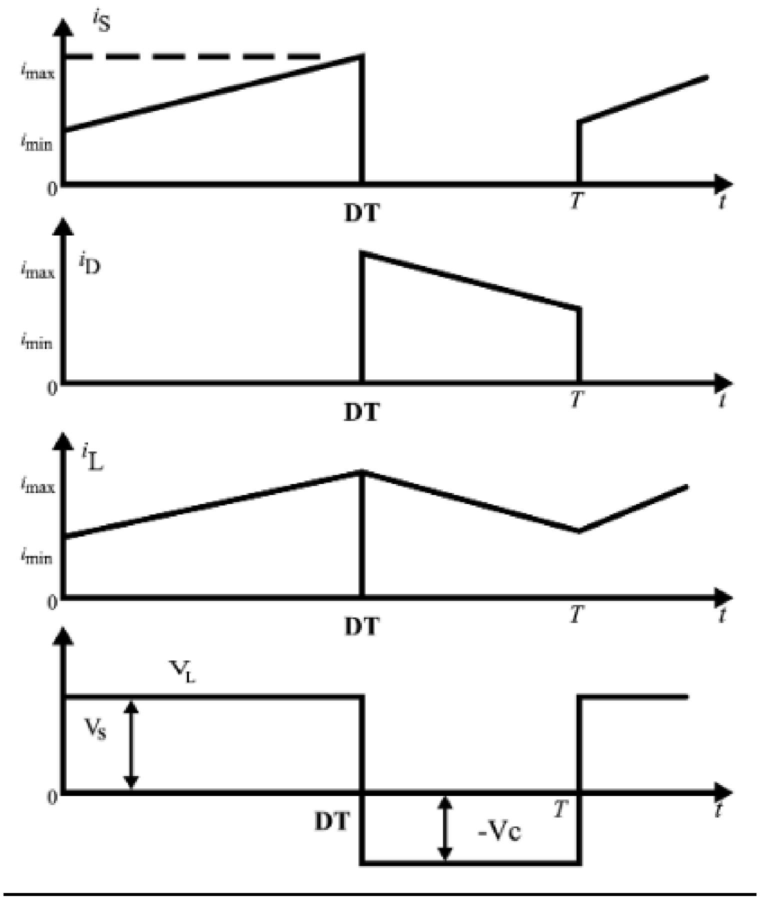


Fig: Output Voltage and Current waveforms of DC-DC Buck Boost converter

Procedure:

1. Make the connections as per the circuit diagram.
2. Observe the voltage and current waveforms

OBSERVATIONS:

Boost Converter:

S.No	Vin	Ton	Toff	D=Ton/T	Vo	Output calculated Vo=D*Vs

OUTPUT WAVEFORMS

Result:

EXPERIMENT 13

SPEED CONTROL OF SINGLE-PHASE INDUCTION MOTOR.

AIM: To perform the speed control of single- phase induction motor

APPARATUS: DC-DC Regulated power supply
Power electronics Kit
3HP Motor

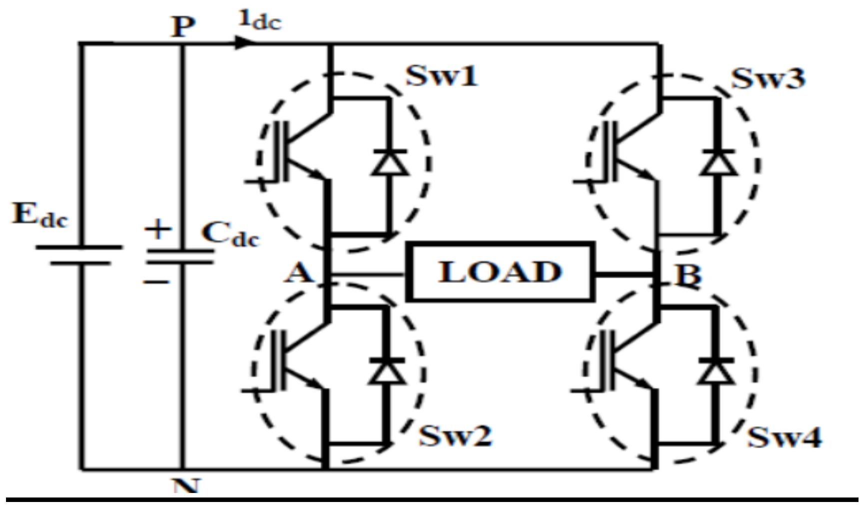


Fig: Single phase inverter

Procedure:

1. Make the connections as per the circuit diagram.

2. Switch on the Supply and turn on the RPS and set the required input voltage

3 Turn on the power electronics kit and press the reset button.

3. Select the open loop or closed loop option

4. In open loop select the duty ratio and note down the corresponding output voltage and output current and speed.

5. Connect the CRO and observe the wave form on CRO.

OBSERVATION TABLE:

S.No	Vin	Duty Ratio	V_0 (V)	I_0(mA)	Speed(rpm)